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Detection of Multiple Targets by Multistatic RADAR

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***Abstract*— The overwhelming majority of radar systems have been developed as single monostatic entities. This is largely due to their relative simplicity and the range of performance of which they are capable. However, the limits of monostatic radar are now beginning to be reached. Sensitivity is limited by power aperture product, location accuracy by aperture and information is limited by a single perspective. Many of these limitations can be addressed by using a multiplicity of transmitters and receivers leading directly to the concept of multistatic radar.**

Adaptive processing can be combined with the basic DPCA cancellation to minimize the clutter residue at the processor output and therefore maximize the improvement factor. Multistatic radar systems with several transmitters and receivers introduce not only new qualities in area surveillance as well as in hardware minimization but also new problems in signal processing and target detection and tracking. This project deals with multistatic radar system consisting of several independent bistatic radars processing signals scattered of surrounding objects. The measured data e.g. range resolution and Doppler imaging functions at individual radar are therefore not associated with a particular target. An optimal detection method should find the proper associations among a great number of their possible combinations.

***Index Terms*—Monostatic, Multistatic, Bistatic.**

I. INTRODUCTION

A. *OVERVIEW OF THE STUDY*

Multistatic radar systems differ from typical modern activeradar systems through consisting of multiple spatially diverse transmitter and receiver sites. This spatial diversity may provide several advantages over conventional monostatic radar. Technologies in such fields as communications and DSP continue to enable development of many aspects of multistatic operation, such as data transfer and fusion, and thus interest continues to grow in the achievable performance of such systems. In this work, a low-cost COTS coherent multistatic system designed at University College London [Derham,2005], named ‘NetRad’, has been developed to explore how these challenges might be dealt with, and what level of performance might be achievable. The system consists of three spatially diverse ‘nodes’ capable of both transmit and receive within the 2.4 GHz Industrial, Scientific and Medical (ISM) band. This work will contribute to the emerging research into multistatic radar, which will as a result be increasingly well understood at both a theoretical and practical level.

The definition of ‘multistatic radar’ is not completely consistent within the literature on the subject. In general terms, it is assumed that a multistatic radar will deal with surveillance areas which are covered by multiple transmitter-receiver pairs and that information from these pairs will be combined to provide target detection and further functions. This differentiates what might be termed as a multistatic radar system from a simple network of radars which have different spatial coverage areas and simply share track or plot information to cover a larger area. The terms ‘multisite radar’ and ‘netted radar’ are commonly interchanged to describe much the same form of system in the literature. Another recently popular subset of multistatic radar is spatial Multiple-Input Multiple-Output (MIMO) radar, and again there are no rigorous definition of what constitutes MIMO radar.

The ‘headline advantages’ of multistatic radar come from the increased information available due to observation of targets from the multiple different transmitter-receiver pairs in the system. These pairs can view different aspects of a target, and may have differing coverage due to geometry. This allows for detection of targets that might otherwise be missed by monostatic radars - either due to the ‘averaging’ effect of utilising multiple returns, or due to gains from intelligently weighting the combination of returns. Multistatic radar can be used to improve resolution and parameter estimation, which are commonly poor in the cross-range dimension for monostatic radars. The larger amount of information obtained on a target may also be used to improve target identification schemes. The development of radar, originally an acronym for Radio Detection and Ranging, can be attributed to many scientists and engineers - starting as far back as Hertz and his experiments to prove the electromagnetic propagation theories proposed by Maxwell. Radar became a very prominent area of research from the 1930’s onward. Several notable implementations took place during the Second World War, indeed Skolnik [1980] suggests that these radars were invented in response to the maturing of the modern airplane and it’s capability as a long range bomber to cause significant damage. Development for military purposes similar to this continues today, although effort is also more diversified over a wider range of radar uses - such as Synthetic Aperture Radar (SAR) for imaging of terrain, short range automotive collision avoidance systems, weather radars and air traffic control.

Multistatic radar is an emerging area, facilitated by the continuing developments in digital technology and hence there is still much to be clarified on how it might be best used. Experimental measurements to demonstrate the feasibility and performance of such systems are of great interest. Such measurements would be the first step to determining in which surveillance situations that multistatic radar might best be implemented. It is also important to show the challenges of system deployment, and thus how much potential such a system might eventually have as a commercial product.

B. OBJECTIVE OF THIS WORK

Multistatic radar systems with several transmitters and receivers introduce not only new qualities in area surveillance as well as in hardware minimization but also new problems in signal processing and target detection and tracking.

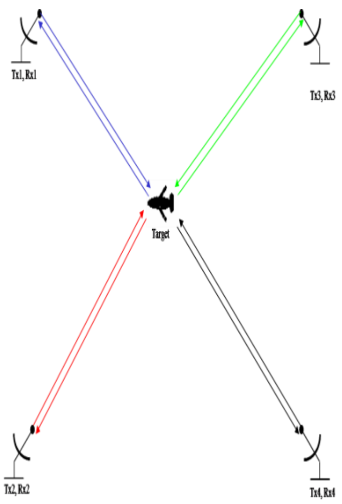
This project deals with multistatic radar system consisting of several independent bistatic radars processing signals scattered of surrounding objects. The measured data, e.g. range resolution and Doppler resolution at individual radar are therefore not associated with a particular target. An optimal detection method should find the proper associations among a great number of their possible combinations.

II. CATEGORISATION OF MULTISTATIC RADAR SYSTEMS

These are divided into three principle categories of operation the first component of categorisation to be examined is the transmitting and receiving options of the nodes in the network. As before:

(i) monostatic operation,
(ii) bistatic operation and
(iii) a combination of (i) and (ii).

In the multiple monostatic case, each radar is transmitting a specific waveform and is receiving only the echo originating from this unique transmitted signal. An example of the multiple bistatic case is a network comprising of one common emitter and N spatially separated receivers. Each transmitter-receiver pair is in fact bistatic radar. In the most general case each node in the network has a transmitting and a receiving point. The receiver this time accepts echoes from all reflected signals. A schematic illustrating these differing topologies is presented in figure 3 point. The receiver this time accepts echoes from all reflected signals. A schematic illustrating these differing topologies is presented in figure 1.



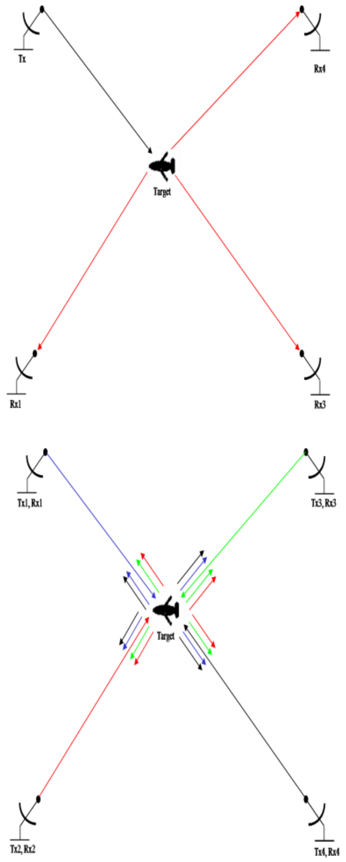


Figure 2.3: Modes of operation: The multiple monostatic case, the multiple bistatic case and the fully multistatic case. The coloured lines indicate the different waveforms used in each of the cases.

A. MONOSTATIC RADAR

The basic functions of radar are to measure the time delay of transmitted burst of electromagnetic energy to reach a target, be reflected and return to the radar receiver. In monostatic radar the transmitter and receiver are nominally in the same place so, after removal of internal radar delays, the time delay is simply due to propagation of a transmission to and from a target along the same path. It is of interest to investigate monostatic radar; providing a useful foundation of radar theory, such as optimal detection methods and further detailing concepts such as resolution. Throughout this work, a spatially separate transmitter or receiver site will be referred to as a node. Monostatic radars typically make use of a pulsed transmission to determine the range of a target1. Due to speed of propagation being equal to the speed of light, the range vector, R, of a point target from monostatic radar can be calculated through measurement of the time delay τ between the start of transmission and the reception of the echoed pulse transmission:

$$\|R\| = \tau c_p/2 \qquad (2.3)$$

Where cp is equal to the speed of light, c_p = 3×108ms−1.

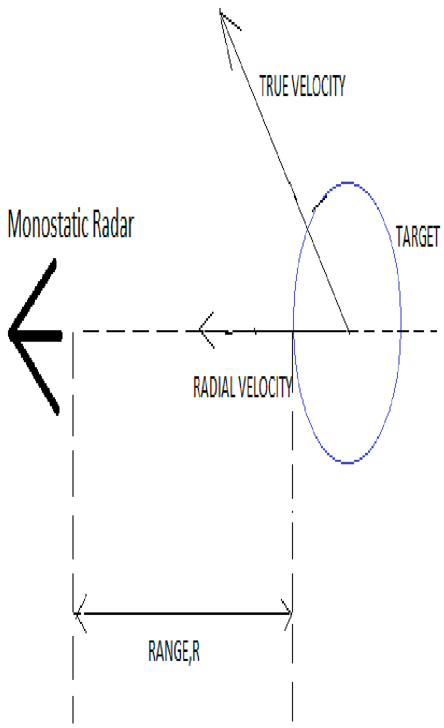


Fig 2.4: Monostatic radar geometry

Figure 2 shows the geometry applicable to the monostatic situation. As well as the range of the point target determining the time delay on the received signal, the radial velocity will cause a Doppler frequency shift, f_d on the received signal relative to the transmitted signal. The relationship between target velocity, v, and this Doppler shift towards the radar is shown in Equation 2.3. λ is the wavelength of the transmitted signal and ˆ R the unit vector of target range vector R:

$$f_d = \frac{-2v\cdot\hat{R}}{\lambda} \qquad (2.4)$$

Any velocity component, v, transverse to ˆ R will not contribute to f_d due to the dot product of the two vectors shown in Equation 2.2. Hence the true velocity vector, v, of the target cannot be completely specified.

During the propagation and reflection process there will be some losses in power. It is important to estimate the power of the desired signal returning from range R, since this will determine in part the coverage (i.e. the surveillance area in which a target might be detected) of the radar system. If a transmitted pulse power Pt is now considered, then for an isotropic antenna at a given distance R the power flux (density of power per unit area) is spread over the area of a sphere of radius R: Power flux at distance R from transmitter = $\frac{pt}{4\pi||R||2}$
(2.5)

A real radar antenna will have some directionality, with energy being focussed towards a certain direction, thus increasing the power flux within this 'beam width'. The equation for power flux may be modified to account for this concentration by inclusion of a transmitter gain term2 Gt. This amount of power reaches the target and is reflected back towards the radar receiver. The effective area from which power is re-radiated at the target location is known as the RCS of the target. This RCS will be dependent on the reflectivity of the target at a given target orientation. The power re-radiated from a target towards the radar receiver must travel the same distance, ||R||, in the monostatic case and thus the returning power flux will be spread over a similar sphere of radius||R||, this time centred on the target. The 'gain term' associated with the directionality of this re-radiation is included in the RCS, ω, thus the powerful at the radar receive antenna is: Power flux at receive antenna = $\frac{PtGt\,\sigma}{4\pi||R||^2}$ (2.6)

The amount of power intercepted, which then enters the receiver chain is determined by the effective antenna areaA_e . This effective area can be calculated if the receivers gain G_r and the carrier wavelength λ are known

$$Ae = \frac{Gr\lambda^2}{4\pi} \qquad (2.7)$$

Thus the power of the returning pulse, Pr, can be calculated through the product of Equations 2.4 and 2.5. The ratio of Pr to inherent noise power N (which will be present at any radar receiver) can be quantified - the Signal to Noise Ratio (SNR). N is generally assumed to be white Gaussian thermal noise. A system loss factor, Ls, is included to collectively account for losses which might typically cause deviation from the theoretical SNR, such as receiver noise figure or cable losses.

$$SNR = \frac{Pr}{N} = \frac{PtGtGr\sigma\lambda 2Ls}{(4\pi)^3||R||^4N} \qquad (2.8)$$

This is a standard form of the Radar Equation which is central to radar detection theory. SNR plays a large part in determining the reliability and ease of detection of target echoes, as well as influencing further higher-level functions such as parameter estimation. An increase in noise relative to the received signal power will decrease the probability of detection and accuracy of parameter estimation. As well as receiver noise, there may be 'clutter' consisting of the unwanted echoes from the surroundings – typically arising from the land scape, buildings, trees and other sources. Of course what might be considered clutter in one surveillance situation may be a target of interest in another. Similarly to noise, the presence of clutter may make detection and parameter estimation of targets rather more problematic- for this reason occasionally a Signal to Clutter Ratio (SCR) may be more appropriate if there is no way to differentiate a large clutter component from targets.

B. BISTATIC RADAR

Many early radar systems relied on the transmission of a single frequency, known as Continuous Wave (CW) radar, from a transmitter to a spatially separate receiver; hence these were in fact bistatic systems. These systems relied on the Doppler shift of the CW transmission on reflection from a moving target for target detection, but had no way of determining range. The invention of the duplexer and pulsed radar amongst other developments shifted much attention towards monostatic radar, which were seen as less complex and costly, and generally gave better performance. In terms of the NetRad, bistatic pairs are formed between any two nodes, where one acts as a transmitter and one a receiver. This is made possible through the shared (distributed) local oscillator and the synchronisation capabilities of the system. Bistatic radar differs from monostatic radar when determining target range, since the time delay of the pulse is now proportional to the sum of two ranges - the distance from transmitter to target RT and the distance from target to receiver RR:

$$\|Rtx\|+\|Rrx\|= \tau cp \qquad (2.9)$$

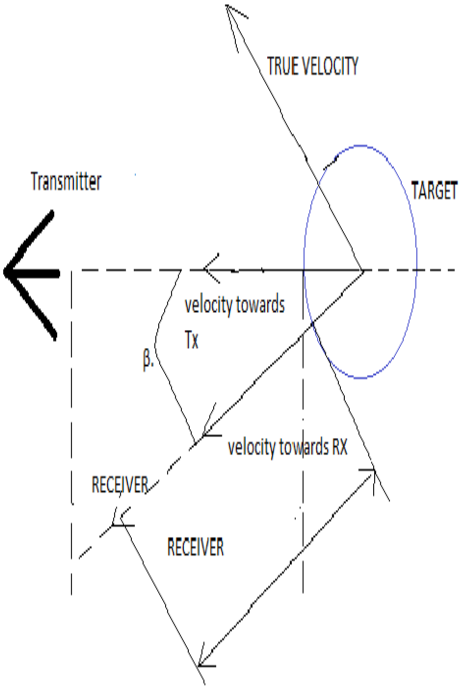


Fig: 2.6 Bistatic radar geometry

Figure 4 shows the geometry applicable to the monostatic situation. The line connecting the transmitter and receiver is known as the bistatic baseline, and the angle between the vectors from target to transmitter or receiver is known as the bistatic angle β. Again it is the radial velocity that will cause a Doppler frequency shift - however since transmitter-target and receiver-target paths are now different; the radial velocities must be considered along each of these paths. This new relationship is described by Equation 2.45.

$$f_d = \frac{(-v\bullet\hat{}\,Rtx)+(-v\bullet\hat{}\,Rrx)}{\lambda} \qquad (2.10)$$

Having two range vectors, R_{tx} and R_{rx} in the equations for range complicates the relationship between propagation delay and target position inherent to ranging. For a given measurement of time delay there are two unknown range terms - thus the target may be anywhere on the locus of the possible values of R_{tx} and R_{rx} that correspond to them ensured time delay. These loci will in fact form ellipsoids around the transmitter and receiver for each time delay value and will be dependent upon the geometry of the system. This is shown in comparison to a monostatic arrangement in Figure 5.

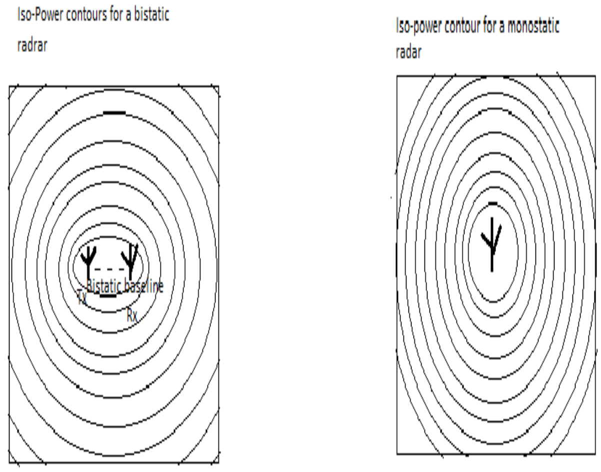


Fig 2.7: Comparison of bistatic to monostatic iso-range contours

The radar equation for the bistatic case is much the same as the monostatic, with the addition of these new range terms for the separated paths:

$$SNR=\frac{Pr}{N}=\frac{PtGtGr\sigma\lambda^2}{(4\pi)^3Rtx^2Rrx^2N} \qquad (2.11)$$

These multiple range terms in the equations above give rise to a locus of points given as specific time delay and a further locus of points given a specific SNR. When plotted, the locus for constant SNR will form the well-known ovals of Cassini, as shown in Figure 2.8.

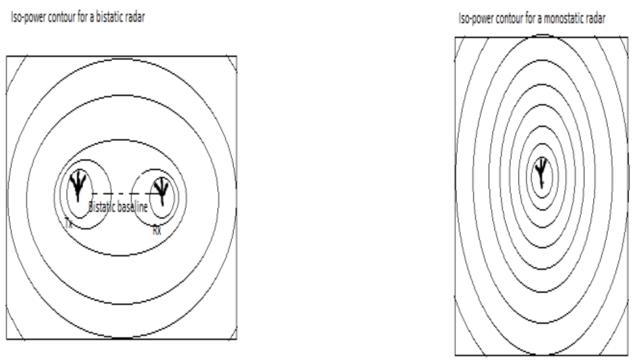


Figure 2.8: Comparison of bistatic to monostatic iso-power contours (Ovals of Cassini)

III. MULTISTATIC RADAR

A. INTRODUCTION:.

Classical monostatic radar with transmitter and receiver situated at the same point measures a positions and velocities of external objects (usually called targets). The accuracy of this measurement reached now its limits due to limited antenna aperture dimensions. Multistatic radar systems break this limitation by situating their antennas at large distances, creating super-antenna structures with extremely big apertures.

In the case of monostatic radar all needed position or velocity parameters are evaluated from the measurement of one radar. The ability to detect many targets simultaneously depends only on the radar resolution and no data association problem exists. A multistatic radar system evaluates the target position (resp. velocity) combining measurements of multiple sensors (individual radars).   .

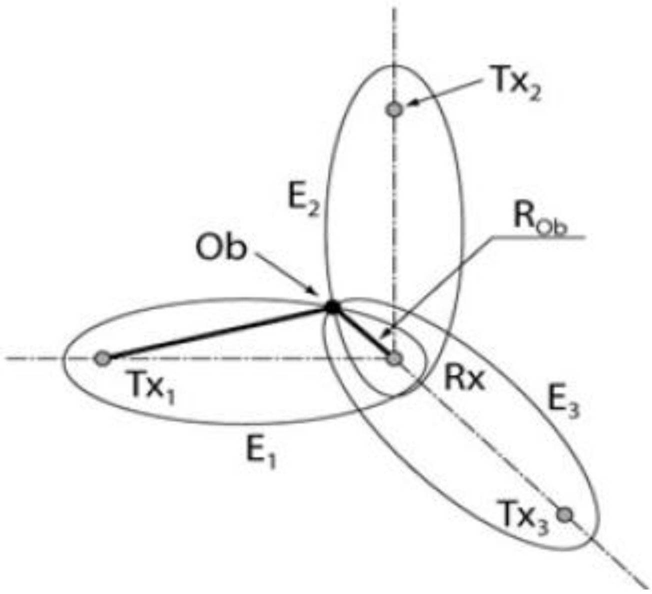


Fig. 3.1: Illustration of multistatic radar system, consisting of one receiver (Rx) and three transmitters (Tx1, Tx2, Tx3). Ob is the scattering object and E1, E2, E3 are ellipses corresponding to constant time delays of signals of individual radars scattered by the object to the receiver.

B. The Multistatic concept

The concept of multistatic radars is not new. It has been under investigation for some time and there was even a special issue from IEE on 1986 on [29] bistatic and multistatic radars. Recent technology advances though, especially in digital transmission, better processing power, more reliable communications and the arrival of GPS offer a means to have a common framework for space and time and has led to a reassessment of multistatic radar.

We begin here by more formerly introducing the underlying concept of a multistatic radar system. As discussed already the basic concept, at the most general level, is one of a number of transmitting and receiving sites or nodes, distributed in space with the potential to cooperate together. A generic four node system is shown in figure 1 where it should be noted that we haven't, at this stage specified whether or not a node is a transmitter a receiver or both transmitting and receiving site. The system as illustrated could be completely coherent making it rather like a sparsely populated phased array or it could be independent, incoherent monostatic radars (or anything in between). In addition, the processing strategy is also not defined but there is an implicit assumption that is possible (but not mandatory) for all data to be sent to a central processor where it can be processed as a single stream. Alternatively a node could itself be autonomous monostatic radar with only target tracks being combined in the central processor. Here we begin to see the range of potential systems embraced by the term multistatic radar. We especially see how the inherent spatial diversity in multistatic radar is the key new design freedom that requires a thorough understanding in order to evaluate where and when it is appropriate to use a multistatic radar system. We can also see new possibilities for detection, tracking and classification of targets as, for example, we now have the potential for the target to be 'inside' the system. This may well lead to radical new forms of sensor but also to new processing challenges such as near field operation.

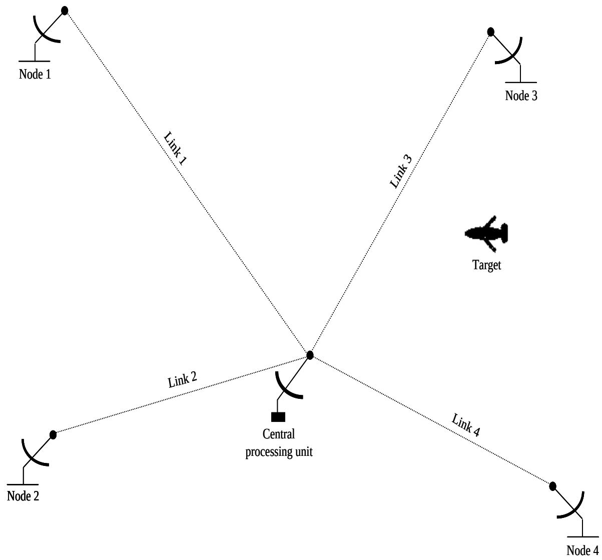


Figure 3.2: Typical scenario of multistatic radar

Multistatic radar may be thought of as being constructed of these basic building blocks. A node in the network can be thought of as having three basic functions. These are: (i) a transmitter, (ii) a receiver, or (iii) both a transmitter and a receiver. When a node is a transmitter, then there are a number of degrees of freedom that can be selected by the system designer in an attempt to optimise system performance. These are:

- The carrier frequency of the signal
- The pulse length
- The power in the pulse
- The pulse bandwidth
- The Pulse Repetition Frequency (PRF)
- The type of signal to be transmitted (i.e. the form of modulation used)
- The polarisation of transmission.

And these are design freedoms that are also available to the designer of the monostatic radar. Similarly, at the receiver, the choice frequency band, bandwidth and polarisation is in the hands of the designer. However, in a multistatic radar system, each node is capable of using different values for the above parameters both for transmitting and receiving modes. Indeed to make many concepts feasible this is an aspect of design that is mandatory. For multistatic radar this leads to the following options for operation:

3.2.3 Full multistatic operation, where the nodes are spatially distributed and the receivers can choose which signals to accept. This might be a network containing either or both cases 1 and 2 .A further important aspect is the various numbers and lengths of the baselines that are formed between the nodes (i.e. a line connecting a transmitter to a receiver). These are an important factor in determining the form, function and performance of the radar network.

It is immediately obvious that a major difference between a distributed system and a co-located system is the need for communication between the nodes of the network. They involve communication wavebands, paths, reliability, traffic, speed and security of performance. The first Criteria to be decided upon are whether or not the link between the nodes and the central processing station will be wireless or wired. If it is assumed that the intended use of the multistatic radar refers to a long baseline scenario (say more than 50 Km), then wireless communication can offer a more flexible solution. Traffic in multistatic radar is an important parameter that requires very careful consideration. There are two main aspects, the first is traffic form the sensors to the central station (measurement data and location values) and the second is data from the station to the nodes (command, reference and database). The types of traffic can include measurement data, repeat period, frequency, Doppler frequency, radar cross-section, phase, beam width, video signal, audio signal and clutter distribution.

IV. MULTISTATIC RADAR DETECTION THEORY

4.1 Range Resolution

4.1.1 Multistatic Range Resolution

The extension to multistatic range resolution is a small one from the bistatic range resolution case. This due to the fact the multistatic configurations can be decomposed into sets of bistatic and monostatic radars. The range resolution is now dependent on the best available set of radars. The best available set is a very cryptic description, especially because the best set varies over time. For the multistatic case radar management starts to play a vital role in optimizing the detection probability and improving the resolution of the image. As explained in the above section, the bistatic range resolution is dependent on the bistatic angle $\emptyset_{bi}$. This means that the best bistatic radar pairs probably have the smallest bistatic angle. The largest improvement over monostatic and bistatic configurations is the possibility of a complete 3D decomposition of the velocity of a target, whereas for mono- and bistatic scenarios only the radial speed of the target could be determined. This 3D decomposition of the target velocity is discussed in above section..

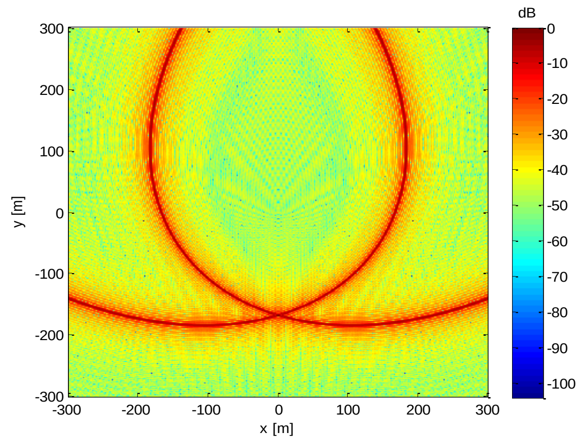
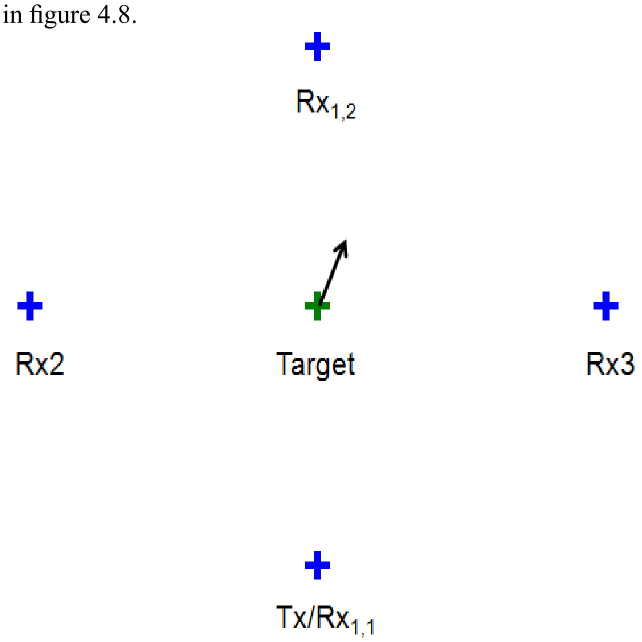


Fig4.7: Multistatic range resolution zoom in at the target location

Another advantage of multistatic target localization is that the cross-range can be greatly improved, without the use of special imaging techniques like (I)SAR. This can be seen in figure 4.7, where one transmitter, red plus symbol at -200,-200, and three receivers, green exes symbols at -200,-200 200,-200 and -200,200, are used to determine the location of a target. The cross-range resolution is with a mono- and bistatic radar always dependent on the range and the beam width of the antenna. The beam width of an antenna is λ d[rad] which results in a cross-range response of R·λ d [m]. With a multistatic configuration it is possible to decouple the cross-range resolution from the range. When orthogonal spaced receivers are used the cross-range resolution is no longer dependent on the range of the target, but on the down-range resolution of the radars. Most of the time orthogonal sets are not available, but the cross-range is then a combination of the down-range resolution and the angle under which the radar sees the target.

4.3 Doppler Imaging

In this chapter about Doppler imaging all the simulations are made with one scenario in mind. The situation sketch is shown in figure 4.8.



For the simulations a monostatic radar is combined with two additional receivers, to create a multistatic radar network. The target is flying with a velocity vector of [20,50] m/s. In section 4.3, the monostatic radar TX/RX1,1 is used. For the bistatic simulation in section4.3.2 the transmitter and RX2 are used. The multistatic simulation encompasses a scenario where the monostatic radar is used with receivers RX2 and RX3. A second multistatic simulation is made to explain a weakness of multistatic radar networks. The second multistatic scenario uses three bistatic radars, namely the transmitter and the receivers RX1,2, RX2 and RX3. For the simulations a sufficiently high PRF1 is chosen, so that the maximum received Doppler shift is well below the maximum detectable Doppler shift.

4.3.3 Multistatic Doppler Imaging

With multistatic Doppler imaging it is possible to determine a 3D velocity vector of the target, due to the factorization of the target's Doppler shift towards different receivers. When the Doppler shifts are combined, a 2D or 3D velocity vector of the target is constructed. This is shown in figure 4.11

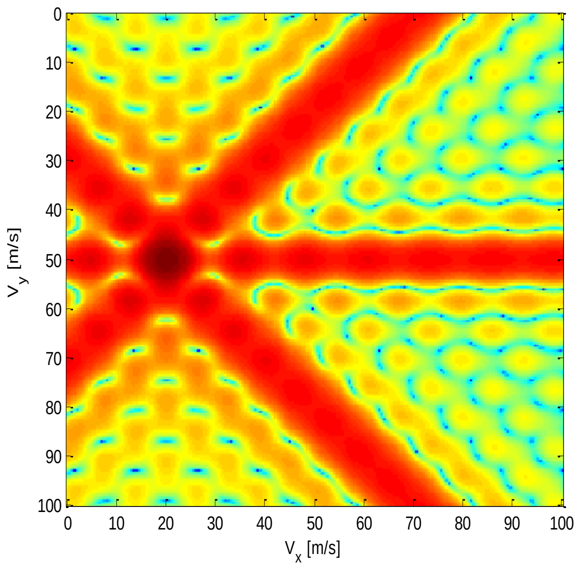


Fig 4.11:Doppler image for multistatic radar detection.

V. ADAPTIVE DISPLACED PHASE CENTRED ANTENNA

5.1 Principle of DPCA

MTI filtering and pulse Doppler processing provide an effective way to detect moving targets whose Doppler shift is in the clear region of the spectrum on at least one PRF. Airborne targets can generally detected in this manner. However slow-moving ground targets having actual Doppler shifts only slightly higher than the ground-clutter will appear in the skirts of clutter spectrum t all PRFs and therefore very difficult to detect.

Displaced phase centred antenna (DPCA) processing is a technique for countering the platform-induced clutter spectral spreading. By minimizing the clutter spectral width, DPCA improves the probability of detection for slow-moving targets. It is a special case of space-time adaptive processing (STAP).The basic concept is to make the antenna appear stationary even though the platform is moving forward by electronically moving the receive aperture backward during operation.

5.1.1 Methodology

One way to improve on this is to use two antennas in such a way that antenna2 moves to the position of anenna1 on subsequent pulses. Thus to a first approximation the scene is viewed from the same position at two slightly different times, this is known as arresting the forward motion of the antenna. Subtraction of the two signals will remove stationary clutter and reveal the moving targets.

5.1.2 Concept of DPCA

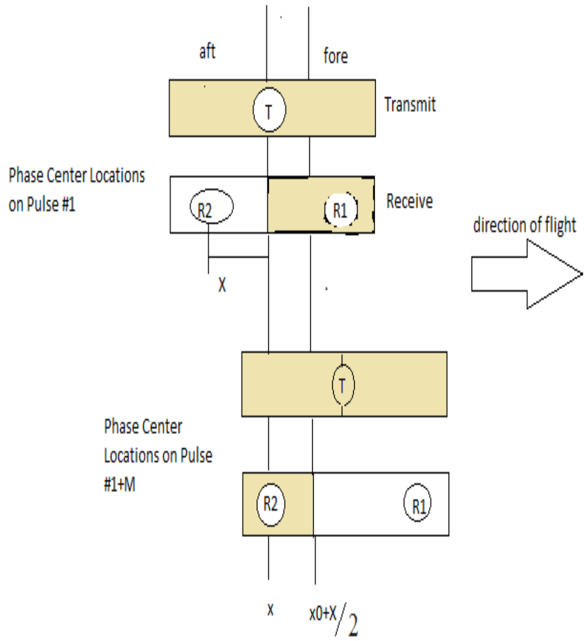


Fig 5.1: Relationship of transmit and receive aperture phase centres in DPCA processing.

Figure 5.1 illustrates the concept using an electronic antenna that has two subapertures.The entire antenna is used on transmission for maximum gain, so the phase centre for transmission is the point T in the middle of the antenna. Each half of the antenna has its own receiver, so there are in effect two receive apertures, having respective phase centres R1 and R2which are each x metres from the transmit phase centres.

5.2 Adaptive DPCA Concept

Adaptive processing can be combined with the basic DPCA cancellation to minimize the clutter residue at the processor output and therefore maximize the improvement factor. Assume that time slip, i.e. an integer delay of one channel with respect to the other is used to achieve coarse time alignment (to within one-half PRI) of two channels to be combined. Furthermore divide each received signal channel into Doppler sub bands using a DFT and perform the cancellation weight to be optimized separately for each subband, improving overall performance. The vector analysis approach will be used to develop the adaptive filtering, so define the coarse-aligned two channel signal vector y[l,m] as

$$y[l,m]=\begin{bmatrix} y_f[l,m] \\ y_a[l,m+M_s] \end{bmatrix}$$

(5.21)

Where y_f[l, m] is the “fore” channel and y_a[l, m] is the “aft” channel. As before, the index l is the range bin index, while m is the pulse number (slow time) index. Collect M pulses in a coherent processing interval (CPI) (thus 0<=m<=M-1) and take the K-point discrete Fourier transform of the data in each range cell to get the Doppler domain data vector

$$Y[l,k]=\begin{bmatrix} Y_f[l,k] \\ e^{-\frac{j2\pi k M_s}{K}} Y_a[l,k] \end{bmatrix}$$

(5.22)

Equation (5.22) pints out that the time slip adjustment add a liner phase term to the DFT of the aft channel data. This effect on the Doppler domain data applies to both target and interference signal components.

The signal at each sub aperture consist of clutter noise, and (if present) target components. A model of the covariance matrix S_I of the Doppler domain interference. The clutter in the two channels is correlated to some degree determined by the platform motion and time slip correction. Furthermore the clutter is not white, meaning its covariance varies as a function of the Doppler index k.The thermal noise is assumed uncorrelated between channels and is white.

Therefore, S_I will take the form

$$S_I[l,k]= S_I[k]=\begin{Bmatrix} \sigma_c^2[k]+\sigma_n^2 & \rho(k)\,\sigma_c^2(k) \\ \rho^*[k]\sigma_c^2[k] & \beta(k)(\sigma_c^2[k]+\sigma_n^2) \end{Bmatrix}$$

(5.23)

In equation (5.23), th coefficient β (k) accounts for any mismatch in the gain and frequency response or sub aperture antenna patterns of the two channels. Note that the form of the covariance matrix is assumed the same in every range bin, varying only with Doppler. As discussed previously, the Doppler spectrum can be divided into clutter and clear regions. The clutter region is that range of the Doppler bin index k where the interference consists of both clutter and thermal noise, but with clutter dominant moving target in range bin l_t is modelled by the time domain signal vector.

$$T[l,m] = A_t \quad \delta\,[l- l_t]\; e^{j2\pi F_D m t}\begin{bmatrix} y_f \\ y_a \end{bmatrix}$$

(5.24)

Where y_f and y_a =complex scalar constants representing the unknown target phase and(possibly unequal)amplitudes in the fore and aft receive channels

A_t=Target amplitude

δ[.] = discrete impulse function

The phase difference of the two signals received at the two sites becomes

$$\Delta\emptyset = \frac{2\pi}{\gamma_k} d_{pc} \quad \sin \quad \theta_a$$

(5.25)

The subscript k on the wavelength has been added to emphasize that the appropriate wavelength should be used for each Doppler bin to which equation 5.25 will be applied.

The exact clutter and noise statistics are not known priori.Consequently,S_I also cannot be known exactly, but it can be known exactly, but it can be estimated from the data. Since the clutter covariance is expected to have essentially the same in every range bin, one way to estimate S_I would be to compute a sample average over several range bins

$$S_I^* \;[k] = \frac{1}{L_2-L_1+1}\sum_{l=L_1}^{L_2} Y^* \;[l,k] \quad Y^{'} \;[l,k]$$

(5.26)

This estimate of S_I^* then replaces the actual S_I in equation (5.23) since the coefficients used to combine the fore and aft data streams are computed from the data itself; this is now an adaptive DPCA processor.

Combining equations (5.23),(5.24)and (5.25) gives the output of the DPCA system .Assuming that S_I^* is a good approximation to S_I is a good approximation to S_I and absorbing all constants into a single constant $k^{'}$ gives

$$z[l,k]= k^{'}\,\{\,\beta[k]\,(1+\frac{\sigma_n^2}{\sigma_c^2})\,Y_f\,[l,k]\text{-}\,\rho^*\,[k]\,e^{+j2\pi M_s k/K}Y_a\,[l,k]\}$$

(5.27)

While complicated, the structure of a two pulse canceller is clearly present in the subtraction of □□[l,k] from □□[l,k].If the interference is clutter-limited so that □²□ >> □²□ and □[□] → 1 so that the clutter is highly correlated across range bins, the output simplifies to

z[l,k]= □′ { □[□]□□ [l,k]- □+□2□□□□□/□□□ [l,k]

(5.28)

The two-pulse canceller structure, applied to each range and Doppler bin, is clearer here. The complex exponential in the Doppler index k is equivalent to a time-domain shift of □□ samples, in accordance with the DPCA condition discussed earlier .The factor □[□] provides a Doppler –dependent weighting factor that can be optimized to maximize cancellation in each Doppler channel.

The matched matched filter design assumes that □*□ is an estimate of the auto covariance of the interference only i.e., it should not contain any target signal components .A practical system must take steps to ensure this is the case, perhaps by skipping the range bins containing targets already in track, averaging over enough range bins to minimize any unknown target influences, rescreening the data for large amplitudes that might indicate a target,or other means .

VI. RESULT AND CONCLUSION

Displaced phase centred antenna (DPCA) processing is a technique for countering the platform-induced clutter spectral-spreading .By minimizing the clutter spectral width; DPCA improves the probability of detection for slow-moving targets. Adaptive processing can be combined with the basic DPCA cancellation to minimize the clutter residue at the processor output and therefore maximize the improvement factor.

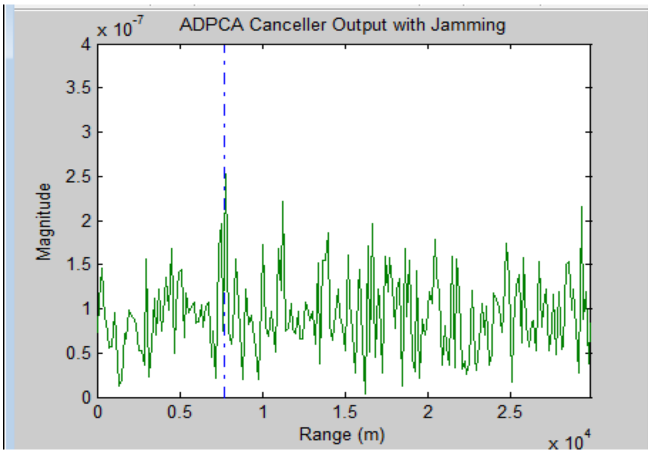


Fig 6.1 : Clutter cancellation by using ADPCA

As we discussed earlier that in ADPCA the entire antenna is used for transmission and reception. The entire antenna is used on transmission for maximum gain .The design of transmitter is more cost effective than the design of receiver. By taking the consideration of cost effective and design analysis we are going to detect the multiple targets by using multistatic radar by taking one transmitter and more number of receivers.

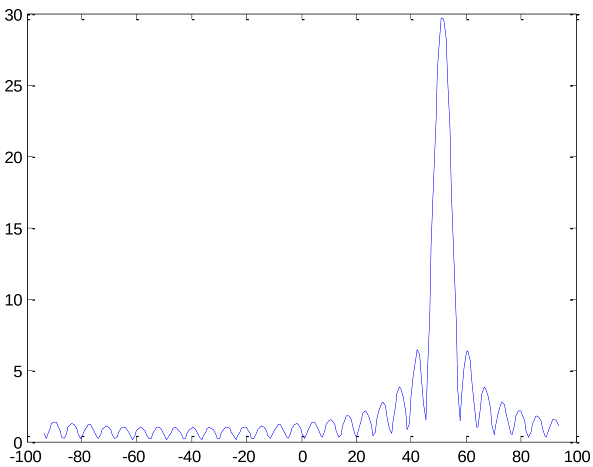


Fig 6.2 Multistatic radar detection output.

Multistatic radar is used to detect the multiple targets by using one transmitter and more than one receiver .The position of targets are also can be determined by the multistatic radar. Main aim of this project is to detect range ambiguity and Doppler ambiguity of the multiple targets. Range ambiguity and Doppler ambiguity of multiple targets by using multistatic radar is

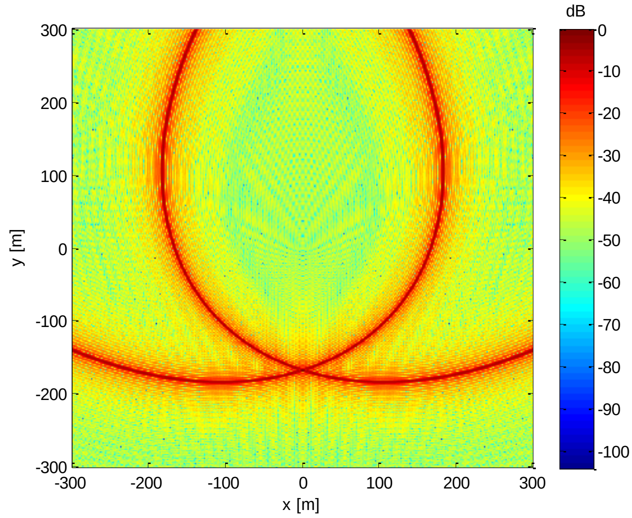


Fig 6.3: Detection of Range resolution by using multistatic radar

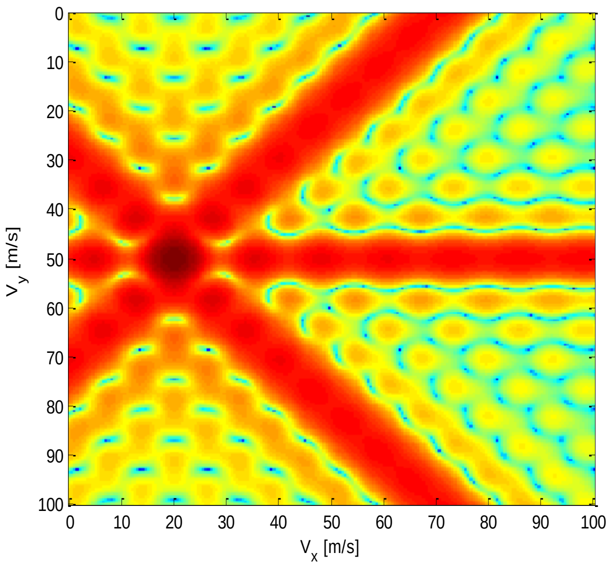


Fig 6.4: Detection of Doppler imaging by using multistatic radar.

VII. FUTURE SCOPE

In this current project we detect the multiple targets by multistatic radar. Multistatic radar systems with several transmitters and receivers introduce not only new qualities in area surveillance as well as hardware minimization but also new problems in signal processing and target detection and tracking. This paper deals with multistatic radar system consisting of several independent bistatic radars processing signals scattered of surrounding objects.

Multistatic radar extended to multidynamic radar .It is similar to multistatic or multi-site radar system at given instant of time. Multidynamic radar has several spatially separated transmitting, receiving and transmitting-receiving radar system. In this Multidynamic radar system the radar platforms are not spatially fixed with time. Multidynamic radar has more target resolution capability, clutter resistance and jammer resistance compared to multistatic radar.

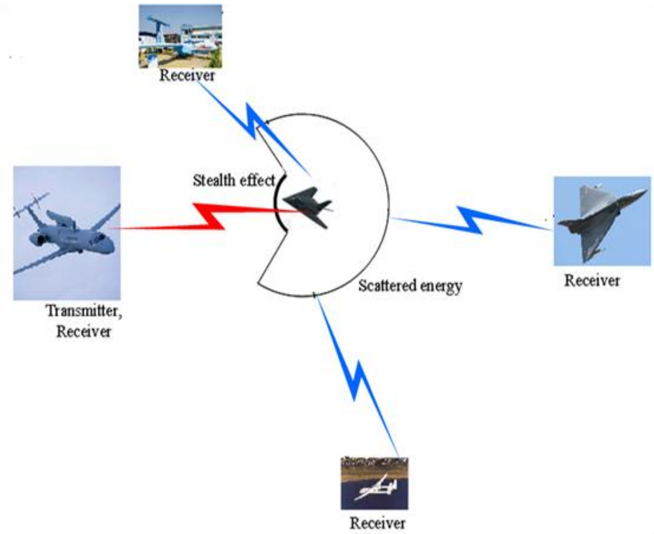


Fig 7.1: Multidynamic radar system

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