Doppler Blind Zone Analysis for Ground Target Tracking with Bistatic Airborne GMTI Radar

Michael Mertens
Sensor Data and Information Fusion
Fraunhofer FKIE
Wachtberg, Germany
michael.mertens@fkie.fraunhofer.de

Thia Kirubarajan
Electrical and Computer Engineering
McMaster University
Hamilton, Canada
kiruba@mcmaster.ca

Wolfgang Koch
Sensor Data and Information Fusion
Fraunhofer FKIE
Wachtberg, Germany
wolfgang.koch@fkie.fraunhofer.de

Abstract—This paper investigates the Doppler blind zone of bistatic transmitter and receiver configurations and its impact on the tracking of ground targets based on measurements from airborne ground moving target indication (GMTI) radar. The Doppler blind zone arises from the clutter cancellation by space-time adaptive processing (STAP). In general, this poses a significant challenge in ground target tracking because low-Doppler targets can easily be hidden within this blind zone, leading to sequences of missed detections that strongly deteriorate the performance of a standard tracking filter. In this study the width of the bistatic Doppler blind zone is calculated and this knowledge is incorporated into a UKF-MHT tracking algorithm. Based on simulation scenarios, it is demonstrated that in contrast to a monostatic configuration with sideways-looking radar, the minimum detectable velocity that characterizes the width of the Doppler blind zone does not need to be constant. Track results reveal the benefit of exploiting this additional knowledge.

Keywords: Target tracking, bistatic, Doppler blind zone, MHT, UKF, ground moving target indication (GMTI), radar.

I. INTRODUCTION

One of the main challenges in ground target tracking based on measurements from airborne GMTI radar is the masking of targets due to the Doppler blind zone of the radar. The information on this blind zone can be incorporated into a tracking algorithm by defining a target state dependent detection probability [1] that accounts for the degraded possibility to obtain a target measurement while it is located within the blind zone. This method has been applied to simulation scenarios [2] as well as real data [3], in all cases resulting in improved tracking performance. This technique was also applied to the tracking of ground targets with a bistatic radar configuration [4]. But in all these cases, the width of the Doppler blind zone was assumed to be a sensor parameter, thus constant. This stems from the fact that the width is known to be constant for the case of monostatic sideways-looking radar that covers the majority of ground target tracking experiments to date. But bistatic configurations with separated transmit and receive antennas will play an increasing role in future reconnaissance systems, e.g., to accomplish covert operations.

The aim of this study is to calculate the true width of the Doppler blind zone for arbitrary bistatic configurations, to examine its evolution in the course of time for a simulation scenario and to incorporate the knowledge of the true blind zone width into a tracking algorithm.

The paper is organized as follows: In the next section, the basics of STAP and the calculation of the Doppler blind zone width are briefly discussed as well as the incorporation of the Doppler blind zone information into a Bayesian tracking filter. In Section III, the analyzed simulation scenarios as well as tracking results are presented and discussed. Finally, concluding remarks are given in Section IV.

II. THEORETICAL ASPECTS

A. Obtaining the Bistatic Doppler Blind Zone Width

The bistatic Doppler blind zone can generally be specified by its center clutter Doppler frequency \( f_D^c \) or range-rate, respectively, and its width. For a given bistatic configuration with position and velocity of transmitter (Tx) and receiver (Rx) given by the 3D vectors \( \mathbf{r}_{\text{Tx}}, \dot{\mathbf{r}}_{\text{Tx}}, \mathbf{r}_{\text{Rx}} \) and \( \dot{\mathbf{r}}_{\text{Rx}} \), the clutter Doppler frequency at the location \( \mathbf{r} \) on the ground is determined by

\[
    f_D^c = \frac{1}{\lambda} \left( \frac{\mathbf{r} - \mathbf{r}_{\text{Tx}}}{||\mathbf{r} - \mathbf{r}_{\text{Tx}}||} \cdot \dot{\mathbf{r}}_{\text{Tx}} + \frac{\mathbf{r} - \mathbf{r}_{\text{Rx}}}{||\mathbf{r} - \mathbf{r}_{\text{Rx}}||} \cdot \dot{\mathbf{r}}_{\text{Rx}} \right)
\]  

where \( \lambda \) is the wavelength of the corresponding signal center frequency. The associated bistatic range-rate of the clutter patch on the ground is then given by \( \dot{r}_D^c = -f_D^c \cdot \dot{r}_D^c \). The width on the other hand is not of physical nature but arises from a special signal processing technique that is used to suppress the ground clutter in order to separate moving target returns from this clutter background: Eq. (1) indicates that whenever moving airborne platforms are involved, the clutter energy is no longer concentrated at zero Doppler. Instead, it becomes a 2D-structure distributed across the angle-Doppler plane, which cannot be suppressed by 1D-filtering in either angle (spatial domain) or Doppler (time domain). To account for this angle-Doppler coupling of the ground clutter, a multi-dimensional filtering is applied instead that is capable of yielding optimal clutter suppression in terms of signal-to-clutter ratio (SCR): the space-time adaptive processing (STAP) technique [5]–[7].

The major task of STAP is the determination of the clutter covariance matrix \( Q \) that contains the full knowledge of the
angle-Doppler coupling of the clutter for a certain (bistatic) range. In real scenarios, $Q$ needs to be estimated from training data due to the fact that ground clutter is in general heterogeneous. In this work, however, the clutter is assumed homogeneous to analyze solely the influence of the bistatic configuration on the Doppler blind zone width. Hence, $Q$ can be calculated and is thus fully known. For a given bistatic configuration as, e.g., shown in Fig. 1, the associated bistatic range defines an ellipsoid with transmitter Tx and Rx as foci. The intersection of this ellipsoid with the ground plane yields the corresponding isorange ellipse. Each clutter patch on this ellipse has a spatially dependent reradiating intensity with which it enters the calculation of the clutter covariance matrix $Q$. Fig. 2 presents the exemplary distribution of the dominant clutter patches along the isorange ellipse contour for the configuration shown in Fig. 1. The efficiency of the STAP clutter cancellation can be assessed by calculating the improvement factor (IF) which reveals a notch at the location of the clutter spectrum in the angle-Doppler plane. Under the assumed optimal conditions, this notch at the location related to the given look direction.

The width of the bistatic Doppler blind zone in the bistatic range-rate domain is described by the minimum detectable velocity (MDV). It is determined by the half-width of the notch in the IF distribution at $-3\,\mathrm{dB}$ for a given azimuth look direction. An exemplary 1D-IF distribution at a fixed look angle is shown in Fig. 3. For the analysis presented in Section III, the following scheme is used to calculate the MDV at each revisit, given the positions of Tx, Rx and ground target:

1) determine parameters of isorange ellipsoid with Tx and Rx as foci, target on ellipsoid surface
2) calculate isorange ellipse (intersection of ellipsoid with flat earth, containing target)
3) determine position and clutter-to-noise ratio (CNR) of clutter patches on isorange ellipse illuminated by Tx, observable by Rx
4) calculate $Q$ with contributions from all clutter patches, taking into account Tx sum beam illumination & Rx angle being related to the direction of the impinging target signal return with respect to the antenna normal vector which is given by

$$\varphi^d = \frac{d}{\lambda} \cos \varphi_L \cos \theta_L$$  \hspace{1cm} (5)$$

The parameter $d$ is the inter-element spacing of the array antenna and $\theta_L$ the elevation angle.
5) calculate improvement factor at Rx look direction towards ground target
6) determine MDV given by half-width of IF at $-3$ dB

B. Exploiting the Doppler Blind Zone Information for Tracking with Bistatic GMTI Measurements

When a target is masked by the Doppler blind zone (or Doppler notch), target measurements are strongly suppressed due to clutter cancellation by STAP and the receive antenna is unable to detect it although such a target may move at a considerable speed. Thus, the detection probability $P_d$ is directly influenced by the existence of this blind zone. Following the approach presented in [1], the detection probability is modeled in such a way that the influence of the bistatic Doppler notch is taken into account and can be written as a function of the target state at time step $k$, $x_k = [r^T_k, \dot{r}^T_k]$, as

$$P_d(x_k, r_{Tx}, r_{Rx}) = P^0_d \left( 1 - e^{-\log 2 \left( \frac{n_b(x_k, r_{Tx}, r_{Rx})}{MDV(x_k, r_{Tx}, r_{Rx})} \right)^2} \right) \tag{6}$$

where $P^0_d$ is the detection probability for a target range-rate well outside the blind zone interval and the Doppler notch function $n_b(x_k, r_{Tx}, r_{Rx})$ measures the distance to the bistatic Doppler blind zone center. It can easily be shown that, in Cartesian coordinates, it is identical to the bistatic range-rate given by

$$n_b(x_k, r_{Tx}, r_{Rx}) = \frac{r_k - r_{Tx}}{||r_k - r_{Tx}||} \dot{r}_k + \frac{r_k - r_{Rx}}{||r_k - r_{Rx}||} \dot{r}_k \tag{7}$$

The MDV is no longer a fixed sensor parameter as in [1], [4] but is calculated instead at each revisit based on the scheme presented in Section II-A. The particular form of the detection probability in (6) is chosen such that if the notch function equals the current width of the Doppler blind zone then $P_d$ drops to 1/2. Hence, target detections become more and more unlikely as the target moves inside the Doppler notch region and for the case that the target's bistatic range-rate matches the range-rate of the surrounding clutter, then the detection probability drops to zero.

The tracking filter used in this study is based on the Bayesian formalism [9], [10]: The probability density $p(x_k|Z^k)$ that describes the target state $x_k$ at time step $k$, conditioned on the measurement sequence $Z^k = \{Z_1, Z_2, ..., Z_k\}$ with $Z_k = \{z_{k,m}^{n_k}\}_{m=1}^{n_k}$ and measurement $z_{k,m}^{n_k}$, is sequentially updated yielding the posterior density

$$p(x_k|Z^k) = \frac{p(Z_k|x_k) p(x_k|Z^{k-1})}{\int dx_k p(Z_k|x_k) p(x_k|Z^{k-1})} \tag{8}$$

In the prediction step, for the prior $p(x_k|Z^{k-1})$ a Gaussian shaped posterior density $p(x_{k-1}|k-1|Z^{k-1})$ is assumed that is propagated to the actual time step $k$ by utilizing a linear motion model with additive white Gaussian process noise.

In the filter update step, the estimate based on the motion model is improved by incorporating the sensor data. For the calculation of the posterior density, the single-target likelihood function $p(Z_k|x_k)$ is needed. It reflects all possibilities to interpret the sensor output and contains a simple sensor model, relevant for the tracking algorithm, given by the detection probability $P_d$ and the false alarm density $\rho_f$. Its standard formulation is [9]

$$p(z_k|x_k) = (1 - P_d) + \frac{P_d}{\rho_f} \sum_{m=1}^{n_k} \mathcal{N}(z_{k,m}^{n_k}, \mathbf{H}_k x_k, \mathbf{R}_k) \tag{9}$$

This function reflects the $n_k + 1$ hypotheses that either all $n_k$ measurements are false alarms or that measurement $m$ is the correct target measurement, all others are false alarms. Due to the bistatic configuration, the measurement equation is nonlinear, $z_k = (r_k, \varphi_k, \theta_k, \dot{r}_k)^T = h(x_k)$ with bistatic range $r_k$, azimuth angle $\varphi_k$, elevation angle $\theta_k$, and bistatic range-rate $\dot{r}_k$. This nonlinearity is accounted for by using the Unscented Kalman Filter (UKF) [11] for the calculation of the hypotheses for each bistatic measurement. For track extraction, a tentative track is initialized with the measurement in Cartesian coordinates. Therefore, the Unscented Transformation is used to transform the bistatic measurements $z_{k,m}^{n_k}$ into the Cartesian coordinate space, yielding $z_{k,m}^{cart}$. And as the target moves in the x-y plane only, this additional knowledge is incorporated by performing a pseudo-filtering step on $z_{k,m}^{cart}$, following the logic in (12).

The final step is now to include the detection probability that contains the knowledge of the bistatic Doppler blind zone into the tracking filter. But before it can be substituted into the likelihood function finally leads (9), the bistatic nonlinear notch function $n_b(x_k, r_{Tx}, r_{Rx})$ is linearized [1] around the predicted target state $x_{k|k-1}$:

$$n_b(x_k, r_{Tx}, r_{Rx}) \approx \tilde{z}_b - \tilde{H}_f x_k \tag{10}$$

This yields a fictitious bistatic measurement $\tilde{z}_b$ and fictitious bistatic measurement matrix $\tilde{H}_f$ which are calculated by

$$\tilde{z}_b = n_b(x_{k|k-1}, r_{Tx}, r_{Rx}) + \tilde{H}_f x_{k|k-1} \tag{11}$$

$$\tilde{H}_f = -\frac{\partial n_b(x_k, r_{Tx}, r_{Rx})}{\partial x_k}|_{x_k=x_{k|k-1}} \tag{12}$$

In that way, the exponential in (6) can be rewritten as a Gaussian, yielding

$$P_d(x_k, r_{Tx}, r_{Rx}) = P^0_d \left( 1 - c \mathcal{N}(\tilde{z}_b^T, \tilde{H}_f^T x_k, Q) \right) \tag{13}$$

with $c = \frac{MDV}{\sqrt{\log(2)/\pi}}$ and $Q = \frac{MDV^2}{2\log(2)}$. The substitution of the detection probability into the likelihood function finally leads to an increased number of hypotheses, $2(n_k + 1)$, to interpret a given sensor output which includes the hypothesis that the target is not detected due to the Doppler notch masking.

The derived tracking scheme is implemented into a track-oriented MHT algorithm, [10]. In order to mitigate the exponential growth of hypotheses, the standard mixture reduction methods [13] gating, pruning and merging are applied. For track extraction and track maintenance, a sequential likelihood-ratio test based algorithm [13], [14] is implemented.
III. Simulation Scenarios and Numerical Results

In the first part of this section, the MDV as a function of time is analyzed for two different simulation scenarios. The second part compares the tracking performance of three target trajectories, based on a different handling of the MDV information in the tracking algorithm. For obtaining the simulation results presented in this section, the parameters listed in Table I were used. A uniform linear array (ULA) with equidistant spacing between elements was chosen as antenna for Tx and Rx.

A. Examination of the MDV for Sideways-Looking Radar

Based on the method described in the previous section for obtaining the width of the Doppler blind zone at each revisit, the MDV was calculated for the simulation scenarios shown in Figs. 4 and 5. The upper plot presents the linear trajectories of transmitter (Tx), receiver (Rx) and ground target and the lower plot reveals the corresponding MDV as a function of time, respectively. The sensor platforms move on parallel paths and for both Tx and Rx a sideways-looking antenna configuration was chosen to guarantee that the target is illuminated by Tx and within the field of view of Rx throughout the scenario. It should be noted, that the only difference between these two scenarios is the trajectory of Tx. In the first case, the target is situated in roughly the same direction for Tx and Rx, whereas in the second case the illuminated area on the ground containing the target is in between Tx and Rx. Interestingly, this change obviously leads to a significantly different shape of the calculated MDV. In the following, the main differences will be analyzed and explained.

For scenario 1, the MDV remains constant throughout the scenario, but it is about three times larger than the minimum value in scenario 2. The reason for this can be found by looking at the distribution of the clutter patches on the isorange ellipse compared to the Doppler isolines on the ground. This is shown for each scenario based on the bistatic configuration at revisit 10 in Fig. 6. For a better visualization, only those clutter patches are displayed which contribute most to the clutter spectrum (at least 5% of the maximum CNR value). The color index refers to the relative CNR value of each clutter patch. In the upper plot, associated with scenario 1, the relevant clutter patches cover a broad interval of clutter Doppler frequencies, whereas in the lower plot, associated with scenario 2, the relevant clutter patches only spread over a small Doppler frequency interval.

Thus, the width of the Doppler blind zone is strongly related to the number of different Doppler frequencies covered by the dominant clutter patches, because this defines the size of the resulting clutter spectrum in the Doppler frequency domain which will be suppressed by STAP.

Besides the different magnitudes of the (minimum) MDV value for the two scenarios, the MDV as a function of time for the second scenario reveals a remarkable shape: After remaining constant at $3 \text{ m/s}$ for about 25 revisits, the MDV rapidly increases to about $12 \text{ m/s}$. The width of the Doppler
The evolution of the width of the Doppler blind zone can be explained by analyzing the plots presented in Fig. 7. For each of the revisits 10, 26, 30, 40, 50 and 75, the left plot exhibits the bistatic configuration, the isodoppler contours, the isorange ellipse and relevant clutter patches with at least 5% of the maximum CNR value and the right plot illustrates the distribution of the clutter patches along the isorange ellipse contour compared to the run of the Doppler isolines, respectively.

In the first part of the scenario, the two platforms approach the target in x-direction, leading to a decrease of the bistatic range. On the other hand, the baseline, i.e., the distance between Tx and Rx remains constant over time. This results in an ellipsoid that becomes smaller in overall size but also more and more cigar-shaped along the baseline. The intersection of this isorange ellipsoid with the ground plane at \( z = 0 \) then leads to an isorange ellipse which becomes smaller and finally consists of a single intersection point when the target is located right in the center between the two platforms. In the second half of the scenario, when the target crosses the baseline between Tx and Rx, the bistatic range increases again. This results in a larger isorange ellipsoid and thus also in an isorange ellipse on the ground increasing in size. This considerable change in size of the isorange ellipse in the course of the scenario can well be observed by examining the corresponding plots in Fig. 7.

At revisit 10, the isorange ellipse is comparably large with the relevant clutter patches covering only a small part of the ellipse contour in the vicinity of the target. As already shown in the lower plot of Fig. 6, the clutter patches only spread over a small Doppler frequency interval. At revisit 26, the clutter patches which contribute most to the clutter spectrum are now distributed over a larger part of the smaller isorange ellipse contour, covering a much larger interval of clutter Doppler frequencies compared to revisit 10, which leads to the large MDV value. This is also true for the situation at revisit 30 with an even smaller isorange ellipse contour. But as the isorange ellipse becomes smaller, the total number and thus also the number of dominant clutter patches is reduced because the extension of the ellipse in cross-range direction as seen from Rx decreases. At revisit 40, only two clutter patches remain corresponding to a single look direction of Rx. Interestingly, these two clutter patches obviously lead to almost the same width of the Doppler blind zone as the several clutter patches at revisit 10. This can be explained by the higher CNR values due to the smaller bistatic range. In the following revisits, the two platforms overtake the target in x-direction, leading to an increase in bistatic range and thus a growing isorange ellipse contour. The dominant clutter patches again cover a larger Doppler frequency interval leading to an increase of the MDV, as plotted for revisit 50. After several revisits, the distribution of the relevant clutter patches along the isorange ellipse contour is again limited to the vicinity of the target and only spread over a small Doppler frequency interval resulting in the original MDV value.

### B. Tracking Scenario

In the second part of this section, the MDV information is used in a 3D-UKF single-target MHT algorithm which has been presented in Sec. II-B and applied to the following

![Image of Doppler contours with 200 Hz spacing and distribution of relevant clutter patches along isorange ellipse for scenario 1 (upper plot) and scenario 2 (lower plot) at revisit 10. The color indicates the relative CNR value of each clutter patch (red: maximum, blue: minimum, at least 5% of max. value)](image_url)
Figure 7. For the bistatic configuration of scenario 2, shown are the isodoppler contour with 200 Hz spacing, the isorange ellipse and relevant clutter patches with at least 5% of max. CNR value (left plot), and the right plot illustrating the distribution of the clutter patches along the isorange ellipse compared to the run of the Doppler isolines for revisits 10, 26, 30, 40, 50 and 75, respectively. The red isoline corresponds to zero clutter Doppler frequency and the colorbar denotes Doppler in Hz.

setup: Based on the general bistatic configuration of scenario 2, the ground target now moves along one of three possible target trajectories, as shown in Fig. 8. The first case is the straight line motion as considered in the previous part, whereas the other two possible target paths are based on winding trajectories. The red lines at each trajectory of Fig. 8 indicate target positions at which the bistatic range-rate is below the true MDV. Thus, in these regions the target is masked by the bistatic Doppler blind zone. Within this blind zone, only sporadic measurements occur because the detection probability is strongly reduced but not equal to zero for most of the time.

Fig. 9 presents the true evolution of the corresponding MDV for each of the three possible target trajectories. The overall shape remains the same, but for trajectories B and C the MDV does not drop to its original value at about half of the scenario time, as is the case for trajectory A.

Four different tracking algorithms that differ in the processing of the bistatic Doppler blind zone information were employed:
For the first algorithm, the MDV was assumed to be constant and equal to the overall minimum value, which can be regarded as the optimistic case. The second algorithm also assumed that the MDV is constant, but in this case the overall maximum value was used, which corresponds to the pessimistic case. The variation of the MDV was considered in the third tracking algorithm, being the realistic case. For reference, a tracking algorithm was used which does not process any information on the bistatic Doppler blind zone. This was achieved by setting the MDV to zero, thus assuming an infinitely narrow blind zone. In order to assess the performance of each algorithm, the track continuity was determined which is defined as the ability of the algorithm to maintain a once extracted track until the final revisit. The results in terms of the aforementioned measure of performance for all combinations of tracking algorithm and target trajectory are presented in Table II and are based on 100 Monte Carlo runs.

As expected, the algorithm which does not exploit any information on the bistatic Doppler blind zone is not capable of maintaining a track at all for any of the three different target trajectories. In this case, the masking of the target by the bistatic Doppler blind zone leads to a sequence of missed detections for several subsequent revisits. The only possibility for the tracking algorithm to interpret this sensor output is to establish the missed detection hypothesis. As a consequence, the track score drops below a predefined threshold within a few revisits, resulting in the termination of the track. In all other cases, the algorithms were capable of extracting and maintaining tracks by making use of the knowledge on the bistatic Doppler blind zone.

In the following, the track results for the algorithms which exploit the knowledge of the blind zone will be analyzed: For the first and second scenario setup (trajectory A and B), the algorithm which assumes the width of the bistatic Doppler blind zone to be equal to the minimum MDV yields only a small number of successfully maintained tracks. The explanation for this can be found by examining the corresponding plots in Fig. 10 which illustrates the evolution of the bistatic target range-rate together with the limits of the bistatic Doppler blind zone based on the true, the maximum and the minimum MDV. The target moves into the actual blind zone several revisits before the blind zone limit related to the minimum MDV is reached. Thus, a sequence of missed detections occurs with the tracking algorithm being unable to interpret this situation correctly. Hence, in most cases the track score quickly decreases leading to the termination of the track. On the other hand, the algorithm which uses the maximum MDV yields an optimal performance. This can be explained as follows: Due to the larger width of the blind zone, this algorithm puts weight into the hypothesis that the target is masked by the bistatic Doppler blind zone well before the target actually enters the blind zone region. But as target measurements are still available and the unnormalized weight of such a filtered measurement hypothesis is higher by several orders of magnitude than that of the blind zone hypothesis, the influence of the falsely set width of the bistatic Doppler blind zone is obviously marginal in the considered cases.

Finally, the algorithm which processes the correct MDV at every revisit shows the expected behavior as it yields a nearly optimal performance for the target trajectories A and B. The results for the third scenario setup (trajectory C) reveal that by solely exploiting the knowledge of the bistatic Doppler blind zone, a good tracking performance cannot be achieved in every situation. Here, the target moves within the blind zone several revisits before the blind zone limit related to the minimum MDV is reached. Thus, a sequence of missed detections occurs with the tracking algorithm being unable to interpret this situation correctly. Hence, in most cases the track score quickly decreases leading to the termination of the track.

![Figure 8](image8.png) Trajectories of the ground target for cases A, B and C. The red bold lines indicate regions with strongly reduced detection probability due to Doppler blind zone masking.

![Figure 9](image9.png) Distribution of the calculated minimum detectable velocity for cases A, B and C.

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<thead>
<tr>
<th>Scenario 2, Trajectory A</th>
<th>Track Continuity</th>
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<tbody>
<tr>
<td>Optimistic case (minimum MDV used)</td>
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<td>Pessimistic case (maximum MDV used)</td>
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<td>No Doppler blind zone processing (MDV = 0)</td>
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<th>Track Continuity</th>
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<td>Optimistic case (minimum MDV used)</td>
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<tr>
<td>Pessimistic case (maximum MDV used)</td>
<td>99 %</td>
</tr>
<tr>
<td>Realistic case (correct MDV used)</td>
<td>98 %</td>
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<td>No Doppler blind zone processing (MDV = 0)</td>
<td>0 %</td>
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<tr>
<th>Scenario 2, Trajectory C</th>
<th>Track Continuity</th>
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<td>Pessimistic case (maximum MDV used)</td>
<td>13 %</td>
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<td>Realistic case (correct MDV used)</td>
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zone in a way which obviously cannot be followed by any of the tracking algorithms due to the lack of measurements. As the target moves out of the blind zone, in most cases the newly available measurements are no longer located within the expectation gate of the track and are thus discarded.

In summary, the following statements can be made: The incorporation of the varying MDV is straightforward and yields expected results in the examined simulation scenarios. The algorithms using a constant MDV are of course only theoretical approaches because without actually calculating the MDV those values remain unknown. But these considerations reveal how important it is not to underestimate the width of the blind zone. On the other hand, one might be tempted to simply set the MDV to a very large value, as the results for cases A and B indicate an almost perfect performance. But this approach would lead to a poor performance especially in situations with low detection probability, because then the blind zone hypothesis would outperform the correct missed detection hypothesis due to the larger weight, surely deteriorating the tracking performance in certain cases.

A possibility to improve the tracking performance is to combine the knowledge of the bistatic Doppler blind zone with road-map information, because then the tracking algorithm has improved information about the possible target positions within the blind zone. At a crossing, for example, the algorithm establishes a new road hypothesis for each possible junction and in that way maintaining all possible target trajectories. As soon as a new target measurement is available, the algorithm can then easily associate the measurement with one of the available road hypotheses. This was already explored for the monostatic case in [15].

IV. Conclusion

This paper investigated the bistatic Doppler blind zone and its impact on the tracking of ground targets by airborne GMTI radar. It was presented how the width of the blind zone can be calculated for a given bistatic configuration and how this additional information can be processed by a tracking algorithm. Based on simulation scenarios it was demonstrated that, in contrast to the monostatic case with sideways-looking radar, the minimum detectable velocity is not constant for certain bistatic configurations. The obtained track results in terms of track continuity finally reveal the benefit of exploiting this additional knowledge.

Future work will focus on the impact of exploiting road-map information on the tracking performance in a bistatic setting. In addition, the influence of a two-dimensional antenna element pattern will be explored.

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References