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Updates to Military Operating Area and Range Noise Model: MRNMap 3.2

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TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

1 INTRODUCTION

The goal of this project was to update the US Air Force's Military Operating Area and Route NoiseMap model (MRNMap), which is the noise model for special use airspaces and routes. This effort updated the computational aspects of MRNMap to fix a disconnect between the MRNMap Version 3.0 Input File Format standard and the calculation stream. In addition, this update reimplemented and corrected additional track operational parameters previously removed from MRNMap by Department of Defense (DOD). These additional track parameters include asymmetric track widths, funneling track widths, and 'Number of Events' for area calculations. Another aspect of this effort involved updating the Fortran source code to current standardized coding. This updated version of MRNMap is 3.2. These updates to MRNMap and this documentation serve as partial completion of Task 12 under the interagency agreement VHM8A421 between the DOD and the Volpe Center.

2 TRACK OPERATION CALCULATION

2.1 Calculation Disconnect

The original formulation of MRNMap's Track calculation used the defined tracks to direct the computational flow. However, the MRNMap Version 3.0 Input File Format standard listed each track mission individually. This disconnect resulted in the omission of track missions that used the same track. The code fix involved changing the computational flow to follow the missions instead of the tracks.

2.2 Reimplementation of Track Parameters

During a previous update to MRNMap code, several track modeling parameters were removed. These included asymmetric track widths, funneling track widths, and turning tracks. The width features were reimplemented and corrected. The turning track feature was not reimplemented because this feature is not needed (turns can be modeled with a series of short, straight segments). MRNMap models tracks based on a centerline track with left and right widths along a series of defined points. When the asymmetric track width feature was being reimplemented, it was discovered that the original code did not model the asymmetry correctly. The original code used an average width instead of the separate left and right widths. The code was updated to properly model asymmetric track widths.

The funneling widths feature (linear variation of the track width between two waypoints) was reimplanted as well, but this feature needed to be consistent with the asymmetric calculation. Thus, this update allows both asymmetric and funneling track widths. Currently, BaseOps allows a user to input both features when defining a track, so the following BaseOps warnings can be removed:

- "The following military training routes have segments for which the left and widths are not equal. The current version of MRNMap does not support segments that have different left and right widths."
- "The following military training routes have segments with non-constant width variation. The current version of MRNMap ignores the width variation settings in

the MRNMap input file, and it treats all segments as if their width variation is constant."

2.3 Computational Flow Improvements

In addition to the updated track implementation, this version update includes two changes to improve the computational speed of MRNMap. The first improvement involves skipping missions that have zero operations. The old version did not skip these operations, which resulted in long computational times and errors in the calculation of L_{Amax}. Obviously, calculating missions with zero operations is inefficient, and in addition, the L_{Amax} from these zeroed out missions was included in the results since L_{Amax} does not include any adjustment by annual operations.

The second improvement removes the printing to screen for the status of the computations. The computational time for the printing to screen is significant and led to long runtimes. Both of these improvements reduce MRNMap's computational run-times by nearly an order of magnitude.

3 NUMBER OF EVENTS AREA CALCULATION

MRNMap's output of the number of events had inconsistencies between specific points within an area and points within an avoidance area. Both calculations had errors in the estimation of the number of events. The calculations were corrected for both cases, and they are now consistent. It should be noted that the number of events for tracks are only calculated for the centerline of the track.

4 FORTRAN CODING UPDATES

The code was updated to standard Fortran coding since most of the code dates to Fortran 77 standards, which have been upgraded over the years. The primary update involved providing interfaces between subroutines to ensure variables were properly defined. This update did find a few cases were input variables were inappropriately changed within a subroutine. These cases were fixed with the interface coding updates.

5 COMPARISON CASES

A series of test cases are used to demonstrate the results of the updated MRNMap program (version 3.2) compared to the old version (version 3.0).[1] These comparisons show the effect of changes in the track computation and the consistency of area computations.

5.1 Single Mission on a Single Track

Figure 1 shows a simple case involving a single mission on a straight track with a constant width. This comparison shows that the result of the basic track calculation between the two versions remains the same.

[1] Version 3.1 was an intermediate update that was not released.

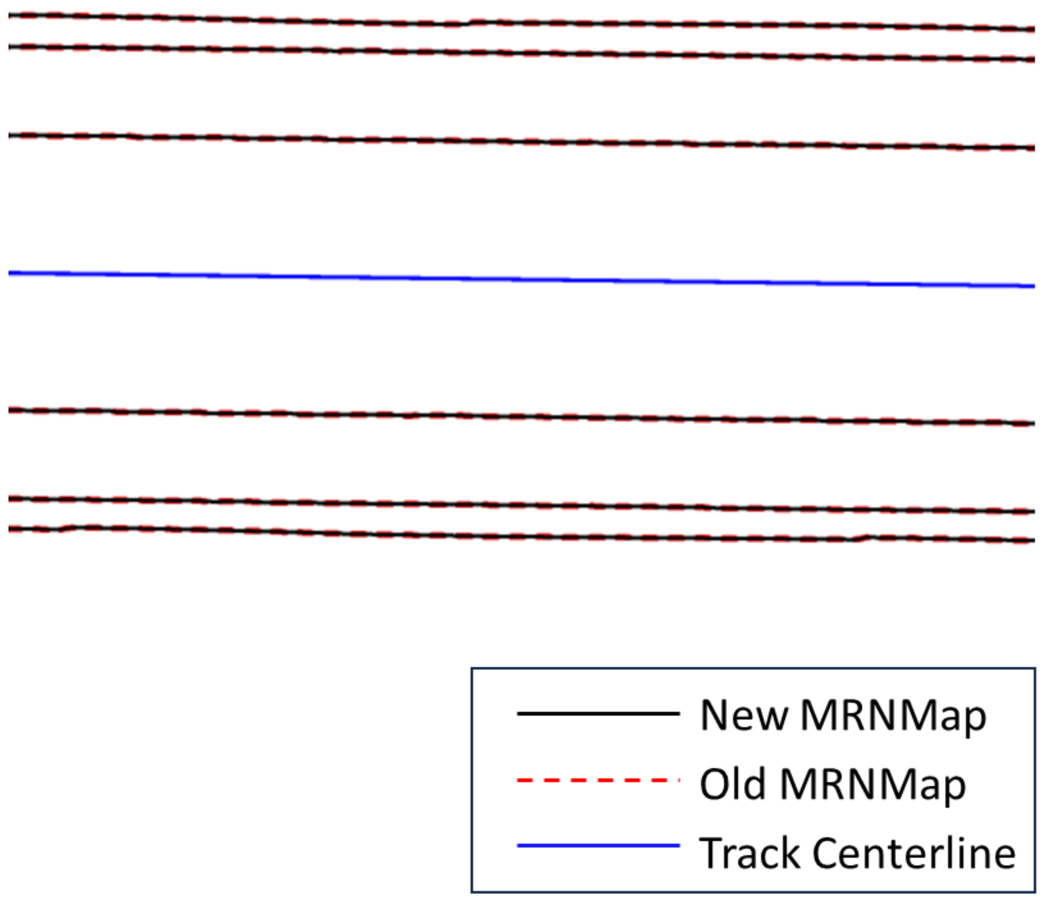

Figure 1. Comparison Between Old and New MRNMap Sound Level Contours for a Single Mission on a Single Track

5.2 Multiple Mission on a Single Track

This next case shows the comparison for multiple missions on a single track. This case involves three separate aircraft missions on a simple track. Figure 2 shows large differences between the two versions. This difference arises from the omission of two of the three missions from the calculation in the old version. This comparison demonstrates the original problem that is addressed by this update.

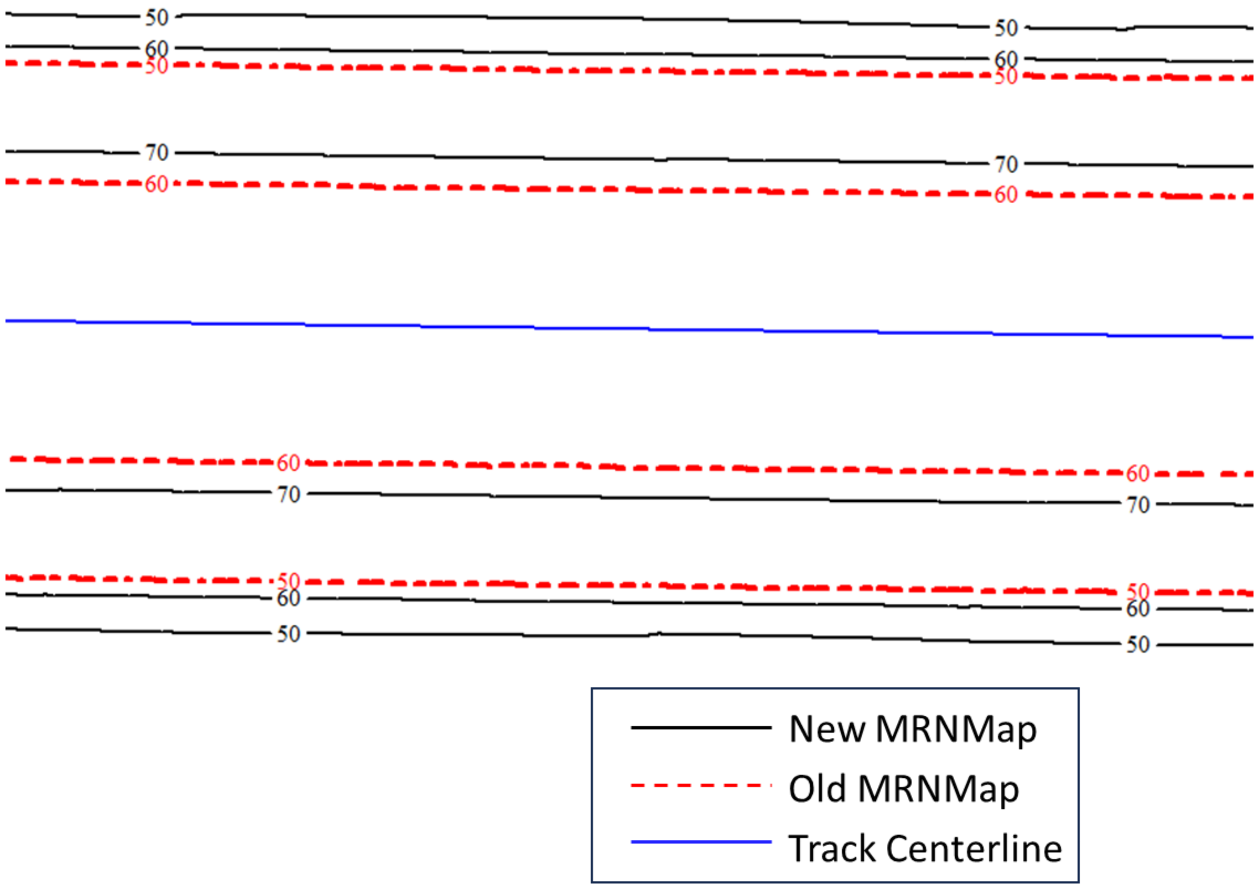

Figure 2. Comparison Between Old and New MRNMap Sound Level Contours for Multiple Missions on a Single Track

5.3 Single Track with Asymmetric Widths

The next case demonstrates the calculation of a single-track mission along a track with asymmetric widths. Figure 3 shows the modeled track and widths used between the two versions. The old version used the two different left and right widths using their average widths, which resulted in symmetrical widths. The new version accounts for the asymmetrical widths. Figure 4 provides the comparison between the two models for this case, which highlights the differences in the asymmetric regions. The differences are a function of the degree of asymmetry between the left and right widths.

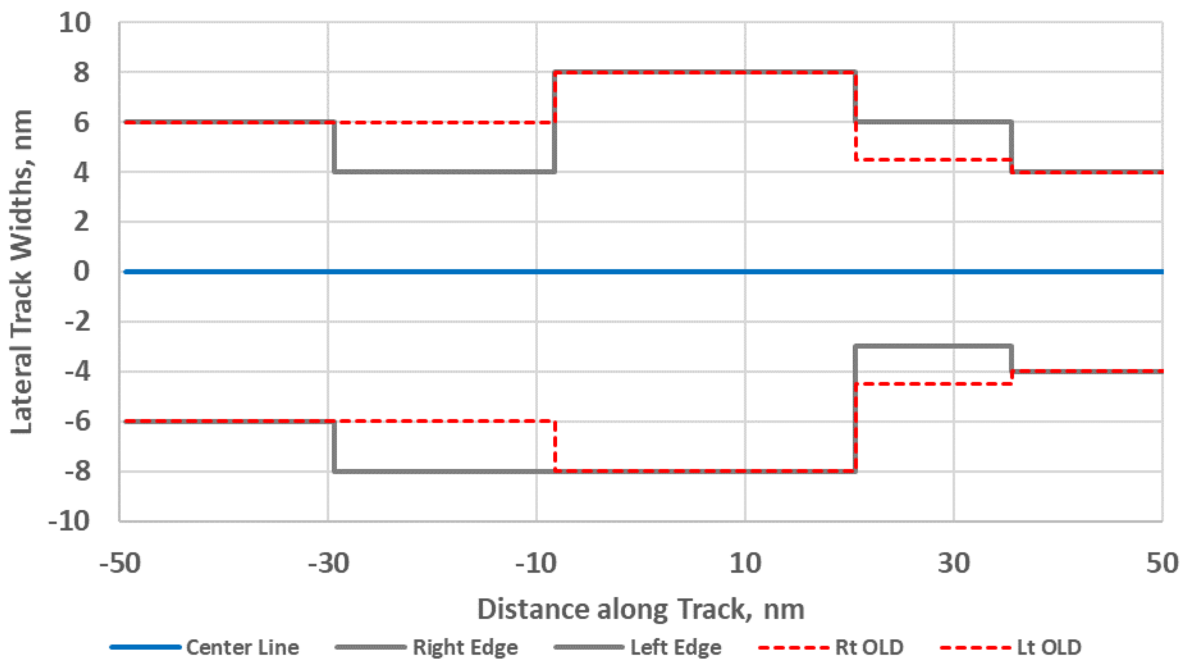

Figure 3. Modeled Asymmetric Track Widths

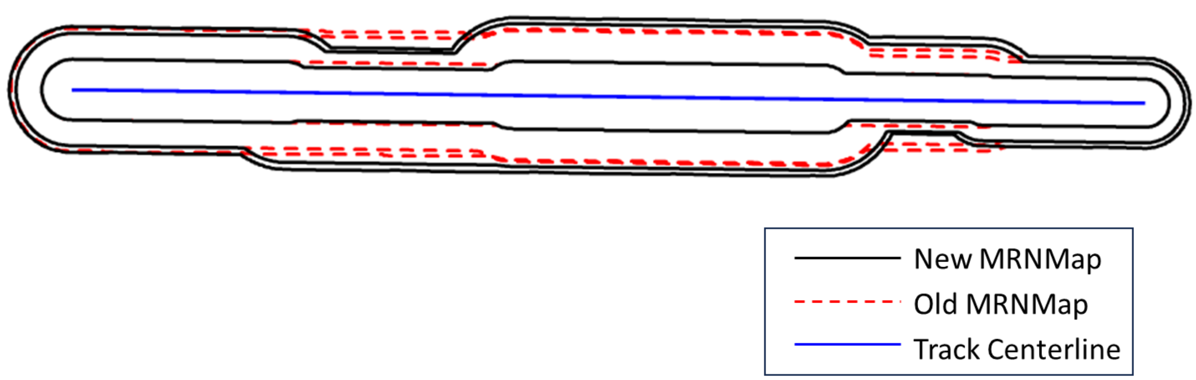

Figure 4. Comparison between Old and New MRNMap Sound Level Contours for a Single Mission on a Track with Asymmetric Widths

5.4 Single Track with Varying Widths

The next case demonstrates the inclusion of varying widths on the calculations for a single mission. Figure 5 shows the differences in the model track widths between the two versions. Figure 6 provides the comparison of the resulting noise calculation. The results from the new version reflect the asymmetric and varying widths along the track whereas the old version does not.

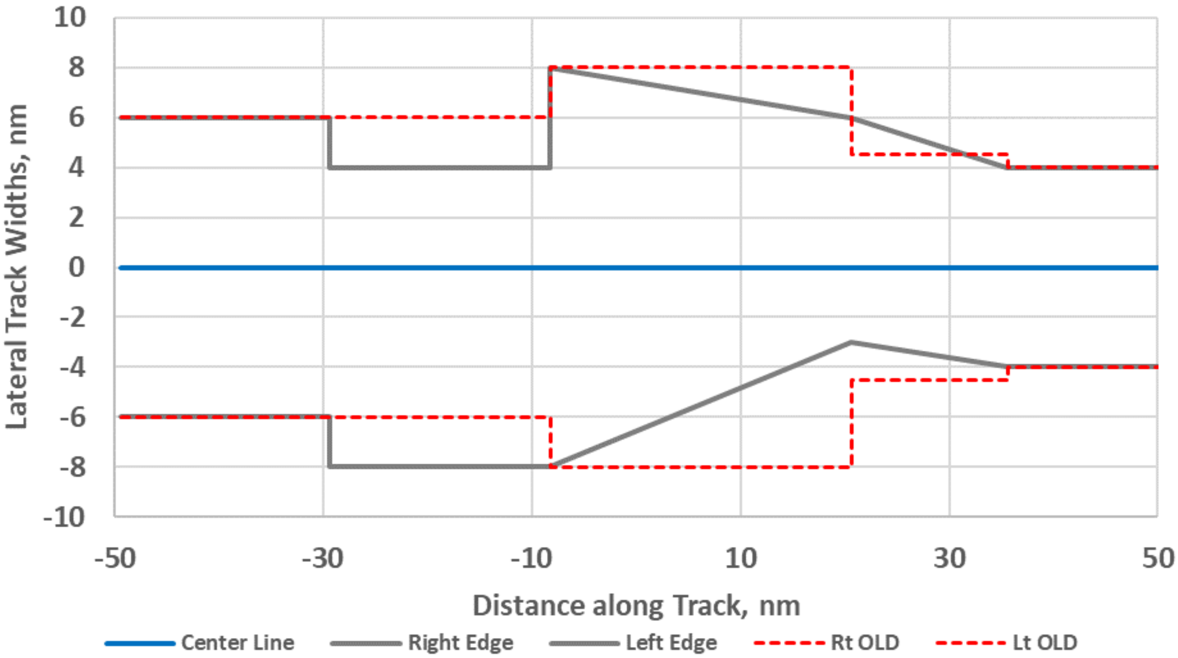

Figure 5. Modeled Asymmetric and Varying Track Widths

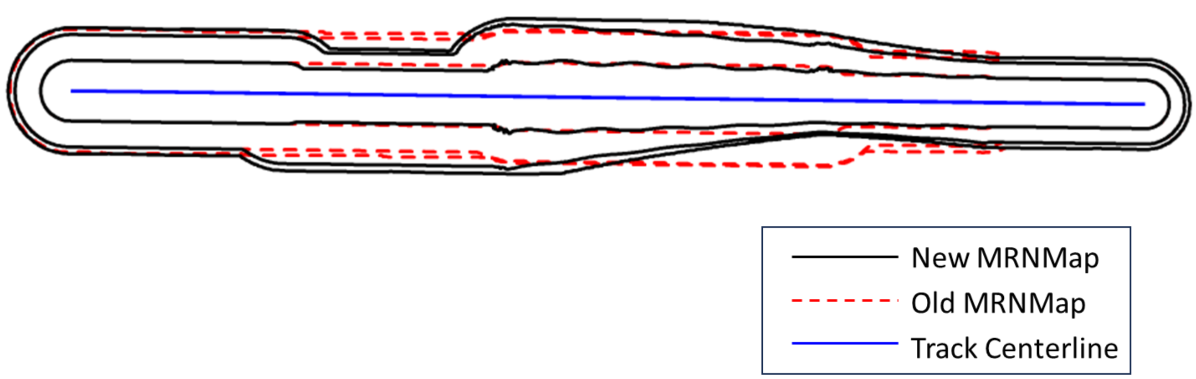

Figure 6, Comparison between Old and New MRNMap Sound Level Contours for a Single Mission on a Track with Asymmetric and Varying Widths

5.5 Mixed Area and Tracks

This section includes comparison of multiple missions for both area and track calculations as well as the Maximum A-weighted Sound Level (L_{Amax}) calculations. These cases are taken from current and recent modeling efforts. However, these cases are simplified to reduce the computational times for comparison. The first comparison involves track operations going through a series of areas. Figure 7 shows the Onset Rate-Adjusted Monthly Day-Night Average Sound Level (L_{dnmr})

results for this comparison. The region near the modeled track shows differences due to the omission of track missions as highlighted in Section 5.2. In the regions not influenced by the track operations, the results between the two versions are the same.

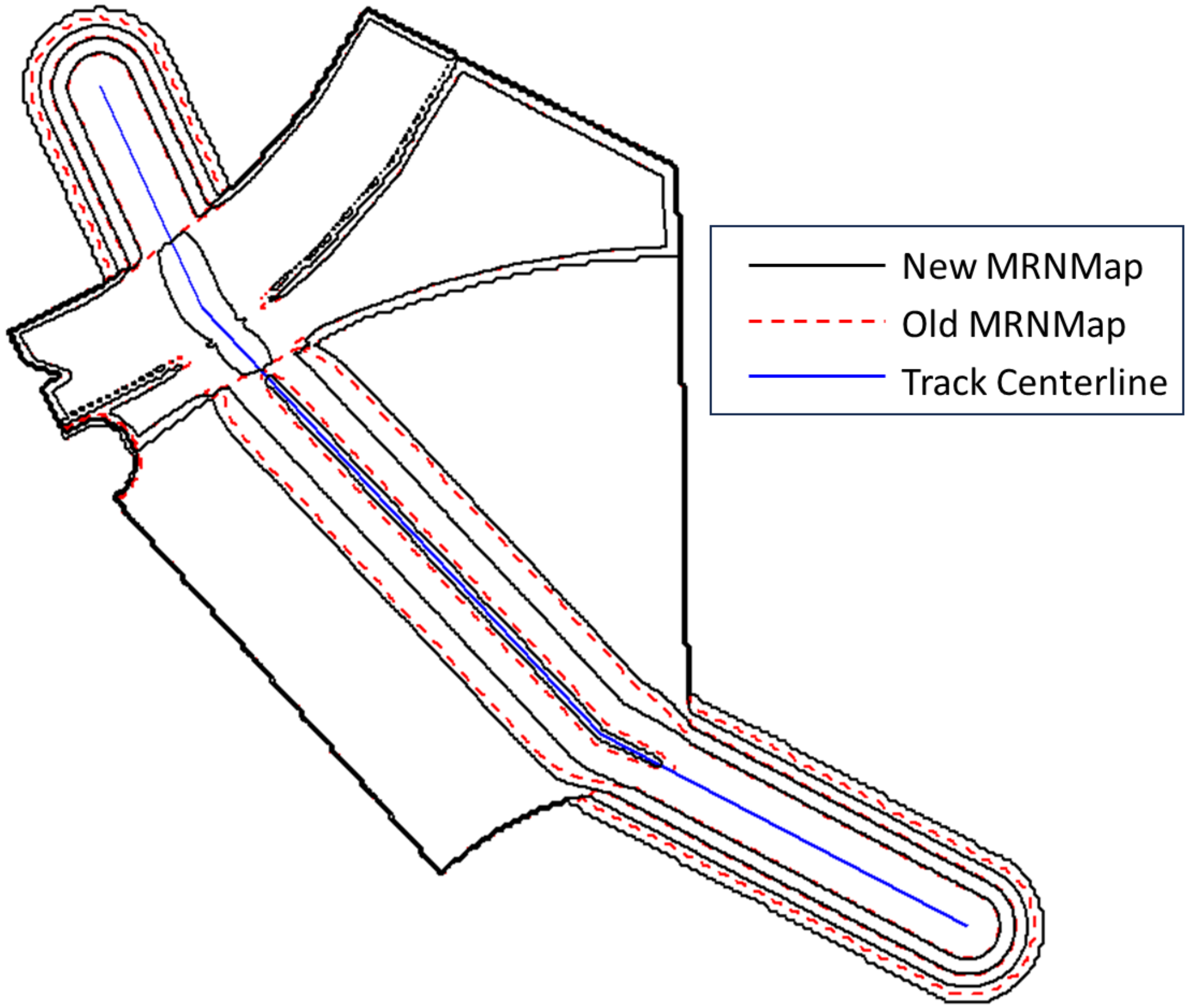

Figure 7. Comparison between Old and New MRNMap Sound Level Contours for Multiple Missions on both Tracks and Areas

The next comparison shows the same case but with the L_{Amax} results. Figure 8 highlights large differences between the two versions. The new version has L_{Amax} levels just above 100 dBA along the modeled track whereas the old version has L_{Amax} levels above 120 dBA throughout the area. This difference highlights the problem described in Section 2.3. This example case had all of the modeled missions for both baseline and proposed operational states. For the baseline case, the proposed missions were zeroed out. However, the old version still calculated the L_{Amax} from these zeroed out missions.

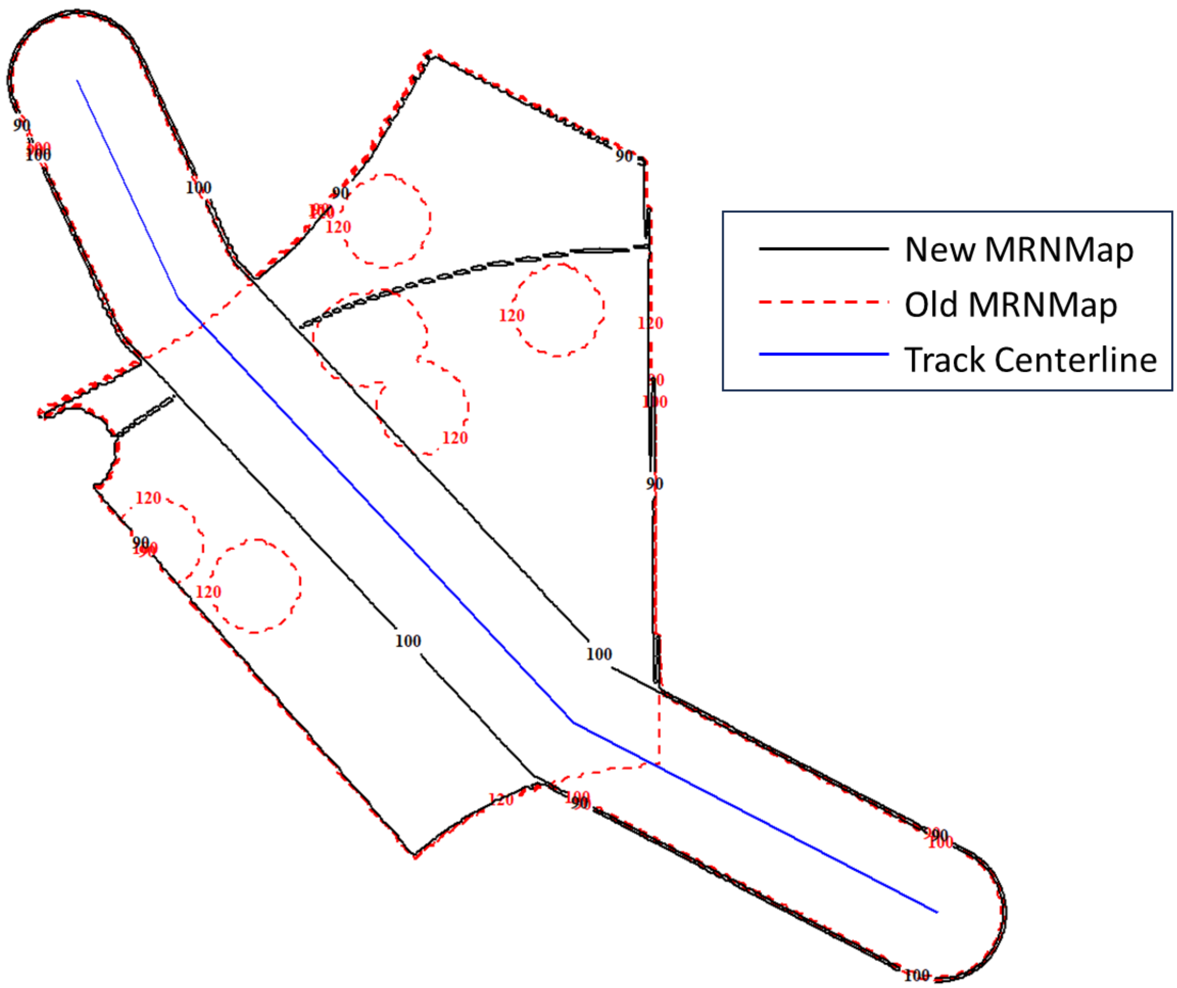

Figure 8. Comparison of L_{Amax} Between Old and New MRNMap Sound Level Contours for Multiple Missions on both Tracks and Areas

The next comparison case has a large mix of areas and tracks with multiple aircraft types and missions. Figure 9 provides the L_{dnmr} results from both the old and new versions. The regions around the modeled tracks show various levels of difference whereas areas outside of the regions are the same. The reason for the differences in the track regions depends solely on the track missions that were omitted. The noise from the track on the west side is totally missed by the old version since the primary noise contributor mission was omitted. The noise for the tracks to the south show various levels of differences as shown in Figure 10. The differences in this region vary from 5 to 10 dB because of the omission of track missions.

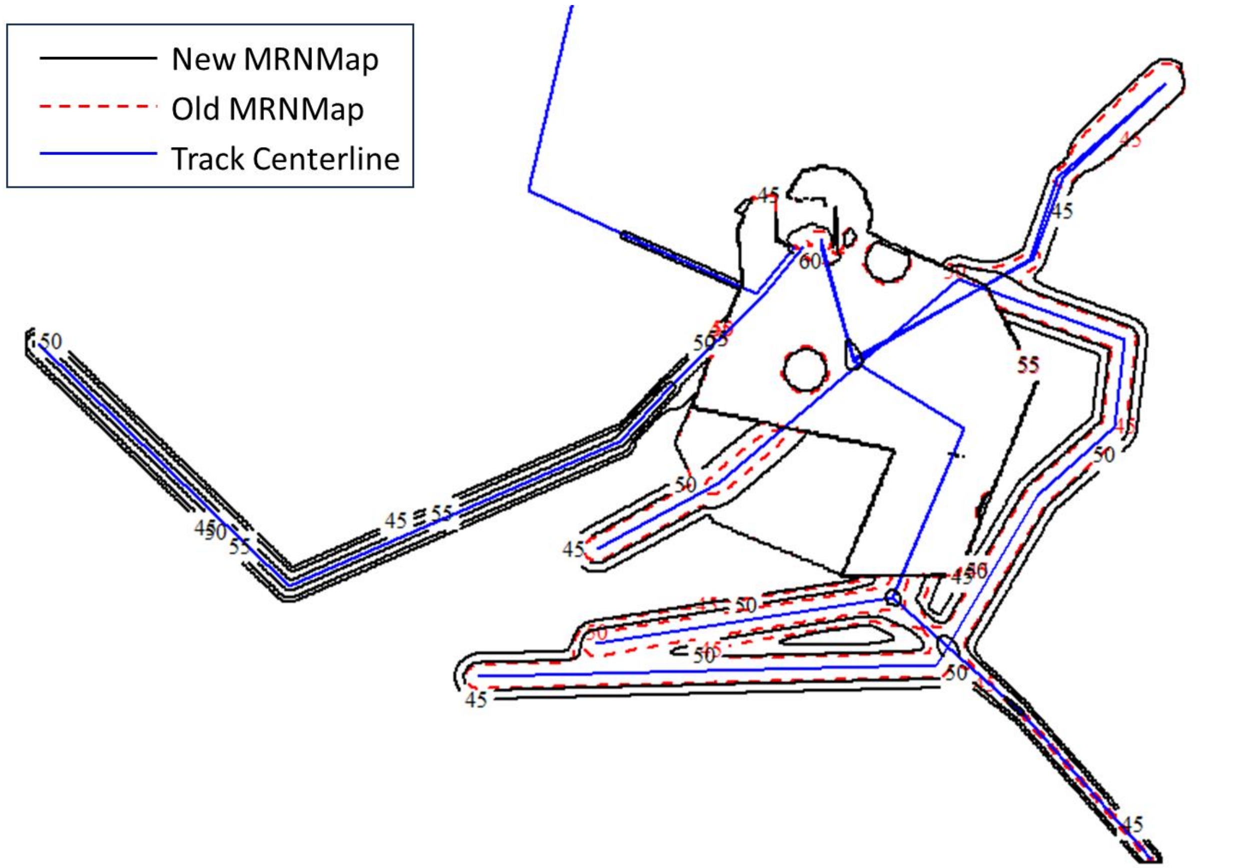

Figure 9. Second Comparison Between Old and New MRNMap Sound Level Contours for a Multiple Missions on Both Tracks and Areas

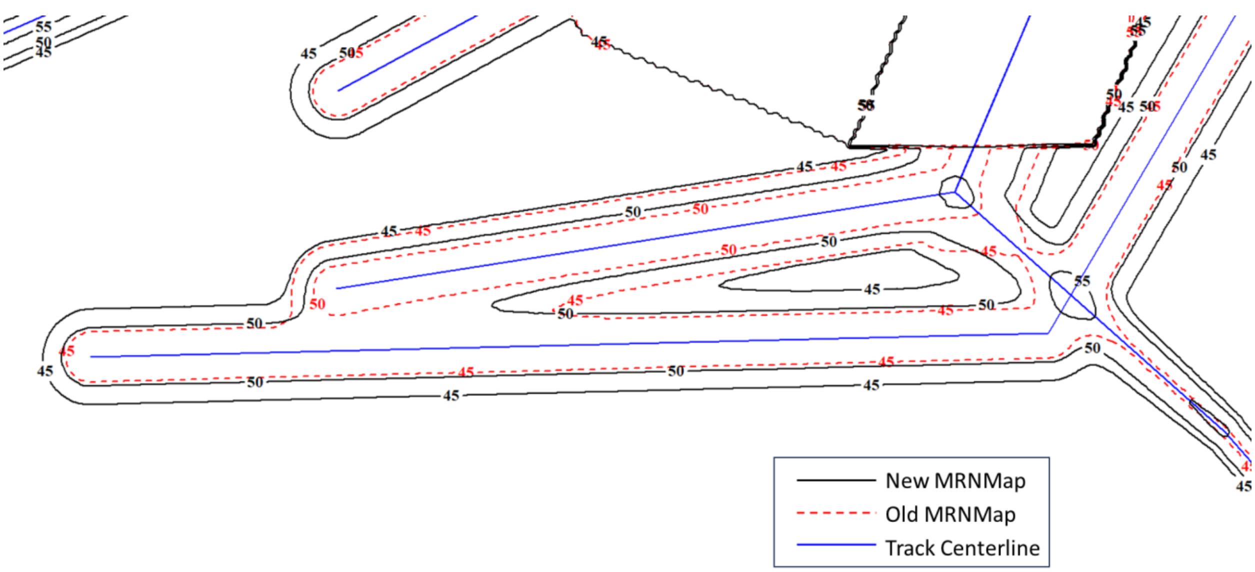

Figure 10. Zoomed in Portion of Second Comparison Between Old and New MRNMap Sound Level Contours for a Multiple Missions on Both Tracks and Areas

5.6 Number of Events

A simple case is provided to show the improved Number of Events estimation for area operations within MRNMap. This case includes a basic rectangular modeled area with four avoidance areas: Center, West, East, and Center 2. Center avoidance is in the center of the modeled area; West area saddles the western edge of the modeled area; and East is on the edge of the eastern border of the area. The first three avoidance areas have ceilings that affect the modeled mission altitude profile, but the last avoidance area ceiling does not impact the modeled mission. The modeled mission is 100 daily events for an F-15 fighter jet. Additionally, two points of interest are included at the centroids of the two Center avoidance areas. Figure 11 provides the L_{dnmr} results for this simple case. Table 1 provides the Number of Events results for this case for both versions. For the old version (version 3.0), the Number of Events for the modeled area in general at 21.3 daily events is less than for the Center Avoidance area of 37.2 daily events. This result is not correct. For the new version (version 3.2), the Number of Event for the modeled area is 41.23; 2.41 for the Center Avoidance, 1.26 for the West Avoidance; 0.88 for the East Avoidance; and 2.52 for the Center 2 Avoidance. This result aligns with the lower sized areas in the avoidance areas as well as their location in relationship to the overall modeled area. The results for the two points of interest at Center and Center 2 are the same as the avoidance areas. This agreement demonstrates that the separate computational streams for avoidance areas and points of interest are consistent.

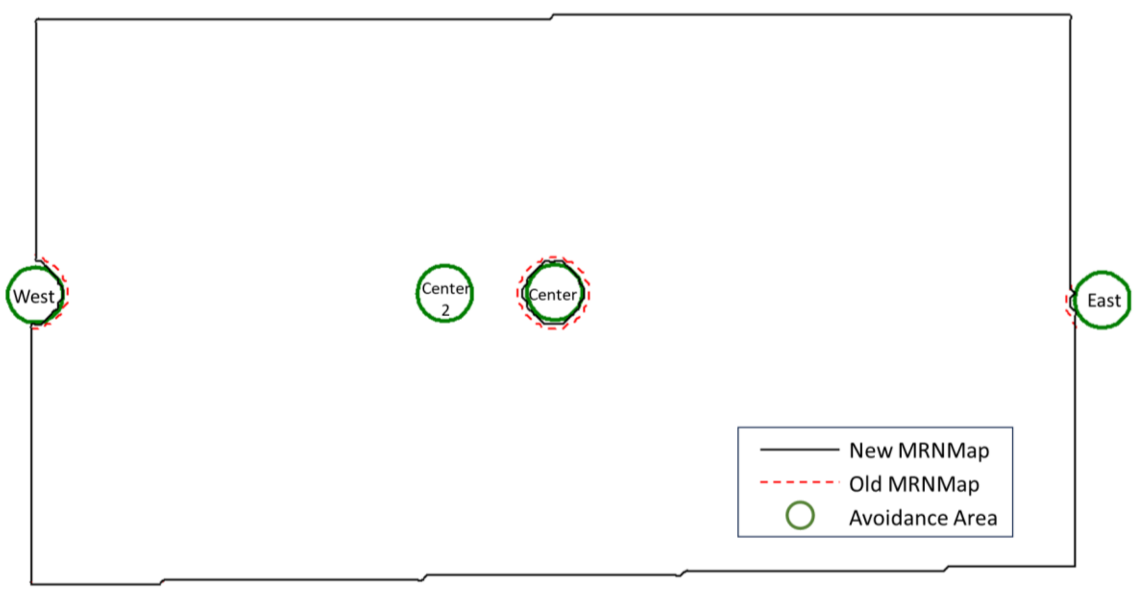

Figure 11. Conceptual Modeled Area with Avoidance Areas to Demonstrate the Number of Events Estimation with MRNMap Area Calculations

Table 1. Number of Events Estimation Comparison

Areas		Number of Events >75 dBA	
		Old	New
	MOA	21.3	41.23
Avoidance Areas	Center	37.2	2.41
	West	19.4	1.26
	East	13.8	0.88
	Center 2	39.6	2.52

6 TRACK AND AVOIDANCE AREAS DECONFLICTION

Another modeling issue was discovered during the update of MRNMap. MRNMap does not account for overlapping tracks and avoidance areas. During the development of the original MRNMap model, DOD managers of Military Training Routes (MTRs) would redefine an MTR to eliminate any conflicts with avoidance areas. Thus, the computational structure of MRNMap never considered handling these conflicts. However, a few incidences of overlaps between MTRs and avoidance areas do now occur, and these conflicts are not handled properly. Modifying MRNMap's computational structure will be a significant effort for a relatively small issue. However, BaseOps is better suited to handle these conflicts. BaseOps can be updated to check for these conflicting overlaps and highlight them to a modeler. A warning should be added in BaseOps to indicate when a conflict occurs and stop the process. Then, a modeler can modify a track's description to remove the conflicts. Two simple cases are provided to help a modeler determine how to remove these conflicts.

The first case involves an MTR whose centerline goes through an avoidance area as shown in Figure 12. A solution to this conflict is to raise the MTR floor above the Avoidance area's ceiling as highlighted in Figure 13. A simple step function in the MTR floor will not reflect how an aircrew fly over the avoidance area. Thus, at some distance before the avoidance area, the floor of the MTR will need to rise. The distance before the area or the angle of this floor increase, a, should be provided by aircrews. The modeler can include this operational data to modify the MTR description. After the avoidance area, a similar procedure can be used to lower the MTR floor back to its published height.

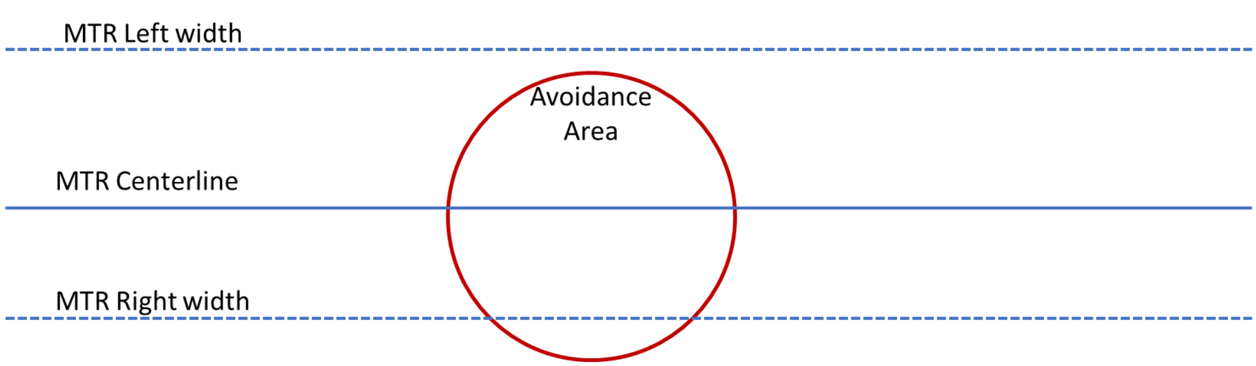

Figure 12. MTR and Avoidance Area Conflict when MTR goes through Avoidance Area

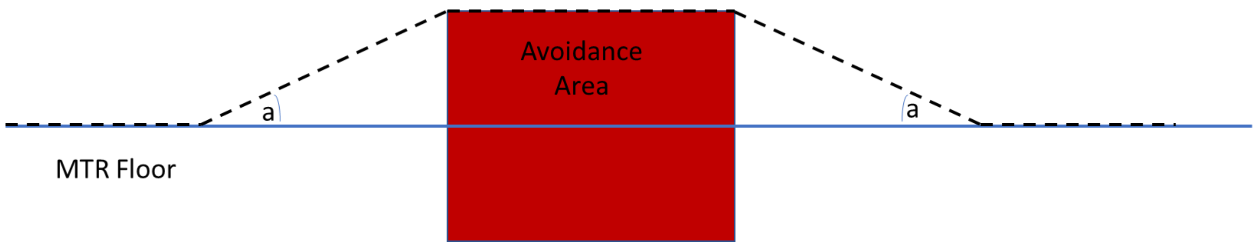

Figure 13. Modeling Solution for MTR and Avoidance Area Overlapping Conflict

The second case involves the sideline of the MTR overlapping an avoidance area but not its centerline, as shown in Figure 14. A potential solution is provided in Figure 15 where the MTR width is modified to remove the conflict. Similar to the floor adjustment discussed above, the MTR's width can be reduced to remove the conflict. The width reduction can start at some distance before the avoidance area and then be expanded once the avoidance area is passed. This distance should be provided by aircrews to ensure accurate modeling.

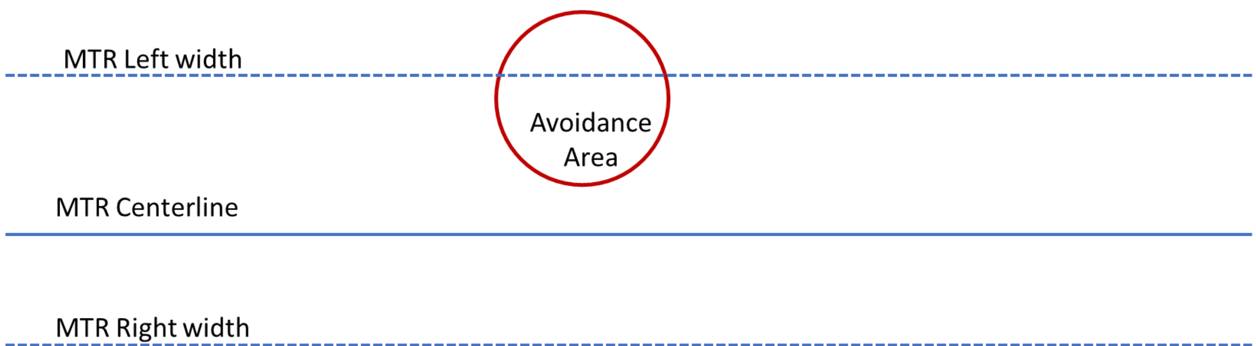

Figure 14. MTR Sideline and Avoidance Area Conflict when MTR Centerline Does Not Go Through Avoidance Area

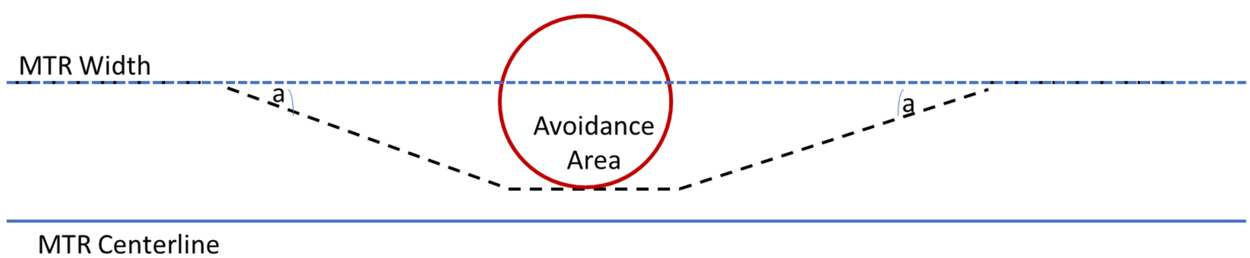

Figure 15. Modeling Solution for MTR Sideline and Avoidance Area Overlapping Conflict

When these conflicts occur, a modeler should consult with aircrews to determine accurate operational modeling parameters. At this time, an automated solution is not recommended since these occurrences are currently rare and set procedures for how aircrews handle these conflicts are not well known.