APPENDIX B

LIT VOR MODELING ANALYSIS

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June 27, 2019

Eric C. Farmer, PE
Senior Project Manager
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Garver, LLC

Via electronic submission to ECFarmer@GarverUSA.com

Dear Mr. Farmer:

Please find attached the final report titled, "Modeling Analysis of a Proposed VOR Relocation Site at Little Rock Airport." This submission is intended to fulfill the requirement for delivery of the final project report as required under Garver project number 15017248.

Please contact me if there are any questions.

Sincerely,

Frank A. Alder

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Attachment: Final Report, OU/AEC TM19-06/15017248-01

Copy: Todd Mueller, Garver (TEMueller@GarverUSA.com)

FINAL REPORT

TECHNICAL MEMORANDUM
OU/AEC TM19-06/15017248-01

MODELING ANALYSIS OF A PROPOSED VOR RELOCATION SITE AT LITTLE ROCK AIRPORT

A modeling analysis has been performed on the Davidson site for the LIT VOR relocation. The potential sources of multipath are the trees located near the site. Modeling analysis shows that a Conventional VOR will perform within tolerance limits, but the performance may be marginal. The analysis also indicates that a Doppler VOR will perform at desirable level.

by

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Prepared for

Garver, LLC

Project Number 15017248

FINAL REPORT

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FINAL REPORT

I. INTRODUCTION AND BACKGROUND

The current VHF Omni-directional Range (VOR) at Little Rock Airport (LIT) in Little Rock, AR resides within the overall Little Rock Port Authority (LRPA) area. The system is a standard conventional VOR that is co-located with a TACAN at a ground elevation of 240 feet MSL.

The location of the VOR and the related clearance zone requirements (building height restrictions) prevent the LRPA from allowing clients to erect structures in an area encompassing several hundred acres. Consequently, the LRPA has inquired with the FAA regarding the possibility of relocating the VOR. Garver, the consulting engineer of record for the LRPA, has requested that Ohio University perform a modeling analysis of a new site for possible relocation of the VOR. The FAA has stated that they will review the modeling analysis and then decide if a field test with a mobile conventional VOR at the selected site is required.

A siting study [1] based on the siting criteria in FAA Order 6820.10 [2] has already been performed by the FAA. Two sites, the Davidson property and the Tulip property, were shortlisted as possible candidate sites. Based on the site study and the potential to acquire the land, Garver requested that Ohio University further analyze the Davidson site to ascertain how a VOR will perform in the environment.

In performing this task, Ohio University utilized the Ohio University Navigation and Landing Performance Prediction Model (OUNPPM) to confirm that the relocated VOR will perform as desired. The OUNPPM is a validated mathematical model based on the physical optics theory for electromagnetic scattering. This model is currently used worldwide to predict the effect of structures on Instrument Landing System (ILS) and the VOR performance.

II. SITE DATA

Garver provided Ohio University with diagrams and information describing the proposed Davidson site. An aerial view of the proposed site is shown in Figure 1. A site visit was also conducted on March 12, 2019.

A. VOR Data

As noted above, the VOR that is currently located at LIT is a conventional system and is co-located with a TACAN system. At the Davidson site, the ground elevation at the proposed VOR location is 247 feet. This is not the highest location available on the Davidson property; however, the ground elevation of all other suitable areas is very similar to the elevation at the chosen location. As noted in the FAA study [1], the chosen location was soft and muddy which required a four-wheel drive vehicle to get to the site. Some pictures showing the state of the site are provided in Figure 2.

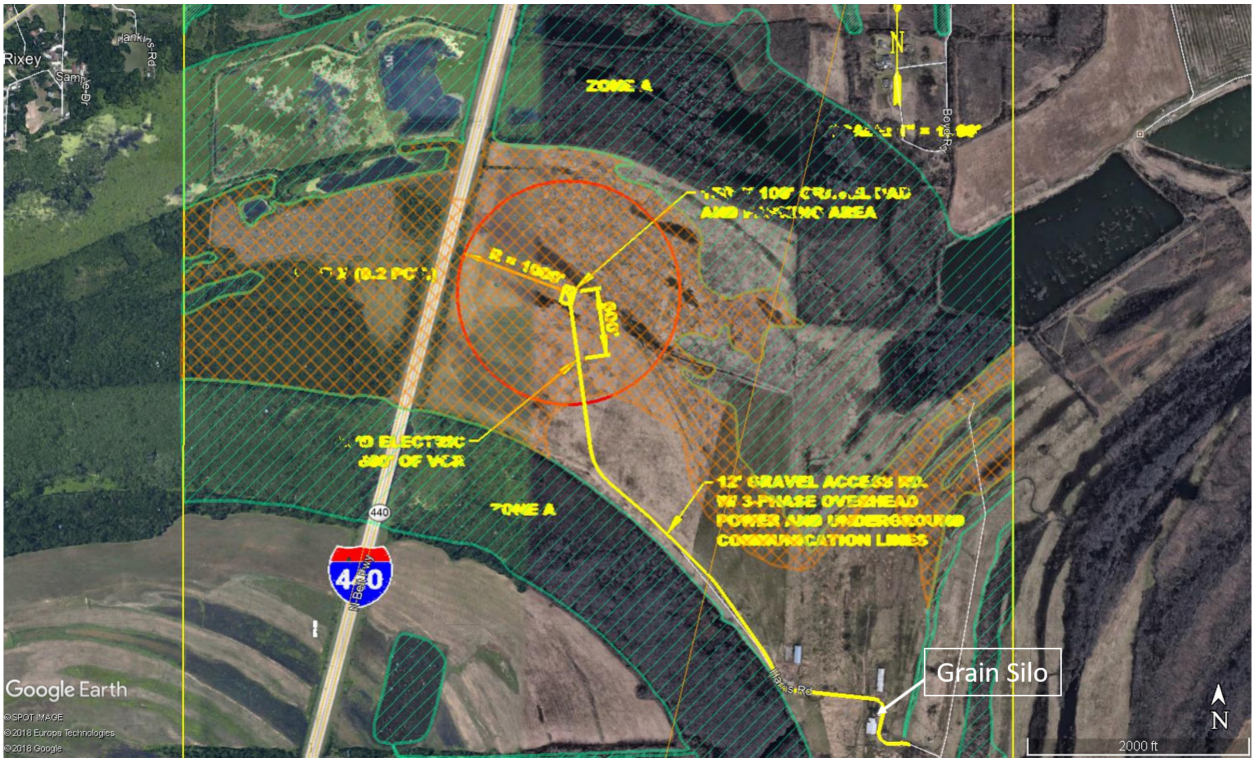

Figure 1. Google Earth image showing proposed Davidson site.

Figure 2. Pictures showing the soft and muddy nature of Davidson site.

B. Sources of Multipath

The site on the Davidson property is essentially free of man-made objects such as buildings and powerlines. Nonetheless, some potential sources of multipath are indicated on the map of Figure 1: a grain silo (pictured in Figure 3) – which is located approximately 4600 feet from the proposed VOR location – and a substantial number of trees. However, the required 1000-foot protection area for the VOR, as indicated in Figure 1, is free of any obstacles or potential sources of multipath.

As noted in the FAA report, there are a number of trees around the site that will penetrate the 2-degree angle specified in the VOR Siting Criteria [2]. Note that the heights of the trees and silo were estimated from Google Earth as no surveyed data was provided.

Figure 3. Grain silo near proposed VOR site.

III. MODELING ANALYSIS

Both conventional and Doppler systems were simulated as part of the modeling analysis. A summary of the system parameters used in the modeling analysis is provided in Table 1.

Table 1. VOR system parameters.

Parameter	Conventional	Doppler
Frequency (MHz)	113.5	113.5
Counterpoise Radius (feet)	26	50
Counterpoise Height (feet)	12	12
Ground Elevation (feet MSL)	247	247

In analyzing the predicted performance for the proposed VOR, criteria set in FAA Order 8200.1D [3] has been applied. FAA Order 8200.1D outlines the three parameters used to evaluate VOR performance: the VOR course alignment; the bends; and the roughness and scalloping. The diagram in Figure 4 shows the roughness/scalloping/bends combinations. The tolerance limits for these combinations should not exceed 6.5 degrees. Additionally, the limit for roughness and scalloping is +/- 3 degrees, while the limit for the bends is +/- 3.5 degrees.

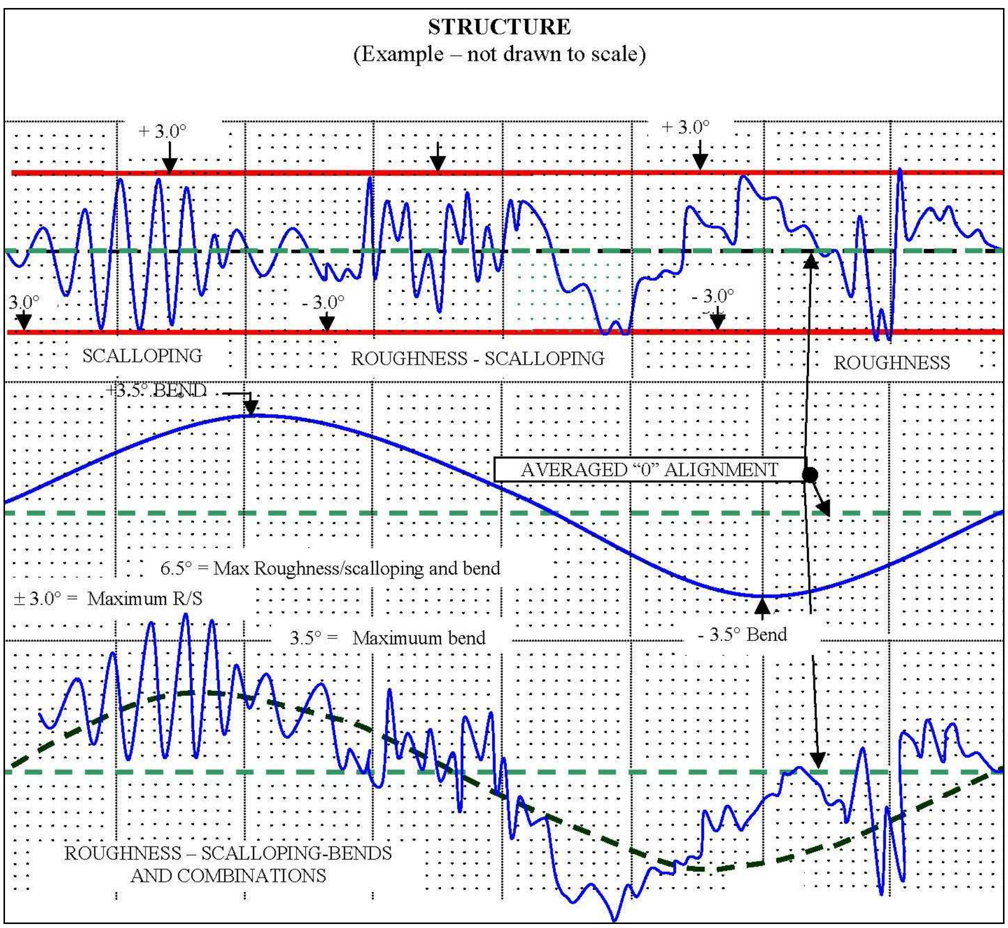

Figure 4. VOR alignment, bends, and roughness and scalloping.

In discussing the results of the VOR analysis, the language in Table 2 will be used to describe the results obtained. The criteria, though not FAA criteria, make use of tolerance limits that are already set for VOR performance in FAA Order 8200.1D [3] as outlined above.

Table 2. Assessment criteria.

Insignificant	---	Less Than 10% of Tolerance Limits
Acceptable	---	10-50% of Tolerance Limits
Significant	---	50-75% of Tolerance Limits
Unacceptable	---	Greater Than 75% of Tolerance Limits

The environment of Figure 1 was analyzed with the OUNPPM software. The environment as analyzed in the software is as shown in Figure 5. Three scenarios were analyzed: (1) conventional VOR with worst-case environment (all potential multipath sources assumed to be reflecting perfectly); (2) conventional VOR with the trees in the environment assumed to be a wall of trees (i.e., no gaps); and (3) Doppler VOR with the trees in the environment assumed to be a wall of trees (i.e., no gaps). For each scenario, an orbital flight was simulated at an altitude of 3000 feet MSL and at a distance of 40 nautical miles from the system. The results for each scenario are presented in Figure 6 through Figure 8.

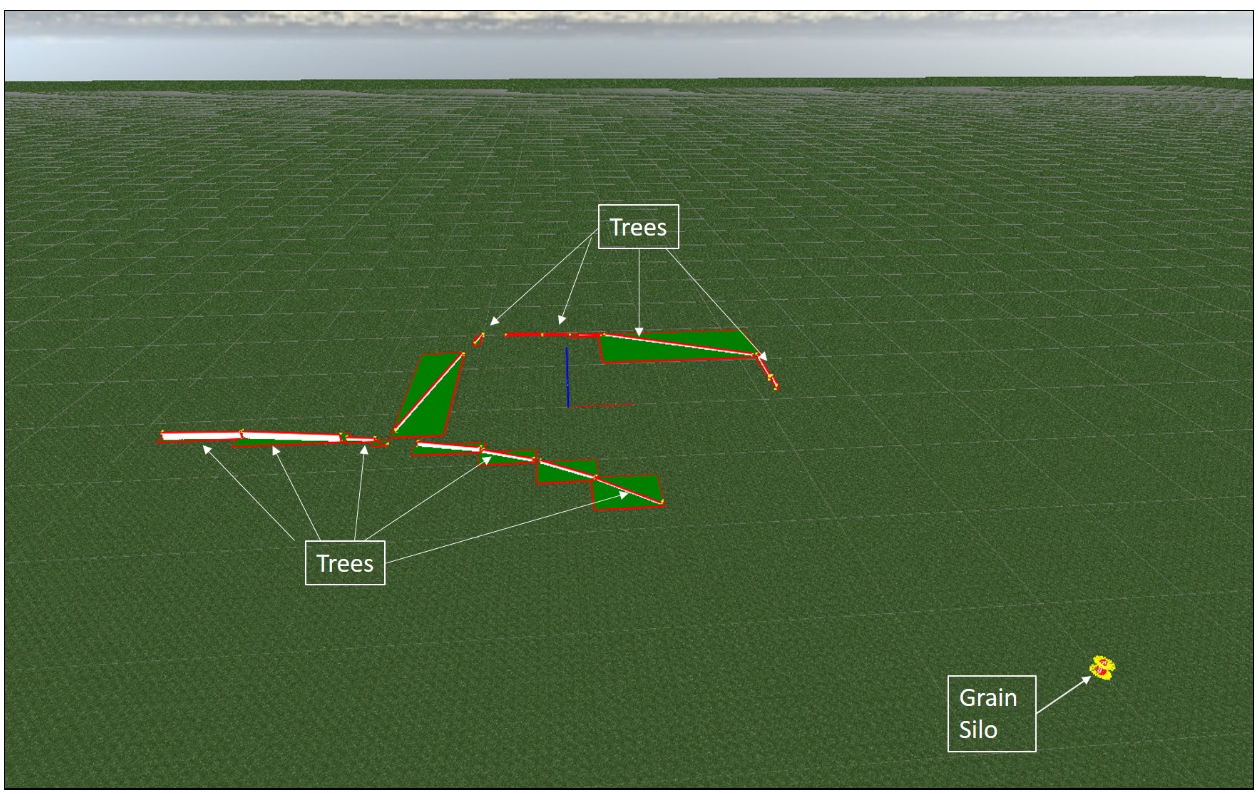

Figure 5. Layout of the Davidson site used in the OUNPPM model.

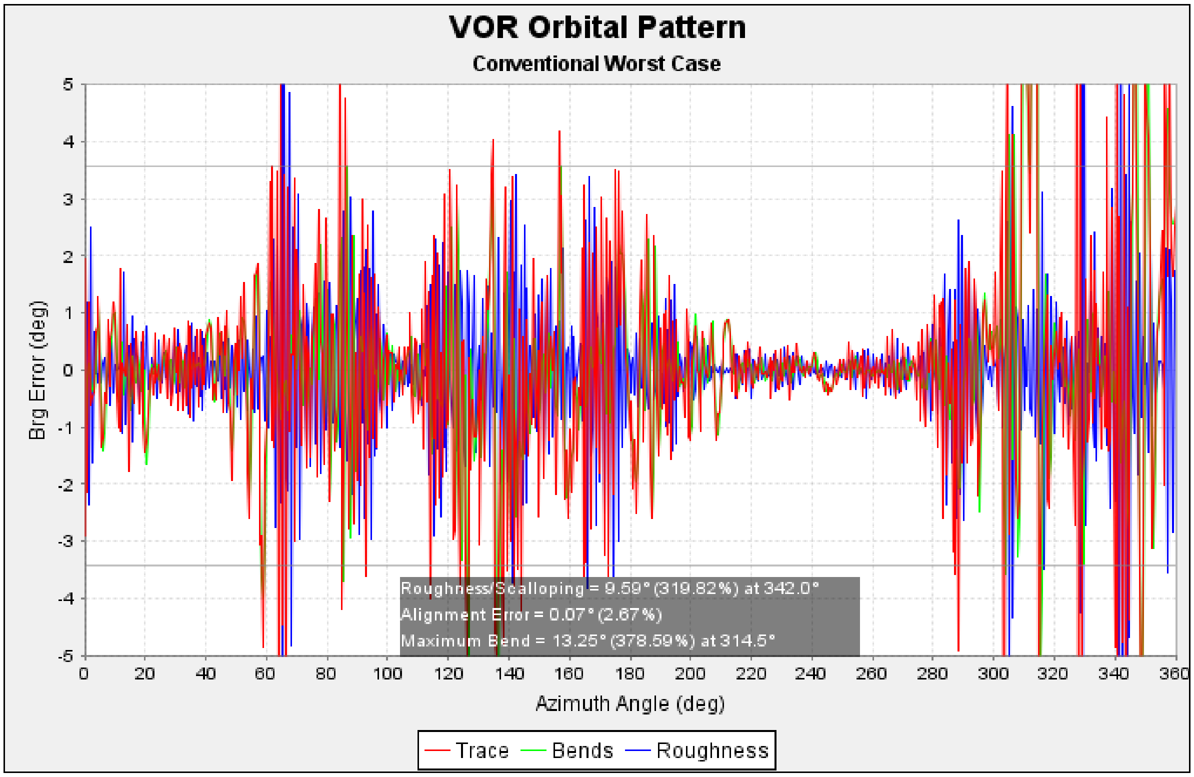

Figure 6. Predicted orbital flight results for Scenario 1 (conventional VOR, worst case).

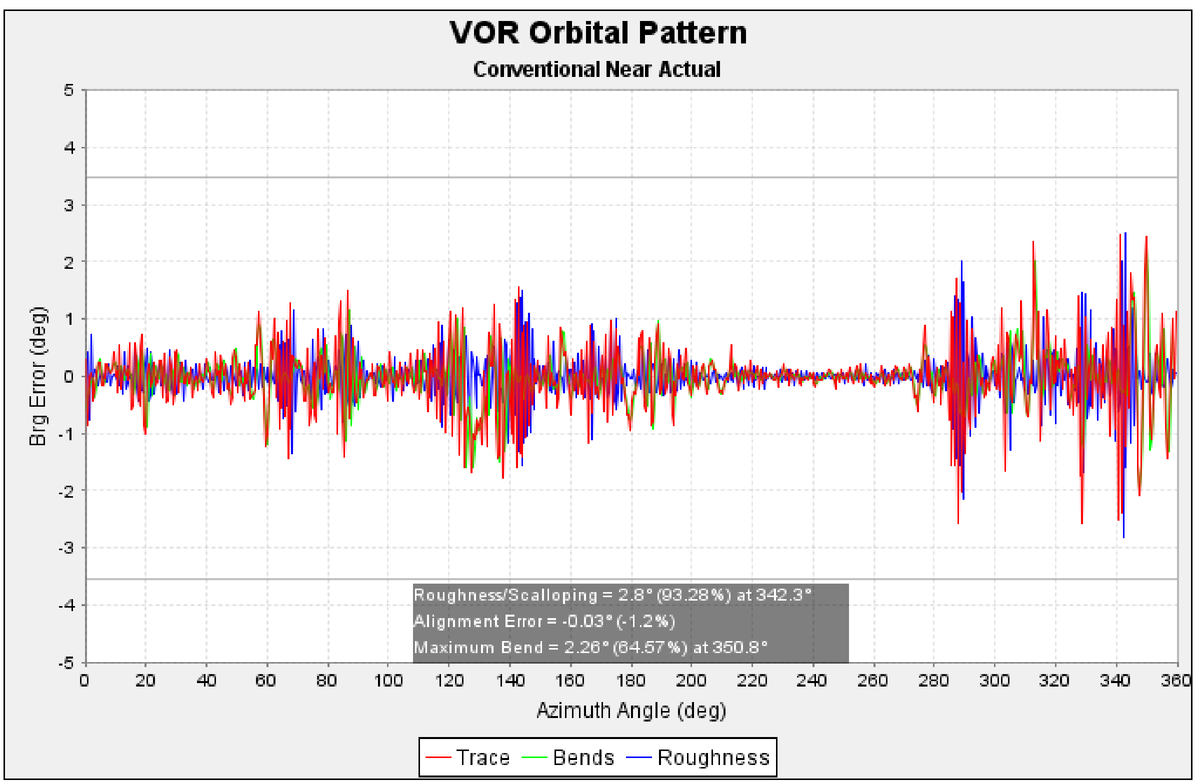

Figure 7. Predicted orbital flight results for Scenario 2 (conv. VOR, wall of trees).

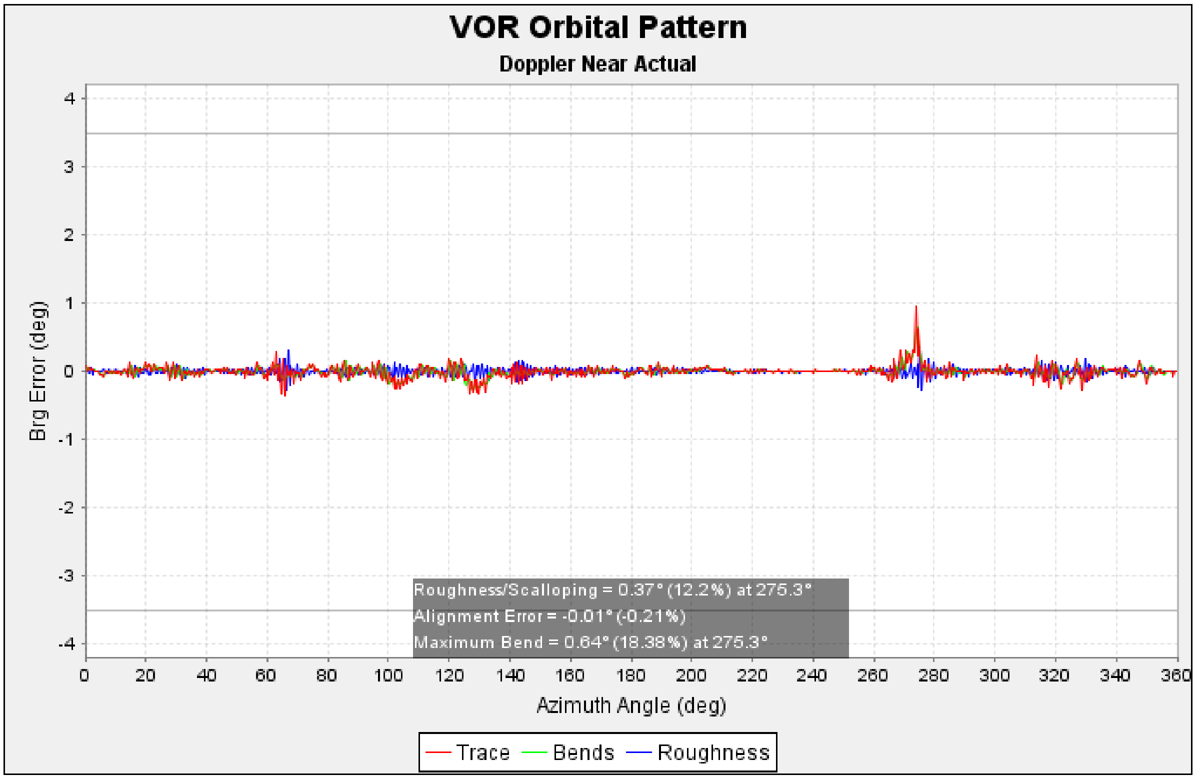

Figure 8. Predicted orbital flight results for Scenario 3 (Doppler VOR, wall of trees).

Based the analysis criteria, the results shown in Figure 6 indicate that the VOR in this scenario cannot perform within the applicable tolerance limits specified in FAA Order 8200.1D (per Figure 4). When the trees on the site are actually modeled as trees, the results of Figure 7 show a performance that is within tolerance limits; however, this performance is deemed *Unacceptable* at 93.28% of tolerance limits. Finally, the results of Figure 8 show that a Doppler system will provide performance well within tolerance limits (18.38%), which is *Acceptable*.

Further inspection of the results shown in Figure 6 though Figure 8 indicates that the bulk of the impact on the VOR is from the trees in the environment; an analysis considering only the silo was performed to independently confirm that the predicted impact of the grain silo is *Insignificant* as noted in the siting report [1]. Since this will be a new location for the VOR, no Victor airway has been tested. However, it is evident from the orbital test that all airways should perform well if a Doppler system is installed. A conventional system should also provide *Acceptable* performance if the trees close to the system that subtend angles greater than 2 degrees are cleared.

IV. CONCLUSIONS AND RECOMMENDATIONS

Based on the results of this study and analysis, the following conclusions and recommendations are presented:

1. A VOR system can be sited at the proposed Davidson location. The impact of the environment on a mobile VOR test facility at the Davidson site can be minimized by cutting the trees that subtend angles greater than 2 degrees from the VOR site. Without cutting the trees, the performance of the mobile system may range from *Significant* to *Unacceptable*.
2. A Doppler system will provide better performance on this site when a full VOR is implemented. The performance of a Doppler VOR is predicted to be *Acceptable*.

V. REFERENCES

[1] S. Bohmfalk, FAA Tech Ops, NAVAIDS Engineering Group, "LIT VOR Siting Report #2 – Little Rock, Arkansas," December 13, 2018.

[2] United States Department of Transportation, Federal Aviation Administration, "VOR, VOR/DME, AND VORTAC Siting Criteria," FAA Order 6820.10, April 17, 1986.

[3] United States Department of Transportation, Federal Aviation Administration, "United States Standard Flight Inspection Manual," FAA Order 8200.1D, February 1, 2007.