RESEARCH & DEVELOPMENT

FREEVAL-NC Development, Training, and Support – Final Report

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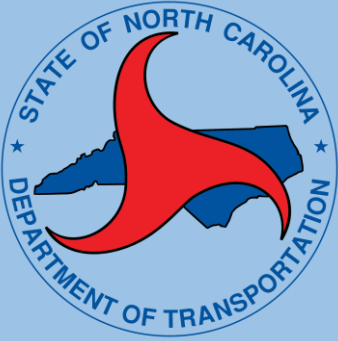
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August 2019

Technical Documentation Page

Report No. 2017-47	Government Accession No.	Recipient's Catalog No.	
4. Title and Subtitle **FREEVAL-NC Development, Training, and Support**		Report Date August 2019	
		Performing Organization Code	
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Performing Organization Name and Address **Institute for Transportation Research and Education North Carolina State University Centennial Campus Box 8601, Raleigh, NC**		Work Unit No. (TRAIS)	
		Contract or Grant No.	
Sponsoring Agency Name and Address **North Carolina Department of Transportation Research and Analysis Group 104 Fayetteville Street Raleigh, North Carolina 27601**		Type of Report and Period Covered **Final Project Report May 2017 to August 2019**	
		Sponsoring Agency Code	
Supplementary Notes:			

Abstract:

This research created a) the statewide segmentation database containing the geometric and demand information for all freeways in North Carolina as well as b) enhancements to the FREEVAL-NC tool (e.g., PDF reports, access segmentation database, enhances demand wizard, etc.). The online segmentation database enables to set up the model in a matter of minutes and then enables the users to perform any single-day and whole-year freeway analyses such as work zone or reliability analyses.

This project contained a significant technology transfer piece, which was to hold six classes and train about 76 participants from NCDOT staff and consultants working on NCDOT projects. One of the classes was held in a webinar format and was recorded for NCDOT's future use cases. The resulting product of this research project are the FREEVAL-NC tool, FREEVAL-NC user guide, online segmentation database, the training material, and the recorded a three-hour webinar.

Key Words **FREEVAL-NC, HCM, Work Zone, Reliability**	Distribution Statement		
Security Classif. (of this report) Unclassified	Security Classif. (of this page) Unclassified	No. of Pages 13	Price $239,945 (TOTAL)

Form DOT F 1700.7 (8-72)   **Reproduction of completed page authorized**

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Acknowledgments

Executive Summary:

Conducting a full operational analysis of freeway facilities is a challenging undertaking, as most available methods either lack the necessary detail for specific geometry and demand patterns or are very data and cost-intensive to implement. For the past few years, NCDOT has been using a customized software application for conducting in-house analyses of freeway facilities, with special emphasis on planning-level applications and work zones. The analysis methodology and associated software tool, FREEVAL-WZ, were deliverables from a prior NCDOT research effort (NCDOT RP 2015-09). The methodology is founded on the analytical method for evaluating freeway facilities in the most recent Highway Capacity Manual but has been enhanced to incorporate work-zone analysis details, as well as some state-specific defaults for its application in North Carolina.

While the aforementioned research accomplished its objectives and produced a tool that is used by NCDOT analysts today, several barriers exist to mainstreaming the tool into standard NCDOT practice and achieving a true technology transfer. Primarily, configuring geometric and traffic demand characteristics have emerged as key challenges for analysts. Additionally, this project made several critical extensions to the methodology that will help NCDOT staff in their day-to-day practice. Through discussion and testing by NCDOT staff, the need for more automated procedures that can boost the analysis process was found to be vital. This project targeted filling these identified gaps, as well as addressing the suggested areas of research and development for planning-level freeway work zone analysis for NCDOT to result in the full integration of a multi-year research and development investment into standard practice.

The focus of this project was on implementing a series of planning-level analysis extensions to the methodology. These extensions were aimed to automate a set of procedures that can be streamlined by bypassing time-consuming manual data gathering and user input with a database linkage and automated logic scripts. Procedures that were targeted in this research project to be automated were 1) freeway segmentation, 2) connection to AADT database, and 3) connection to incident/crash database for reliability analysis. The research team developed a central database to contain FREEVAL-NC analysis segments (for the entire state), crash information, and AADTs so that the analysis packages can communicate and acquire the necessary information automatically. Availability of these data for freeway analyses enables NCDOT staff to evaluate the impact of freeway improvements, work zones, and traffic management strategies on reliability performance measures in a very time-efficient way. The research project also contained a significant training component, to assure that NCDOT central office and division staff along with consultants in North Carolina are properly trained in the use of the tool.

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1. Introduction

The evaluation of the operational performance of freeway facilities and an assessment of the impacts of work zones on freeways are important focus-areas for the NCDOT Safety and Mobility Division. NCDOT analysts previously applied the FREEVAL-WZ tool, which was developed through a prior research effort, and which builds on the freeway facilities method in the Highway Capacity Manual. The tool provides NCDOT with an in-house software system that can be used to estimate the impacts of various work zone strategies and compare alternatives for the purpose of making informed decisions for work zone traffic control and staging. However, some limitations and critical additions were identified at the conclusion of the previous project but were deemed to be beyond the scope of the original research effort. In addition, NCDOT staff have identified several shortcomings and areas of required enhancements for the methodology and tool.

The specific areas of methodological extensions to be addressed in this project included:
1. Create a database of HCM segmentation for all freeways in North Carolina so that the analysis would only require two GPS coordinates or mile markers to fully specify the spatial domain of the analysis.
2. Create an AADT database for all freeway facilities in North Carolina and fill unavailable data with results of balancing computations. This database will be queried by FREEVAL-NC automatically through a new mapping and GIS interface.
3. Integrate the HCM reliability methodology, along with a crash/incident and weather database specific to North Carolina and connect FREEVAL-NC tool to this database. This will result in significant time savings for conducting reliability analysis with or without work zones.

In addition to these methodological extensions, the project contained a significant training component, to assure that NCDOT central office and division staff are properly trained in the use of the tool.

2. Project Objectives

Objective of the research was to build a universal FREEVAL-NC computational tool to assist the NCDOT and its contractors in the evaluation of freeway performance and reliability across the State of North Carolina, using NC-specific input and calibration data, and to provide extensive training for central office, division staff, and contractors in the use and application of these tools.

3. Literature Review

The 6th edition Highway Capacity Manual (*HCM, TRB 2016*), offers new methods to evaluate travel time reliability, as well as work zones on freeways. These methods are based on recently completed research by members of this team (*SHRP2-L08 and NCHRP 03-107*). In freeway analyses, the impacts of work zones are typically expressed through their impacts on a reduction in capacity, either in the form of a reduced number of lanes, a reduced per-lane capacity (of the remaining lanes), or oftentimes, both (*TRB, 2016*). The freeway chapters in the HCM further distinguish between the effects of long-term and short-term work zones. In a funded NCDOT project (*NCDOT 2015-09*), FREEVAL-WZ was developed for NCDOT to assist work zone analysis on freeway facilities. FREEVAL-WZ can perform planning level work zone analysis requiring minimum input data. The standard PDF reports automatically generated at the end of analysis which will make NCDOT capable of tracking planning level work zone analysis working with their subcontractors.

The scope of this research effort is concentrated on "significant" work zones, which are expected to have a high impact on the travel time reliability and are oftentimes located on freeway facilities. As such, the FREEVAL tool is ideally suited for analysis, since it is fundamentally based on the HCM6 freeway facilities methodology (*NCDOT 2015-09*). The tool has been effectively used in national-level research to model the effects of recurring freeway bottlenecks (*Hall, F., et al., (2000), Validation Results for four Models of Oversaturated Freeway Facilities, Journal of the Transportation Research Board 1710, pp.161-170. Best Paper Award for TRB A3A10 Committee.*) and was found to be significantly more efficient when compared to simulation-based analysis tools. The reliability version of FREEVAL considers non-recurring congestion sources such as weather and incident impacts which enables a comprehensive assessment of the freeway facilities (*SHRP2-L08*).

Other existing deterministic tools for work zone evaluation, include QUEWZ-98 (*QUEWZ User Guide, User's Manual for QUEWZ-98. Research Report 1745-2. Texas Transportation Institute. May 1998*), representing the previous state-of-the-practice at NCDOT, which evaluates the performance of a freeway segment with and without a lane closure and provides estimates of queues and user cost from the work zone, based primarily on 1998 Texas data. Alternatively, another spreadsheet-based tool, Quickzone (*QUICKZONE User Guide, Quickzone Delay Estimation Program. Version 0.99. Prepared for Federal Highway Administration by MTS. March 2001*), offers greater flexibility than QUEWZ by allowing a network-level analysis. However, it requires significant resources to set up the network and lacks the operational detail of the effect of weaving segments and ramps. Both tools have been applied in research to model work zone impacts (*Rouphail, Nagui, and B. Schroeder, Analysis Tools for Analyzing Operational Effects of Level I and II Work Zones in North Carolina. Final Report of NCDOT Technical Assistance*

Agreement. Raleigh, NC. October 2008). Other analysis tools investigated in technical assistance report all require high levels of data input, user training and are expensive. The investigated simulation-based tools include CORSIM, VISSIM, AIMSUN, PARAMICS, and DYNASMART-P.

In summary, FREEVAL has been identified as the tool most appropriate for in-house analysis for the NCDOT, as well as providing a broader application to other sections in the NCDOT Traffic Management Unit, including congestion management. With the proposed customization, FREEVAL-NC combines the efficiency of a quick planning-level analysis with the potential for conducting a detailed operational evaluation of freeway operations with or without a work zone.

4. Summary of Research Tasks and Methodology

This section of the final report summarizes the team's effort in terms of defined tasks in this project.

4.1. Task 1 – Kick-Off Meeting:

In this task, the research team met with NCDT Steering and Implementation Committee (StIC) to assure clarity on the scope of the work as well as schedule (august 2017).

4.2. Task 2 – Tool Development:

A significant amount of time was invested in developing new features for FREEVAL-NC that are contained throughout this project:

- New demand wizard that contains a new method to add or edit demand information for a FREEVAL-NC file. This method keeps the information in a PDF report such as AADTs and hourly demand profile that was used to breakdown AADTs into 15 minutes demand flow rates
- New PDF reports developed in FREEVAL-NC for the single day analysis, scenarios assessment, and travel time reliability analyses. The new PDF reports contain new elements such as new sets of charts and mapping views for the subject freeway facility.
- Access to online segmentation database: this feature enables the FREEVAL-NC tool to query the online segmentation database and download all necessary information including geometry, demand, and safety data for different types of analysis.
- New scenario assessment feature that enables users to evaluate a scenario with a work zone, incident, or weather event. Eventually, a customized PDF report can be created documenting all information and assumptions modeled in the analysis.
- Several small changes to FREEVAL to enable database creation as well as increasing user-experience.
- 65 weather stations in North Carolina have been included, and the HCM defined weather conditions data embedded in FREEVAL-NC.

- A user guide was developed that documents all the features in the FREEVAL-NC tool. It is accessible at freeval.org.

4.3. Task 3 – NC Segmentation Database:

The project team constructed the online segmentation database and included entire freeways in North Carolina. The database contains geometric, AADT, and safety data. Freeways in North Carolina include 6,723 segments and covers about 4,000 miles of directional freeways. The online segmentation database is accessible directly from FREEVAL-NC or the users can access it via freeval.org. Figure 1 shows the view of the segmentation database accessed directly from FREEVAL-NC.
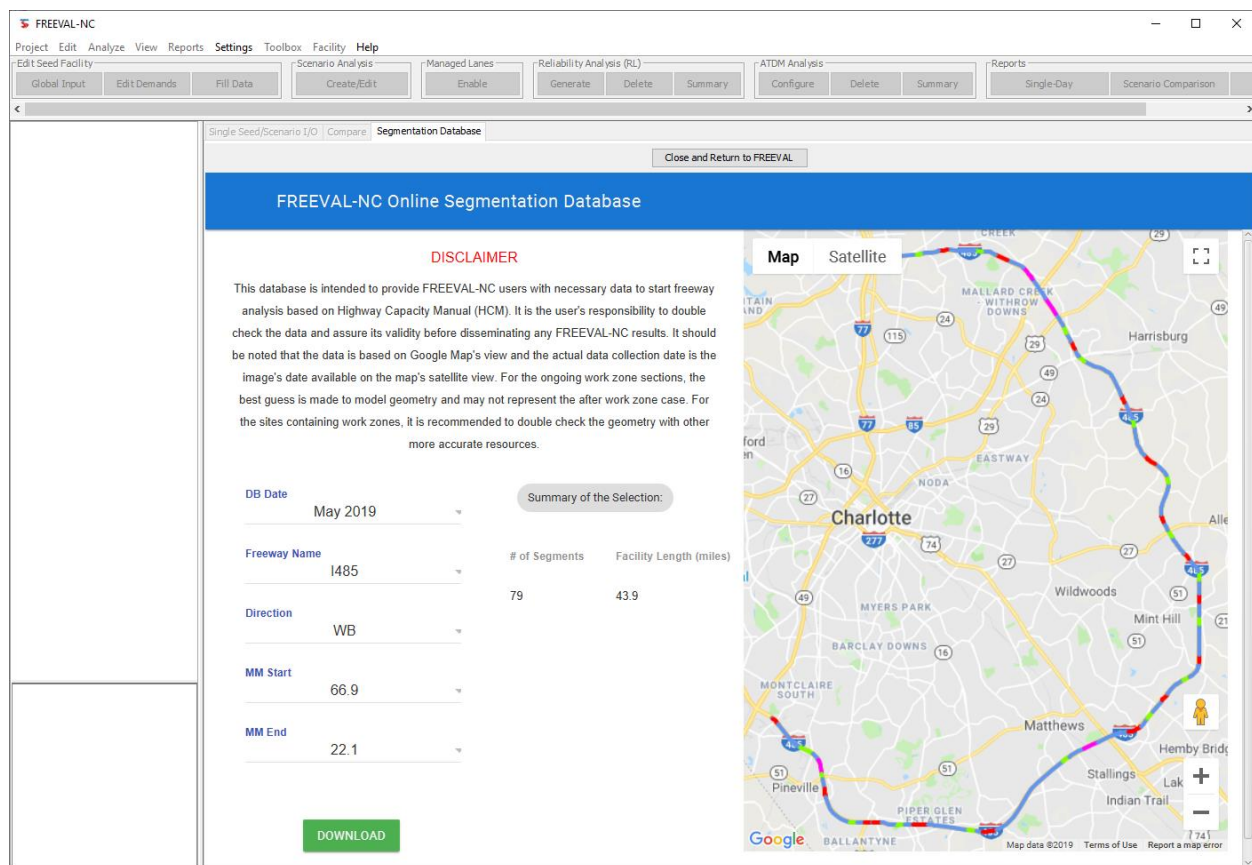

Figure 1 – Segmentation Database Accessed Directly from FREEVAL-NC tool

4.4. Task 4 –Case Studies:

Several case studies were developed for use in training and tool demo. These are documented in the training material as hands-on examples.

4.5. Task 5 – Training Development:

The project team developed training material used for an eight-hour class.

4.6. Task 6 – Training Delivery:

The project team held six classes between May 20, 2019, to July 23, 2019, and trained 76 participants. Table 1 shows the details of each training:

Class No.	Type	Date	No. of Participants	Location
1	Hands-on Class	May 20, 2019	14	NCDOT, Garner, NC
2	Hands-on Class	June 18, 2019	8	CDOT, Charlotte, NC
3	Hands-on Class	June 25, 2019	17	NCDOT, Garner, NC
4	Hands-on Class	June 26, 2019	14	NCDOT, Garner, NC
5	Webinar/Hands-on Class	July 18, 2019	14	Online/ NCDOT, Garner, NC
6	Hands-on Class	July 23, 2019	9	NCDOT, Garner, NC
			Total=76	

The recorded webinar is accessible via the following link:
http://itre.adobeconnect.com/pehrkjp9w734/

4.7. Task 7 – Support and Maintenance:

Support and maintenance were provided during the draft delivery of the tool for use in the training the classes. Bugs in the FREEVAL-NC tool were identified during the training classes and were corrected prior to finish delivery of the tool.

5. Summary and Conclusions

This research included the creation of a) statewide segmentation database containing the geometric and demand information for all freeways in North Carolina as well as b) enhancements to the FREEVAL-NC tool (e.g., PDF reports, access segmentation database, enhances demand wizard, etc.). The online segmentation database enables users to set up the model in a matter a few minutes and then perform any single day and whole year freeway analysis such as work zone or reliability analyses.

This project contained a significant technology transfer piece, which included holding six classes and trained 76 participants from NCDOT staff and consultants working on NCDOT projects. One of the classes held in a webinar format and recorded for NCDOT's future use.

The webinar recording is accessible via the following link:

http://itre.adobeconnect.com/pehrkjp9w734/