VOLUME III

Incorporating Reliability into Transportation Planning and Programming

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LIST OF EXHIBITS

I-1. INTRODUCTION

This brief volume of the final pilot study report summarizes the project team presentations and the roundtable workshop and discussion held with a select gathering of NCDOT and MPO professionals on the topic of incorporating travel time reliability into the transportation planning and programming function. The workshop was held October 18, 2020.

The meeting included two presentations by the pilot study team. The first presentation was a summary of key findings and recommendations from the published documentation for the SHRP2 L05 "Incorporating Reliability Performance Measures into the Transportation Planning and Programming Processes" project. The second presentation provided an overview of the functionality of the special version of the FREEVAL L08 tool that was created for NCDOT under the research project RP 2017-46 "FREEVAL-NC Development, Training and Support." An open discussion among the meeting participants was ongoing during the presentations and software demonstration. The presentation materials and attendant discussion are summarized in the following sections.

I-2. SHRP2 L05 – KEY FINDINGS AND RECOMMENDATIONS

The SHRP2 L05 project produced three final products that are currently available online via direct links from the project web page – (https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=2194):

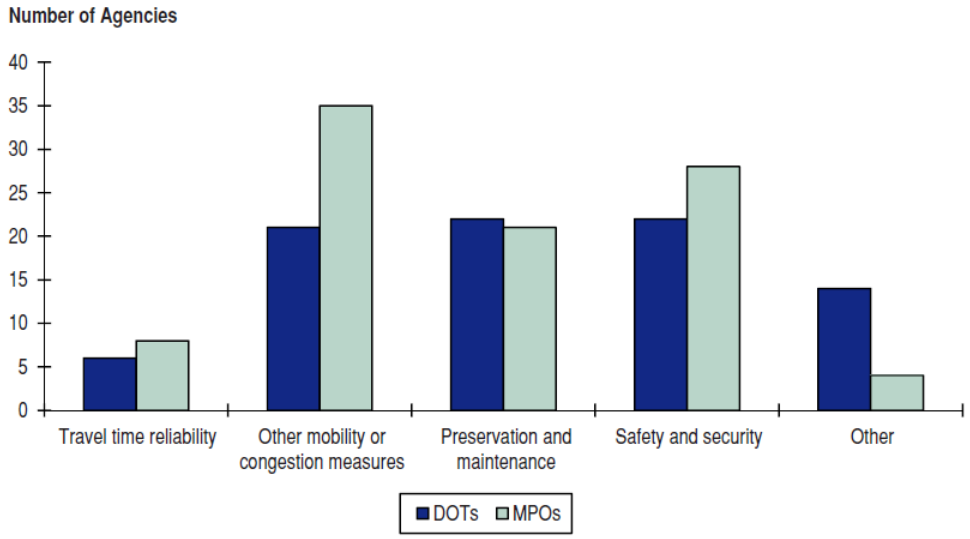
- Final Report – "Incorporating Reliability Performance Measures into the Transportation Planning and Programming Processes"
- Guidebook – "Guide to Incorporating Reliability Performance Measures into the Transportation Planning and Programming Processes"
- Technical Reference – "Incorporating Reliability Performance Measures into the Transportation Planning and Programming Processes: Technical Reference"

Each of these documents was published in 2014. The technical reference document provides methodological details implementing the concepts presented in the final report and the general guidance provided in the guidebook as well as details on a series of case studies performed during the course of the L05 project. The L05 project web page had at one time provided a link to access the spreadsheet tools used in the case studies. However, the case study spreadsheets are no longer available. The pilot study team was able to review the spreadsheets before access was removed. The spreadsheets were special purpose analysis tools developed specifically for each of the L05 case studies. Therefore, although they had value in illustrating how the case study analyses were conducted, they were not general-purpose analytical tools that could be used in other cases without significant reprogramming.

I-2.1. State of the Practice Survey

The L05 project team was conducted the state of the practice survey in 2010, before the advent of the MAP-21 reliability performance measurement requirements. Nonetheless, although states are now compelled to consider travel time reliability, at least as far as is necessary to compute the Level of Travel Time Reliability (LOTTR) performance measure, the relatively low prevalence of travel reliability reporting pre-MAP-21 is instructive. One key finding that factored into this low prevalence was the lack of a formal definition of travel time reliability. The L05 state of the practice survey found that only 25% of the DOTs and MPOs responding to the survey had developed a formal definition of travel time reliability. Of the 92 total respondents to the state of the practice survey, there were 29 DOTs and 39 MPOs, i.e. 68 total DOT/MPO respondents. Exhibit III - 1 below from the L05 final report illustrates the relatively low number of these respondents who indicated that they report a travel time reliability performance measure.

Exhibit III - 1: Performance measures reported by DOTs and MPOs



Source: SHRP2 L05 Final Report

I-2.2. Case Studies

The L05 project conducted seven case studies, three DOTs and four MPOs. The case studies provide breath because the objectives were unique for each case study. However, the unique objectives and approach for the case studies makes it difficult to summarize their findings and results and difficult to develop general lessons learned or recommendations based on the case studies. There is a statement in a table of "key findings and lessons from the validation case studies" presented in tabular form in the L05 Technical Reference that is salient –

> "Success factors include having robust amounts and sources of traffic data, using corridor-level measures and effective reporting graphics, defining reliability in a way that can be easily understood by multiple audiences, and having a performance measurement working group consisting of agency staff, technical/policy board members, local stakeholders, and the public."

These "success factors" remain a challenge for DOTs and MPOs alike. Robust data sources, effective methods for visual communication, broadly understandable definitions of travel time reliability, etc. have all seen improvements but there is still much work to do. The roundtable attendees generally agreed that North Carolina DOTs, MPOs and other transportation agencies, as well as the transportation profession at large has not yet settled on a concise, precise, and easy to understand and communicate definition of travel time reliability. This is the most foundational "success factor."

I-2.3. L05 Framework

The L05 project developed a framework for incorporating travel time reliability into planning and programming by aligning with and building on the PlanWorks system develop under the SHRP2 Capacity Program through project C01 "A Framework for Collaborative Decision Making on Additions to Highway Capacity." According to the tools website, PlanWorks is a "web-based resource to improve decision making throughout their transportation planning and project development processes." PlanWorks tracks planning and project development through *Key Decision Points* (KDPs) within four planning and programming phases:

- Long-range planning
- Corridor planning
- Programming
- Environmental review and permitting

The L05 framework highlighted KDPs within the PlanWorks system where reliability should be incorporated in one of four ways:

- Incorporate reliability in policy statements
- Measuring and tracking reliability performance
- Evaluating reliability needs and deficiencies
- Using reliability performance management to inform investment decisions

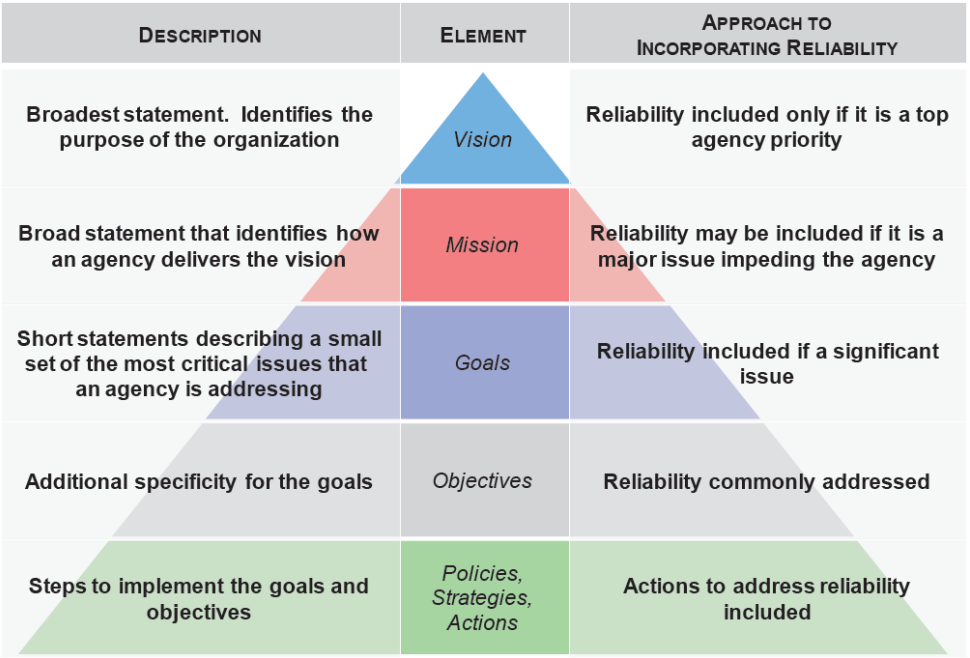
For example, KDP "Approve plan scenarios" is designated as LRP-7 under the Long-range planning phase. If travel time reliability analysis were to play a substantive role in this selection, this would be one of the KDPs where travel time reliability would need to be considered. The framework for incorporating travel reliability presented in the L05 final report includes the following statement for the "Approve plan scenarios" KDP –

> "*Using Reliability Performance Measurement to Inform Investment Decisions.* At this KDP, planners will make use of reliability and other performance measures to help compare and package together scenarios that include a range of strategies (both short and long term). **This step will require significant analytic capabilities to provide a robust analysis of the impacts of various scenarios on travel time reliability**." [emphasis added]

In presenting this example at the roundtable, we highlighted the sentence bolded above. Although developing a clear functional definition of travel time reliability is foundational, once this definition is in hand, the L05 framework makes clear the nonetheless obvious fact that trustworthy and valid analytical methods are necessary if travel time reliability impacts are to inform project investment decisions. The FREEVAL-NC tool discussed later in this report volume is a strong first step toward providing such a tool for evaluating project alternatives for specific freeway routes. However, "significant analytic capabilities" is not an accurate description of reality in general across all transportation facilities and modes.

In terms of the need highlighted by L05 to "Incorporate reliability in policy statements," the L05 guidebook included the following figure to illustrate how the perception and priority travel time reliability relates to the appropriate policy level at which reliability should be emphasized and addressed.

Exhibit III - 2: Incorporating reliability into various levels of policy statements



Source: SHRP2 L05 Guidebook

The roundtable participants engaged in a spirited discussion of which of the level illustrated above is appropriate for NCDOT. There was general agreement that travel time reliability is important. However, few were of the opinion that reliability was high enough a priority on its own to be explicitly included in the agency's mission or vision. Nonetheless, there was general agreement that travel time reliability is an important implicit component of NCDOT's current mission, especially in relation to efficiency, customer focus, and economic enhancement as embodied in the current NCDOT mission statement –

> *Connecting people, products and places safely and efficiently with customer focus, accountability and environmental sensitivity to enhance the economy and vitality of North Carolina*

In terms of the need highlighted by L05 to provide "measuring and tracking of reliability performance," NCDOT has made great strides and has rich data and analytical resources, especially for the National Highway System within the state. However, this data does not include nor is it aggregated from actual vehicle trajectories and travel time. The MAP-21 mandated performance measure as mentioned above is LOTTR. The roundtable participants expressed general understanding that LOTTR is not an actual travel time measure. This is true despite the fact that MAP-21 and the implementing rules set the reliability performance measure as "Percent of Person-Miles Traveled on the Interstate [or Non-Interstate NHS] That Are Reliable." As mention above, no states have actual data on miles traveled based on actual vehicle trips, not to mention person-trips.

The fact is that LOTTR is in essence a segment speed-based measure. Archived segment average speeds for specific time periods are converted to "travel time" based on segment length. The LOTTR may prove to be a sufficiently accurate surrogate for overall system travel times, but it is important for policy makers, agency officials, and system managers to understand that it is not a direct measure of the reliability of person-miles traveled. Furthermore, its application to planning and programming must been done in a manner that recognizes the risk of misinterpreting what LOTTR is saying about the state of the transportation system. To be more specific, LOTTR is defined as the ratio of 80th to 50th percentile "travel time" (in parenthesis because as stated above the segment data are not true travel times). A segment is reliable if its LOTTR is below 1.5 in all four time periods specified by the rule, namely

- Weekdays 6 a.m. to 10 a.m.
- Weekdays 10 a.m. to 4 p.m.
- Weekdays 4 p.m. to 7 p.m.
- Weekends 6 a.m. to 8 p.m.

It is well known and discussed that reliable by the LOTTR definition does not necessarily mean a quality travel experience for the segment users. Segments that are congested at least 50% of

the time in each time period would likely meet the 1.5 threshold in all four time periods and therefore be considered "reliable." In this case, the segment would be reliability congested.

NCDOT recognizes the limitations of LOTTR and therefore has developed and continues to develop creative ways to use the data and analysis tools from its data providers to monitor the reliability of the highway system. This ongoing monitoring is invaluable in tracking the performance of the system over time and in helping to identify locations for investment in system improvements. Even so, direct incorporation of these tools and their results into planning and programming of investments is in general not an option. Fortunately, NCDOT has invested in the development of a tool that will enable rigorous modeling of alternative freeway route improvements that includes valid estimation of the comparative impact to travel time reliability of the alternative under consideration. This is the FREEVAL-NC tool mentioned above and briefly introduced below.

I-3. FREEVAL-NC

The pilot study team provided the roundtable participants with a brief overview of Highway Capacity Manual-based freeway reliability analysis, followed by a brief introduction and demonstration of FREEVAL-NC. As mentioned above FREEVAL-NC was developed under the NCDOT-sponsored research project RP 2017-46 "FREEVAL-NC Development, Training and Support." FREEVAL-NC is build on the FREEVAL-RL tool developed under SHRP2 L08 "Incorporation of Travel Time Reliability into the Highway Capacity Manual" with subsequent functional improvements. The FREEVAL-RL methodology and tool are covered in detail in Volume II of this pilot study report. Therefore, readers of this volume who are interested in a detail discussion of how FREEVAL-RL works and in a case study application to illustrate the quality of its results are referred to Volume II.

The FREEVAL-NC project team was led by the ITRE/NCSU in collaboration with Kittelson and Associates. The team include the key members of the L08 project team who developed the *Highway Capacity Manual* reliability methodology and the FREEVAL-RL tool. The vision for FREEVAL-NC was to enable rapid, statewide use of the tool by pre-coding all exiting interstate and non-interstate freeway routes within North Carolina. The project was completed in 2019. The FREEVAL-NC software and access to the web-based tool to create custom FREEVAL routes from the pre-coded freeway segments is publically available at –

http://freeval.org

Some additional detail on the FREEVAL versions available on the site above will be useful. There are three versions available on the site. The base version is what has been referred to above as FREEVAL-RL. This version is now referred to as FREEVAL-HCM. The base version includes the following key features –

- Freeway Capacity Analysis
- Travel Time Reliability Analysis
- Managed Lanes Analysis
- Work Zone Analysis

The second version available is FREEVAL+. This enhanced version includes all the base version capabilities plus –

- Map-Based Segmentation and Visualization
- Planning Level Demand Data Entry
- Demand and Capacity Calibration Tools

Map-based segmentation is an enhancement that allows a user to more easily create the freeway route segmentation using an embedded link to Google Maps. Planning level demand data entry allows the user to generate results without having detailed ramp volume data. This method takes AADT data at the segment level and uses a set of temporal volume profiles that the user can select from to estimate the necessary analysis period demands. Demand and capacity calibration tools enables to user to perform demand and capacity adjustment calibration so that the model outputs better match user-downloaded speed profiles.

Finally, FREEVAL-NC, the most feature-rich version, include all the FREEVAL-HCM and FREEVAL+ features plus –

- Access to Online Segmentation Database
- Generates PDF Format Reports

The online segmentation database access allows FREEVAL-NC users to access the online database from within the tool. PDF report generation provides professional quality reports. The format and content of the PDF reports were developed based on consultation with the NCDOT FREEVAL-NC project steering and implementation committee.

I-4. SUMMARY

The meeting participants felt that the presentations and discussions were valuable in continuing the dialogue on the monitoring and modeling of travel time reliability and on possible ways to incorporate travel time reliability into transportation planning and project programming/development. There was a fruitful discussion of FREEVAL-NC use cases and eagerness to implement the tool.

I-5. REFERENCES

1. Cambridge Systematics, Inc. *SHRP2 Report S2-L05-RW-1: Incorporating Reliability Performance Measures into the Transportation Planning and Programming Processes*. Transportation Research Board, Washington, D.C., 2014.
2. Cambridge Systematics, Inc. *SHRP2 Report S2-L05-RR-2: Guide to Incorporating Reliability Performance Measures into the Transportation Planning and Programming Processes*. Transportation Research Board, Washington, D.C., 2014.
3. Cambridge Systematics, Inc., A. Vandervalk, H. Louch, J. Guerre, and R. Margiotta. *SHRP2 Report S2-L05-RR-3: Incorporating Reliability Performance Measures into the Transportation Planning and Programming Processes: Technical Reference*. Transportation Research Board, Washington, D.C., 2014.

APPENDIX III – A: WORKSHOP ATTENDEES

Participants

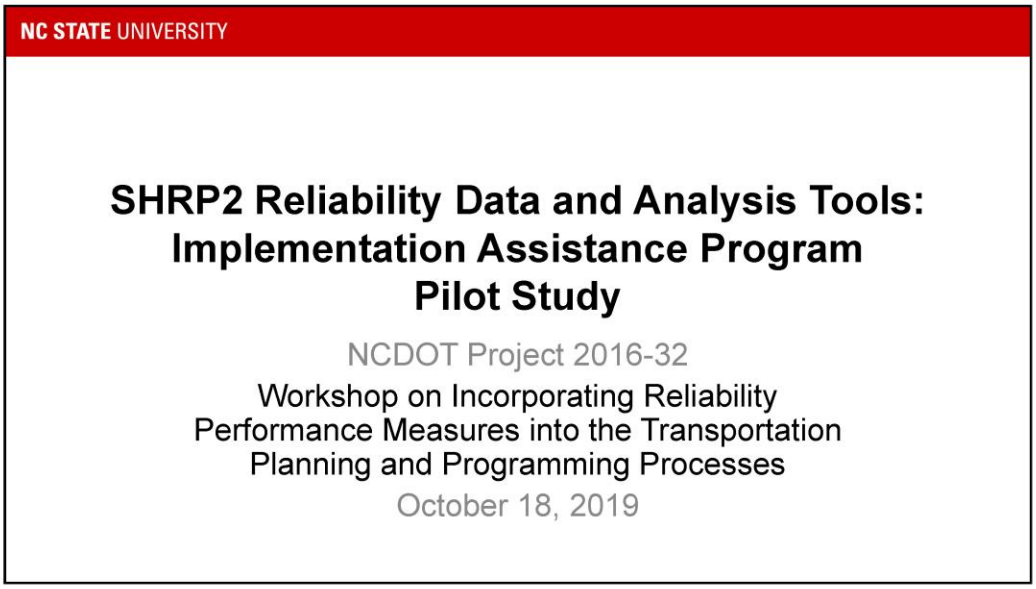
Name	Affiliation
James Dunlop	Congestion Management - NCDOT
Joe Hummer	Traffic Management Unit - NCDOT
Brian Wert	Transportation Planning - NCDOT
Justin Green	Strategic Prioritization Office (SPOT) – NCDOT
Mike Bruff	Capital Area Metropolitan Planning Organization
Jason Schronce	Strategic Prioritization Office (SPOT) – NCDOT
David Keilson	Highway Division 5 - NCDOT
Shank York	Feasibility Studies Unit - NCDOT
Jennifer Portanova	Traffic Systems Operations - NCDOT
Meredith McDiarmid	Transportation Systems Management & Operations - NCDOT
Dominic Ciaramitaro	Traffic Systems Operations - NCDOT

Presenters

Name	Affiliation
Billy Williams	ITRE/NCSU
Nagui Rouphail	ITRE/NCSU
Behzad Aghdashi	ITRE/NCSU

APPENDIX III – B: WORKSHOP PRESENTATIONS

SHRP L05 Reliability Product Summary



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Pilot Study History

- Successful application to FHWA under Round 4 of the SHRP2 Implementation Assistance Program
- Pilot Study to Investigate the Usefulness of the SHRP2 "Reliability Bundle" Research Products
  - L02 *Establishing Monitoring Programs for Mobility and Travel Time Reliability*
  - L05 *Incorporating Reliability Performance Measures into the Transportation Planning and Programming Processes*
  - L07 *Evaluation of Cost-Effectiveness of Highway Design Features*
  - L08 *Incorporation of Travel Time Reliability into the Highway Capacity Manual*
  - C11 *Development of Improved Economic Analysis Tools Based on Recommendations from project C03*

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Pilot Study Bundle Classification

- Tools for Reliability Monitoring – L02
- Tools for Reliability Modeling – C11, L07, and L08
- Tools for Incorporating Reliability into Planning and Programming – L05
- Pilot Study Report Organized with a Volume for Each Tool Grouping

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Pilot Study History

- Originally tied to anticipated statewide advanced transportation management systems formerly known as "NC SmartLink"
- Study of the Monitoring and Modeling Tool Groups Completed in 2018
- Drafts of the Following Report Sections Review in Fall 2018
  - Pilot Study Executive Summary
  - Volume I: Reliability Monitoring Tools (L-02)
  - Volume II: Reliability Modeling Tools (C-11, L-07, and L-08)

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Today's Workshop

- The Final Pilot Study Element
- Based on Today's Discussions and Feedback
  - The *Pilot Study Executive Summary* will be updated
  - *Volume III: Incorporating Reliability into Transportation Planning and Programming* will be drafted
- The full draft pilot study report will then be submitted for review

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Summary of L05 Products

- Final Report
- Guidebook
- Technical Reference – Details on Case Studies
- There were case study spreadsheets available, but these have been removed
- We will focus on the Final Report and Guidebook

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Final Report – State of the Practice Survey

- 92 survey responses
  - 29 State DOTs
  - 39 MPOs
  - Data was gathered in 2010 (pre-MAP21)

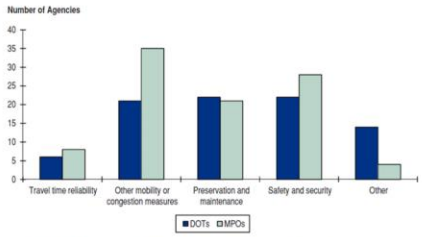

Figure 3.3. Performance measures reported by DOTs and MPOs.

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Final Report – Case Studies

- Seven Case Studies
  - 3 State DOTs
  - 4 Metro Areas
- Objectives were unique for each case study
- Findings not easy to summarize and generalize
- Any important takeaways?

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Final Report – Framework

- Aligned with SHRP 2's PlanWorks *Key Decision Points* (KDPs)
- KDPs are in turn aligned with four planning and programming phases
  - Long-range planning
  - Corridor planning
  - Programming
  - Environmental review and permitting
- PlanWorks framework was expanded to include
  - Operations planning
  - Congestion management

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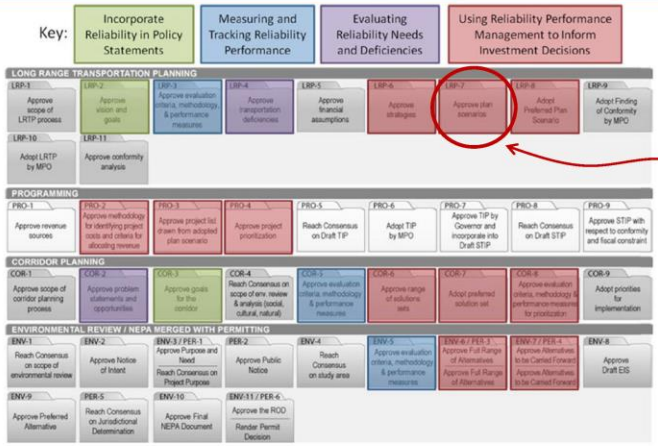

Example on next slide

Figure 6.1. Incorporating reliability into the PlanWorks framework.

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From Table 6.1

Incorporating Reliability into Long-Range Planning

7: Approve plan scenarios	Identify plan scenarios for testing and comparison in order to select a preferred plan scenario for the region	*Using Reliability Performance Measurement to Inform Investment Decisions.* At this KDP, planners will make use of reliability and other performance measures to help compare and package together scenarios that include a range of strategies (both short and long term). This step will require significant analytic capabilities to provide a robust analysis of the impacts of various scenarios on travel time reliability.

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Guidebook – The Opening Statement

WHAT DO WE MEAN BY RELIABILITY?

Reliability is a measure of the variability of travel times. When a system is reliable, it means that people and goods get to their destinations on time, nearly every time. It means travelers leaving for the airport and knowing that they will catch their flights. It means not paying another late fee at day care. It means leaving for work in the morning at 7:15 a.m., as usual, and getting into the office at 8:00 a.m. nearly every day. It means reducing the stress of traveling, knowing when you will arrive at your destination. Reliability is important to commuters and businesses. Consistently, research shows that commuters value reliability in similar measure to the way they value overall travel time, and shippers routinely value being able to specify when shipments will arrive at their destination.

Thoughts on this definition?

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Incorporate Reliability in Policy Statements

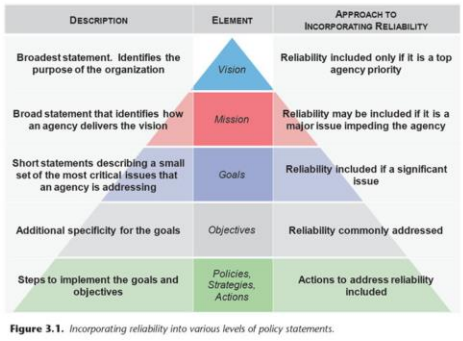

Figure 3.1. *Incorporating reliability into various levels of policy statements.*

How high should reliability be on this scale for NCDOT?

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Measuring and Tracking Reliability Performance

- NCDOT has rich data and analytical resources
- MAP-21 and implementing rules sets the NHPP reliability performance measure as "Percent of Person-Miles Traveled on the Interstate [or Non-Interstate NHS] That Are Reliable."
  - LOTTR is the measure
  - Does LOTTR match the stated performance measure?
- What are NCDOT's emerging best practices for monitoring reliability?

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Level of Travel Time Reliability

- Segment-based
- Is it really travel time?
- Does it have a strong correlation with actual experienced travel times?
- Reporting is divided into four time periods:
  - Weekdays 6 a.m. to 10 a.m.
  - Weekdays 10 a.m. to 4 p.m.
  - Weekdays 4 p.m. to 7 p.m.
  - Weekends 6 a.m. to 8 p.m.

- LOTTR for a segment is the ratio of 80th to 50th percentile "travel time"
- Reliable is defined as LOTTR below 1.5 in all four periods
- Does reliable by this definition mean "good" from the traveler's perspective?
- Would LOTTR improve if heavy congestion spread through an entire time period?

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Evaluating Reliability Needs and Deficiencies

- How well do NCDOT's emerging reliability monitoring practices support evaluating reliability needs and deficiencies?
- How important are "reliability needs and deficiencies" (assuming they can be identified) in planning and programming?
- What role, if any, should NCDOT's reliability monitoring have in planning and programming?

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Using Reliability Performance Management to Inform Investment Decisions

- How accurate are our reliability modeling tools?
- Assuming we can model reliability impacts of system investment alternatives with sufficient accuracy, how do we use this information?
  - What is the monetary value of reliability?
- Are there examples of decisions where knowledge of reliability impacts would have significantly improved decision-making?

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Overarching Question

- How much control does NCDOT have on the factors that influence travel time reliability over time?
  - What factors does NCDOT have some control over within its mission, capabilities, and resources?
  - What factors are beyond NCDOT's control?

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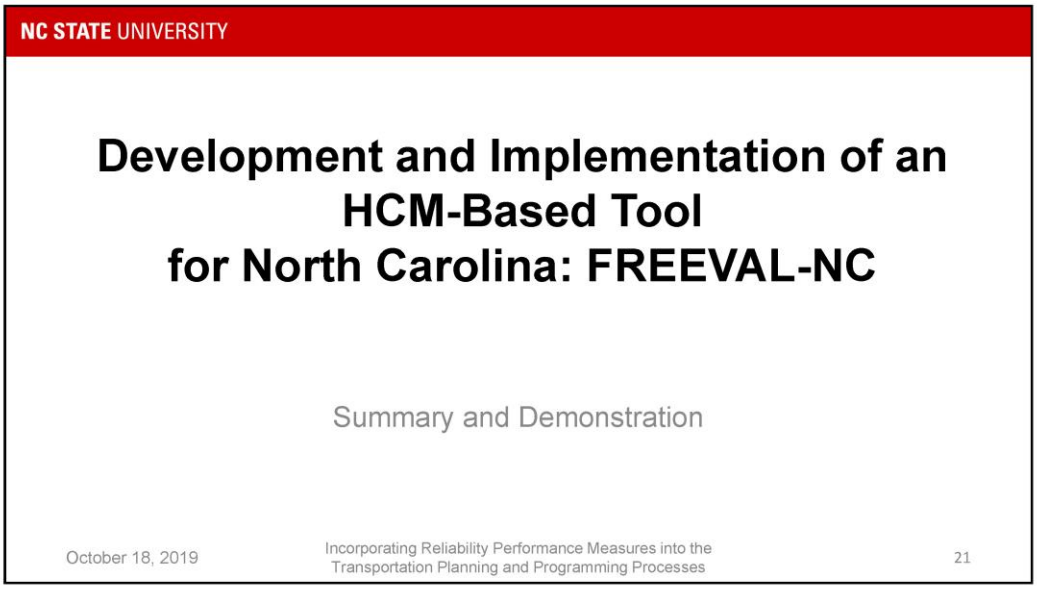
Back to Reliability Impact Assessment

- Recall the statement in the L05 Final Report – "This step will require significant analytic capabilities to provide a robust analysis of the impacts of various scenarios on travel time reliability."
- The pilot studies findings are that none of the sketch planning or segment-based tools provide useful results
- Both the original L-38 independent validation and the pilot study found FREEVAL does provide accurate results
- NCDOT has an exciting tool available in FREEVAL-NC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Development and Implementation of an HCM-Based Tool for North Carolina: FREEVAL-NC
Summary and Demonstration
October 18, 2019
Incorporating Reliability Performance Measures into the Transportation Planning and Programming Processes
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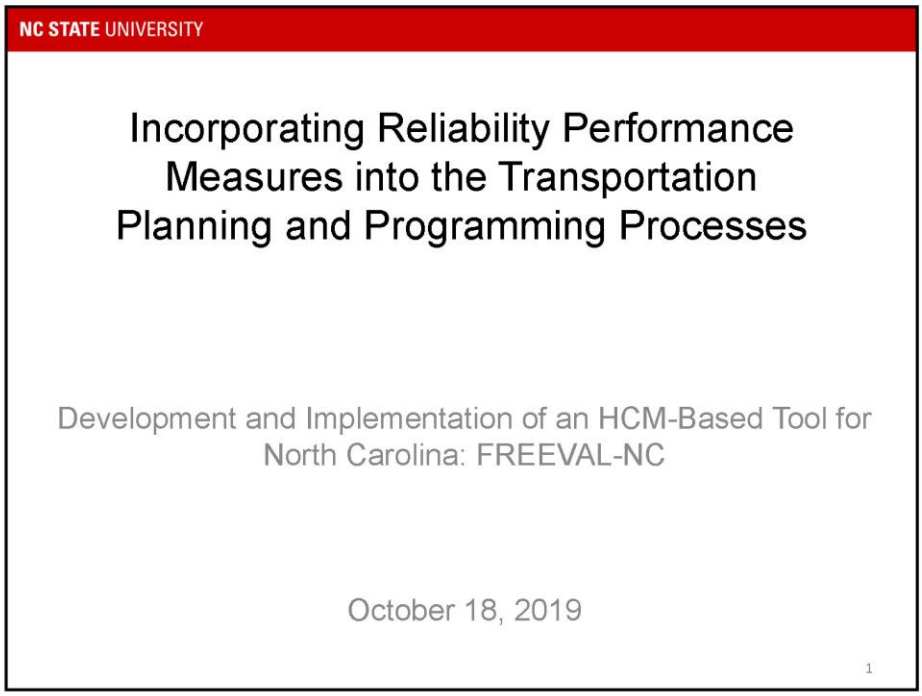
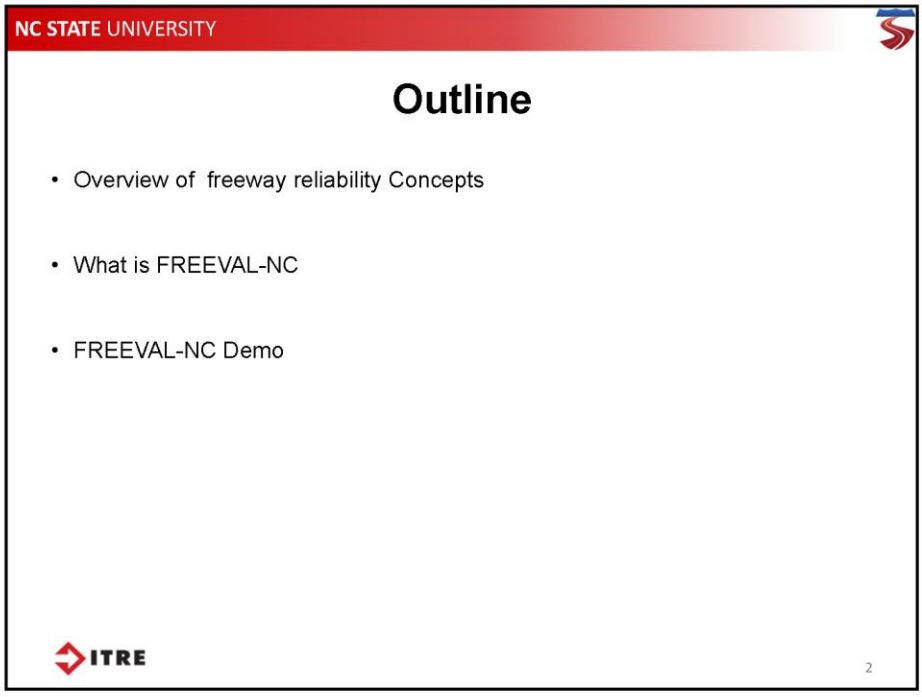
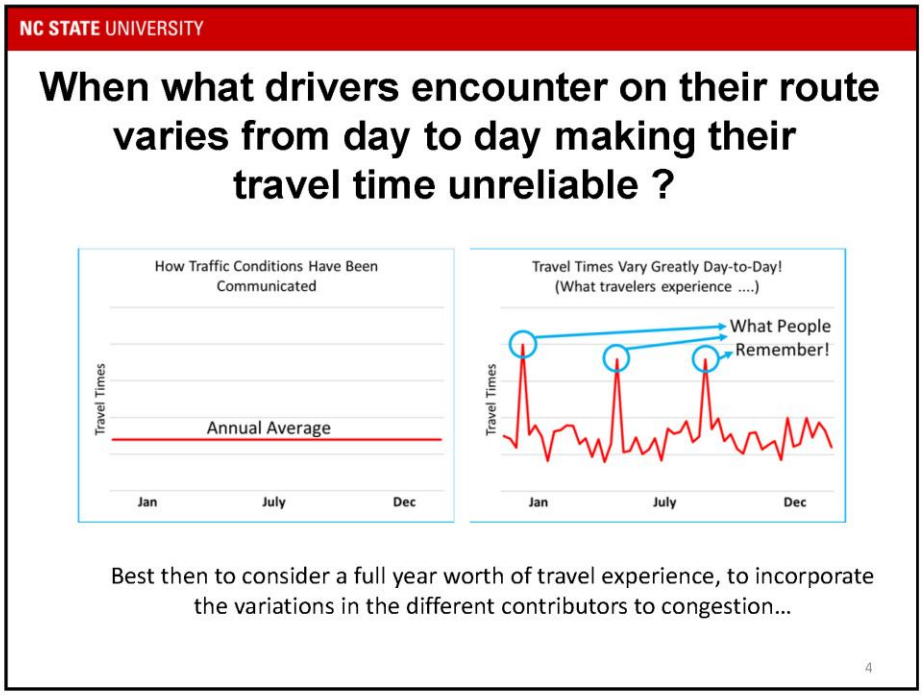
FREEVAL-NC Overview and Demonstration






WHY DO WE CONTINUE TO ANALYZE THE AVERAGE DAY?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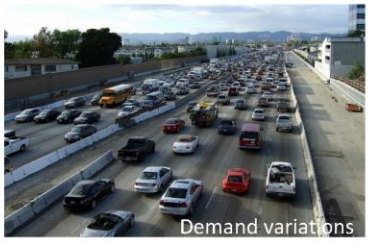
When what drivers encounter on their route varies from day to day making their travel time unreliable ?
How Traffic Conditions Have Been Communicated
Travel Times
Annual Average
Jan
July
Dec
Travel Times Vary Greatly Day-to-Day!
(What travelers experience ....)
What People Remember!
Travel Times
Jan
July
Dec
Best then to consider a full year worth of travel experience, to incorporate the variations in the different contributors to congestion…
4

Sources of (Un)Reliable Travel



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Freeway Reliability Analysis in the HCM

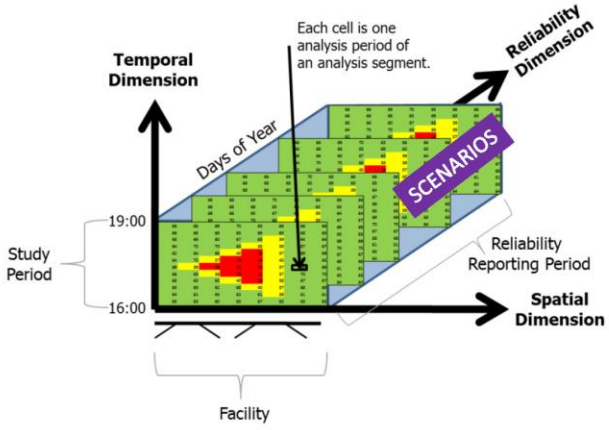

Exhibit 11-1
Schematic Representation of Freeway Reliability Analysis Time–Space Domain

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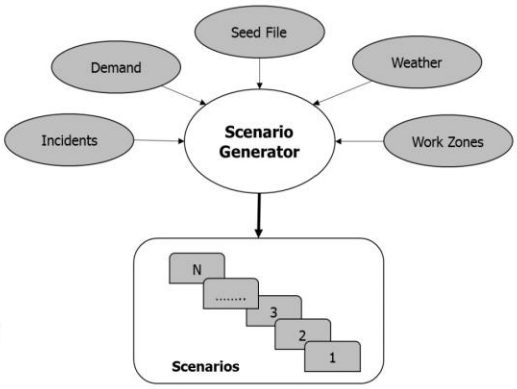
Scenario Generation

- *The 6th edition of HCM* uses an enhanced scenario-generation approach compared to the SHRP2-L08 method.
- The method uses both deterministic and stochastic modeling in an optimization scheme to generate scenarios
- A scenario typically represents a single day with variations in volume, weather and incidents from day to day



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Representing Scenarios
in Facility Time-Space Domain

- Each Scenario may contain several non-recurring events.
- Overlap between different types of events is allowed.
- The following example shows a single scenario with the effects of a rain event (R) lasting 45 minutes, a two-lane closure incident (I-2) lasting one hour, and a shoulder-closure incident (I-S) lasting 15 minutes.

Analysis Period	Segment Number									
	1	2	3	4	5	6	7	8	9	10
1										
2										
3	R	R	R	R	R	R	R	R	R	R
4	R	R	R	R	R	R	R	R	R	R
5	R	R	R	R	R	R	R	R and I-2	R	R
6								I-2		
7								I-2		
8								I-2		
9										
10										
11			I-S							
12										

Exhibit 11-5
Scenario Illustrating Weather and Incident Events

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8

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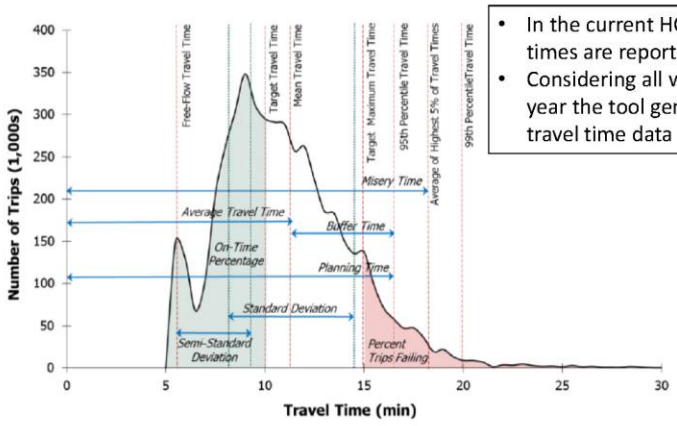
Travel Time Distribution
for Reliability Analysis



- In the current HCM tool travel times are reported each 15 min
- Considering all weekdays in a year the tool generates 23,040 travel time data points

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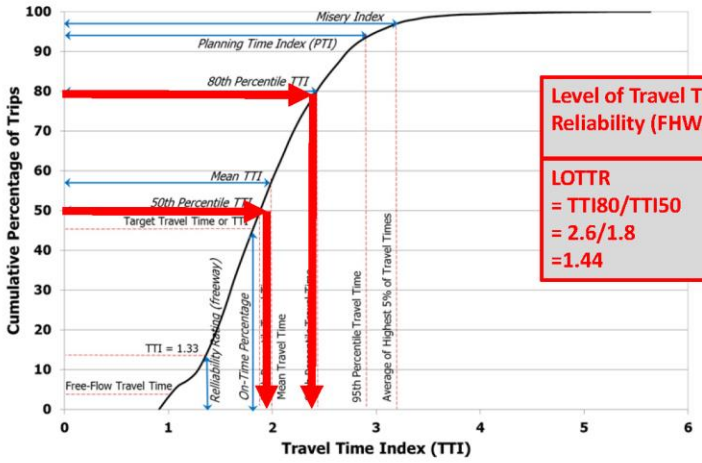
Reliability Performance Measure Examples



Level of Travel Time Reliability (FHWA)

LOTTR
= TTI80/TTI50
= 2.6/1.8
=1.44

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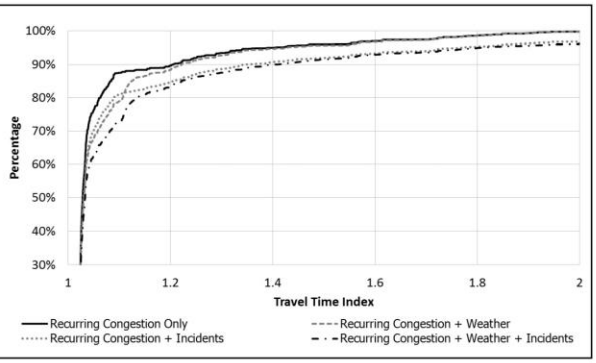
The Effect of Different Sources of Reliability

Exhibit 11-14
Illustrative Effects of Different Non-Recurring Sources of Congestion on the TTI Distribution

FFS= 60 mph



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Types of treatments where the HCM tool can quantitatively demonstrate travel time reliability improvements

- Any type of geometric improvement through lane adds, managed lanes, auxiliary lanes, ramp improvements, etc.
- New freeway facilities that may also improve the reliability of existing facilities through diversions
- Incident management improvements that may reduce incident response times (IMAP)
- Safety targeted improvements that can generally reduced the amount of crashes on a facility
- Incident alerts on CMS that can reduce traffic flow through diversion at the incident site
- Moving work zone activities to night time operations in off peak hours

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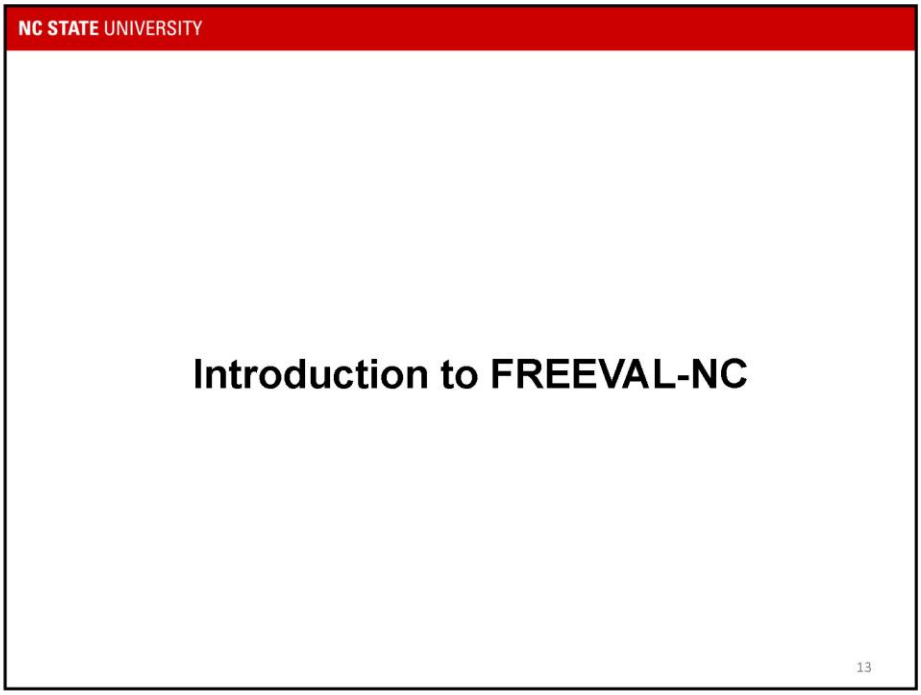
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Introduction to FREEVAL-NC
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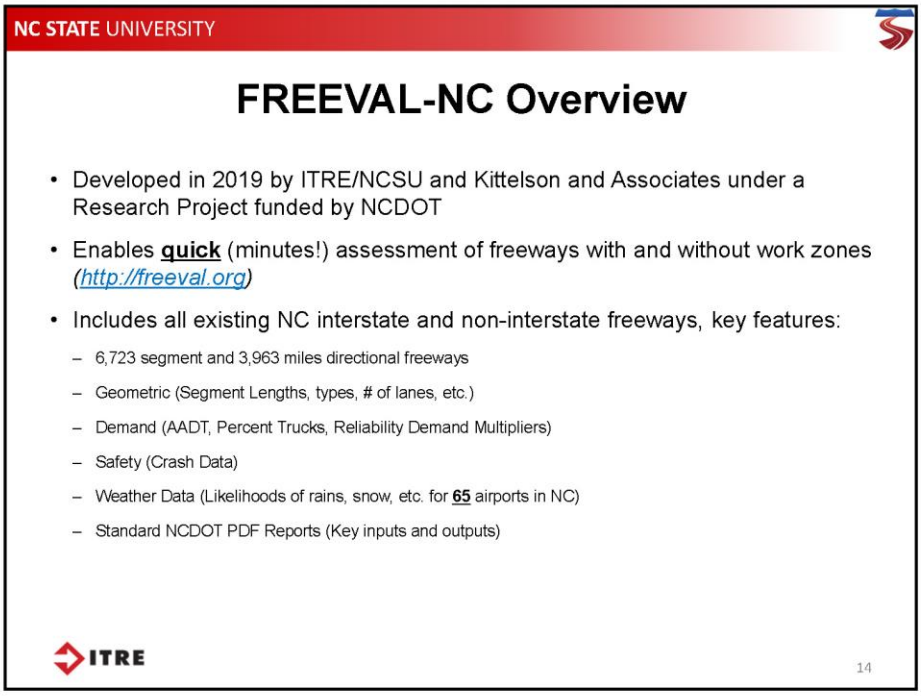
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FREEVAL-NC Overview
• Developed in 2019 by ITRE/NCSU and Kittelson and Associates under a Research Project funded by NCDOT
• Enables quick (minutes!) assessment of freeways with and without work zones (http://freeval.org)
• Includes all existing NC interstate and non-interstate freeways, key features:
– 6,723 segment and 3,963 miles directional freeways
– Geometric (Segment Lengths, types, # of lanes, etc.)
– Demand (AADT, Percent Trucks, Reliability Demand Multipliers)
– Safety (Crash Data)
– Weather Data (Likelihoods of rains, snow, etc. for 65 airports in NC)
– Standard NCDOT PDF Reports (Key inputs and outputs)
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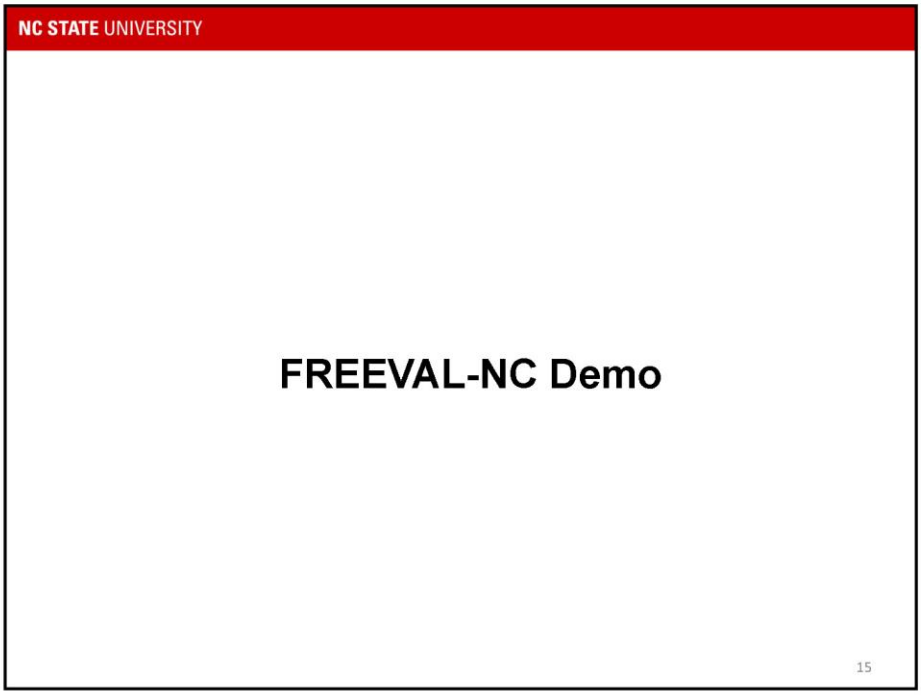
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FREEVAL-NC Demo
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