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PRESENTATION TOPICS

▪ Introduction
▪ Literature Review
▪ Practice Evaluation
▪ Simulator Study
▪ Field Study
▪ Key Findings and Recommendations
▪ Complex Interchange Analysis Tool
INTRODUCTION

The Federal Highway Administration has sponsored research related to complex interchanges with the purpose of:

- Determining design elements and traffic characteristics that contribute to complexity
- Determining characteristics that increase confusion (e.g., lane drops, lane splits, left exits)
- Quantifying interchange complexity
- Understanding practitioner experience and gathering input regarding complex interchange design characteristics
LITERATURE REVIEW

Built off of past FHWA work by focusing on the following categories:

- Driver expectations of freeway signing
- Identifying complex situations
- Existing design guidance
- Interchange design practice
LITERATURE REVIEW

Results of this effort identified:

▪ Practices that have been implemented to try and address issues related to interchange complexity

▪ Examples of inconsistent signing and pavement marking practices

▪ A list of 15 barriers to best practice in signing and marking interchanges

▪ Scenarios that make an interchange complex
  ▪ These scenarios served as the basis for compiling the attributes contributing to complexity
LITERATURE REVIEW:
ATTRIBUTES CONTRIBUTING TO COMPLEXITY

TRAFFIC CONTROL DEVICES

TRAFFIC SIGNING

INFORMATION LOAD

SIGN DENSITY

ALL SIGNS

CRITICAL SIGNS

SIGNS ON ONE STRUCTURE

EXCESSIVE AUXILIARY SIGNING

USE OF BUSINESS LOGO AND SPECIFIC SERVICE SIGNS IN URBAN AREAS

MESSAGES PER SIGN

MESSAGES PER STRUCTURE

GUIDE SIGNS FOR OPTION LANES

DISTANCES ON ADVANCE SIGNING?

"DISCRETE ARROW"

"BLENDED ARROW" (ARROW-PER-LANE)

DIAGRAMMATIC

Shown for detail
210 attributes were defined and categorized

10 topic areas were identified to guide the remainder of the project

The hierarchal organization system is flexible to accommodate additions in the future
PRACTICES EVALUATION
PRACTICES EVALUATION

Purpose:
To determine, by means of site visits and a scan of photographs and videos available to the project team, the variations in the application of engineering design undertaken by various States
PRACTICES EVALUATION

Example variations found:

- Option lane signing
- Use of short continuing auxiliary lanes ("escape lanes")
- Arrangement of legend on exit gore signs
- Omitting distances on advance guide signs
- Institutional operational and management policies (e.g., availability of formal training and guidance)
PRACTICES EVALUATION

Option lane signing
PRACTICES EVALUATION

Use of short continuing auxiliary lanes ("escape lanes")
PRACTICES EVALUATION

Arrangement of legend on exit gore signs
PRACTICES EVALUATION

Omitting distances on advance guide signs
SIMULATOR STUDY
SIMULATOR STUDY

- Evaluated driver lane selection in complex interchange situations
- Scenarios typical of the existing field applications were designed with multiple signing alternatives
- The effectiveness of driver decision-making was evaluated in terms of:
  - Accurate lane choices
  - Potential impacts to safety and efficiency
The study's sample was 121 research participants (60 male and 61 female) in 3 different geographic areas:

- Orlando, Florida
- Myrtle Beach, South Carolina
- Gainesville, Virginia

The simulation was conducted using the National Advanced Driving Simulator MiniSim in a mobile laboratory.
SIMULATOR STUDY

Findings:

- Participants were found to be very accurate regardless of the signing approach used
SIMULATOR STUDY
SIMULATOR STUDY

Findings:

- Participants seemed to understand the signing alternatives as, in general, there was an average of less than one unnecessary lane change per interchange
SIMULATOR STUDY

Findings:

▪ Signing alternatives affected where participants tended to make their lane changes
SIMULATOR STUDY

Findings:

- Drivers tend to understand a series of guide signs leading up to complex interchanges as long as the interchanges are designed consistently and with good signing practices.
FIELD STUDY
The project team identified four agencies to partner with and focus on for the practices evaluation:

<table>
<thead>
<tr>
<th>Participating Agency</th>
<th>Characteristics</th>
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</table>
| Florida DOT (FDOT)           | • Established practices for freeway signing with uniformity throughout the state  
                                 | • I-4 through Kissimmee features multiple braided ramps along a segment inclusive of five interchanges in an area with a high percentage of unfamiliar drivers                                                                 |
| Georgia DOT (GDOT)           | • Atlanta area is home to several interchanges with original, retrofitted, and new designs  
                                 | • GDOT is implementing arrow-per-lane signing                                                                                                                                                                 |
| Minnesota DOT (MnDOT)        | • Established practices for freeway signing with uniformity throughout the state and central office oversight of freeway signing  
                                 | • I-35W/TH 62 interchange features two subsequent option lane splits with multiple approaching lanes for each split                                                                                         |
| Washington State DOT (WSDOT) | • Freeway signing duties split between central office and region staff  
                                 | • Extensive use of option lanes throughout the state  
                                 | • Retrofits of existing interchanges to ease congestion                                                                                                                                                      |
FIELD STUDY

▪ The project team collected data from six complex interchanges across the United States.

<table>
<thead>
<tr>
<th>State</th>
<th>Location</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Florida</td>
<td>I-4</td>
<td>UAV</td>
</tr>
<tr>
<td></td>
<td>US 192 to SR 535</td>
<td></td>
</tr>
<tr>
<td>Georgia</td>
<td>I-85 (northeast junction)</td>
<td>Photographs</td>
</tr>
<tr>
<td>Georgia</td>
<td>I-20 (west junction)</td>
<td>Video</td>
</tr>
<tr>
<td>Minnesota</td>
<td>I-35W TH 62</td>
<td>Video</td>
</tr>
<tr>
<td>Washington</td>
<td>I-5 I-405 and Washington SR 518</td>
<td>Photographs</td>
</tr>
<tr>
<td>Washington</td>
<td>I-5 US 101 to SR 510</td>
<td>UAV</td>
</tr>
</tbody>
</table>
FIELD STUDY

Example video still from ground-mounted camera in Georgia
FIELD STUDY

UAV Equipment
FIELD STUDY

UAV Equipment
FIELD STUDY

Example video still from UAV-mounted camera in Washington.
FIELD STUDY

Findings:

- Field video analysis identified the most common driving behaviors as vehicles approached each interchange
Atlanta, GA
Route: I-20
Direction: Eastbound
Location: Exit 51A

Percent of Exiting Traffic
1: 50%
2: 18%
3: 17%
4: 12%
5: 3%
FIELD STUDY

Findings:

▪ One common finding across all sites was that exiting traffic was found to most commonly use the EXIT ONLY lane rather than the option lane

▪ Few common behaviors identified through the field video show last-minute lane changes; drivers typically entered their target lane well upstream of the interchange
PROJECT KEY FINDINGS AND RECOMMENDATIONS

PUTTING IT ALL TOGETHER...
SO, IN THE END, WHAT IS “COMPLEXITY”? 

“How many choices can be made from a given lane or group of lanes and how proximate are the successive decision points?”
PROJECT KEY FINDINGS

- Consistent application of signing principles, both among locations and within various geometric design scenarios, leads to correct driver response

- The existence of explicit technical policy typically results in improved consistency in signing, pavement markings, and geometric design
PROJECT KEY FINDINGS

▪ A well-developed pavement marking and delineation policy generally results in appropriate application of pavement marking patterns

▪ The consistent use of arrows on guide signs appears to correspond with a design that correlates with intention in the signing of freeway-grade facilities and is generally indicative of fewer design and fabrication errors in the field
PROJECT KEY FINDINGS

- Providing specific guide signing with corresponding appropriate delineation appears to reduce the likelihood of roadway departures and abrupt lane changes.

- A uniform application of warning signs for lane reductions, for both mainline lanes and entering lanes, is lacking in many jurisdictions.
PROPOSED TREATMENTS

The treatments that were selected for the development of practice-ready recommendations are those that emerged from applying the working definition of complexity to each of the selected topics in development of the research activities.

<table>
<thead>
<tr>
<th>Treatment Number</th>
<th>Treatment Description</th>
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<tbody>
<tr>
<td>1</td>
<td>Ramp terminal arrangements</td>
</tr>
<tr>
<td>2</td>
<td>Sign layout: sign legend arrangement and panel configuration</td>
</tr>
<tr>
<td>3</td>
<td>Sign placement: arrows, distances, and relationship to geometric design</td>
</tr>
<tr>
<td>4</td>
<td>Delineation for exiting lanes and special use lanes</td>
</tr>
<tr>
<td>5</td>
<td>Lane reduction methods, signing, and delineation</td>
</tr>
<tr>
<td>6</td>
<td>TCDs education and design review workshops</td>
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PROPOSED TREATMENTS

Each proposed treatment includes:

▪ Introduction: Describes the treatment with examples of undesirable practices and anticipated and observed outcomes

▪ Design guidelines: Provides existing design guidelines with a general perspective on implementations in multiple jurisdictions

▪ Research findings: Outlines the primary principles of the concept and provides application examples

▪ Recommendations: Provides specific recommendations to address undesirable practices

▪ Implementation: Summarizes the breadth and depth of implementation options
PROPOSED TREATMENTS: RAMP TERMINAL ARRANGEMENTS AND DESIGN

- Provide Clear and Consistent Overhead Signing
- Construct Deceleration Lanes with Adequate Delineation
- Ensure Clarity with Pavement Markings
- Construct Entry Lanes with Adequate Signing and Markings
PROPOSED TREATMENTS:
GUIDE SIGNING: SIGN LEGEND ARRANGEMENT
AND PANEL CONFIGURATIONS

- Provide Separate Panels for Separate Movements
- Place Control Cities in Designated Order
- Properly Align Exit Numeral Plaques
- Provide Additional Guidance on Legend Size
- Clarify Requirements for Larger Initial Capital Letters
- Provide Consistent Option Lane Signing
PROPOSED TREATMENTS:
GUIDE SIGNING: SIGN PLACEMENT AND USE OF ARROWS AND DISTANCES

▪ Provide Distances to the Departure Point on all Primary Guide Signing

▪ Use Arrows Appropriate for the Sign Location and Geometry

▪ Provide One Arrow Shaft Over Each Lane

▪ Accommodate Angled Down Arrows

▪ Place Exit Direction Signs Adjacent to the Departure Point
PROPOSED TREATMENTS: DELINEATION FOR EXITING LANES AND SPECIAL USE LANES

- Provide Differentiated Markings
- Provide Lane Use Arrows for all Exiting Lanes
- Provide Solid Lane Markings Upstream and Downstream of Decision Points
PROPOSED TREATMENTS:
LANE REDUCTION METHODS, SIGNING, AND DELINEATION

- Provide Signing for Beginning of Lane Reduction Tapers
- Provide Differentiated Pavement Markings for Varying Conditions
- Provide Lane Reduction Arrows for All Lane Reductions
- Improve Maintenance Practices
PROPOSED PRACTICE: TCD EDUCATION AND DESIGN REVIEW WORKSHOPS

▪ Involve Operations Personnel in the Design Process

▪ Provide High-Level Review of Signing Plans by a Multidisciplinary Team

▪ Require Central Office or Region Approval for all Guide Signs

▪ Require Inspection of Fabricated Signs

▪ Provide Resources and Training for Sign Design
COMPLEX INTERCHANGE ANALYSIS TOOL
QUESTIONS?

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