I-4 Ultimate
Traffic Design Challenges
SIGNING, ITS, SIGNALS & LIGHTING

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System-wide Traffic Lead

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Purpose of Presentation:

- Design Challenges - Tight Urban Interstate
- Interstate & Express Lanes Signing & ITS
- 3 Highway Agencies (L/A facilities)
- Lessons Learned
Layout of I-4 Ultimate

• **70% Elevated**
  ➢ Viaduct & High Fill Segments Supported by MSEW
  ➢ The largest public-private partnership (P3) in the United States to date and the largest transportation project in Florida history.
I-4 Ultimate Encompasses:

- 3 System Interchanges
- 18 Service Interchanges  
  (Includes 5 Split Urban Diamond Interchanges in Downtown)
- Average Interchange Spacing = 1 per mile
Project ÷ 4 Major Areas:

- Each area comprised of multiple construction packages
  - I-4 Design Manager

- 4 Area Design Managers (ADM)
  - Relied on System-wide Discipline Leads

- Most Accelerated Design Periods
  - Simultaneous components submittal except bridges
Signing & ITS for Free & Toll Lanes:

- Major Overhead Guide Sign @ 400’ average

- Limiting Factors:
  - Interchange Density
  - Location of Access Points to & from EL
Guide Signs & Preferential Lanes Signing for Free & Toll Lanes:

➢ 15 major guide signs in 1.25 miles = 1 Sign /440’
Signing for Toll Lanes: Intermediate Entry
Inside Express Lanes:
Drilled shaft is inside the fill back of MSEW
Innovative Sign Structure Location & Design

Viaduct Section: Widening Existing Bridges

Creating Diaphragm
Innovative Sign Structure Location & Design

Pile supported Slab

MVC = 16.5’
Direct Access Points from GPL to EL

Eastbound Direction: 4 Ingress Points
Westbound Direction: 4 Ingress Points

Total Main Entry Points from GPL to EL = 8

Average: 1 Main Entry Point / 5 ¼ Miles
Direct Access Points from Crossroads to EL
Weave Distances-Ingress & Egress Points

- HCM 6th Edition: 23 Equations to get the results

\[ N_{WL} = 3 \]

TWO-SIDED WEAVE SEGMENT WITH THREE LANE CHANGES
Weave Distances-Ingress & Egress Points

- HCM 6th Edition: 23 Equations to get the results

\[ N_{WL} = 3 \]
Weave Distances-Ingress & Egress Points

HCM 6th Edition: 23 Equations to get the results

**L_{MAX} = \left[3728 \times (1 + VR)^{1.6} \right] - [1566 \times N_{WL}]**

\[ LC_{NW} = \frac{L_{S} \times ID \times V_{NW}}{10,000} \]

**LC_{ALL} = LC_{W} + LC_{NW}**

\[ S_{W} = 15 + \left( \frac{FFS - 15}{1 + W} \right)^{0.789} \]

\[ W = 0.226 \times \left( \frac{LC_{ALL}}{L_{S}} \right)^{0.5} \]

**S_{NW} = FFS - (0.0072 \times LC_{MN}) - (0.0048 \times V_{N})**

\[ S = \frac{V_{W} + V_{NW}}{S_{W}} \text{ or } \frac{V_{NW}}{S_{NW}} \]

**LC_{NW1} = (0.206 \times V_{NW}) + (0.542 \times L_{S}) - (192.6 \times N)\]

**LC_{NW2} = 2.135 + 0.223 \times (V_{NW} - 2,000)\]

Then:

\[ LC_{NW} = LC_{NW1} \text{ if } l_{NW} \leq 1,300 \]

\[ LC_{NW} = LC_{NW2} \text{ if } l_{NW} \geq 1,950 \]

\[ LC_{NW} = LC_{NW1} + (LC_{NW2} - LC_{NW1}) \times \left( \frac{l_{NW} - 1300}{650} \right) \text{ if } 1,300 < l_{NW} < 1,950 \]

**D = \frac{V}{S}**

**Density (pc/mi/ln)**

<table>
<thead>
<tr>
<th>LOS</th>
<th>Density (pc/mi/ln)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0 – 10</td>
</tr>
<tr>
<td>B</td>
<td>&gt;10 – 20</td>
</tr>
<tr>
<td>C</td>
<td>&gt;20 – 28</td>
</tr>
<tr>
<td>D</td>
<td>&gt;28 – 35</td>
</tr>
<tr>
<td>E</td>
<td>&gt;35</td>
</tr>
<tr>
<td>F</td>
<td>\text{v/c &gt; 1.00}</td>
</tr>
</tbody>
</table>
Weave Distances-Ingress & Egress Points

- Managed Lanes Modeling - TTI

<table>
<thead>
<tr>
<th>Design Year Volume Level</th>
<th>Allow up to 10 mph Mainlane Speed Reduction for Managed Lane Weaving?</th>
<th>Intermediate Ramp (between freeway entrance/exit and managed lanes entrance/exit)?</th>
<th>Recommended Minimum Weaving Distance Per Lane (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium (LOS C or D)</td>
<td>Yes</td>
<td>No</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>Yes</td>
<td>600</td>
</tr>
<tr>
<td>High (LOS E or F)</td>
<td>Yes</td>
<td>No</td>
<td>700</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>Yes</td>
<td>750</td>
</tr>
</tbody>
</table>

Note: The provided weaving distances are appropriate for freeway vehicle mixes with up to 10 percent heavy vehicles; higher percentages of heavy vehicles will require increasing the per lane weaving distance. The value used should be based on engineering judgment, though a maximum of an additional 250 feet per lane is suggested.

All I-4 weave distance between ML & Intermediated Interchange EN-EX & EX-EN, EX-EX met the minimum weave distance.
ITS Subsystems

- DMS (Walk-in)
- DMS (Non-Walk-in)
- EL Status DMS
- Toll DMS
- CCTV (Freeway)
- Verification CCTV (Toll and Status Signs)
- Pedestrian tunnel (Security)
- MVDS (GPL and EL separated)
- RSS
- Emergency Access Gates
- Tolling Points
- Communication (Self-healing Ring Topology)
- Power Substations
ITS Device Co-Location

- Challenges in Bifurcated (independent) Segments
- Too many standalone support structures if not co-locating with sign structures capturing full coverage
ITS Device Co-Location
ITS Device Co-Location

Lessons Learned:
Don’t Co-locate MVDS with Light Pole

24’ Opening in OVB

MVDS on Light Pole
Maintenance Of Communication (MOC)

- Technical Requirements: Maintain existing subsystems at all time for all 3 highway owner agencies (D-5, FTE, CFX)
- Abandoned Existing FOC Trunk Line on I-4
- Used temporary wood poles for the length of I-4
- 72 counts of SM FOC overhead
- Used PLS-CADD program to size the support cables and poles
- Developed plans and profiles
All existing aerial cables and other obstructions within ROW should be removed before building these line segments.

A1K-02 to A1K-09 built during early work; see those P&P’s for additional information.
Permanent Communication Topology
Communication Master Hubs

Lessons Learned:
Don’t attach the master communication hub to Toll Room
Permanent Communication Locations

Comm. Backbone below the shoulder
Communication Trunk Under Paved Shoulder Via 8” Sleeve

Electrical JB

Splice Box

Front Face of Wall

End Bent
Emergency Access Gates

- 10 Locations, Total
- 110 Feet Long Design Envelop
- Controlled Remotely & Manually
EAG
Where Not To Install EAG Envelop

- On Curves
- On tangent-Run-outs & Tangent Run-offs ($e_{max}$)
- Where drainage inlets are proposed
- Approach slabs
- Bridges
- Median barrier wall transitions
Signal Design & Maintaining Agencies

City Of Orlando
Orange County
Seminole County
City Of Maitland
City Of Winter Park
City Of Altamonte Springs
Signal Visibility @ TUDI

1984-1990 ASSHTO Green Book:
\[ d = 100 + 15 (V - 20), \text{ Now table 4D-2 of MUTCD} \]
Signal Visibility @ TUDI

Design Speed (mph) = 30
Signal Sight Distance (ft) = 250.00
Distance from Stop Line to Signal (ft) = 127.50

X (ft) = 98.00  \( X = \text{Distance from Signal Head/Sign to Low Bridge Beam} \)
Elev Vehicle = 81.04  \( \text{Roadway elevation at vehicle} \)
Elev Signal = 81.83  \( \text{Roadway elevation at minimum signal clearance point} \)

H (ft) = 4.00  \( H = \text{Height of Signal Head (4'V or 2'H) or Sign (Varies)} \)
Min. Clearance (ft) = 17.50  \( \text{Standard Min. Vertical Clearance (PPM Tables 2.10.2 and 2.10.3)} \)
Drivers Eye Height (ft) = 3.50  \( \text{Standard Drivers Eye Height (PPM Tables 2.7.1 and 2.7.2)} \)
Min. Beam Elev = 98.45  \( \text{Minimum Required Beam Elev at Critical Pt} \)

Upper Rdwy Critical Sta = 2231+13.64
Upper Rdwy PGL = 107.91
Cross Slope = 0.030
Distance (ft) = 59.54
Deck Elev at Critical Pt = 109.70
Bridge Depth (ft) = 9.00  \( \text{Includes Deck Slab Thickness & SIP Forms} \)
Actual Low Beam Elev = 100.70  \( \text{Actual Beam Elev at Critical Pt} \)

Sufficient Bridge Clearance? = Yes  Excess Bridge Clearance (ft) = 2.24
Aesthetic Lighting

- Ethernet-Based Controller
- Daisy Chain Configuration
- Data Enabler: Integrated data & power to intelligent color and tunable white LED lighting fixtures
- Used I-4 FOC drop to the controller cabinet
Questions?