Role of TSM&O in Improving Freeway Operations

Presented by:
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Presentation Outline

1. What is TSM&O?
2. Need for TSM&O
3. Ramp Meters
4. Dynamic Message Signs
5. Express Lanes
What is TSM&O?

Achieve the Safety & Mobility Goals of the Agency!

Processes, procedures, policies, and agreements to use the technology

Traffic engineering principles and practices

Traffic Ops

Safety & Mobility

ITS

Technologies

Achieve the Safety & Mobility Goals of the Agency!

Processes, procedures, policies, and agreements to use the technology

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Technologies
Conventional Improvements vs. TSM&O Strategies

- Lets add more lanes!!
- Lets invest in Express Lanes!
Proactive TSM&O Strategies

With Ramp Metering Signals

Lets add more lanes!!

Lets deploy ramp meters!
Proactive TSM&O Strategies

Dynamic Message Sign informing drivers about the crash downstream

Drivers may detour after reading the message
TSM&O Strategies are ...

Integrated | Performance Based | At All Stages | Multimodal
TSM&O Strategies are ...

- Integrated
- Performance Based
- At All Stages
- Multimodal

<table>
<thead>
<tr>
<th>Key Performance Measures</th>
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<tbody>
<tr>
<td>Average travel time</td>
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<tr>
<td>Travel time reliability</td>
</tr>
<tr>
<td>Incident response &amp; clearance time</td>
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<tr>
<td>Total travel delays</td>
</tr>
<tr>
<td>Crashes</td>
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<tr>
<td>Secondary crashes</td>
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</table>

**Average travel time**

- 2015: 4.50
- 2016: 4.54

**Travel time reliability**

- 2015: 1.35
- 2016: 1.30

**Incident response & clearance time**

- Average duration of daily congestion: +4 minutes
- Unreliability (variability) of travel: -7 points
TSM&O Strategies are ...
TSM&O Strategies are ...

Integrated | Performance Based | At All Stages | Multimodal
TSM&O Strategies ...

- Preserve Capacity
- Improve Safety
- Improve Reliability of Transportation System
Vision:
Increase the delivery rate of \textit{fatality-free} and \textit{congestion-free} transportation systems supporting the FDOT Vision and Florida Transportation Plan Goals.

Mission:
Identify, prioritize, develop, implement, operate, maintain, and update TSM&O strategies and measure their effectiveness for improved safety and mobility.
Ramp Metering

Traffic signals along freeway on-ramps to control and regulate the frequency at which vehicles join the freeway mainline.
Advantages

Help manage entrance demand on freeway mainline thereby preventing traffic flow breakdowns

Break up the platoons by controlling the rate at which vehicles enter the mainline from the ramp
Deployment

I-95 in Miami-Dade County
Ives Diary Road to NW 62$^{nd}$ Street

I-95 in Broward County
Commercial Blvd to Hallandale Beach Blvd

Source: Zhu et al. 2007

Source: Hadi et al. 2017
Data

Traffic Data
• RITIS

RMS Operations Data
• FDOT District 6 RTMC

Contextual Data
• Google Maps

Crash Data
• SunGuide® Incident Database
Methodology: Safety Benefits

Matched Crash and Non-crash Cases

Crash Precursors

Penalized Logistic Regression

Bootstrap Resampling
### Results: Safety Benefits

Ramp metering decreased the crash risk by 41%

#### Crash Precursors: RMSs ON

<table>
<thead>
<tr>
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<th>Average</th>
<th>Coefficient of variation</th>
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<tbody>
<tr>
<td>Speed</td>
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<td>✗</td>
</tr>
<tr>
<td>Occupancy</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Volume</td>
<td>✓</td>
<td>✗</td>
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#### Crash Precursors: RMSs OFF

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Average downstream volume
Methodology: Mobility Benefits

RMSs turned ON versus turned OFF

RMS turned ON due to recurrent congestion

RMS turned OFF because of system malfunctioning
Mobility Benefits

- Travel time reliability measured using Buffer Index (BI)
- Time cushion that most travelers add to their average travel time when planning trips to ensure on-time arrival

\[
BI = \frac{95\text{th percentile travel time} - \text{Average travel time}}{\text{Average travel time}}
\]

- RMS reduce BI by 22% during moderate congestion
- RMS reduce BI by 30% during severe congestion
Dynamic Message Signs

Programmable electronic signs used for disseminating real-time information to road users
DMSs are .... Everywhere (Almost)!

~869 DMSs displaying messages on major roadways

Operational 24/7 to convey time-sensitive information to motorists
Advantages

- Reduce secondary crashes
- Minimize travel delays
- Enable fast and appropriate response to incidents
- Assist motorists make informed routing decisions
Data

1. FDOT District TMCs
   - DMS Locations
   - Lat/Long or Mile markers
   - DMS Logs
   - Timestamps for each message

2. RITIS
   - Real-time Traffic Data
   - Speed, Volume and Occupancy

3. Signal Four Analytics
   - Crash Data
   - Time, Location and Other factors

- 23 DMSs along I-75
- Analysis Period: 2016 – 2018
Quantify Benefits

1000 ft (Legibility distance)

Direction of travel

Upstream detectors

Downstream detectors

Downstream off-ramp
Quantify Benefits

Crash Messages
Convey information about crashes downstream and suggest drivers’ reaction

Clear Messages
Convey general or advisory information that do not require any change in the traffic patterns
Results - Benefits of Dynamic Message Signs

When Crash Messages are displayed on the DMSs

- Average Speed
- Speed Variance
- Number of Crashes Downstream of DMSs
Study Limitations

- The reduction in average speeds observed when the DMSs display *crash messages* may be attributed to other sources of information such as *Waze*, Highway Advisory Radio, etc.
- The analysis did not consider other potential factors such as incidents downstream which may result in speed reduction.
Express Lanes

Express lanes are managed toll lanes, separated from general-purpose lanes or general toll lanes within a freeway facility.
Deployment

In Operation
(~62 miles)

- I-95
- I-595
- I-75
- Veterans Expressway / SR 589

In Planning/Design
(~298 miles)

- Turnpike Mainline
- I-95
- Sawgrass Expressway / SR 869
- Palmetto Expressway / SR 826
- I-295
- I-95
- Turnpike Mainline
- I-4
- Seminole Expressway / SR 417

Under Construction
(~99 miles)

- Turnpike Extension (HEFT)
- I-95
- Palmetto Expressway / SR 826
- I-295
- Beachline West Expressway / SR 528
- Turnpike Mainline
- I-4
- I-275
Advantages

- Reduce overall traffic congestion
- Provide a safe and predictable trip in terms of travel time
- Increase the capacity of the highway
Mobility Benefits of Express Lanes

Quantify the mobility benefits of Express Lanes by comparing:

- The performance of ELs with that of their adjacent GPLs
- The performance of GPLs when:
  - ELs were operational versus
  - ELs were closed
Data

Traffic data
• RITIS

Contextual data
• Google maps

Express Lanes Operations Data
• FDOT District 4 and 6
Mobility Benefits of Express Lanes

Two years of travel time data aggregated into 5-minute intervals

Typical weekday travel time data aggregated into 5-minute intervals

Buffer Index measures calculated

Performance of ELs and GPLs was compared
Both EL and GPLs are open
Performance of GPLs

**Buffer Index for Northbound GPLs**

**Buffer Index for Southbound GPLs**

**Statistical Test:** Welch’s t-test (unequal variance t-test) was used to determine if there was a statistically significant difference in the Buffer Indices (BIs)
Both EL and GPLs are open
Performance of EL Facilities

Statistical Test: Welch’s t-test (unequal variance t-test) was used to determine if there was a statistically significant difference in the Buffer Indices (BIs)
Results – Mobility Benefits

- When the ELs were operational, the performance of the adjacent GPLs improved
- In general, both the ELs and the GPLs performed better when the ELs were operational
Safety Analysis of Express Lanes... Ongoing!

Goal: Quantify the effects of separation types on the safety performance of managed lanes facilities

- **Objective #1**: Develop SPFs under specified base conditions
- **Objective #2**: Develop CMFs for different separation treatments and other geometric attributes (other than the base conditions)
- **Objective #3**: Develop SDFs to estimate the expected crash frequency for different crash severity levels
Expected Project Benefits - Quantitative

<table>
<thead>
<tr>
<th>Project Requirements</th>
<th>Other By-products</th>
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<tbody>
<tr>
<td>❑ SPFs</td>
<td>❑ A spreadsheet application</td>
</tr>
<tr>
<td>❑ CMFs</td>
<td>❑ A GIS inventory of managed lanes in Florida</td>
</tr>
<tr>
<td>❑ SDFs</td>
<td>❑ One-page summaries</td>
</tr>
<tr>
<td></td>
<td>❑ A one-hour recorded webinar</td>
</tr>
<tr>
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<td>❑ A set of sample problems</td>
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</table>
Managed Lanes Separation Treatments

- Pavement Marking Buffer Separation
- Wide Median Buffer Separation
- Concrete Barrier separation
- Pylons Buffer Separation
Project Milestones

- Project Kick-off Meeting
- Review of Existing Literature
- Methodology for Data Collection
- Data Collection, Data Analysis, & Development of SPFs and CMFs
- Draft Final Report
- Project Close-out Teleconference & Final Report

Timeline:
- June 2020: Task 1
- November 2020: Task 2
- January 2021: Task 3
- November 2021: Task 4
- January 2022: Task 5
- April 2022: Task 6
In Summary

- TSM&O strategies are proven to improve safety and mobility of the transportation network.
- The safety and operational benefits are unique to the strategy.
- While some strategies provide direct quantifiable benefits, it is difficult to measure the impacts of some strategies.
- TSM&O strategies provide feasible alternatives to achieve the safety and mobility goals of the agencies.
Research Team
Thank You!

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