TOWARD A BEST PRACTICE MODEL FOR MANAGED LANES IN TEXAS

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Report 0-6688-P2
Project 0-6688
Project Title: Evaluation of the I-10 Katy Freeway Managed Lanes

Performed in cooperation with the
Texas Department of Transportation
and the
Federal Highway Administration

Published: September 2013

TEXAS A&M TRANSPORTATION INSTITUTE
College Station, Texas 77843-3135

DISCLAIMER

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ACKNOWLEDGMENTS

This project was conducted in cooperation with TxDOT and FHWA. The authors thank the project director, Lucio Vasquez, and the members of the Project Monitoring Committee: Wade Odell, Duncan Stewart, Lucio Vasquez, Marcy Saenz, Eddie Sanchez, Patrick Gant, Mike Alford and Alex Power. The authors gratefully acknowledge the contributions of the interviewees that provided thoughtful insight on the development of the Katy Managed Lanes. In addition, we appreciate TxDOT allowing a link to the survey on their TranStar website – it greatly increased survey participation. The authors also thank Lisa Castañeda of the Harris County Toll Road Authority for her input on the project and Michelle Benoit and Stacey Bricka of the Texas A&M Transportation Institute for editorial assistance. We would also like to thank the staff of TTI Communications—especially Michelle Benoit, Joanna Dickens, Michelle Jones, and Vicky Nelson—for their work in processing the project's deliverables and helping create the products.

Toward a Best Practice Model for Managed Lanes in Texas

Product 0-6688-P2

Project 0-6688:
Katy Freeway: An Evaluation of a Second-Generation Managed Lanes Project

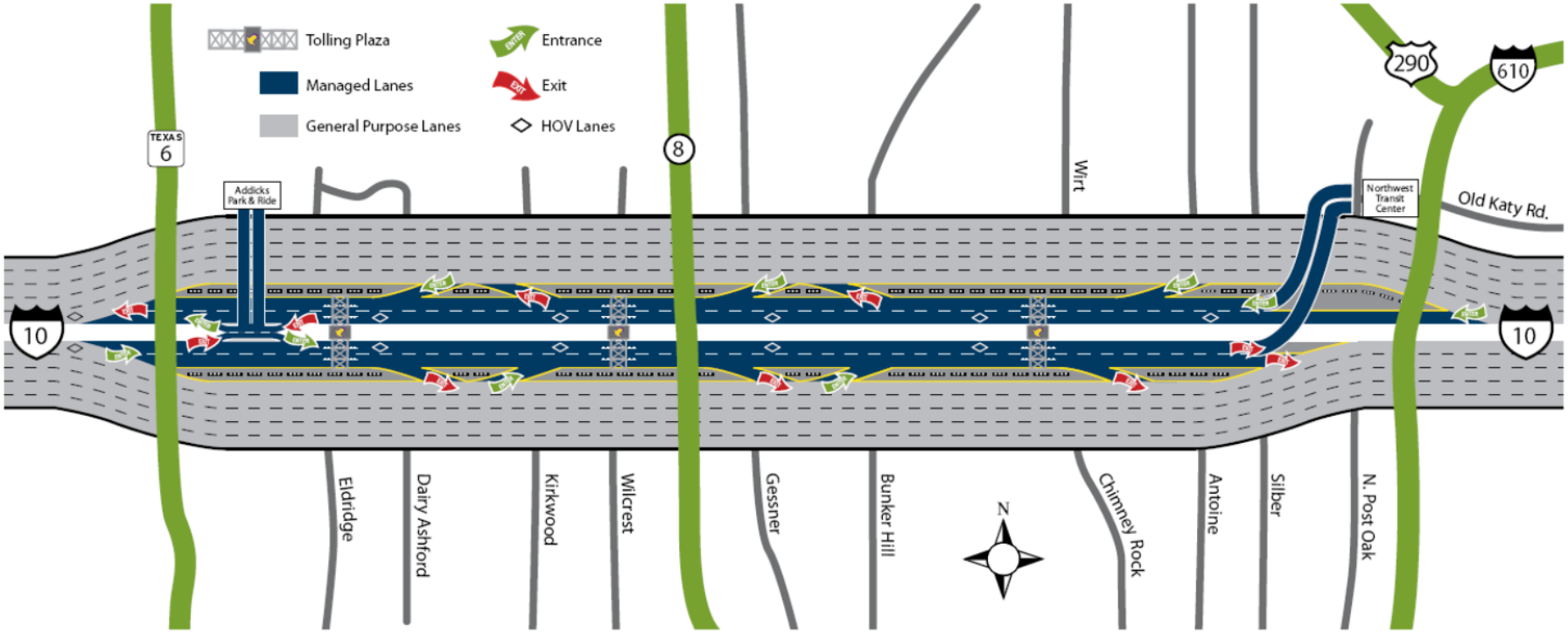
Texas Department of Transportation

Texas A&M Transportation Institute

Project Overview

- Increasing implementation of managed lanes in the United States
- Katy Freeway Managed Lanes (KML) offers lessons learned for other projects
  - First operational, multilane, variably priced, managed facility in Texas
  - Became operational in 2009
- No one-size-fits-all strategy
  - KML has unique operational features
  - Unusual path to implementation
  - No formal concept of operations, late policy adjustments

Project Overview (cont.)



The KLM Facility, Including Tolling Plazas and General Purpose, Managed, and HOV Lanes. Source: HCTRA website.

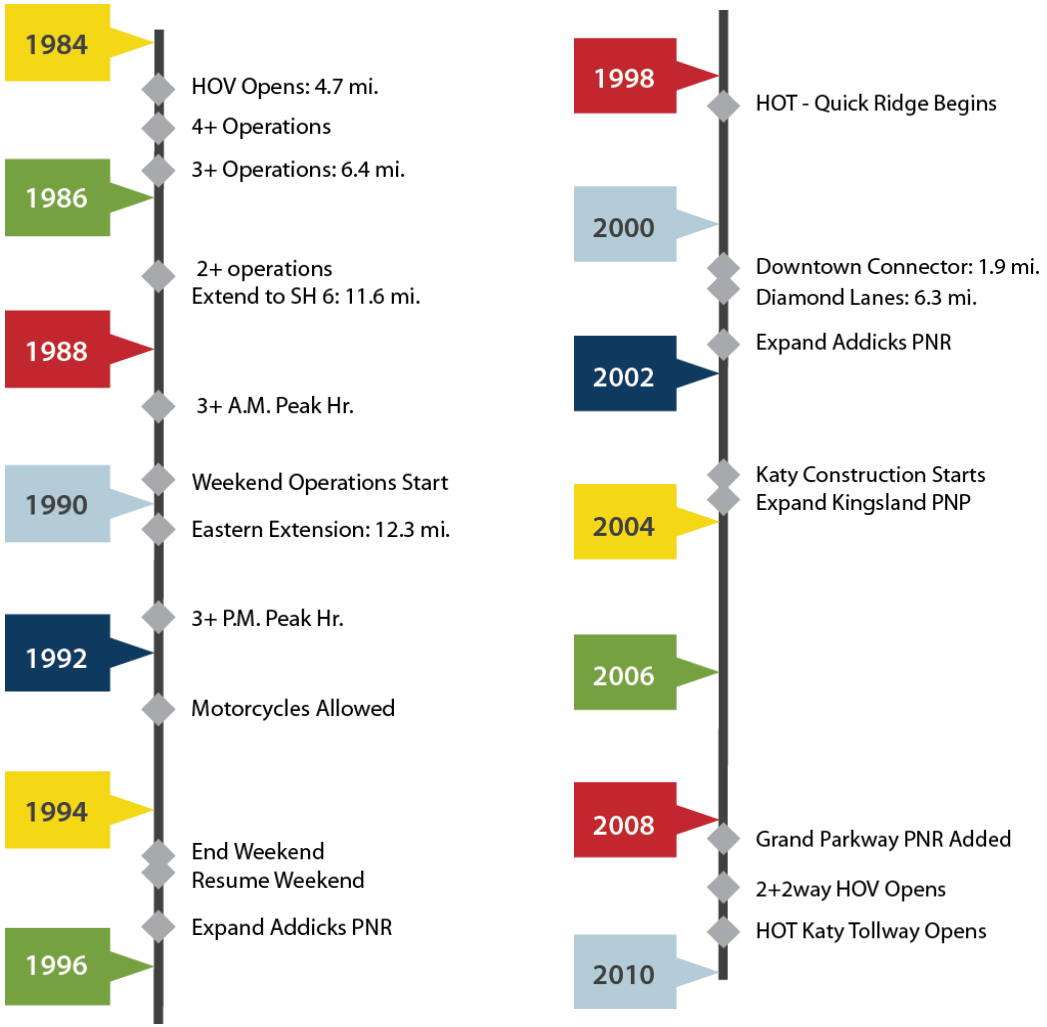
Project Overview (cont.)

- Studied 10 operational areas to determine best practices:
  - **Congestion**
  - **Safety**
  - **Enforcement**
  - **Maintenance**
  - **Toll and pricing**
  - **Access design**
  - **Lane separation**
  - **Operational policy**
  - **Public attitudes/ perceptions**
  - **Project delivery**

- **Purpose:** To lay the foundation for establishing best practices for managed lanes in Texas

KML: History and Operational Summary

The Development of the KML over Time.



KML: Developmental History

❖1980s–1990s

- ➢1982: METRO suggested constructing a single, reversible bus lane
- ➢1984–1987: Katy HOV lane opened and METRO systematically relaxed requirements for users
  - Eventually included 2+ to 4+ carpools
- ➢1995: TxDOT evaluated the Katy Freeway
  - Maintenance costs 4x average Texas expressway
  - Inadequate to carry 200K vehicles daily
  - Major investment study launched to determine community's mobility needs

KML: Developmental History (cont.)

❖1980s–1990s (cont.)

- ➢1998: QuickRide program implemented, introducing $2 fee per trip
  - Toll resulted in decreased demand for 2+ carpools, regardless of the travel-time savings
  - Demonstrated that variable pricing can change motorist behavior

KML: Developmental History (cont.)

❖2000 and Beyond

- ➢2003: construction began on alternative
  - 2 special-use lanes in each direction, I-610 to SH 6
  - Additional GP lanes and frontage roads
  - Designed to accommodate future growth
- ➢2008: construction complete
  - Originally planned as HOT-3+
  - Occupancy requirement lowered to 2+ carpools (free)
- ➢2009: KML opened

KML: Developmental History (cont.)

- KML represents first tri-party agreement to operate toll lanes on a U.S. Interstate Highway
  - Partners: TxDOT, HCTRA, FHWA
- Success attributed to 3 key characteristics of agreement
  - Shared operating agreement
  - Financing through county-based toll operator
  - Using open road electronic tolling
- Detailed operating plan signed in 2009

KML: How It Works

❖ Facility Administration

- ➢ HCTRA manages incidents within tolled managed lanes
- ➢ Operating committee comprised of three partners, chaired by TxDOT
  - Reviews KML operational and maintenance procedures
  - Produces quarterly operations report
- ➢ Closure requests re: GPs or MLs must be made one week in advance

KML: How It Works (cont.)

- **Facility Operations**
  - ~ 2,200 vehicles per hour
  - Assessing new toll-rate schedule
    - Time-of-day pricing scheme
  - Inside lane designated HOV during peak periods
  - SOVs and commercial vehicles travel on outside ML during peak periods
  - HOVs use MLs toll free but only during peak periods (6-11 A.M. eastbound, 2-8 P.M. westbound)

KML: How It Works (cont.)

- **Facility Operations (cont.)**
  - 2012: HCTRA changes lane spacing to differentiate HOV and toll lanes
    - 12-foot buffer discourages last-minute lane jumping
    - Moved HOV lane closer to the enforcement area to facilitate enforcement
  - HOVs not required to use lanes
  - Enforcement accomplished via vehicle positioning

KML: How It Works (cont.)

❖ Unique Features of the KML

- Generous lane, shoulder, and buffer widths
- Additional GP capacity to enhance non-toll travel in the corridor
- Unique, varied access configurations
- Implementation relied public-public partnership and active involvement of project champions
- Absence of formal concept of operations and late adjustments to the tolling and HOV occupancy policies, which had no detrimental effect on operations at opening

KML: How It Works (cont.)

KML Project Design Features

$237.5 million construction cost as part of the larger reconstruction project for the Katy Freeway

12-mile corridor from SH 6 to I-610

4 managed lanes total
2 in each direction

8 general purpose lanes total
4 in each direction

3 access points

18- to 20-foot buffer with white pylons spaced at 10-foot intervals separates the managed and general-purpose lanes

3 tolling plazas with electronic gantries (both directions) and occupancy observation booths

Provides separate access ramps for the Addicks Park and Ride Lot and the Northwest Transit Center

Congestion and Travel Time

- Tracked, analyzed historical trends in traffic volume, travel time, and transit usage
  - Evaluated both peak and off-peak direction
- Evaluating solutions for where merge congestion occurs

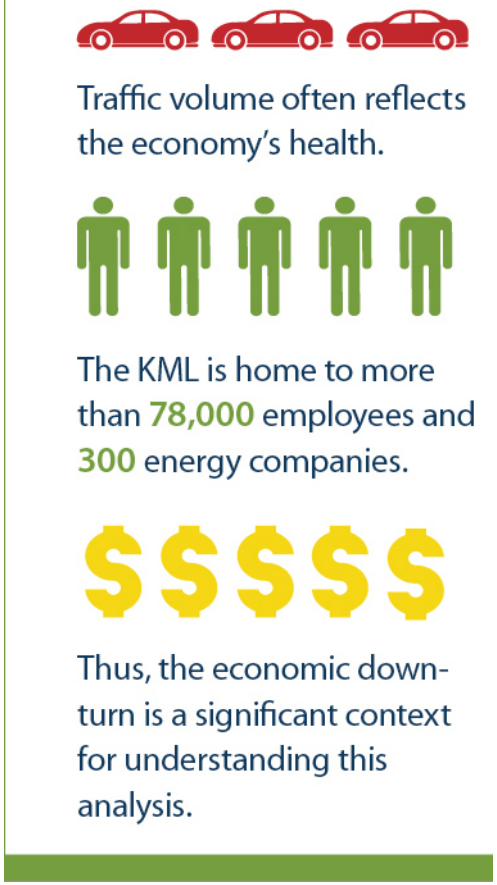
Congestion and Travel Time (cont.)

- Trends noted
  - Increasing travel times reflect increasing traffic volumes
  - AM, PM peak-hour travel times have increased (most significantly in the PM peak period)
  - Off-peak-direction ("reverse commute") traffic volumes have increased in the PM peak period
    - HOV volume is almost as high as the peak-direction HOV volume on other HOV facilities)
    - Growing at a rapid rate due to increased congestion in the off-peak direction
    - Result of the growth in the energy corridor district of west Houston

Safety

- Harris County Constable Precinct 5 provides enforcement, incident response
- Research team used CRIS data to determine crash trends
- Contextual factors for study
  - Effects of reconstruction
  - Diversion of traffic from other corridors
  - Economic downturn (2008–2010)

Safety (cont.)



- Economic Downturn
  - KML home to 78,000 employees, 300 energy companies
  - Unemployment: 4 percent to 8.9 percent between 2007 and 2011
  - Compounded by BP Deepwater Horizon explosion (and fallout)

Safety (cont.)

- Analysis Results
  - Lower crash rate due to improved geometrics, reduced congestion
  - Similar crash patterns to those prior to 2009
    - Rear-end crashes most frequent
    - Crash rates about equal comparing KML to its HOV lane predecessor
      - HOV lane: high congestion, narrow geometrics, reversible flow, fewer lanes
      - KML: four lanes, more ingress/egress locations, 22-foot buffer area
  - Improved crash data reporting could provide more accurate details for future analyses

Enforcement

- Studied before, after ML implementation
- Interviews and site visits to determine how different agencies (METRO and Precinct 5) approach duties differently
- Compiled monthly HOV citation and toll violation statistics to measure driver compliance

Enforcement (cont.)

- METRO
  - Enforced Katy Freeway HOV lane prior to Oct. 2008
  - Emphasized occupancy requirements when citing offenders
  - Recognized officers should not impede traffic flow
  - Issued more citations for failing to meet occupancy requirements (54 percent)

Enforcement (cont.)

- Precinct 5
  - Enforces reconstructed facility MLs (post Oct. 2008)
  - Emphasizes facilitating traffic flow while ensuring security for users
  - Provides disabled motorists with assistance
  - Issues more citations for speeding compared to, other infractions (e.g., toll evasion, 16 percent of citations issued)

Maintenance

- Interviewed TxDOT, HCTRA, and METRO maintenance supervisors re: activities and costs
  - Pre-KML: TxDOT owned the Katy HOV lane, METRO operated, sharing maintenance
  - KML: HCTRA took over maintenance
- Overall finding: active lane-use enforcement is beneficial to reducing maintenance and operational issues
- Other than sweeping, debris pickup, delineator replacement is most intensive maintenance activity

Maintenance (cont.)

- Observations re: pylon use
  - Higher-cost, higher-intensity, most often dealt with
  - Entry, exit gore areas suffer higher hit rates
    - Attributed to driver workload, distracted driving

  - Enhanced enforcement can reduce pylon hits
  - Contrast markings do not reduce entry, exit hits
  - Fewer roadside maintenance for MLs usually result in lower maintenance costs

Maintenance (cont.)

- Observations re: pylon use (cont.)
  - Driving public expects tolled facilities (e.g., MLs) to maintain a higher standard (appearance, maintenance, operations)
  - Buffer width spacing impacts maintenance, replacement
    - 2-3 feet (8-12 inches from pylon to edge line)
    - Wider spacing equates to reduced maintenance
  - Shorter, wider, thicker profile pylons more durable

Maintenance (cont.)

- Observations re: pylon use (cont.)
  - Raised pavement/profile markings might reduce pylon hits by enhancing the tactile and visual conspicuity of the pylon-treated area
  - ML-related sign messaging, size, placement critical to safe operations
    - Pylons can reinforce but not replace signing schemes
  - Use traditional paint, thermoplastic markings when applying retroreflective pavement marking tape
  - Horizontal signing can reinforce lane assignment at entrance, exit locations, especially where horizontal curvature distorts the lane/sign relationship

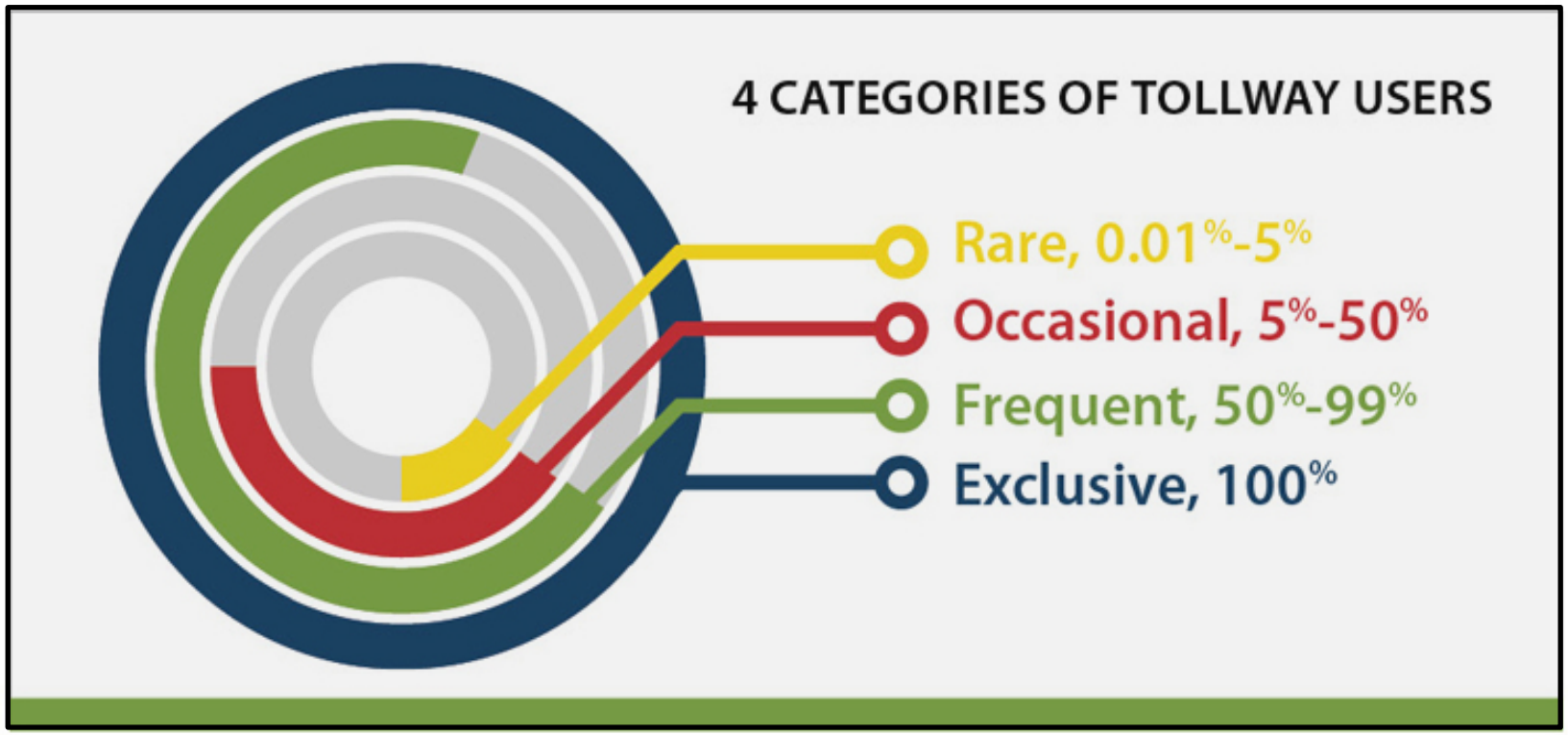
Tolling and Pricing

- Conducted comprehensive analysis using traffic sensor data
  - Assessed number, percentage of KML trips on the Katy Freeway
  - Determined conditions contributing to ML use
  - Calculated revenues derived from MLs and travel-time savings
- Overall finding: After travel-time savings (or traveling for free in carpools), survey respondents cited most often the following reasons for using the KML:
  - Less stress
  - Safer commute (perceived)
  - Absence of trucks

Tolling and Pricing (cont.)

- Tollway users broken into four categories:
  - **Exclusive**: only used tollway lanes
  - **Frequent**: used tollway lanes for between 50 and 99 percent of Katy Freeway travel
  - **Occasional**: used tollway lanes for between 5 and 50 percent of their Katy Freeway travel
  - **Rare**: used tollway lanes for between 0.01 and 5 percent of their Katy Freeway travel

Tolling and Pricing (cont.)



Tolling and Pricing (cont.)

- Exclusive users traveled during a weekday at peak times in peak direction (compared to other users)
  - Only 24 percent of trips at peak times, direction
- The less often a user drove the KML, the less often they drove it during the peak period
- Indicates travelers find value in MLs beyond travel-time savings (e.g., stress, safety, absence of trucks)

Tolling and Pricing (cont.)

- Travel-Time Savings
  - Assessed 8.29 million trips occurring in 2011
  - 270,393 total hours saved (both directions)
  - Commuters saved $5,675,547
    - Uses $20.99 per passenger car hour (TxDOT)
  - Revenues equaled $7,025,185 (toll and HOV lanes)
    - Differential implies TxDOT's per-hour figure is too low
      - $59.07 calculated for SOV toll lane users
      - $77.80 calculated for HOV toll lane users

Access Design

- Focused on 4 direct-merge access ramps, access points, and the park-and-ride facility
  - 1,033 ML access maneuvers
  - 20 hours of peak, non-peak periods
  - 37 cross-facility weaving maneuvers
- Study Considerations
  - ML and GP traffic volumes
  - Elapsed time to complete maneuvers
  - Vehicle position within access ramps
  - Peak vs. non-peak comparative performance

Access Design (cont.)

- General Finding
  - Access design sufficiently accommodates driver demand on the KML
- Direct-Merge Ramps
  - Access-point design meets expected demand
  - Single-lane changes: 1–3 seconds
  - Entire access maneuvers: 10–25 seconds
  - Early/late maneuvering more frequent at peak periods

Single lane changes typically require

1 to 3 seconds

Drivers complete entire access maneuvers

10 to 25 seconds

Access Design (cont.)

- Cross-Facility Weaving
  - 7,200 feet between ML exit (Echo Lane) and exit to the Sam Houston Tollway
    - Additional 1,400 feet for early- , late-maneuvering drivers
    - Requires 6 to 7 lane changes to travel between access points
  - 200 vehicles observed, 37 completed maneuver
  - Findings indicate sufficient design distance
  - Overall elapsed times: 2 minutes (peak period), 1.4 minutes (non-peak period)

Access Design (cont.)

- "Funnel" Operations
  - KML design requires that only initial lane changes needed studying
  - Operations proved "unremarkable"
  - 250–300 vehicles every 15 minutes (GP lane) in both peak and non-peak periods
  - Number of peak-period vehicles and access maneuvers increased 5x in diamond lane
  - Findings indicate sufficient design distance

Lane Separation

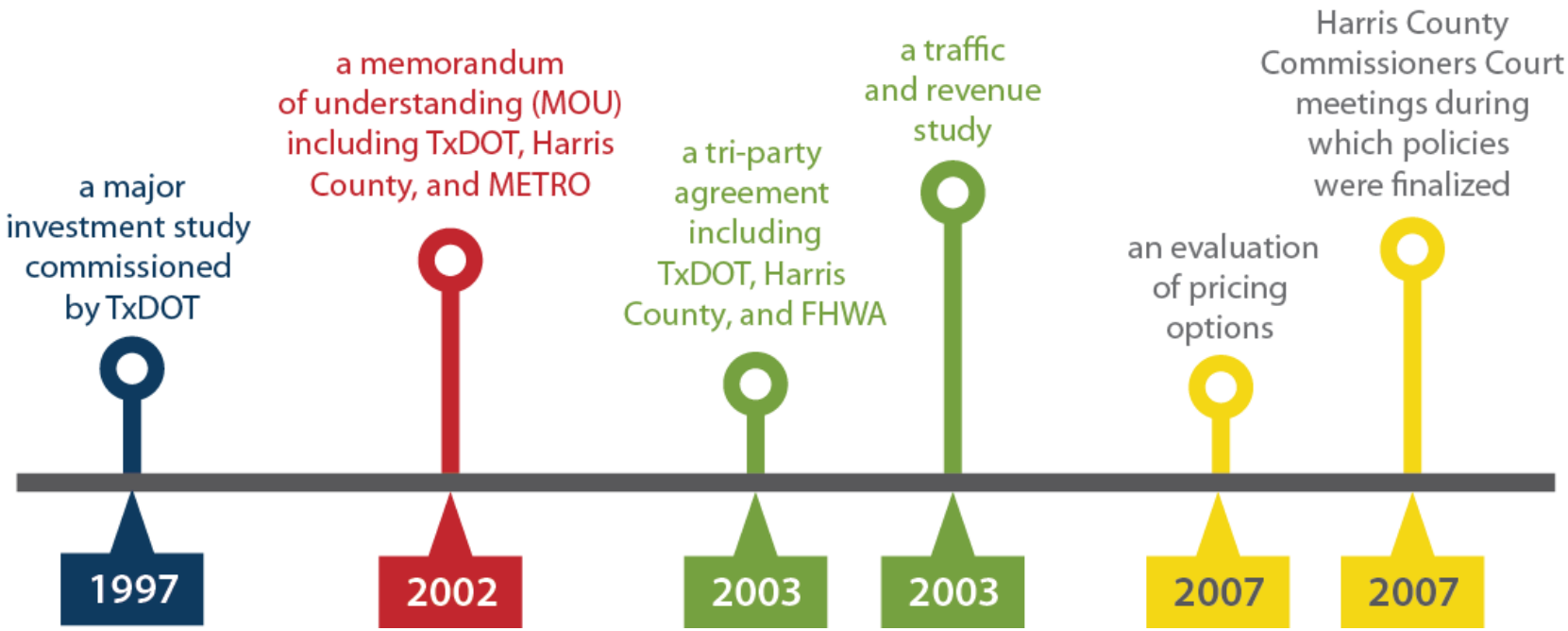
- Considerations for Choosing Lane Separators
  - Cost of construction
  - Operational flexibility
  - Enforcement and safety impacts
  - Maintenance
- Evaluated CTBs and Pylons
  - CTBs physically prevent encroachment
  - Pylons enhance compliance but do not stop encroachment

Lane Separation (cont.)

- Comparing CTBs and Pylons
  - Variables often site specific
  - ROW (buffer space) and maintenance costs are directly related, as demonstrated by this study
  - ROW and maintenance costs are two of the largest life-cycle costs influencing separator chosen
  - Other trade-off considerations for designers
    - Incident management
    - Cost of enforcement
    - Driver expectancy based on design consistency across the region, state

Operational Policy

- Examined entire history of KML development and reviewed potential future policies



Operational Policy (cont.)

- Current policies evolved as studies, agreements happened
  - HOV policy consistently recommended or assumed HOV-3+ commuters would freely use toll road and HOV-2 commuters would pay
    - Public's influence evident
  - Tolling policy changed multiple times
    - Tolling as strategy for generating revenue, managing demand to time-of-day pricing to dynamic pricing back to time-of-day pricing
    - Modeled after SR 91 Express Lanes in San Diego, Calif.

Operational Policy (cont.)

Proposed Future Policy	Characteristics and Notes
Introduce dynamic pricing	• Uses sensors on the roadway to detect congestion. • Changes the price at regular intervals to charge a rate commensurate with the traffic level. • Discussed as an option in the 2007 pricing evaluation document.
Increase toll rates	• Manages the demand on the roadway by reducing the number of motorists willing to use the priced option on the road. • Represents a strategy HCTRA has already used (effective 9/7/12).
Increase occupancy requirements for HOVs beyond 2+	• Manages demand by reducing the number of vehicles eligible to use the facility for free. • Requiring HOV-3+ was discussed extensively prior to the KML opening, but public resistance kept it from happening.
Develop an automatic system that adjusts both tolling and HOV operations using performance measures and benchmarks	• Would trigger rate changes (based on pre-approved policies) once an established threshold, such as traffic volume or speed, is exceeded. • Policy shifts could be flexible enough to allow different vehicle types or occupancy requirements (e.g., requiring HOV-2 to pay). • Since the changes would be pre-approved, individual rate fluctuations would not require a referendum or policy discussion prior to implementation.

Public Attitudes, Perceptions

- Assessed in 2012 via traveler survey
  - Advertised by online and traditional media
  - Available via the Internet 8/15/12–9/19/12
  - 1,067 responses
- Also interviewed those who helped develop the KML and those responsible for ongoing operations

Public Attitudes, Perceptions (cont.)

- Survey Results
  - 58 percent used MLs at least once
  - Few differences between SOVs and carpools
  - Reasons cited for using MLs
    - Time saved, less stressful driving environment, avoiding congestion
  - Reasons cited for not using MLs
    - Cost, not enough travel-time savings, desire to avoid tolling when possible
  - Travel time saved
    - Perceived: ~10 minutes
    - Actual: ~4 minutes

Public Attitudes, Perceptions (cont.)

- Modeling Lane Choice Using Survey Results
  - Team developed models of lane choice from survey data
    - Models showed average value time of $20.80/hour
    - Value of reliability: $2.20/hour
  - Disparity of results compared to actual usage
    - Much lower than average value time of $60/hour derived from actual use of the Katy MLs
    - Likely the result of how respondents answered survey questions

Project Delivery Mechanism

- Complex environment
  - Multiple agencies, stakeholders seeking influence, dissatisfied public
  - Required close collaboration and coordination
  - Agency agreements (both informal and, later, formal) key to success

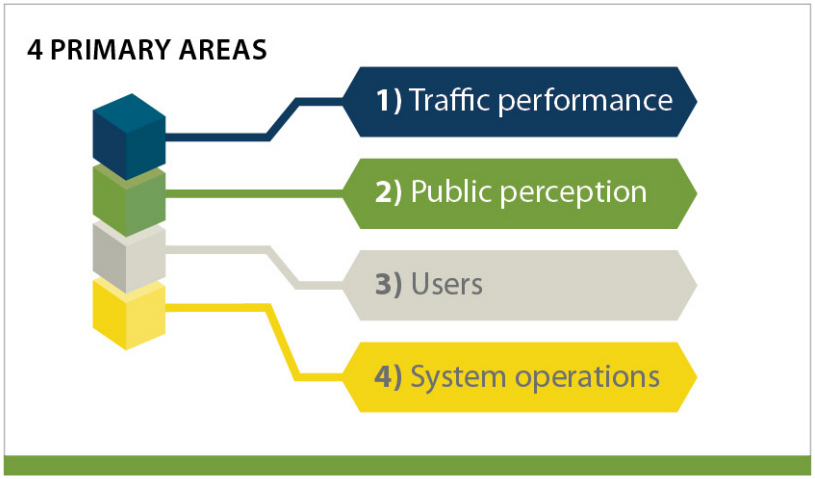
Project Delivery Mechanism (cont.)

- Finding Common Cause
  - Overriding sentiment: Do something about the Katy Freeway
  - Out-of-the-box attitude and a willingness to do whatever it takes
  - Shared cause helped motivate finding shared solutions through compromise
    - Ground-breaking agreements, innovative strategies, creative thinking

Project Delivery Mechanism (cont.)

Lesson Learned	Description
Account for Conflicting Visions	Each agency and/or stakeholder had a unique project vision and carried a certain responsibility to address that vision. Each group had objectives and goals, and occasionally those conflicted.
Find Stakeholders and Project Champions	Stakeholders and project champions can have powerful influence, and this can come in handy in mitigating conflicts and pushing projects through to completion. For example, when an agency threatened to stall the project on principle, stakeholders mediated the dispute; when the project ran short of funding, stakeholders brought HCTRA onto the team as a financial partner.
Establish Agreements to Define Roles	As identified by several interviewees, though difficult to establish, interagency agreements enabled agencies to cooperate and collaborate. Initial agreements, such as memoranda of understanding, served as a framework to develop subsequent, more detailed agreements. Guided by these agreements, the operating committee helped resolve conflicts in a timely fashion.
Build in Flexibility	Not all events are foreseeable, and changes to the initial agreements acknowledged this. Supported by the framework establishing the working relationships, agencies had to learn to adapt to dynamic circumstances. Several interviewees emphasized how vital this was to the project's success.
Agree on a Lead Agency	Coordination problems sometimes occurred. TxDOT would occasionally step in as the lead agency and make unilateral decisions to help resolve thorny issues and move the process move forward.
Maintain Strong Working Relationships	Respecting the other agencies involved proved vital to success. Interviewees acknowledged that trusting each other and knowing they could challenge one another's ideas helped them maintain an open mind and craft creative solutions that served the project's long-term best interests.

Overview: KML Best Practices



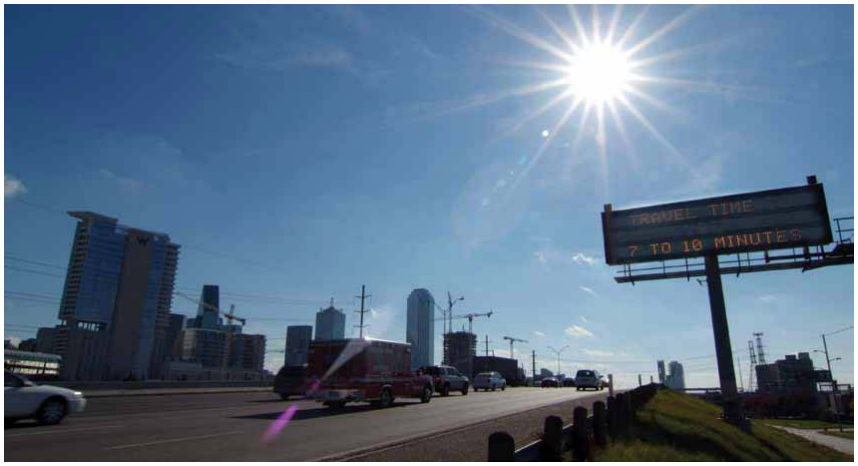
- TxDOT partnered with local entities to create an innovative delivery process for funding, operating, maintaining MLs
- Project focused on 4 primary areas: traffic performance, public perception, users, operations
- Future suggested research: signing, carpooling, transit, economic impacts

KML Best Practices: Traffic Performance

- Managed-lane volumes have **doubled** over time. Some congestion has emerged on the GP lanes despite the freeway's expansion. This is partly attributed to **latent demand** and partly to **growth** in the energy corridor.
- Travel-time savings are approximately **5 minutes (morning)** and **14 minutes (afternoon)** in peak directions, an advantage over the GP lanes that has increased as volumes have grown.
- Managed lane off-peak speeds ran consistently at 70 mph but dropped to **a low of 52 mph (morning peak)** and **50 mph (afternoon peak)**. Both speeds correspond to the GP lanes' most-congested travel periods.
- Off-peak volumes are growing at a rapid rate on the managed lanes.

KML Best Practices: Public Perception

- Travelers use managed lanes to **save time, reduce stress** and to **avoid congestion**. They avoid managed lanes due to cost and limited travel time **savings** compared to the **expense**.
- Most ML travelers estimated travel-time savings at more than **twice** the actual time saved.



KML Best Practices: Users

- Over **80 percent** of the half million ML commuters used them for 60 or fewer trips annually (slightly more than one ML trip per week). Approximately **11 percent** used the managed lanes more than twice per week. Just over **3 percent** used the managed lanes for all trips.
- A small portion of commuters even use the managed lanes when **no travel-time savings** occur. In 2011, **1.1 percent** of toll-lane trips occurred when the managed lanes operated at a lower-average speed than the GP lanes.
- Some **49 percent** of ML users surveyed **changed** their usual freeway access point to reach the managed lanes.

KML Best Practices: System Operations

- Improved geometric design and reduced congestion helped reduce crashes from **128.3 crashes** (pre-construction) to **57.3 crashes** (post-construction) per million vehicle-miles.
- The KML's various access types have **proven sufficient** to handle the expected demand of drivers entering and exiting the lanes.
- Using a wide 20-foot buffer and plastic delineators, most KML sections were built assuming ideal conditions for effectively separating traffic flowing simultaneously and in the same direction. Attributed to the **wide buffer**, pylon hits and needed replacements are less frequent (averaging **25 percent** replaced per year) compared to other ML projects.

KML Best Practices: System Operations (cont.)

- Enforcement operations have evolved, both institutionally and operationally, to ensure a **balance** between deterring cheaters and enforcing laws at the cost of disrupting traffic flow.
- All agencies interviewed agree: **active enforcement** of lane use and having the **physical space** to conduct enforcement activities help to **reduce maintenance** and **operational issues**.

KML Best Practices: Summary

- Finding the right stakeholders with a shared, vested interest in the project's success.
- Outlining clear partner roles and feedback mechanisms, including dispute resolution procedures.
- Gaining public trust, buy-in, and feedback throughout the facility's life.
- Setting quantifiable project goals and establishing performance measures to use in assessing how well the facility is meeting them.
- Building flexibility into planning and operational policies and procedures to ensure responsiveness dynamic situations and unforeseen future circumstances.