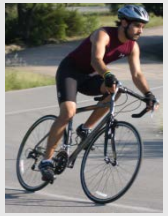
TEXAS DEPARTMENT OF TRANSPORTATION



# SYSTEM SAFETY & PERFORMANCE-BASED PRACTICAL DESIGN

2018 Transportation Short Course

October 16, 2018

# Table of contents


| | | |
|---|---|---|
| 1 | TxDOT's Mission, Goals and Objectives | 3-8 |
| 2 | System Safety | 9-12 |
| 3 | Performance-Based Practical Design | 13-21 |
| 4 | Summary | 22 |
| 5 | Questions | 23 |
| 6 | References | 24 |

# TxDOT's Mission, Goals & Objectives

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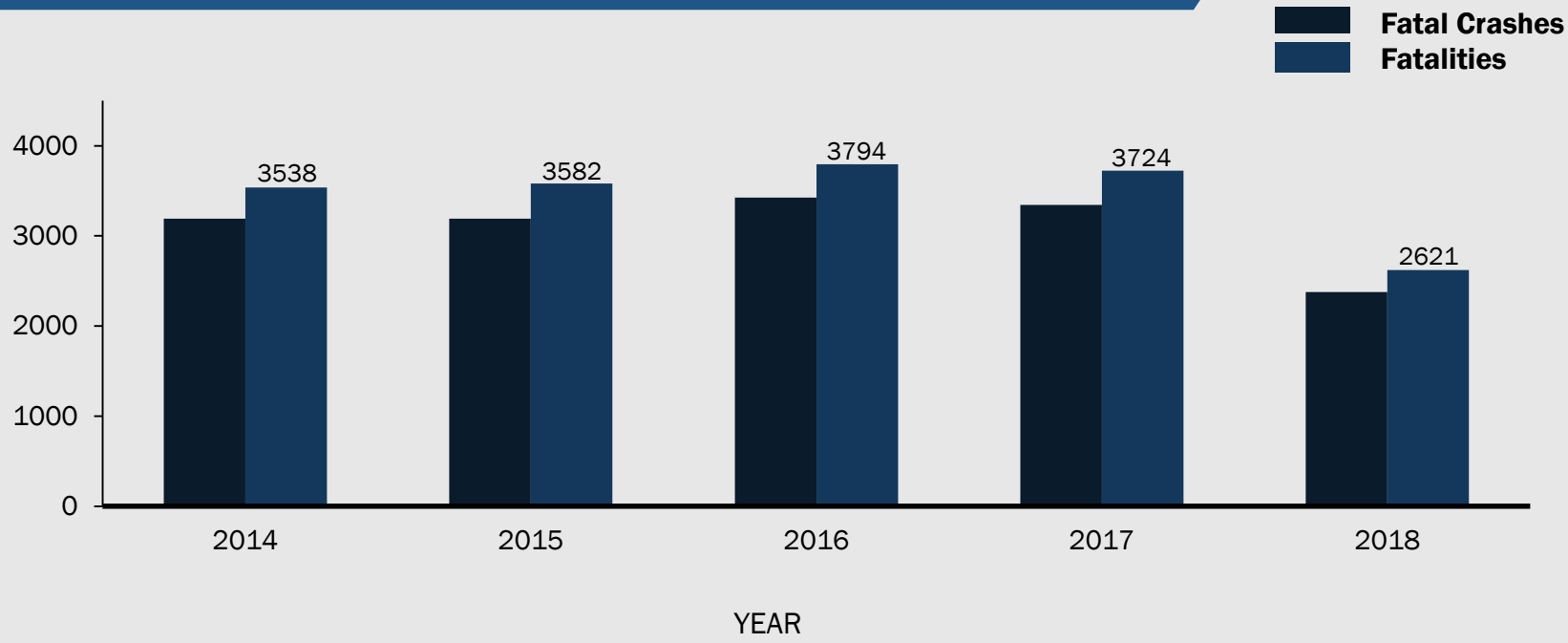
## Calendar Year 2014 to 2018 Fatal Crash and Fatality Count through Oct. 9, 2018



# TxDOT's Mission, Goals & Objectives

We ask drivers to improve their driving for safety, but what can we, at TxDOT, do better on our part to improve the safety on our roadways?

# TxDOT's Mission, Goals & Objectives

## MISSION

**Through collaboration and leadership, we deliver a safe, reliable, and integrated transportation system that enables the movement of people and goods.**

### GOALS & OBJECTIVES

- Deliver the Right Projects
- Focus on the Customer
- Foster Stewardship
- Optimize System Performance
- Preserve our Assets
- Promote Safety
- Value our Employees

# TxDOT's Mission, Goals & Objectives

| VEHICLE OPERATIONS | PERSONAL PROTECTION | PLANNING | | DESIGN | STANDARDS | CONSTRUCTION | MAINTENANCE |
|---|---|---|---|---|---|---|---|
| SMITH System Driving | Hazardous Communications Training | Unified Transportation Program (UTP) | Environmental Documents | Horizontal and Vertical Alignments | Manual for Assessing Safety Hardware (MASH) | Traffic Control Plans (TCPs) | Rail/End Treatment Repair |
| 360º Walk-Around | 123 Safe Days of Summer | Texas Transportation Plan 2040 | Crash Analysis | Pavement design | Design Criteria | Materials Tests & Inspections | Pavement Repair |
| Backing and Spotting | Personal Protective Equipment (PPE) | Highway Safety Improvement Program (HSIP) | Public meetings | Drainage | Load and Resistance Factor Design (LRFD) | Retroreflectivity | Clearing / Mowing |
| Lights On for Safety | Buckle-Up – Seat Belts Save Lives | Pavement Management Information System (PMIS) | Corridor Studies | Geotechnical | Standard Sheets | Traffic Barriers | Emergency Contracts |
| Defensive Driving | Stretch and Flex | Bridge Maintenance and Improvement Program (BMIP) | Accelerated Construction | Access Control | Crash Tests | Vehicle Impact Attenuators | Sweeping |

**Safety is integrated into everything we do at TxDOT.**

Safety: Mission ZERO

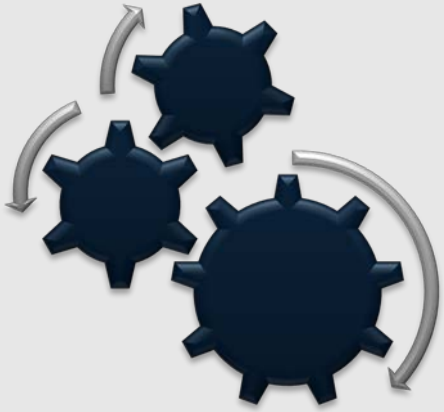
*Safety Never Stops!*

# SYSTEM SAFETY

Merriam-Webster "***system***" definition

**sys·tem** \'si-stəm\ (n): a regularly interacting or interdependent group of items forming a unified whole,

- such as, a group of devices or artificial objects or an organization forming a network especially for distributing something or serving a common purpose



# System Safety

**Projects can meet criteria but may not necessarily address specific safety concerns. Safety enhancements may require designing above minimum criteria, and desirable criteria is not necessarily the maximum. Engineering judgment must play a part.**

- Safety enhancement elements must be considered during planning and design.
  - Crash history, problem areas
  - Coherent signing and striping
  - Superelevations
  - Traffic control plans (TCPs)
  - Illumination
  - Pavement condition
  - Clear zones
  - Railing/end treatments
  - Sight distance
  - Drainage problems
  - Maintenance issues
  - Site visit

# **PLANNING** for System Safety Enhancements

(with TxDOT goals in mind)

- ✓ Deliver the Right Projects
- ✓ Preserve our Assets
- ✓ Optimize System Performance

Effective planning enables us to design for the future and to minimize design exceptions.

# PERFORMANCE-BASED PRACTICAL DESIGN

## What is Performance-Based Practical Design (PBPD)?

(per FHWA)

**PBPD** is a decision-making approach that helps agencies better manage transportation investments *and* serve system-level needs and performance priorities with limited resources. By focusing on system-wide performance, agencies can better manage the cumulative effectiveness of individual project investments and build upon the goals of Context Sensitive Solutions, flexibility in design, Practical Design, Asset Management, and Value Engineering.

## Performance-Based Practical Design (PBPD):

- is based on quantitative analysis for system performance
- does not compromise on existing design standards, regulatory requirements, operations or safety
- allows flexibility in design while still meeting both project **and** system objectives
- is a method to get the "most bang for your buck" (maximizes benefits while minimizing costs)
- allows improvements to more projects as compared to traditional project development approaches

**How does Performance-Based Practical Design work?**

Consider Nominal vs. Substantive safety:

***Nominal safety*** refers to adherence to applicable design criteria and standards.

***Substantive safety*** refers to the predicted, or actual, safety performance of a highway or proposed design.

**PBPD** is based on substantive safety, which allows enhancements to safety, or a "design-up" approach, that may not require going above design criteria.

## Operational and Safety Analysis Tools that incorporate PBPD

**OPERATIONS**

Traffic Simulation
Highway Capacity Manual
Integrated Corridor Management

- considers traffic volumes with various roadway and traffic data
- used to predict levels of service and/or delay

**SAFETY**

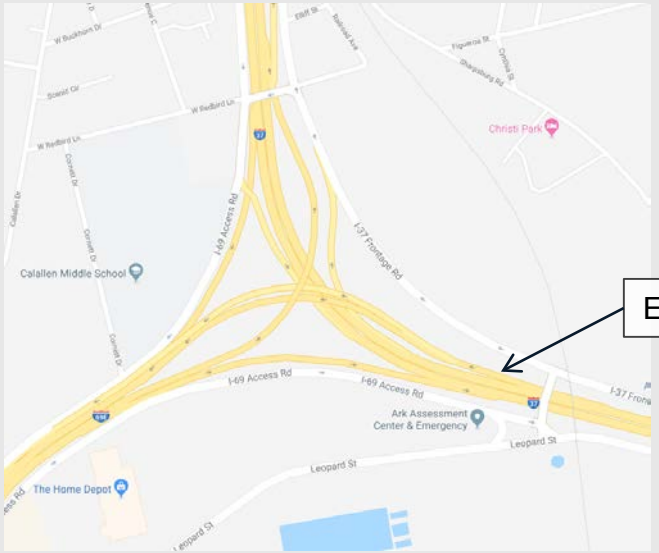
**Highway Safety Manual**
- Crash Modification Factors Clearinghouse
- Safety Analyst
- Interactive Highway Safety Design Model (IHSDM)
- NCHRP HSM Data Needs Research Digest
- Interchange Safety Analysis Tool (ISAT)

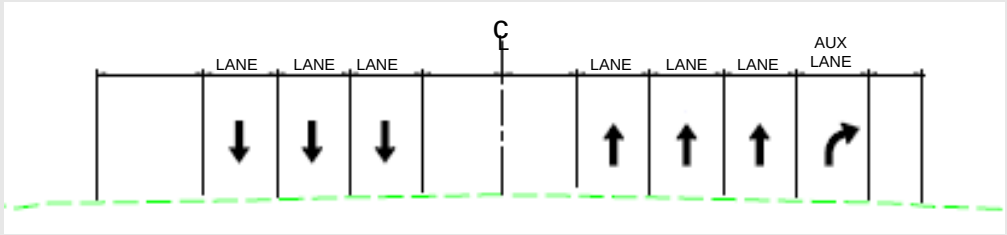
- considers traffic volumes with various roadway geometrics and features
- uses a predictive method to predict crash frequency, based on actual crash history

When used in planning and design, these tools can be used to compare and select alternative designs based on the operations and/or the number of predicted crashes for each alternative.

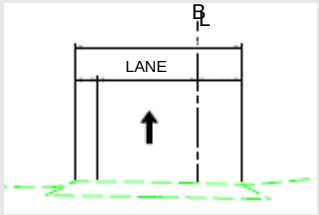
**SCENARIO:**

Urban freeway queuing on the mainlanes at exit ramp connecting to another freeway and frontage road



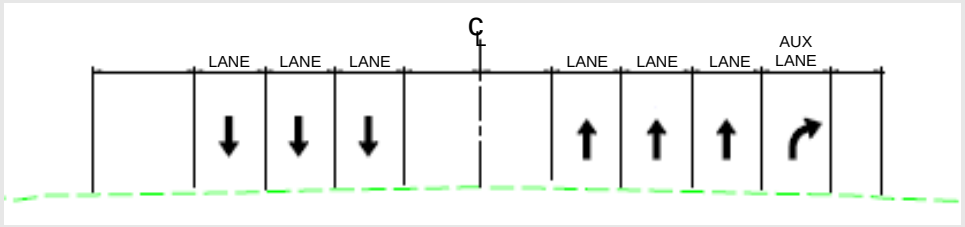

EXISTING TYPICAL SECTION




EXISTING RAMP SECTION

## PBPD Alternative:

Through a substantive analysis, the level of operation (LOS) was shown to improve for current and future conditions by re-signing the outside travel lane and restriping the ramp to two lanes with minimum pavement widening

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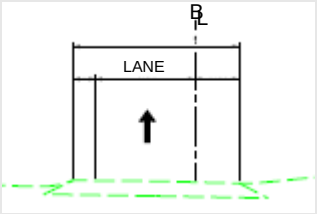
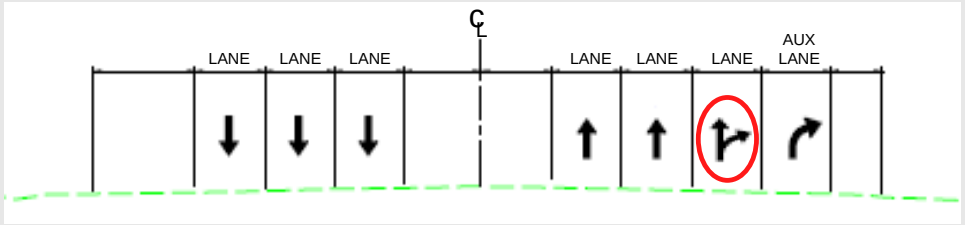
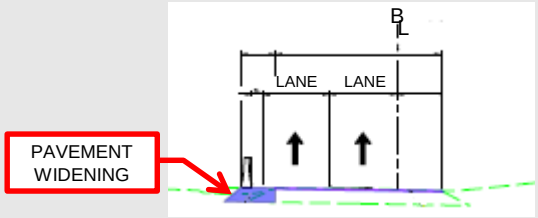



EXISTING RAMP SECTION




PROPOSED TYPICAL SECTION




PROPOSED RAMP SECTION

**SCENARIO:**

An added capacity project on an urban freeway is adding new travel lanes within a restricted ROW between numerous businesses where nominal lane and/or shoulder widths cannot be attained

<u>Possible Alternatives</u>:

1. Buy ROW to widen to nominal lane and shoulder widths
2. Analyze performance of roadway with less than nominal criteria

## Analysis Based on Highway Safety Manual Methodologies

- Crash Modification Factors (CMFs)

  CMF = 1: Meets base conditions or the treatment has no effect on the predicted crash frequency
  CMF < 1: The treatment reduces the predicted crash frequency
  CMF > 1: The treatment increases the predicted crash frequency

- Nominal shoulder width is 10’

**SAFETY IMPACTS OF NARROWING THE SHOULDER**

| Inside Shoulder Width (feet) | Crash Modification Factor (CMF) | | Change from preferred design value | |
|---|---|---|---|---|
| | Property Damage Only Crash | Fatal and Injury Crash | Property Damage Only Crash | Fatal and Injury Crash |
| 10 | 0.941 | 0.934 | | |
| 8 | 0.970 | 0.966 | 0.029 | 0.032 |
| 4 | 1.031 | 1.035 | 0.090 | 0.101 |

# Summary

- Enhancement of system safety must be considered for all projects, with consideration at the early planning stage of project development.
- While it may seem logical that simply designing above/beyond nominal criteria would enhance system safety, this is not always the case. Safety and operational improvements should be justified using Performance-Based Practical Design (PBPD) methods and engineering judgment.
- The decision-making approach provided by PBPD is a quantitative analysis for system performance (including safety); it does not compromise on existing design standards, regulatory requirements, operations or safety.
- If designs do not meet nominal design criteria, PBPD should be used to demonstrate the safety and operational impacts of those designs.

***When roadway elements are analyzed together as a whole and the shift to consider safety and PBPD in planning and design is utilized statewide, the resulting outcome will be a transportation system efficiently-funded and designed to operate with efficiency and enhanced safety.***

# QUESTIONS?

# References

- FHWA Performance-Based Practical Design – https://www.fhwa.dot.gov/design/pbpd
- FHWA Performance-Based Practical Design Start-Up Guide – https://www.fhwa.dot.gov/design/pbpd/documents/hif17026.pdf
- Highway Safety Manual – www.highwaysafetymanual.org
- Crash Modifications Factors Clearinghouse – www.cmfclearinghouse.org