

# NHTSA'S 2013 LIGHT VEHICLE CIB/DBS PERFORMANCE EVALUATION

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# Research Objectives

**Validate test methods developed to objectively evaluate crash imminent braking (CIB) and dynamic brake support (DBS) technologies on the test track**

## **Specific areas of interest**

- Test procedure performability
- The effect of different brake application strategies (DBS)
- The effect of test targets
- Ability to satisfy the assessment factors

**Evaluate test vehicles equipped with contemporary production systems**

# 2013 Test Track Evaluation Overview

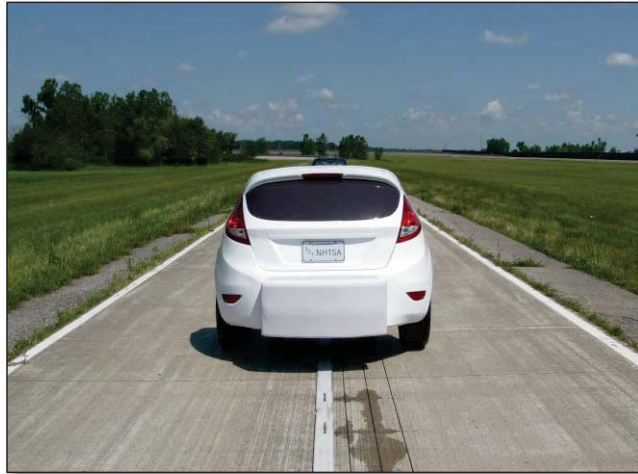
- **Performed from July 15 – November 19, 2013**
- **Seven diverse light vehicles**
- **Two test targets**
- **Seven test maneuvers**
- **Two brake application techniques (for DBS tests)**

# 2013 Test Track Evaluation Vehicles and Sensors

Vehicle	Sensing Technology				LIDAR	Pedestrian Detection
	RADAR		Cameras			
	SRR (24 GHz)	LRR (77 GHz)	Mono	Stereo		
A		2	✓			
B	2	1	✓			
C		1				
D	2	1		✓		✓
E		1				
F		1		✓		✓
G				✓		✓

# 2013 Test Track Evaluation Surrogate Vehicles

## NHTSA SSV



## ADAC AEBS Target (Euro NCAP Vehicle Target, EVT)



# 2013 Test Track Evaluation

## Test Maneuvers (Applicable to CIB and DBS)

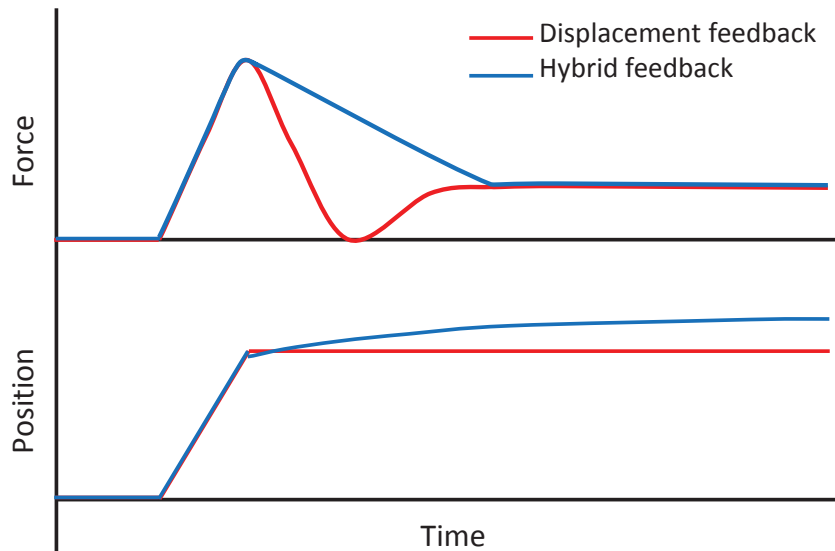
Maneuver	Speed (mph)		Comment
	SV	POV	
LVS_25_0	25	0	Stopped lead vehicle.
LVM_45_20	45	20	Slower moving lead vehicle. Test also used in the FCW NCAP.
LVM_25_10	25	10	Slower moving lead vehicle. Least severe test in the matrix.
LVD_35_35	35	35	Decelerating lead vehicle. POV brakes at 0.3g. Avoidance or impact occurs <b>while the POV is moving.</b>
LVD_25_25	25	25	Decelerating lead vehicle. POV brakes at 0.3g. Avoidance or impact occurs <b>while the POV is at rest.</b>
STP_45	45	--	Higher speed false positive test. SV is driven over a 8' x 12' x 1" steel trench plate.
STP_25	25	--	Slower speed false positive test. SV is driven over a 8' x 12' x 1" steel trench plate.

Added after  
the 07/03/12  
Request for  
Comment

# 2013 Test Track Evaluation

## Brake Applications Used For DBS

- Displacement feedback maintains constant brake pedal position for the duration of the application
- Hybrid applications use displacement feedback to establish the initial pedal position, then switches to force-based control



Hybrid braking added in response to the 07/03/12 Request for Comment

Conceptual comparison of displacement versus hybrid feedback brake applications (for a vehicle whose brake pedal falls towards the floor during a DBS intervention).

# 2013 Test Track Evaluation Data Analysis

## **Maneuver Performability**

- Can tests be repeatably and accurately performed within the tolerances provided in the draft test procedures?

## **Test Track Performance**

- Can the performance levels presently under consideration be achieved by contemporary production vehicles?



# 2013 Test Track Evaluation

## Maneuver Performability: Key Test Tolerances

**SV and POV speed:**  $\pm 1$  mph (1.6 km/h)

**SV and POV lateral position from road center:**  $\pm 2$  ft (0.6 m)

**SV-to-POV lateral orientation relative to each other :**  $\pm 1$  ft (0.3 m)

**SV-to-POV headway:**  $\pm 8$  ft (2.4 m)

**SV yaw rate:**  $\pm 2$  deg/s

**SV brake application range to POV:**  $\pm 2$  ft (0.6 m)

**SV throttle release timing:**  $>1$  s prior to brake application

**SV brake application rate:**  $\pm 1$  in/s (25.4 mm/s)\*

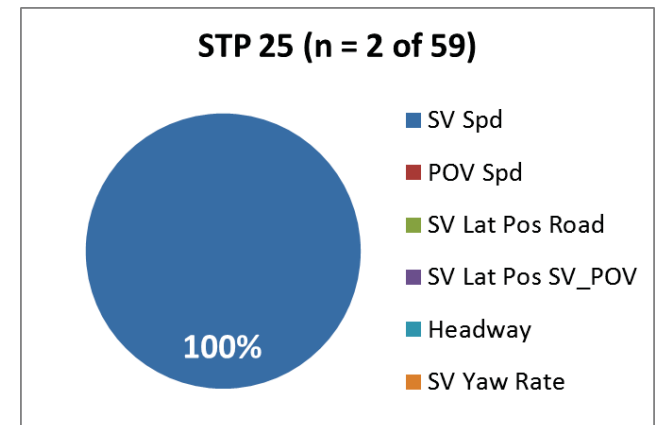
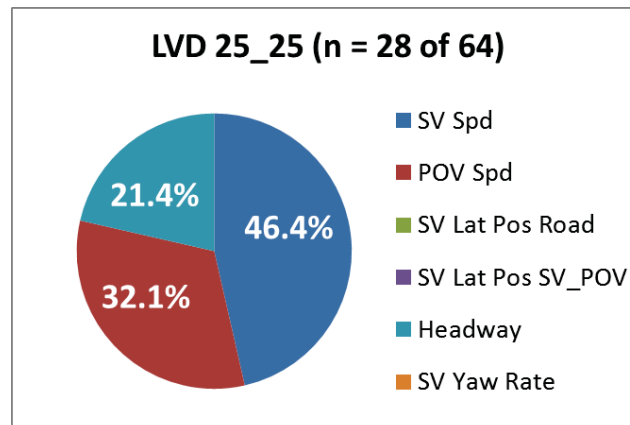
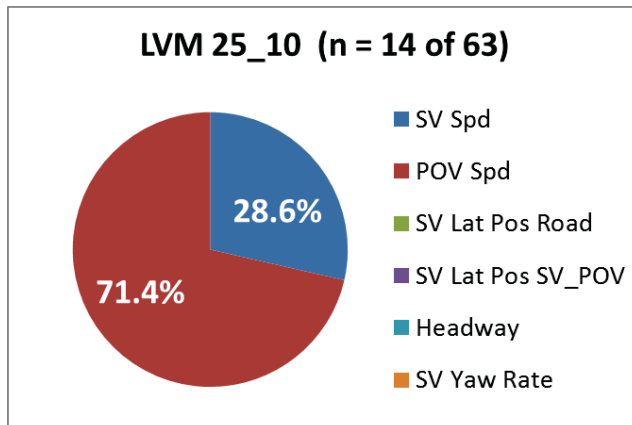
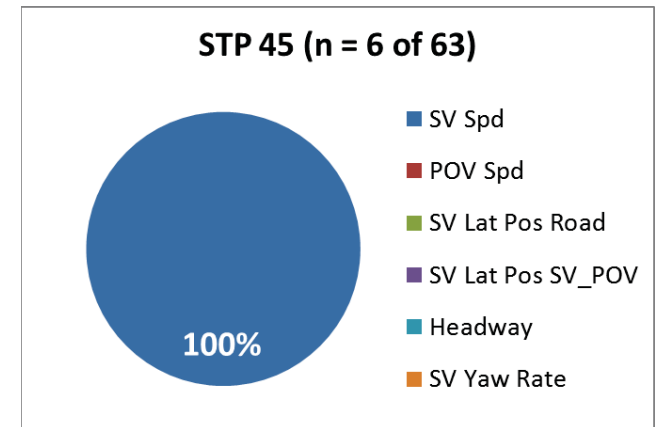
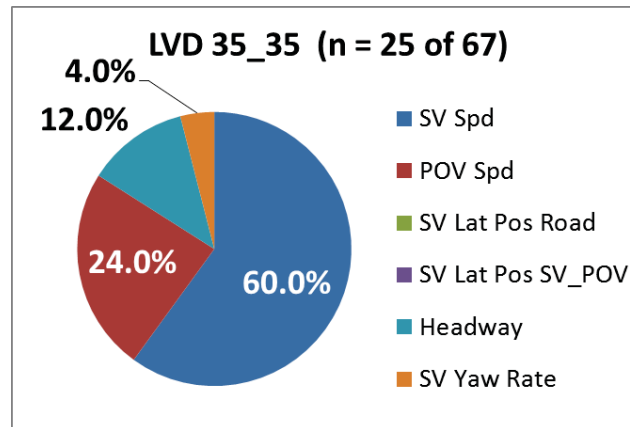
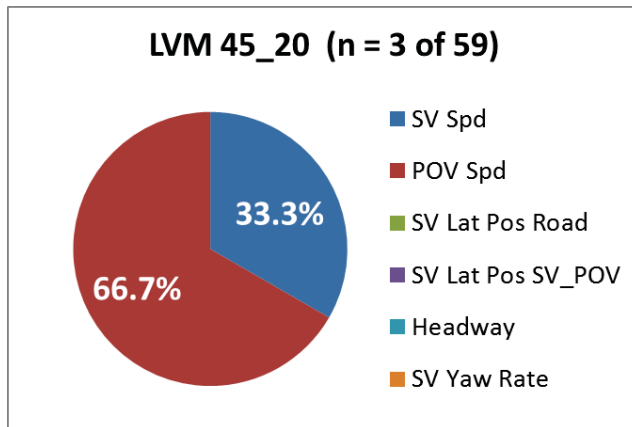
**POV deceleration:**  $\pm 0.03g$  (nominally, applicable to LVD tests)\*

\*Data not discussed in this presentation

# 2013 Test Track Evaluation

## Maneuver Performability: Test Violations By Maneuver (CIB)

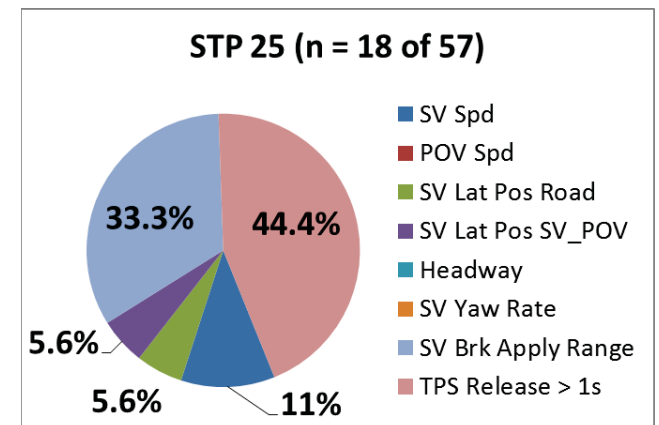
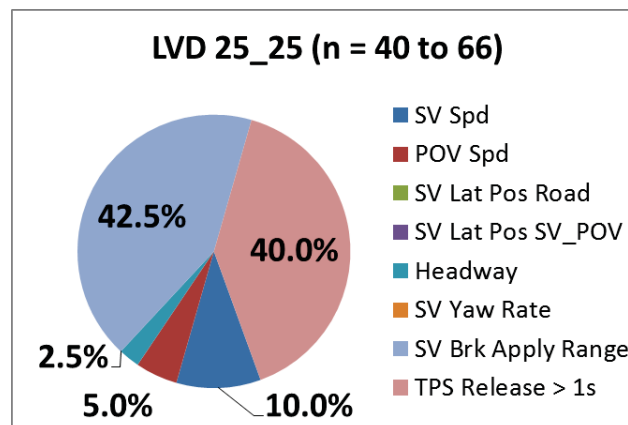
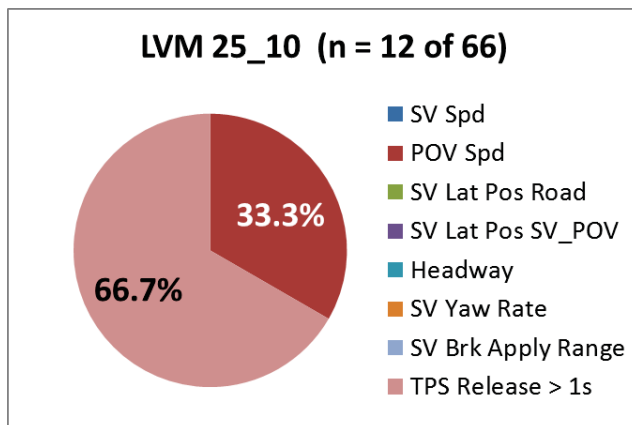
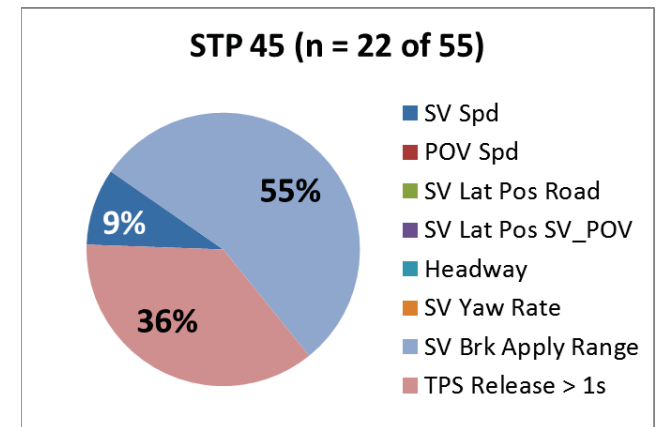
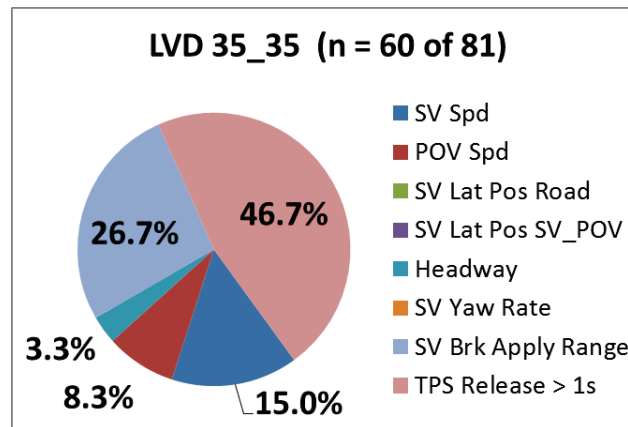
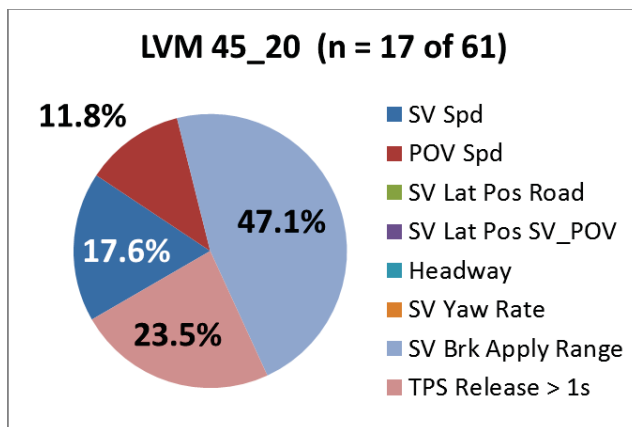
n = number of all trials performed with a validity violation, per maneuver  
 Of the “n” trials, the cause of the violation is presented.



# 2013 Test Track Evaluation

## Maneuver Performability: Test Violations By Maneuver (DBS)

n = number of all trials performed with a validity violation, per maneuver  
 Of the “n” trials, the cause of the violation is presented.



# 2013 Test Track Evaluation Assessment Reference Values

FCAM Technology	LVS 25_0	LVM 45_20	LVM 25_10	LVD 35_35	LVD 25_25	STP_45 (FP)	STP_25 (FP)
CIB	9.8 mph	9.8 mph	Crash Avoidance	10.5 mph	9.8 mph	No Activation	
DBS	Crash Avoidance					No Activation	

## Assessment factors:

- Assessment reference values must be realized during at least 7 of 8 trials per condition, for each condition
- CIB speed reductions achieved by 0.6g braking from TTC = 0.6s
- LVS and LVM speed reductions were introduced in a 2012 RFC
- LVD speed reductions are new, but are intended to be the same stringency

# Ability to Satisfy CIB Assessment Reference Values (Data not screened for test validity)

Vehicle	LVS 25_0		LVM 45_20	LVM 25_10	LVD 35_35	LVD 25_25	STP_45 (CIB FP)	STP_25 (CIB FP)
	SSV	ADAC						
A	--	--	8/8	0/9	12/12	7/8	8/8	9/9
B	--	--	8/8 8/8 <sup>6</sup>	6/13 <sup>1</sup> 7/9 <sup>2</sup>	0/10 <sup>2</sup>	8/8 <sup>2</sup>	11/11	9/9
C <sup>2</sup>	9/9 <sup>4</sup>	8/8 <sup>4</sup>	9/9 <sup>4</sup>	5/10 <sup>3</sup> 8/9 <sup>4</sup>	3/8 <sup>4</sup>	9/9 <sup>4</sup>	9/9	8/8
D	9/9	8/8	8/8	9/9	8/8	8/8	8/8	8/8
E	--	--	10/10	10/10	9/9	8/8	9/9	8/8
F	8/8	8/8	8/8	8/8	9/9	9/9	13/13	10/10
G	8/8	8/8	8/8	8/8	10/10	14/14	8/8	9/9

-- = test not performed

<sup>1</sup>Minimum range was less than 1-ft for all tests where no impact occurred

<sup>2</sup>Result achieved with full FMVSS 135 burnish

<sup>3</sup>Driver attempted to maintain constant throttle position before and after FCW-based throttle pedal pushback

<sup>4</sup>Result achieved with throttle release after FCW-based throttle pedal pushback

# Ability to Satisfy CIB Assessment Reference Values (Valid\* tests shown)

Vehicle	LVS 25_0		LVM 45_20	LVM 25_10	LVD 35_35	LVD 25_25	STP_45 (CIB FP)	STP_25 (CIB FP)
	SSV	ADAC						
A	--	--	8/8	0/7	8/8	6/7	8/8	7/7
B	--	--	8/8	6/8 <sup>1</sup>	0/7 <sup>1</sup>	7/7	8/8	8/8
C <sup>1</sup>	8/8 <sup>2</sup>	8/8 <sup>2</sup>	8/8 <sup>2</sup>	7/8 <sup>2</sup>	3/8 <sup>2</sup>	8/8 <sup>2</sup>	8/8	7/7
D	8/8	8/8	8/8	8/8	8/8	8/8	8/8	8/8
E	--	--	8/8	8/8	8/8	7/7	8/8	8/8
F	8/8	8/8	7/7	6/6	6/6	5/5	8/8	7/7
G	8/8	8/8	7/7	3/3	2/2	4/4	8/8	8/8

-- = test not performed

<sup>1</sup>Result achieved with full FMVSS 135 burnish

<sup>2</sup>Result achieved with throttle release after FCW-based throttle pedal pushback

\*Validity assessment does not consider POV deceleration

# Ability to Satisfy DBS Assessment Reference Values (Displacement-based brake applications; no validity screen)

Vehicle	LVS 25_0		LVM 45_20	LVM 25_10	LVD 35_35	LVD 25_25	STP_45 (DBS FP)	STP_25 (DBS FP)
	SSV	ADAC						
A	0/8	2/12	8/9	0/8	5/9	8/8	8/8	8/8
B <sup>2</sup>	11/11	7/8	8/8	9/9	1/12	7/8	8/8	8/8
C <sup>2</sup>	8/8	8/8	9/9	9/9	11/13	9/9	9/9	8/9
D	9/9	10/10	8/8	10/10	10/10	8/8	3/10	2/8
E	10/10	8/8	9/9	9/9	11/11	10/10	3/3 <sup>1</sup>	8/8
F	8/9	4/8	9/9	10/10	4/12	8/8	9/9	9/9
G	8/8	11/11	9/9	9/9	14/14	15/16	9/9	9/9

<sup>1</sup>Only three tests performed due to weather and vehicle lease constraints

<sup>2</sup>All DBS tests performed after a full FMVSS 135 burnish

# Ability to Satisfy DBS Assessment Reference Values (Valid\* displacement-based brake applications)

Vehicle	LVS 25_0		LVM 45_20	LVM 25_10	LVD 35_35	LVD 25_25	STP_45 (DBS FP)	STP_25 (DBS FP)
	SSV	ADAC						
A	0/8	1/8	7/8	0/7	4/7	8/8	1/1	8/8
B <sup>1</sup>	8/8	7/8	8/8	8/8	1/8	6/7	6/6	8/8
C <sup>1</sup>	8/8	8/8	8/8	8/8	5/5	6/6	7/7	4/5
D	8/8	8/8	8/8	8/8	8/8	8/8	3/8	2/7
E	8/8	8/8	6/6	6/6	4/4	no valid tests	no valid tests	7/7
F	1/2	4/5	5/5	6/6	no valid tests	no valid tests	3/3	2/2
G	8/8	8/8	2/2	8/8	8/8	7/8	7/7	8/8

<sup>1</sup>All DBS tests performed after a full FMVSS 135 burnish

\*Validity assessment does not consider POV deceleration



# Ability to Satisfy DBS Assessment Reference Values (Hybrid-based brake applications; no validity screen)

Vehicle	LVS 25_0		LVM 45_20	LVM 25_10	LVD 35_35	LVD 25_25	STP_45 (DBS FP)	STP_25 (DBS FP)
	SSV	ADAC						
A <sup>1</sup>	--	--	--	--	--	--	--	--
B <sup>2</sup>	10/11	7/8	8/8	9/9	--	8/8	--	--
C <sup>2</sup>	9/9	8/8	8/8	9/9	--	--	--	--
D	10/10	8/8	8/8	8/8	--	--	--	--
E	0/9	0/9	9/9	8/8	--	--	--	--
F	7/9	7/8	9/9	11/12	--	--	10/10	9/9
G	1/11	5/5 <sup>3</sup>	8/8	9/9	--	--	--	--

-- = test not performed

<sup>1</sup>Hybrid brake applications were not performed correctly (fallback force was 6.1N rather than 6.1 lbf)

<sup>2</sup>All DBS tests performed after a full FMVSS 135 burnish

<sup>3</sup>Only five tests performed due to instrumentation issues

# Ability to Satisfy DBS Assessment Reference Values (Valid\* hybrid-based brake applications)

Vehicle	LVS 25_0		LVM 45_20	LVM 25_10	LVD 35_35	LVD 25_25	STP_45 (DBS FP)	STP_25 (DBS FP)
	SSV	ADAC						
A <sup>1</sup>	--	--	--	--	--	--	--	--
B <sup>2</sup>	7/8	7/8	8/8	8/8	--	6/6	--	--
C <sup>2</sup>	8/8	8/8	8/8	8/8	--	--	--	--
D	8/8	8/8	8/8	8/8	--	--	--	--
E	0/4	0/8	8/8	8/8	--	--	--	--
F	3/3	4/5	8/8	6/7	--	--	2/2	4/4
G	0/8	5/5 <sup>3</sup>	2/2	8/8	--	--	--	--

-- = test not performed

<sup>1</sup>Hybrid brake applications were not performed correctly (fallback force was 6.1N rather than 6.1 lbf)

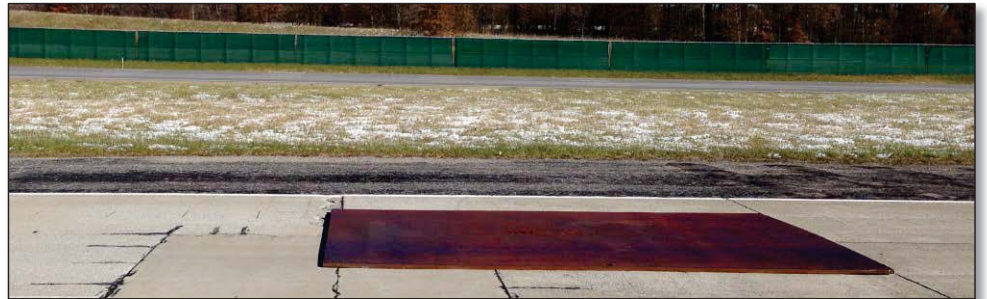
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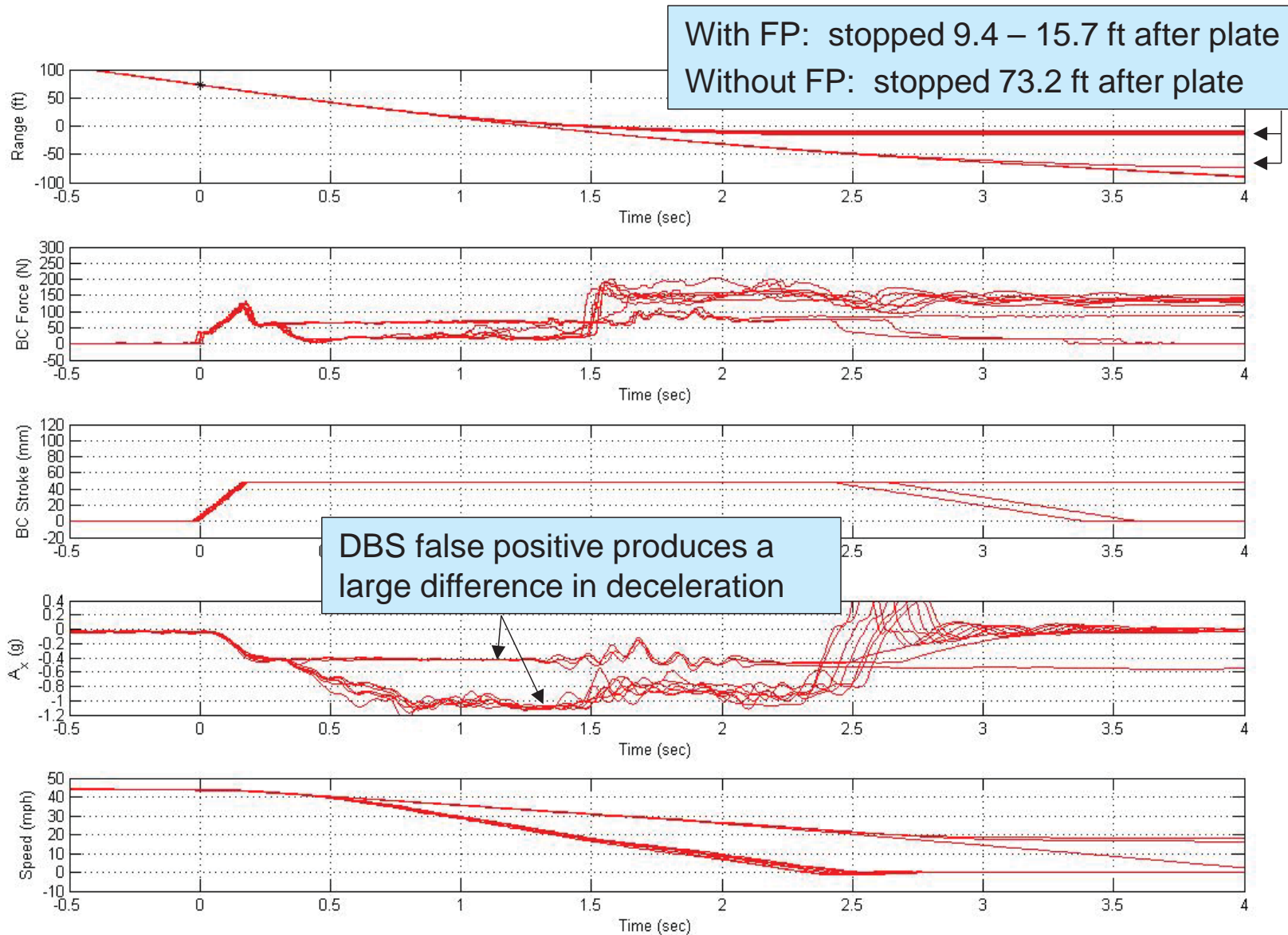
# 2013 Test Track Evaluation Steel Trench Plate

- Used to temporarily cover pavement during road repairs, construction, etc.
- ASTM A36 steel
- Nominal dimensions: 8' x 12' x 1" (2.4 m x 3.7 m x 25 mm)



# 2013 Test Track Evaluation

## DBS False Positives Produced In Response to the STP



# Concluding Remarks

## System performance

- The assessment reference values are achievable
  - CIB speed reduction criteria: 3 vehicles
  - DBS speed reduction criteria: 3 vehicles\*
  - CIB false positive suppression: 7 vehicles (all)
  - DBS false positives: 6 vehicles
- The vehicles equipped with the largest number of sensors did not necessarily perform better than those equipped with a single sensing technology
- CIB performance was not always indicative of DBS performance
- No consistent test target responses differences were observed
- With few exceptions, the vehicles achieved better DBS performance with displacement feedback-based brake applications

\*Finding considers raw and valid test trials

# Concluding Remarks

## Test procedures

- Inclusive of real-world rear-end crashes
- The 35 mph LVD tests are the most complicated to perform, but the additional vehicle response data are valuable
- STP test results indicate false positives remain a challenge, and that the tests should be retained
- Multiple brake application options may not be necessary

# NHTSA's Anticipated 2014 Work

## Research dissemination

- Available through docket NHTSA-2012-0057
- Updated CIB / DBS draft test procedures
- Technical reports describing 2013 test track work
- Updated NHTSA SSV design specifications

## Complete SSV durability tests

## Perform repeatability tests

- Tests repeated twice a month for six months using the same vehicle(s)

# Key Test Procedures Updates for 2014

- Additional surrogate vehicle details
- Inclusion of the two LVD and steel trench plate test scenarios
- Revised throttle release specifications
- Multiple brake application options (for DBS evaluations)
- Reduced yaw rate and lateral position tolerances
- Subject vehicle test weight specifications
- Inclusion of applicable FMVSS 135 brake burnish and temperature specifications



# Questions?

