



# NHHTSA

NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

## Test Track Evaluation of FCW and BSW Installed on Motorcycles

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# Project Overview

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- Assess the current state of two motorcycle-based safety technologies:
  - Blind spot warning (BSW)
  - Forward collision warning (FCW)
- Adapt existing light vehicle test procedures for motorcycle-based testing.
  - [Automatic emergency braking systems for light vehicles](#)
  - [Blind spot warning system confirmation test procedure](#)

# Subject Vehicles

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## 2024 BMW R 1300 GS



- Front radar
  - ACC
  - FCW
- Rear radar
  - Lane change warning
  - Rear end collision warning system

## 2024 Moto Guzzi Stelvio



- Front radar
  - ACC
  - FCW
- Rear radar
  - Lane change decision aid system

# Instrumentation

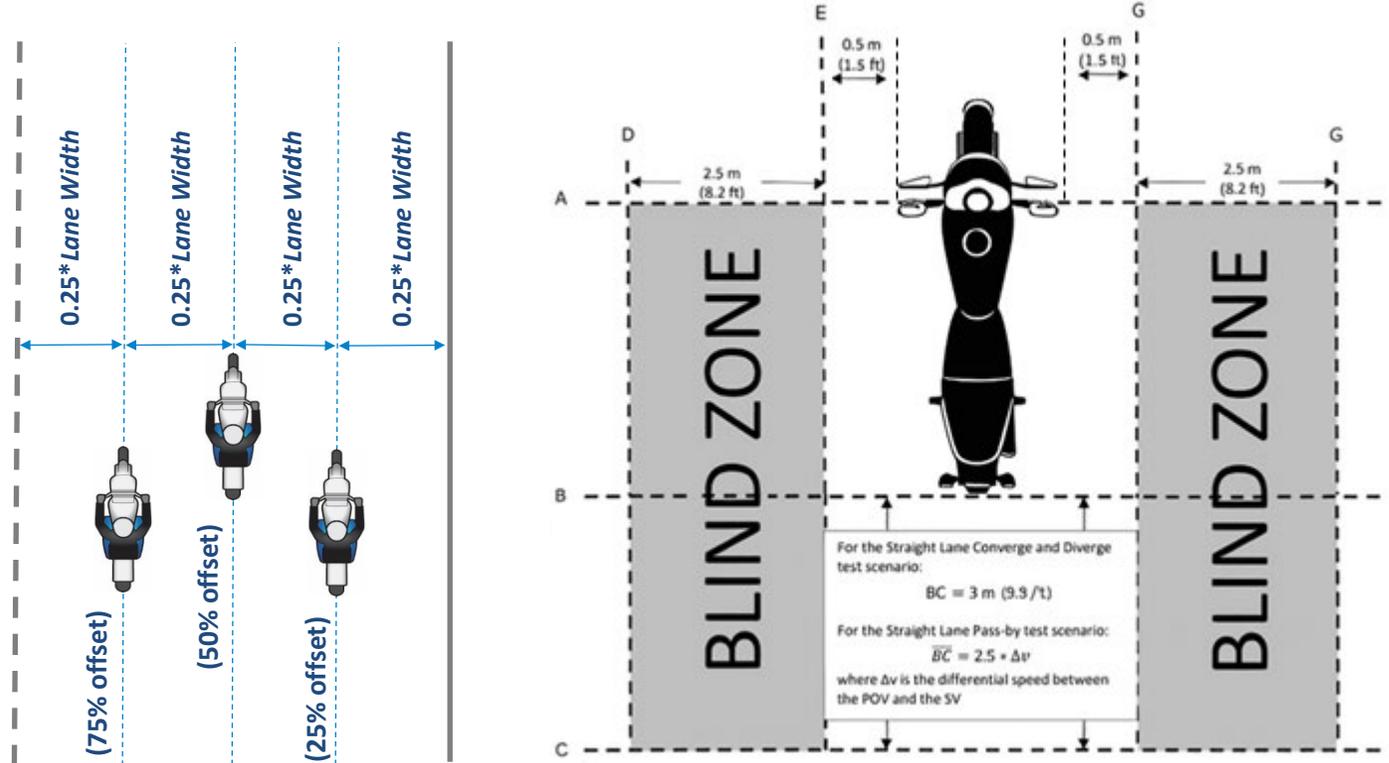
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- Space constraints created a need for new solutions.
- Utilized aftermarket rack and case system for.
- New display for driver information.
- Created custom sensor mounts for measuring rider inputs.



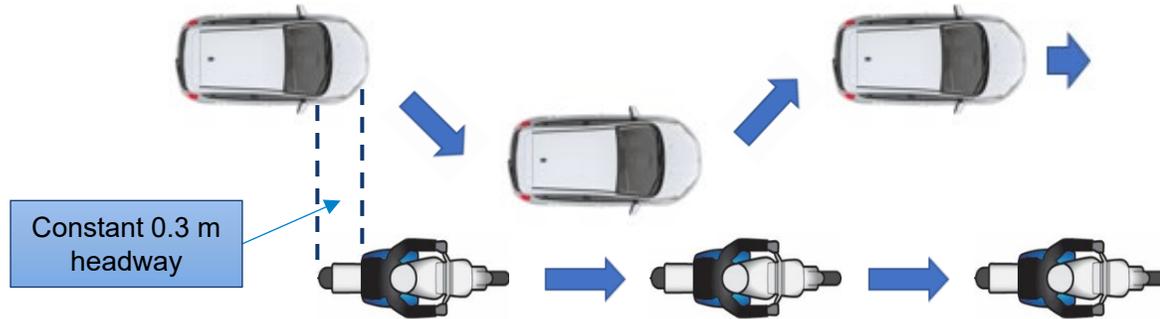
# BSW Overview

- NHTSA's BSW system confirmation test procedure for light vehicles was adapted for motorcycle-based testing.
- Blind zone starts at the motorcycle's handlebars
- Lane offsets were added.
- Scenarios:
  - Converge and diverge
  - Straight lane pass-by



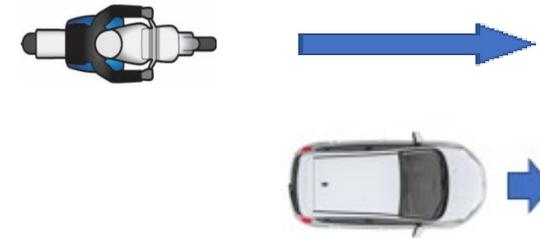
# BSW Scenarios

## Straight Lane Converge and Diverge



- Test speed (km/h): 72.4
- POV approaches from left and right
- SV travel lane offset (%): 50
- Turn signal off

## Straight Lane Pass-By



- Test speed (km/h):
  - SV: 72.4
  - POV: 80.5, 88.5, 96.5, 104.6
- POV approaches from left and right
- SV travel lane offset (%): 25, 50, 75
- Turn signal: enabled or disabled

# BSW Results

## Converge and Diverge

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2024 BMW R 1300 GS Distance to POV at BSW (m)						
72.4 km/h Converge & Diverge						
Approach	Left			Right		
Onset	4.6	4.6	4.5	3.4	3.3	3.4
Termination	6.1	6.1	6.2	5.2	5.2	5.3

2024 Moto Guzzi Stelvio Distance to POV at BSW (m)						
72.4 km/h Converge & Diverge						
Approach	Left			Right		
Onset	4.1	4.1	4.1	3.3	3.3	3.1
Termination	5.9	6.1	6.0	5.1	5.2	5.4

= Criteria met

= Criteria not met

# BSW Results

## Straight Lane Pass-By

2024 BMW R 1300 GS Distances to POV at BSW Onset																			
SV Speed = 72.4 km/h																			
Turn Signal		Disabled																	
Approach		Left									Right								
Lane Offset		75%			50%			25%			75%			50%			25%		
POV Speed (kph)	80.5	7.2	7.1	7.9	7.2	7.4	7.1	7.4	7.2	7.1	6.0	7.0	7.0	7.7	7.2	7.2	7.1	7.6	7.4
	88.5	15.0	15.6	15.1	14.5	15.0	14.8	15.7	14.7	14.4	15.1	14.9	14.3	15.3	15.1	13.4	14.7	14.8	16.1
	96.6	21.6	21.7	22.9	21.5	23.1	23.0	22.6	22.2	22.1	22.4	22.1	22.1	22.3	23.2	22.6	22.8	23.3	22.8
	104.6	29.6	30.3	30.5	29.8	29.5	30.2	30.2	30.1	30.0	30.1	30.0	29.1	29.8	30.4	30.9	29.9	29.7	29.4

2024 BMW R 1300 GS Distances to POV at BSW Termination																			
SV Speed = 72.4 km/h																			
Turn Signal		Disabled																	
Approach		Left									Right								
Lane Offset		75%			50%			25%			75%			50%			25%		
POV Speed (kph)	80.5	0.2	0.2	0.3	0.3	0.5	0.3	0.4	0.4	0.5	0.9	0.6	0.7	0.4	0.4	1.5	0.3	0.3	0.1
	88.5	1.9	2.3	2.2	1.8	1.8	1.9	2.5	2.1	1.7	2.5	2.3	2.3	2.3	1.8	2.1	2.0	2.0	2.1
	96.6	2.5	3.1	3.0	2.9	2.8	3.2	3.3	3.3	3.1	2.3	3.2	3.0	3.1	3.1	2.8	3.5	3.5	2.6
	104.6	3.0	3.5	3.7	2.9	3.2	2.9	2.9	2.7	3.3	2.9	3.0	2.8	2.8	3.4	3.4	3.1	3.0	3.3

= Criteria met

= Criteria not met

# BSW Results

## Straight Lane Pass-By

2024 Moto Guzzi Stelvio Distances to POV at BSW Onset																			
SV Speed = 72.4 km/h																			
Turn Signal		Disabled																	
Approach		Left									Right								
Lane Offset		75%			50%			25%			75%			50%			25%		
POV Speed (kph)	80.5	1.8	4.8	7.3	9.1	8.9	8.6	8.1	8.5	8.5	8.4	8.5	8.6	8.0	8.3	8.2	8.4	8.1	8.6
	88.5	11.5	4.1	2.6	17.9	16.4	16.6	17.3	16.4	17.4	16.5	17.4	15.4	16.0	13.6	16.9	16.6	15.6	13.1
	96.6	7.0	1.9	2.8	24.4	23.8	23.2	23.8	22.6	23.4	22.2	23.2	22.4	23.9	23.8	23.7	21.5	13.6	21.9
	104.6	1.8	1.3	1.3	24.5	25.0	25.0	25.5	23.4	23.4	25.7	25.2	24.5	23.8	24.6	24.2	20.9	18.2	23.8

2024 Moto Guzzi Stelvio Distances to POV at BSW Termination																			
SV Speed = 72.4 km/h																			
Turn Signal		Disabled																	
Approach		Left									Right								
Lane Offset		75%			50%			25%			75%			50%			25%		
POV Speed (kph)	80.5	-0.4	0.0	-0.1	0.6	0.2	-1.8	0.7	3.8	0.8	1.0	1.0	0.9	0.3	-2.8	-3.6	0.3	0.0	0.3
	88.5	-0.9	-0.6	-0.2	1.1	0.2	-0.2	7.8	3.2	0.1	0.5	0.2	0.2	0.1	-1.0	2.7	-1.2	3.0	-1.5
	96.6	1.9	2.5	4.9	2.2	1.7	2.2	2.8	1.6	5.9	5.1	5.7	5.4	5.4	2.0	2.4	5.1	1.2	1.3
	104.6	7.5	6.9	4.0	4.5	7.1	5.2	4.4	5.0	4.6	4.7	4.7	5.3	5.0	5.0	4.5	4.3	4.3	7.0

☐ = Criteria met

☐ = Criteria not met

# BSW Results

## Straight Lane Pass-By

2024 BMW R 1300 GS Distances to POV at BSW (m)																		
SV Speed = 72.4 km/h, POV Speed = 80.5 km/h																		
Turn Signal	Enabled																	
Approach	Left									Right								
Lane Offset	75%			50%			25%			75%			50%			25%		
Onset	7.4	7.0	7.0	7.8	7.0	7.1	7.0	7.2	7.1	7.1	7.4	7.2	7.1	7.1	7.2	7.3	7.6	7.5
Termination	0.3	-0.2	-0.2	0.0	0.6	0.7	0.6	0.7	0.4	0.2	0.2	0.5	3.8	0.4	0.6	0.2	0.2	0.2

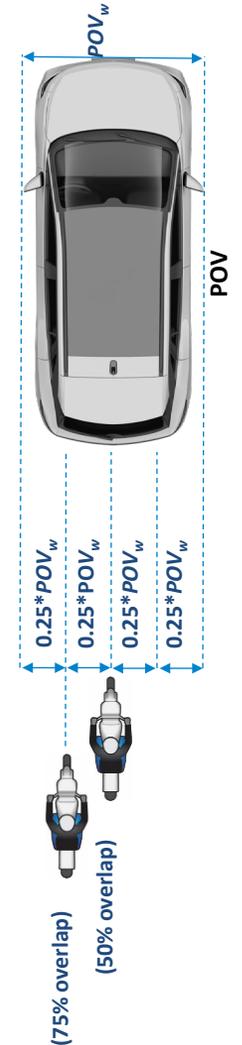
2024 Moto Guzzi Stelvio Distances to POV at BSW (m)																		
SV Speed = 72.4 km/h, POV Speed = 80.5 km/h																		
Turn Signal	Enabled																	
Approach:	Left									Right								
Overlap:	75%			50%			25%			75%			50%			25%		
Onset	5.1	1.2	6.5	8.4	7.6	7.0	7.8	7.7	7.8	7.9	7.9	7.9	7.5	6.9	7.8	6.8	4.0	7.0
Termination	-1.8	-2.6	-3.6	-1.7	-4.9	-0.6	-1.4	0.8	-1.7	-1.3	-0.1	-0.5	-4.4	-1.1	-1.7	-2.3	-4.5	-1.7

■ = Criteria met

■ = Criteria not met

# FCW Overview

Test Scenario	Test Speeds (km/h)		Headway (m)	POV Decel. (g)	SV Lateral Overlap (% of POV width)
	SV	POV			
 Lead Vehicle Stopped (LVS)	10, 40, 50, 60, 70, 80	0	--	--	50, 75
 Lead Vehicle Moving (LVM)	40, 50, 60, 70, 80	20	--	--	50, 75
 Lead Vehicle Decelerating (LVD)	50, 80	50, 80 (same as SV)	12, 40	0.3, 0.5	50, 75
 Steel Trench Plate (STP)	40, 80	--	--	--	50
 Pass Through (PT)	40, 80	0	--	--	--



**Note:** 3 repeated trials per test condition were performed

# Example FCW Testing

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# FCW Results

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- Lead vehicle stopped
  - Both motorcycles were not equipped to respond to LVS scenarios.
  - LVS tests were conducted to verify the scenario was performable.
  - No FCWs were observed.
- Steel trench plate and pass-through
  - No FCWs were observed for false positive tests.

# FCW Results

## LVM and LVD, 75% Overlap

2024 BMW R 1300 GS																
TTC at FCW (s)																
Scenario:		LVM - 20			LVD-40-0.3			LVD-40-0.5			LVD-12-0.3			LVD-12-0.5		
SV Speed (km/h):	40	1.8	1.8	1.7												
	50	1.9	1.2	1.9	2.3	2.3	2.8	2.5	2.5	2.6	2.0	2.0	2.0	1.4	1.4	1.4
	60	2.1	1.9	1.7												
	70	1.6	1.8	1.8												
	80	1.8	1.9	1.5	2.7	2.5	3.4	2.8	2.8	2.7	1.8	1.9	1.9	2.4	2.2	

2024 Moto Guzzi Stelvio																
TTC at FCW (s)																
Scenario:		LVM-20			LVD-40-0.3			LVD-40-0.5			LVD-12-0.3			LVD-12-0.5		
SV Speed (km/h):	40	1.8	1.7	1.8												
	50	1.8	1.7	1.7	1.4	1.4	1.3	1.3	0.3	1.3	1.1	1.1	1.2	1.0	0.9	1.0
	60	2.1	1.8	1.8												
	70	2.3	2.3	2.3												
	80	2.2	2.6	2.5	1.6	1.5	1.4	1.3	1.1	1.3						

# Valid test (# = TTC sec)

Planned, but not performed

TTC @ swerve out shown for LVD w/ no FCW present

# FCW Results

## LVM and LVD, 50% Overlap

2024 BMW R 1300 GS																
TTC at FCW (s)																
Scenario:		LVM - 20			LVD-40-0.3			LVD-40-0.5			LVD-12-0.3			LVD-12-0.5		
SV Speed (km/h):	40	1.8	1.8	1.8												
	50	1.9	1.9	1.9	2.7	2.9	2.3	2.5	2.2	2.6	2.2	2.0	2.0	1.4	1.4	1.3
	60	2.1	2.1	2.2												
	70	2.2	2.1	2.1												
	80	2.1	1.8	1.9	3.7	3.2	3.4	2.2	2.7	2.9						

2024 Moto Guzzi Stelvio																
TTC at FCW (s)																
Scenario:		LVM-20			LVD-40-0.3			LVD-40-0.5			LVD-12-0.3			LVD-12-0.5		
SV Speed (km/h):	40	1.8	1.5	1.8												
	50	1.8	1.7	1.6	1.2	1.4	1.1	0.4	0.4	1.4						
	60	2.0	2.0	1.6												
	70	2.3	2.1	2.2												
	80	2.5	2.6	2.0	1.5	1.5	1.5	1.3	1.3	1.1						

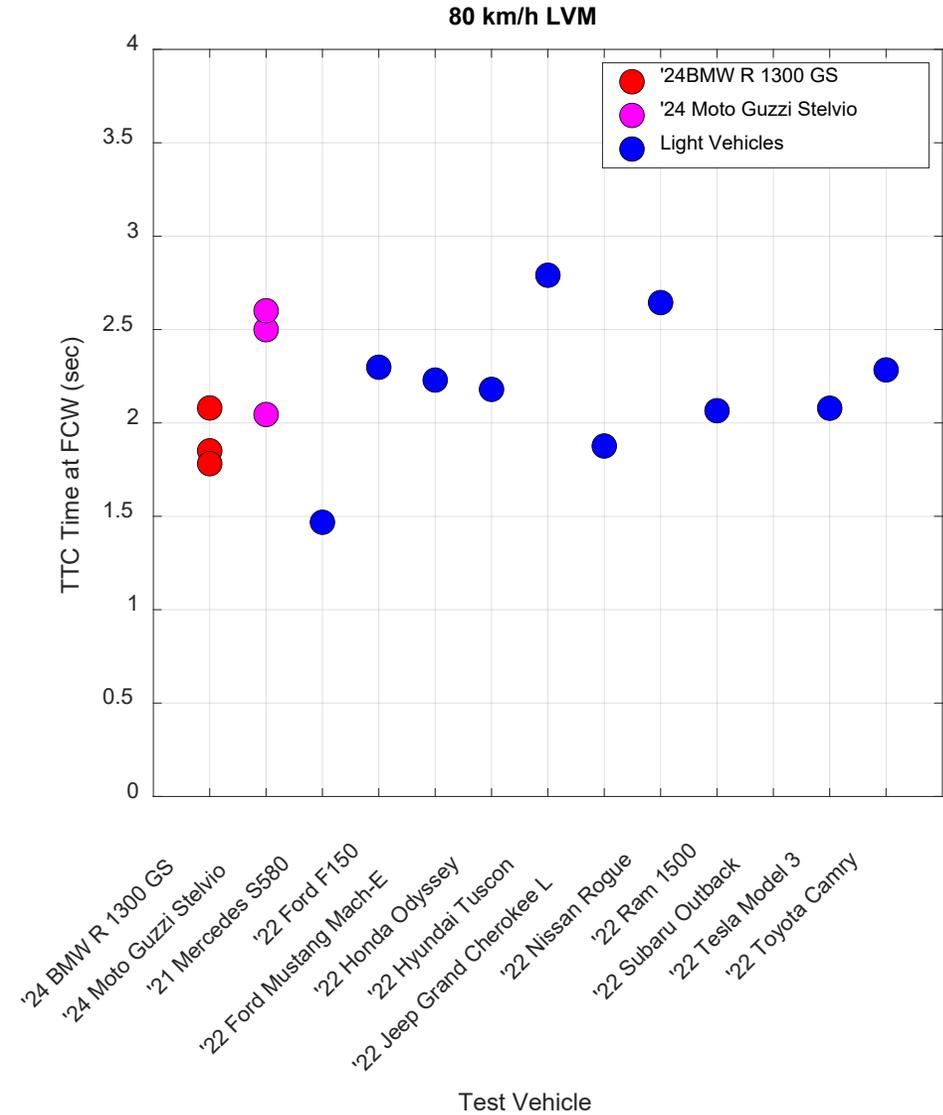
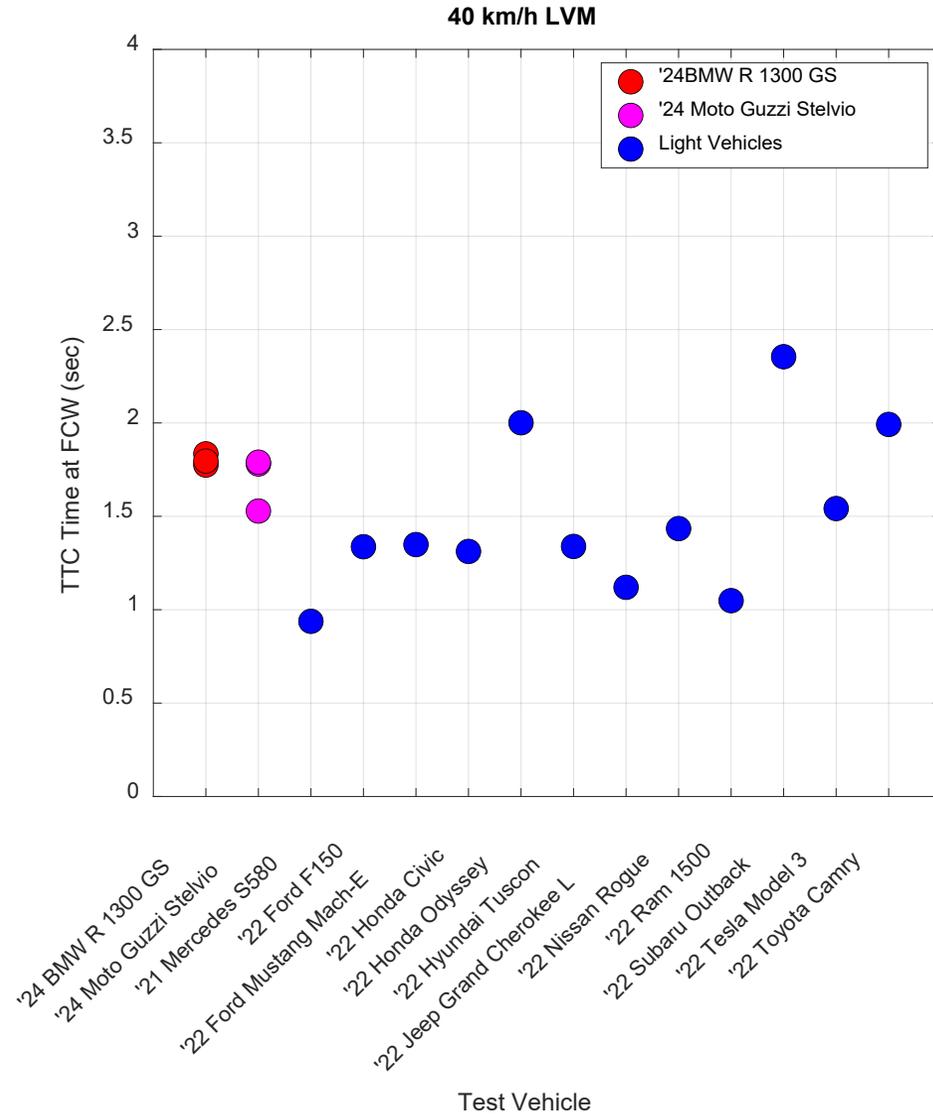
# Valid test (# = TTC sec)

Planned, but not performed

TTC @ swerve out shown for LVD w/ no FCW present

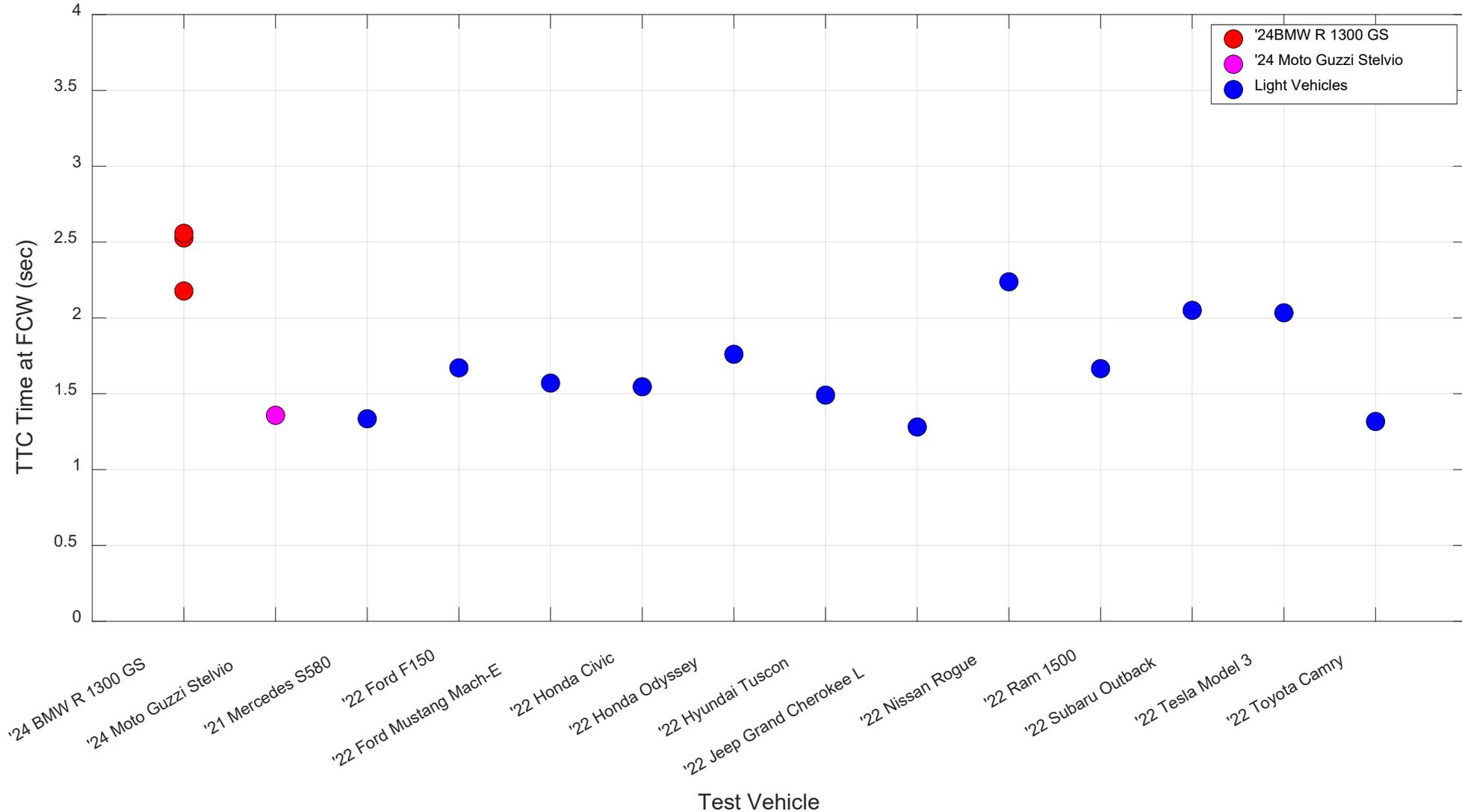
# FCW Comparison

## LVM, 50% Overlap



# FCW Comparison

LVD, 50 km/h, 50% Overlap, 0.5G Decel



# Concluding Remarks

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- The FCW and BSW procedures developed in this study for motorcycle-to-car testing were performable.
- Lane offsets applied during BSW tests can adversely affect system performance.
- Safety concerns observed for FCW LVD tests performed with a 12 m headway.
- Considering motorcycle and light-vehicle FCW timing,
  - The BMW presented warnings within the distribution of the light vehicle FCWs for comparable LVM scenarios. The LVD scenario produced FCWs earlier than light vehicles.
  - The Moto Guzzi presented warnings within the distribution of light vehicle FCWs for each comparable scenario.

# Thank you

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