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Frontal Corner Impacts – Crash Tests and Real-World Experience

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ESAR 2014

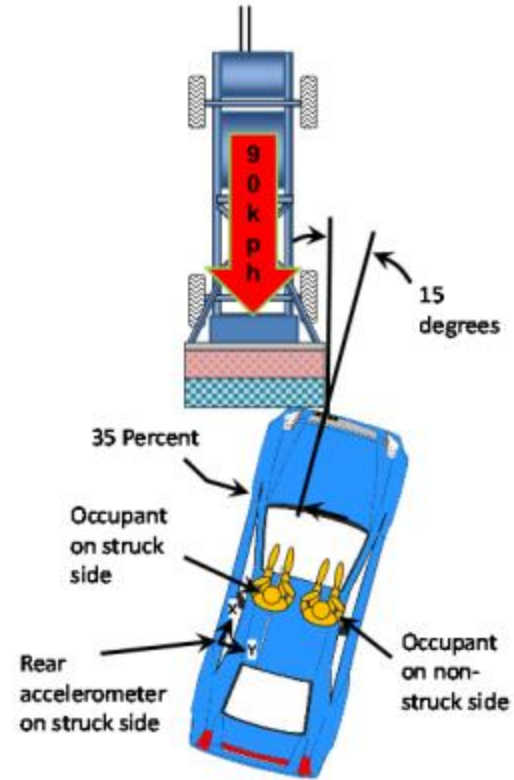
20-21 June, 2014

Safety is our passion - analysis is our specialty

Small-overlap Crash Tests



IIHS Small Overlap Impact (SOI)



NHTSA Oblique-frontal Impact (OBL)

Methodology - NASS

- National Automotive Sampling System (NASS)/
Crashworthiness Data System (CDS)
- 1999-2010 datasets
- Vehicle model year ≥ 2000
- Frontal (F) impacts, 11-01 o'clock PDOF
- Planar, no significant non-frontal secondary impacts
- FL, FY, and FD damage groupings
- Belted drivers
- Exposed population
- MAIS ≥ 3
- Head, face or chest injury

Composition of Driver Sample by Damage Extent

| GAD1/SHL1 DOF GROUP | CDC Extents | Weighted | | | Raw | | |
|------------------------|---------------|-----------|---------------|--------------------------------------|---------|---------|--------------------------------------|
| | | Exposed | MAIS>=3 | AIS Head/Face and/or Chest >=3 | Exposed | MAIS>=3 | AIS Head/Face and/or Chest >=3 |
| FL, PDOF= 11, 12 | 1 to 2 | 5.4% | 3.50% | 2.0% | 4.8% | 2.4% | 2.6% |
| | 3 to 6 | 4.8% | 6.58% | 3.9% | 5.4% | 6.3% | 6.1% |
| | 7 to 9 | 1.9% | 5.12% | 3.2% | 2.3% | 6.0% | 7.2% |
| FY, PDOF= 11, 12 | 1 to 2 | 10.0% | 7.05% | 11.7% | 9.8% | 3.4% | 2.0% |
| | 3 to 6 | 1.4% | 13.59% | 12.1% | 3.3% | 12.6% | 13.5% |
| | 7 to 9 | 0.1% | 0.07% | 0.1% | 0.1% | 0.4% | 0.9% |
| FD, PDOF= 11, 12, 01 | 1 to 2 | 45.1% | 14.70% | 10.9% | 40.1% | 16.6% | 11.5% |
| | 3 to 6 | 4.0% | 31.05% | 31.7% | 8.2% | 31.6% | 34.6% |
| | 7 to 9 | 0.1% | 1.65% | 1.7% | 0.6% | 3.2% | 4.9% |
| OTHER | 1 to 2 | 17.8% | 6.93% | 9.1% | 16.6% | 5.5% | 4.0% |
| | 3 to 6 | 7.2% | 8.21% | 10.7% | 7.3% | 10.1% | 10.7% |
| | 7 to 9 | 2.1% | 1.55% | 2.7% | 1.5% | 1.9% | 2.0% |
| All | | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| Population Counts | | 3,219,979 | 57,924 | 26,217 | 8,664 | 746 | 347 |

EDR Field/Crash Test Data

Field Data (~7,300 EDR reports)

- NASS calendar years 2001-2010
(belted drivers)
- NASS calendar years 2011-2012
(all EDR-equipped vehicles)

Crash Test Data (255 EDR reports)

- NHTSA Crash Test Vehicle Database
- NHTSA SOI and OBL tests

EDR – Sample Outputs

CDR File Information

| | |
|----------------------------|--------------------------------|
| User Entered VIN | 3GCPCPEA7CG248097 |
| User | |
| Case Number | RC0185 |
| EDR Data Imaging Date | 05/17/2013 |
| Crash Date | |
| Collected with CDR version | Crash Data Retrieval Tool 10.2 |
| Reported with CDR version | Crash Data Retrieval Tool 10.2 |
| EDR Device Type | Airbag Control Module |
| Event(s) recovered | Deployment |

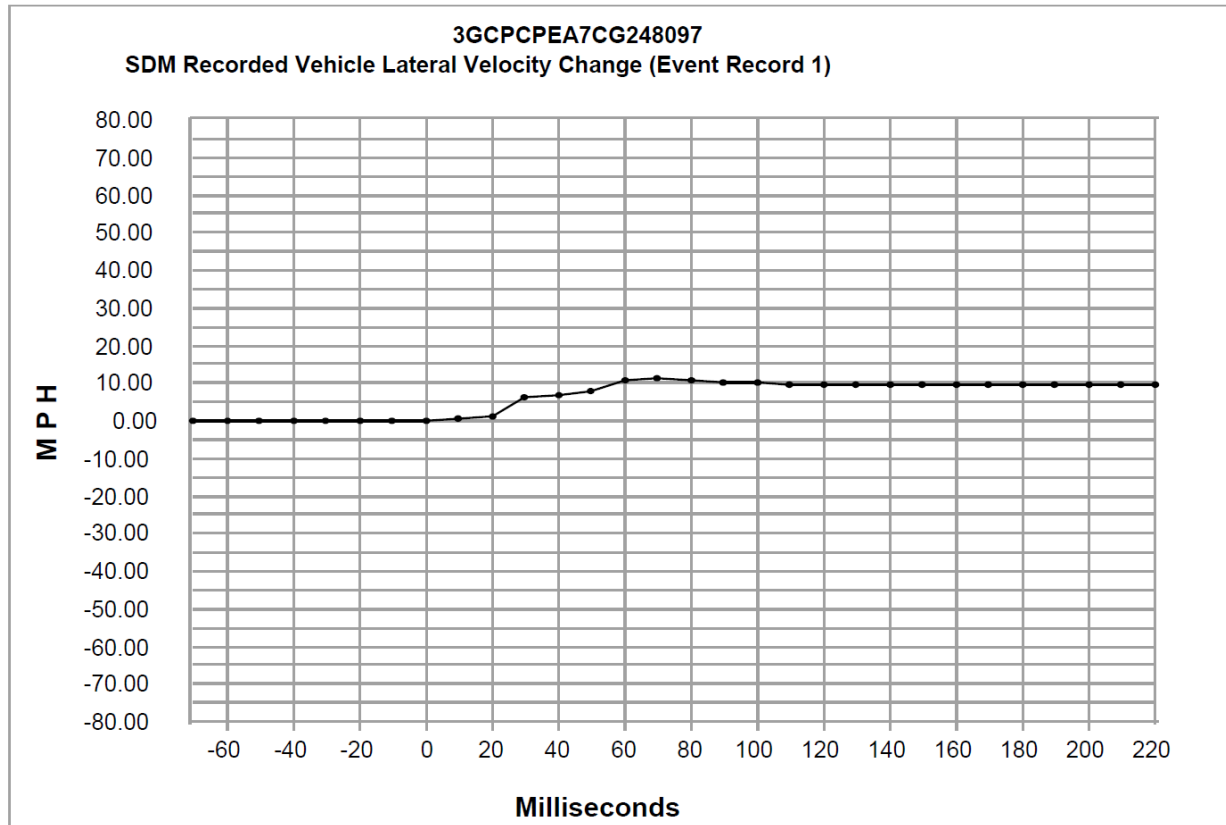
| | |
|---|------------------|
| Safety Belt Status, Driver | ON |
| Safety Belt Status, Front Passenger | ON |
| Occupant Size Classification, Front Passenger | AM50 (Not Child) |
| Frontal Airbag Suppression Switch Status, Front Passenger | SNA |

| | |
|--|-----------|
| Longitudinal SDM Recorded Vehicle Velocity Change at time of Maximum SDM Recorded Vehicle Velocity Change MPH [km/h] | -25 [-41] |
| Lateral SDM Recorded Vehicle Velocity Change at time of Maximum SDM Recorded Vehicle Velocity Change MPH [km/h] | 10 [16] |
| Time From Frontal Algorithm Enable to Pretensioner Event Severity Met (msec) | 6 |
| Time From Frontal Algorithm Enable to 1st Stage Frontal Event Severity Met (msec) | 11 |
| Time From Frontal Algorithm Enable to 2nd Stage Frontal Event Severity Met (msec) | 11 |

EDR – Sample Outputs

| | |
|---|-----|
| Frontal Airbag Deployment, Time to 1st Stage Deployment, Driver (msec) | 17 |
| Frontal Airbag Deployment, Time to 1st Stage Deployment, Front Passenger (msec) | 17 |
| Pretensioner Deployment, Time to Fire, Driver (msec) | 6 |
| Pretensioner Deployment, Time to Fire, Front Passenger (msec) | 6 |
| Frontal Airbag Deployment, Time to 2nd Stage, Driver (msec) | 27 |
| Frontal Airbag Deployment, Time to 2nd Stage, Front Passenger (msec) | 27 |
| Active Head Restraint, Time to Deploy, Driver (msec) | SNA |
| Active Head Restraint, Time to Deploy, Front Passenger (msec) | SNA |
| Side Curtain Airbag Deployment, Time to Deploy, Driver (msec) | 17 |
| Side Curtain Airbag Deployment, Time to Deploy, Passenger (msec) | 17 |
| Rear Window Airbag Deployment, Time to Deploy (msec) | SNA |

EDR – Sample Outputs

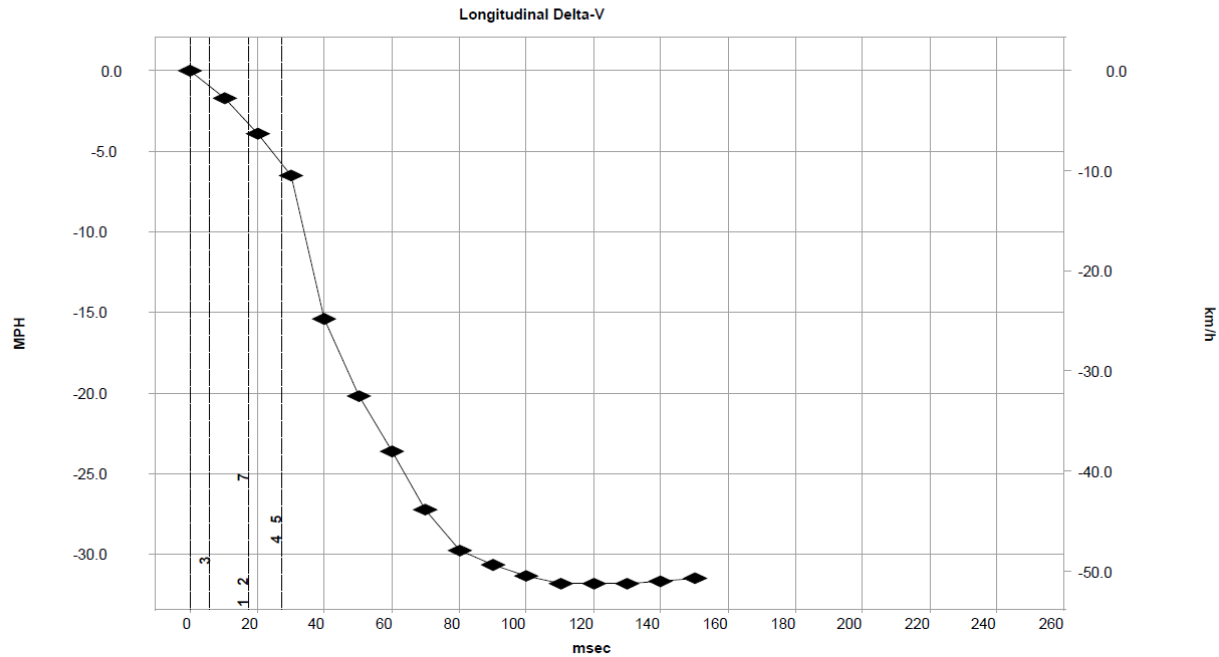


EDR – Sample Outputs

| Time (msec) | Delta-V, lateral (MPH) | Delta-V, lateral (km/h) |
|-------------|------------------------|-------------------------|
| -70 | 0.0 | 0.0 |
| -60 | 0.0 | 0.0 |
| -50 | 0.0 | 0.0 |
| -40 | 0.0 | 0.0 |
| -30 | 0.0 | 0.0 |
| -20 | 0.0 | 0.0 |
| -10 | 0.0 | 0.0 |
| 0 | 0.0 | 0.0 |
| 10 | 0.6 | 1.0 |
| 20 | 1.2 | 2.0 |
| 30 | 6.2 | 10.0 |
| 40 | 6.8 | 11.0 |
| 50 | 8.1 | 13.0 |
| 60 | 10.6 | 17.0 |
| 70 | 11.2 | 18.0 |
| 80 | 10.6 | 17.0 |
| 90 | 9.9 | 16.0 |
| 100 | 9.9 | 16.0 |
| 110 | 9.3 | 15.0 |
| 120 | 9.3 | 15.0 |
| 130 | 9.3 | 15.0 |

EDR – Sample Outputs

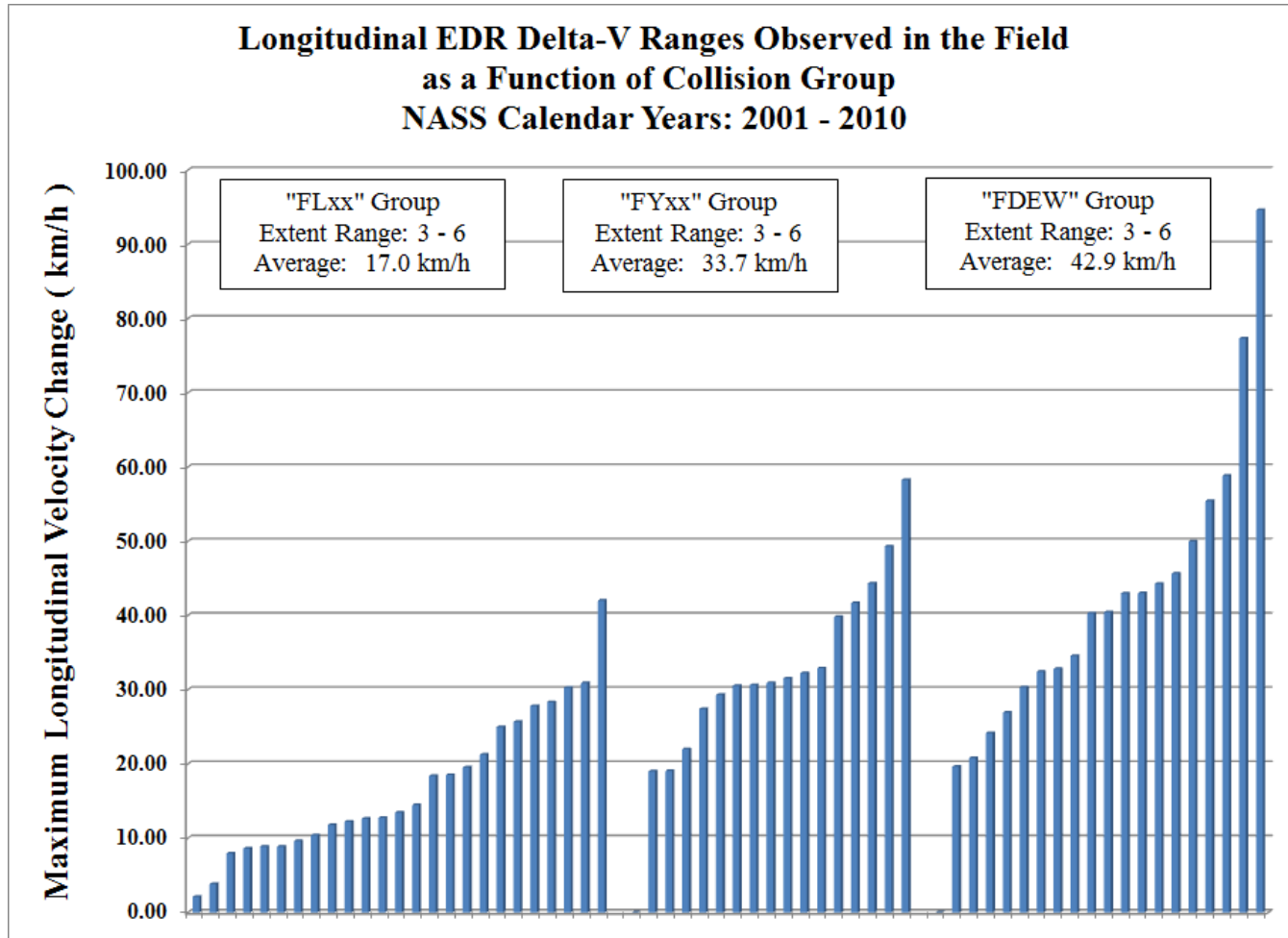
| | |
|--|-------------|
| Length of Delta-V (msec) | 150 |
| Max. Longitudinal Delta-V (MPH [km/h]) | -32 [-51.6] |
| Time, Maximum Delta-V, Longitudinal (msec) | 123 |
| Power Supply Status at Max. Delta-V | ON |



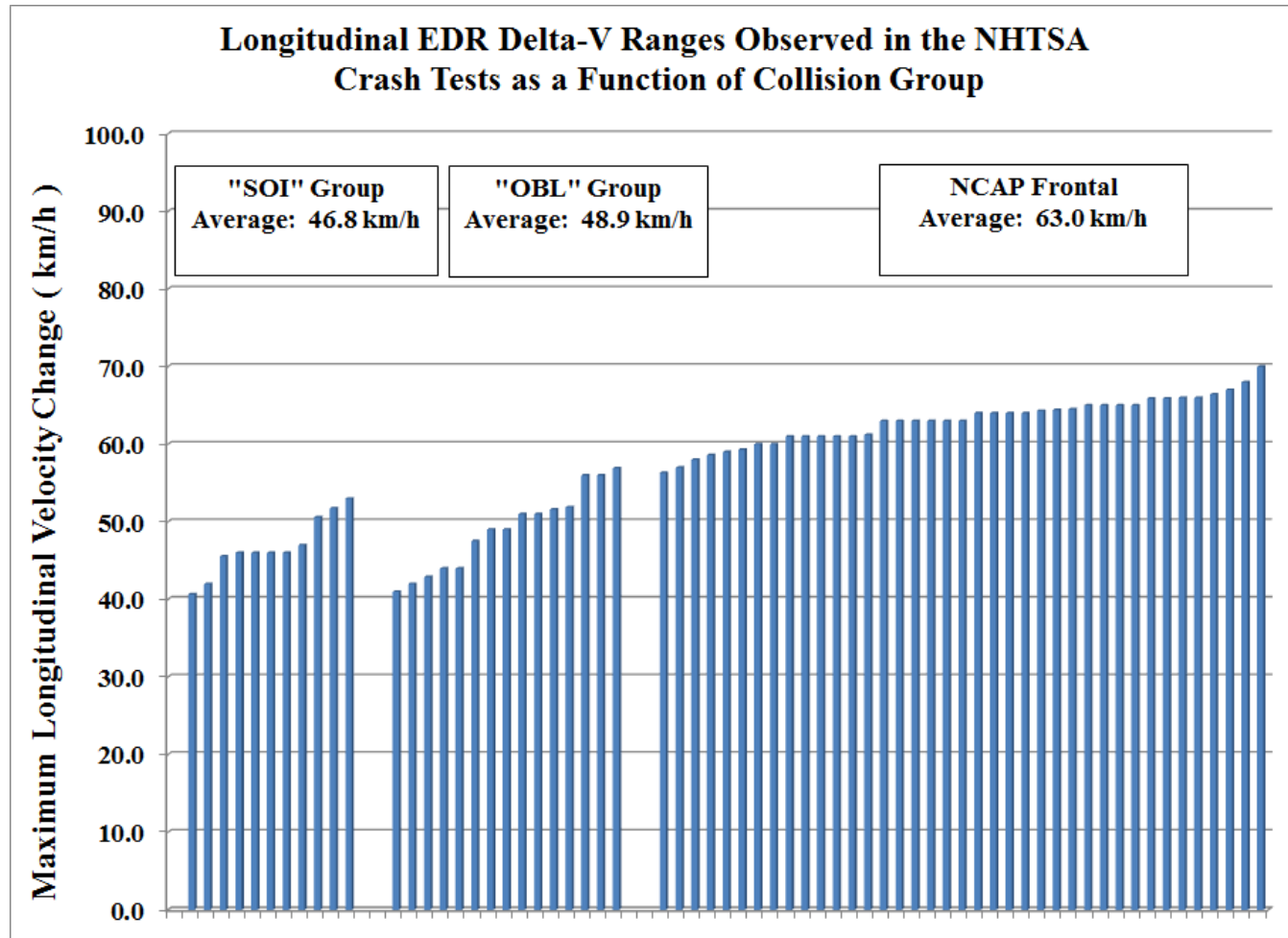
Deployment Time Marker Key

| | |
|---|---|
| 1 | Driver Airbag Deployment Time |
| 2 | Passenger Airbag Deployment Time |
| 3 | Driver/Passenger Pretensioner |
| 4 | Driver 2nd Stage Airbag Deployment Time |
| 5 | Passenger 2nd Stage Airbag Deployment |
| 6 | Driver/Passenger AHR |
| 7 | Driver/Passenger CSA |
| 8 | Rear Window Airbag Deployment Time |

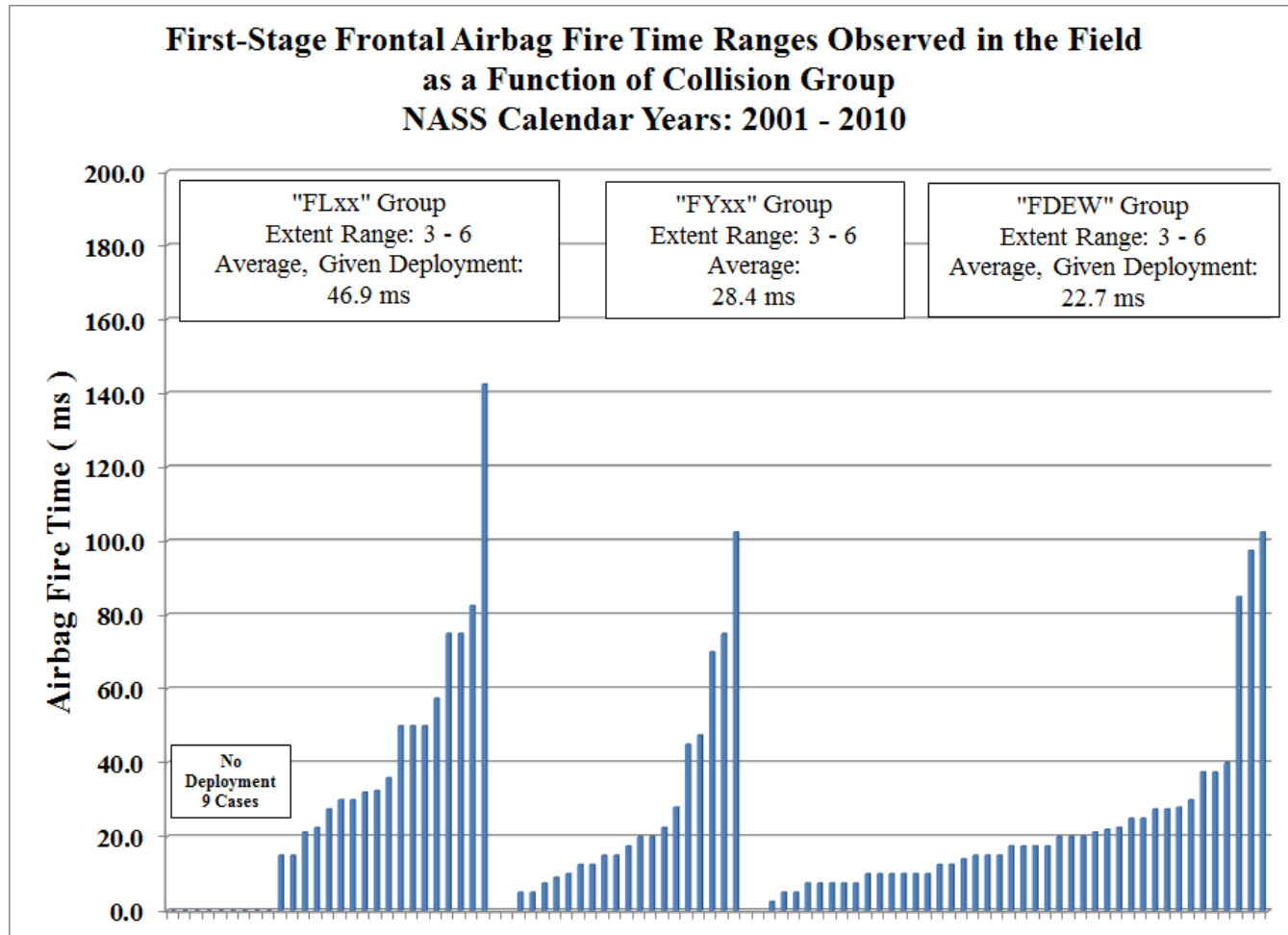
Longitudinal ΔV (Field)



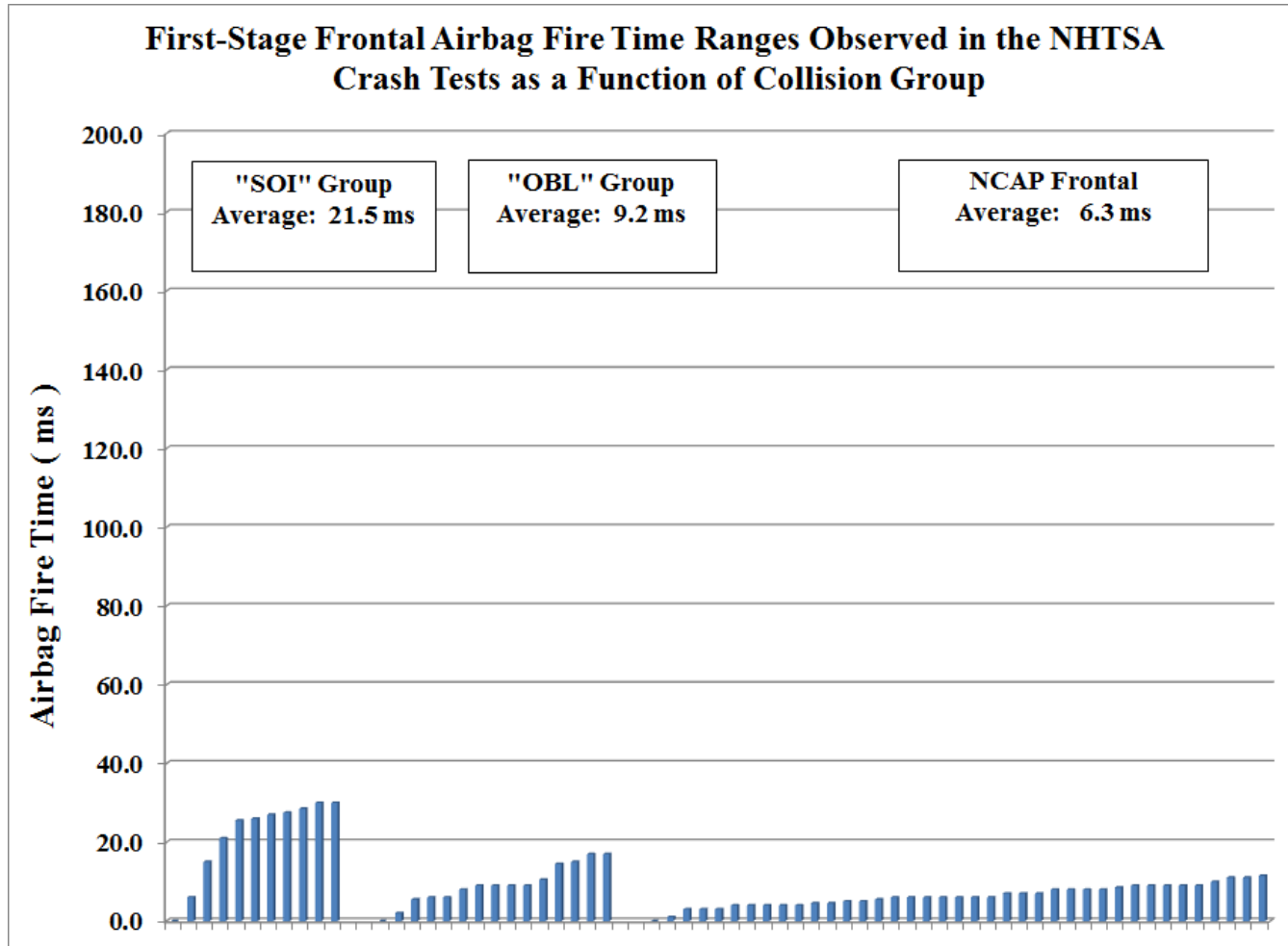
Longitudinal ΔV (Crash Tests)



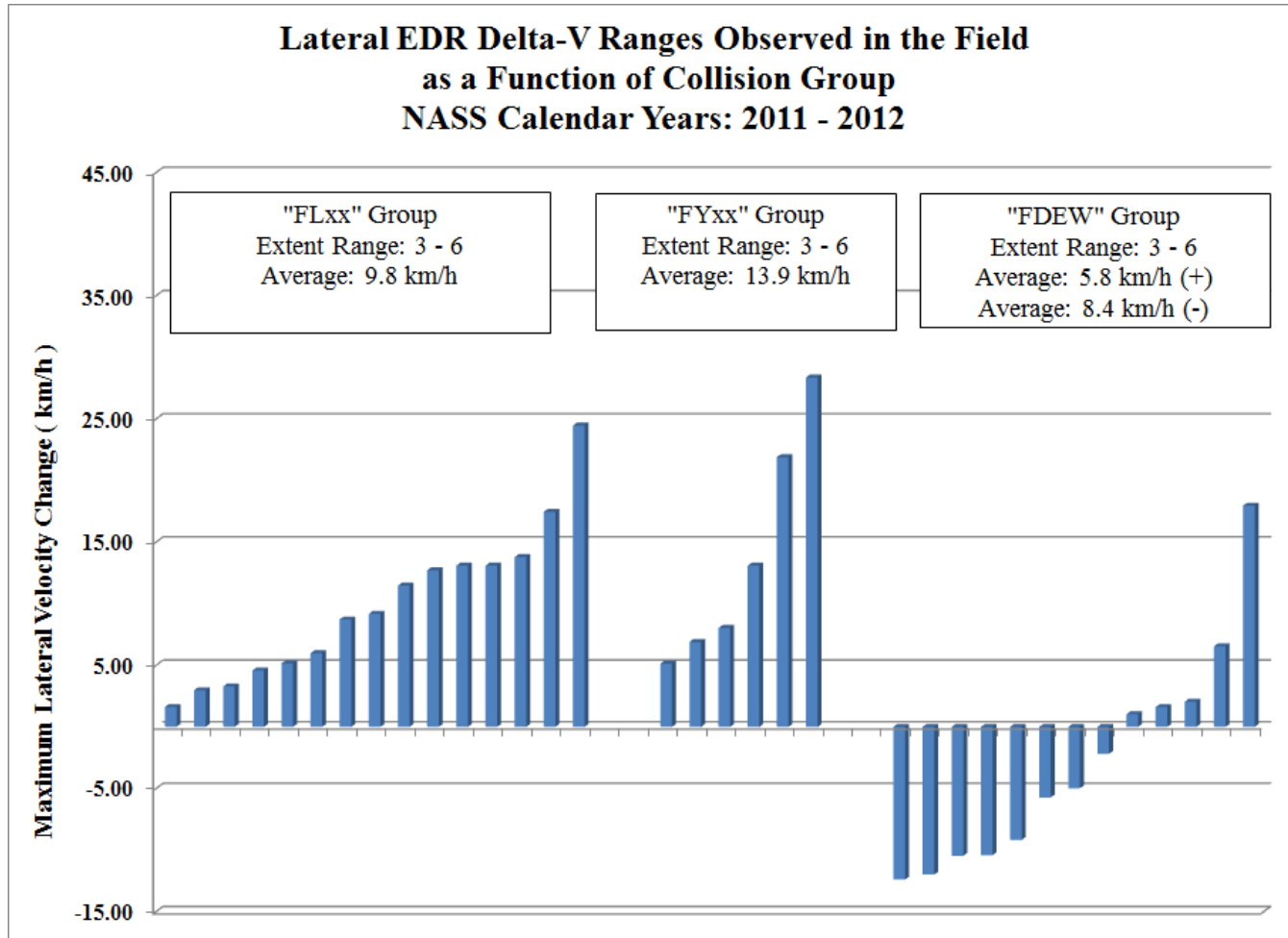
Firing Times (Field)



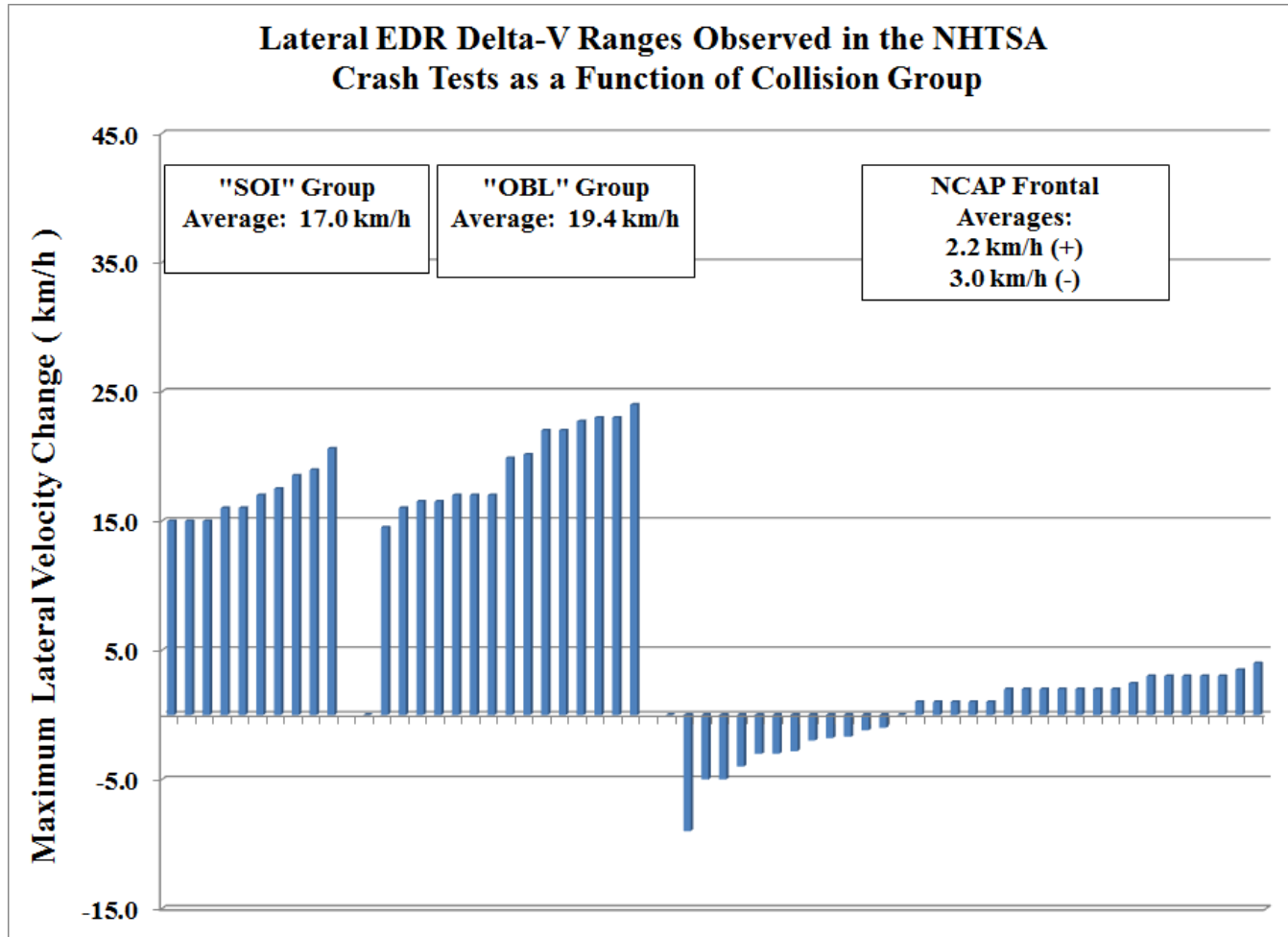
Firing Times (Crash Tests)



Lateral ΔV (Field)



Lateral ΔV (Crash Tests)



NASS Case Studies



| | | | | | | | | | | | | | | | |
|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Time (milliseconds) | -70 | -60 | -50 | -40 | -30 | -20 | -10 | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 |
| SDM Lateral Axis Recorded Velocity Change (MPH) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.68 | 0.68 | 2.71 | 6.78 | 10.84 | 11.52 | 13.55 | 17.62 | 16.94 | 16.26 |
| Time (milliseconds) | 80 | 90 | 100 | 110 | 120 | 130 | 140 | 150 | 160 | 170 | 180 | 190 | 200 | 210 | 220 |
| SDM Lateral Axis Recorded Velocity Change (MPH) | 16.26 | 16.94 | 16.94 | 17.62 | 17.62 | 17.62 | 17.62 | 17.62 | 17.62 | 17.62 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

NASS Case Studies



| Time (msec) | Lateral Delta-V, Airbag ECU Sensor (MPH [km/h]) |
|-------------|---|
| -24 | 0.2 [0.3] |
| -18 | 0.4 [0.7] |
| -12 | 0.6 [1.0] |
| -6 | 0.4 [0.7] |
| 0 | 0.6 [1.0] |
| 6 | 1.0 [1.7] |
| 12 | 1.4 [2.3] |
| 18 | 1.4 [2.3] |
| 24 | 3.1 [5.0] |
| 30 | 6.0 [9.6] |
| 36 | 8.0 [13.0] |
| 42 | 10.5 [16.9] |
| 48 | 12.8 [20.6] |
| 54 | 13.6 [21.9] |

Summary

- EDR's – a powerful tool for safety research
- Quantify the residual safety problem
- Assist in developing and validating test protocols
- Implement field-relevant testing protocols to optimize vehicle safety systems
- Preliminary evidence suggests MDB test protocols addressing frontal corner impacts would benefit from changes to shape, stiffness, and mass of the barrier, and a reduced impact angle

NASS Case Studies



| NASS_ACCID | VIEW CASE | NASS_VEHID | VIEW EDR REPORT |
|-------------|-----------------------------|-----------------|---------------------------------|
| 2011-08-192 | 2011-08-192 | 2011-08-192-V01 | 2011-08-192-V01 |

| | | | | | | | | | | | | | | | |
|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Time (milliseconds) | -70 | -60 | -50 | -40 | -30 | -20 | -10 | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 |
| SDM Lateral Axis Recorded Velocity Change (MPH) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.68 | 0.68 | 2.71 | 6.78 | 10.84 | 11.52 | 13.55 | 17.62 | 16.94 | 16.26 |
| Time (milliseconds) | 80 | 90 | 100 | 110 | 120 | 130 | 140 | 150 | 160 | 170 | 180 | 190 | 200 | 210 | 220 |
| SDM Lateral Axis Recorded Velocity Change (MPH) | 16.26 | 16.94 | 16.94 | 17.62 | 17.62 | 17.62 | 17.62 | 17.62 | 17.62 | 17.62 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |



Thank You