

NHTSA

NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

Limousine Crashworthiness Research

SAE Government Industry Meeting

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Agenda

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1. Real-world Incidents
2. Congressional Pull
3. Research Projects
4. Limousine Crashworthiness
5. Frontal Barrier Results
6. Limousine Seat Research
7. Limousine Market Study
8. Next Steps

Note: This presentation is published in the interest of advancing motor vehicle safety research. While the information may provide results from research or tests using specifically identified motor vehicle models, it is not intended to make conclusions about the safety performance or safety compliance of those motor vehicles, and no such conclusions should be drawn.

Real-World Incidents

- **Schoharie, NY**[1] – A stretch limousine with failed brakes sped down a steep grade. It struck a parked SUV at over 100 mph, and crashed into a ravine, killing all 18 occupants and 2 pedestrians.

- **Cranbury, NJ**[2] – A tractor-trailer failed to slow for queued traffic and struck a limo van, triggering a multi-vehicle crash that killed one passenger and seriously injured four others. Post-crash, the limo van's sliding door was jammed closed and facing upwards. There were no other emergency exits, which forced first responders to cut the privacy wall to gain access to the rear passengers.

- **Bryce Canyon City, UT**[3] – A medium-size bus departed the roadway at highway speed, overcorrected, rolled onto its side, struck a guardrail, and completed a full rollover. The NTSB found that the bus's roof structure deformed and collapsed during the rollover, compromising passenger survival space and contributing to fatal and serious injuries.

- **Suffolk County, NY**[4] – A stretch limousine attempted a U-turn, but it was struck by a pickup traveling at an estimated 51-56 mph. The Grand Jury report indicated that the limo had major structural deficiencies in the welding and anti-intrusion beam structure which likely contributed to the injuries and fatalities.


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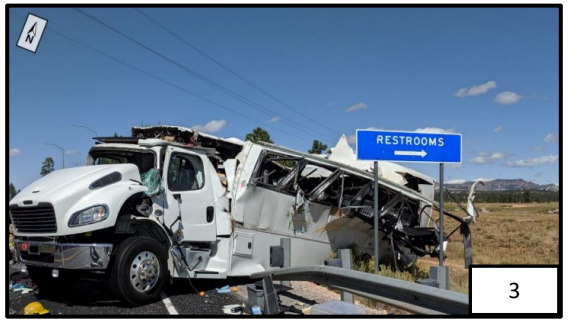

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Congressional Pull. IIJA § 23015.[5]

- **Crashworthiness Research**: Research into the development of motor vehicle safety standards for side impact protection, roof crush resistance, and air bag systems for the protection of occupants in limousines with alternative seating positions, including perimeter seating arrangements.
- Resulting in Safety Standards or Report to Congress on limousine side impact, roof crush, and air bags.

- **Seat and Seat belts**: Research seat belt and vehicle seat performance in limousines

SEC. 23015. LIMOUSINE RESEARCH.

Deadlines. 49 USC 30111 note.

(a) DEFINITIONS.—In this section:

(1) LIMOUSINE.—The term "limousine" means a motor vehicle—

(A) that has a seating capacity of 9 or more persons (including the driver);

(B) with a gross vehicle weight rating greater than 10,000 pounds but not greater than 26,000 pounds;

(C) that the Secretary has determined by regulation has physical characteristics resembling—

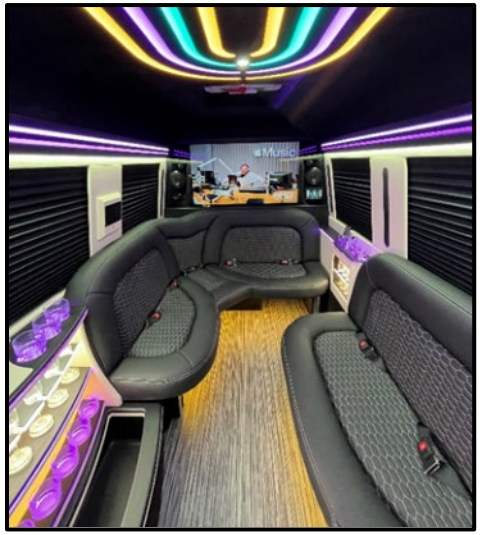
(i) a passenger car;

(ii) a multipurpose passenger vehicle; or

(iii) a truck with a gross vehicle weight rating of 10,000 pounds or less; and

(D) that is not a taxi, nonemergency medical, or para-transit motor vehicle.

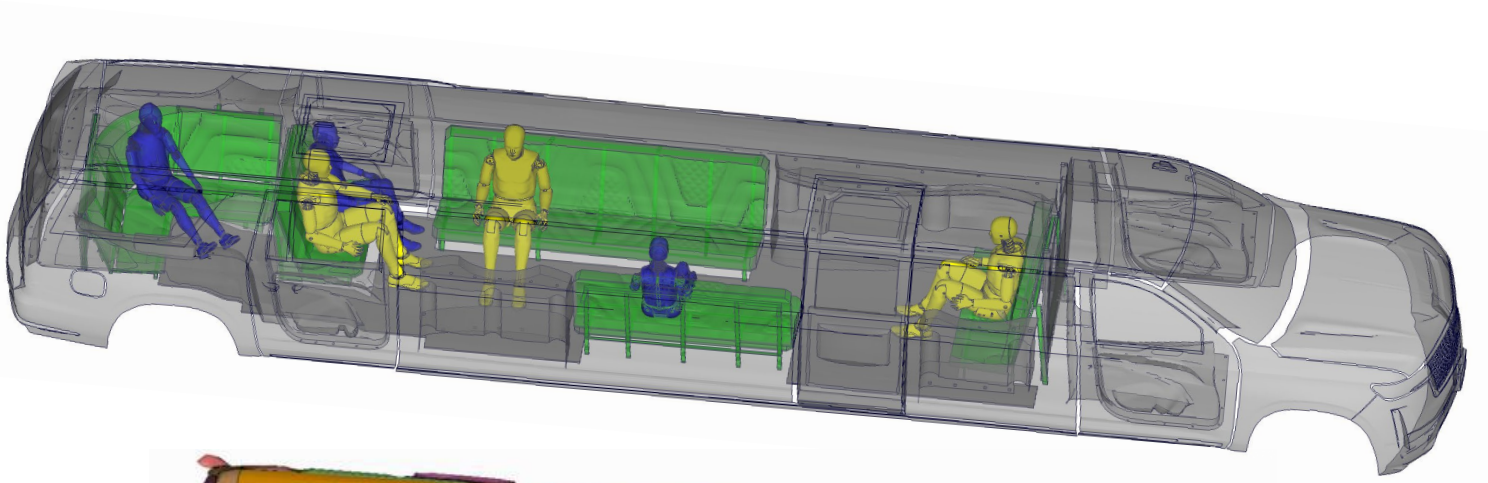






Research Projects

- **Limousine Crashworthiness Modeling**:
  - Develop two new validated limousine vehicle finite element models.
  - Stretch limousine fabricated from Cadillac Escalade.
  - Van-conversion limousine upfitted from Mercedes Sprinter.
  - Study limousine and occupant responses over a rang of crash scenarios, occupant sizes, seating positions, and restraints.



- **Seat and Seat belt Research**:
  - Study limousine seat performance under standardized conditions.
  - Confirm FMVSS test procedures apply to limousine vehicle environment.
  - Refine seat and seat belt FE models.



- **Limousine Market Study**:
  - Characterize the limousine market.
  - Interview limo fleet operators and fabricators to identify limousine vehicle characteristics related to evacuation, seating, and restraints.

Limo Crashworthiness Objectives

Objectives:

- Develop Escalade and Sprinter FEA models.
- Validate structure, interior, and restraints models under frontal-, side-impacts, and roof crush.
- Study limousine crash performance across range of crash scenarios, occupant sizes, and seating positions.
- Investigate various generic restraint designs to improve our understanding of rear cabin occupant safety.
- Compare Roof Crush procedures and the structural upgrades necessary to meet FMVSS 216 and/or 226.

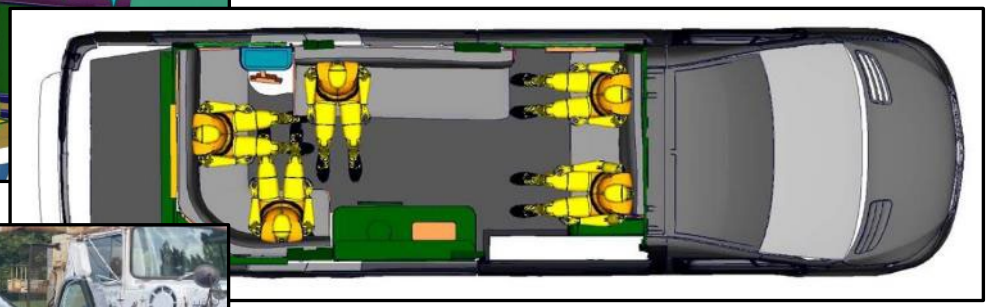
Add'l value add:

- Models could be used to study unconventional seating configurations (e.g., side- and rear-facing vehicle seats), like those seen in motorcoaches and certain ADS-equipped vehicles.







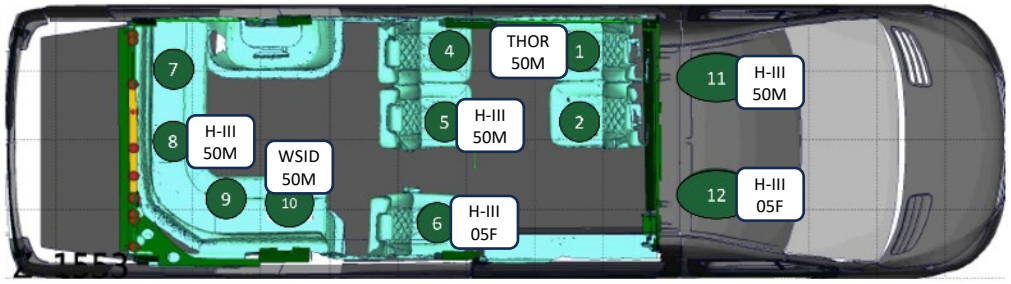








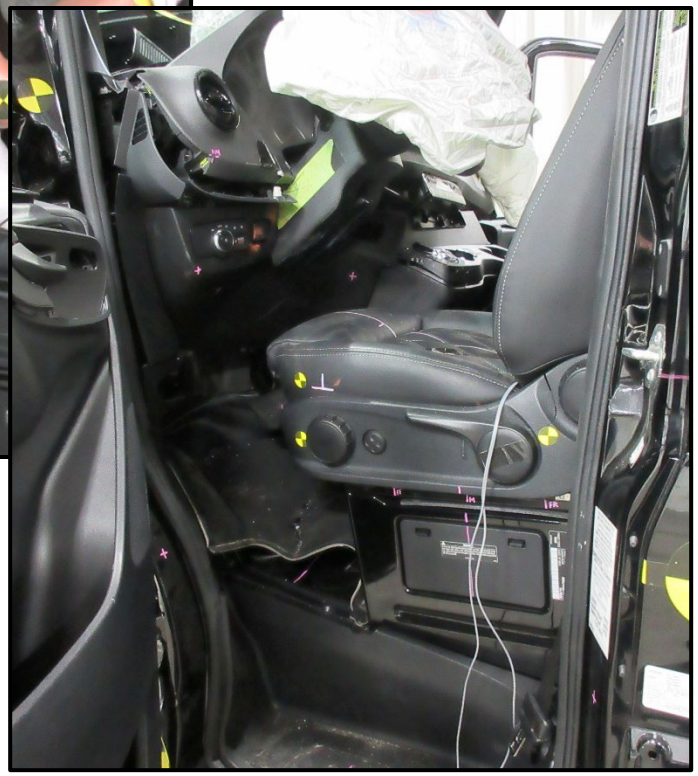
Sprinter, FFRB Summary



P11: H3-50th driver. Standard frontal kinematics. Significant floor deformation and acceleration pedal detached.
P12: H3-5th passenger. Standard frontal kinematics. Significant intrusion.







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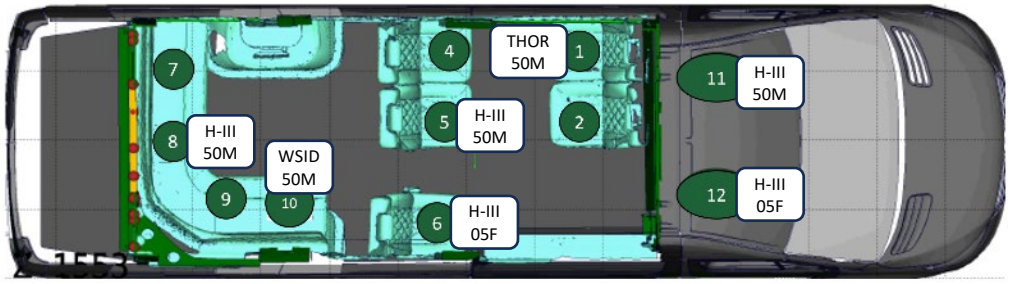
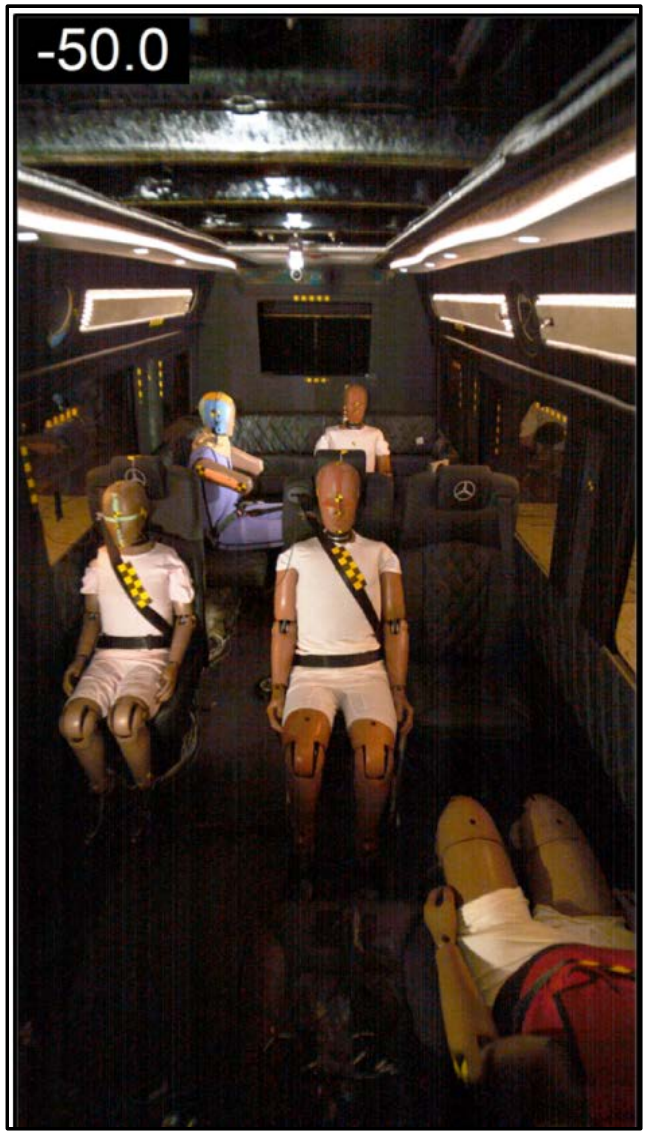
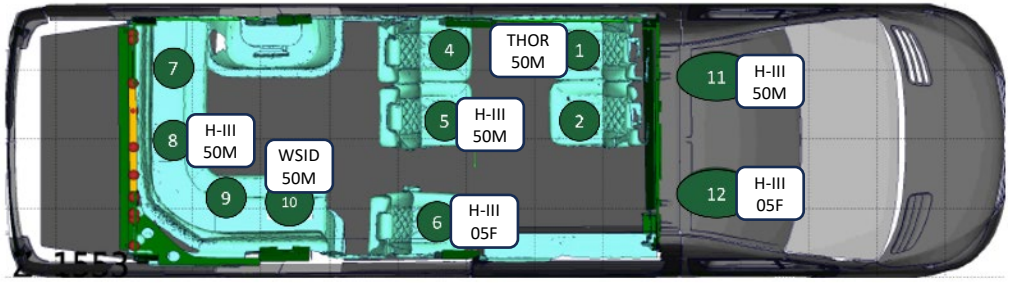




P1:THOR-50M. Stiff seatback and head contact to divider wall
P5: H3-50th. Partial seat collapse. Submarining. Near-miss head-to-leg.
P6: H3-5th. Partial seat collapse. Submarining.
P8: H3-50th, reinforced L-bench seat structure and belt anchorages, lap belt only. Head-to-leg contact. Seatback detached.
P10: WSID-50M, reinforced seat and belt structure, lab belt. High lap belt loads. Lower spine assembly separated. Head contact to forward seatback.



Sprinter, FFRB Results

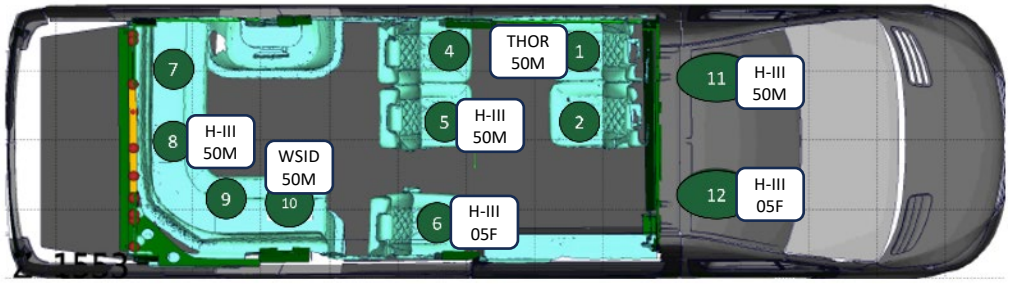


Injury Criteria	Driver H3-50M (11)		Pass H3-AF05 (12)	
	Threshold	Result	Threshold	Result
HIC15	700	574	700	327
NIJ	1	0.425	1	0.387
Neck Tension (N)	4170	2148.5	2620	1303
Neck Comp (N)	-4000	-969.7	-2520	-399.6
3ms Chest Clip (g)	60	39.7	60	36.2
Chest Deflection (mm)	63	40.9	52	QD
Left Femur Force (N)	-10000	-2961.2	-6805	-2394.9
Right Femur Force (N)	-10000	-3564.5	-6805	-1562.6

Front row:

- Both Driver and Front Passenger met 208 criteria for FFRB at 35 mph.
- Pos 12: Chest deflection pot anomaly

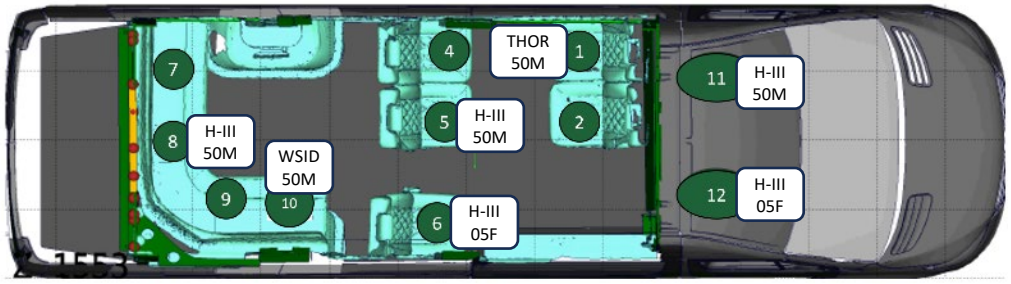
Sprinter, FFRB Results



Injury Criteria	THOR-50M (1)		H3-AM50 (5)		H3-AF05 (6)		H3-50M (8)	
	Threshold*	Result	Threshold	Result	Threshold	Result	Threshold	Result
HIC15	700	167	700	280	700	124	700	QD **
NIJ	0.88	0.436	1	0.333	1	0.642	1	0.62
Neck Tension (N)	3842	879.9	4170	1609.9	2620	1260.9	4170	2516.6
Neck Comp (N)	-3799	-940.7	-4000	-47.2	-2520	-157.3	-4000	-2960
3ms Chest Clip (g)	60	53.3	60	26.4	60	28.1	60	29.7
Chest Deflection (mm)	58.8	22.0	63	39.9	52	23.6	63	7.2
Left Femur Force Compression (N)	-9450	-543.5	-10000	-6930.2	-6805	-1100	-10000	-523.9
Right Femur Force Compression (N)	-9450	-647.5	-10000	-1125.9	-6805	-1162.9	-10000	-466
Left Femur Force Tension (N)	N/A	184.8	N/A	1424.6	N/A	1498.1	N/A	5838.3
Right Femur Force Tension (N)	N/A	322.3	N/A	1730.5	N/A	3439.8	N/A	6158.2

* Proposed THOR IARV's, ** Position 8: Head X data anomaly, *** Position 10 IARV's and results not listed due to lost data.

Sprinter, FFRB Results



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Left Femur Force Tension (N)	N/A	184.8	N/A	1424.6				
Right Femur Force Tension (N)	N/A	322.3	N/A	1730.5				

Rear Cabin:

- Position #1 THOR-50M Chest Clip at 53.3 / 60 g.
- Position #5 H3-AM50 and Position #6 H3-AF05 met FMVSS No. 208 criteria.
- Position #8 H3-AM50 met 208 criteria. HIC not included, due to Head_Ax sensor anomaly.
- Position #10 data anomaly. All WSID data lost.

* Proposed THOR IARV's, ** Position 8: Head X data anomaly, *** Position 10 IARV's and results not listed due to lost data.

Limousine Seating Research

Objectives:

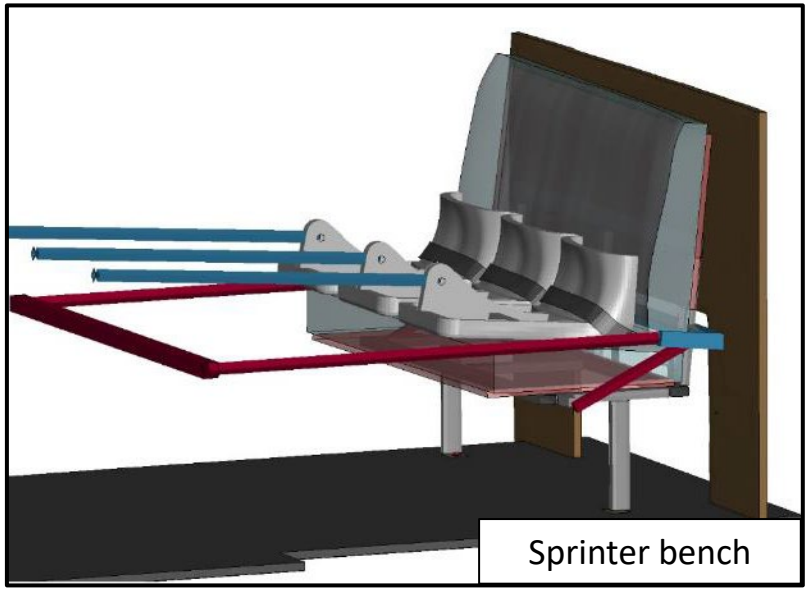
- Confirm FMVSS test procedures apply to limousine vehicle environment.
- Study limousine seat performance under standardized conditions.
- Refine seat and seat belt FE models.

Results:

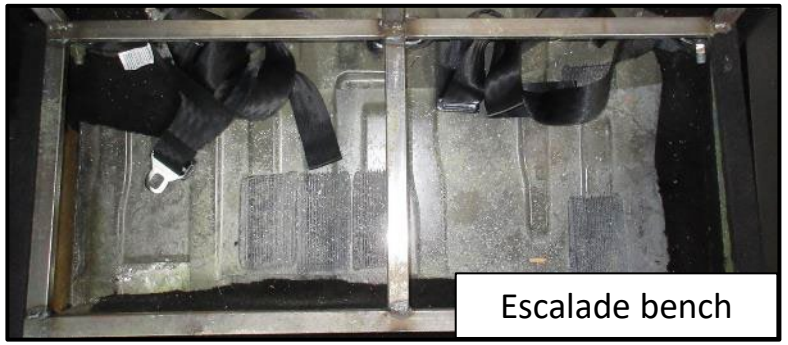
- Applied FMVSS No. 207/210 procedures to limousine seats successfully using rigid floor plate.
- Sprinter bench and captain's chairs failed FMVSS 207/210, even though aftermarket seat supplier provided passing test report.
- Escalade seats welded to floor. May test post-crash vehicle seats in future. Plans TBD.



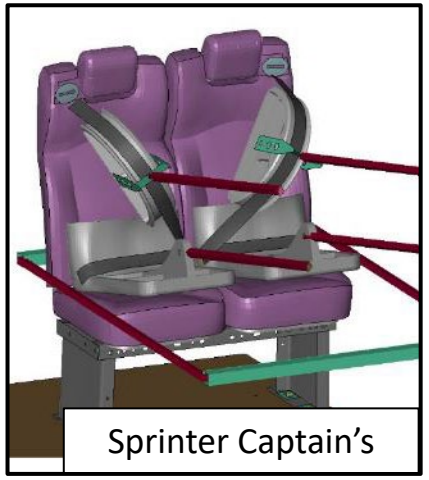
Escalade bench



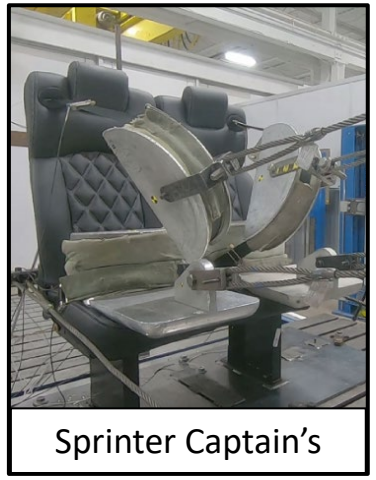
Sprinter bench



Escalade bench



Sprinter Captain's



Sprinter Captain's

Limousine Market Study

Objectives:

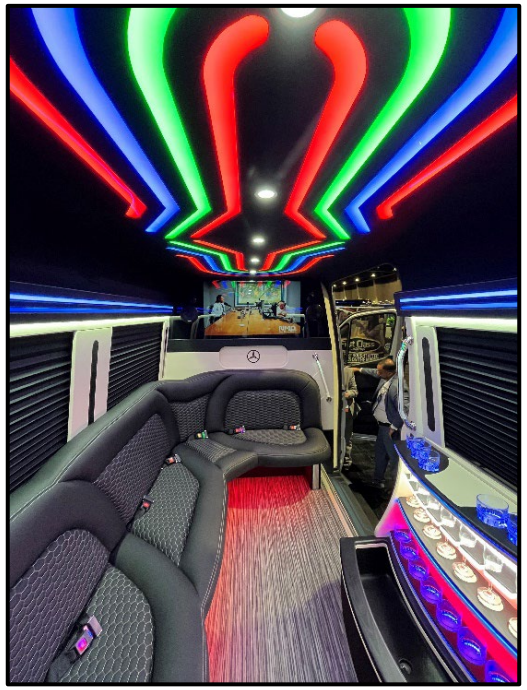
- Characterize the limousine market.
- Interview limo fleet operators and fabricators to identify limousine vehicle characteristics related to evacuation, seating, and restraints.

Filtering:

- Commercial vehicle registration database,
- Standard Industrial Classification (SIC).
- Ownership list to include various key words associated with limousines.
- Model Year 2018+.
- Removed Class 4 - Class 8 trucks.

Limitations:

- Limousine vehicle market opaque, due to “modified” (aftermarket) vehicles.
- Fabricators are decentralized, which could yield significant variation in mfg. processes.
- OEMs eliminated original vehicles. Market changing rapidly.





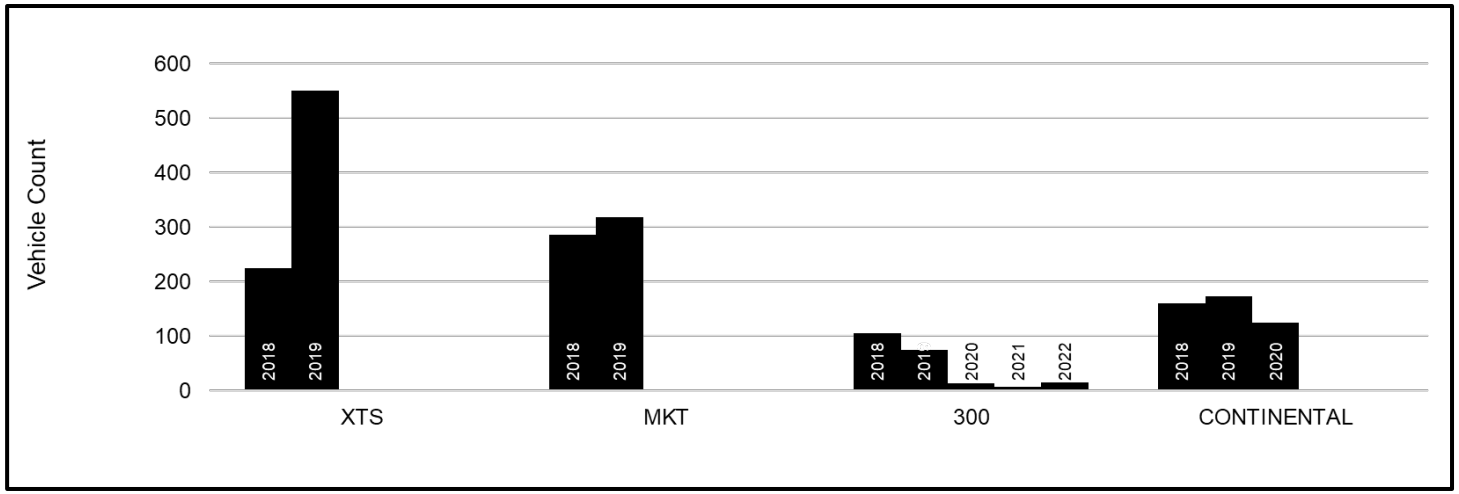


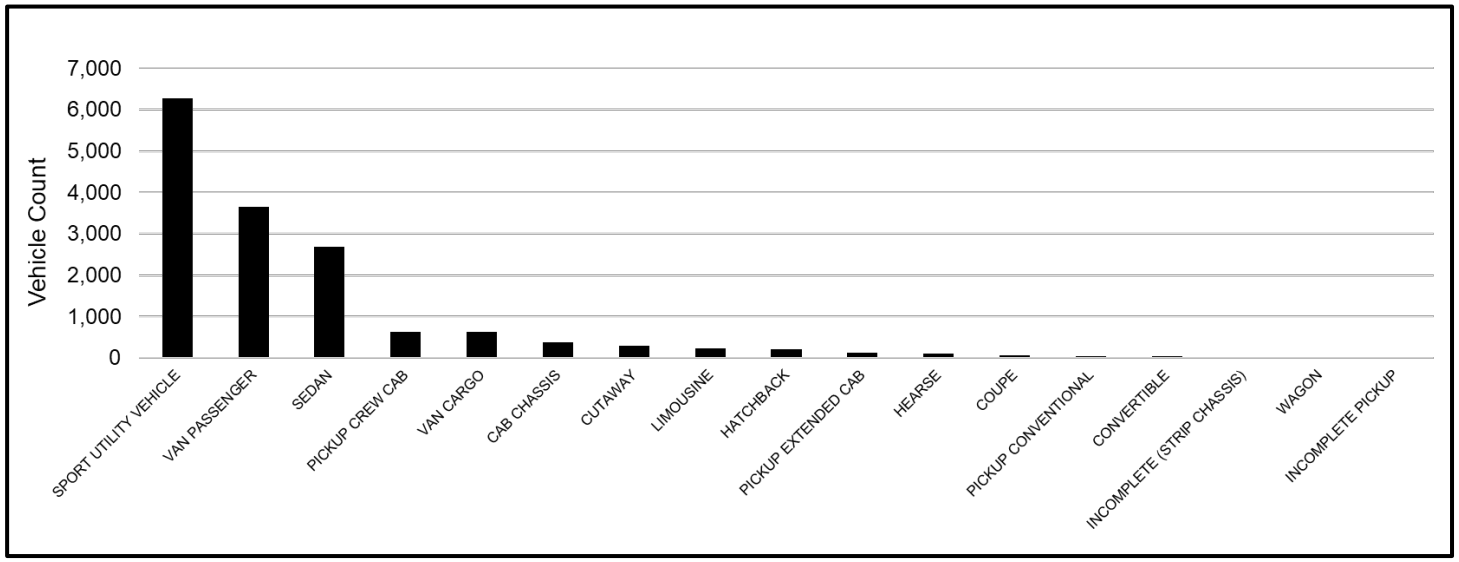


Limousine Market Study

Results: *

- Many popular base OEM vehicles upfitted into stretch limousines are now out of production.
- Vehicle OEMs eliminated some limousine fabricator support programs.
- Limousine fabrication industry is decentralized.
- The lack of OEM control and direct customer-to-fabricator relationship is pushing these vehicles and their fabricators to the fringes of the limousine market.
- Livery market dominated by SUV and van body styles.
- Reduced number of vehicles covered by limousine definition in IIJA § 23015(a)(1).





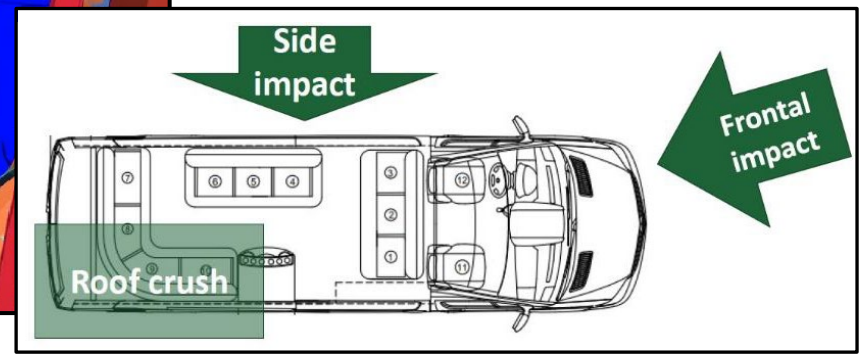
* Market study does not include an analysis of crash risks.

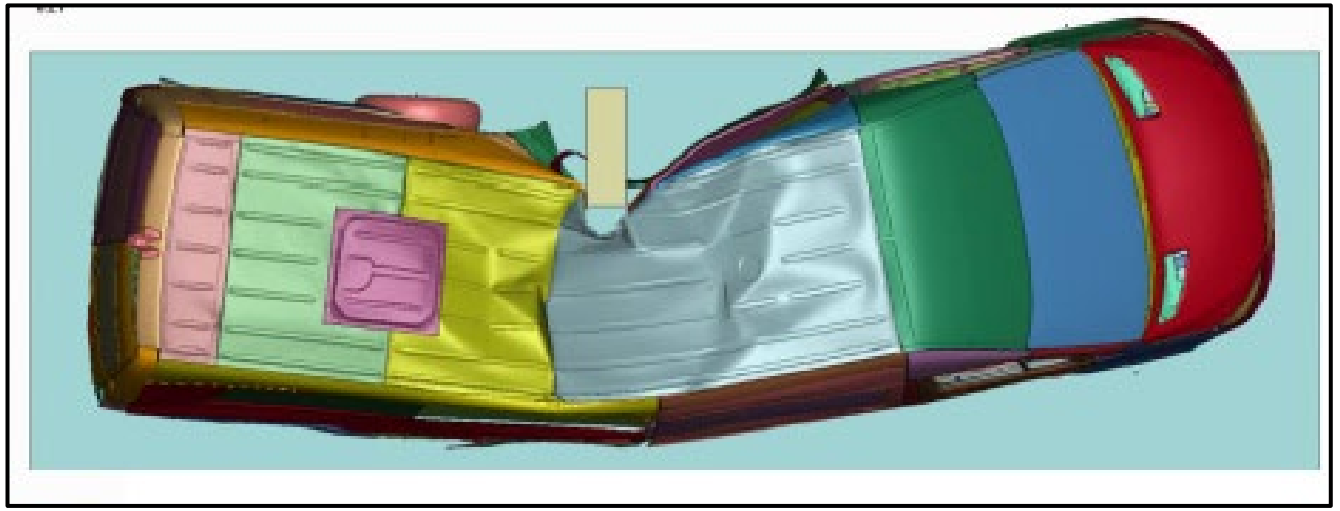
Next Steps

- **Limousine Crashworthiness**
  - Frontal. Continue studying limousine crash scenario, vehicle, and restraint characteristics.
  - Side. Validate side crash scenarios. Study parametrics, interiors, and restraints.
  - Publish results via report in National Transportation Library.[7]
  - Publish FE models on NHTSA's modeling website.[8]

- **Limousine Market Study**
  - Publish results via report in National Transportation Library.[7]







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Limousine Crashworthiness Research

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