

Status of NHTSA's Research on Occupant Protection in Rollovers

NHTSA / GM Research Meeting
March 29, 2006

Light Vehicle Rollovers

Problem Definition

- **29,098 Annual Rollovers (1995-2003)**
 - 2% of all light vehicle crashes
- **10,378 Rollover Fatalities in 2003**
 - 33% of all fatalities in light vehicles
 - 59% of fatalities in SUVs
 - 58% were ejected
- **245,142 Annual Non-Fatal Injuries (1995-2003)**

Crashworthiness Research Areas

- **Identified in the IPT Report on Rollover (June 2003)**
- **Ejection Mitigation - Side Windows**
 - 60% of ejected fatalities
 - 60% in rollovers, 40% in non-rollovers
- **Protection for Non-Ejected Occupants**
 - Roof crush (NPRM issued August 2005)
 - Improved restraints in rollovers

Ejection Mitigation

Problem Definition

- **52,897 Annual Ejections (1995-2003)**
 - 1% of all crash-involved occupants
- **10,210 Annual Ejected Fatalities**
 - 32% of all fatalities
 - 6,124 through side windows
- **10,177 Annual Rollover Fatalities**
 - 3,703 ejected through side windows

Ejection Mitigation 3-Phase Approach

Phase 1

**Partial
Ejections in
Side Impacts
(FMVSS 214
Pole Test)**

Phase 2

**Occupant
Containment
Capability**

Phase 3

**Rollover
Sensor
Performance**

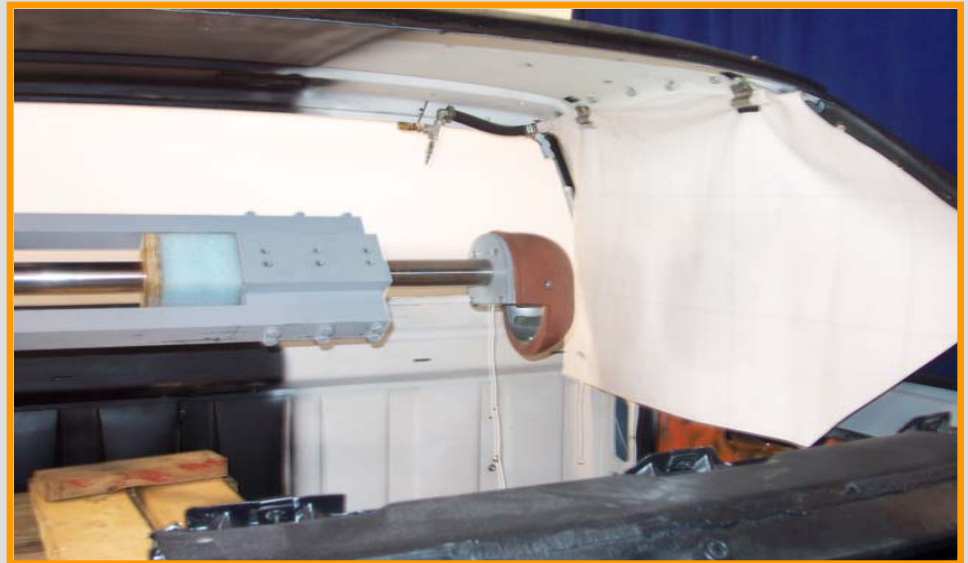
Ejection Mitigation

Phase 2 Research Program Goals

- **Demonstrate Countermeasure Feasibility**
 - Evaluate ejection mitigation capability of prototype and current production systems
 - Evaluate injury-causing potential
- **Develop Occupant Retention Test**
 - Full-scale rollover tests not repeatable

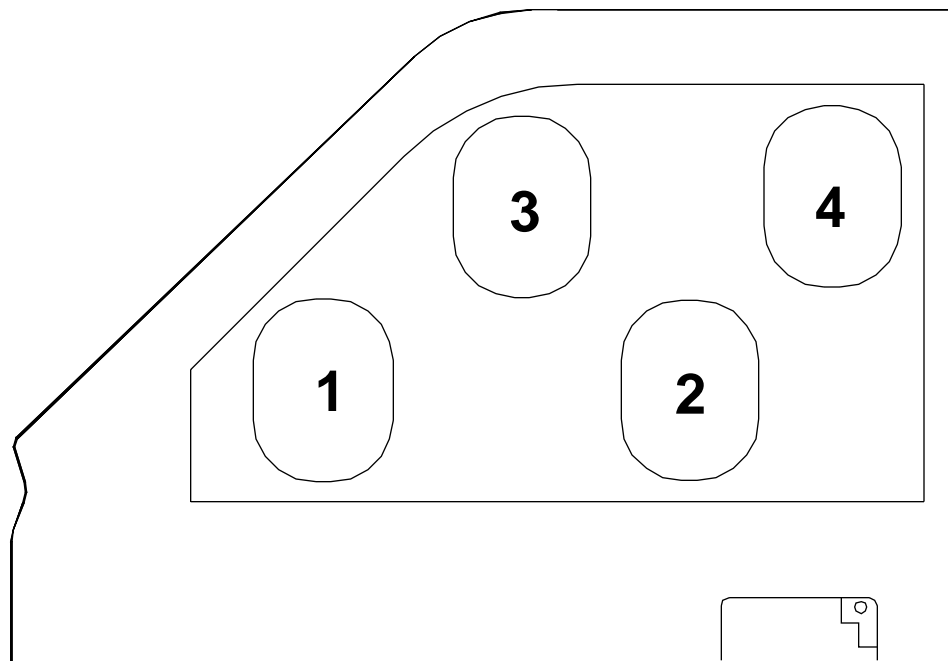
Ejection Mitigation Guided Impactor

- **18 kg Mass**
- **Featureless Headform**
 - Average of front & side of head geometries
 - More uniform shape
- **Measures Displacement**
- **Positioned Inside Vehicle**
- **Impact a Variety of Locations**



Ejection Mitigation

Front Side Window Impact Locations



Ejection Mitigation Systems Evaluated on C/K Platform

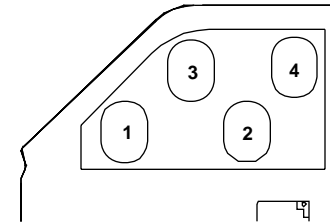
- **Inflatable Systems**
 - Modified Advanced Head Protection System (AHPS)
 - Zodiac Automotive US
 - Prototype Window Curtain
 - TRW Automotive
- **Inflatable/Laminated Glazing Combination**
 - Less door frame modifications than glazing alone



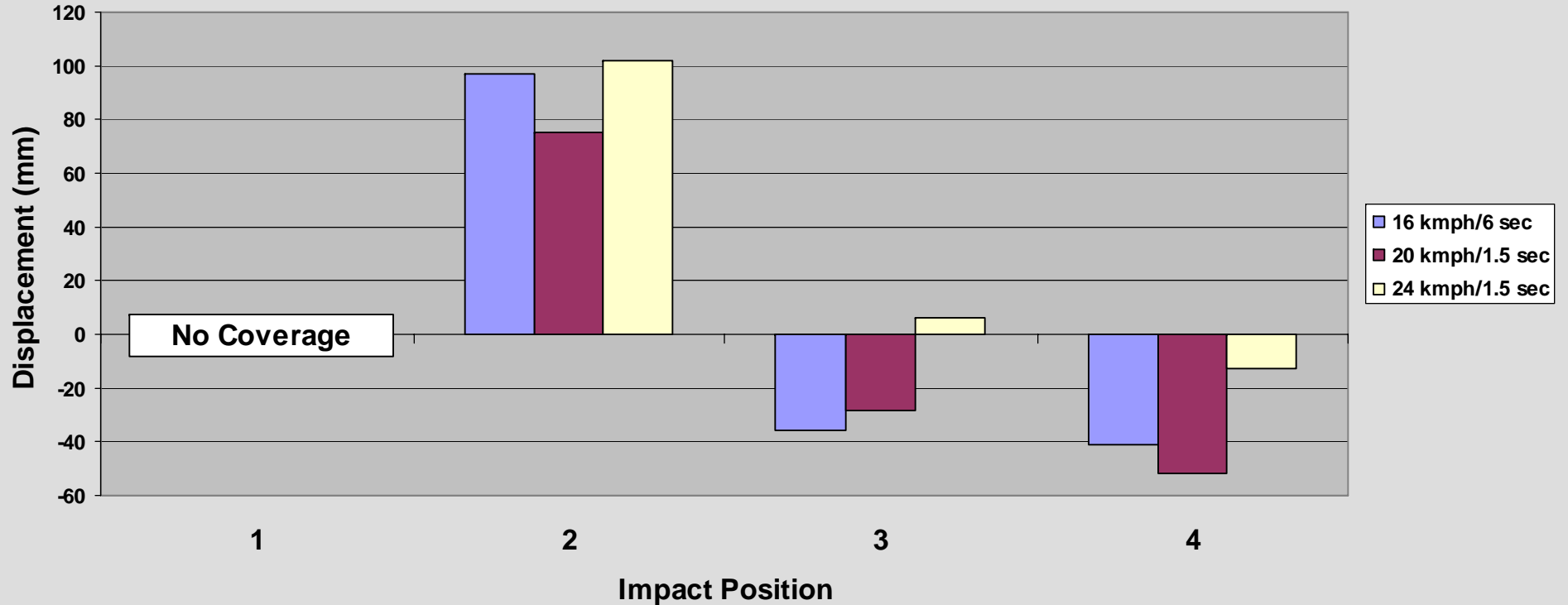
Ejection Mitigation Pre-Broken Glazing



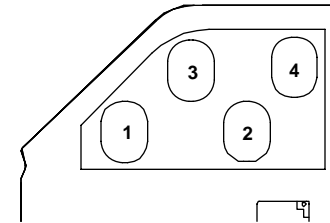
Ejection Mitigation Impactor Results



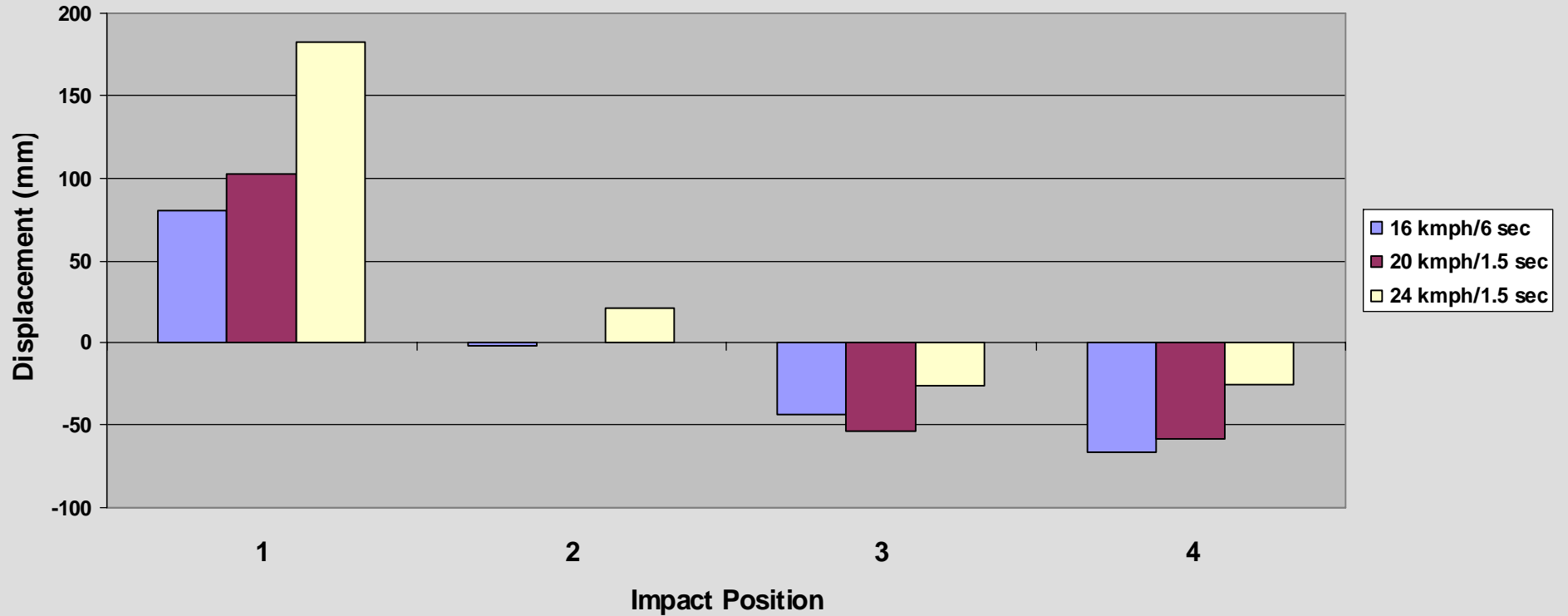
Maximum Excursion Beyond Window Plane
TRW - No Glazing



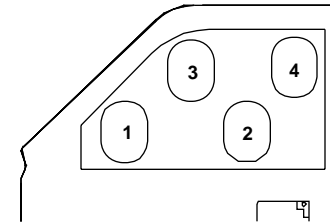
Ejection Mitigation Impactor Results



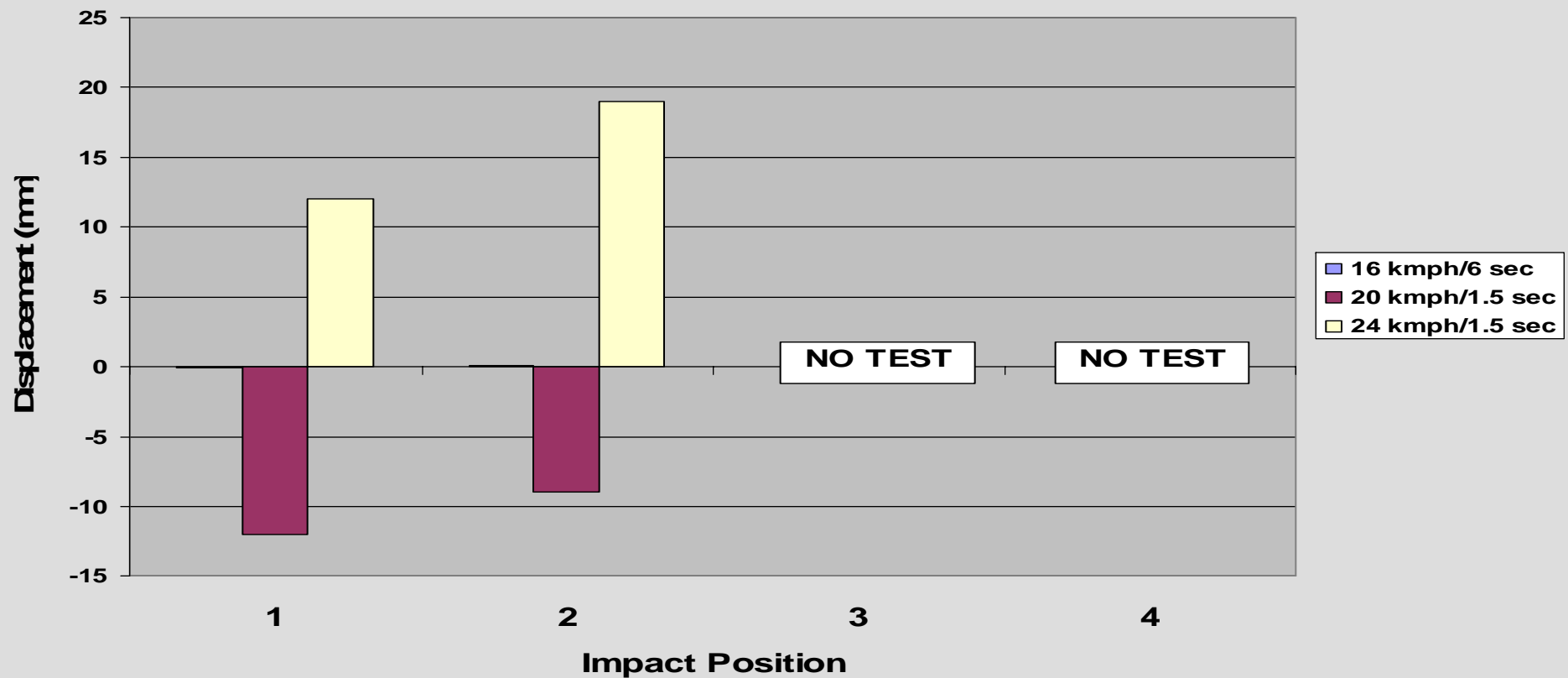
Maximum Excursion Beyond Window Plane
TRW - Pre-Broken HP Laminate



Ejection Mitigation Impactor Results



**Maximum Excursion Beyond Window Plane
Zodiac AHPS(beltline) - No Glazing**



Ejection Mitigation

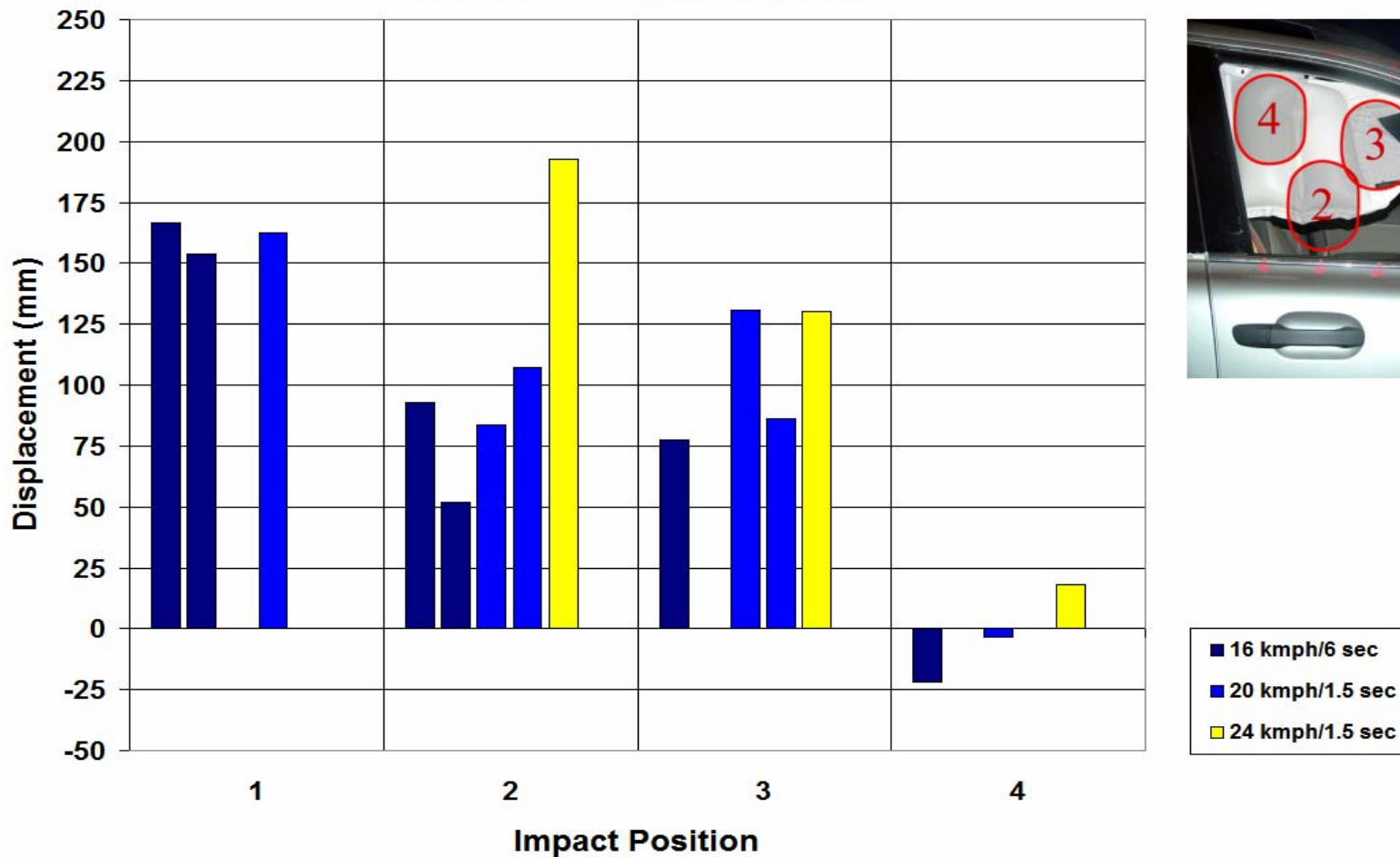
Additional Systems Evaluated

- **Inflatable Systems**
 - Production Window Curtains
 - 2003 Lincoln Navigator
 - 2004 Volvo XC90
 - Advanced Head Protection Curtain (AHPC)
 - Zodiac Automotive US
- **Inflatable/Laminated Glazing Combination**
 - 2003 Lincoln Navigator (front only)
 - 2004 Volvo XC90



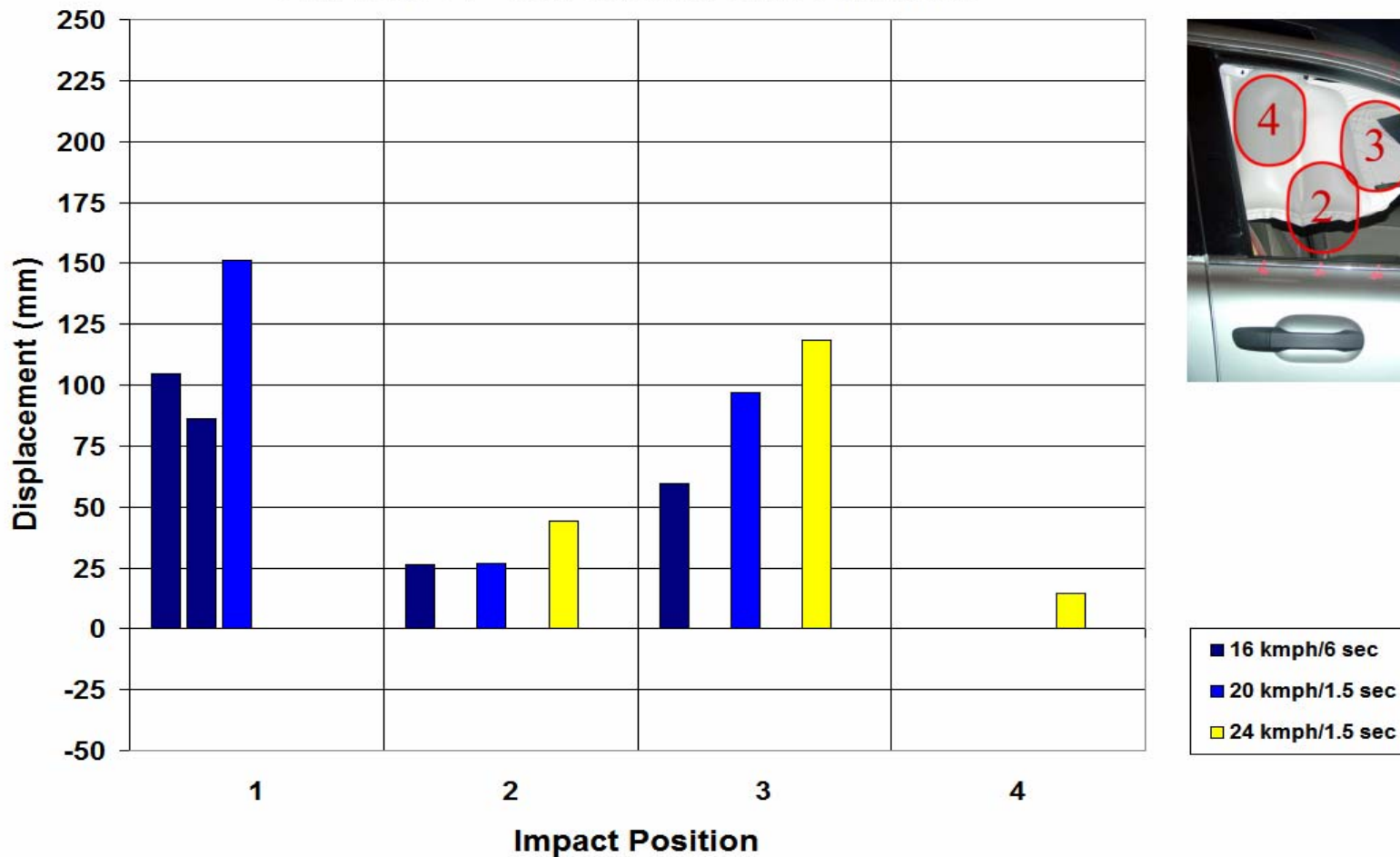
Ejection Mitigation Impactor Results – Front Window

Maximum Excursion Beyond Window Plane
Volvo XC90 - Open Window



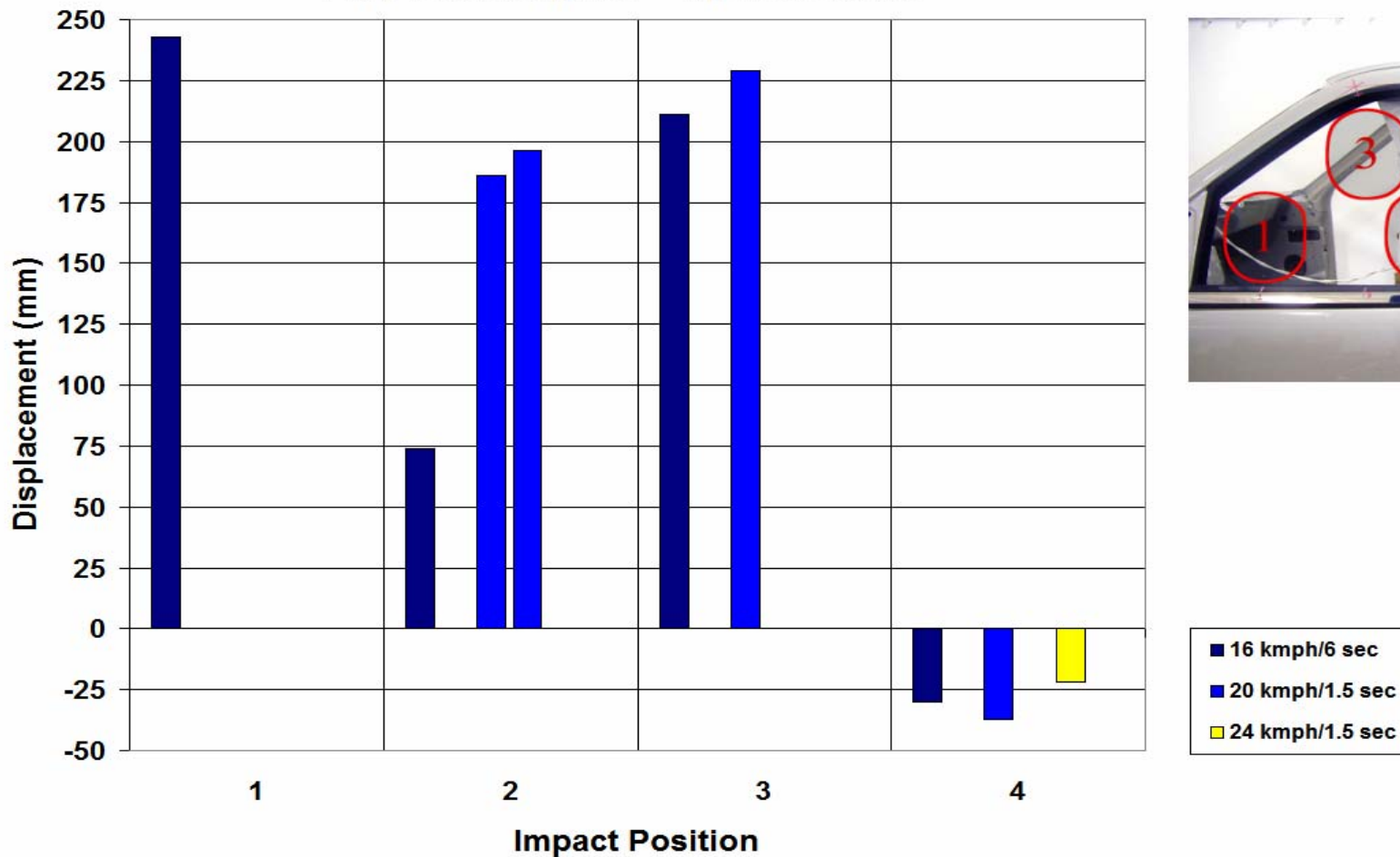
Ejection Mitigation Impactor Results – Front Window

Maximum Excursion Beyond Window Plane
Volvo XC90 - Pre-Broken Side Laminates



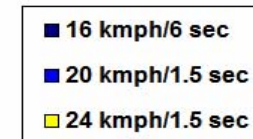
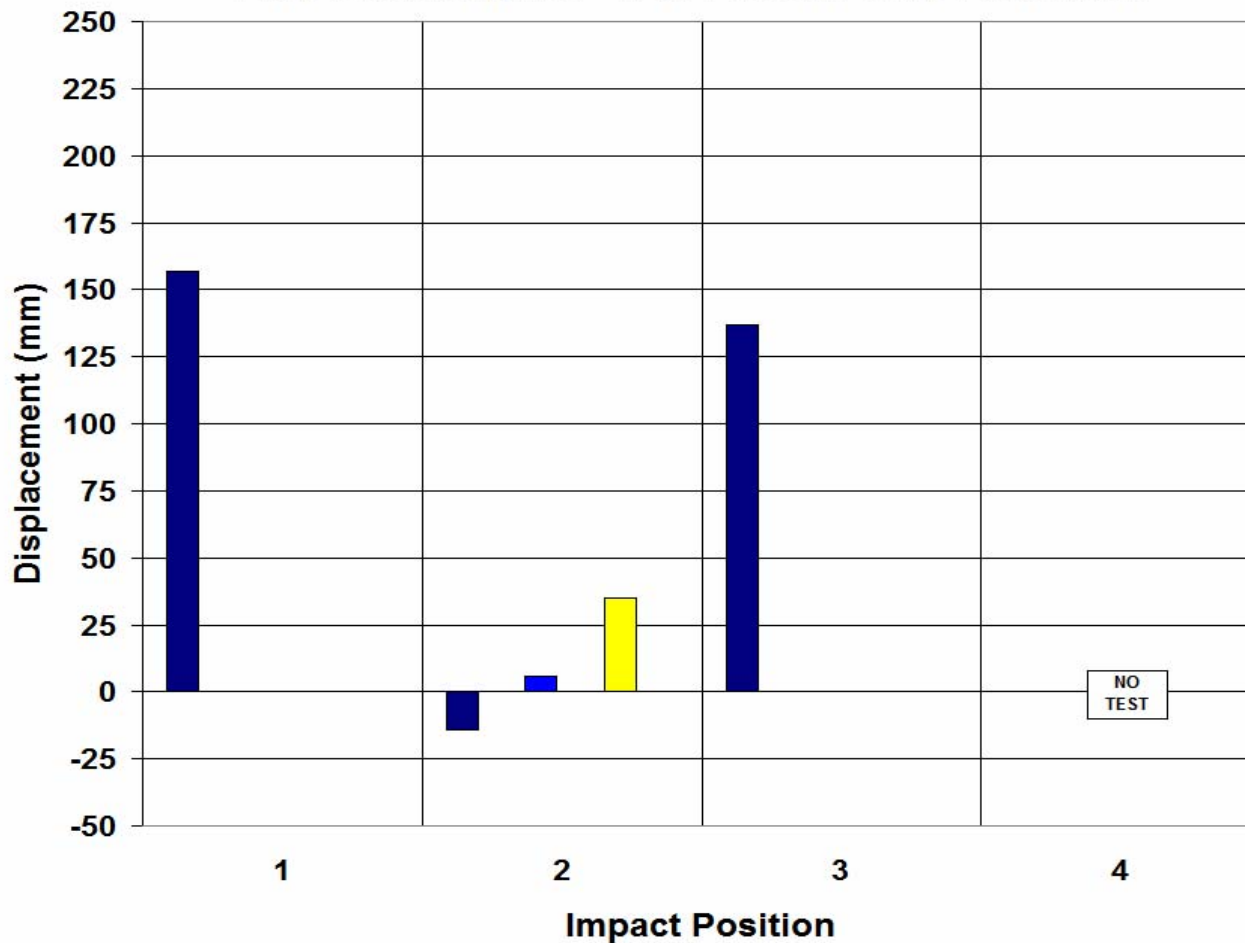
Ejection Mitigation Impactor Results – Front Window

Maximum Excursion Beyond Window Plane
Lincoln Navigator - Open Window



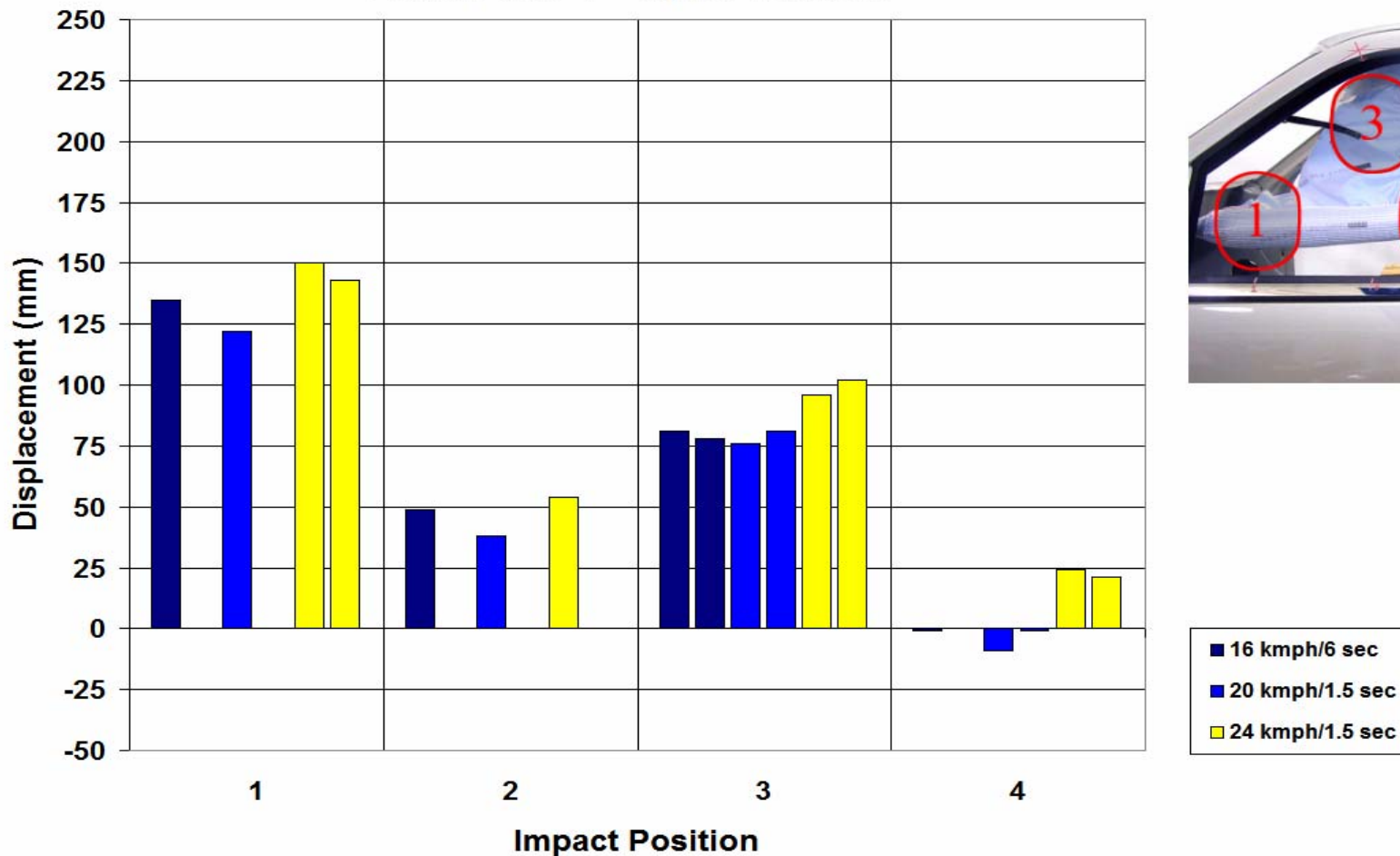
Ejection Mitigation Impactor Results – Front Window

Maximum Excursion Beyond Window Plane
Lincoln Navigator - Pre-Broken Side Laminates



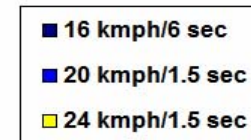
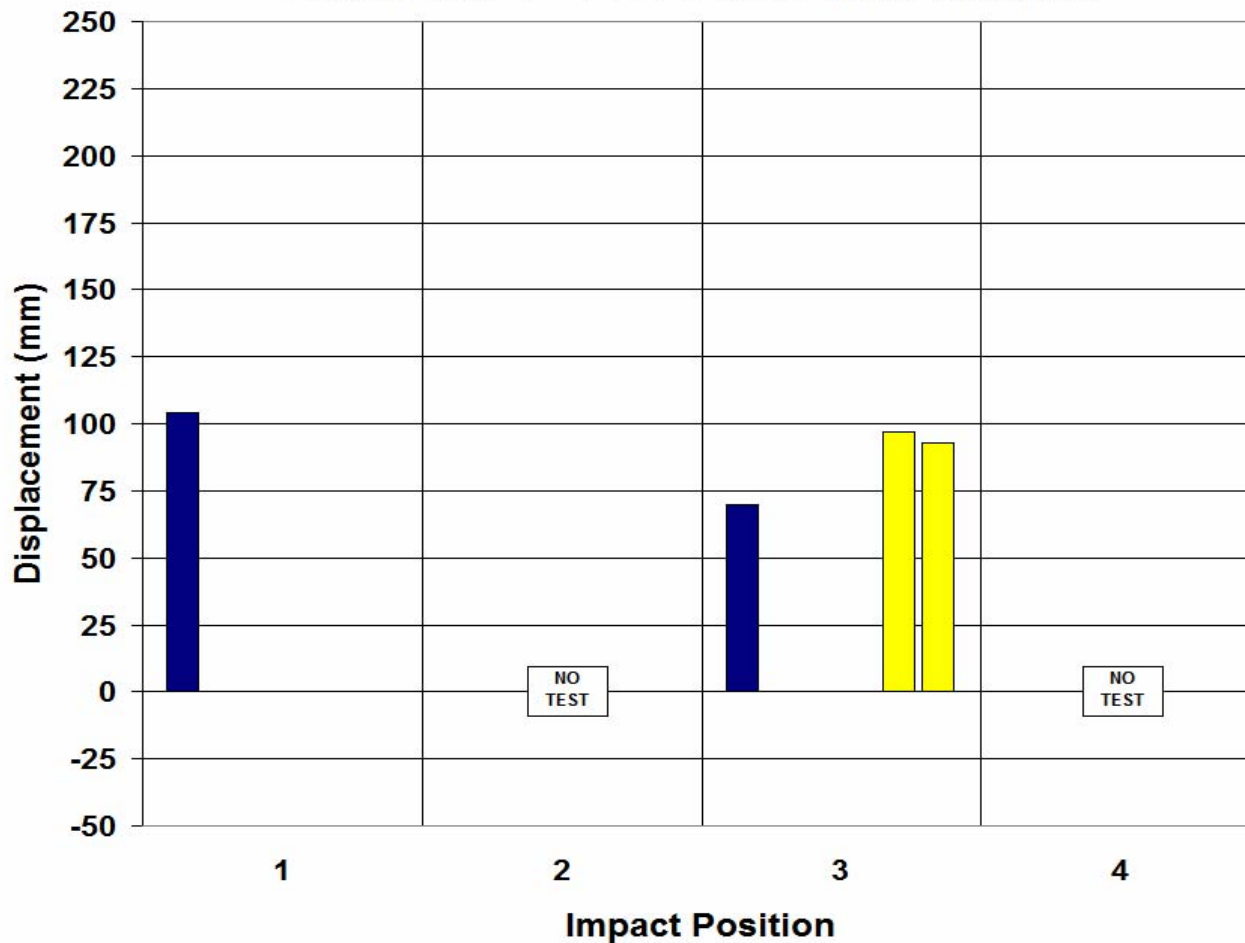
Ejection Mitigation Impactor Results – Front Window

Maximum Excursion Beyond Window Plane
Zodiac AHPC - Open Window



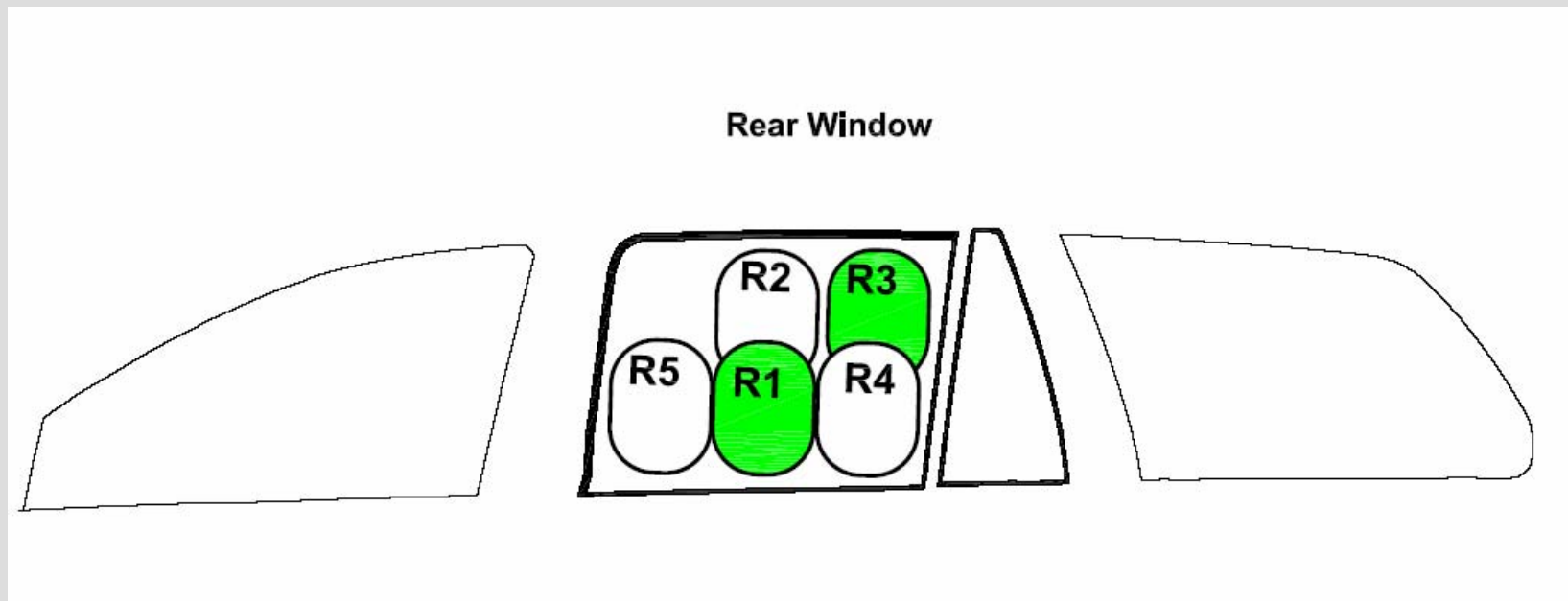
Ejection Mitigation Impactor Results – Front Window

Maximum Excursion Beyond Window Plane
Zodiac AHPC - Pre-Broken Side Laminate



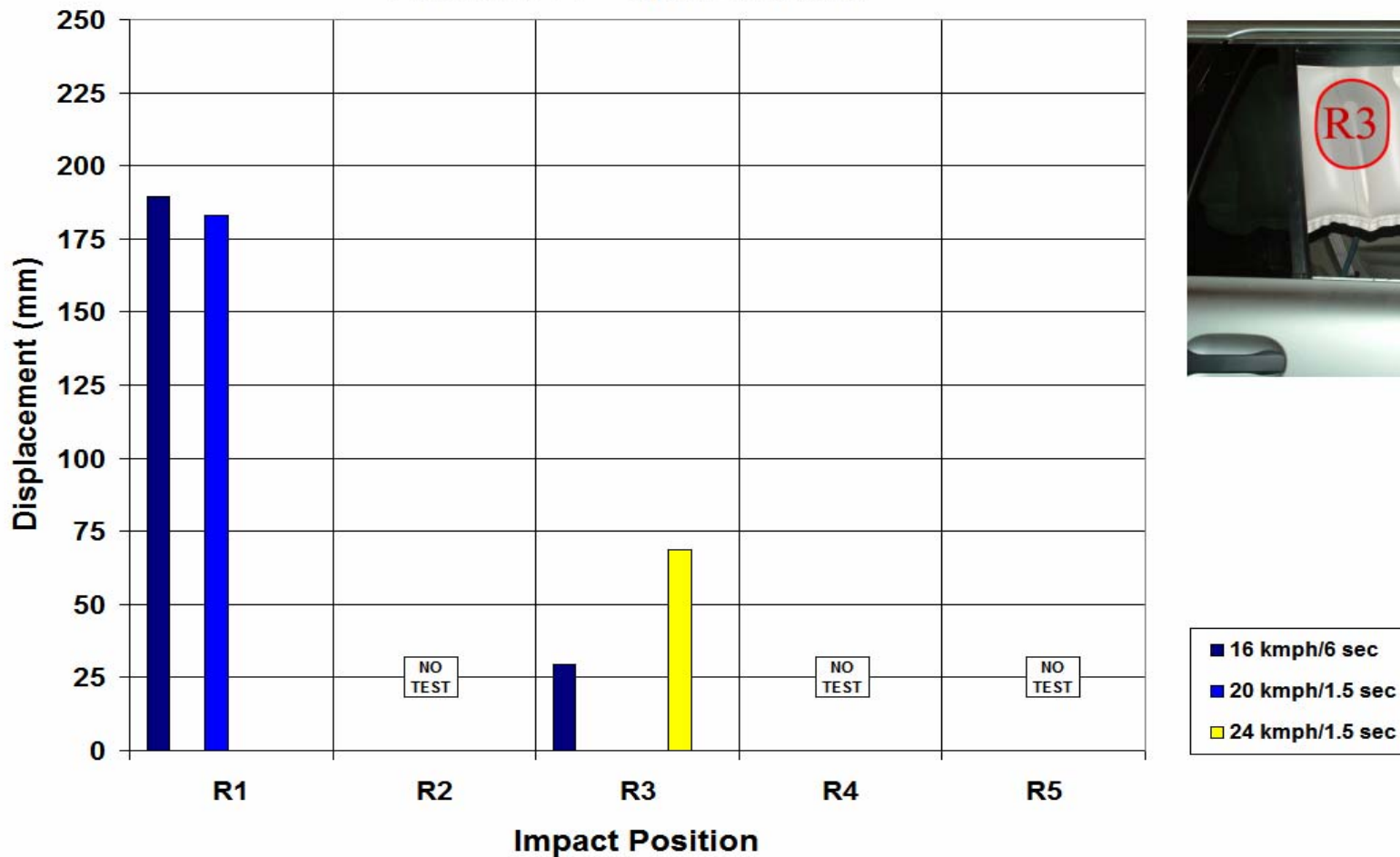
Ejection Mitigation

Rear Side Window Impact Locations



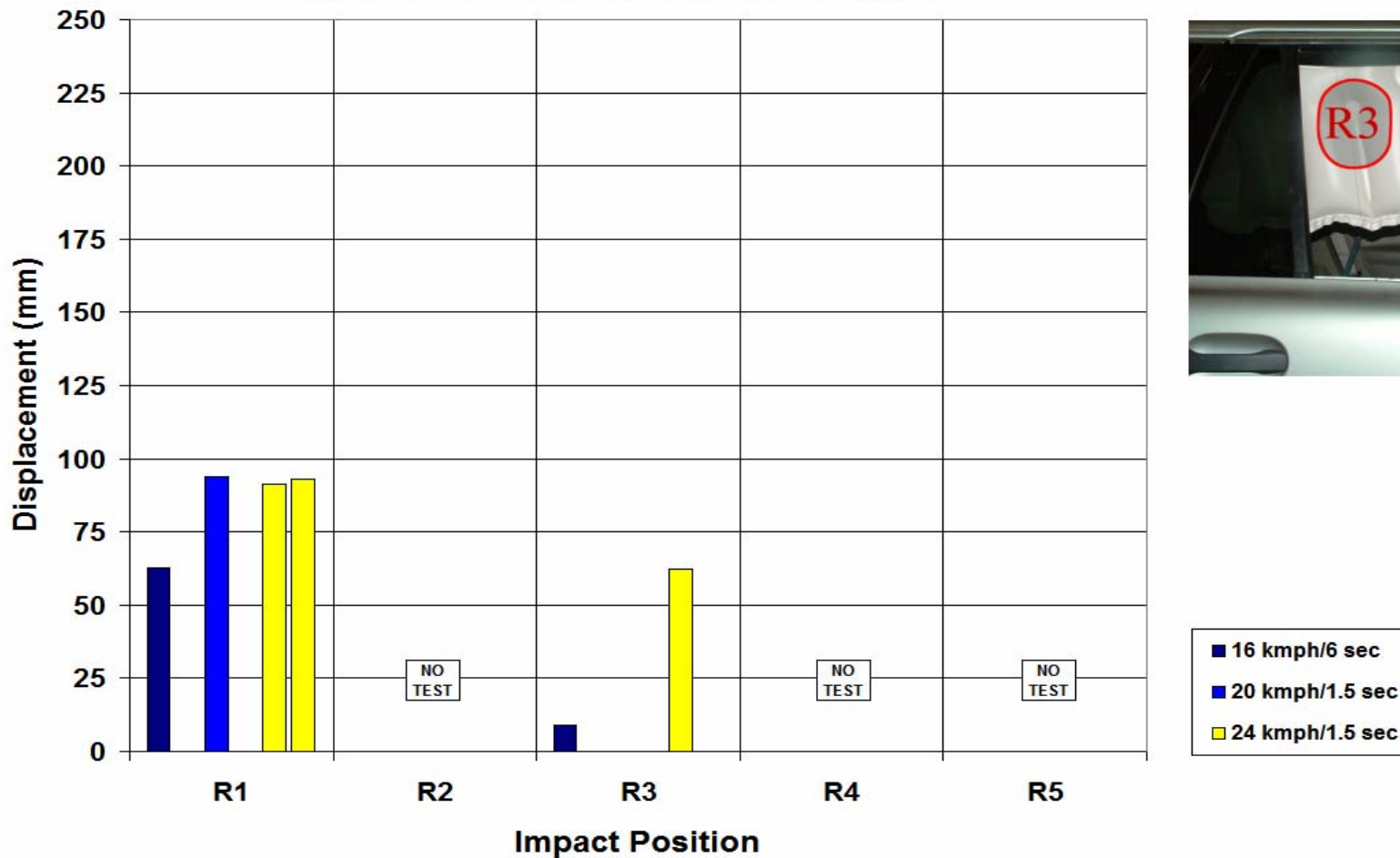
Ejection Mitigation Impactor Results – Rear Window

Maximum Excursion Beyond Window Plane
Volvo XC90 - Open Window



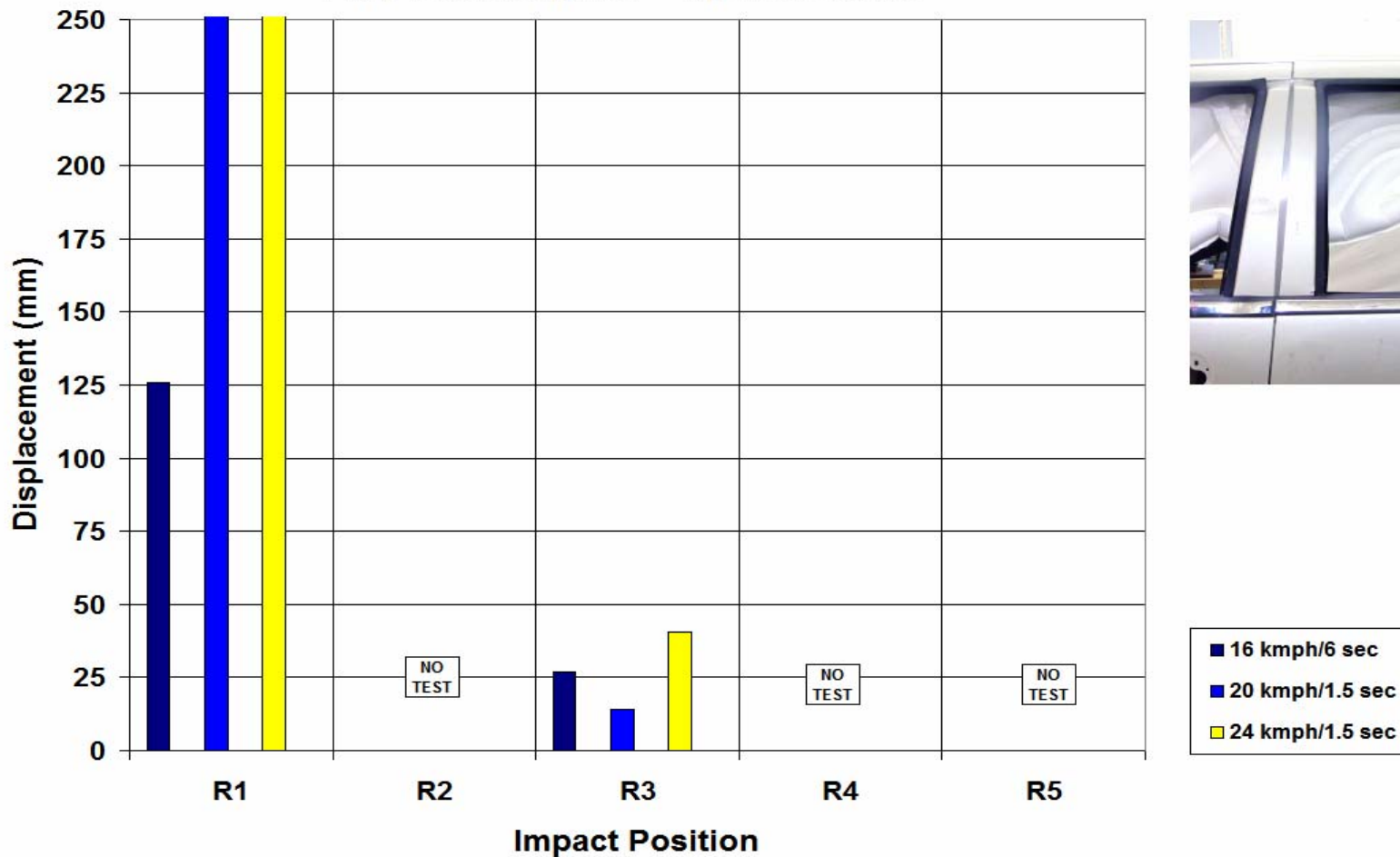
Ejection Mitigation Impactor Results – Rear Window

Maximum Excursion Beyond Window Plane
Volvo XC90 - Pre-Broken Side Laminate



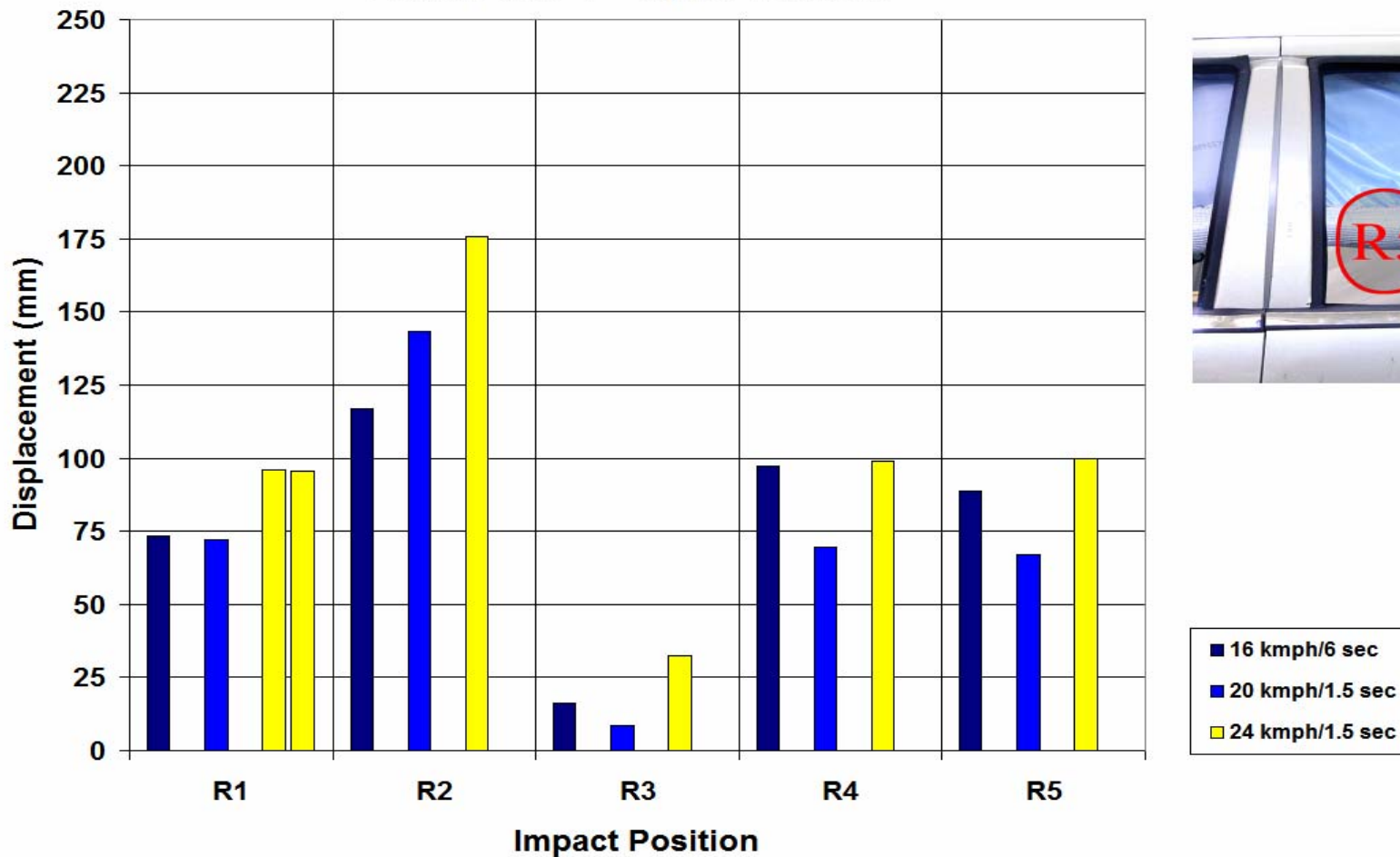
Ejection Mitigation Impactor Results – Rear Window

Maximum Excursion Beyond Window Plane
Lincoln Navigator - Open Window



Ejection Mitigation Impactor Results – Rear Window

Maximum Excursion Beyond Window Plane
Zodiac AHPC - Open Window



Ejection Mitigation

Ongoing Phase 2 Research

- **Continue to Evaluate Current Production Systems**
 - Those that offer protection in rollovers
- **Evaluate Possible Excursion Limit**
- **Refine Method to Pre-Break Glazing**

Improved Restraints in Rollovers

- **OBJECTIVE: To Evaluate the Effectiveness of Current and Advanced Restraints in Rollover Crashes**
- **Possible Restraint Systems**
 - Standard bucket seat with lap/shoulder belt
 - Integrated seats
 - Pretensioners
 - Inflatable seat belts
 - Pelvic air bags

Improved Restraints in Rollovers

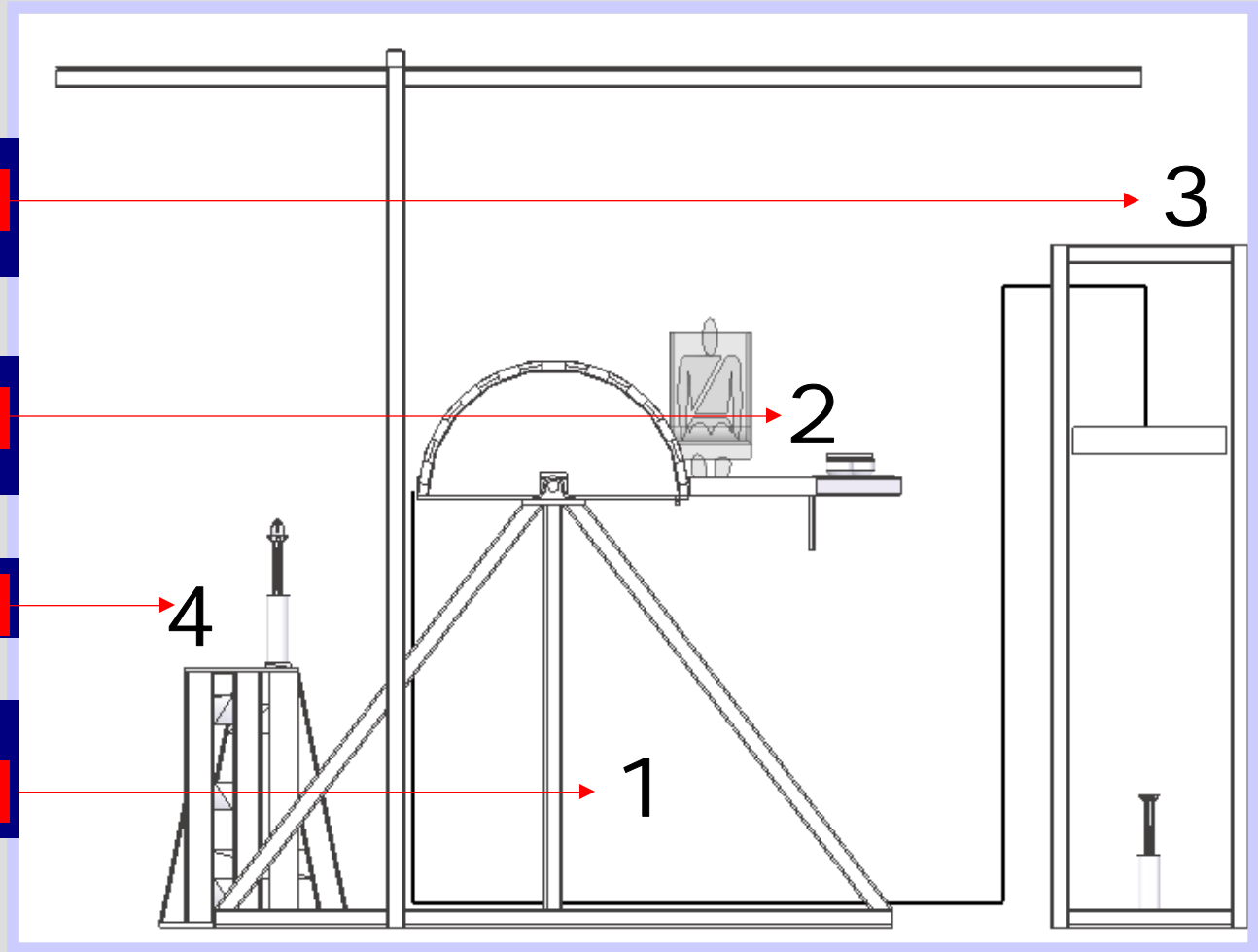
Rollover Restraint Tester

Free-Weight
Drop Tower

Rotating Test
Platform

Shock Tower

Support
Framework



Improved Restraints in Rollovers

Test Methodology

- **Static Tests**
 - Measure innate belt slack
 - Upright and inverted
- **Dynamic Tests**
 - 180° rollover with impact
 - Measure dynamic dummy excursion from seat

Improved Restraints in Rollovers

Initial Test Configurations

- **Integrated Seat**
 - Outboard and inboard shoulder belt mount
- **Standard Seat With 3-Point Belt**
 - Upper and lower D-ring position
 - Retractor pretensioner
 - Buckle pretensioner
 - Retractor and buckle pretensioners
 - Motorized retractor pretensioner
 - Motorized retractor and buckle pretensioners
- **4-Point Belt System With Pretensioners**

THE END