

# Status of NHTSA's Research on Occupant Protection in Rollovers

NHTSA / HATCI Research Meeting  
March 1, 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**

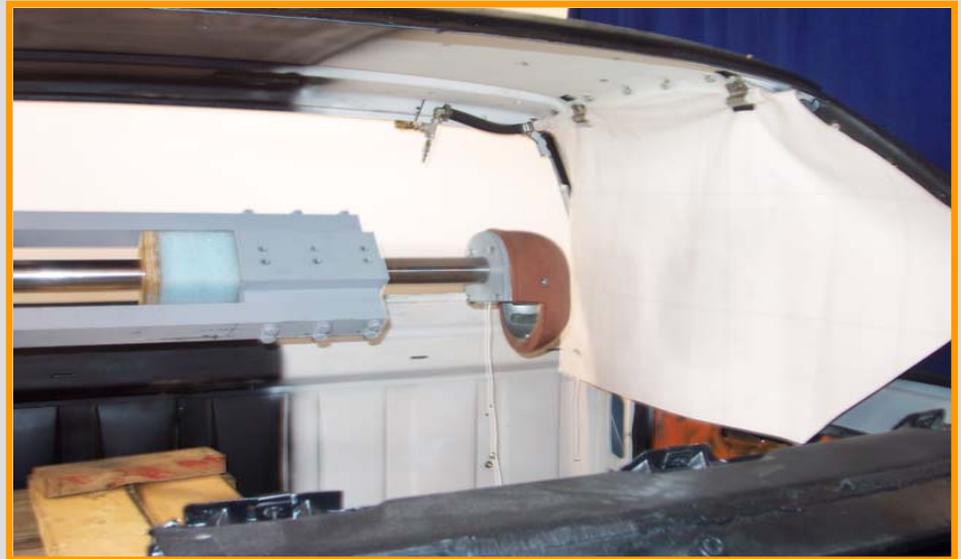
# Ejection Mitigation

## 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

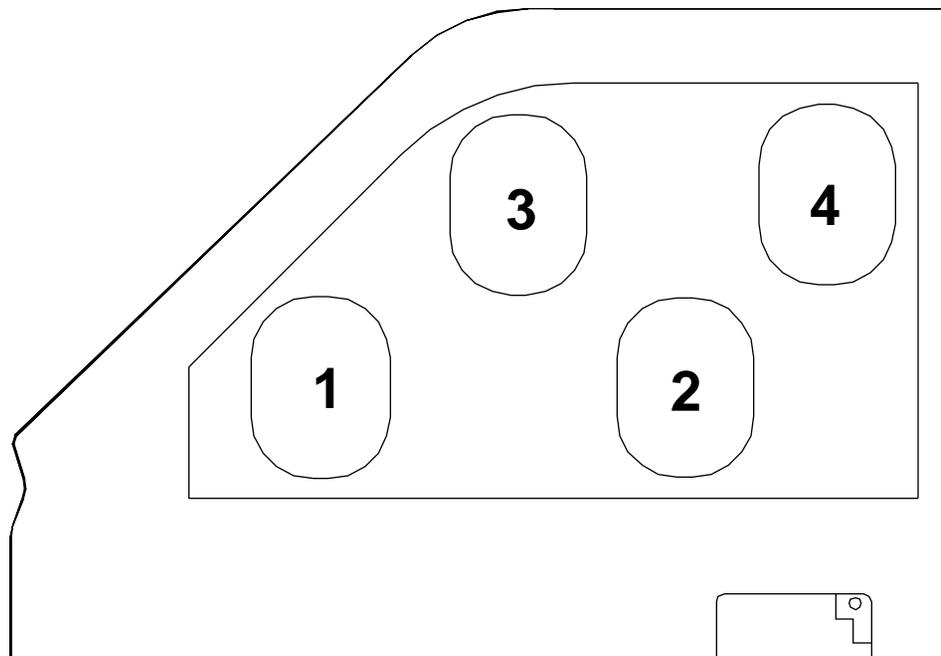
# Ejection Mitigation Guided Impactor

- **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

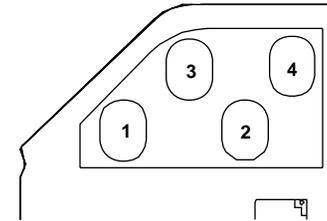
- **Inflatable Systems**
  - Modified Advanced Head Protection System (AHPS)
    - Zodiac Automotive US
  - Prototype Window Curtain
    - TRW Automotive
- **Inflatable/Laminated Glazing Combination**
  - Less door frame modifications than glazing alone



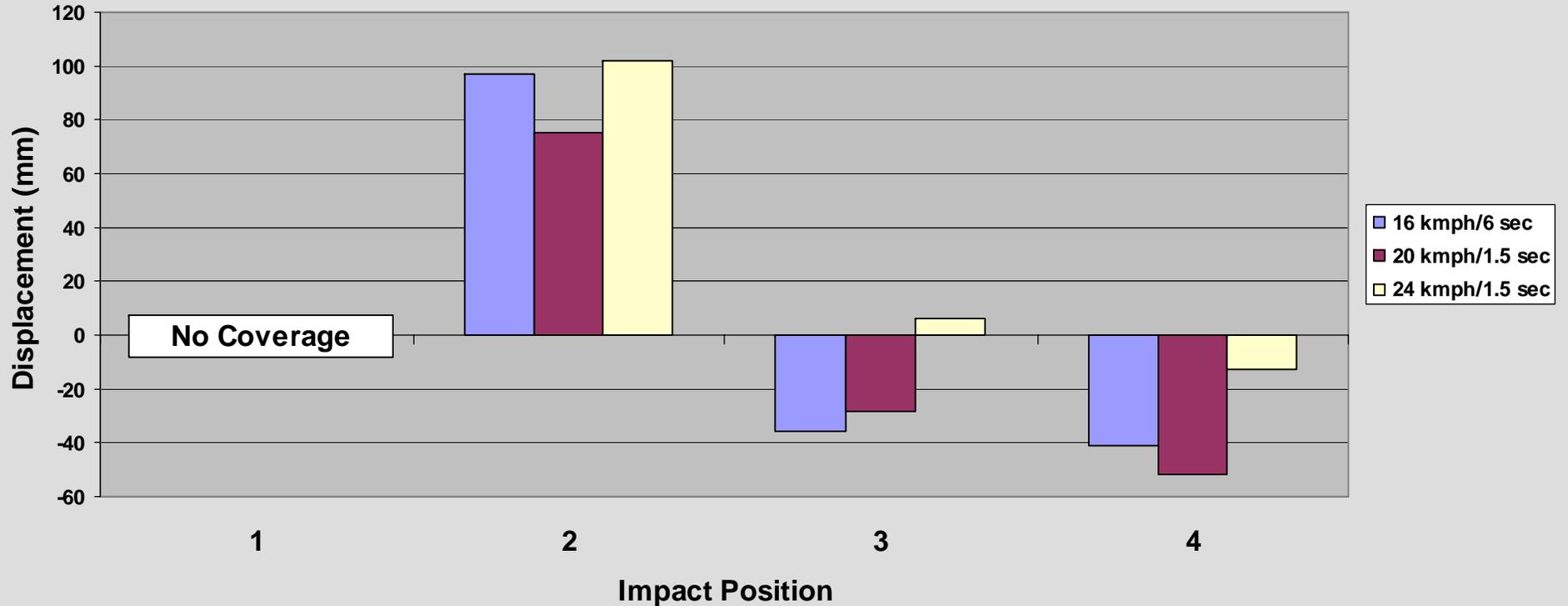
# Ejection Mitigation Pre-Broken Glazing



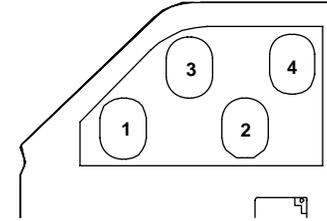
# Ejection Mitigation Impactor Results



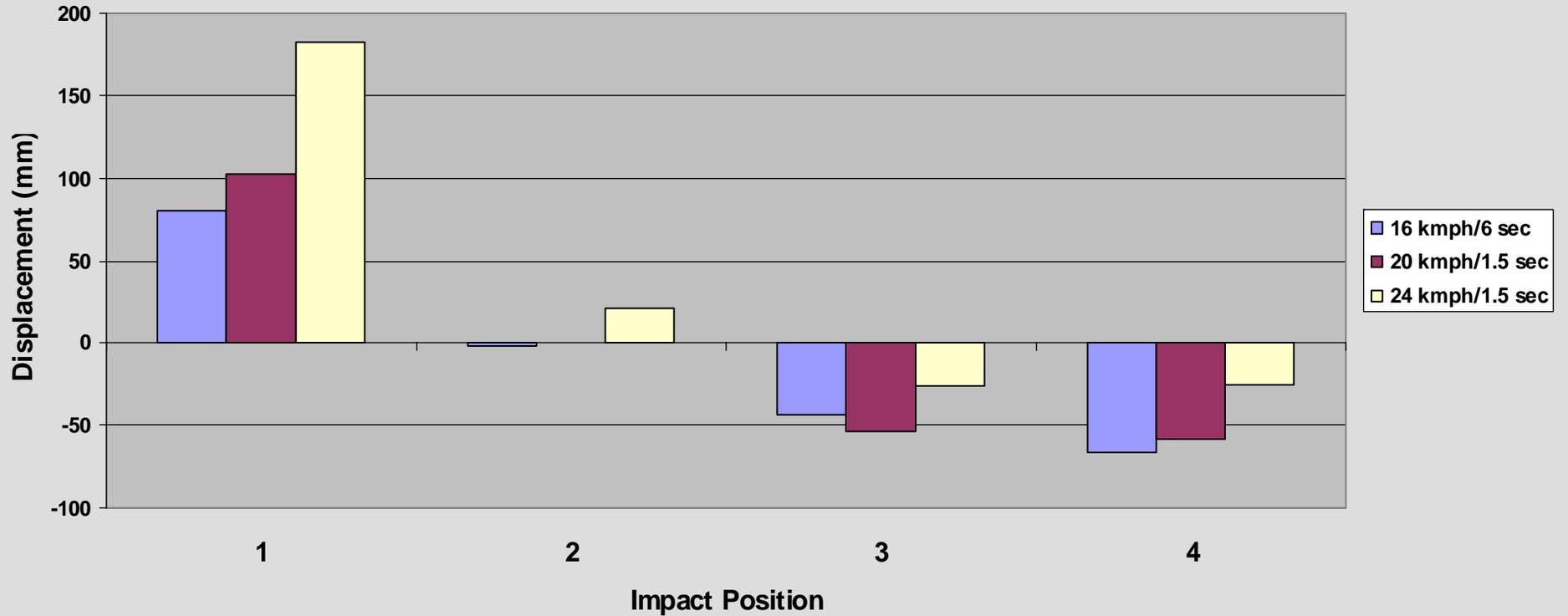
**Maximum Excursion Beyond Window Plane**  
TRW - No Glazing



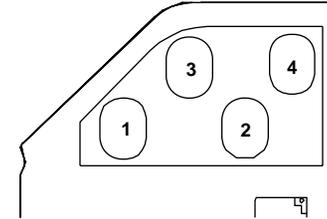
# Ejection Mitigation Impactor Results



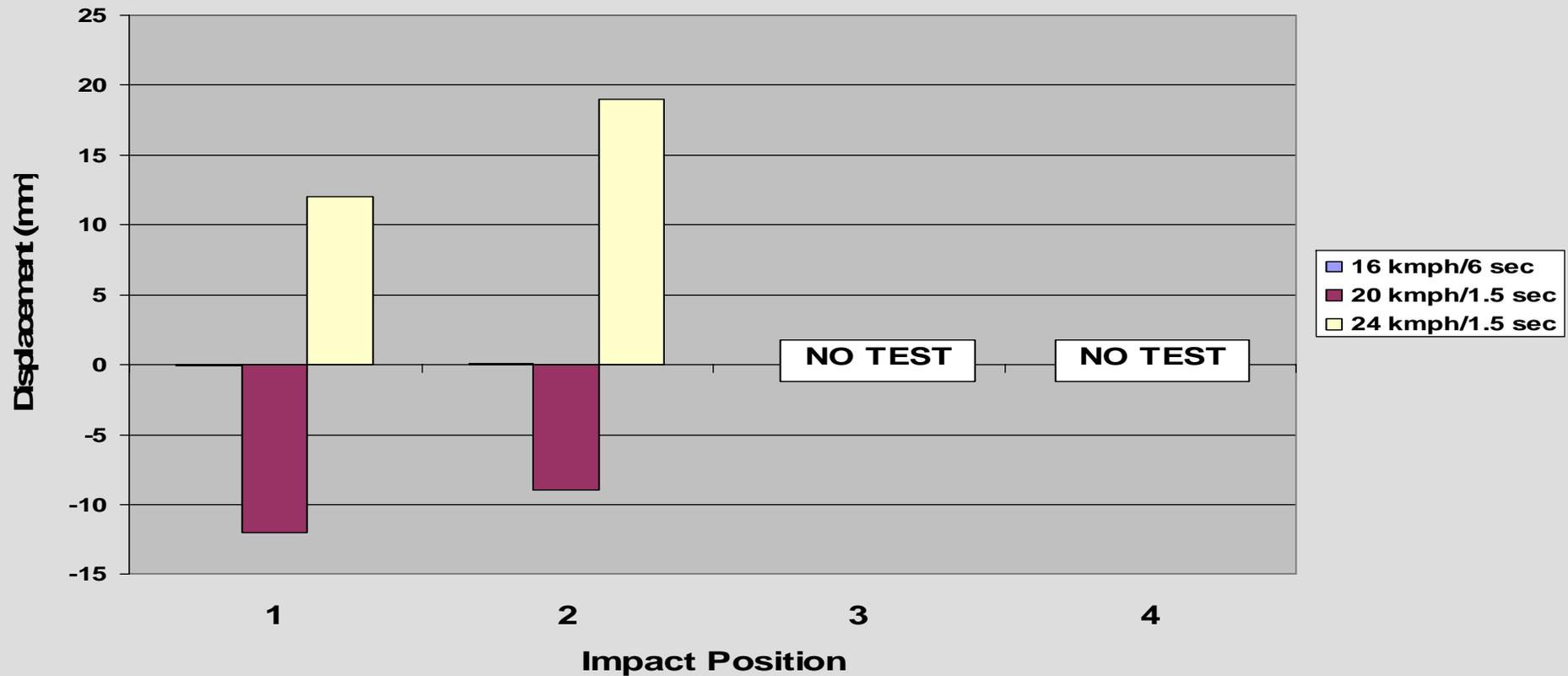
**Maximum Excursion Beyond Window Plane**  
TRW - Pre-Broken HP Laminate



# Ejection Mitigation Impactor Results



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



# Ejection Mitigation

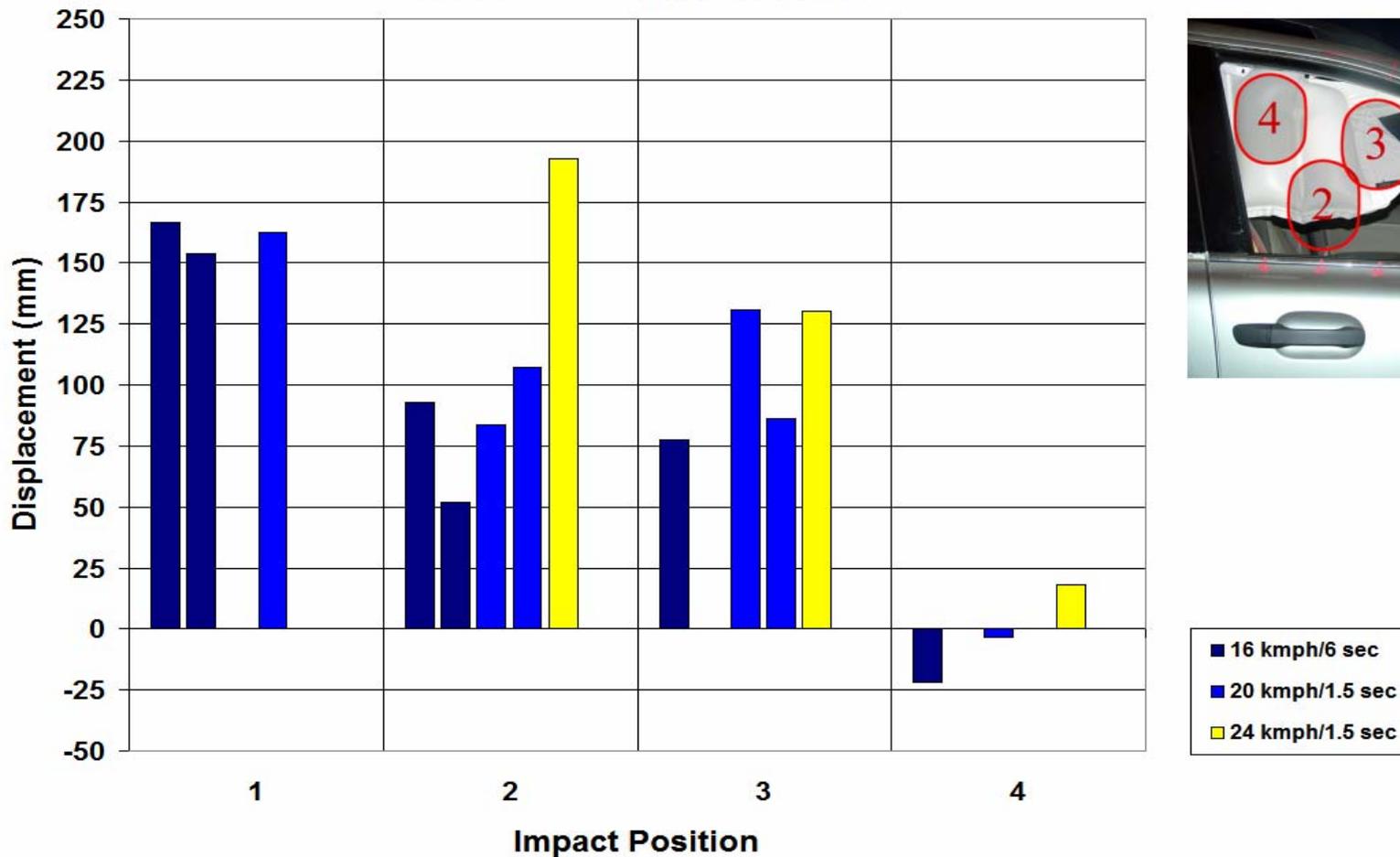
## Additional Systems Evaluated

- **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



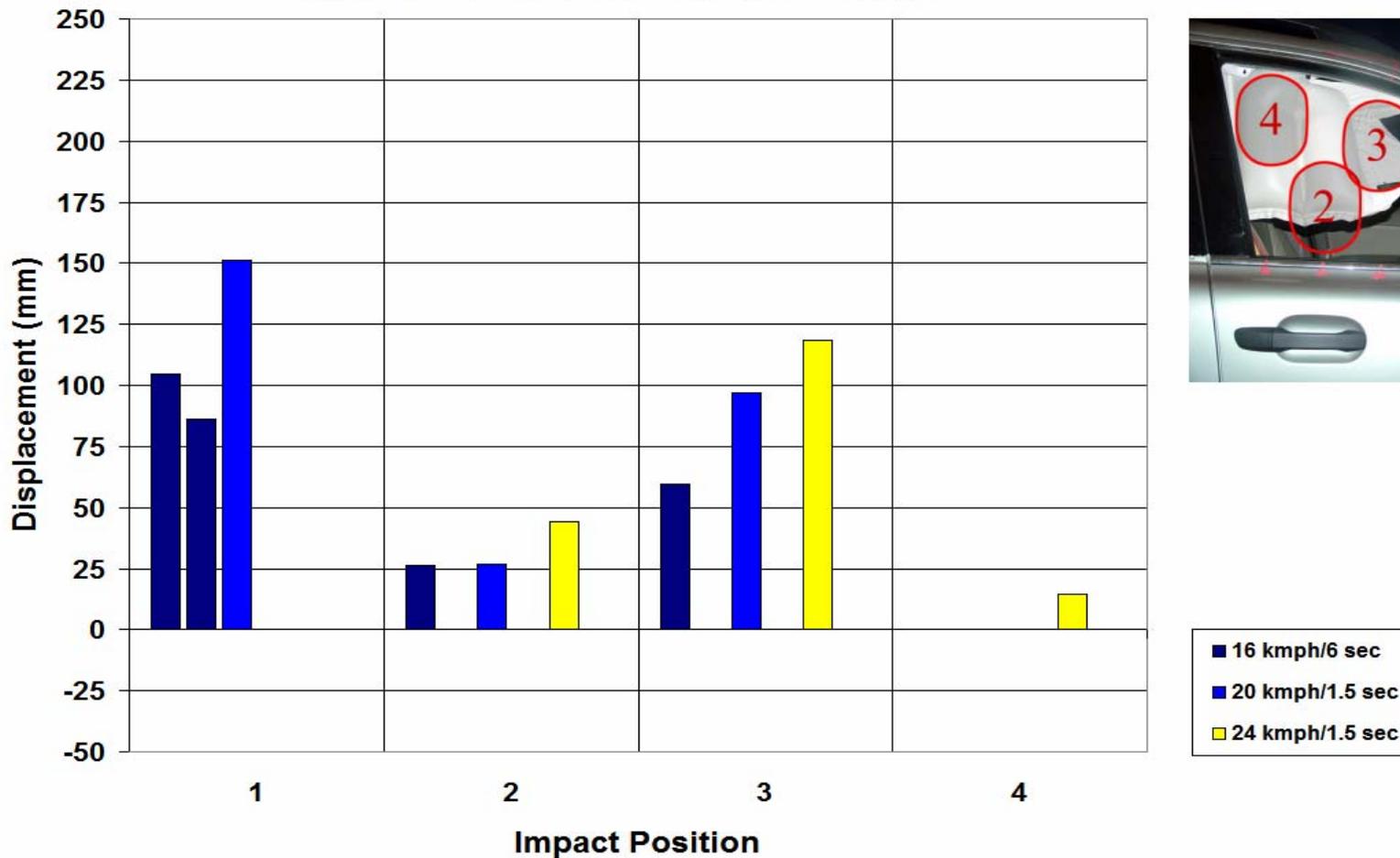
# Ejection Mitigation Impactor Results – Front Window

Maximum Excursion Beyond Window Plane  
Volvo XC90 - Open Window



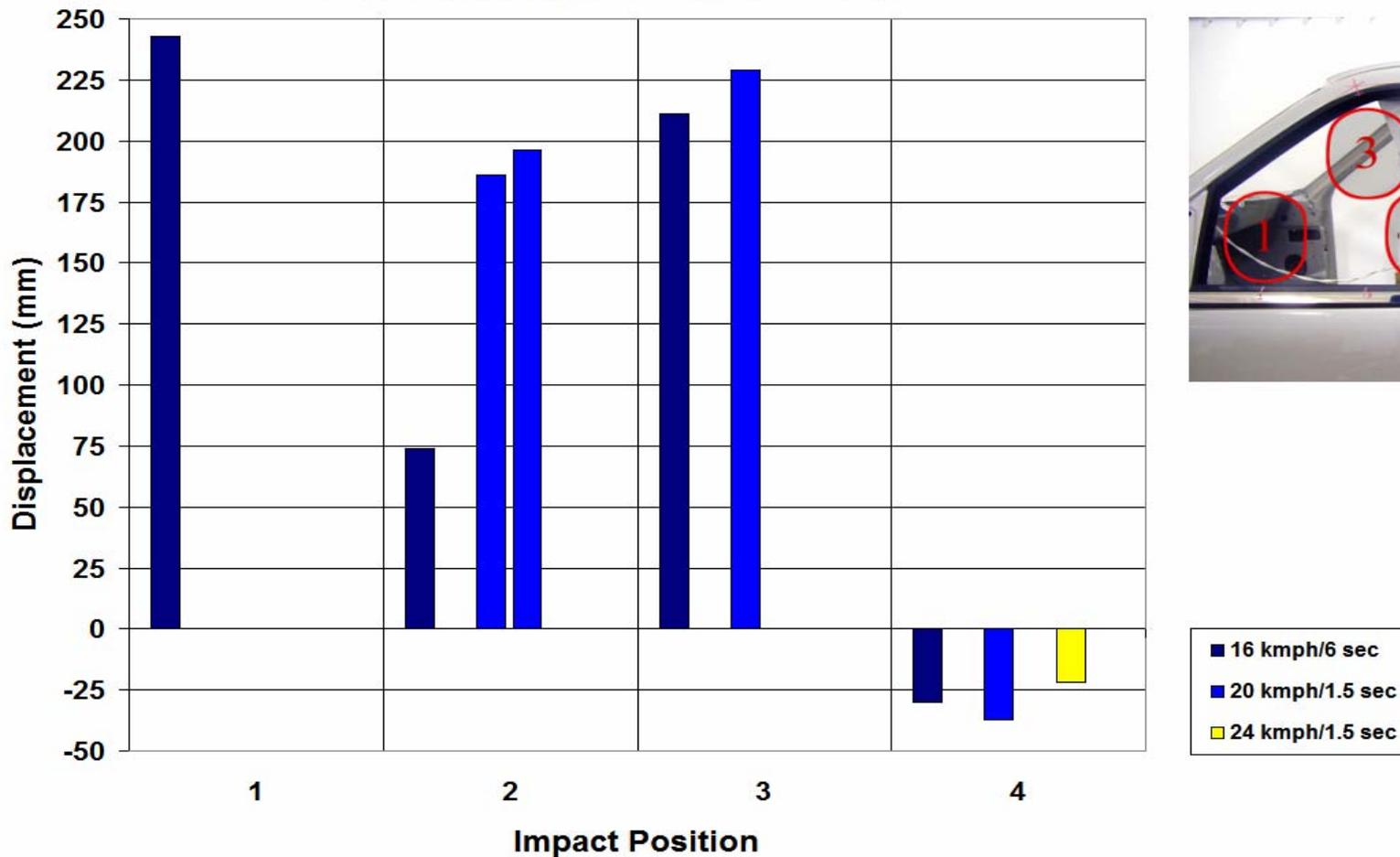
# Ejection Mitigation Impactor Results – Front Window

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



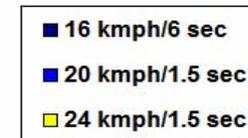
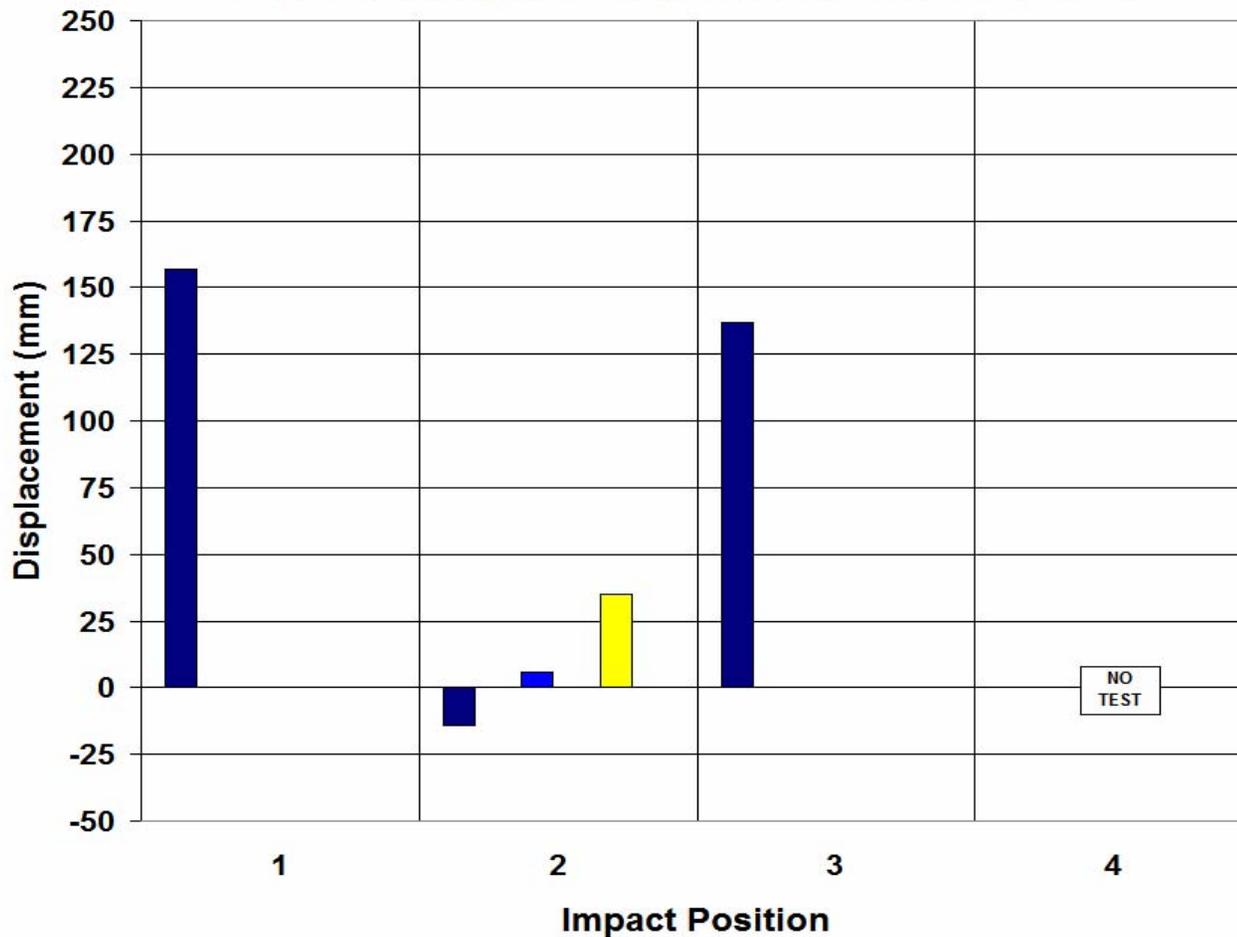
# Ejection Mitigation Impactor Results – Front Window

Maximum Excursion Beyond Window Plane  
Lincoln Navigator - Open Window



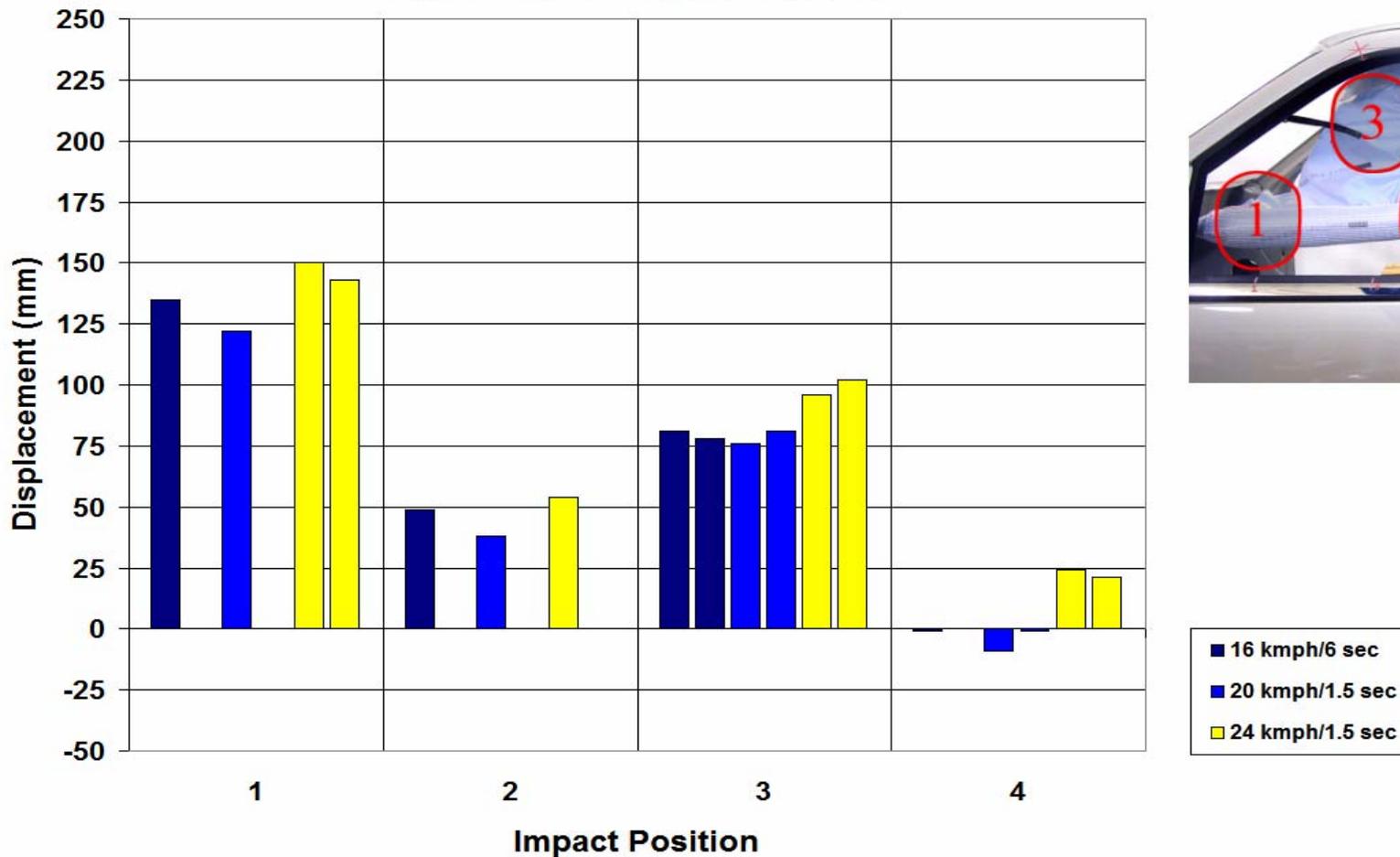
# Ejection Mitigation Impactor Results – Front Window

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



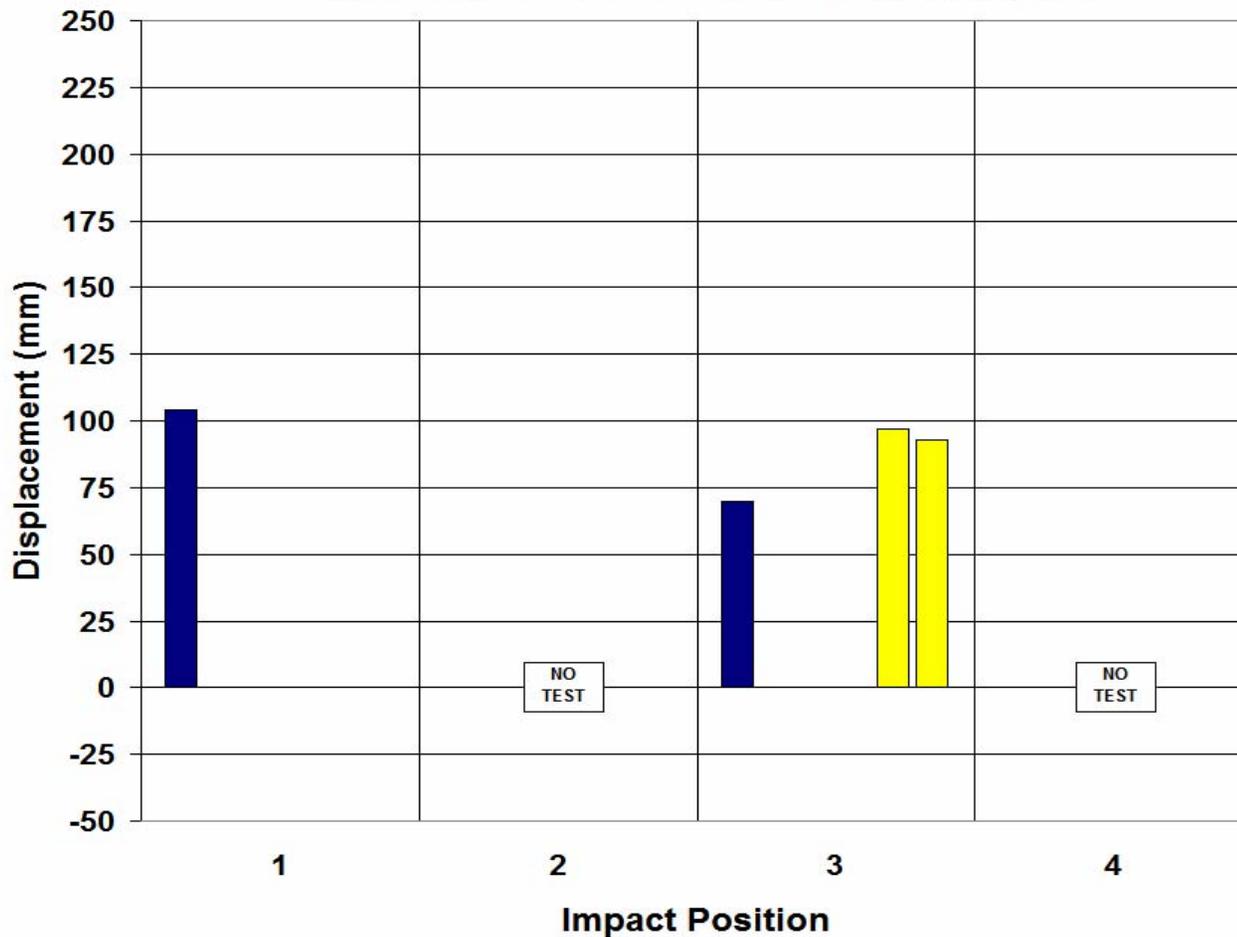
# Ejection Mitigation Impactor Results – Front Window

Maximum Excursion Beyond Window Plane  
Zodiac AHPC - Open Window



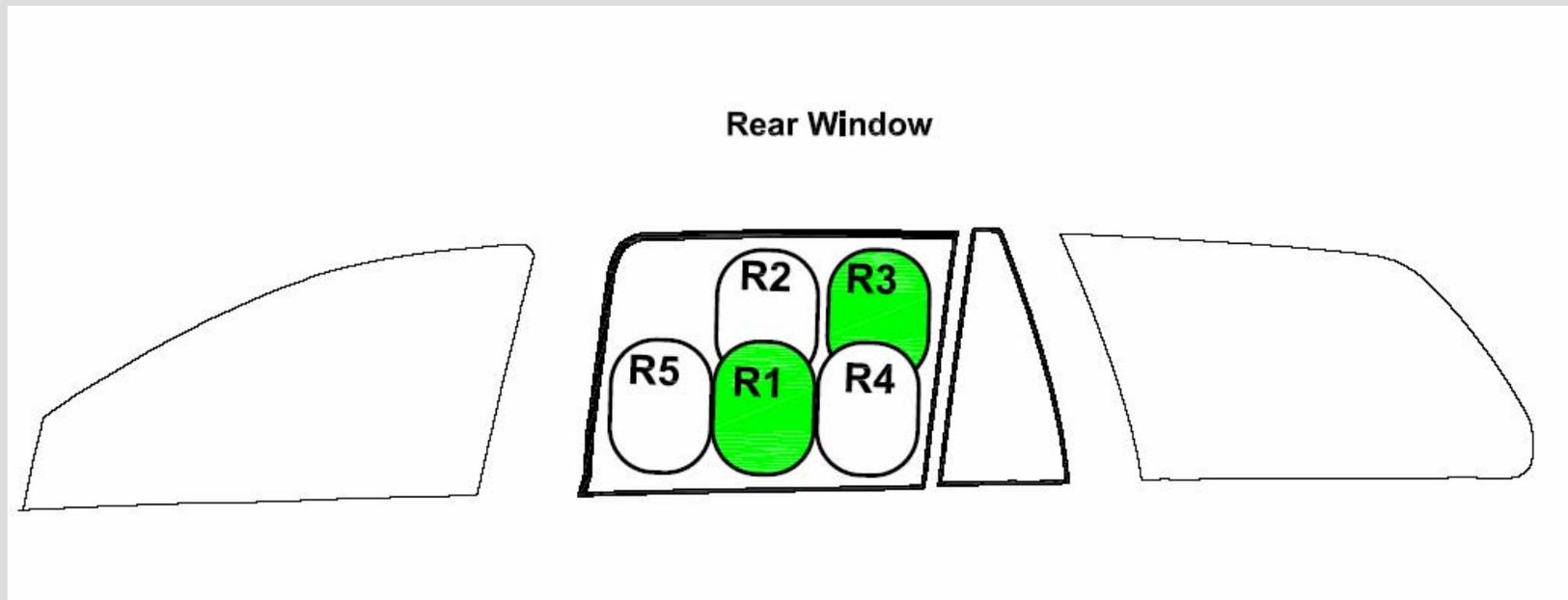
# Ejection Mitigation Impactor Results – Front Window

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



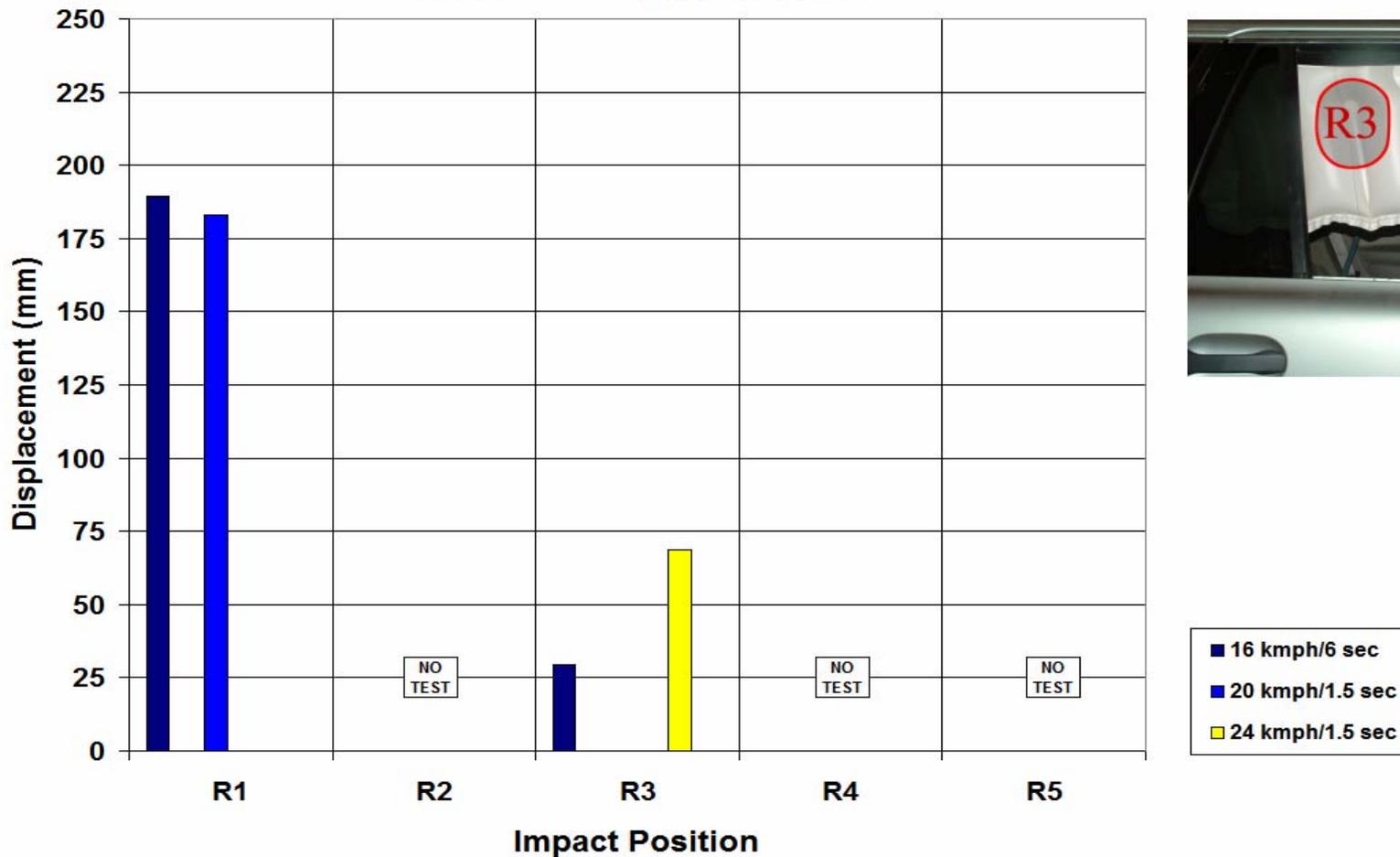
# Ejection Mitigation

## Rear Side Window Impact Locations



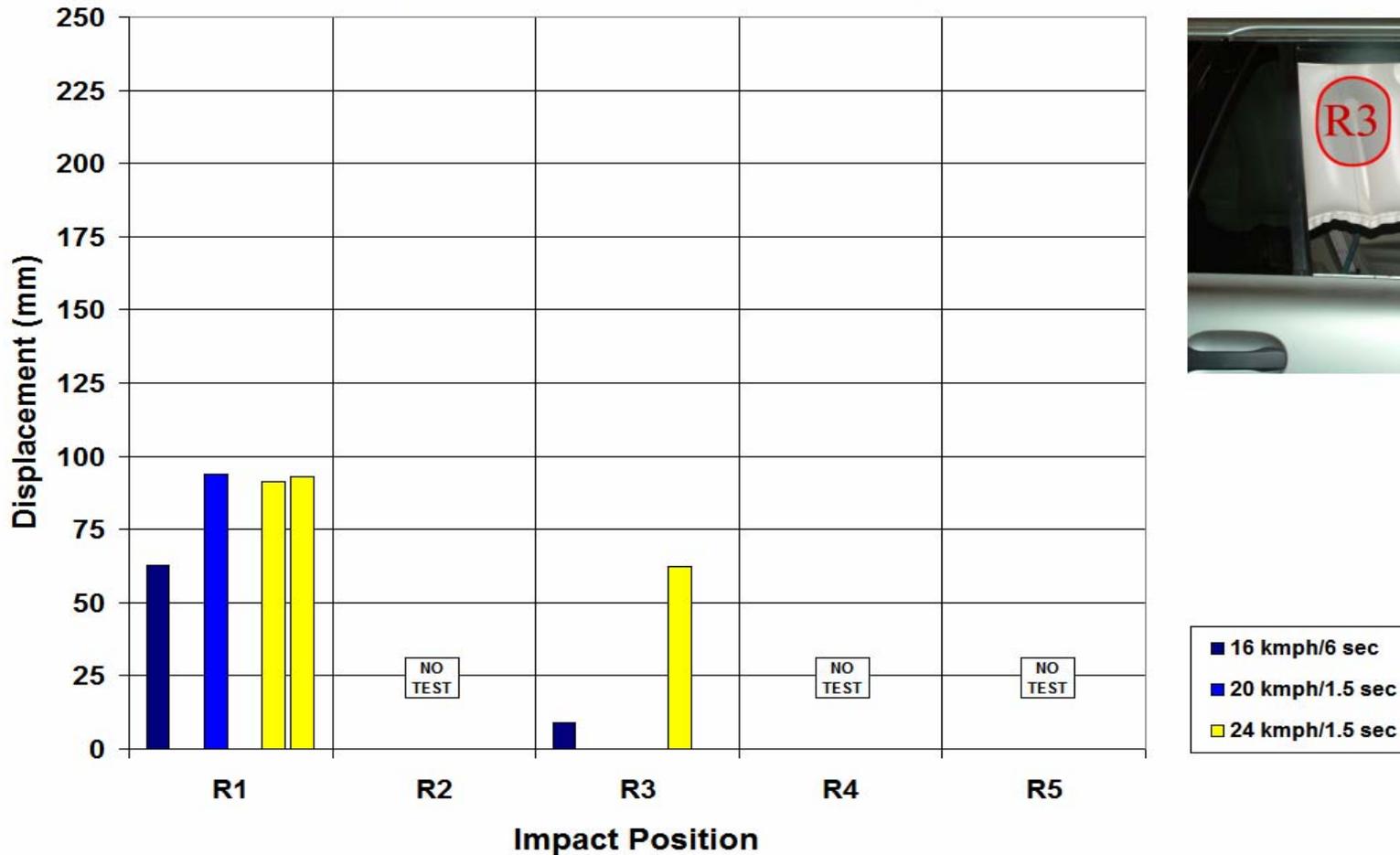
# Ejection Mitigation Impactor Results – Rear Window

Maximum Excursion Beyond Window Plane  
Volvo XC90 - Open Window



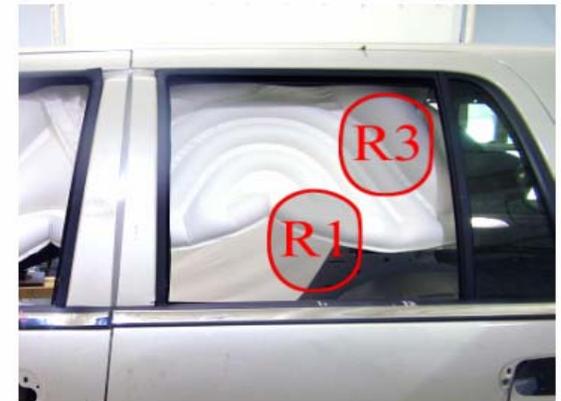
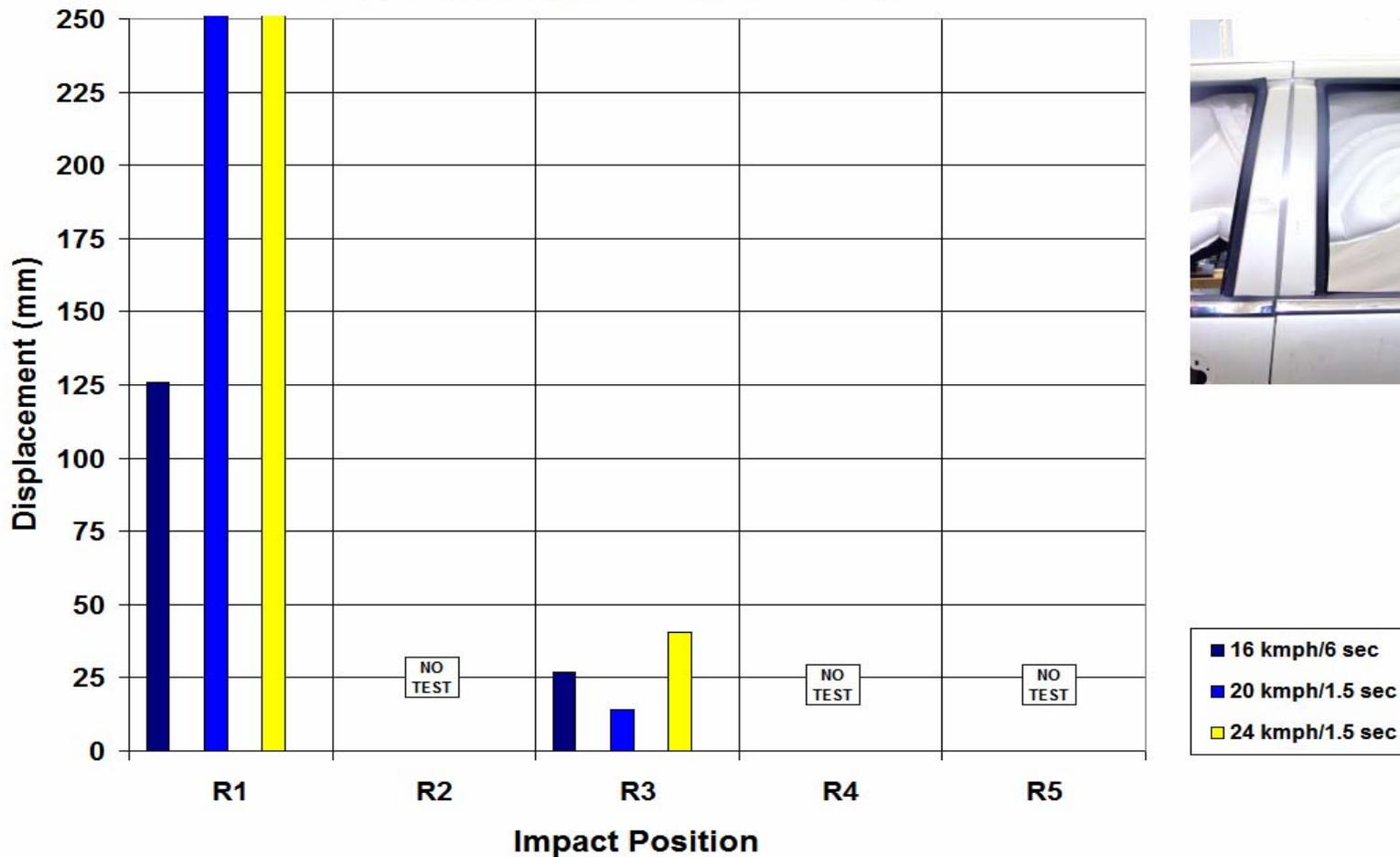
# Ejection Mitigation Impactor Results – Rear Window

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



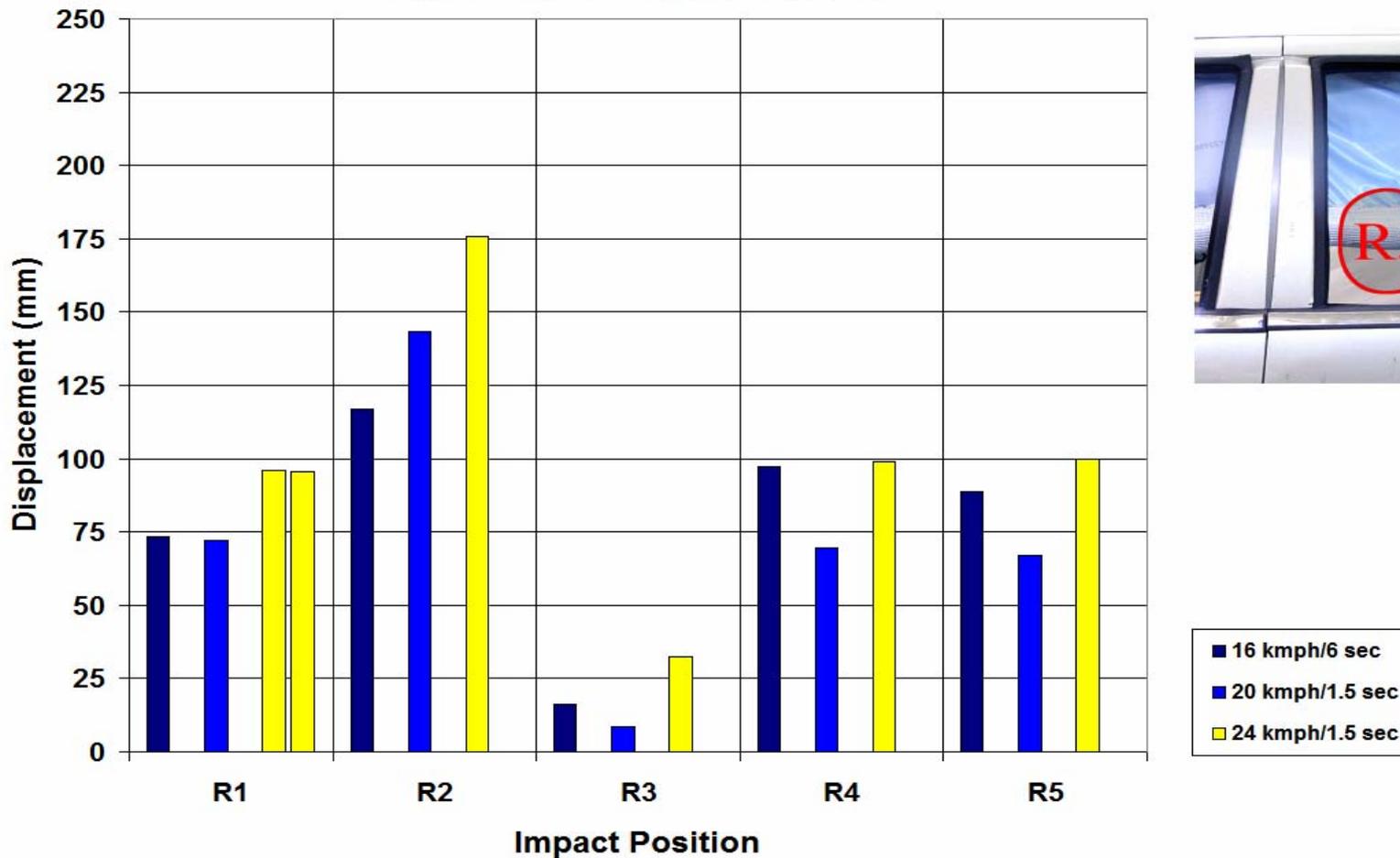
# Ejection Mitigation Impactor Results – Rear Window

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

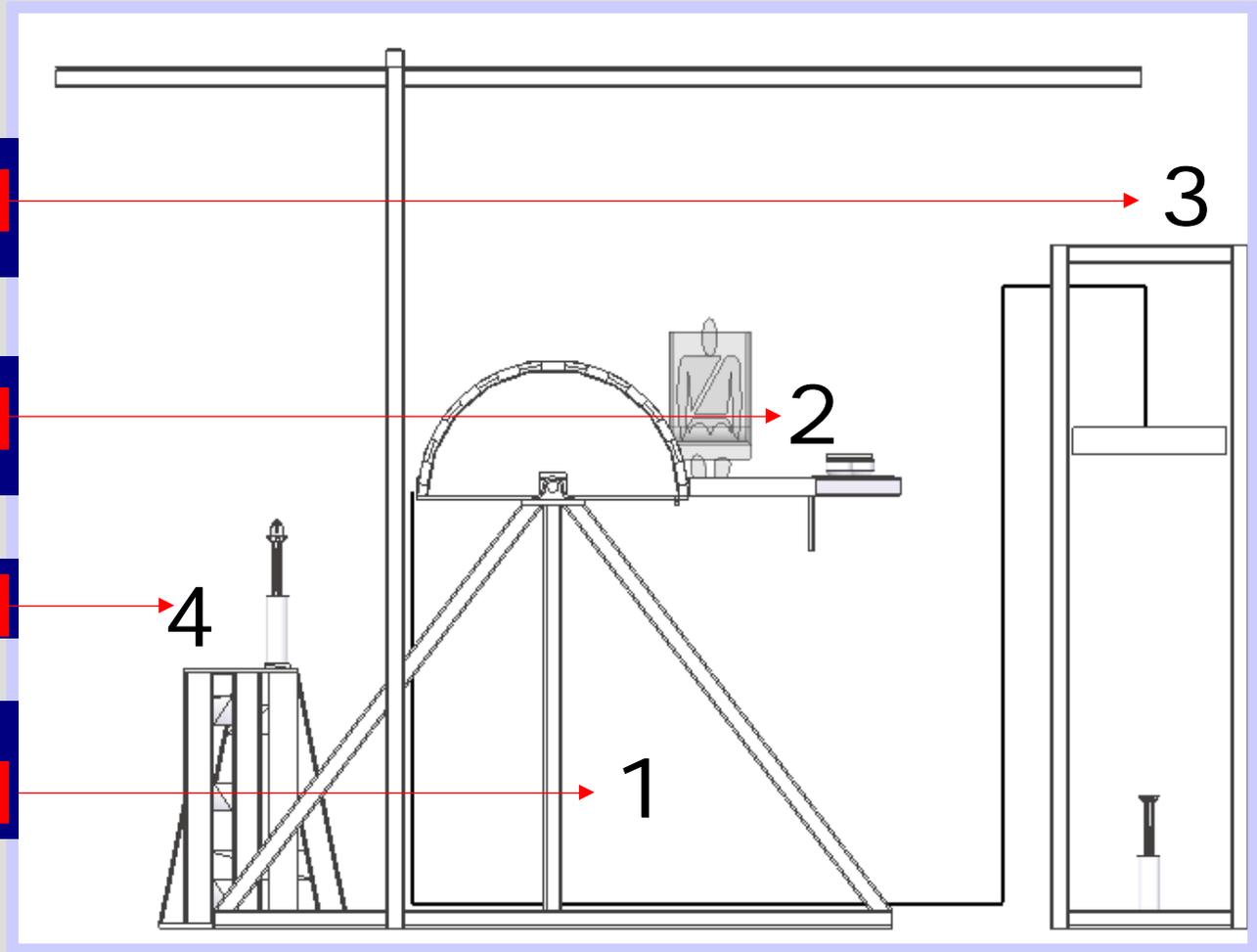
## Rollover Restraint Tester

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**