

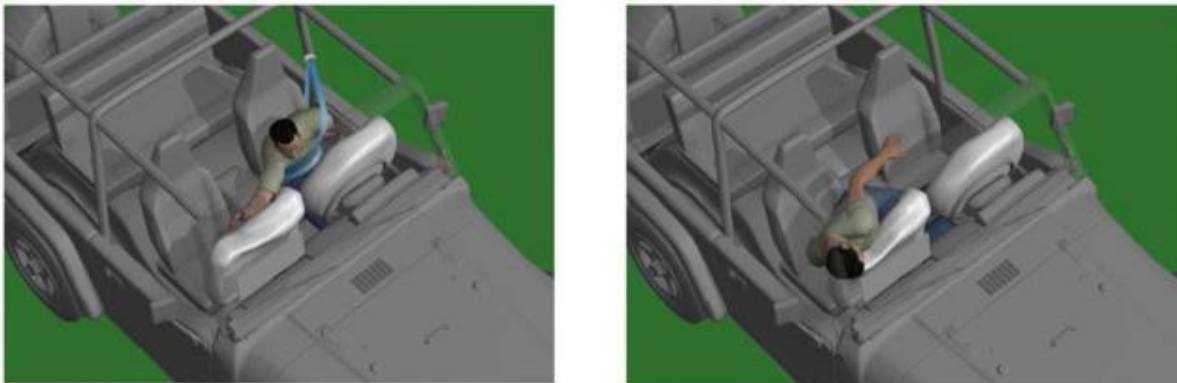
## Occupant Protection / Restraints

### Overview

Exponent's consulting staff has a broad experience base and unmatched capabilities related to occupant protection and restraint systems. Our biomechanical staff work closely with the vehicle engineering practice to maintain an up-to-date knowledge base concerning restraint technology. We research and publish regularly on a wide array of occupant protection topics. Our approach combines comprehensive documentation and evaluation of physical evidence with surrogate demonstrations; physical testing, ranging from static roll demonstrations and airbag deployments to sled simulations and full-scale crash testing; and review of available statistical data and literature to assess occupant protection concerns. Applications include investigation of accidental injury and support for design review of new or modified occupant protection systems.

### Active Restraints — Manual Seat Belts

Exponent has extensive experience in evaluation of seat-belt systems and their relationship to occupant protection and injury mitigation. Key areas of investigation include evaluations of seat-belt geometry, fit and performance, effectiveness, occupant excursion, partial or complete ejection, and possible allegations of seat belt non-use or misuse, in a variety of accident scenarios. We have published studies and continue ongoing research into claimed seat-belt failure mechanisms, including inertial unlatching and inadvertent release, and the resulting physical evidence and occupant entanglement and injury characteristics.



**Figure 1.** Illustration of occupant excursion with and without seat belt during angled frontal impact

### Passive Restraints — Airbags and Related Systems

Exponent's scientists and engineers study issues related to airbag systems, including frontal, side, and side curtain (rollover) systems. Areas of investigation include deployment timing and envelope relative to occupant kinematics, airbag safety and effectiveness for different crash types, and airbag-induced injury, including issues related to airbag interaction with unbelted or out-of-position occupants. We are also experienced with other passive systems such as automatic seat-belt systems.



**Figure 2.** Out-of-position surrogate demonstrating how head can bypass inflated airbag during frontal impact

Exponent can provide assistance with a broad spectrum of concerns related to child restraints. We are familiar with the myriad types of child restraints available, including infant-only, rear-facing, forward-facing, convertible, and various types of booster seats, and have performed research studies on the performance of such systems in crash environments. Exponent can provide assistance in evaluation of child restraint fit, performance, proper usage, effectiveness, testing, and interaction with other restraint-system elements, such as adult seat belts and LATCH systems.



**Figure 3.** Dynamic testing of child restraint system

### **Other Occupant Protection**

Many other elements of a vehicle's interior may be involved in providing protection to the occupant during an accident. Our staff provides the necessary expertise to evaluate the complex interactions of an occupant with such elements as head restraints, seatbacks, steering wheels, and other interior structures, such as knee bolsters, door beams, footwells/controls, consoles, and trim panels. Other issues considered include the relative safety of various seating positions in a given accident (e.g., rear-seat safety for child occupants), the effect of unrestrained occupants or cargo on restrained-occupant safety, and the performance of rollover protection systems (ROPS) in applicable vehicles.

### **Restraint Technology**

Exponent's consultants have the background and research experience to evaluate the occupant protection issues related to current and advanced technological developments in restraint systems, including seat-integrated restraints, energy management systems, pretensioners and motorized tensioning systems, advanced/"smart" head restraints, occupant position-sensing systems, and "black box" restraint status information.