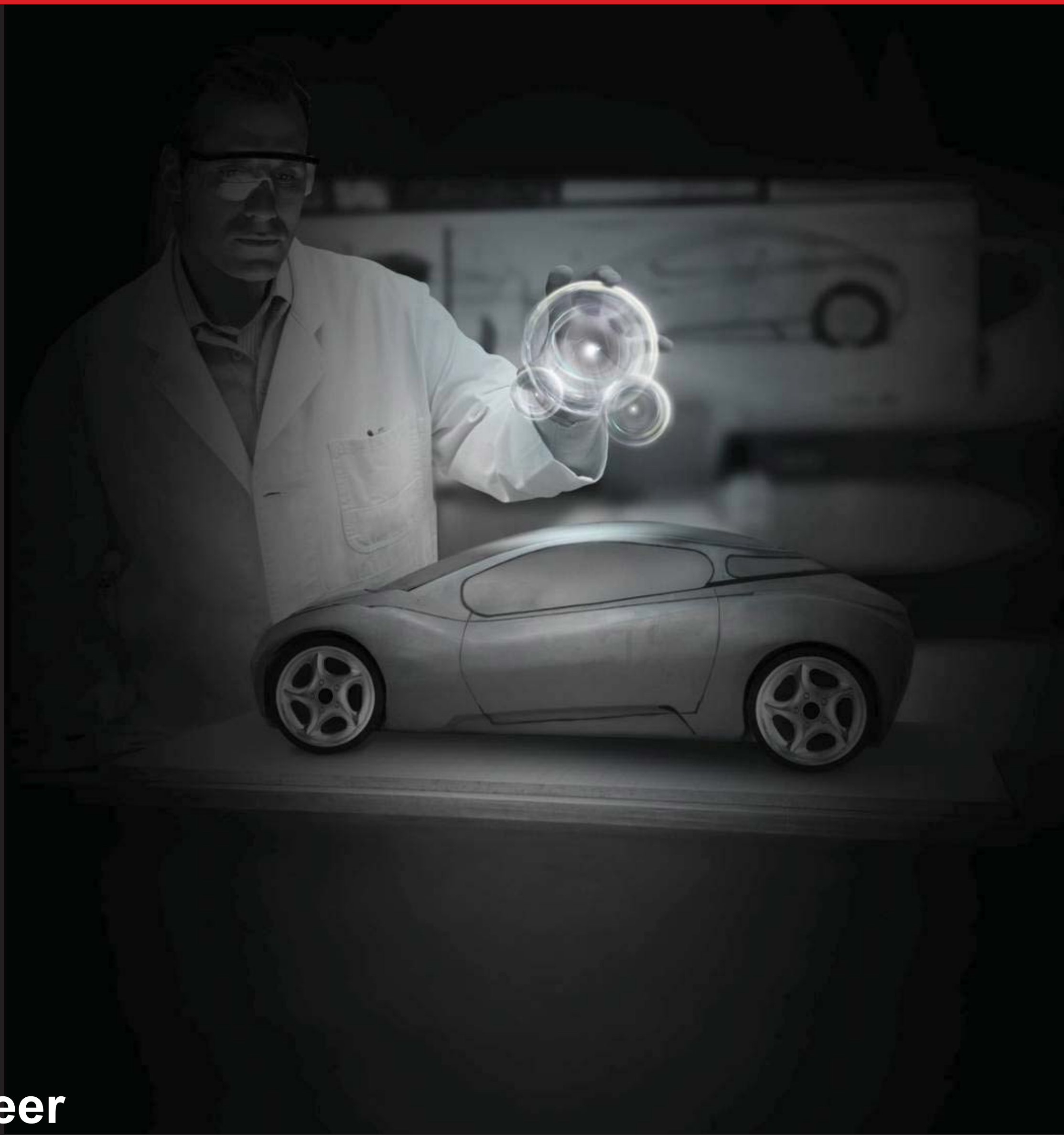
UMTRI Automotive Safety Conference

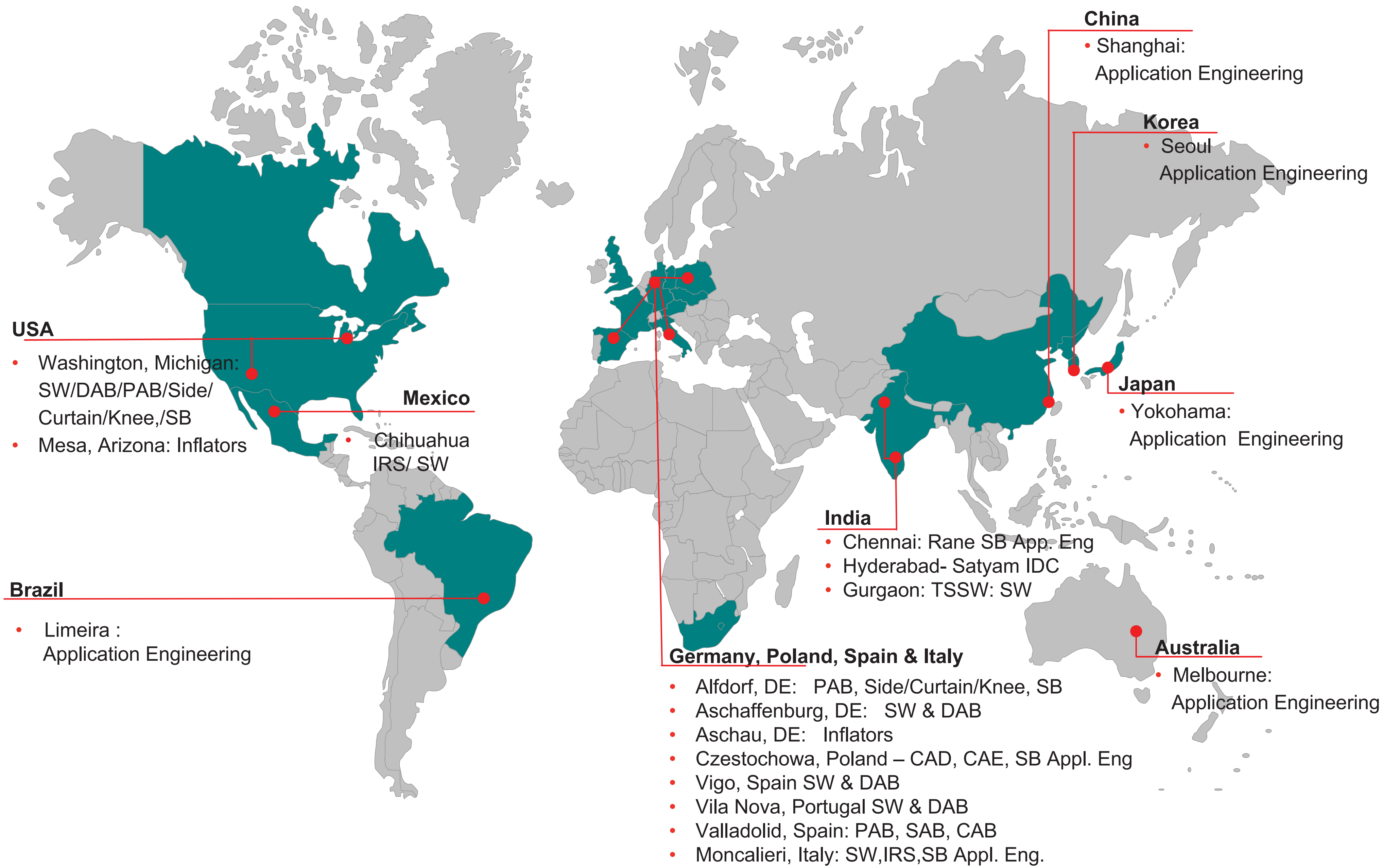


A Supplier's Perspective on Automotive Safety – Past, Present & Future

February 16th, 2011

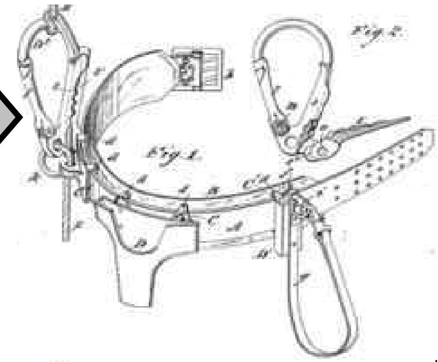
Kurt Fischer – Senior Staff Engineer

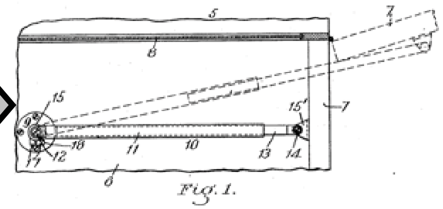
Global OSS Engineering Presence

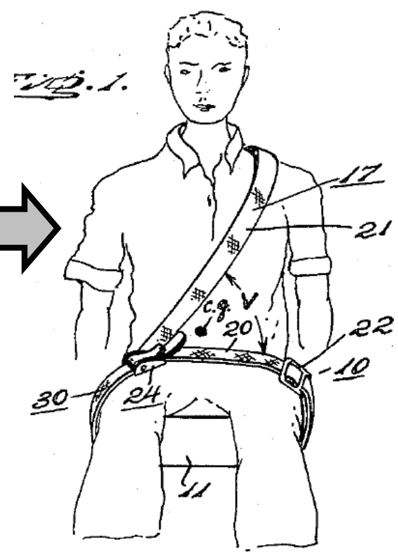


Automotive Safety – The Earlier Years

- 1885 - The first U.S. patent for automobile seat beats was issued to Edward J. Claghorn of New York, New York. United States Patent #312,085.
- 1920’s - Irvin Air Chute received an order for seat belts for Barney Oldfield's Indianapolis 500 racecar.
- 1927 – Fred H. Rowe applied for a first automatic restraint. US Patent #1,775,256.
- 1951 – The first three point belt (CIR-Griswold restraint) was patented by Americans Roger W. Griswold and Hugh De Haven. But, they left the buckle in the middle.







Safety Belt Devised For Car

DESIGNED to hold passengers firmly in their seats in event of a crash so that they will not be thrown violently against the car interior, a newly developed safety belt for automobiles may eliminate injuries attributed to this cause.

Mechanix Illustrated – July 1938

Automotive Safety – The Earlier Years

- **1952 - Walter Linderer's airbag was based on a compressed air system, either released by bumper contact or by the driver. Linderer received German patent #896312.**
- **1953 - John Hedrik received U.S. Patent #2,649,311 for what he called a "safety cushion assembly for automotive vehicles.“**
- **1955 - Ford Motor Company announced that a "safety package," including seat belts, padded dashboard and sun visors, would be offered as an option for their 1956 model year.**
- **1958 – Swedish Saab first introduced seat belts as standard.**
- **1959 – Volvo introduced, Swedish inventor’s, Nils Bohlin three-point seat belt. United States Patent #3,043,625.**
- **1962 - Irvin Air Chute was awarded a production contract by General Motors to supply two safety belts for each Corvette manufactured.**
- **1965 – SAE J4c was issued as a seat belt standard.**

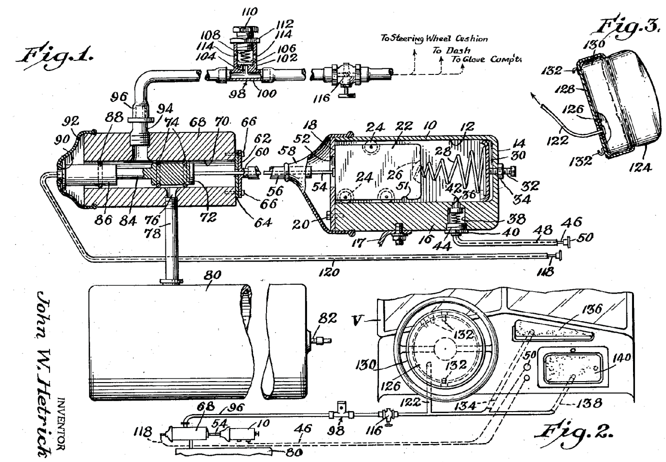
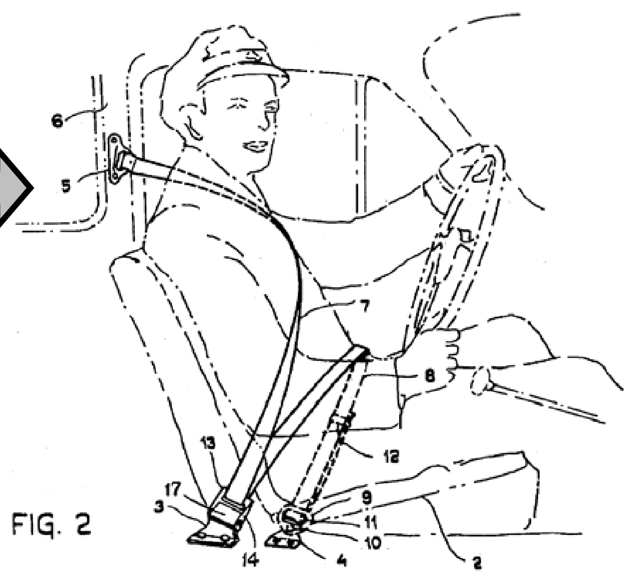


FIG. 2



Automotive Safety – The Earlier Years

- 1967 – FMVSS 209 was issued as the first regulation for seat belts.
- 1968 – FMVSS 208 was issued. It required lap belts on all forward facing seat positions and shoulder harnesses on the front outboard positions.
- 1968 - Allen Breed patented the world's first electromechanical automotive airbag system. (U.S. #5,071,161)
- 1971 – Cadillac introduced computerized anti-lock rear brakes as optional equipment.
- 1971 – Ford had planned on introducing air bag (aka "Auto-Ceptor") equipped vehicles for the 1971 model year. The program was shelved at the end of 1969 due to insurmountable problems. *Eaton Yale & Towne received 21 patents during this development.*
- 1972 - The inflatable seatbelt was invented by Donald Lewis and tested at the Automotive Products Division of Allied Chemical Corp. Ref an early patent US 3,841,654.

Pillow protects you in auto crashes

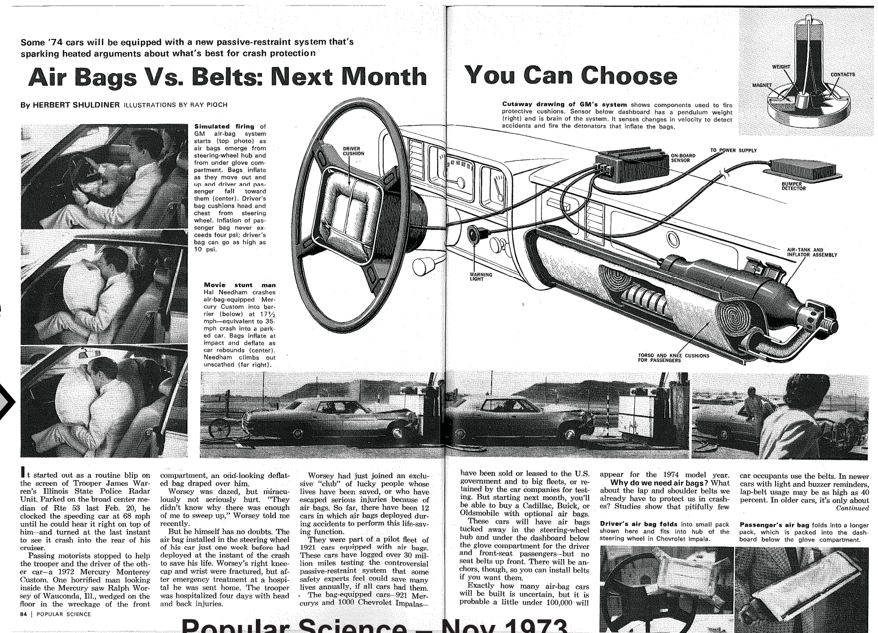
This "Auto-Ceptor" pillow is designed to prevent or lessen injuries in car accidents. Triggered by a crash sensor, it inflates in 1/25 second between the instrument panel and the driver and passenger. A model and dummy child demonstrate it here. It's a joint product of two companies: Eaton Yale & Towne and the Ford Motor Co.

94 | POPULAR SCIENCE

Popular Science – May 1968

Automotive Safety – The Earlier Years

- **1973 – General Motors manufactures 1,000 Chevrolets equipped with experimental air bags and provides them to fleet customers for testing. Infant, unrestrained on the passenger seat of one of the experimental Chevrolets, is killed when a passenger bag deploys in a wreck. GM considers that the first air bag fatality.**



Some '74 cars will be equipped with a new passive-restraint system that's sparking heated arguments about what's best for crash protection

Air Bags Vs. Belts: Next Month

By HERBERT SHULDINER ILLUSTRATIONS BY RAY PIOCH

You Can Choose

Popular Science – Nov 1973

- **1975 – Oldsmobile Toronado is considered the first production GM vehicle to offer a air bag system as a option.**
- **1975 – Volkswagen Rabbit was the first commercial car to use automatic seat belts.**
- **1978 - NCAP initiated to provide the customer with a measure of safety performance**
- **1979 – Chevrolet Chevette joined the Rabbit as the only cars for automatic seat belts.**
- **1981 - Mercedes-Benz introduced the airbag in Germany as an option on its high-end S-Class (W126). In the Mercedes system, the sensors would automatically pre-tension the seat belts to reduce occupant's motion on impact (now a common feature), and then deploy the airbag on impact.**

Mercedes' steering-wheel air bag

Chest-protecting air bag inflates from the steering wheel in 1/30 of a second, preventing injury as the driver is thrown forward. After driver hits it, the bag deflates.

A combination of air bag and seat belt protects the driver who opts for Mercedes' new safety package. The air bag is the only one offered as a production option by any auto maker.

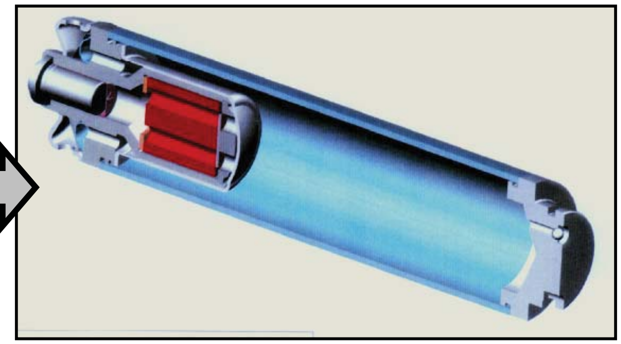
In an impact of over nine mph, a pendulum sensor on the drive-shaft tunnel detects deceleration. A tiny pellet of solid rocket fuel then detonates; as it burns, it produces nitrogen gas that balloons a neoprene bag from the steering wheel. When the driver hits the bag, it deflates slowly. The driver is also restrained by his seat belt.

Instead of an air bag, an inertial reel belt restrains the front passenger. The same sensor triggers gas from a separate capsule. The gas expands against a piston that forces fluid onto a miniature hydraulic-turbine wheel mounted on the belt reel. This tightens any belt slack in 12 milliseconds. When the ignition is switched on, a dashboard check light glows for a few seconds, indicating that the system is functioning properly. The safety package is available as an option only in Europe on Mercedes S-Class cars. Price: about $620.—*David Scott*

Popular Science – Nov 1981

Automotive Safety – The Recent Years

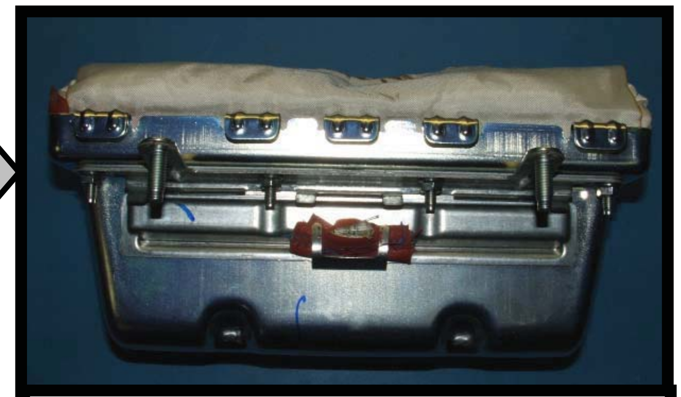
- 1984 – In the US, the Ford Tempo was offered with driver airbag as an option.
- In 1987, the Porsche 944 turbo became the first car in the world to have driver and passenger airbags as standard equipment. The same year also saw the first airbag in a Japanese car, the Honda Legend.
- 1988 – In the US, Chrysler became the first company to offer air bag restraint systems as standard equipment.
- 1984 - The U.S. government amended FMVSS 208 to require cars produced after 1 April 1989 to be equipped with a passive restraint for the driver. An airbag or an automatic seat belt would meet the requirements of the standard. Airbags were not mandatory on light trucks until 1997.
- 1994 - TRW began production of the first gas-inflated airbag.
- 1995 – The Volvo 850 was the first automobile with side airbags (Autoliv).
- 1996 – Mercedes E-Class was launched with a door mounted side bag was launched with a seat mounted side bag. (TRW)
- 1998 - FMVSS 208 was amended to require dual front airbags, and de-powered, or second-generation airbags were also mandated. FMVSS 208 continues to require that bags be engineered and calibrated, and tested using an *unbelted* 50th-percentile size and weight "male" crash test dummy.
- 1999 – The Toyota Progress (Toyoda-Gosei), Daimler E-Class and Volvo S80 (Autoliv), and Audi A4 (TRW) were launched with curtain airbags.

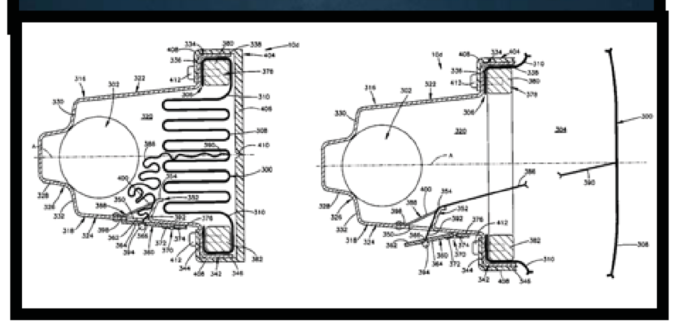


NOTE: Product launch dates are approximate and used for reference only

Automotive Safety – Up to Present

- **2003 – Alliance of Automotive Manufacturers issues voluntary commitment to side impact protection, pledging to voluntarily make 50% of the vehicle fleet meet either FMVSS 201 pole or IIHS High Movable Deformable Barrier (MDB) by 2007 and 100% meet IIHS High MDB by 2012.**
- **2005 – Ford introduces the Explorer with Active Venting and Active Tethering (TRW)**
- **2007 – FMVSS 214 was issued adding angular pole test, different dummies at two different seating positions and expanded injury assessment criteria. Implementation starts at 20% and100% by 2012.**
- **2007 – Dodge Nitro is launched with the first tethered vent as on out-of-position counter measure (TRW).**
- **2008 – Chrysler launches the Dodge Ram with the first low risk deployment passenger airbag (Takata).**
- **2011 – NHTSA updates the NCAP test.**
- **2011 – FMVSS 226, Ejection Mitigation, is issued. It mandates fitment of side curtain airbags for occupant containment. Implementation starts at 25% by 2013 and 100% by 2016.**



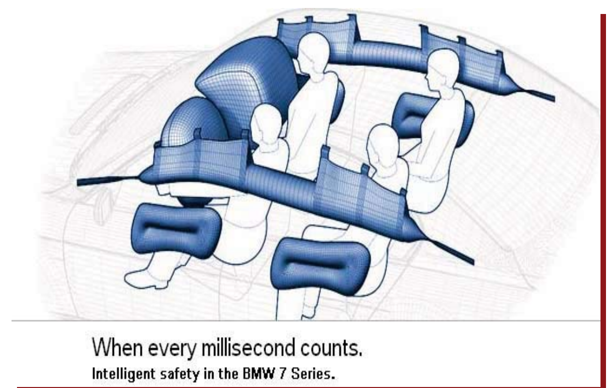


NOTE: Product launch dates are approximate and used for reference only

Regulatory and Industry Safety Trends

- **Current Activities**
  - New U.S. NCAP for Model Year 2011 Vehicles
    - Including front & side criteria, adds small stature adult
    - Includes additional criteria for neck & femur injuries
    - Raises the bar to achieve a “5 Star” Crash Rating
    - Requires a “Systems” approach to balance requirements, may include knee bags, changes to airbags, seat belts, and so on.

  - Improved Side Impact Protection (FMVSS214)
    - Improves protection in side collision with “pole”
    - Incorporates smaller stature occupant
    - Generally requires enhanced curtain airbags
    - Currently being phased in thru 2014



  - Ejection Mitigation (FMVSS 226)
    - Regulation for enhancing occupant retention in vehicle during rollover
    - May drive further curtain airbag and test protocol changes

The Regulatory Landscape

Summary

Roof Deflection
FMVSS 216

Head Rests
FMVSS 202 ECE-R 17, 25 EG 78/932

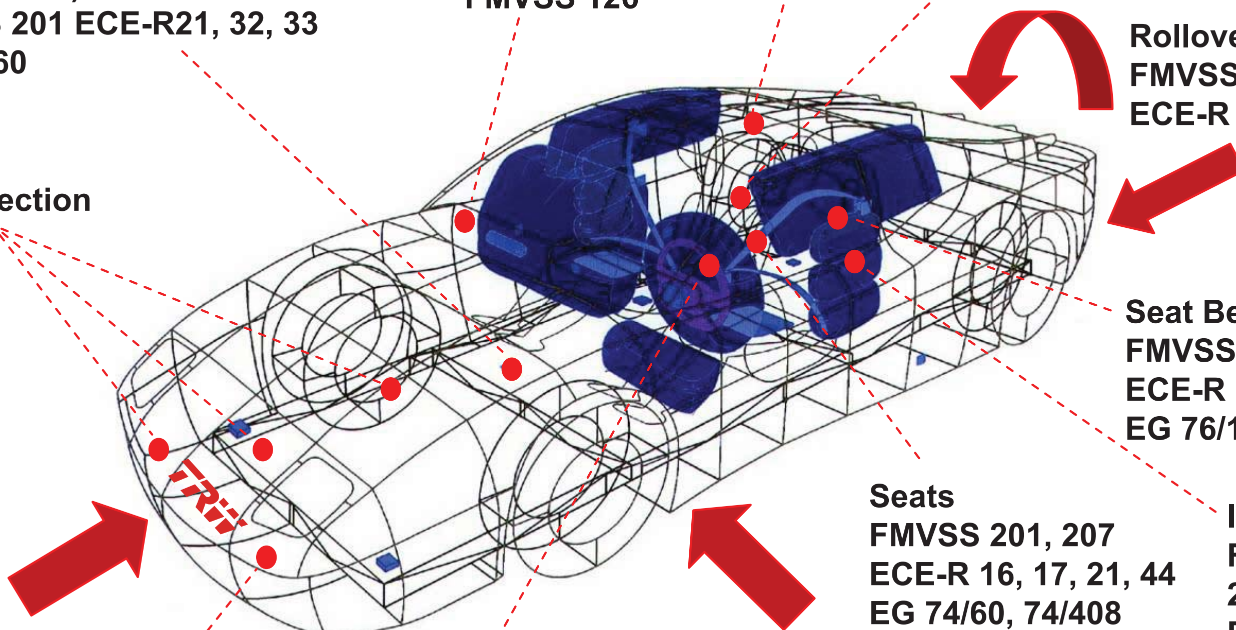
Instrument Cluster (Dashboard)
FMVSS 201 ECE-R21, 32, 33
EG 74/60

Vehicle Stability
FMVSS 126

Rollover
FMVSS 201, 208, 216
ECE-R 21

Pedestrian Protection
2003/102/EG

Rear Impact
FMVSS 202, 207, 223, 224, 301, 581
ECE-R 17, 25, 32, 42



Seat Belts
FMVSS 208, 209, 210, 213
ECE-R 14, 16
EG 76/115, 77/541, 96/27, 96/79

Seats
FMVSS 201, 207
ECE-R 16, 17, 21, 44
EG 74/60, 74/408

Interior
FMVSS 201, 202, 203, 204, 205, 207, 213, 225
ECE-R 12, 16, 17, 21, 44

Front Impact
FMVSS
203,204,205,208,209,210,212,301
ECE-R 12,14,16,33,94

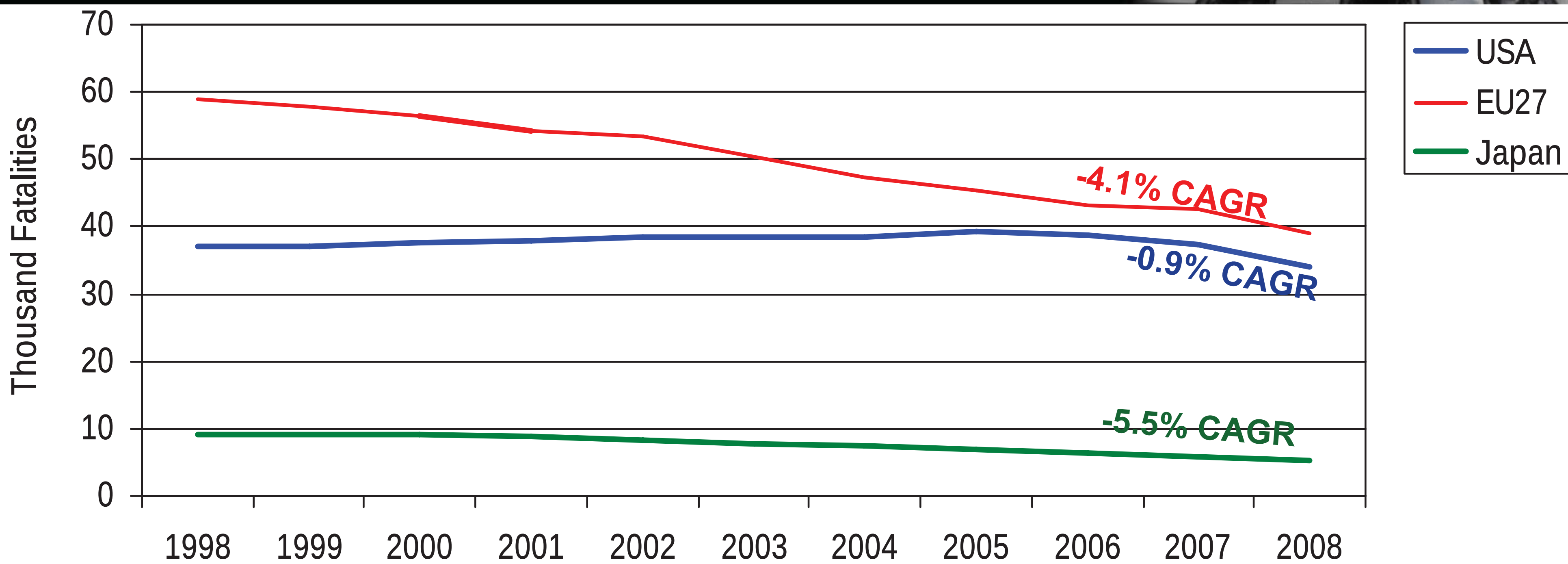
Side Impact
FMVSS 201, 205, 206, 214, 301
ECE-R 11, 95
EG 96/27

Event Data Recorder
US FR Part 563

Steering Wheel
FMVSS 203, 204
ECE-R12
EG 74/297

Bumper
FMVSS 581 ECR-R 42
2006/66/EC (for “Bull bars”)

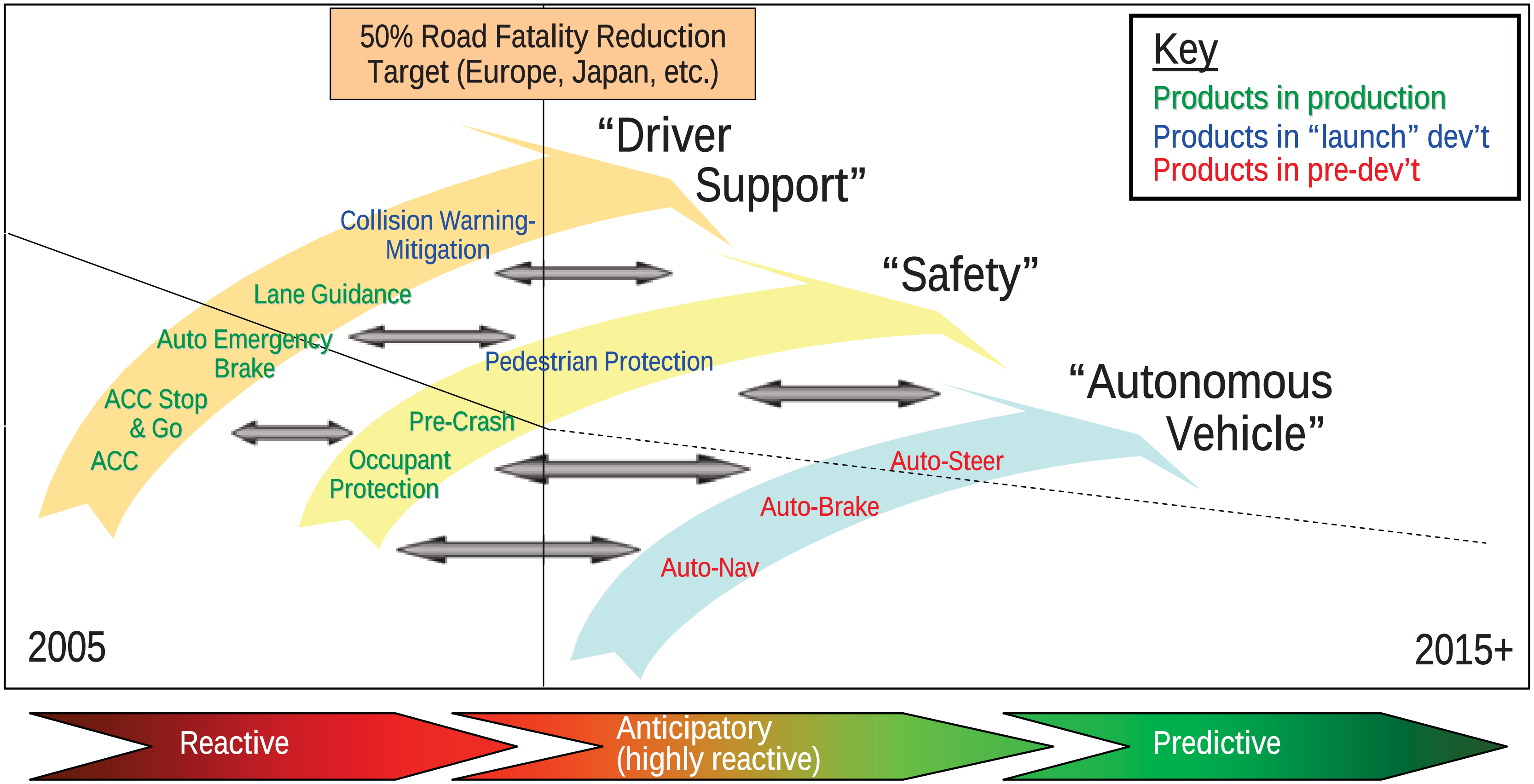
Government Accident Data



- Global vehicle fatality rates continue to trend downward, but at a flattening rate
- Active Safety technologies provide driver assistance in four types of accidents (run-off-road, rear-end, lane change and crossing path) which comprise 85% of accidents and 75% of fatalities in the USA

US trend data: FARS 2008
EU Trend data: 2009 CARE Database
Japan trend data: 2009 data, Official Statistics of Japan Website

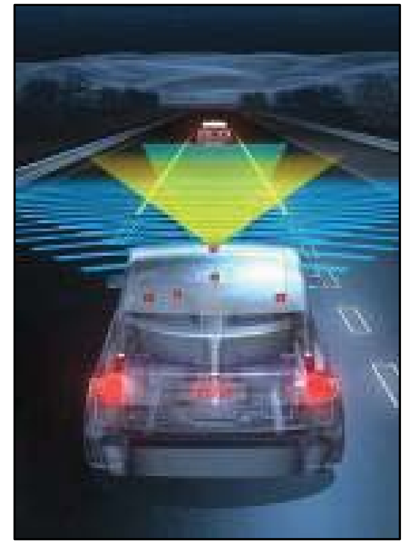
Passive/ Active/ Cognitive Safety Roadmap



- As systems move from reactive to predictive electronics, software and data fusion is the critical thread enabling cognitive, Active Safety solutions

Regulatory and Industry Safety Trends

- **Current Activities**
  - In North America, NHTSA has identified for promotion three active safety technologies with the potential to improve road safety:
    - Electronic Stability Control (ESC) systems
    - Forward Collision Warning systems
    - Lane Departure Warning/ Lane Keeping Systems
  - NHTSA has already mandated ESC starting 2012, and is currently assessing the capabilities of Collision Warning and Lane Departure Warning systems to determine if they should be mandated in the future: (next agency decision in 2011)
  - In Europe the European Commission has mandated the fitment of Lane Departure Warning and Automatic Emergency Braking systems on heavy trucks and buses, starting from 2014MY

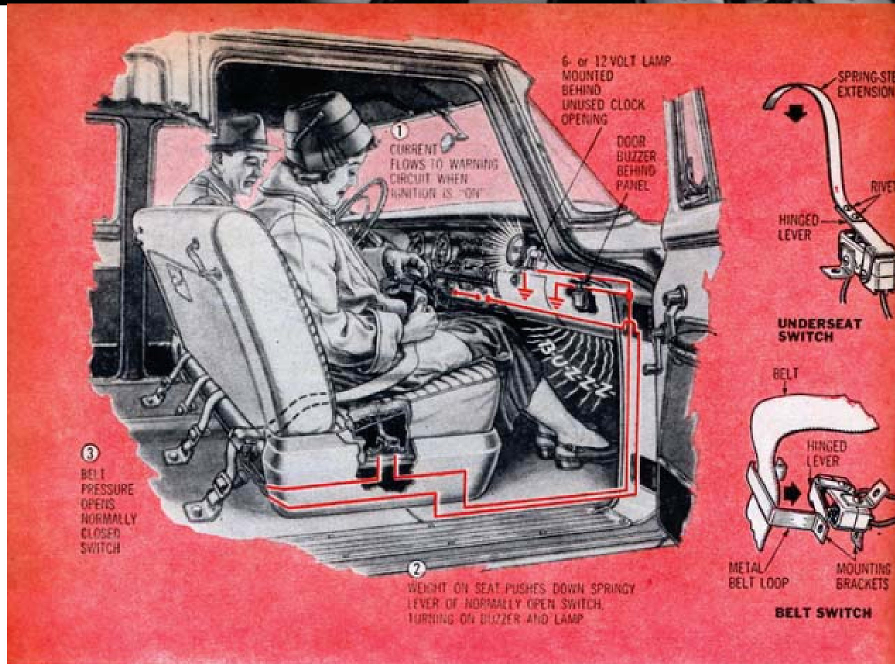


Regulatory and Industry Safety Trends

Current Trends

- Pedestrian Protection
- CAFÉ Requirements – reduced weight, low CO_2 Emissions
- Rear Seat Occupant Protection (dummy development, test methods, regulations all under evaluation by NHTSA)
- Belt Usage Enforcement (possibility for more aggressive belt minder) – *Things haven't changed……*
- Enforcement on Distracted Driving (Cell phone, texting)
- Use of Event Data Recorders (Not mandated but under investigation by NHTSA)

nhtsa "People Saving People"



How I Got My Wife to Use a Seat Belt

FOR 10 years I have used safety belts in my car. But each time we went for a ride I have had to tell my wife to fasten her belt. She is a most stubborn person and uses all kinds of excuses for not doing so.

I have finally won. These drawings show how. The system tells her to put the belt on. It works like magic every time. It saves arguments. The little reminder consists of a light, the words "Safety Belt," a buzzer, and two cunningly wired snap switches.

When my wife gets into the front seat beside me, her weight trips a normally open snap switch under the seat. Two things happen: First a doorbell buzzer begins sounding behind the dash, attracting my wife's attention toward it. Second, in the opening where a clock usually is mounted, the words "Safety Belt" are illuminated by a lamp behind the dash.

The second snap switch, normally closed, is mounted under one strap of the belt so that it is opened by the pressure of pulling the belt across the waist. This breaks the circuit, stopping the buzzer and turning off the lamp. As long as my wife sits in the seat, she'd better have the belt on correctly or the buzzer will let her know. [Editor's note: An optional cut-out switch is shown in the drawing for those who might like one.]

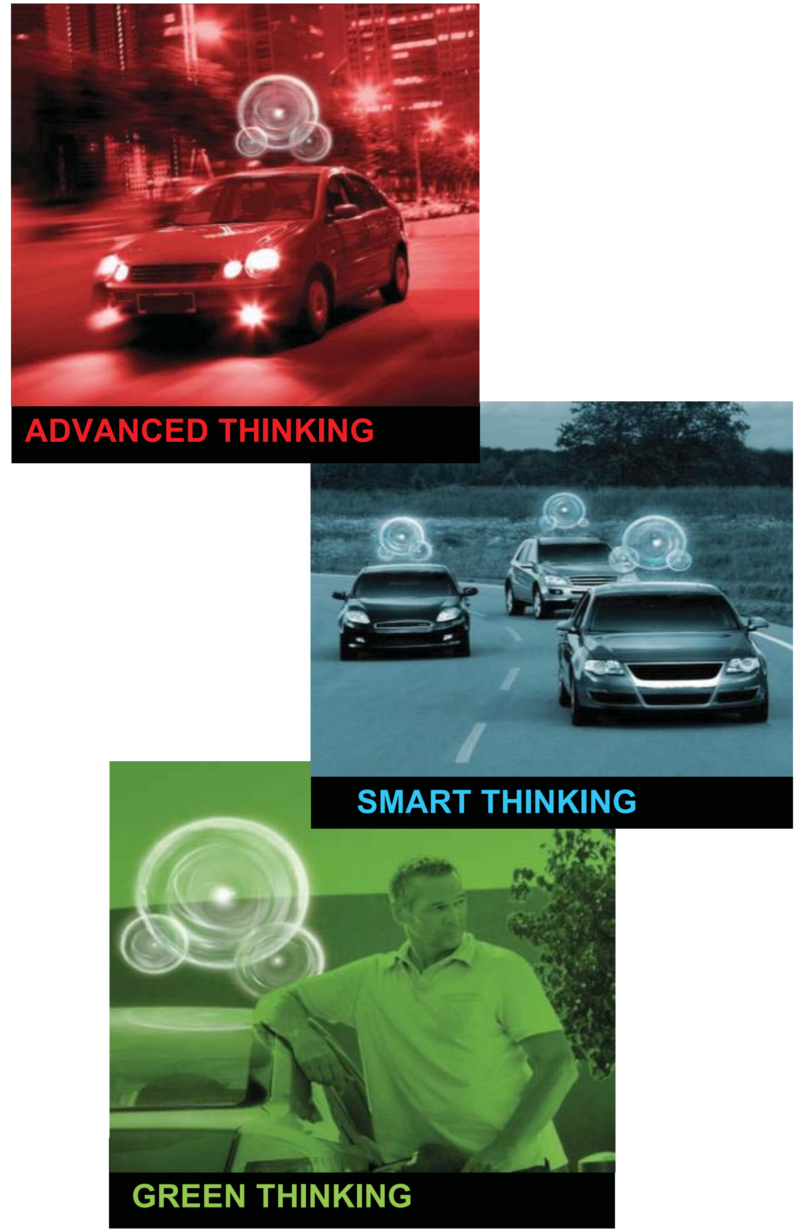
Now, when we start out, she races me to fasten the belt before I can use the ignition key and turn on the circuit. Seems she doesn't like to hear the buzz. The only way to stop the buzz is to get out of the seat or turn off the ignition—or put on the belt. If she wants to go for a ride that leaves her little choice.—*Wes Jayne, Woodhaven, N.Y.*

118 POPULAR SCIENCE JUNE 1960

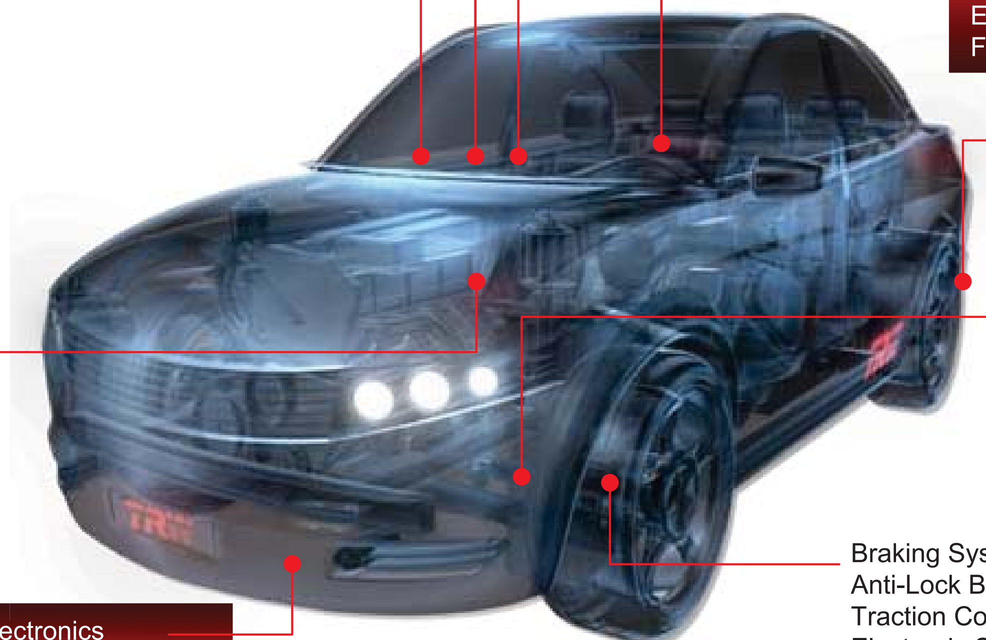
Popular Science – June 1960

Regulatory and Industry Safety Trends

- **Other Industry Trends**
  - Comfort & Convenience
  - Smaller Vehicles
  - Electrics & Hybrids
  - Global Footprint
    - Competitive Costs for products
    - Competitive Costs for Engineering/Development
    - Developing Regions, local supply of low cost products



Active and Passive Safety Technologies



Airbags
Driver & Passenger Airbags
Self Adapting Vent
Active Venting
Low Risk Deployment
Knee & Side Airbags
Curtain/Rollover Airbags

Driver Assist Systems
Adaptive Cruise Control
Lane Guide Systems
Collision Warning

Seat Belt Systems
Active Control Retractor
Seat Belt Retractors
Load Limiters
Buckle Pretensioners
Active Buckle Lifter

Steering Wheel Systems
Touch Sensor in Steering Wheel Rim
Vibrating Steering Wheel
Illumination Technology
Contactless Horn System
Path-free use of Horn
Steering Wheel with Integrated Microphone
Electrical Connections
Fixed Driver Airbag Module

RF Systems
Direct Tire Pressure Monitoring
Remote Keyless Entry

Steering Systems
Speed Proportional Steering
Electrically Powered Hydraulic Steering
Electrically Powered Steering Column Drive
Electrically Powered Steering Rack Drive
Active Steering

Linkage & Suspension Systems
Active Dynamic Control
Control Arms
Ball Joints
Stabilizer Links
Tie Rods
Modules

Safety Electronics
ECU and Remote Sensors
Vision System
Pedestrian Protection
Weight Sensing System

Braking Systems
Anti-Lock Braking (ABS)
Traction Control
Electronic Stability Control (ESC)
Slip Control Boost
Electric Park Brake
Integrated Park Brake
Calipers
Actuation

Adaptive Frontal Airbags

Adaptive Airbag Systems

Prior Systems

(Airbag stiffness is not adapted to the occupant)

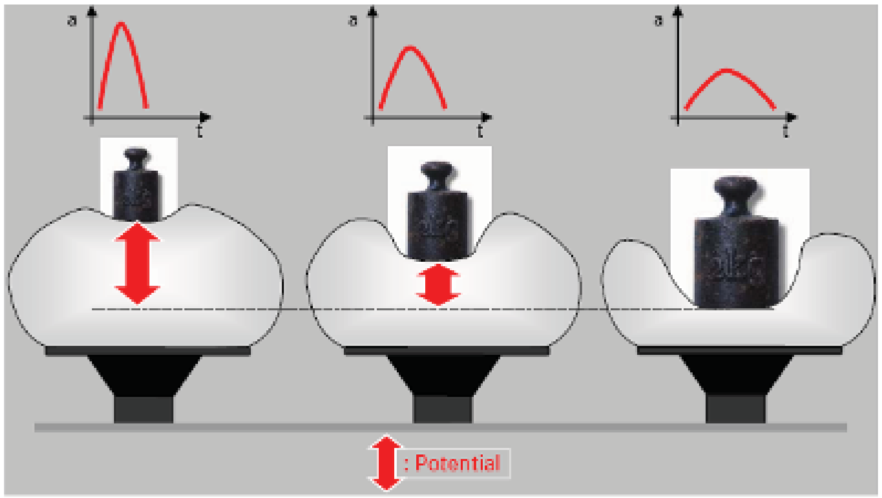


Figure 4: Indentation depth and accelerations for an airbag system without adaptation

Current & Future Systems

(Airbag stiffness adaptive to the occupant size, position and weight)

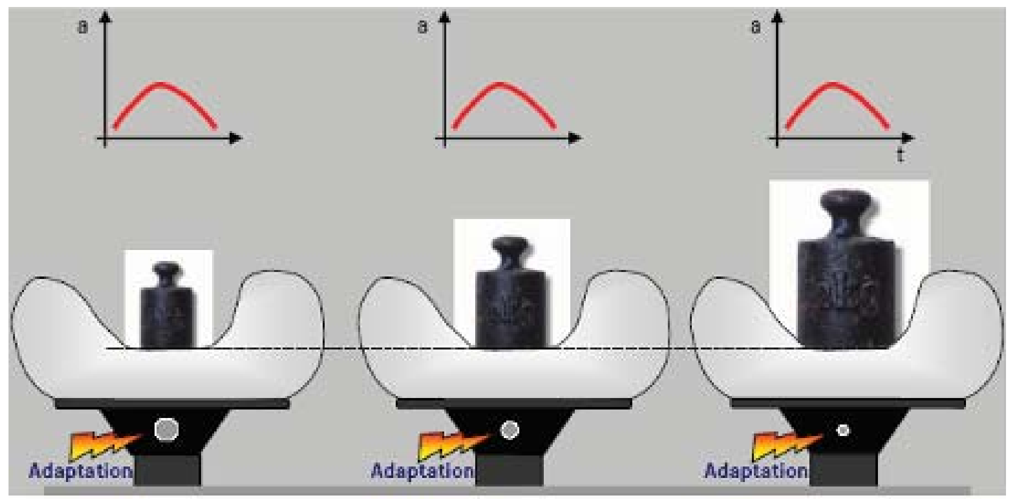
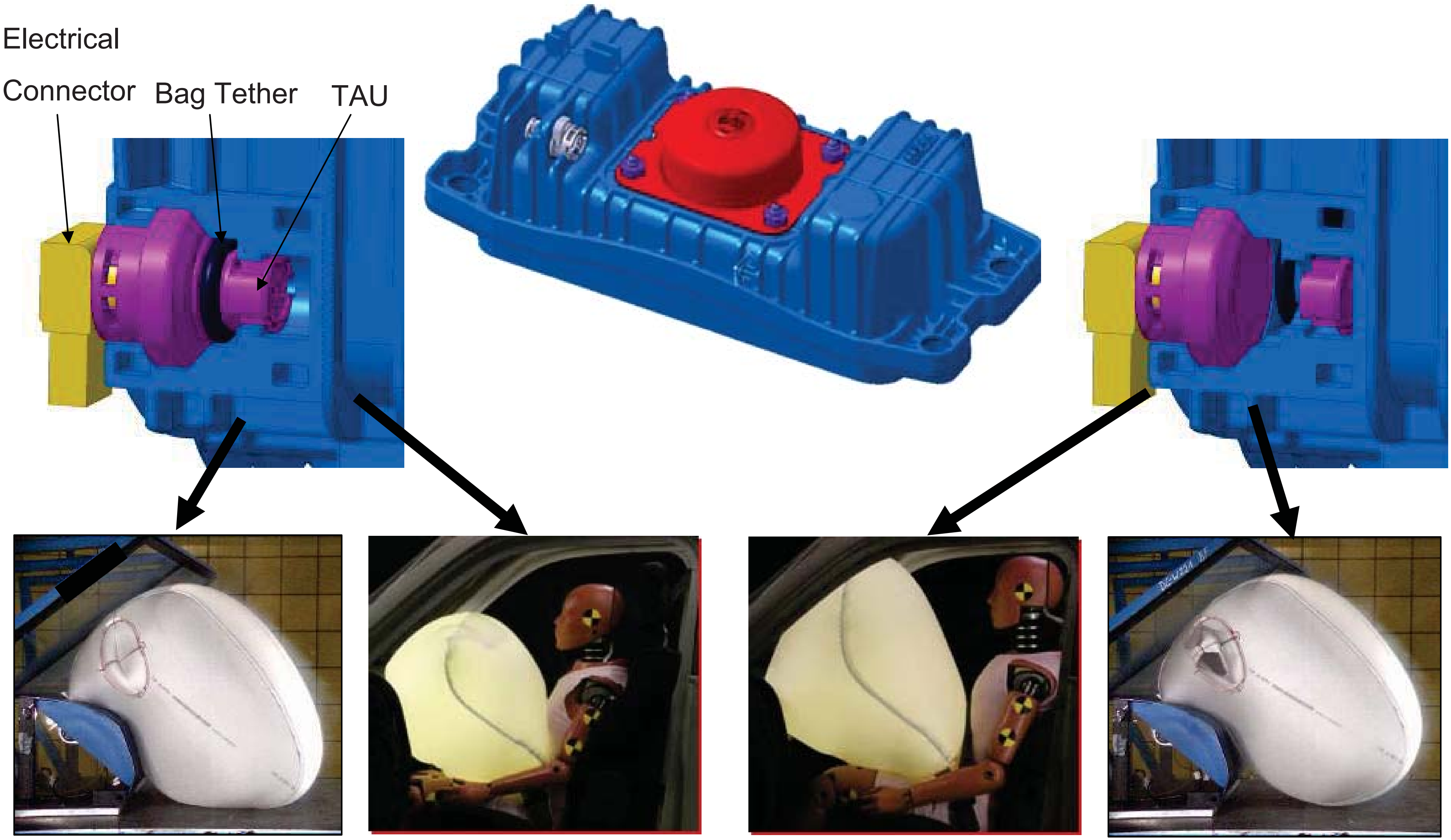


Figure 5: Indentation depth and accelerations for an airbag system with adaptation

Source:
Dr. R. Schöneburg,
K-H.Baumann, C.D.Rüdebusch
- Individual Safety -
Vortrag Airbag 2004

TRW's Adaptive Airbag: Venting & Shaping



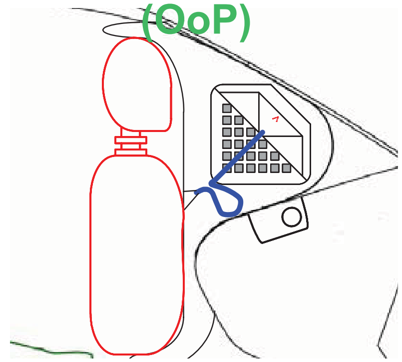
Retained

Released

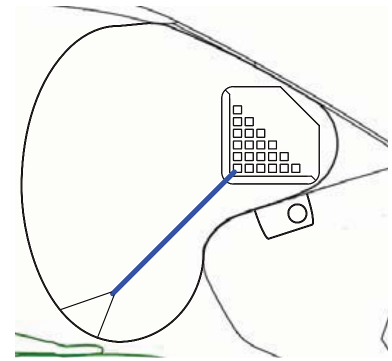
SAVe – Self Adaptive Vent

- **SAVe us an acronym for**
  ***S*elf *A*daptive *V*ent**
- **Function**
  - During an obstructed deployment, like an Out-of-Position occupant, the obstruction prevents the bag from tensioning the tether thus allowing the vent to remain open.
  - During a normal deployment the bag fills and creates tension in the tether and pulls SAVe closed.

Obstructed Deployment (OoP)



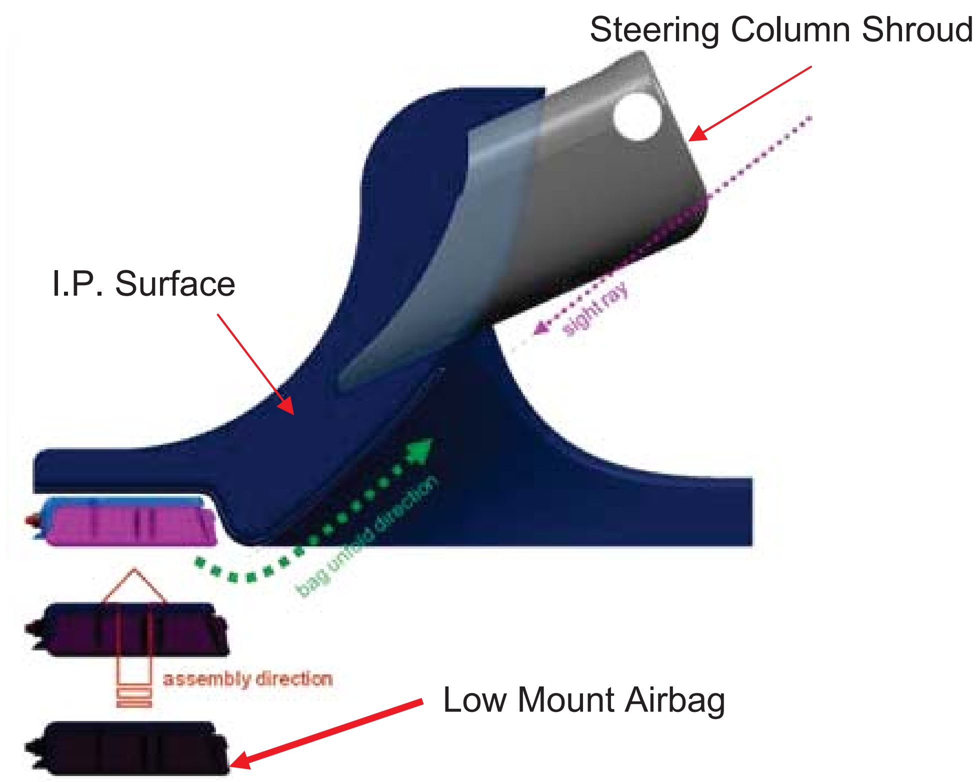
Normal Deployment



Consequence of Global Company

Knee Airbag

- Knee airbags have the potential to *reduce chest deflection* because of pelvis coupling to the vehicle and potentially *advantageous occupant kinematics*
- Improvements can be observed for both driver (50th) and passenger (5th) dummies
- Additional benefits for unbelted FMVSS 208 test mode

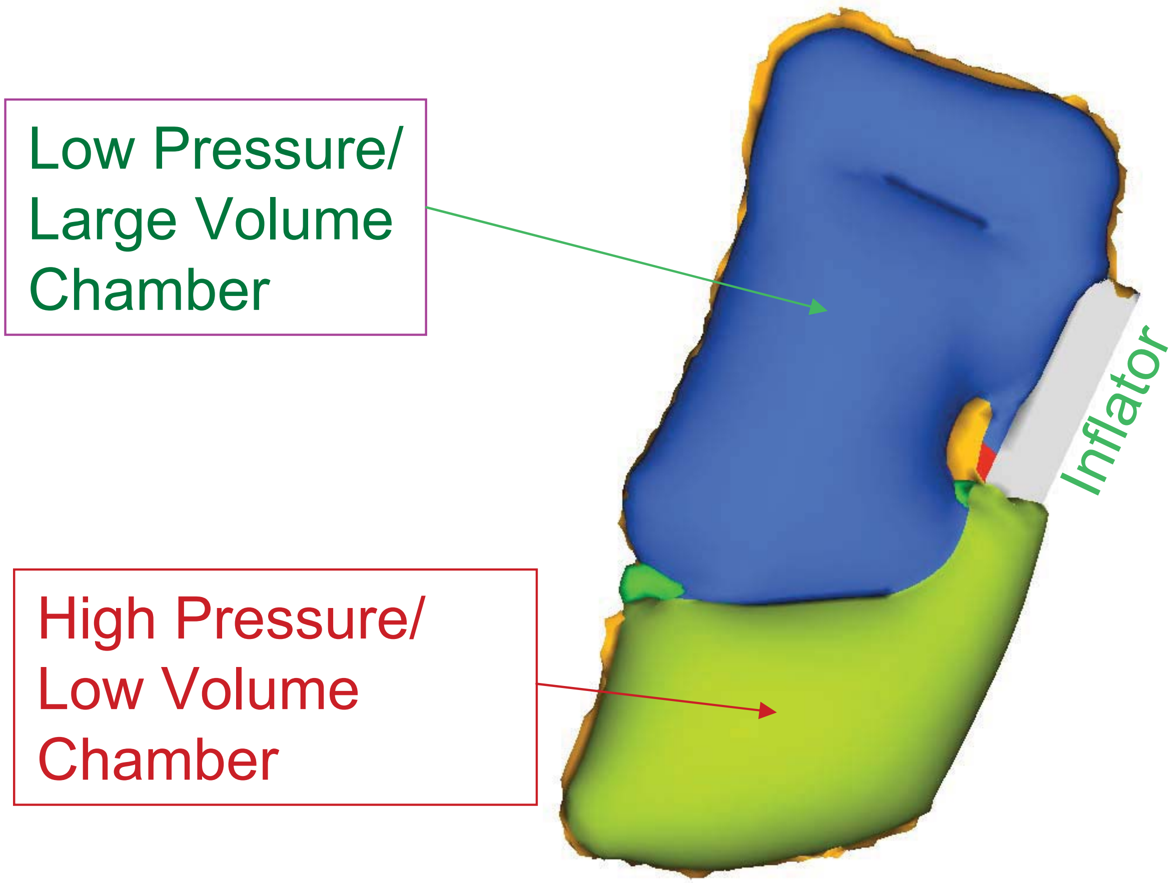


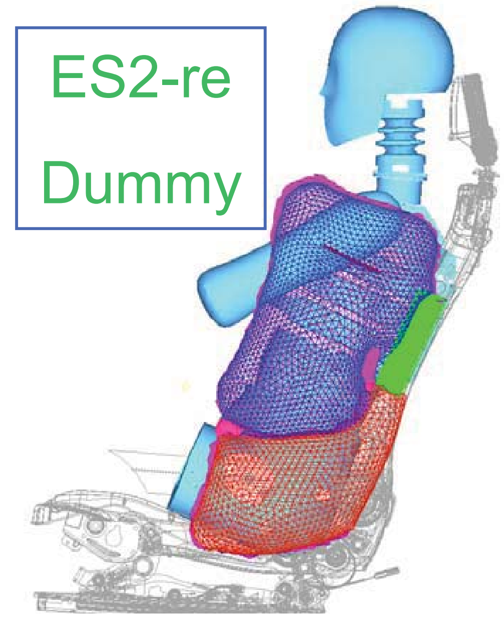
Conclusion: Adaptive Frontal Airbags

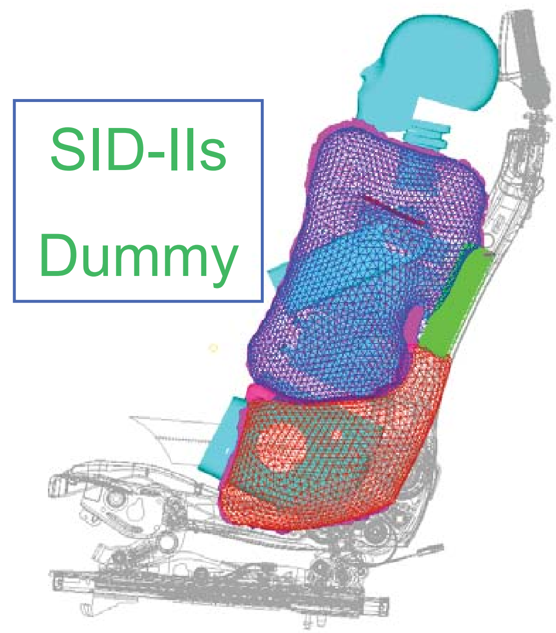
- NCAP "star" ratings are most influenced by Chest Deflection and Neck Injury Criteria
- Softer bag is generally favorable for smaller size occupants, whereas a stiffer bag is generally favorable for larger size occupants
- TRW airbag technologies enable the restraint system to adapt to occupant size & weight.
- Dual volume or a dual depth bag may be preferred, to manage between smaller & larger occupants
- Active venting, to manage between belted and unbelted modes
- Current restraints system can be tuned with additional bag / seatbelt features to meet all regulatory and industry frontal impact modes
- Knee airbags are a potential benefit for both US-NCAP & regulatory requirements
- Knee airbag reduces femur forces.

Adaptive Side Airbags

Dual-Chamber Thorax- Pelvis Side Airbag

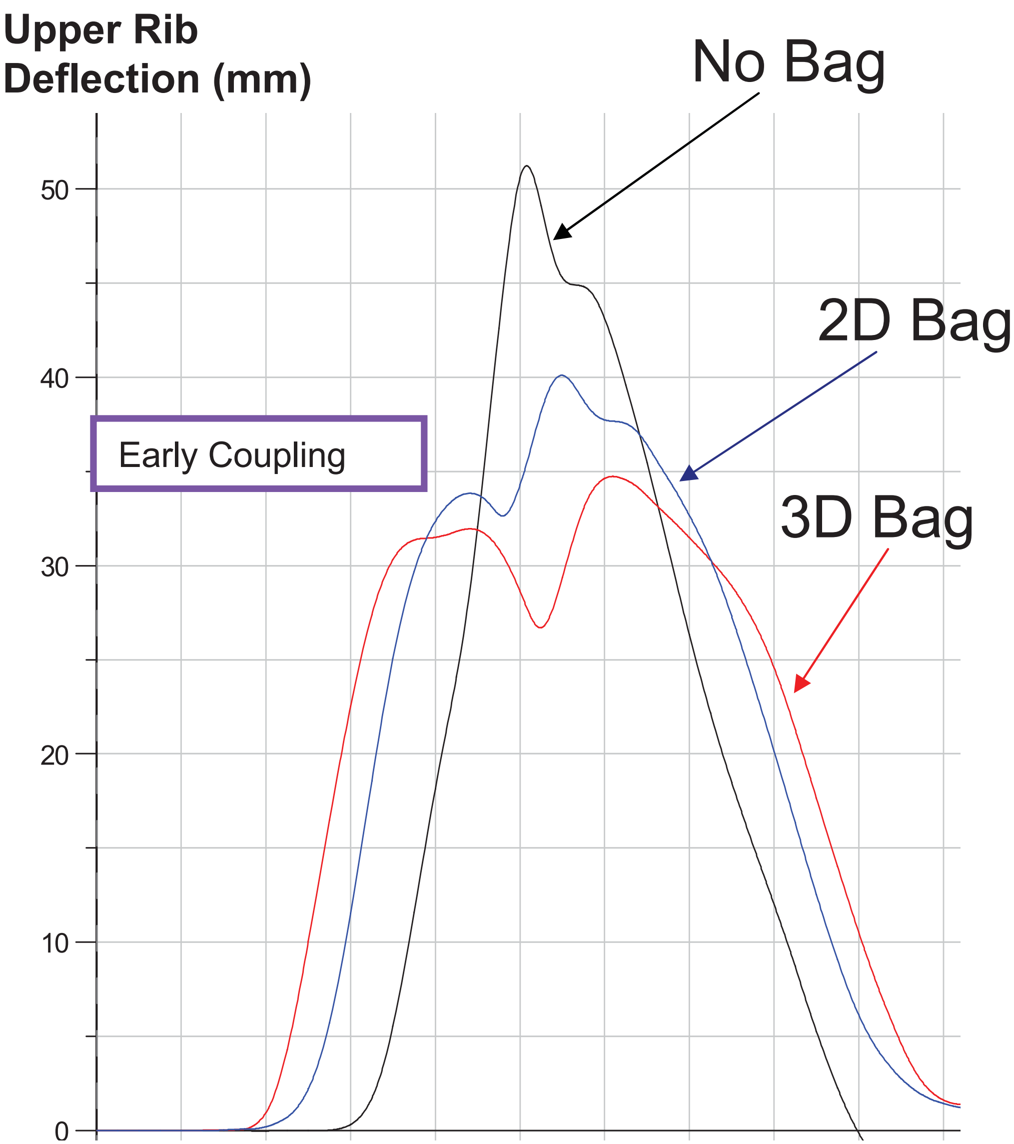




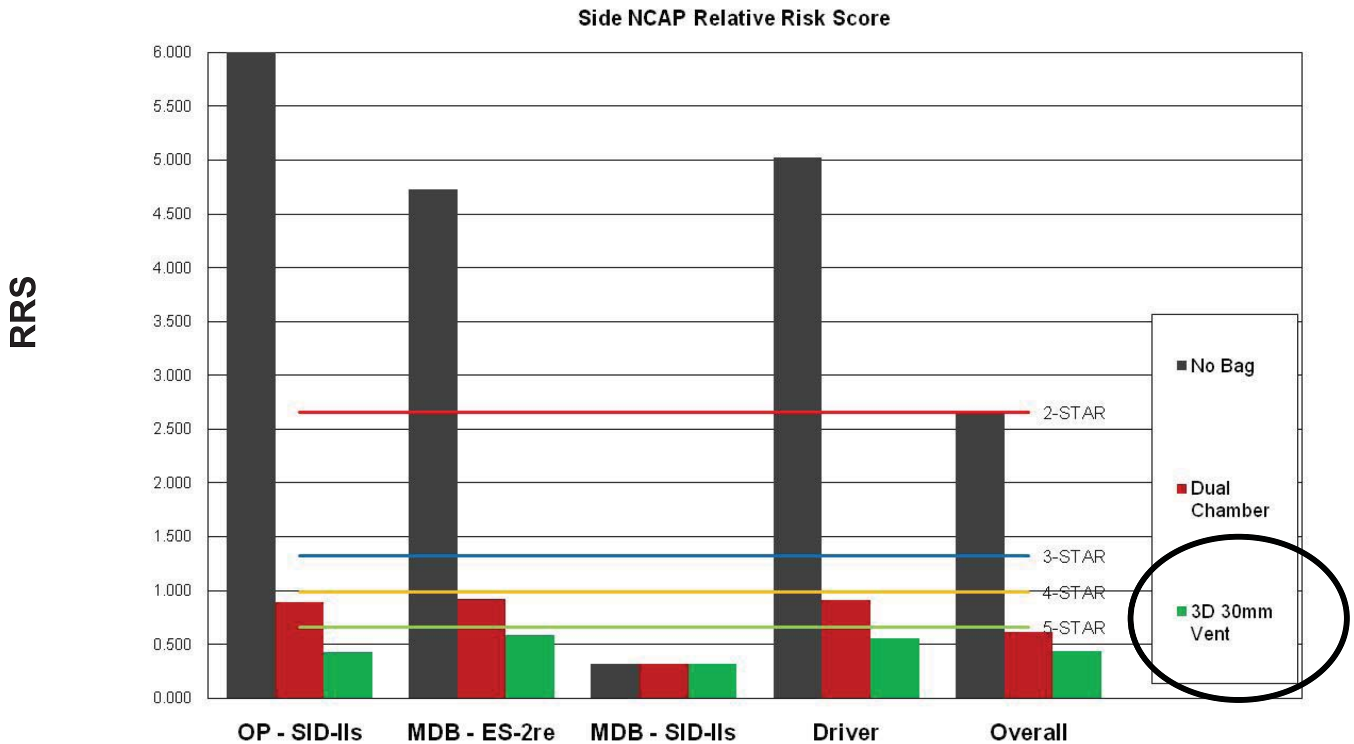


3D Single-Chamber Side Airbag

IIHS Side Barrier



SiNCAP – Relative Risk Score & Star Rating



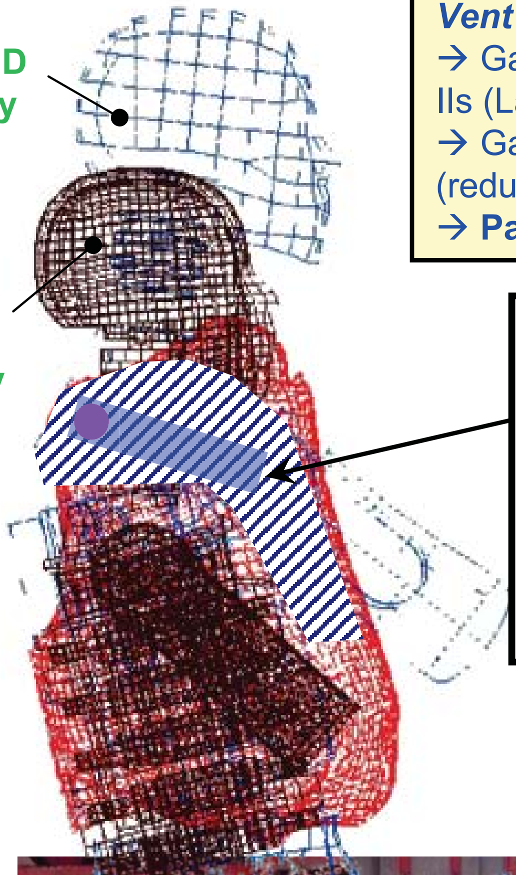
Note - Curtain airbag presence was assumed in all iterations

- **TRW Simulation Analysis Demonstrates:**
  - Both of TRW's dual- chamber & 3D single- chamber side airbags are able to meet the new US Side NCAP 5-Star rating
  - The 3D bag offers a larger cross section to support the thorax of the SID-IIs dummy and can improve thorax IARV's for the SID-IIs in both regulatory (FMVSS214) oblique pole and consumer test (IIHS) MDB (Moving Deformable Barrier) crash modes

SAB Adaptive Restraint System

EuroSID Dummy

SID-IIs Dummy



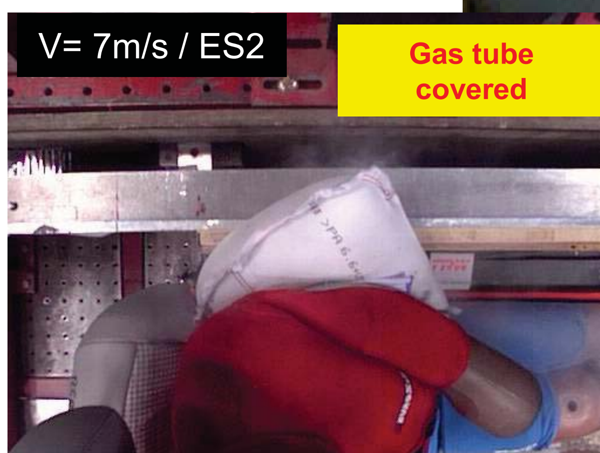
Vent 2 including gas channel

→ Gas channel not closed by SID-IIs (Large bag venting)

→ Gas channel closed by the ES-II (reduced bag venting)

→ **Passive restraint feature !**

**This area is covered through the torso of the EuroSID-Dummy.
The small SID-IIs dummy doesn’t contact this area during the crash in the restraint phase (up to approx. 40ms+ttf) !**



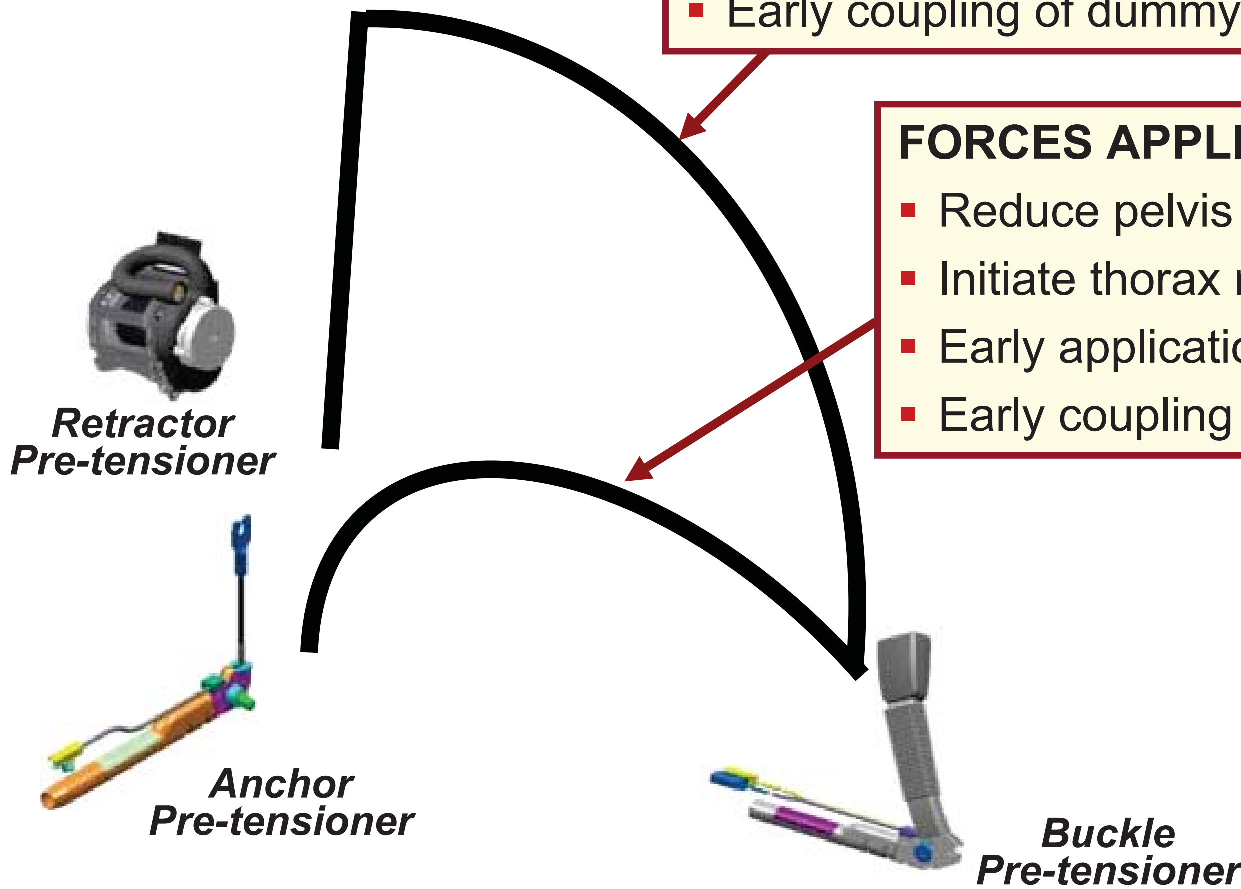
Adaptive Seat Belt Technologies

Seat Belt Technology: Dual Pre-tensioning

- **TRW's Pre-tensioning Technology**

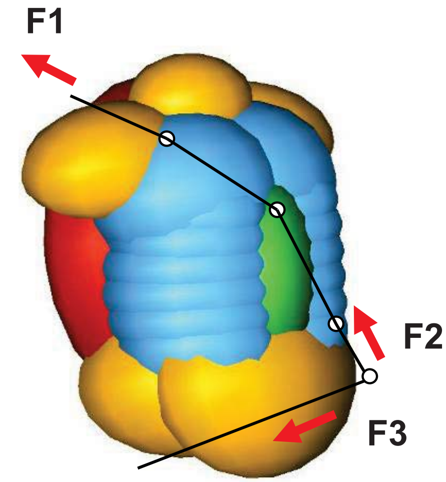
FORCES APPLIED ON UPPER TORSO
- Control thorax forward excursion
- Early application of forces
- Early coupling of dummy kinematics

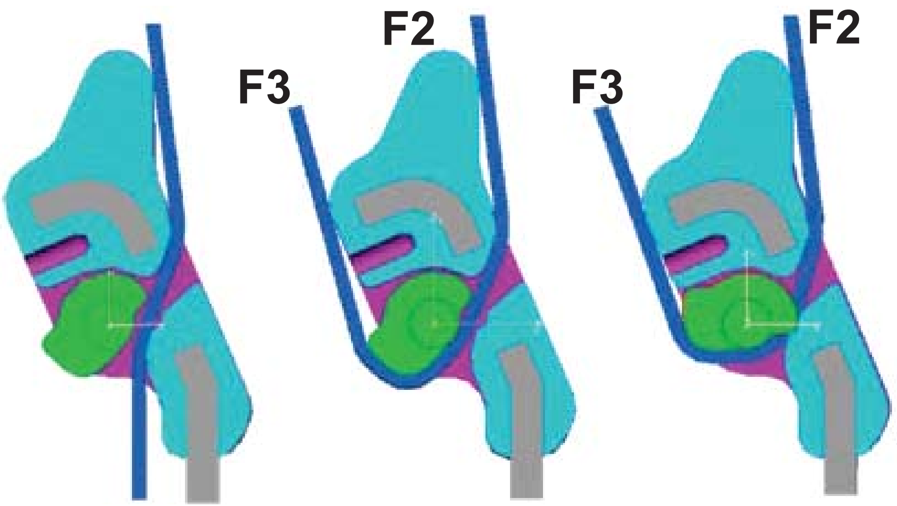
FORCES APPLIED IN LAP BELT
- Reduce pelvis forward movement
- Initiate thorax rotation
- Early application of forces
- Early coupling of dummy kinematics



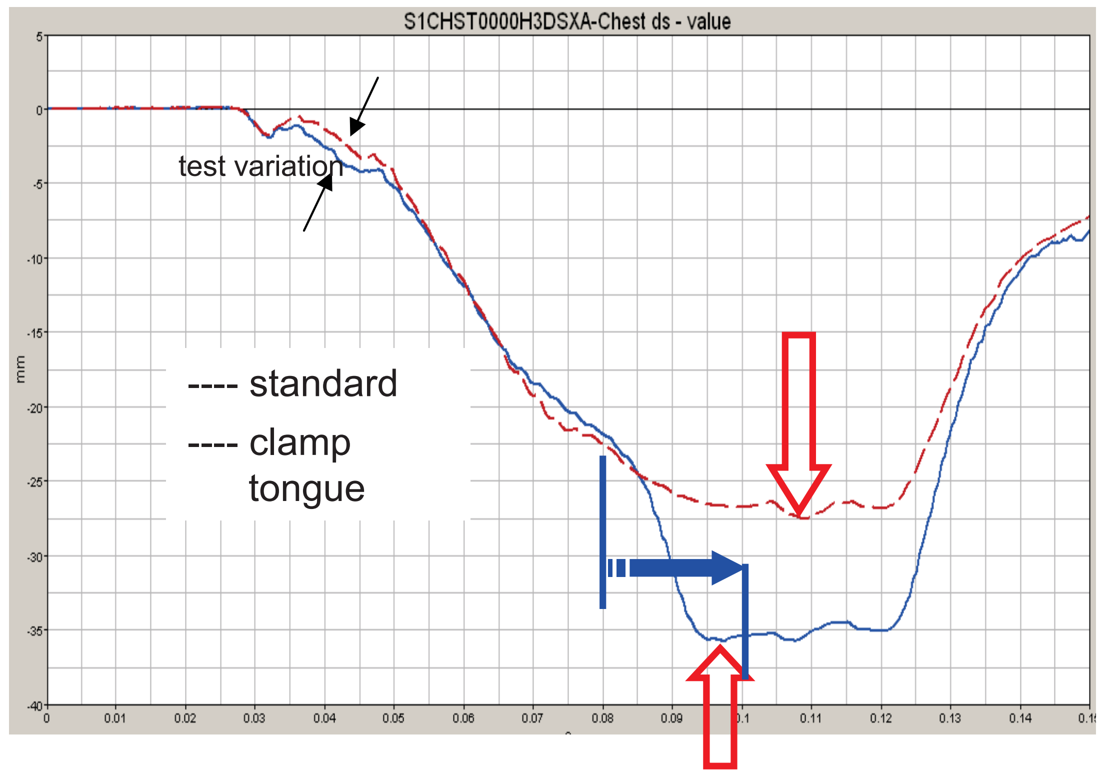
Seat Belt Technology: Dynamic Locking Tongue

- **Dynamic Locking Tongue**
  - Promotes thorax rotation and potentially reducing chest deflection by holding the webbing at the occupant's hip





F3 ≈ F2 F3 >> F2



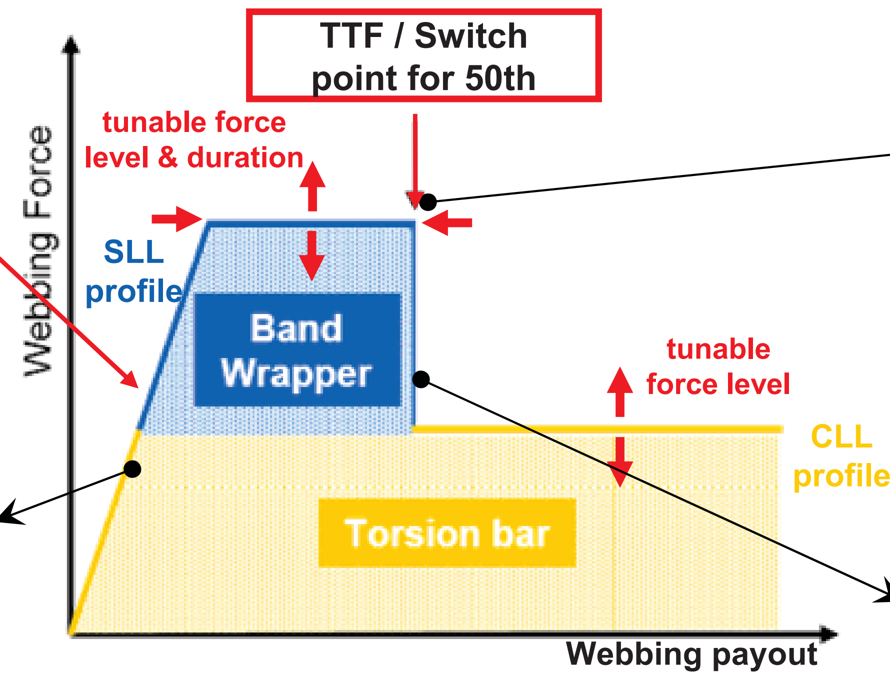
- **Switchable Load Limiter**

ADAPTIVITY

Different energy absorption profiles for different crash scenarios improve compatibility between 5th and 50th

CLL Constant Load Limiting ***vs.*** ***SLL Switchable Load Limiting***

TTF / Switch point for 5th



ENERGY MANAGEMENT

Maximum level of initial force must be controlled at this stage due to high chest compression influence

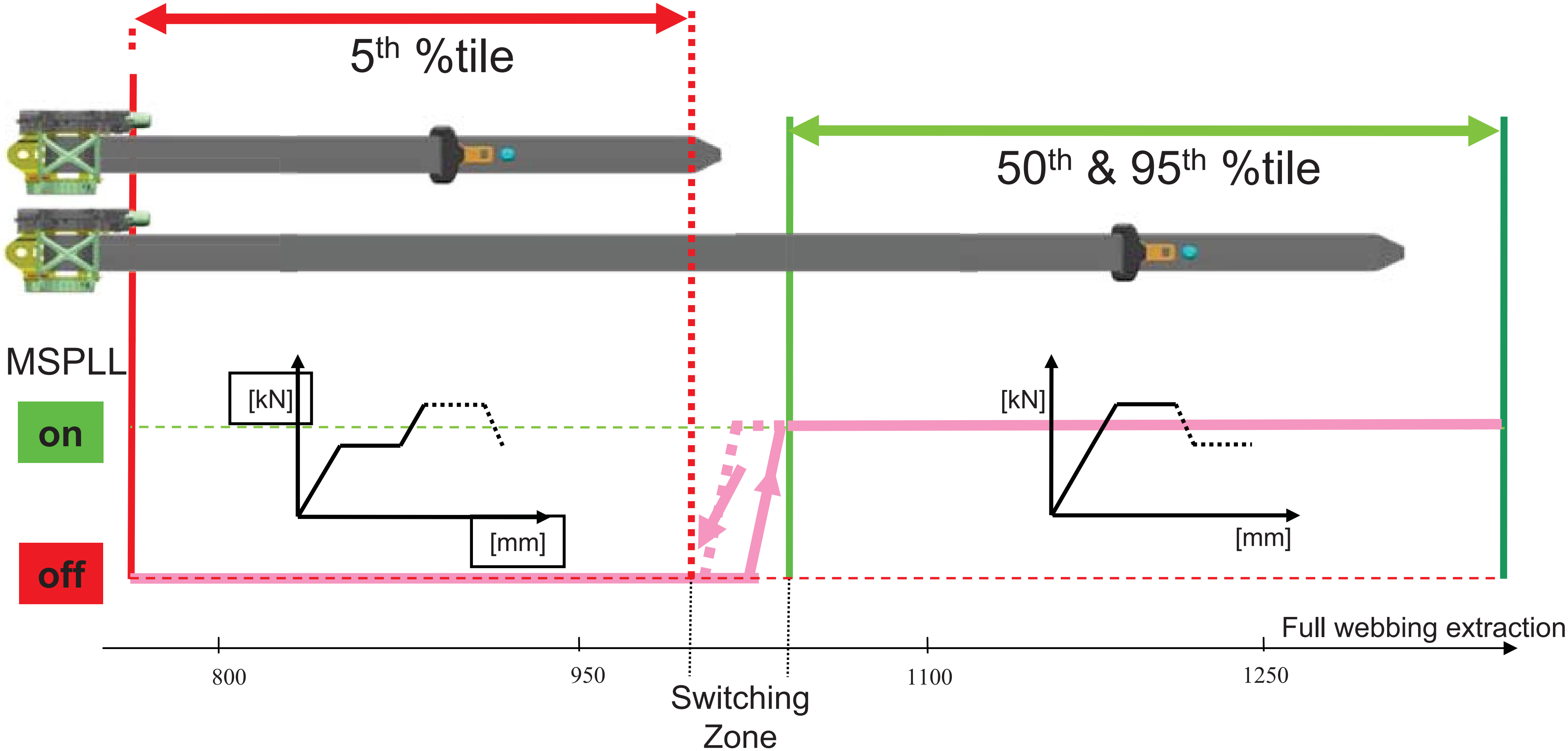
ENERGY MANAGEMENT

Early coupling: initial energy reduction leads to higher control on thorax acceleration

ENERGY MANAGEMENT

Later reduction of force level reduces load on chest to complement forces applied through airbag

Seat Belt Technology: SALL



- **SALL is somewhat similar to the Switchable Load Limiter (SLL), but the SALL is a completely autonomous seat belt retractor – no external sensors, controllers, or wiring are required.**
- **The SALL mechanism will change the initial load between a high level (for the larger occupant) and a low level (for the smaller) based on the webbing-on-spool, with the point of switching generally being designed to fall in the range between the 5th and the 50th percentile occupant.**

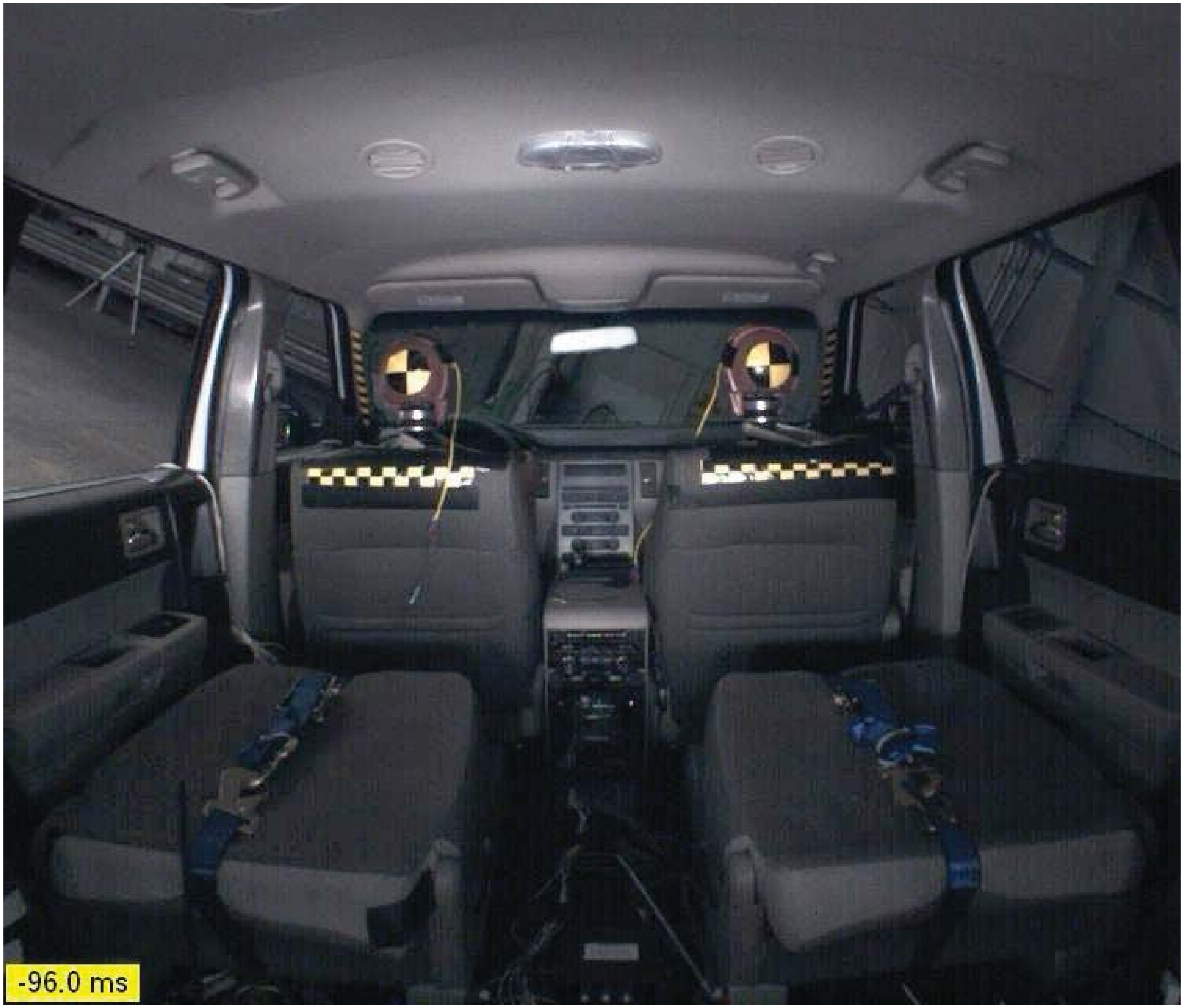
Occupant Ejection Mitigation

Occupant Ejection Mitigation (youtubevideo)

Occupant Ejection Mitigation

Rollover Test with Curtain Airbag

Large Crossover



Active Safety / DAS Integration

Drivers for Active Safety
Government Strategies

- In North America, NHTSA has identified for promotion three active safety technologies with the potential to significantly improving road safety:
  - **Electronic Stability Control (ESC) systems**
    - Combination of anti-lock brakes and inertial sensors
  - **Forward Collision Warning systems**
    - Using radar or Lidar (laser) sensors to measure relative speeds and distances to impeding objects, for improved *longitudinal* vehicle control
  - **Lane Departure Warning/ Lane Keeping Systems**
    - Using object recognition cameras to detect lane markings and relative vehicle position, for improved *lateral* vehicle control
- These technologies provide driver assistance in four types of accidents (run-off-road, rear-end, lane change and crossing path) which comprise 85% of accidents and 75% of fatalities in the USA

TRW DAS Sensor Portfolio

- TRW offers a wide range of DAS radar and camera products:
  - 24GHz radar
    - TRW is leading the market in the development of affordable 24GHz radar for forward-facing safety applications - our "AC100" radar is almost half the cost of a typical 77Ghz radar. This will enable the widespread fitment of Collision Warning and Limited Emergency Braking safety technologies to mass-market vehicles from 2011.
  - 77GHz radar
    - TRW has been manufacturing high-performance 77GHz radars since 2002 for VW and heavy truck customers, for Adaptive Cruise Control and Collision Warning applications.
  - Object Recognition Cameras
    - TRW has been manufacturing DAS cameras since 2008 and currently offers a low-cost camera optimised for Lane Departure Warning/ Lane Keeping - the camera is linked to the vehicle steering to gently guide the driver back to safety if the vehicle is drifting out of its lane unintentionally. TRW is also developing a more powerful object recognition camera capable of identifying other vehicles and pedestrians and estimating their position, and can warn the driver in the event of a potential collision.

24GHz Radar

77GHz Radar

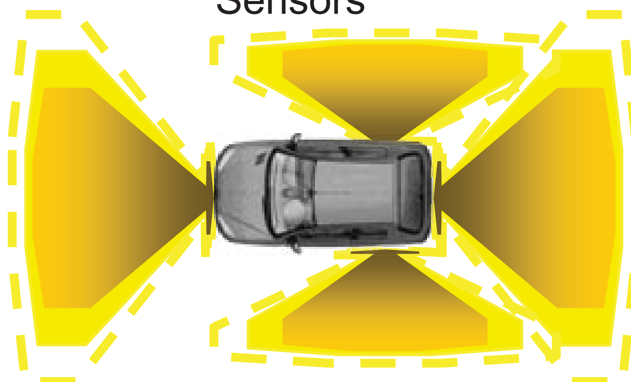
LDW Camera

Lane Departure Warning (LDW)

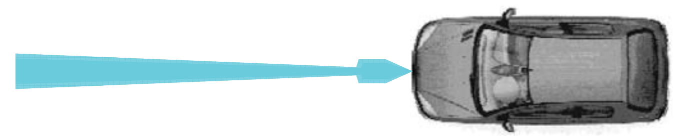
- **A "hazardous situation" detecting system needs to be installed in the car, for example through the use of :**

Video camera

Sensors



Radar
(short or long range)



- **Possible "Hazardous Situation" include:**
  - Changing lanes or drifting
  - Rapid approach to a slow moving vehicle
  - Objects in blind spot
  - Driver alertness
  - Pedestrians

- **The Vibrating Steering Wheel portion of the LDW system is composed of:**
- **The motor is driven by a pulse with modulation signal**
  - Adaptable vibration intensity and duration
  - Creates a specific warning characteristic depending on situation

Active Safety Technology

Active Head Restraint

- **The U.S. and E.U. regulatory requirements and consumer ratings have been rapidly evolving for rear impact protection**
  - U.S. FMVSS 202a upgrades static HR performance rqmts, or allows for a dynamic compliance option
    - Implementation started MY2010
    - Static option is low-cost but raises comfort issues
    - Dynamic option HIII AM50 / 17.3kph / 5.6g half-sine
      - Measure read rotation and HIC
  - IIHS testing and rating focus
    - IIHS notes 26 vehicles models did not receive their "TOP SAFETY PICK" rating in 2008 due to inadequate head restraints
    - Already driving implementation of improved and active HR
  - EuroNCAP
    - Added rear impact assessment to the 5-star rating effective 2/2009. Expected to increase application rate of AHR in Europe.
    - IIHS and ENCAP use BioRID, various neck assessments, THRC, etc

ACR Technology

Features

- **Active and Passive Safety System**
- **Belt slack reduction**
- **Proven ACR technology**
- **Proven situation management algorithm**
- **Reversible actuation**

Benefits

- **Enhanced safety (as ACR)**
- **Improved occupant position (as ACR)**
- **Cost effective by simplified electronics and reduced functionality**

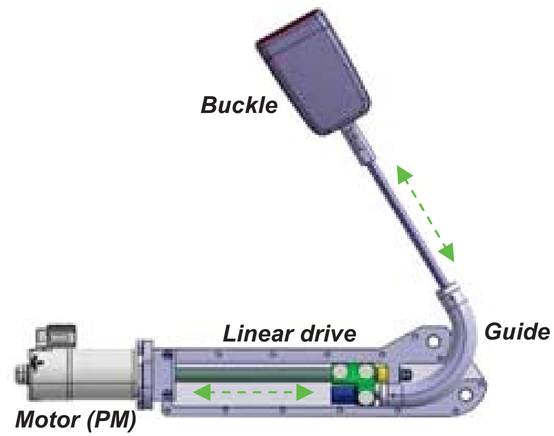
Function

- **Algorithm recognizes critical events:**
  - panic braking
  - skidding
- **In a critical situation the ACR is pre-pretensioning the seat belt**
  - to take out belt slack
  - to reduce occupant displacement
- **If the critical situation ends without an accident the system automatically releases the belt**

Active Buckle Lifter

Concept:

- ***Enhance the user's convenience and the perceived safety of the vehicle by actively controlling the position of the seat belt buckle***



Comfort mode ("presentation" at entry)

- Presentation height: 90 mm
- Presentation time: ~ 2 sec.
- Increases convenience of "buckling up"

Safety and Dynamic Support mode

- Retract length: 60mm
- Retract time: < 0,5 sec.
- Reduces belt slack in dynamic drive situations
- "Crash safe" in all positions

TRW

WE PUT THE THINKING IN SAFETY SYSTEMS.

Integrated thinking. Our Cognitive Safety Systems are elevating the intelligence of safety. Seamlessly integrated technology that analyzes and adapts to ever-changing conditions to help keep passengers and drivers safer. Always aware. And always thinking.

COGNITIVE SAFETY SYSTEMS