Global OSS Engineering Presence

**Germany, Poland, Spain & Italy**
- Alfdorf, DE: PAB, Side/Curtain/Knee, SB
- Aschaffenburg, DE: SW & DAB
- Aschau, DE: Inflators
- Czestochowa, Poland – CAD, CAE, SB Appl. Eng
- Vigo, Spain SW & DAB
- Vila Nova, Portugal SW & DAB
- Valladolid, Spain: PAB, SAB, CAB
- Moncalieri, Italy: SW, IRS, SB Appl. Eng.

**USA**
- Washington, Michigan: SW/DAB/PAB/Side/Curtain/Knee/SB
- Mesa, Arizona: Inflators

**Brazil**
- Limeira: Application Engineering

**Mexico**
- Chihuahua: IRS/SW

**China**
- Shanghai: Application Engineering

**Korea**
- Seoul: Application Engineering

**Japan**
- Yokohama: Application Engineering

**India**
- Chennai: Rane SB App. Eng
- Hyderabad: Satyam IDC
- Gurgaon: TSSW: SW

**Australia**
- Melbourne: Application Engineering
1885 - The first U.S. patent for automobile seat belts 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.
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.


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.
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.
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.

1975 – Oldsmobile Toronado is considered the first production GM vehicle to offer a air bag system as an 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.
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 airbag 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% and 100% 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*
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

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

- **Pedestrian Protection**
  - 2003/102/EG

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

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

- **Vehicle Stability**
  - FMVSS 126

- **Steering Wheel**
  - FMVSS 203, 204
  - ECE-R12EG 74/297

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

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

- **Roof Deflection**
  - FMVSS 216

- **Rollover**
  - FMVSS 201, 208, 216
  - ECE-R 21

- **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

- **Event Data Recorder**
  - US FR Part 563
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
As systems move from reactive to predictive electronics, software and data fusion is the critical thread enabling cognitive, Active Safety solutions.
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
Current Trends

- Pedestrian Protection
- CAFÉ Requirements – reduced weight, low CO₂ 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)
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

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

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

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

- **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

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

- **RF Systems**
  - Direct Tire Pressure Monitoring
  - Remote Keyless Entry

- **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

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

- **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

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Adaptive Frontal Airbags
Adaptive Airbag Systems

Prior Systems
(Airbag stiffness is not adapted to the occupant)

Current & Future Systems
(Airbag stiffness adaptive to the occupant size, position and weight)

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

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

- Electrical Connector
- Bag Tether
- TAU

Retained

Released
SAVe – *Self Adaptive Vent*

- **SAVe** us an acronym for *Self Adaptive Vent*

- **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.
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

Low Pressure/ Large Volume Chamber

High Pressure/ Low Volume Chamber

ES2-re Dummy

SID-IIs Dummy
3D Single-Chamber Side Airbag

IIHS Side Barrier

Upper Rib Deflection (mm)

No Bag

Early Coupling

2D Bag

3D Bag
SiNCAP – Relative Risk Score & Star Rating

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

Note - Curtain airbag presence was assumed in all iterations
**SAB Adaptive Restraint System**

- **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)!

- **Gas leakage**
  - V = 10m/s / SID2-S

- **Gas tube covered**
  - V = 7m/s / ES2
Adaptive Seat Belt Technologies
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
Dynamic Locking Tongue

- Promotes thorax rotation and potentially reducing chest deflection by holding the webbing at the occupant’s hip

\[ F3 \approx F2 \quad F3 >> F2 \]
Seat Belt Technology: Switchable Load Limiter

- Switchable Load Limiter

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

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

CLL
Constant Load Limiting

SLL
Switchable Load Limiting

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

TTF / Switch point for 5th

TTF / Switch point for 50th

Webbing Force vs. Webbing payout
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
Rollover Test with Curtain Airbag

Large Crossover
Active Safety / DAS Integration
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.
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
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