Passive Safety Basics

March 16th, 2023, Vehicle Safety Course (VSC) in Politeknik APP, Jakarta

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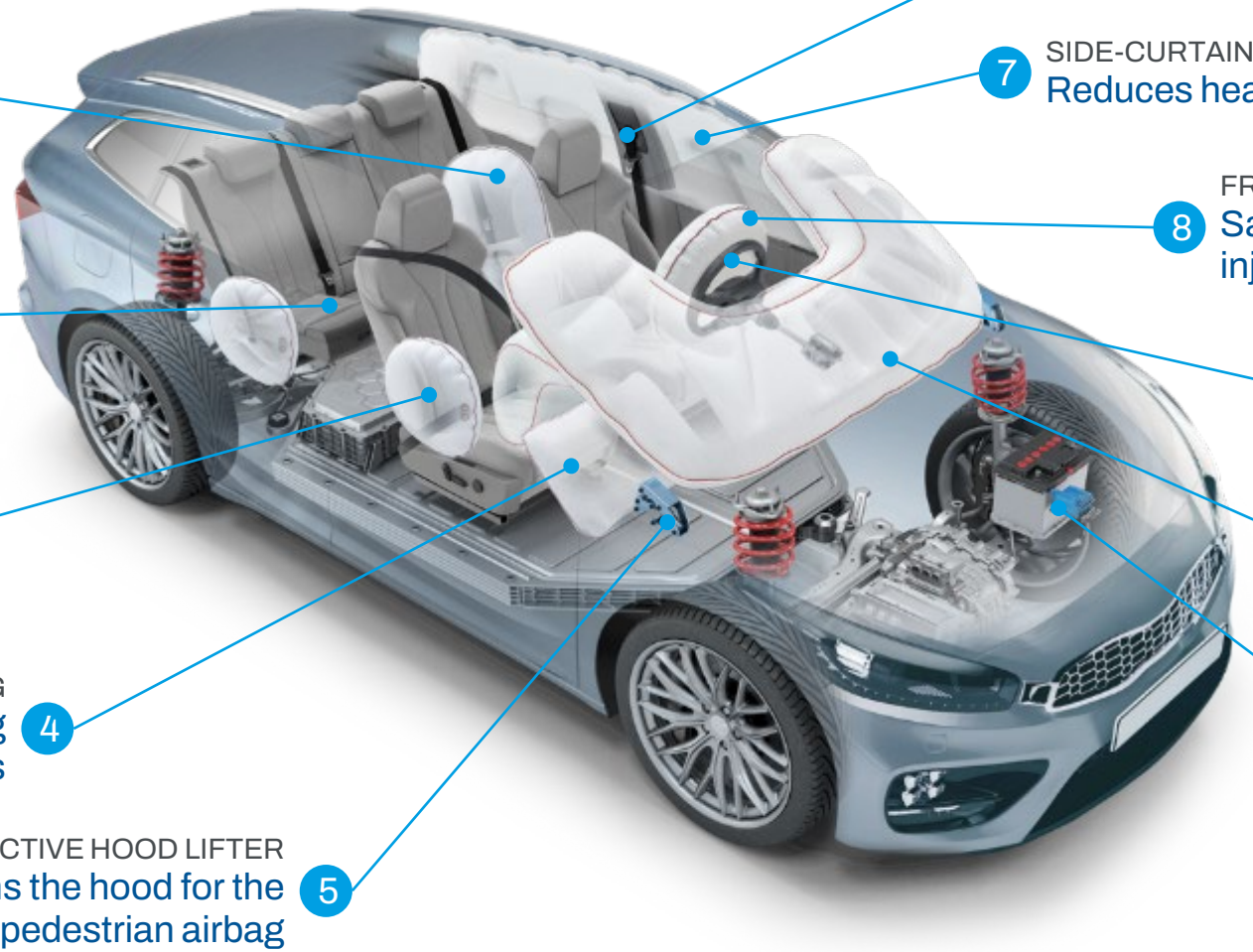
Autoliv Product Portfolio



1 FRONT CENTER AIRBAG
Enhances front row protection

2 INTEGRATED CHILD BOOSTER SEAT
Provides protection and comfort

3 SIDE AIRBAG
Protects from side collisions

4 KNEE AIRBAG
Protects from serious leg injuries

5 ACTIVE HOOD LIFTER
Opens the hood for the pedestrian airbag

6 SEATBELT
Top life-saving device

7 SIDE-CURTAIN AIRBAG
Reduces head injuries

8 FRONTAL AIRBAG
Saves lives and reduces injuries

9 STEERING WHEEL
With the life of others in your hands

10 PEDESTRAIN AIRBAG
Protects pedestrians

11 PYRO SWITCH
Stops the fire

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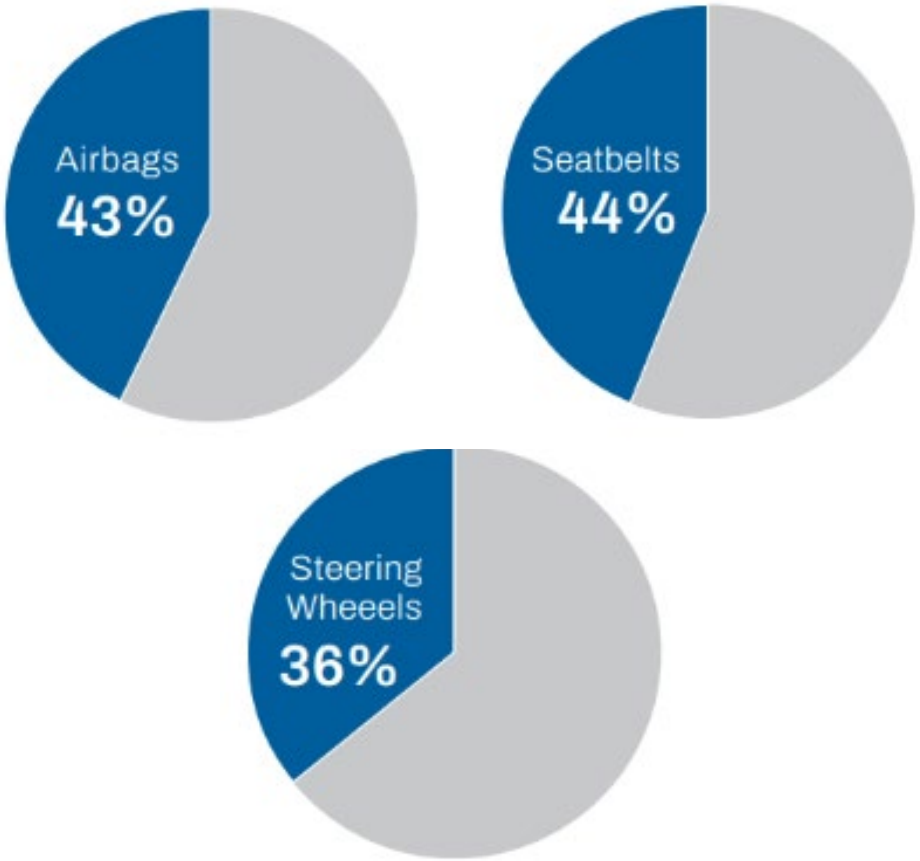
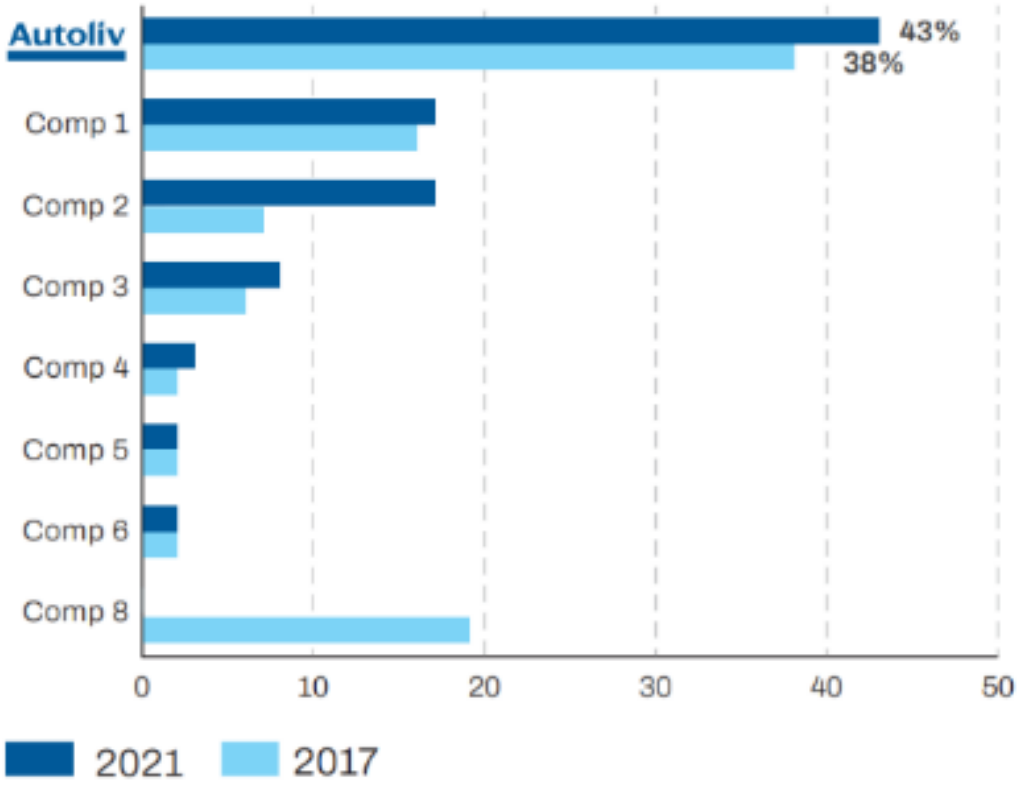
Restraint Devices Market Share

2021 market share
by product area



Firm industry leader at 43%
with growing market share



Company estimates. Based on Autoliv's passive safety market definition including airbags, seatbelts, steering wheels and pedestrian safety.

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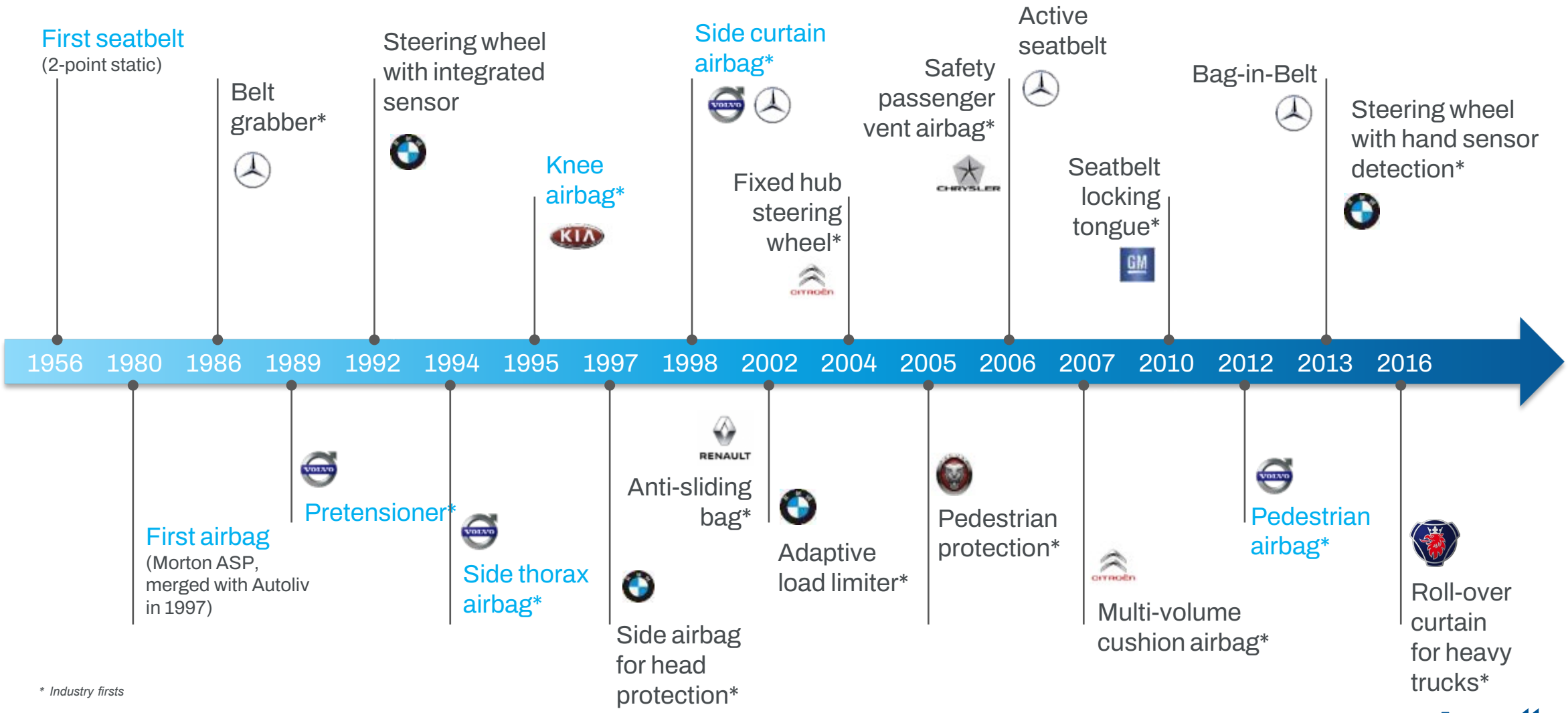
World First History



* *Industry firsts*

Our Focusing Areas

Autonomous delivery vehicles

Autoliv and Nuro, a leading autonomous vehicle company, are collaborating to ensure a high safety standard for the delivery of Nuro's new third-generation, production-grade autonomous vehicle.

Motorized two-wheelers

The airbag system for powered two-wheelers is mounted on the vehicle frame and will deploy in milliseconds, for greater rider safety.

Electrical battery vehicles

The Pyrotechnic Safety Switches disconnect the high voltage battery before a short circuit can occur as a result of vehicle deformation in a crash.

Airbag inflators for non-automotive

By combining our core airbag inflator competence and industry experience, we develop, manufacture and sell inflators for non-automotive applications such as inflatable jackets for motorcyclists, avalanche airbag backback for skiers etc.

Vulnerable road users

To protect vulnerable road users, such as pedestrians, cyclists and riders of powered two-wheelers, cars can be equipped with pedestrian airbags or active hood lifters. In the event of frontal collisions with a vulnerable road user, the system protects the occupant by an outside airbag or by raising the rear-end of the hood and use it as cushion.

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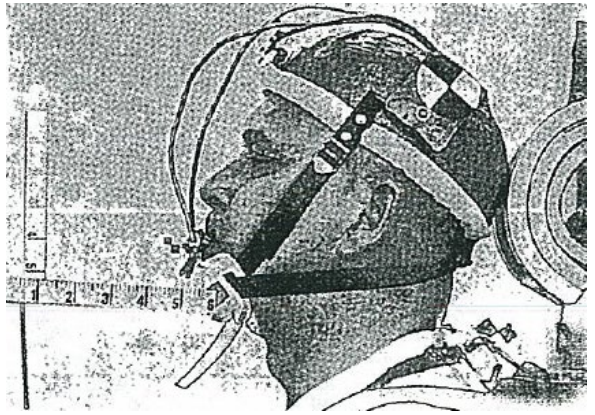
- Impact biomechanics
- Restraint system
- Crash Regulations & Ratings
- How about motorcycle?

Impact Biomechanics

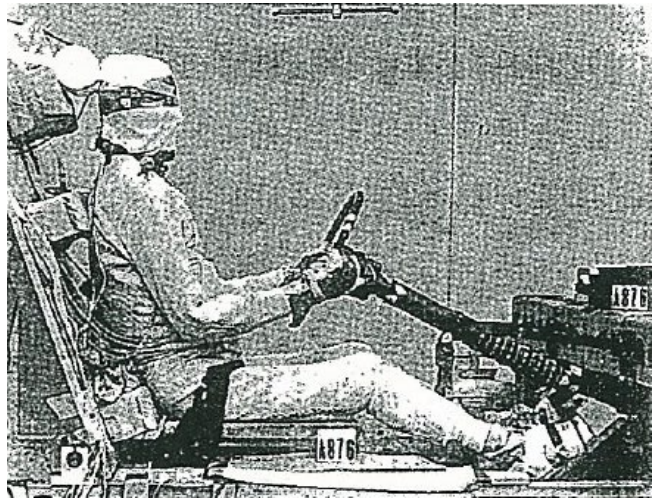
Before developing safety systems, to understand the injury mechanism

How to evaluate injuries by impact?



- **Human volunteer**
  Best, but allowed to only very low level impact with only young male adult

- **Human cadaver (PMHS)**
  Very expensive, very few number, young and child are almost nothing, Big variation, No muscle tension



- **Experimental animal**
  Anatomically/physiologically different, correlation to human is difficult, some animals to be used instead

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Human body tolerance property research
< Head >

- Head is the most frequent cause of fatality for every crash loadcase

- Two factors are the indicator to assess the risk
  1. Linear acceleration (Skull fracture)

     Wane State Tolerance Curve (WSTC) 1960

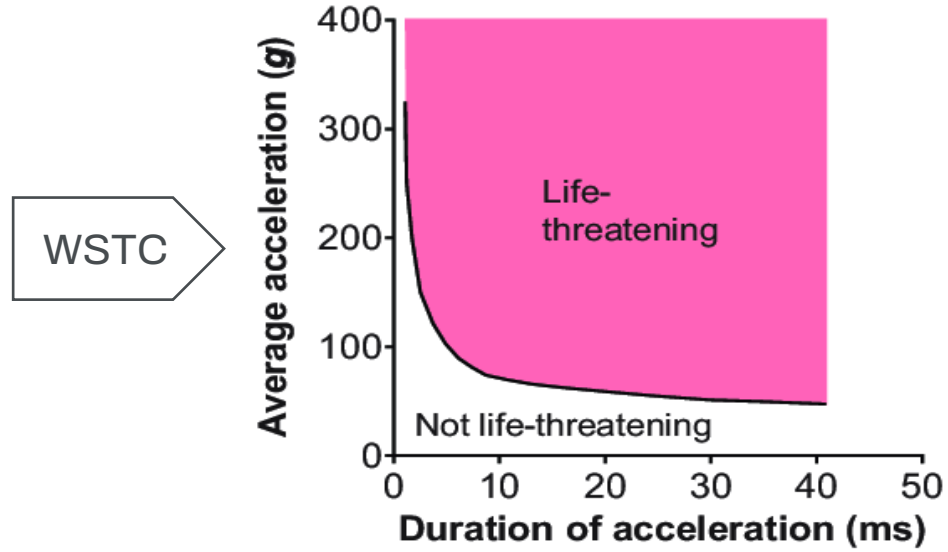
     PMHS head has been fallen to rigid ground, recorded the limit of linear skull fracture

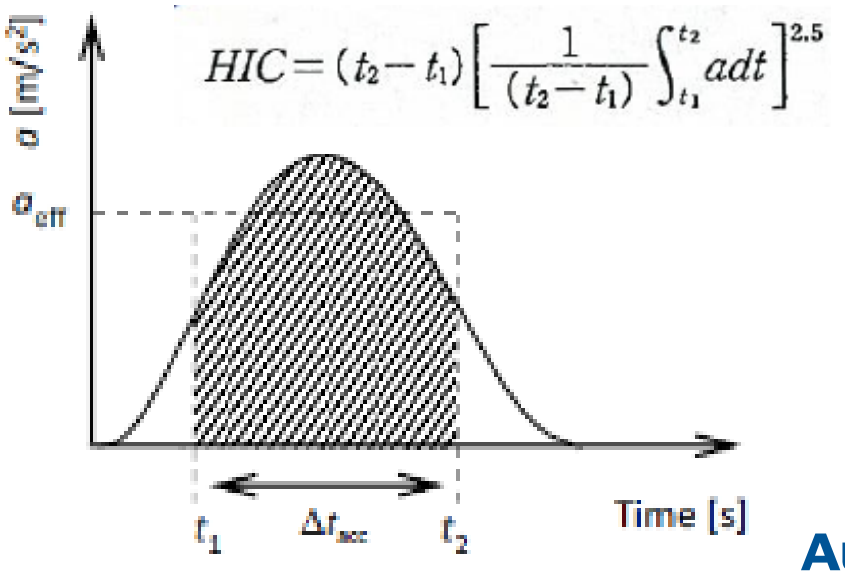
     Concluded the acceleration level and its duration is the key

     ➔ HIC(Head Injury Criteria)

  2. Angular acceleration/Velocity (Brain)

     It is new indicator, still under development



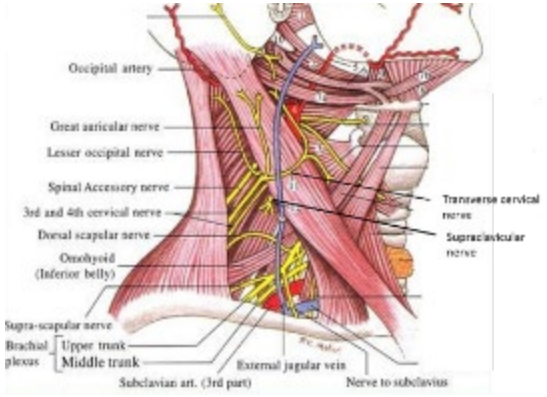


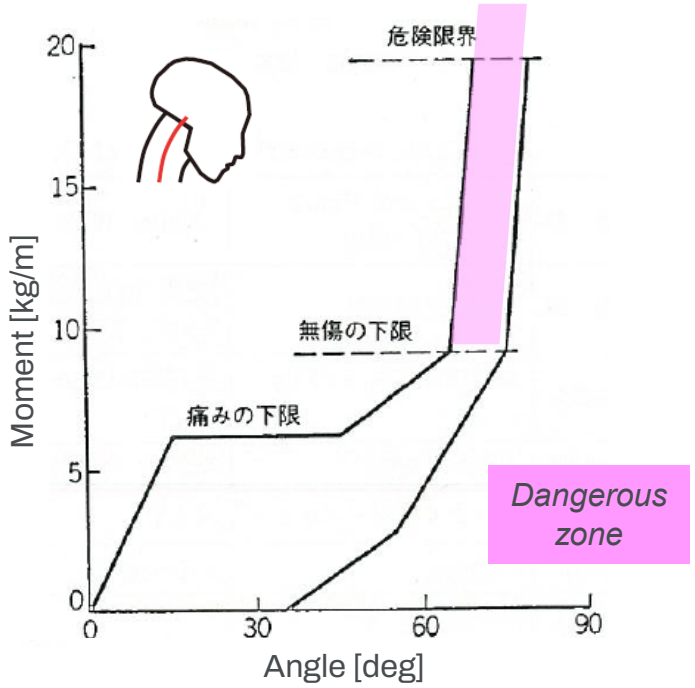
Human body tolerance property research
< Neck >

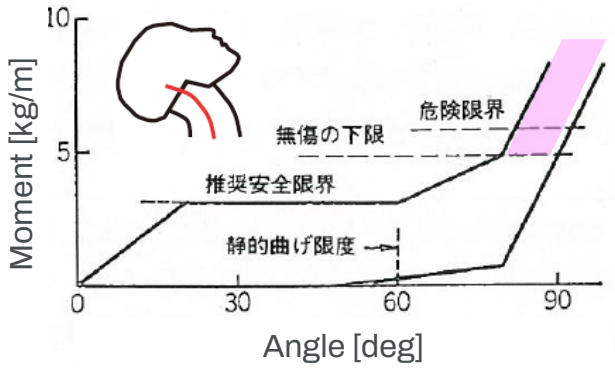
- Neck consists of cervical spine, spinal cord, nerve, blood vessel, respiratory organ, and muscles ➔ very complex
- Tolerance property: see right figure, 1970 Mertz et al
- This result is correlated to ATD measured value of

$$N_{ij} = \frac{F_z}{F_{int}} + \frac{M_y}{M_{int}}$$

F_x: axial force (compression or extension) [N], F_{int}: intercept of axial force [N] (6806N for extension and 6160N for compression), M_y: bending moment (flexion or extension) [Nm], M_{int}: intercept of bending moment [Nm] (310Nm for flexion and 135Nm for extension)







- Most popular injury is whiplash but the mechanism is not yet figured out. Likely mechanism is explained as, Head inertia produces shear force between head and neck, it could damage to nerve system

Human body tolerance property research
< Chest >

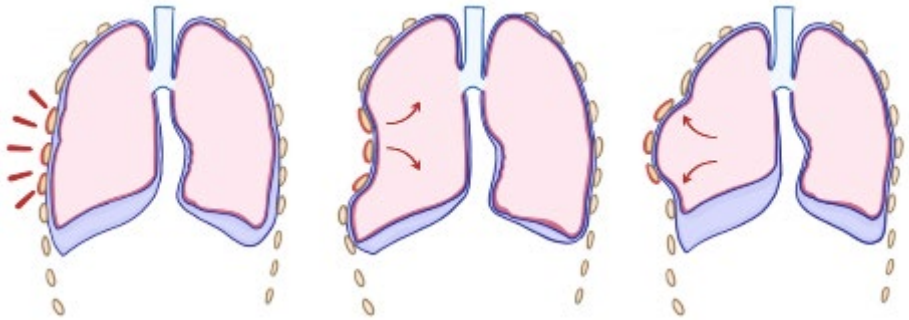
- Injuries comes from compression by Steering wheel, I/P and Seatbelt

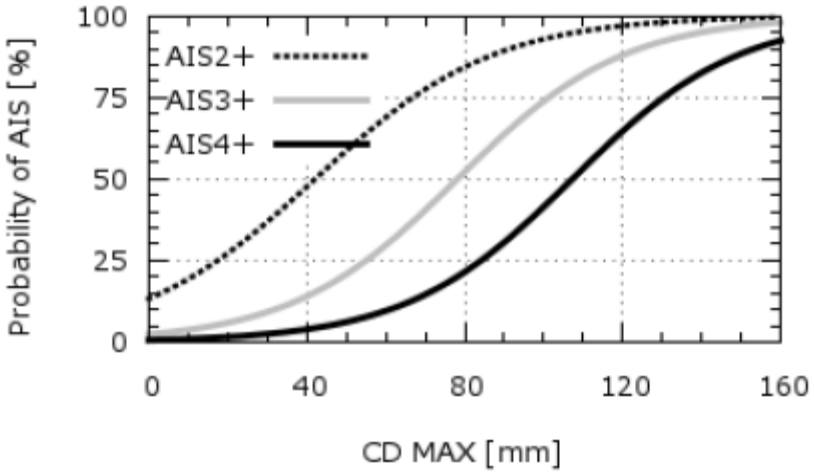
➢ Expected injuries:

1. Rib fracture by Chest compression
2. Organ injured by its inertia acceleration

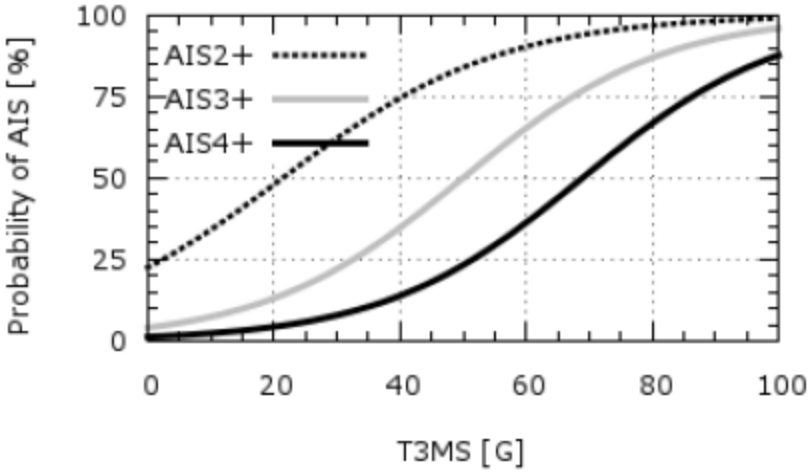
✓ Rib fracture (≧3 ribs) causes Flail chest (breathing difficulty)

✓ Rib fracture risk depends on the age very much





(b) Max. deflection based injury



(a) Max. 3 ms acceleration based injury

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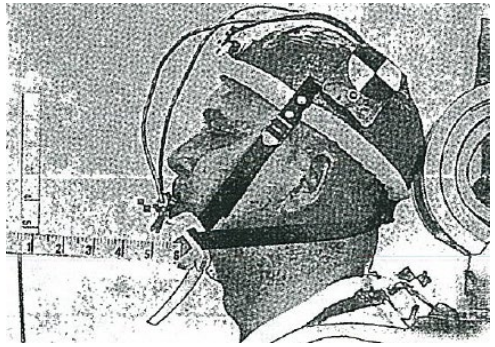
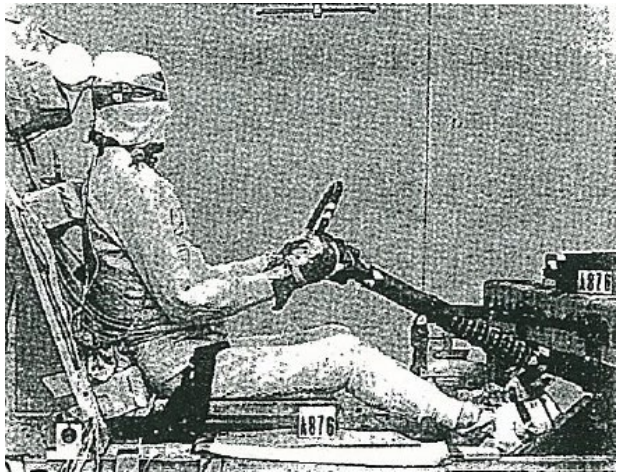
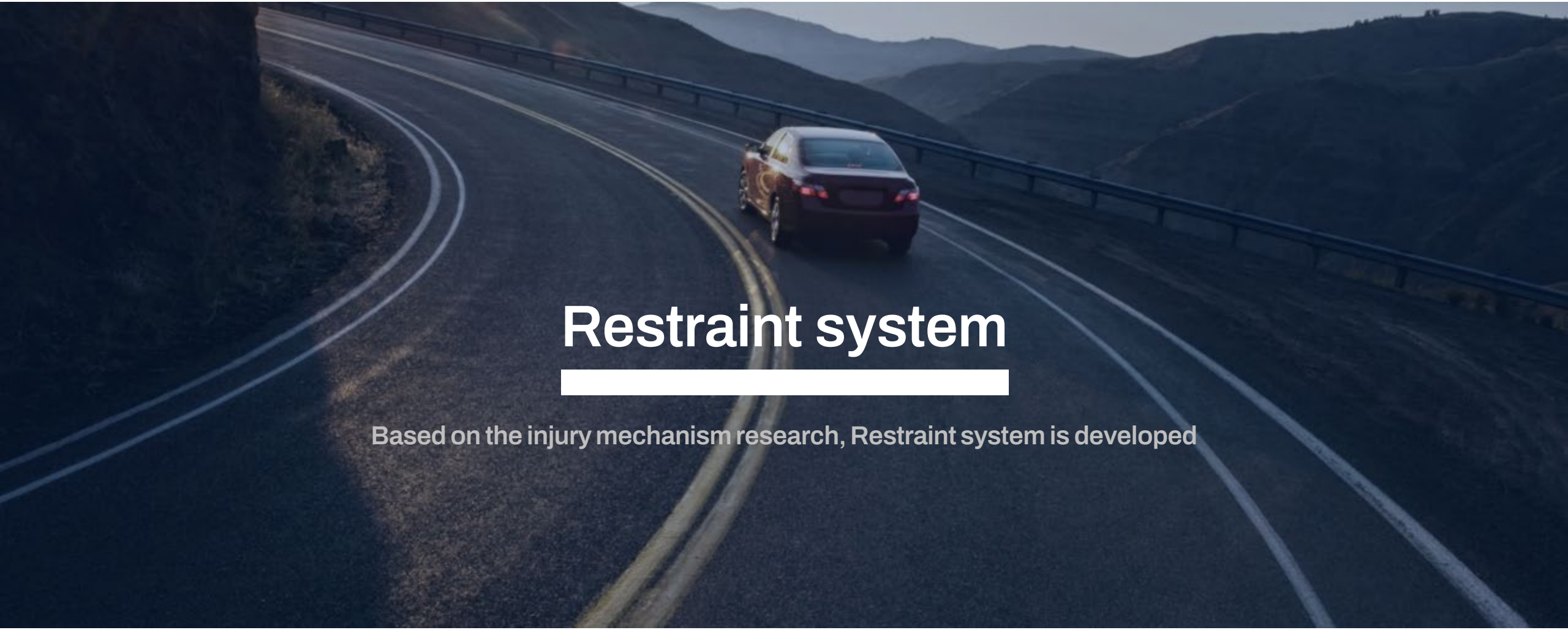
ATD: Evaluation tool for Passive Safety development





- **Anthropomorphic Test Devices (ATD)**
  expensive but trustable, repeatable

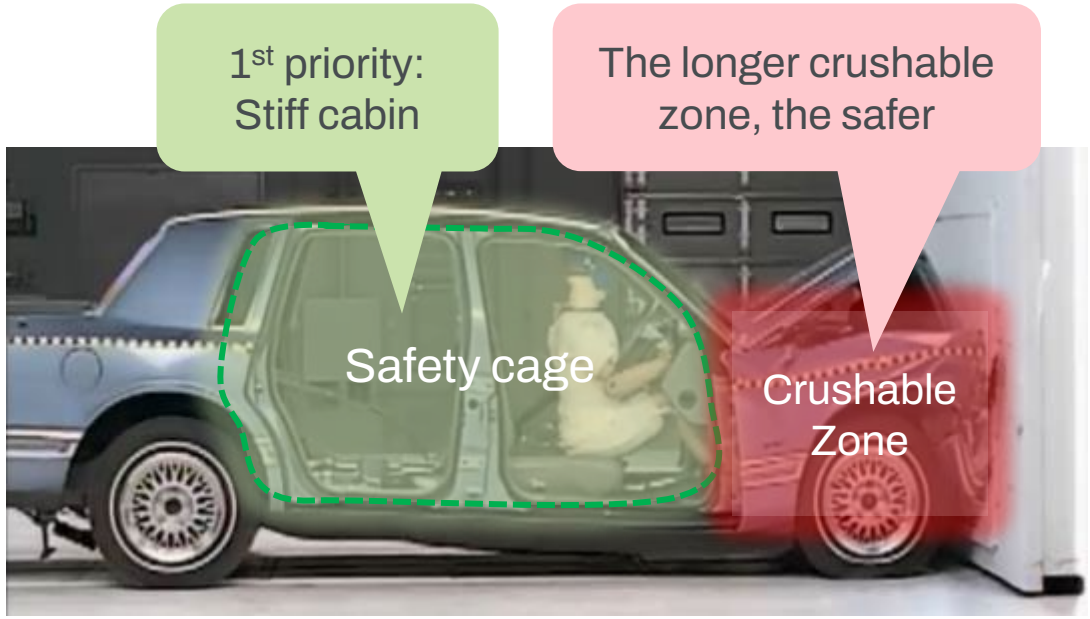


Restraint system

Based on the injury mechanism research, Restraint system is developed

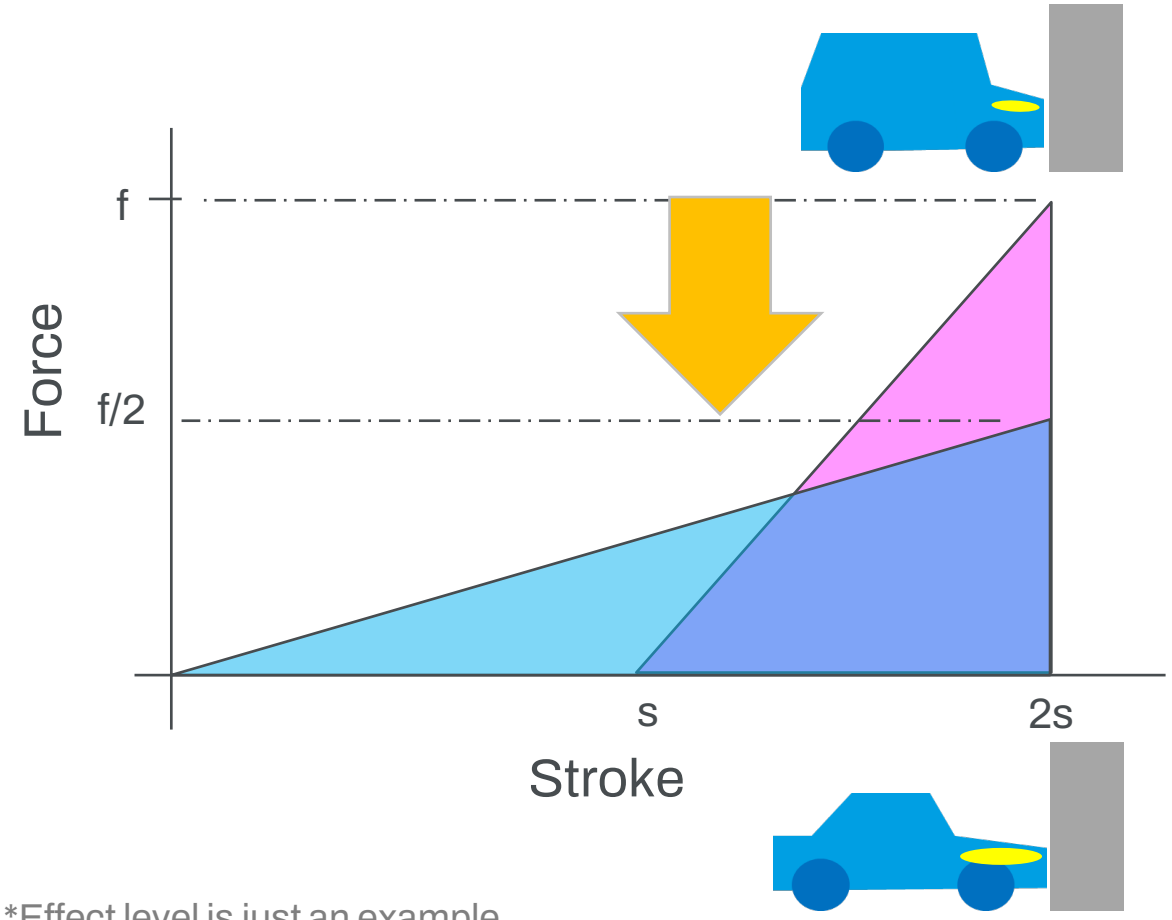
Basis: Stiff cabin + Crushable zone

If cabin to be collapsed, any safety devices cannot work properly



Physic principle for vehicle body development

To make it safer ➔ to make the acceleration lower



*Effect level is just an example

- Energy = ∫ (Force × Stroke) ds
- Force = mass × acceleration

1. Before a crash, the vehicle has,
   Kinetic energy = 0.5 × mass × Velocity^2
2. In a crash, same potion of the kinetic energy must be absorbed by something until zero joule (i.e. stop)
3. If the absorption stroke could be longer, the peak force could be reduced
4. The peak force to be reduced, the acceleration to be reduced (mass is constant factor) ➔ severity to be decreased

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Restraint system

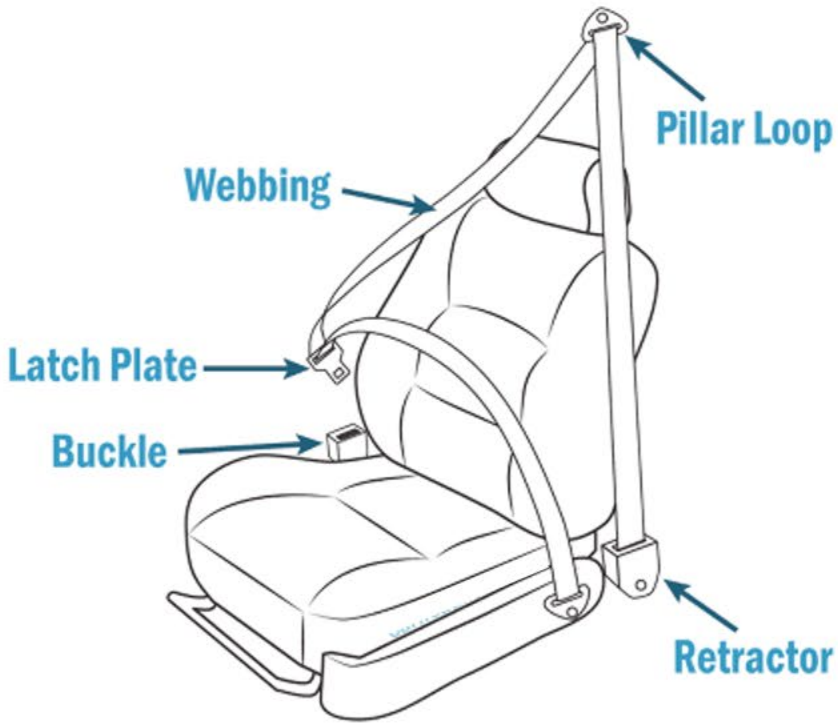
- **Seatbelt** – Primary restraint system

- **Airbag** – Supplemental Restraint System (SRS)

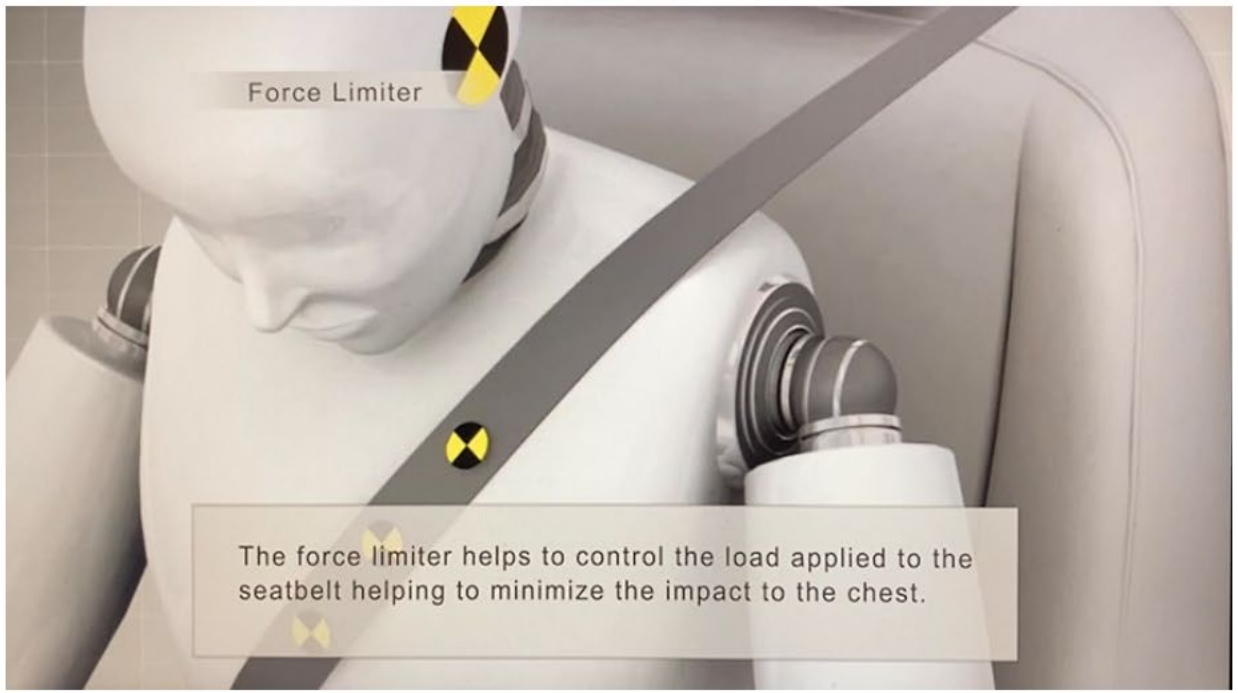
- ✓ **Note**: Other Interior parts of, steering wheel, column shaft, seat, and door inner panel, etc. can affect the restraint performance. Especially a seat cushion has very important role.

Source: https://www.carwale.com/features/carwale-gyan-everything-you-need-to-know-about-airbags-46529/

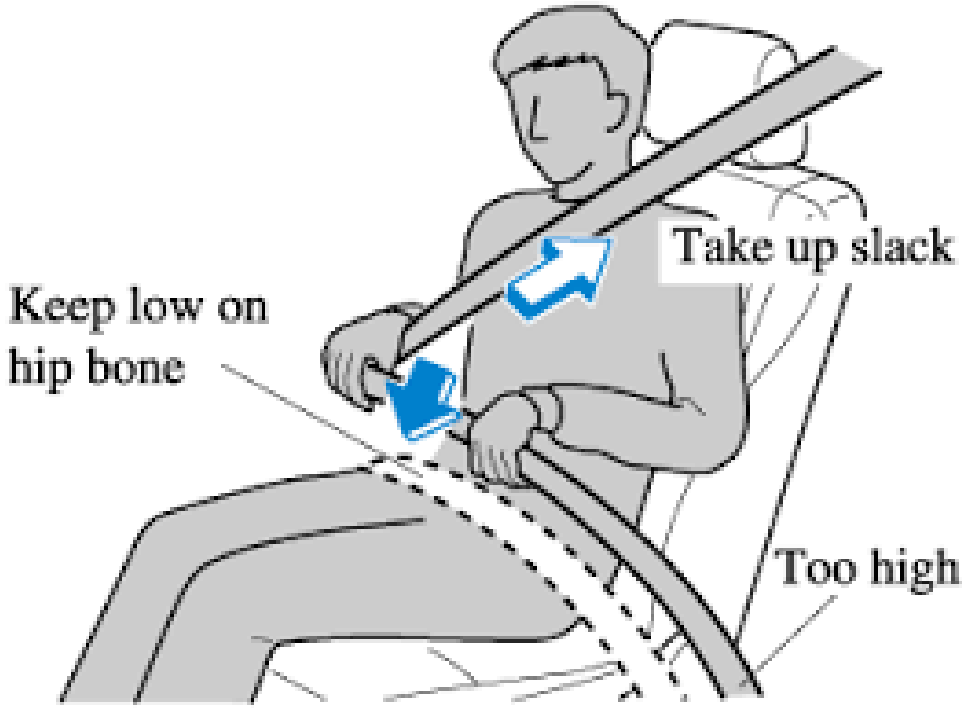
Seatbelt components and Functions



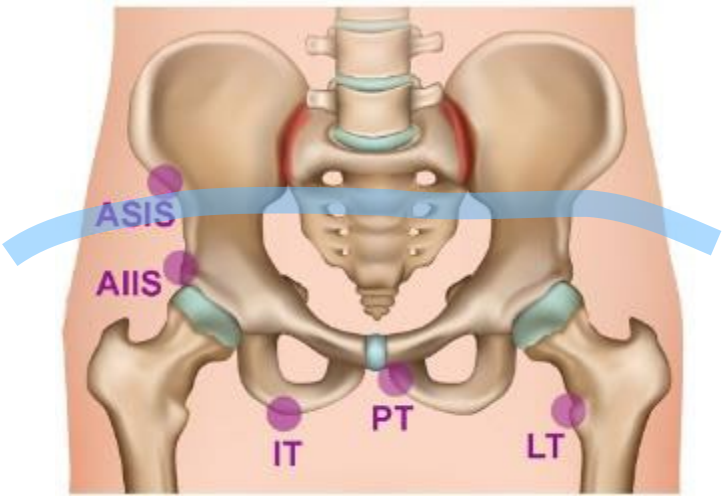
1. Stop the forward motion of an occupant to avoid hard contact
2. Decelerate passenger movements, coupling with a decelerated vehicle (Ride-down effect): by Pretensioner to achieve early coupling
3. Avoid the too high deceleration (high loading onto a chest): by Force Limitter



Seatbelt properly Fitted and Positioned



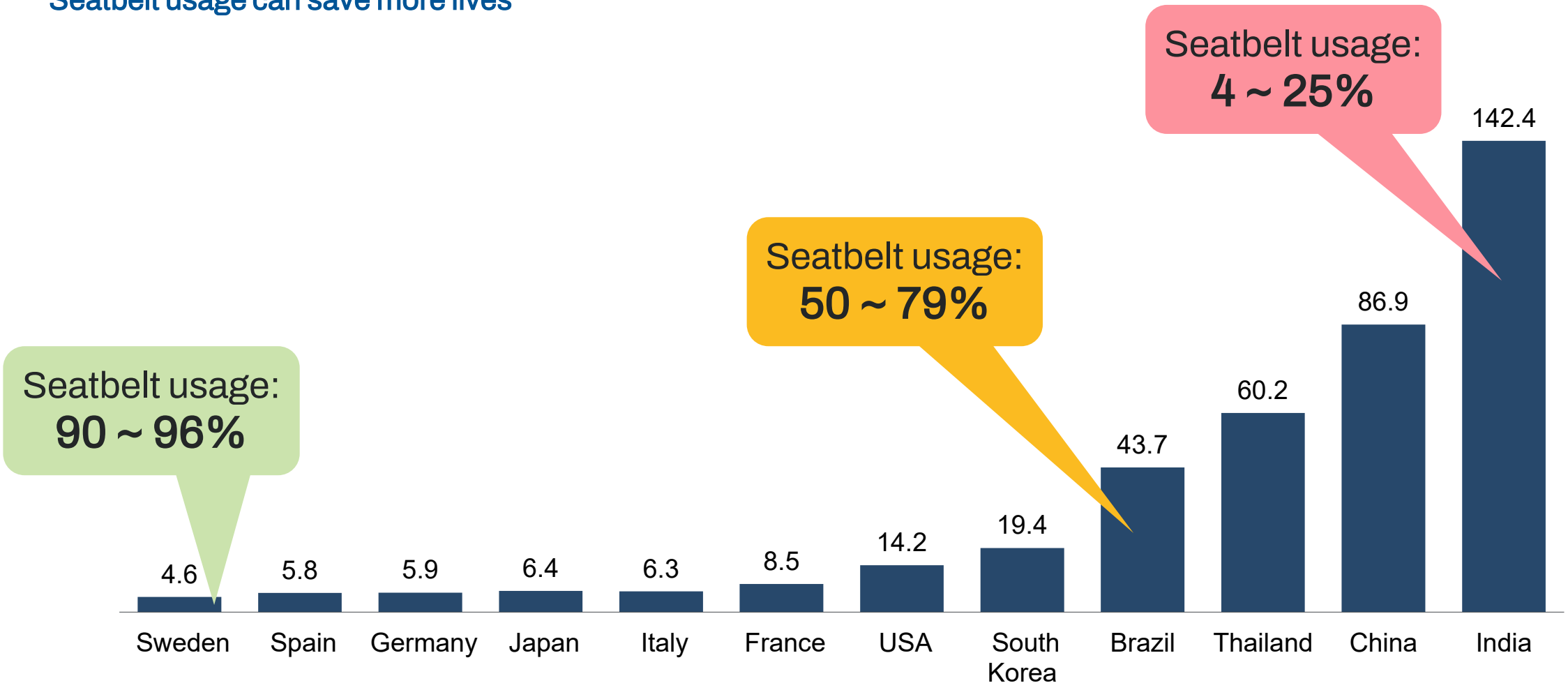
Fit into ASIS:
most durable and available part



Source:-https://learndriving.tips/learning-to-drive/proper-way-to-wear-seat-belt/
https://storagewyh.blob.core.windows.net/manuals/SCORPIO-LCCR/owners-manual-SCORPIO-LCCR.html
https://owners-manual.mazda.com/gen/en/2016/cx-3_en/contents/03020200.html

Road Fatalities by Country per 100,000 vehicles

Seatbelt usage can save more lives



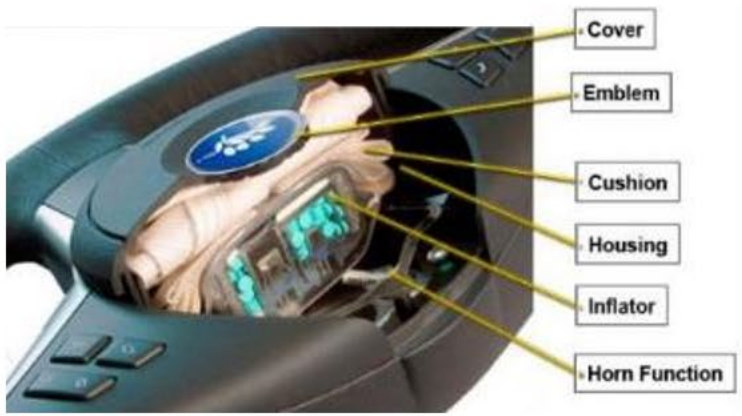
Sources: [WHO Global Status Report on Road Safety 2018]

Airbag Functions

In Frontal Impact

Head protection after seatbelt restraint

1. Seatbelt restrains at chest and pelvis
2. Head continues to move by inertia
3. Head could impact onto hard interiors
4. Absorb the kinetic energy of head pendulum motion
5. With bag stiffness control by venting



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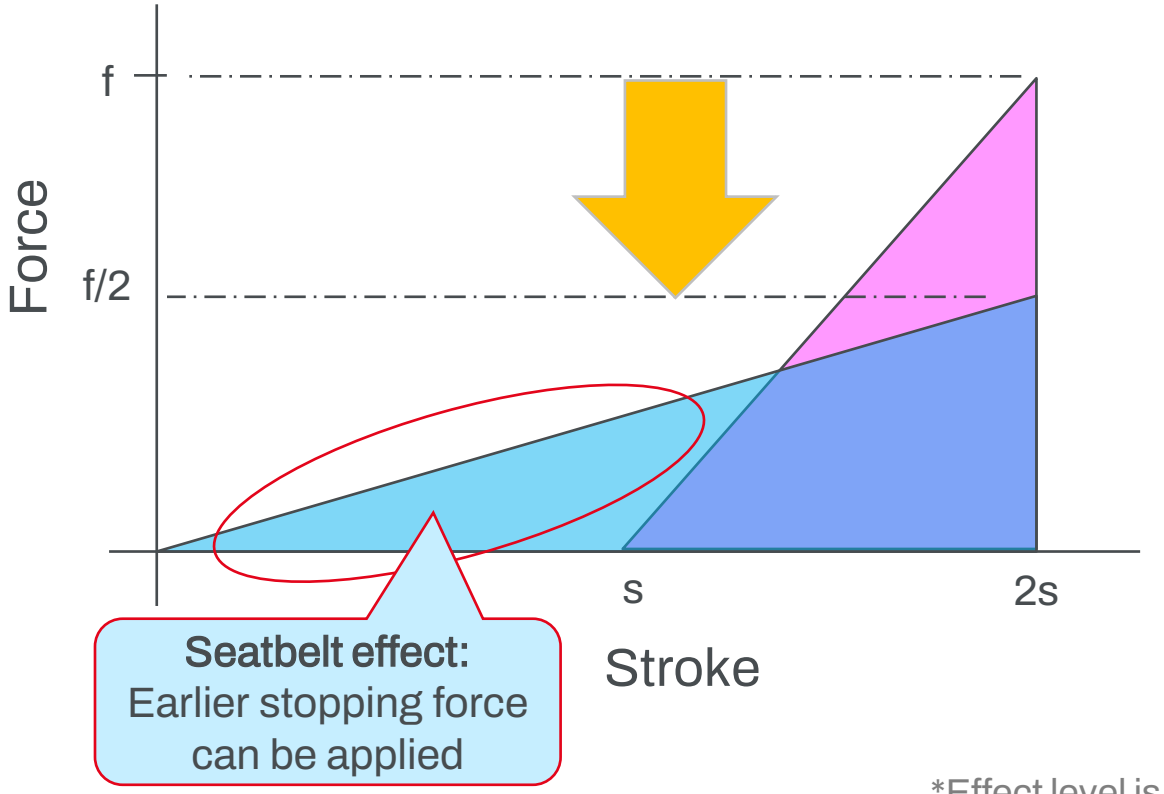
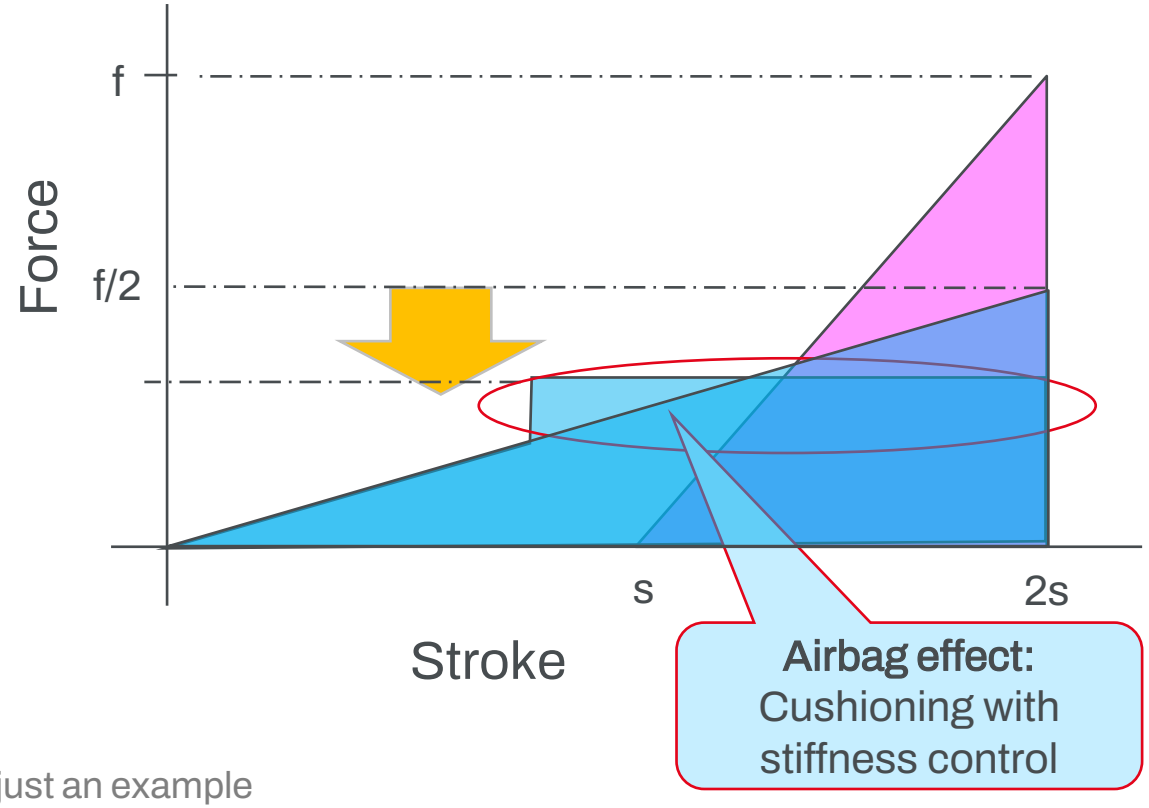
Physic principle for Restraint system development

Energy conservation law

If a Seatbelt to be applied,



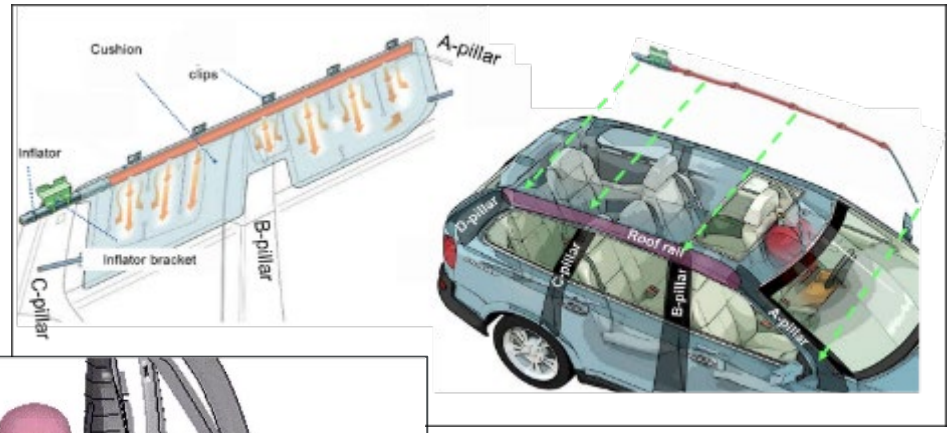
Further, If an Airbag to be applied,

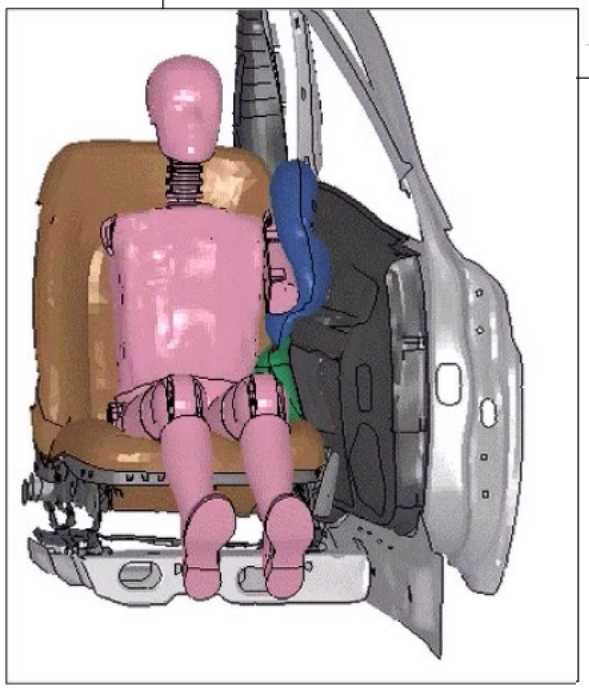


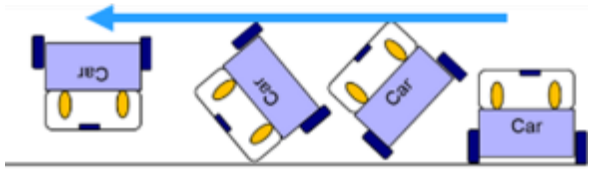
*Effect level is just an example

Airbag Functions

In Side Impact, Roll-over



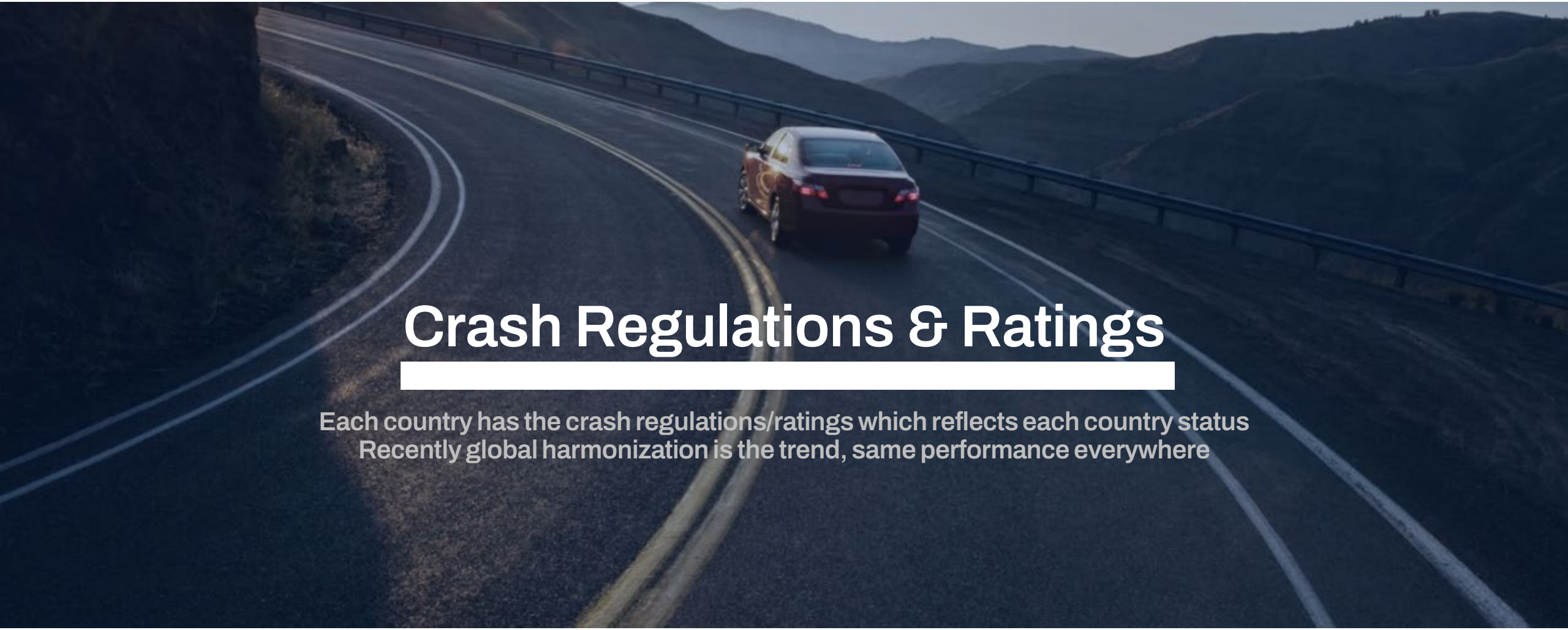




1. Side airbag positions between chest(~pelvis) and door

   Cushioning the door impact

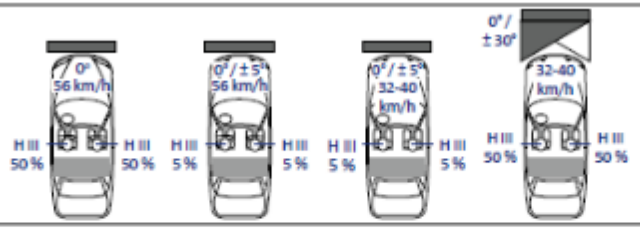
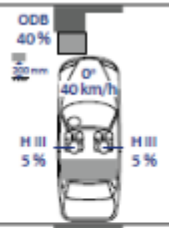
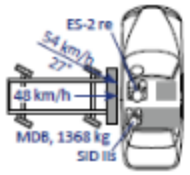
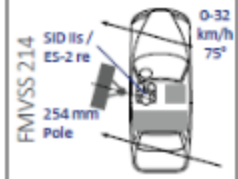
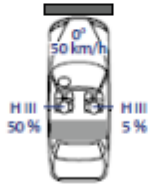
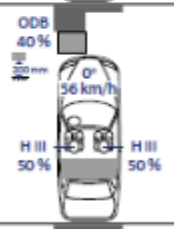
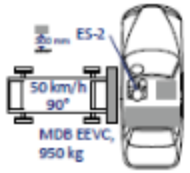
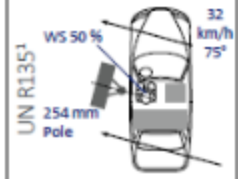
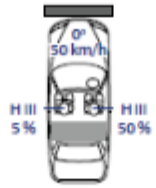
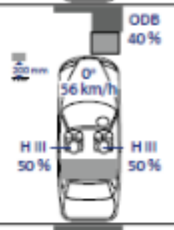
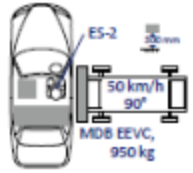
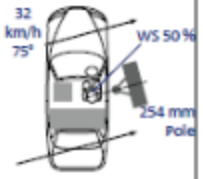
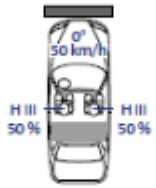
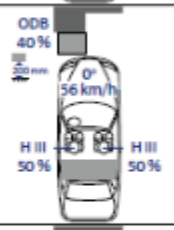
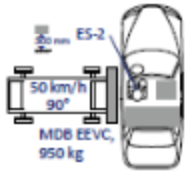
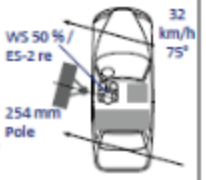
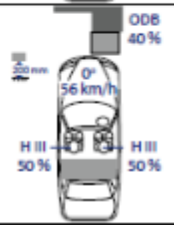
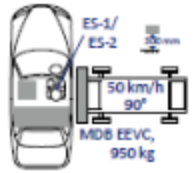
2. Curtain airbag positions between head and window/*-pillar
   - Cushioning the window/*-pillar impact
   - Avoiding the occupant ejection by shielding window in a Roll-over loadcase



Crash Regulations & Ratings

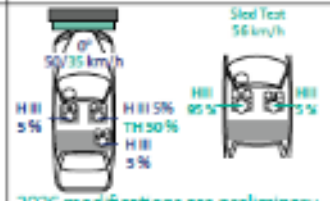
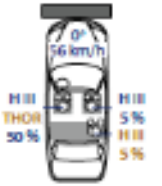
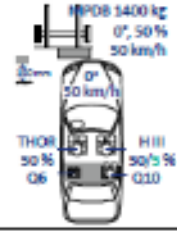
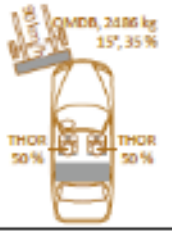
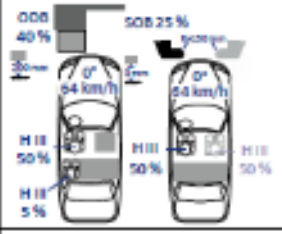
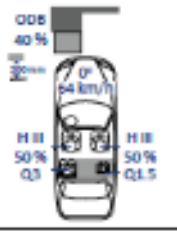
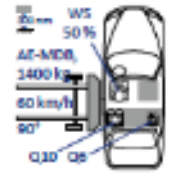
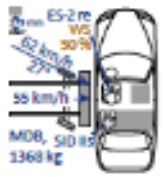
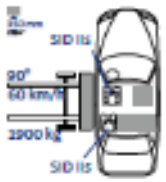
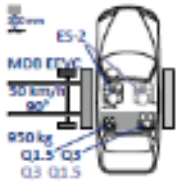
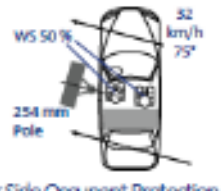
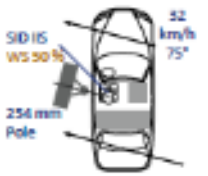
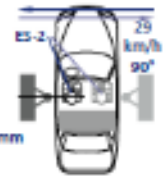
Each country has the crash regulations/ratings which reflects each country status
Recently global harmonization is the trend, same performance everywhere

Rules & Regulations

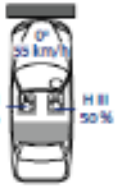
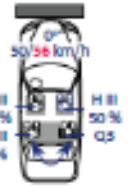
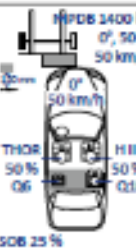
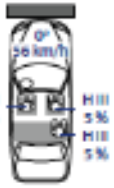
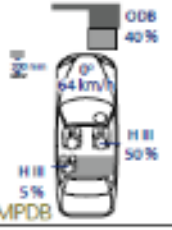
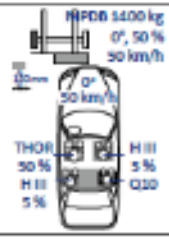
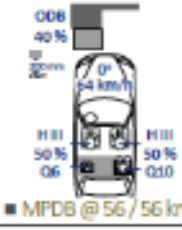
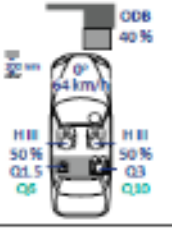
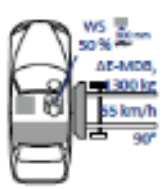
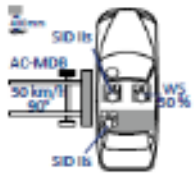
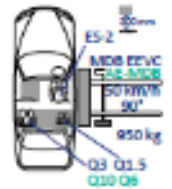
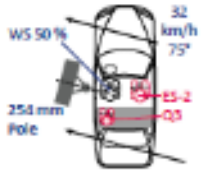
	Full-width Frontal	Offset Frontal	Side Barrier	Side Pole	Pedestrian	Rear	Head Impact	Rollover
USA	FMVSS 208 	FMVSS 208 	FMVSS 214 	FMVSS 214 		FMVSS 202a FMVSS 301	FMVSS 201	Roof Crush: FMVSS 216a Ejection Mitigation: FMVSS 226
Europe	UN R137[1] 	UN R94 	UN R95 	UN R135[1] 	UN R127 R (EU) 2019/2144[1] R (EU) 2021/535	UN R34 UN R153	UN R21	
Japan	Art. 18 	Art. 18 	Art. 18 	Art. 18 	Article 18	Article 22-4	Article 20	
China	GB 11551-2014 	GB/T 20913-2007 	GB 20071-2006 	GB/T 37337-2019 	GB/T 24550-2009	GB 20072-2006	GB11552-2009	Roof Crush: GB26134-2010
India		AIS-098 	AIS-099 		AIS-100	AIS-101	IS15223	

Assessment programs

Items written in italics are not part of the overall rating 2023 2026 date of implementation unknown

	Euro NCAP / ANCAP	U.S. NCAP	IIHS	Latin NCAP
Full-width	 2026 modifications are preliminary		Get familiar with NCAP tests in just 2 days with our seminar: **NCAP - New Car Assessment Programs: Tests, Assessment Methods, Ratings** learn more on ➲ page 32	
ODB / SOB				
MDB	 ■ Far Side Occupant Protection			
Pole	 ■ Far Side Occupant Protection			

Items written in italics are not part of the overall rating 2023 2024 2025 2026

	JNCAP	C-NCAP	C-IASI	KNCAP	ASEAN NCAP
Full-width					
ODB / SOB	 ■ MPDB			 ■ MPDB @ 56 / 56 km/h	
MDB		 except EV/HEV		 ■ Far Side Occ. Prot.	
Pole		 EV/HEV only		 ■ Far Side Occ. Prot.	

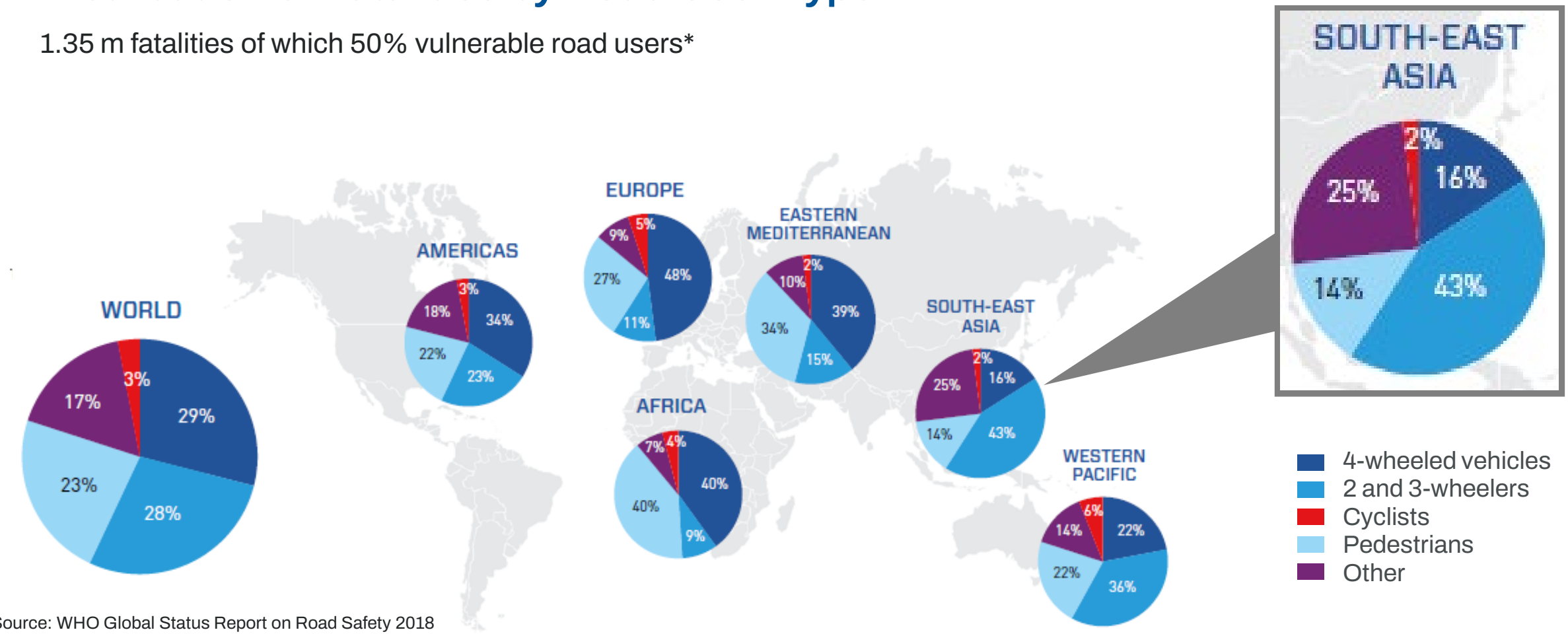
Autoliv

How about motorcycles?

Car safety was researched, developed and matured thru 50years,
the knowledge about motorcycle safety is not sufficient

Distribution of Fatalities by Road User Type

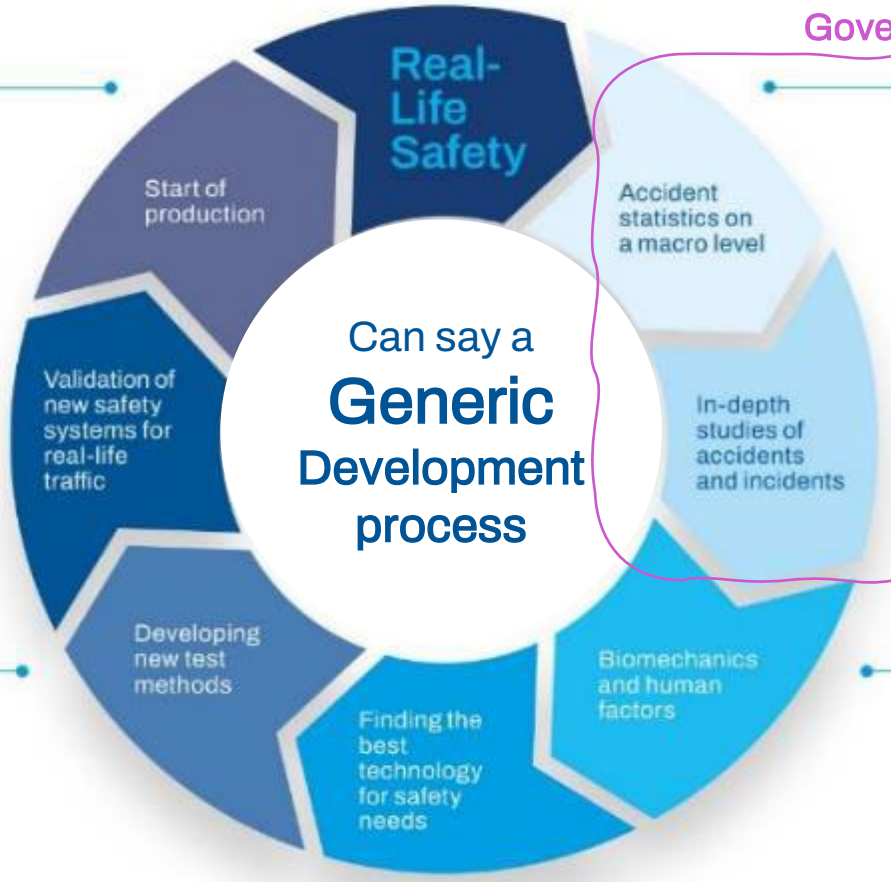
1.35 m fatalities of which 50% vulnerable road users*



Source: WHO Global Status Report on Road Safety 2018

Real-Life Safety
Autoliv has a research-based approach to Saving More Lives in real-lite situations. This approach has allowed us to be a leader in automotive safety for almost 70 years.

First & significant process:
Governmental support must be needed



Start of Production
Once validated, these new technologies move into the Autoliv production system.

Validation of New Safety Systems
We then validate the feasibility of these technologies in real-life traffic situations.

Developing New Test Methods
Continued research also drives us to develop new methods for testing real-life safety technologies.

Accident Statistics on a Macro Level
Autoliv's research team gathers and analyzes real-life safety statistics on a global level to understand traffic accidents.

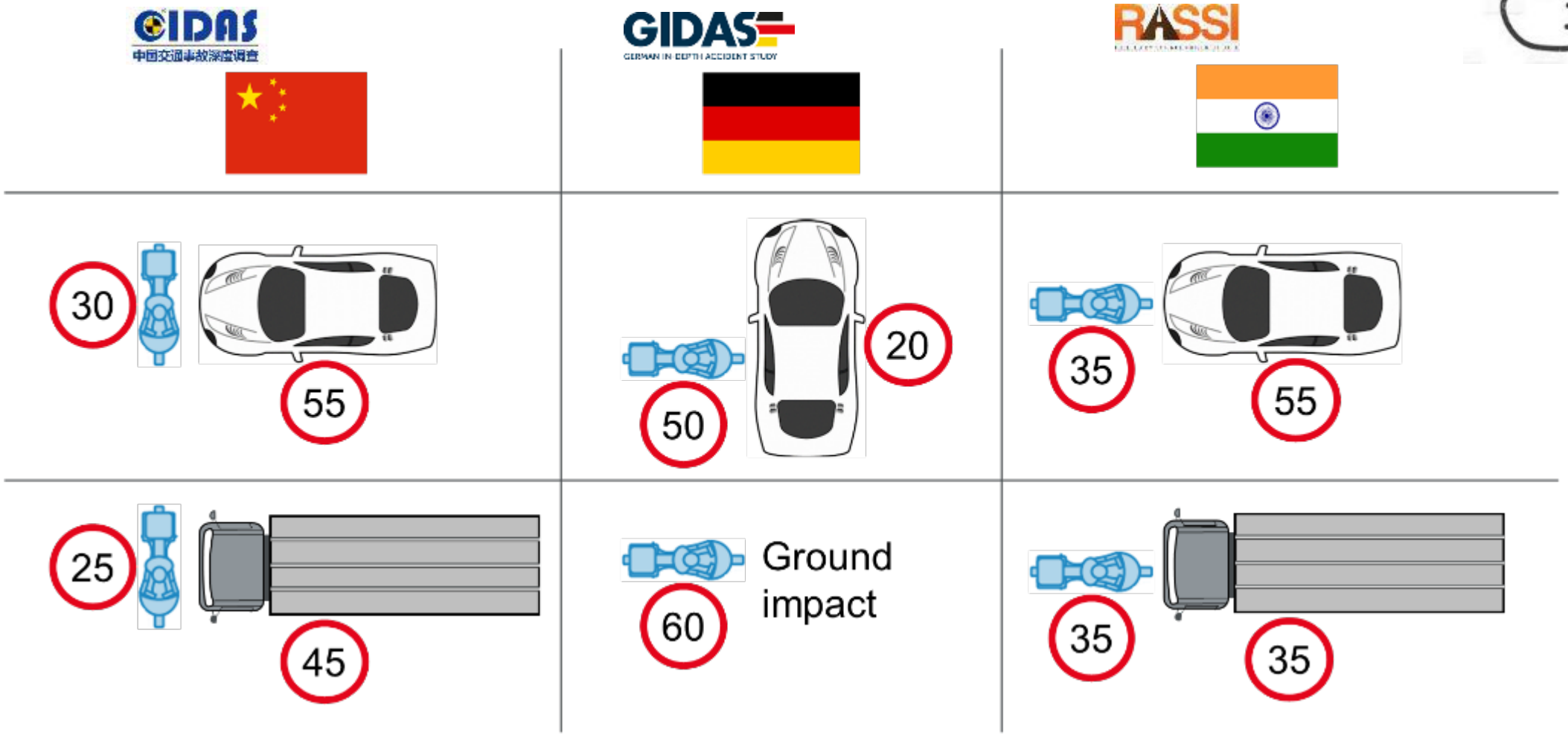
In-Depth Studies of Accidents and Incidents
Autoliv partners with leading safety institutions to study traffic accidents, their causes and outcome.

Biomechanics and Human Factors
Autoliv is a global leader in understanding how biomechanics and driver behavior affects the safety in real-life traffic conditions.

Finding the Best Technology
Our research allows us to develop technologies that meet the needs of real-life traffic situations for all people.

Prioritized Loadcases

Motorcycles (China, Germany, India)

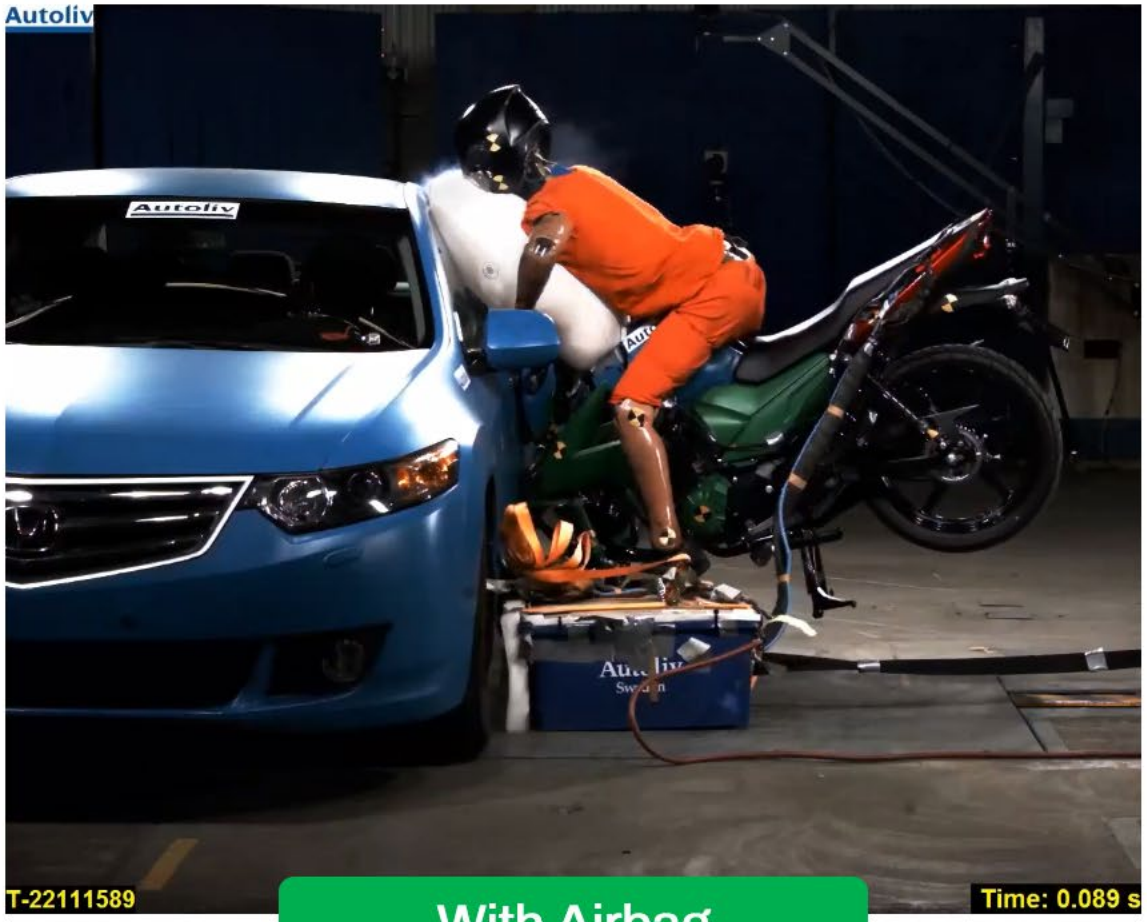


Puthan P, Lubbe N, Shaikh J, Sui B, Davidsson J. Defining crash configurations for Powered Two-Wheelers: Comparing ISO 13232 to recent in-depth crash data from Germany, India and China. Accident; Analysis and Prevention. 2021

PTW Airbag

Full-scale test 50km/h onto Stationary car

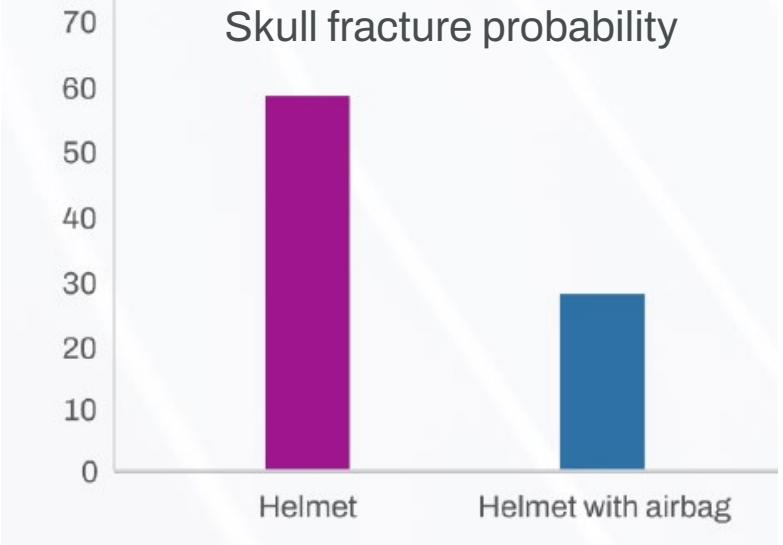
Without Airbag



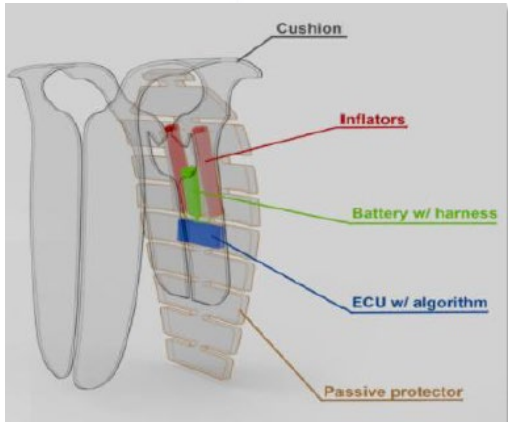
With Airbag

Helmet and Jacket with Airbag

Two times safer than conventional helmet

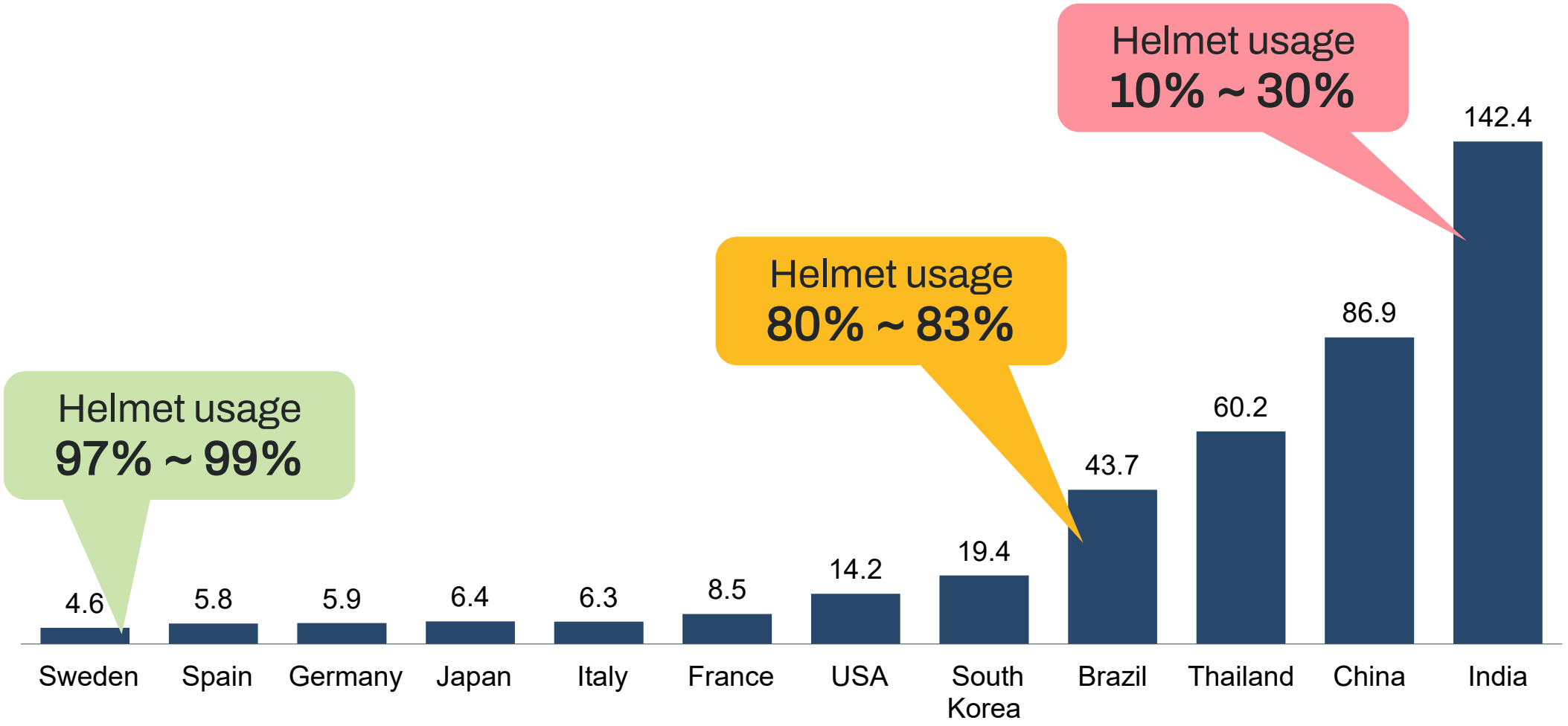


Requirement	Target
In positioning time	10-20 ms
Stand Up time	1 sec
Coverage	Forehead and sides (Temporal Fossa area)
Weight	Airbag max 250 g
	Helmet + Airbag 1650 ± 50 g



Autoliv

Road Fatalities by Country per 100,000 vehicles



Sources: [WHO Global Status Report on Road Safety 2018]

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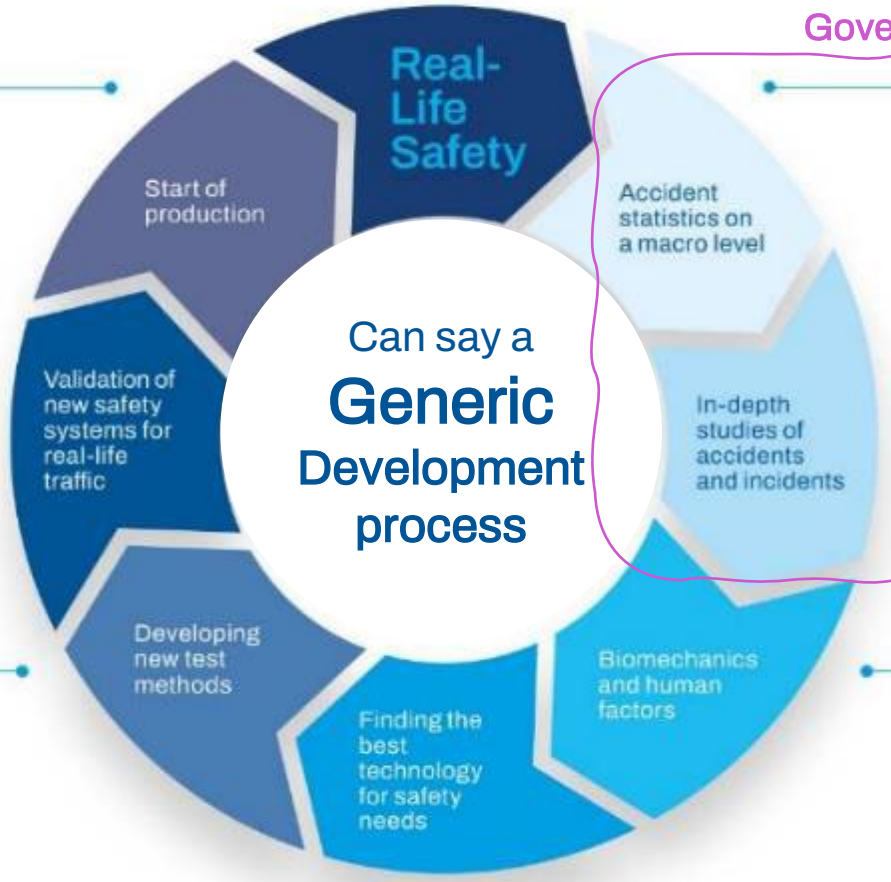

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Finding the Best Technology
Our research allows us to develop technologies that meet the needs of real-life traffic situations for all people.

Messages

- ✓ We are the passive safety system supplier, but the road safety cannot be established by only safety devices

- ✓ Let’s achieve further safer road in ASEAN together with governments, Research institutes, Universities, OEMs and Suppliers like us