Active Safety at Autoliv

From Driver Assistance to Autonomous Driving

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Driven for Life.

Safe Harbor Statement *

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(*) Non-US GAAP reconciliations are disclosed in our 8-K/10-K/10-Q filings available at www.sec.gov or www.autoliv.com
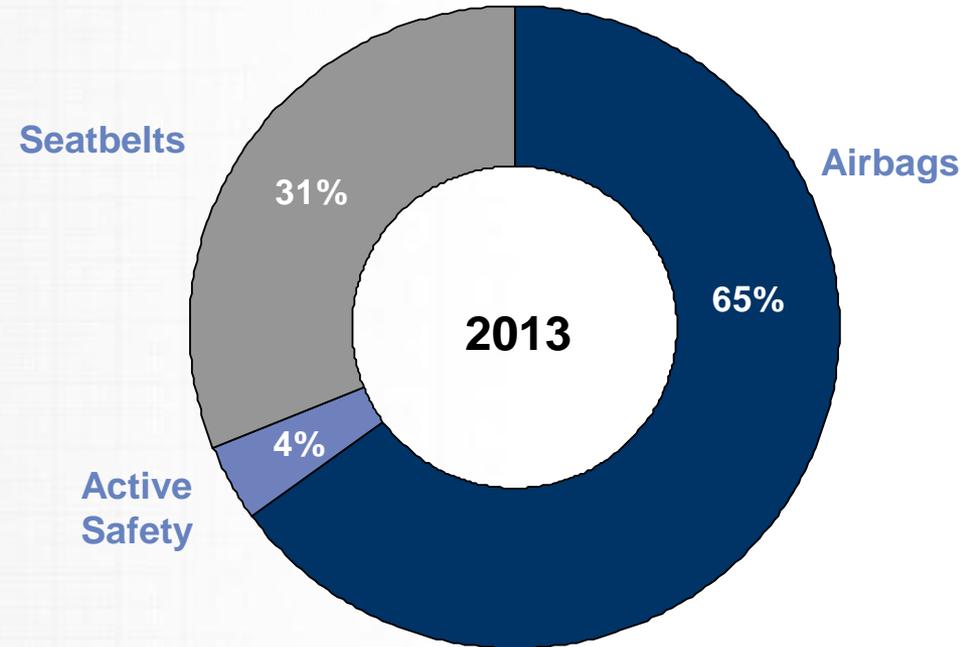
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Autoliv's Mission

Human lives saved by our products
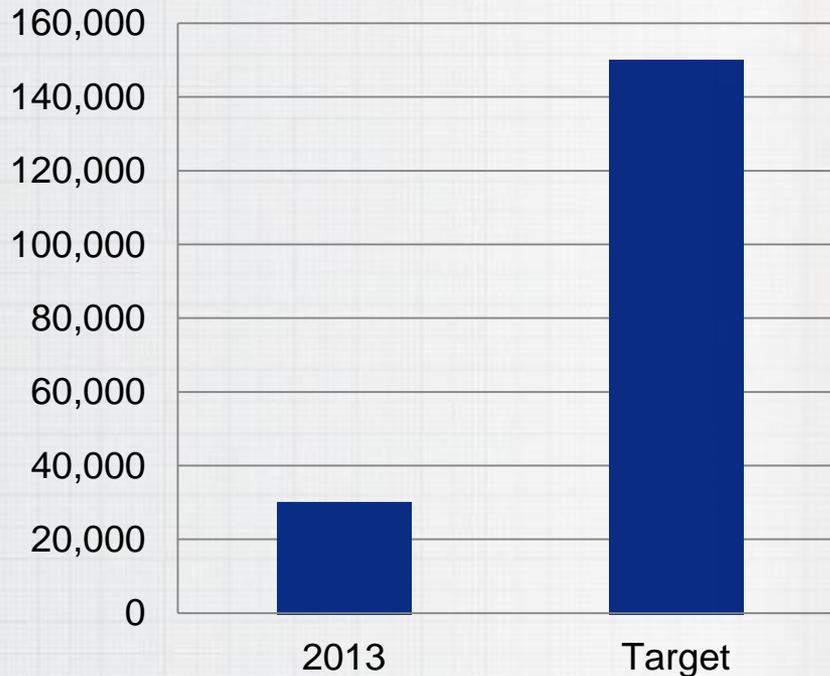
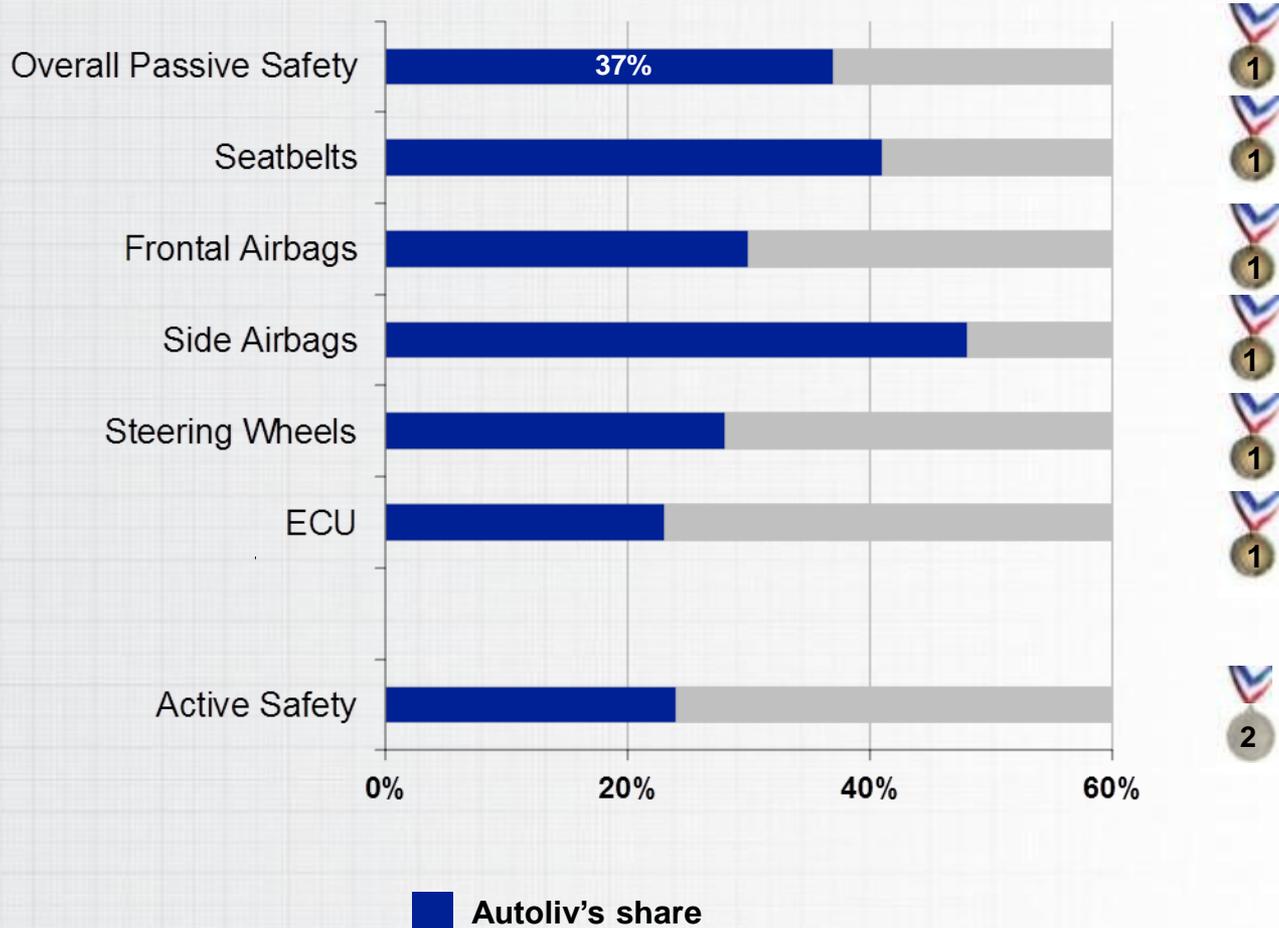*...additionally, our products prevent ten times as many severe injuries*

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Autoliv in Brief

- Sales and technology leader

- Sales LTM US$9.0 billion

- Sales to all major vehicle manufacturers

- Fortune 500 company with an A- credit rating (S&P)

- ~ 80 facilities in 29 countries

- 18 technical centers and 20 crash test tracks

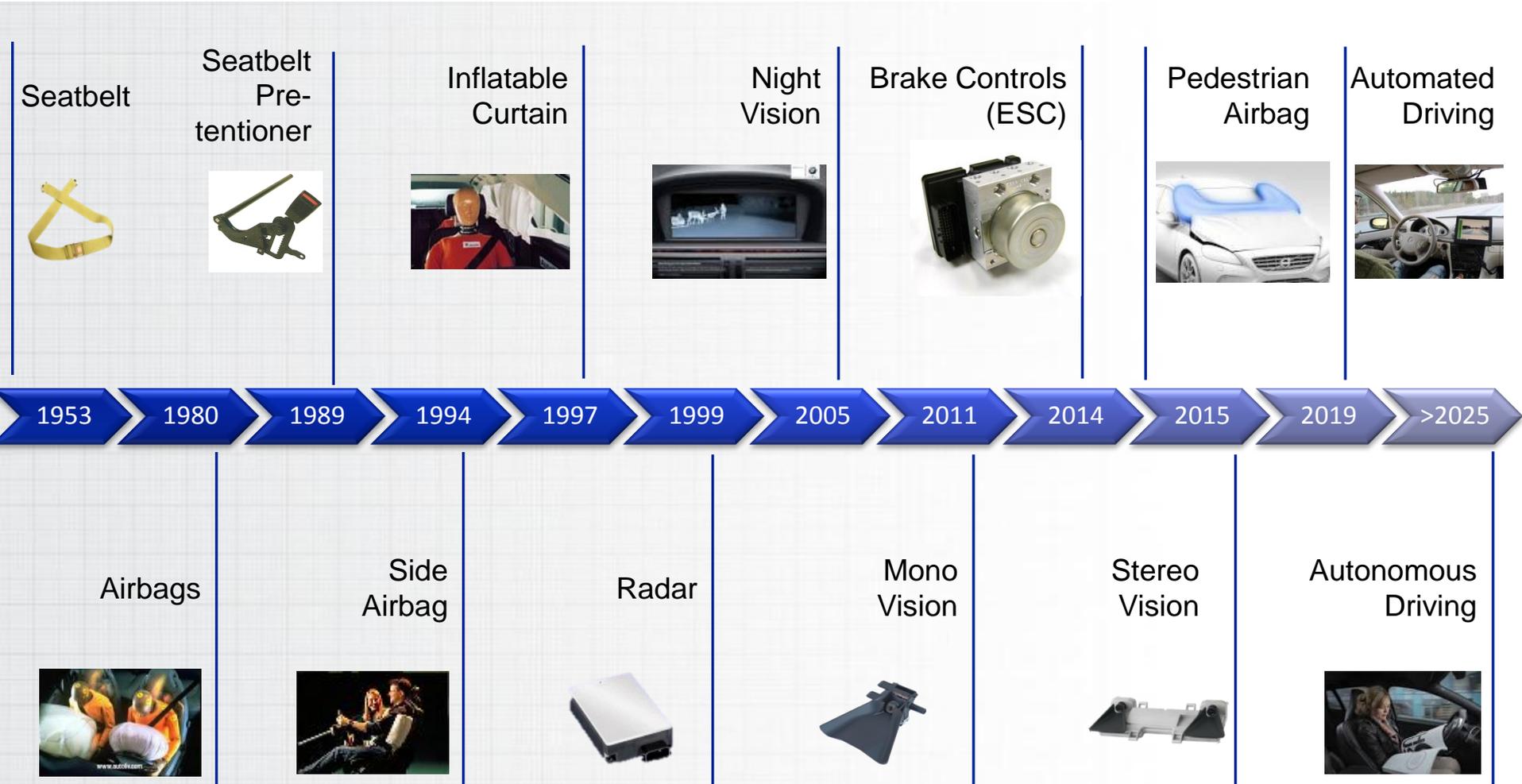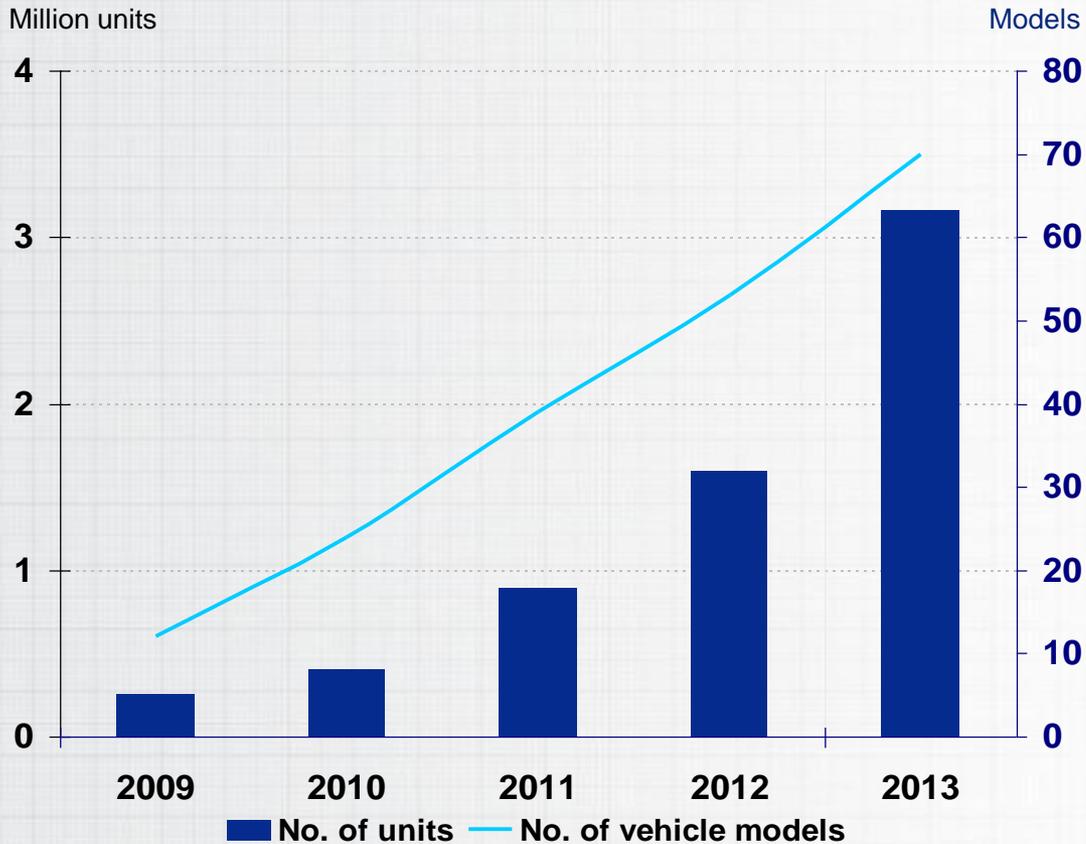- ~ 58,000 associates of which ~ 5,000 in R,D&E

Seatbelts 31%

Active Safety 4%

Airbags 65%

2013

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Market Shares 2013
- Global Safety Market Share by Product

Market share chart showing Autoliv's share by product:
- Overall Passive Safety: 37%
- Seatbelts
- Frontal Airbags
- Side Airbags
- Steering Wheels
- ECU
- Active Safety

X-axis: 0%, 20%, 40%, 60%

Legend: ■ Autoliv's share

Medals: Rankings 1 for Overall Passive Safety, Seatbelts, Frontal Airbags, Side Airbags, Steering Wheels, ECU; Ranking 2 for Active Safety

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Autoliv Safety from 1950

Seatbelt	Seatbelt Pre-tentioner		Inflatable Curtain		Night Vision	Brake Controls (ESC)		Pedestrian Airbag	Automated Driving

| 1953 | 1980 | 1989 | 1994 | 1997 | 1999 | 2005 | 2011 | 2014 | 2015 | 2019 | >2025 |

	Airbags		Side Airbag		Radar		Mono Vision		Stereo Vision		Autonomous Driving

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Active Safety Adoption

Million units

Models

Chart data (left axis: Million units 0–4, right axis: Models 0–80):

Year	No. of units	No. of vehicle models
2009	~0.3	~12
2010	~0.4	~24
2011	~0.9	~40
2012	~1.6	~55
2013	~3.2	~70

■ No. of units — No. of vehicle models

- ■ The rapid **adoption of Active Safety** continues.

- ■ In 2013, we shipped almost twice as many Active Safety units as in 2012.

- ■ Organic sales grew by 57%, and we delivered Active Safety products to almost 70 different vehicle models.

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The needs now and later …

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Active Safety Features

AEB: Autonomous Emergency Braking

Function:
alerts the driver, tightens the active seatbelt, puts the brakes in an alert mode, and applies the brakes autonomously.

(radar or vision)

TSR: Traffic Sign Recognition

Function:
a symbol is displayed in the instrument cluster or on the Head-up Display showing the current speed limit or other important road signs.
(vision)
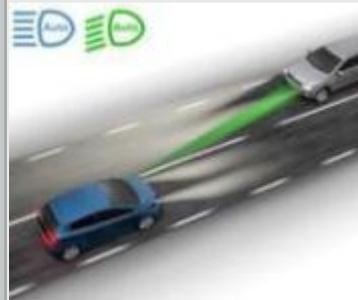
HBA: High Beam Assist

Function:
automatically switches between high and low beams.

(vision)
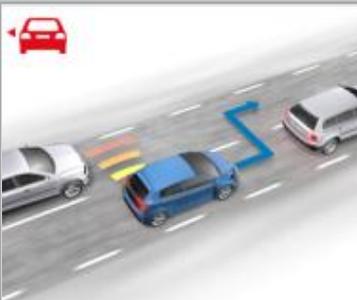
BSM: Blind Spot Monitor

Function:
alerts the driver by lighting a warning indicator on the appropriate side.

(radar)
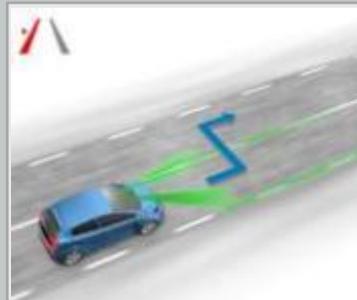
LKA: Lane Keeping Assist

Function:
alerts the driver with acoustical or haptic warnings and/or a symbol on the head-up display, and applies steering autonomously.
(vision)
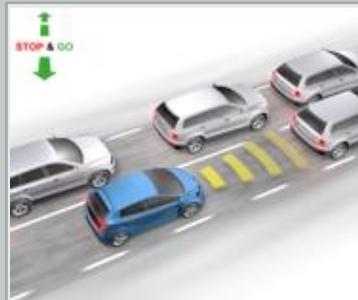
QA: Queue Assist

Function:
maintains a set speed/distance to a vehicle ahead down to a standstill.

(radar or vision)

Pedestrian Detection / Warning

Function:
warns the driver or even autonomously brakes the vehicle.

(vision)
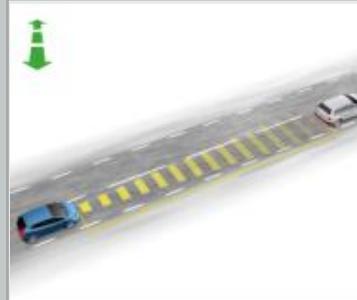
ACC: Adaptive Cruise Control

Function:
maintains a set speed/distance to a vehicle ahead.

(radar)

CTA: Cross-Traffic Assist

Function:
acoustic alert for rear crossing obstacles.

(radar)

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"Assistance – Prevention – Protection"
- Safety in all aspects

POINT OF NO RETURN

Assistance Features	Prevention Features	Protection Features
▪ Adaptive Cruise Control ▪ Blind Spot Monitor ▪ High Beam Assist ▪ Traffic Sign Recognition ▪ Rear Cross Traffic Alert	▪ Forward Collision Warning & Auto. Emergency Braking ▪ Lane Departure Warning & Lane Keeping Assist ▪ Pedestrian Warning ▪ ABS & Stability Control	▪ Airbags ▪ Seatbelts ▪ Pre-pretensioners ▪ Pedestrian Protection

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Automated Driving

Traffic Deaths

Pie chart: Traffic Deaths - Human Error ~93%, Other ~7%

By eliminating human errors that cause traffic accidents, Automated Driving can:
- Prevent millions of crashes
- Reduce the severity of injuries and property damage
- Save lives

Additional benefits:
- Increase driver comfort and productivity
- Use infrastructure more efficiently
- Reduce environmental impact
- Improve mobility

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Automated Driving Definitions
- NHTSA 2013

>2025

Target 2019

2014

Now

Now

Level 4
Autonomous
Vehicle

Level 3
Automation with
full monitoring of
environment

Level 2
Automate two
or more
primary tasks

Level 1
Automate one
primary driving
task

Level 0
No Automation

No occupants
required to be in the
vehicle. Potentially
no steering wheel,
pedals, etc.

Driver is not required to
monitor the system, but
may be required to take
control after an
"appropriate" transition
time (e.g., 10 seconds)

Driver is required to monitor
and take over driving
immediately

Automated Highway Driving
(e.g., traffic jam, low speeds,
etc.)

Driver is overall
responsible for driving

- Adaptive Cruise
  Control
- Autonomous
  Emergency Braking

Driver controls all vehicle
motion

- Blind-Spot Monitoring
- Lane Departure
  Warning

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New Car Assessment Program (NCAP)

Specification	Current Status	2013	2014	2015	2016	2017	2018
EuroNCAP	AEB City		Start rating AEB City				
	AEB Inter-Urban		Start rating AEB Inter-Urban				
	AEB Pedestrian				Start rating AEB Pedestrian		Night performance
	LDW/LKA		Start rating LDW/LKA			Upgrade with regards to LKA	
	Speed Assist	Start rating SAS					
JNCAP	Crash avoidance technologies		LDW AEB for vehicles	Blind Spot (BS), Rear Crossing Traffic Alert (RCTA)	LKA; AEB for pedestrian	Night-time pedestrian warning	
KNCAP	Crash avoidance technologies	FCW, LDW			AEB Interurban	AEB Pedestrian, AEB City, LKA, BSD, RCTA, ACC	
NHTSA/IIHS	Crash avoidance technologies		FCW, LDW	AEB Interurban			

(grey)	Current version
(yellow)	Decided or probable changes
(pale yellow)	Potential changes based on what we know today

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Market Direction For The Future: Higher Levels of Automation

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Technology Enablers and Challenges

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System Components, Functional Diagram

Driver's Inputs & Status

Steering Wheel & Pedals

Driver Monitoring

Vehicle Motion Sensors

Wheel Speeds

Gyros & Accelerometers

Environment Sensors

Camera

RADAR

GPS + Maps

Communication

Sensor Fusion / System Controller

Software

Driver's Intention & Status

+

Vehicle's Position, Path & Speed

+

External Hazard Positions, Paths & Speeds

Software

Desired Vehicle Position, Path & Speed

+

Coordinated Actuator Control

+

Desired Restraining Levels

Actuation

Engine & Drivetrain

Brakes

Steering

Restraints

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Key Active Safety Sensors

Are important to Understanding Surroundings, State of Driver and Vehicle

- **Camera based** – Visual features like lane, traffic signs, light, vehicles and pedestrians

- **Radar based** – Accurate & robust measurement of distance and velocity to various objects

- **Far Infrared based** – sensing living objects like animals and pedestrians using the object thermal signature

- **Other Technologies** – Lidar, Laser etc

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Active Safety Sensors
- Radar Technology

- **Enabling Radar Sensor Technologies**
  - 25GHz Ultra Wide Band Radars
  - 24GHz Narrow Band Radars
  - 77GHz Multi Mode Radars

- **High Performance Features Enabled**
  - Blind Spot Detection
  - Rear Cross Traffic Alert
  - Lateral Collision Avoidance
  - Forward Collision Warning
  - Rear End Collision Mitigation
  - Autonomous Emergency Braking
  - Adaptive Cruise Control

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Active Safety Sensors
- Vision Technology

- **Enabling Vision Sensor Technologies**
  - Mono Camera
  - Stereo Camera
  - Far Infrared Camera

- **High Performance Features Enabled**
  - Lane Departure Warning / Lane Keep Assist
  - Lane Centering
  - Traffic Sign Recognition
  - Headlight Automation
  - Forward Collision Warning
  - Pedestrian Detection & Collision Warning
  - Animal Detection & Collision Warning
  - Dynamic Spot Light
  - Road Surface Information / Free Space Information
  - Autonomous Emergency Braking
  - Adaptive Cruise Control

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Video samples

Videos:

- Radar in fog
- Lane Detection
- Traffic Sign Recognition
- Vehicle Detection
- Pedestrian Detection
- General Object Detection
- Free Space Detection
- Night Vision

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Key Enablers
- System Elements & Design Considerations

Electronic Controllers with powerful microcontrollers and multiple communication ports

Software / Algorithms for execution of performance feature logic

- Sensor Data Fusion
  - Higher automation and autonomy require multiple sensors
- Reasoning and Decision Making
- Actuation Control
- Operating System

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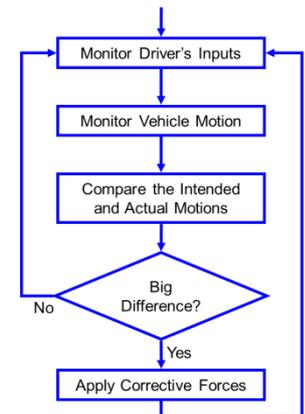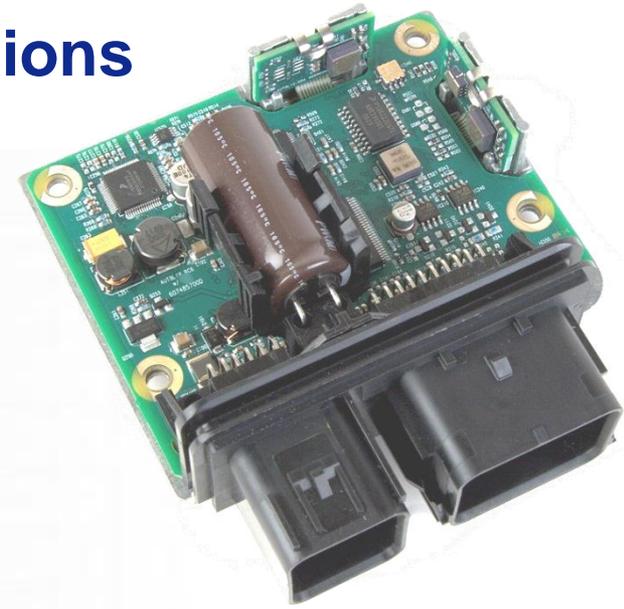
Key Enablers
- System Elements and Design Considerations

System Architecture Design

- Interconnections of sensors, controllers, and actuators
- Partitioning of software functions among controllers
- Communication networks (CAN, FlexRay, Ethernet, etc.)
- Power distribution

Considerations for fault handling (redundancies, back-up modes), for product quality, and for world-wide coverage

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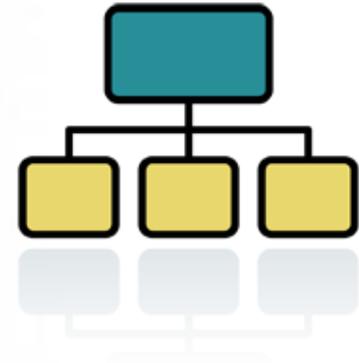
Summary

- Rapid adoption of Active Safety continues

- Automated driving will improve safety, comfort, mobility, and efficiency

- Higher levels of automation and autonomy require more sensors, more controllers, more software, and greater communication bandwidth

No. of units — No. of vehicle models

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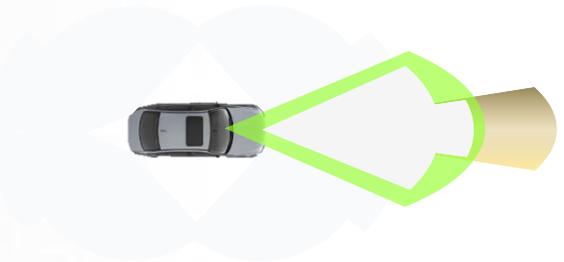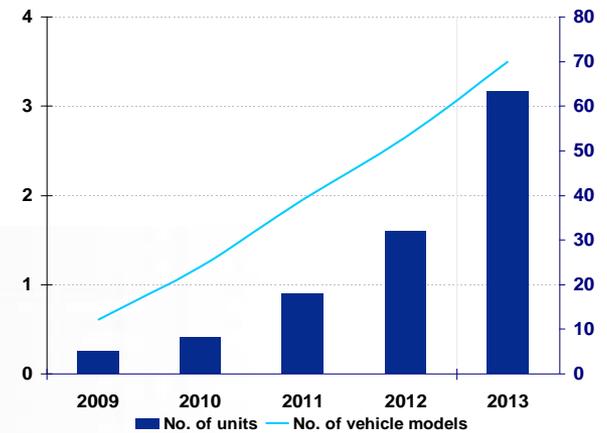
Every year our products save over 30,000 lives

and prevent ten times as many severe injuries

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