Active Safety at Autoliv

From Driver Assistance to Autonomous Driving

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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
Autoliv’s Mission

Human lives saved by our products

...additionally, our products prevent ten times as many severe injuries
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

2013

- Airbags 65%
- Seatbelts 31%
- Active Safety 4%
Market Shares 2013
- Global Safety Market Share by Product

Overall Passive Safety: 37%
Seatbelts: 40%
Frontal Airbags: 37%
Side Airbags: 48%
Steering Wheels: 28%
ECU: 2%
Active Safety: 37%

Autoliv’s share
Autoliv Safety from 1950

1953: Seatbelt
1980: Airbags
1989: Side Airbag
1994: Inflatable Curtain
1997: Radar
1999: Night Vision
2005: Brake Controls (ESC)
2011: Mono Vision
2014: Stereo Vision
2015: Pedestrian Airbag
2019: Autonomous Driving
>2025: Automated Driving

Features:
- Seatbelt
- Pre-tensioner
- Inflatable Curtain
- Night Vision
- Brake Controls (ESC)
- Pedestrian Airbag
- Autonomous Driving

Other features:
- Airbags
- Side Airbag
- Auto Brakes
- Pedestrian Airbag
- Autonomous Driving

Development Timeline:
- 1953: Seatbelt
- 1980: Airbags
- 1989: Side Airbag
- 1994: Inflatable Curtain
- 1997: Radar
- 1999: Night Vision
- 2005: Brake Controls (ESC)
- 2011: Mono Vision
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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.
The needs now and later …
### Active Safety Features

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
<th>Image</th>
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<tbody>
<tr>
<td>AEB: Autonomous Emergency Braking</td>
<td>Alerts the driver, tightens the active seatbelt, puts the brakes in an alert mode, and applies the brakes autonomously.</td>
<td><img src="image" alt="AEB Image" /></td>
</tr>
<tr>
<td>TSR: Traffic Sign Recognition</td>
<td>A symbol is displayed in the instrument cluster or on the Head-up Display showing the current speed limit or other important road signs.</td>
<td><img src="image" alt="TSR Image" /></td>
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<tr>
<td>HBA: High Beam Assist</td>
<td>Automatically switches between high and low beams.</td>
<td><img src="image" alt="HBA Image" /></td>
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<td>BSM: Blind Spot Monitor</td>
<td>Alerts the driver by lighting a warning indicator on the appropriate side.</td>
<td><img src="image" alt="BSM Image" /></td>
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<tr>
<td>LKA: Lane Keeping Assist</td>
<td>Alerts the driver with acoustical or haptic warnings and/or a symbol on the head-up display, and applies steering autonomously.</td>
<td><img src="image" alt="LKA Image" /></td>
</tr>
<tr>
<td>QA: Queue Assist</td>
<td>Maintains a set speed/distance to a vehicle ahead down to a standstill.</td>
<td><img src="image" alt="QA Image" /></td>
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<tr>
<td>Pedestrian Detection / Warning</td>
<td>Warns the driver or even autonomously brakes the vehicle.</td>
<td><img src="image" alt="Pedestrian Detection Image" /></td>
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<tr>
<td>ACC: Adaptive Cruise Control</td>
<td>Maintains a set speed/distance to a vehicle ahead.</td>
<td><img src="image" alt="ACC Image" /></td>
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<tr>
<td>CTA: Cross-Traffic Assist</td>
<td>Acoustic alert for rear crossing obstacles.</td>
<td><img src="image" alt="CTA Image" /></td>
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“Assistance – Prevention – Protection”
- Safety in all aspects

### Assistance Features
- Adaptive Cruise Control
- Blind Spot Monitor
- High Beam Assist
- Traffic Sign Recognition
- Rear Cross Traffic Alert

### Prevention Features
- Forward Collision Warning & Auto. Emergency Braking
- Lane Departure Warning & Lane Keeping Assist
- Pedestrian Warning
- ABS & Stability Control

### Protection Features
- Airbags
- Seatbelts
- Pre-pretensioners
- Pedestrian Protection
Automated Driving

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
Automated Driving Definitions - NHTSA 2013

Level 0
No Automation

- Driver controls all vehicle motion
- Blind-Spot Monitoring
- Lane Departure Warning

Now

Level 1
Automate one primary driving task

- Driver is overall responsible for driving
- Adaptive Cruise Control
- Autonomous Emergency Braking

Level 2
Automate two or more primary tasks

- Driver is required to monitor and take over driving immediately
- Automated Highway Driving (e.g., traffic jam, low speeds, etc.)

Level 3
Automation with full monitoring of environment

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

Target 2019

Level 4
Autonomous Vehicle

>2025

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

Car of the Future, City Bank, NY 2014 v.1.1 - 12
## New Car Assessment Program (NCAP)

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<td><strong>EuroNCAP</strong></td>
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<td>AEB City</td>
<td>Start rating AEB City</td>
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<td>AEB Pedestrian</td>
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<td>Night performance</td>
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<td>LDW/LKA</td>
<td>Start rating LDW/LKA</td>
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<td>Upgrade with regards to LKA</td>
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<td>Speed Assist</td>
<td>Start rating SAS</td>
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<td><strong>JNCAP</strong></td>
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<td>Crash avoidance technologies</td>
<td>LDW AEB for vehicles</td>
<td>Blind Spot (BS), Rear Crossing Traffic Alert (RCTA)</td>
<td>LKA; AEB for pedestrian</td>
<td>Night-time pedestrian warning</td>
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<td><strong>KNCAP</strong></td>
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<td>Crash avoidance technologies</td>
<td>FCW, LDW</td>
<td>AEB Interurban</td>
<td>AEB Pedestrian, AEB City, LKA, BSD, RCTA, ACC</td>
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<td><strong>NHTSA/IIHS</strong></td>
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*Current version*

*Decided or probable changes*

*Potential changes based on what we know today*
Market Direction For The Future: Higher Levels of Automation
Technology Enablers and Challenges
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

- 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
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
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
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
Video samples

Videos:
- Radar in fog
- Lane Detection
- Traffic Sign Recognition
- Vehicle Detection
- Pedestrian Detection
- General Object Detection
- Free Space Detection
- Night Vision
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
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
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
Every year our products save over 30,000 lives and prevent ten times as many severe injuries.