"Towards Zero Fatalities - Volvo Vision 2020 and Swedish Vision Zero"

Anders Eugensson, Volvo Car Corporation
Our vision is to design cars that should not crash. In the shorter perspective the aim is that by 2020 no-one should be killed or seriously injured in a new Volvo.
Vision Zero

Goal
The long term goal is that no-one shall be killed or seriously injured within the Swedish road transport system.

Safety Philosophy:
• Robust Traffic system:
  • People make errors, mistakes and misjudgements. The traffic system must be robust and human errors should not lead to serious consequences.
• Requirements based on biomechanical tolerance limits
• The chain of events can be cut at many places
• Focus on injuries not crashes
• The responsibility is shared between road users and system designers
Kinetic Energy is the Problem

• People are blind to kinetic energy!

• Humans are not perfect, mistakes, misjudgements and misinterpretations must be absorbed

• That’s why you cannot put all responsibility on the road user.
Fatalities - Sweden

• Less than 10 fatalities per 100,000 cars
• Very positive progress w.r.t. fatalities
Co-operation Between Swedish Transport Administration and Volvo Car Corporation

- Agreement signed in 2008
- Governed by a steering group.
- Key safety strategists from both STA and Volvo Cars.
- Heavy truck representatives participating.
- Sub-groups are created as required.
- Presently three sub-groups:
  - Division of responsibilities
  - Lane markings and other interfaces
  - Road sign strategies
Division of Responsibilities

Car manufacturers, governments and local authorities need a common view on the division of responsibilities.

Below this speed: vehicle responsible. Above this speed: infrastructure responsible.

<table>
<thead>
<tr>
<th>Speed</th>
<th>Passive</th>
<th>Active</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>60</td>
<td>20</td>
</tr>
<tr>
<td>40</td>
<td>10</td>
<td>30</td>
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<td>70</td>
<td>55</td>
<td>15</td>
</tr>
<tr>
<td>110</td>
<td>80</td>
<td>30</td>
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</table>

- **Head-on**
- **Pedestrians**
- **Side**
- **Rear-end**
- **Large animals**
Division of Responsibilities

Example: traffic separation for avoiding head-on collisions > 80 km/h
Vehicles / Infrastructure

Interfaces between vehicles and infrastructure important.

Not so good strategy for road signs!
Improved Crash Protection

- Decoupling of structures
- More use of high strength steel
- Non-linear materials
- More effective restraint systems
Help the driver to remain in or be pushed back into normal driving mode!

- Assist and warn the driver
- Vehicle acts autonomously when the driver has not acted

Volvo Cars Safety Strategy
What causes accidents?

The four D’s:
- Distraction
- Drowsiness
- Driving while intoxicated
- Driver capabilities

“Any system which depends on human reliability is unreliable.”

The Focus is to assist drivers and if necessary take over the control of the vehicle in critical situations.
Assessing Driver Attention Selection

Monitoring of driver attention and assessing driver capabilities helps vehicle to decide on appropriate measures.

Eye and field of view tracking
Interaction Driver/ Vehicle

- Very high level of driver capability or very focused and attentive driver
- Average driver
- Experienced and focused driver
- Low level of driver capability or distracted driver
- Very high level of driver capability or very focused and attentive driver
Adaptation in biological systems

- Viable zone
- Adaptive behaviour

Axes:
- Temperature
- Food
Measures to Stay in ’Viable Zone’
Rear-end Collisions

Distance to vehicle in front

Feeling of discomfort

Distance alert
Forward Collision Warning
Automatic Emergency Braking
Safety margin
Safety zone boundary

Comfort zone boundary
Lead vehicle braking

Collision Mitigation by Braking

Severe crash
Less severe crash

Feeling of comfort

Lost control

Attention to roadway

Long
Short

Low
High
Active safety systems

Active systems = driver support systems + autonomously activated systems

1. **Reduction of violence**
   - Autonomous braking
   - Remaining speed at impact
   - Initial speed

2. **Steering away**
   - For frontal collisions steering away is the most effective way to avoid an accident.

3. **Warn and assist the driver**
   - Drowsiness
   - Lane departure
   - Assistance at lane change
   - Traffic information
'The Safety Cocoon'

Connectivity

Vehicle Cocoon

“Immediate” Influence (cm to m)

Road Side Equipment

“Local” Influence (cm to km)

V2I

V2V

RSDS

RACam

“Regional” Influence (cm to >km)

Road Condition
Curve Speed Indication
Road Sign Recognition
Bridge Rejection

Final Destination

"Immediate" Influence (cm to m)

"Local" Influence (cm to km)

"Regional" Influence (cm to >km)
Volvo Active Safety Systems in Production

Lane Departure Warning
• Warns the driver when the vehicle crosses a lane marker while the turn indicator is not used.

Adaptive Cruise Control
• The system automatically adapts the speed to keep the distance.

Collision Warning with Auto Brake
• Intuitive audible and visual warning by flashing the Head Up Display.
• Prepares the brake system by precharging it.
• When a collision is unavoidable, Auto Brake will brake autonomously.
Collision Warning with Auto Brake
Volvo Active Safety Systems in Production

Drowsiness (Driver Alert)
- Analyses the driving behaviour.
- Driver alerted via an audible signal
- “Time for a break” is shown.

Distance Alert System
- When the distance to the car in front is too short, the middle segment of the Head-Up Display is lit up.

Blind Spot Information System (BLIS)
- A red lamp is lit if a car or a motorcycle is in the blind zone of the rearview mirrors.
Drowsiness Prevention Systems
**Volvo Active Safety Systems in Production**

- **Alcohol Interlock System (Alcoguard)**
  - Prevents starting the engine if the blood alcohol content is above the legal limit

- **Low Speed Autonomous Braking System (City Safety)**
  - City Safety will brake automatically just before a collision and avoids collisions up to 15 kmh.
  - Will reduce the severity of collisions at speeds up to 30 kmh by 15 kmh.

- **Lane Keeping Aid**
  - If car drifts out of lane a gentle torque is applied to steer back.
City Safety System
City Safety System Benefits

### Volvo XC60 City Safety Losses

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<tr>
<th></th>
<th>vs. other midsize luxury SUVs</th>
<th>vs. other Volvos</th>
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<tbody>
<tr>
<td>Property damage liability</td>
<td>-27%</td>
<td>-19%</td>
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<tr>
<td>Bodily injury liability</td>
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<td>-49%</td>
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<tr>
<td>Collision</td>
<td>-22%</td>
<td>-17%</td>
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</table>

<table>
<thead>
<tr>
<th></th>
<th>claim frequency</th>
<th>claim severity</th>
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<tbody>
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<td>- $17</td>
<td>- $17</td>
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<tr>
<td>Bodily injury liability</td>
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<tr>
<td>Collision</td>
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<tr>
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<tr>
<td>Collision</td>
<td>-$147</td>
<td>-$53</td>
<td>-$53</td>
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Pedestrian Detection and Full Autonomous Braking System
Pedestrian Detection and Full Autonomous Braking System

The radar and camera scan the area in front of the car.

If the situation becomes critical - red warning flashes on the windscreen.

If no driver reaction autonomous full braking (1.0g)

Pedestrian accidents: avoided for vehicle speeds lower than 35 kmh.

For higher speeds, impact speed can be reduced by 35 kmh.
Pedestrian Detection and Full Autonomous Braking System
Pedestrian Detection and Full Autonomous Braking System
Predicted Accident and Fatality Reduction with Pedestrian Detection & Auto brake

AVOIDANCE; no car-pedestrian impact 30%

MITIGATION; reduction of impact speed 31%

Fatalities

* Lindman et.al, ESAR 2010
Pedestrian and Bicyclist Detection and Full Autonomous Braking System
Intersection Threat Assessment
Traffic Jam Assist

Radar Detection Area in Medium Range Mode
Approx +/- 45 deg, 55 m

Camera Detection Area
approx +/- 25 deg, 100 m

Radar Detection Area in Long Range Mode
Approx +/- 10 deg, 150 m

Keeps a distance, follows the car in front and stays in the lane.
Detecting/ Braking for Wild Animals

• Further development of the system for detecting and braking for pedestrians.

Deer  Elks
Future Development

• Curve speed warning and assistance systems
• Emergency lane assist systems – collision avoidance by steering
• Reducing risk for driver distraction
• Further development of systems preventing DUI
• Enhanced systems for preventing drowsiness
• Automatic braking for more objects
• Vehicle to vehicle (VtV), Vehicle to Infrastructure (VtI) and Vehicle to Infrastructure to Vehicle (VtItoV) communication
• >1.0 g braking
• Platooning – car trains for long haul journeys.
  • Increases safety and comfort, reduces congestion and CO2 emissions
Autonomous driving opens up possibilities for improvements on:

- Safety
- Fuel economy
- Traffic efficiency
- Improved mobility
- Infrastructure investments
- Comfort
- City planning
Assuming the Control from the Driver.

• Limp-home functions outside of driver control for certain situations:

Driver Incapacitated, Severe Sudden Illness, Drowsiness, etc:
The vehicle of the future - Just like the farmer’s horse:

• Can be steered actively and in full control by the farmer but

• It can handle a situation where the farmer falls asleep and still find its way home and

• It will not accept being steered into a tree or off a cliff
Thank you!