Frost & Sullivan’s Research and Market Consulting Group

Global Trends, Technology Roadmaps and Strategic Market Analysis

AUTOMOTIVE SAFETY & DAS

Presentation to Automotive World Briefing – 14th May 2008

Nick Ford – Senior Consultant
Overview of the Market for Safety and DAS Technologies

Active Safety Technologies – Identifying Growth Opportunities

Passive Safety Technologies – Growth Opportunities in a mature market

Customer Attitudes and Perceptions towards Safety Technologies

Conclusions
Overview of the Market for Safety and DAS Technologies

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Conclusions & Recommendations
Key Product Launches in Automotive Safety Market – 2007

Collision avoidance is a key development area – Europe’s first system using Radar + Camera sensor fusion for Emergency braking

**Driver Alert Control (DAC)**
- **Production Models**: S80, V70 and XC70
- **Sensor Used**: CMOS Camera
- **Developed by**: Volvo, Mobileye
- **System Functioning**: LDW camera monitors distance between the car and the road lane markings to determine whether the driver risks losing control or not.

**Collision Warning with Automatic Braking**
- **Production Models**: S80, V70 and XC70
- **Sensor Used**: Camera + Radar
- **Developed by**: Volvo, Mobileye, Delphi
- **System Functioning**: Sensor fusion of radar and camera data for obstacle detection with initial audio and video warnings followed pre-charging of the brakes or automatic-braking in the case of driver inaction.

**Park4U Semi-autonomous Parking**
- **Production Models**: VW Touran, Tiguan
- **Sensor Used**: Ultrasonic sensors
- **Developed by**: Valeo
- **System Functioning**: The system measures a parallel parking space and guides the car into the gap taking steering control, with the driver required to just accelerate or brake.

**PathFindIR – Automotive Night Vision (Aftermarket)***
- **Sensor Used**: Far Infra-red camera
- **Developed by**: FLIR + NAV-TV
- **System Functioning**: PathFindIR is an autonomous, stand-alone camera system that uses thermal imaging for improved road visibility in night driving conditions. The system can be installed on any vehicle platform quickly and easily.

**Lane Departure Warning (LDW) – Camera Based**
- **Production Models**: BMW 5-Series
- **Sensor Used**: CMOS Camera
- **Developed by**: Siemens VDO + Mobileye

* Launched in 2008
Key events/concepts in Automotive Safety Market – 2007

Renewed interest in monitoring driver and driving behaviour for accident prevention

**Attention Assist System**
- Expected Launch Year: 2009
- Developed by: Mercedes
- System Functioning: The system warns the driver of tiredness using various sensors to analyse driving behaviour. The system creates a driver behaviour profile during normal driving and compares it in different scenarios to detect fatigue.

**Blaupunkt “Dual View” System**
- Expected Launch Year: 2009
- Developed by: Bosch
- System Functioning: The system displays two different programs on a single screen with the driver and passenger able to view different images based upon the angle of viewing, with space requirements remaining the same.

**Integrated Project GST**
- (Global System for Telematics)
- Developed by: Renault + BMW
- System Functioning: Renault and BMW jointly developed a rescue scenario and implemented it for the first time in vehicle prototypes, focusing specifically on inter-vehicle communication. The prototypes have interoperable telematics with open architecture for easy communication.

**Saab – Driver Attention Warning System**
- Developed by: Saab
- System Functioning: Development project for designing a system that Detects Driver Drowsiness & Driver Inattention – Utilizes two miniature infra-red cameras, one installed at the base of the driver’s A-pillar and the other in the center of the main fascia, focused on the driver’s eyes.

* Announced in 2008
Asia is the Major Contributor to the Global Safety Systems Market Revenues Attributable to Wider Installation in Japan

Global Safety Systems Market – Revenue Forecast

Year 2006

- Active Safety:
  - $11.6 Billion
  - 46.7%

- Passive Safety:
  - $15.8 Billion
  - 53.3%

Year 2012

- Active Safety:
  - $10.9 Billion
  - 53.0%

- Passive Safety:
  - $15.8 Billion
  - 56.8%

CAGR 6.6%

Asia is the Major Contributor to the Global Safety Systems Market Revenues Attributable to Wider Installation in Japan

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Note: All figures are rounded. Source: Frost & Sullivan
Global Active Safety Systems Market Revenues to Exceed 20 Billion USD by 2012

Global Active Safety Systems Market: Revenue Forecasts (in Million US$), 2006 and 2012

- ABS/ESC – Antilock Braking System / Electronic Stability Control
- TPMS – Tyre Pressure Monitoring System
- LDW – Lane Departure Warning
- BSD – Blind Spot Detection
- NVS – Night Vision System
- IPA – Parking Assistance
- ACC – Adaptive Cruise Control

Note: All figures are rounded. Source: Frost & Sullivan
Legislation driven technologies like ESP, e-Call and Tyre Pressure Monitoring systems are expected to have a high penetration in EU

<table>
<thead>
<tr>
<th>Penetration</th>
<th>A – Technologies Driven By Legislation</th>
<th>B – Features Standard in higher segment vehicles, but optional in mid and lower segments</th>
<th>C – Features that will only be available as option</th>
</tr>
</thead>
<tbody>
<tr>
<td>70.0%</td>
<td>EPS -&gt; CEPS + PEPS + REPS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>75.0%</td>
<td>Stolen Vehicle Tracking</td>
<td></td>
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<tr>
<td>75.0%</td>
<td>RVD</td>
<td></td>
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<tr>
<td>91.0%</td>
<td>MP3/ WMA</td>
<td></td>
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<tr>
<td>100.0%</td>
<td>Standard ESP</td>
<td></td>
<td></td>
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<tr>
<td>100.0%</td>
<td>e-call</td>
<td></td>
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<tr>
<td>100.0%</td>
<td>DPF (% of diesel)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100.0%</td>
<td>Tyre Pressure Monitoring System</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20.0%</td>
<td>Active Steering</td>
<td>Pay as you drive (PAYD) 35 - 40%</td>
<td></td>
</tr>
<tr>
<td>24.0%</td>
<td>DVD</td>
<td>Turbocharger (% of gasoline) 40.0%</td>
<td></td>
</tr>
<tr>
<td>25.0%</td>
<td>Air Suspension</td>
<td>Embedded Navigation 40.0%</td>
<td></td>
</tr>
<tr>
<td>30.0%</td>
<td>Start-stop system</td>
<td>VVT (% of gasoline) 42.5%</td>
<td></td>
</tr>
<tr>
<td>33.2%</td>
<td>Occupant Sensing Systems</td>
<td>In-vehicle Displays 48.0%</td>
<td></td>
</tr>
<tr>
<td>35.0%</td>
<td>DCT + AMTs</td>
<td>Passive Hands free 55.0%</td>
<td></td>
</tr>
<tr>
<td>35.0%</td>
<td>Advanced ESP</td>
<td>GDI (% of gasoline) 57.5%</td>
<td></td>
</tr>
<tr>
<td>36.0%</td>
<td>Multi-functional Switches</td>
<td>Whiplash Protection Systems 61.1%</td>
<td></td>
</tr>
</tbody>
</table>

Lane Departure Warning (LDW) 4.3%
Blind Spot Detection (BSD) 6.0%
Adaptive Cruise Control 8.2%
Seat - Active Massage (Driver/Passenger) 8.5%
EHB + Hybrid braking+ EMB / EWB 14.0%
Seat - Ventilation (Driver/Passenger) 19.2%

Source: Frost & Sullivan
Agenda for Safety & DAS

Overview of the Market for Safety and DAS Technologies

Active Safety Technologies – Identifying Growth Opportunities

Passive Safety Technologies – Growth Opportunities in a mature market

Customer Attitudes and Perceptions towards Safety Technologies

Conclusions & Recommendations
Active Safety Systems – The Burning Topics

Success of DAS features will be significantly influenced by quality of HMI

Potential end-user demand for DAS in the aftermarket – new products entering market

Obstacle sensors to become commodity products – CMOS presents strong growth opportunities

Non-chassis suppliers making in-roads into DAS market including low-speed maneuvering

Integration of DAS with navigation and post-crash safety systems reaching introduction phase

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Obstacle sensors to become commodity products – CMOS presents strong growth opportunities

Non-chassis suppliers making in-roads into DAS market including low-speed maneuvering

Integration of DAS with navigation and post-crash safety systems reaching introduction phase
Key Dimensions – Systems, Sensors, HMI

Driver Warning and Information Systems

Driver Assist Systems

Blind Spot Detection
Infrared Sensors
Radar 24 GHz > 79 GHz
Push Button Warning Light and Audible
Push Button Visual Display

Collision Warning (CW)
CMOS
Radar 24 GHz > 79 GHz
Automatic Audible and Visual

Night Vision System (NVS)
CMOS based Near Infrared Sensors
Far Infrared Sensors
Push Button Visual Display

Lane Departure Warning (LDW)
Push Button Haptic

Adaptive Cruise Control (ACC)
Radar 76/77 (1998)
Push Button Automatic braking and acceleration.

Intelligent Park Assist
CMOS
Push Button Visual Display

CMOS Sharing ACC, LDW, NVS & CW
24 GHz Sensors > 79 GHz Sensors
Fusion of Radar 76/77 & CMOS

European Active Safety Technology Roadmap

Input Options
Output Options
Driver Assistance System
Sensors Used


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### OEMs Need to educate Consumers of Benefits of Haptic Feedback

**Example of HMI Preferences**

<table>
<thead>
<tr>
<th>Systems</th>
<th>Input</th>
<th>Preferred Location</th>
<th>Output</th>
<th>Preferred Location</th>
</tr>
</thead>
</table>
Haptic: Steering Wheel, Seats |
| Park Assist System | ![Input Image] | Haptic: Centre Stack, Steering Wheel | ![Output Image] | Visual: Rear View Mirror, Central Display |
Haptic: Steering Wheel |
Haptic: Steering Wheel |
Haptic: Steering Wheel |
Host of ADAS Applications where Digital Map Data is a Key Component for Enhanced Accuracy and Results

- **Bosch, BMW**
- **Aisin, Toyota**
- **ACC**
- **Electronic Stability Control**
- **Continental, Mercedes Benz**
- **Lane Departure Warning**
- **Fuel Economy**
- **Valeo, PSA**
- **Navimatic Transmission**
- **Adaptive Front Lighting**
- **Visteon (Ford)**

**Example of digital map acting as a sensor**

- **Steering angle sensor**
- **Vehicle speed sensor**
- **Vehicle height sensor**

**Digital Map data key for Many ADAS Applications**

**Curve Warning & Driving Stability Improvement System**

- Toyota jointly developed with Aisin and currently available in Europe on select Toyota models.
- System uses digital map data to sense curvature radius.
- Suspension damping forces gets optimum control in line with the curvature radius.
Case Study - TomTom GO was launched in a market dominated by complex, expensive, built-in car navigation systems. TomTom GO managed to position itself not just as another technical product, but as an easy, smart and accessible consumer solution, moving to take a 56% market share.

Source: TomTom

Source: Frost & Sullivan

<table>
<thead>
<tr>
<th>Today</th>
<th>Tomorrow for DAS</th>
<th>Systems Already in Market</th>
</tr>
</thead>
<tbody>
<tr>
<td>- New Car Buyers</td>
<td>Car Drivers</td>
<td>HUD</td>
</tr>
<tr>
<td>- Built-in</td>
<td>DIY / Aftermarket Installed</td>
<td>TPMS</td>
</tr>
<tr>
<td>- Car System</td>
<td>Warning / Information Systems</td>
<td>Park Assist</td>
</tr>
<tr>
<td>- Complicated</td>
<td>Easy-to-Use</td>
<td>LDW</td>
</tr>
<tr>
<td>- Expensive</td>
<td>Affordable Value</td>
<td></td>
</tr>
<tr>
<td>- Functional</td>
<td>Indispensable for safe driving</td>
<td></td>
</tr>
<tr>
<td>- Need</td>
<td>Want / Incentivised by insurance</td>
<td></td>
</tr>
</tbody>
</table>

Source: Frost & Sullivan
Overview of the Market for Safety and DAS Technologies

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Global Passive Safety Systems Market Revenues to Reach 17.4 Billion USD by 2012


- 2006: $13.5 Billion
  - Airbags: $5.4 Billion (12.5%)
  - Seatbelts: $5.1 Billion (12.9%)
  - Side Airbags: $6.8 Billion (12.3%)
  - Curtain Airbags: $13.6 Billion (15.8%)
  - Whiplash Protection Systems: $27.0 Billion (28.5%)
  - Occupant Sensing Systems: $27.0 Billion (26.2%)

- 2012: $17.4 Billion
  - Airbags: $7.7 Billion (4.2% CAGR)
  - Seatbelts: $7.9 Billion (7.7%)
  - Side Airbags: $16.9 Billion (26.8%)
  - Curtain Airbags: $12.2 Billion (28.5%)
  - Whiplash Protection Systems: $12.7 Billion (29.9%)
  - Occupant Sensing Systems: $11.4 Billion (32.1%)

Note: All figures are rounded. Source: Frost & Sullivan
Seat is the Heart of Occupant Safety in all Crash Scenarios

OCS Estimated to Cost around 26.5% of Seat

**Whiplash Protection Systems**
- **Active:** 5.3% (2005) – 3.8% (2010)
- **Reactive:** 2.7% (2005) – 2.1% (2010)
- **Passive:** 1.3% (2005) – 0.7% (2010)

**Side Airbags**
- 5.0% (2005)
- 3.5% (2010)

**Pre-Tensioners**
- 2.4% (2005)
- 1.6% (2010)

**Seatbelt Reminders**
- 2.1% (2005)
- 1.4% (2010)

**Anti-submarine Technologies**
- 4.2% (2005)
- 3.1% (2010)

**Occupant Detection and Classification Systems**
- 26.5% (2005)
- 18.8% (2010)

Source: Frost & Sullivan
Key Take Home Points for Passive Safety Systems

- **Role of seat in safety**: Shift to an electronically controlled occupant safety system.
- **Active passive integration**: Lead to installation of more reversible passive safety systems.
- **Dual stage airbags**: Have more application in the European market compared to other smart technologies like variable stage airbags.
- **Reversible active whiplash protection systems**: Have maximum market potential among any other whiplash protection systems.
- **Unlike US, Occupant detection systems**: Have stronger demand than occupant classification systems in Europe.
List of Clients who Invested in a Recent Multi-Client Study

- Frost & Sullivan developed this study to enable manufacturers and suppliers to better understand the expectation of customers, their desirability for safety and willingness to pay.
- The quality of the methodology is emphasised by **6 OEMs and 4 Tier 1 suppliers** sponsoring the study.
- List of clients for this study -

![Logo Images]
Methodology - Benefits of Safety Systems

**Vehicle Stability Systems**
- **Alerting** the driver if vehicle deviates from the lane inadvertently
- **Emergency Braking Assistance**
- **Active Steering**

**Driver Warning and Info Systems**
- **Tyre Pressure Monitoring**
- **Lane Deviation warning**
- **Blind Spot warning**
- **Driver Drowsiness**
- **Stealth Warning**

**Collision Avoidance Systems**
- **Adaptive Cruise Control Systems**
- **Lane change assistance system**
- **Lane keeping System**

**Occupant Protection Systems**
- **Ensuring** the vehicle keeps a safe distance from those ahead
- **Front airbags**
- **Side airbags**
- **Curtain Airbags**
- **Anti-submarining Airbags**
- **Knee airbags**
- **Feet airbags**
- **Whiplash protection**
- **Occupant classification and detection systems**
- **Rear seat Passenger protection**

**Other Passive Safety Systems**
- **Pedestrian Protection Systems**
- **Crash compatibility solutions**
- **SOS button**
- **Post-crash automatic notification systems**
- **Automatic summoning emergency services in case of a crash**
- **Allowing** the driver to change lanes only if it is safe to do so

**Legend**
- Normal driving Situation
- Emergency Situation
- Pre-Crash Situation
- In-Crash Situation
- Post-Crash Situation
Respondents perceive technologies (ABS, Seatbelts, Airbags) traditionally associated with accident scenarios to play an important part in vehicle safety. Technologies not primarily associated with accident scenarios are perceived to be not as important to vehicle safety.

Q.2 How important are the following technologies to overall vehicle safety?

- **Seat Belts**: 85% Plays an Important Role, 12% Contributes somewhat to Safety, 2% Contributes little to Safety
- **Front Airbags**: 81% Plays an Important Role, 17% Contributes somewhat to Safety, 21% Contributes little to Safety
- **Anti-lock Braking System**: 79% Plays an Important Role, 19% Contributes somewhat to Safety, 11% Contributes little to Safety
- **Side Airbags**: 74% Plays an Important Role, 23% Contributes somewhat to Safety, 3% Contributes little to Safety
- **Emergency Brake Assist**: 55% Plays an Important Role, 35% Contributes somewhat to Safety, 3% Contributes little to Safety
- **Electronic Stability Control**: 46% Plays an Important Role, 39% Contributes somewhat to Safety, 6% Contributes little to Safety
- **Tyre Pressure Monitoring**: 34% Plays an Important Role, 50% Contributes somewhat to Safety, 12% Contributes little to Safety
- **Speed Warnings**: 32% Plays an Important Role, 44% Contributes somewhat to Safety, 22% Contributes little to Safety
- **Lane Departure Warning**: 29% Plays an Important Role, 44% Contributes somewhat to Safety, 16% Contributes little to Safety
- **Adaptive Cruise Control**: 19% Plays an Important Role, 36% Contributes somewhat to Safety, 24% Contributes little to Safety

*Source: Information from Consumer research study done with 1,635 respondents*
Across Europe, 'traditional' occupant protection and braking technologies are preferred over newer active technologies.

<table>
<thead>
<tr>
<th>Features that help maintain correct speed in driving zone</th>
<th>8%</th>
<th>37%</th>
<th>13%</th>
<th>30%</th>
<th>13%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Features that enhance braking under different conditions</td>
<td>17%</td>
<td>46%</td>
<td>18%</td>
<td>19%</td>
<td>1%</td>
</tr>
<tr>
<td>Features that warn or inform driver of potential risks</td>
<td>9%</td>
<td>41%</td>
<td>21%</td>
<td>28%</td>
<td>2%</td>
</tr>
<tr>
<td>Features that help maintain safe distance b/w vehicles</td>
<td>8%</td>
<td>37%</td>
<td>17%</td>
<td>30%</td>
<td>8%</td>
</tr>
<tr>
<td>Features that aid driver vision</td>
<td>12%</td>
<td>43%</td>
<td>21%</td>
<td>23%</td>
<td>1%</td>
</tr>
<tr>
<td>Features that protect occupants in collision</td>
<td>30%</td>
<td>39%</td>
<td>16%</td>
<td>14%</td>
<td>1%</td>
</tr>
<tr>
<td>Features that relay for assistance after collision</td>
<td>9%</td>
<td>34%</td>
<td>20%</td>
<td>33%</td>
<td>4%</td>
</tr>
</tbody>
</table>

- Will not purchase vehicle if absent
- Will purchase vehicle if standard
- Will likely purchase as option
  - Nice to have
  - Don't want

Q.10 How important are the following to you when you consider a package of safety features for your vehicle?
Consumers in Europe Significantly Concerned About Front-end Collisions Contrast to US Consumers Concerned about Rear-end Impact
Consumers Prefer Audio / Visual Feedback for Most Emergency Situations – Need to Educate Benefits of Haptic Feedback

- **You are fast approaching an obstacle ahead**
  - EU: 32.80% Visual, 32.40% Audio & Visual, 31.10% Audio & Haptic, 35.00% Haptic, 22.40% Audio
  - US: 32% Audio & Visual, 13% Audio, 3% Haptic, 40% Visual, 8% Audio & Haptic

- **Your vehicle drifts from its lane when your attention is diverted**
  - EU: 15.00% Audio, 6.60% Visual, 32.80% Haptic, 14.90% Audio & Visual, 9.30% Audio & Haptic
  - US: 15.40% Audio, 9% Visual, 36% Haptic, 14% Audio & Visual, 3% Audio & Haptic

- **Changing lanes when a vehicle is in your blind spot**
  - EU: 13.60% Audio, 3.50% Visual, 29.70% Haptic, 12.80% Audio & Visual, 7.80% Audio & Haptic
  - US: 13% Audio, 4% Visual, 35% Haptic, 12% Audio & Visual, 3% Audio & Haptic

- **A vehicle/pedestrian suddenly appearing ahead**
  - EU: 17.40% Audio, 5.00% Visual, 32.40% Haptic, 32.00% Audio & Visual, 8% Audio & Haptic
  - US: 15% Audio, 3% Visual, 35% Haptic, 10% Audio & Visual, 3% Audio & Haptic

- **Major malfunction in your vehicle (e.g. low tyre pressure)**
  - EU: 7.50% Audio, 4.20% Visual, 32.10% Haptic, 3.30% Audio & Visual, 5.30% Audio & Haptic
  - US: 7.50% Audio, 3% Visual, 30% Haptic, 6% Audio & Visual, 3% Audio & Haptic

Legend:
- **Audio**
- **Visual**
- **Haptic**
- **Audio & Visual**
- **Audio & Haptic**
- **Visual & Haptic**
Providing protection to passengers in a collision, and the enhancement of braking, are the attributes most expected to be standard. Vehicles with these features will be considered for purchase.

On average, speed correction, keeping distance, and summoning for emergency assistance (SOS) after a collision, are the attributes most considered for purchase as an option, and least expected to be standard.

* These are based on the mean scores of the importance ratings for each attribute.
Only 28 percent of the respondents have heard of Euro NCAP, with the highest in France (36 percent) and lowest in Italy (22 percent)

- The A&B segment in Italy registered the lowest level of awareness in Europe, with 16 percent and the highest awareness was within the D&E segment (43 percent) in France.
- Half of the respondents who know of Euro NCAP want more than the rating to assess the safety of vehicles, with the highest being in Spain, and the lowest in the UK.
- 21% of all respondents say a good Euro NCAP will make them more likely to purchase the vehicle. However, this increases to significantly in the case of respondents already aware of Euro NCAP.
- Hence, while Euro NCAP is effective, measures need to be put in place to increase consumer awareness of its purpose and benefits.

Source: Information from Consumer research study done with 1,635 respondents
Influence of Euro NCAP Awareness in Vehicle Purchasing Decision

Respondents who were aware of Euro NCAP were more likely to be influenced by a good Euro NCAP rating.

45.8% of respondents who were aware of Euro NCAP were likely to purchase a vehicle with a good NCAP rating, while 35.8% of respondents who were not aware of NCAP were not likely to be influenced by a good NCAP rating. Awareness of Euro NCAP is a major and significant factor on the influence of a good Euro NCAP rating in the purchase decision (Chi-Square= 279.0, at p=0.0000)

Source : Information from Consumer research study done with 1,635 respondents
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Conclusions
Conclusions in Europe

- Aftermarket suppliers entering the market offering fast introduction of ADAS using dealer fit programmes.
- Expect passive pedestrian safety solutions to be increasingly offered as a differentiator.
- Expect increased focus on Blind spot detection and Lane departure warning technologies rather than Adaptive Cruise Control.
- Passive safety systems – occupant detection / dual airbag systems still a major safety technology and will grow further.
- Expect more affordable driver assistance systems in the Small car segment and increase ADAS offerings in the SUV segment.

Key Conclusions

- According to a Frost & Sullivan consumer research study, around 30% of the respondents in Europe are willing to pay for pedestrian safety systems.
Thank You for your Attention

Questions?