ADAS: A Safe Eye on The Road

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Mobility Innovation Factors

- Cleaner world
- Secure Connectivity
- Safer World
- Mobility for everyone
The Individual Benefit of ADAS

Efficient Transportation
Freight transport, car sharing

Energy Management
Lighter car
Fuel efficiency

Time Management
Available time
Comfort zone

Safety
Reduced risks & impact
The Social Effect of ADAS

Traffic Flow Management
On-demand transportation and higher mobility

Sustainable Mobility
Convenience, cost efficiency

New Car Ownership
Shared cars in vehicle experience

‘Zero Fatalities’ Goal
Safer – dependable – reliable driving experience
Mobility: Independence, Freedom and Fun

From independent drivers to autonomous cars
Evolution of Advanced Driver Assistance Systems

Collision Mitigation
- Passive Systems

Collision Avoidance
- Reactive Systems

Collision Prediction
- Predictive and Warning

Semi-Autonomous
- Predictive Actuators
**ADAS Market Trends**

<table>
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<tr>
<th>Comfort while Driving</th>
<th>Safe Driving</th>
<th>Self Driving</th>
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<td><strong>Keeping the Car on the Road</strong></td>
<td><strong>360° Surround</strong></td>
<td><strong>Managing Co-driving</strong></td>
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<tr>
<td>• Camera and radar</td>
<td>• Rear/side camera, sat. radar, ultrasonic, lidar</td>
<td>• Large data-object handling</td>
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<td>• Cognition algorithms to extract features / classify objects</td>
<td>• 3D image techniques and data fusion</td>
<td>• 3D environmental modeling allowing self-navigation</td>
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<td>• No display necessary</td>
<td>• 2.5D and 3D with high quality</td>
<td>• Ego motion</td>
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<td>• Functional safety applied to longitudinal motion</td>
<td>• Greater safety as lateral movements are controlled</td>
<td>• Greatest safety – longitudinal and lateral motion prediction</td>
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<td><img src="image1.png" alt="Comfort while Driving" /></td>
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A Simplified Taxonomy for ADAS

Today

- Sensor
- Driver active
- Fail safe

Assist

- ACC
- LDW
- BSD
- Headlight
- TSR

Automate

- Sensor fusion & maps
- Co-pilot
- Dependable & reliable

By 2020

- Park assist
- EBA
- Highway platoons
- ACC with steer

By 2030

- Sensors, maps & V2X
- Driverless
- Fail operational

Autonomous

- Commercial autonomous vehicles (drones-big vehicle)
- Driverless public transport
- ACC with steer
Areas for Investigation

• **Hand-over** – How car gives back control and user accepts this while driving
  - A safety concern
  - A liability concern (driver responsibility)

• **Acceptance** – How user accepts an intelligent but not yet fully independent vehicle
  - Safety, enjoyment and trust

• **Personalization** – Car adapts actively to driver
  - Security of data
  - Privacy and ownership of acquired data
Technical and Development Challenges

• **Risk-assessment software**
  - Complex, innovative and critical
  - Flexible approach for new software models

• **Integration of multiple independent systems**
  - Fusion needs large, coherent data
  - Computational performance and large bandwidth

• **Validation and verification: Gebrauchssichereit**
  - Anticipating big data approach
  - Protection of ownership for acquired data
Asking Different Questions

OEMs are not yet offering a consistent bundle of intelligent assistance systems

- How will they agree vs. compete?
- How will they manage the app data acquired?

Strong bond between driver and car

- How will driver privacy be protected as the car assimilates the driver’s nature as it collects data?
- Will OEMs allow transportability of data from one vehicle to a competitor model?

The future brings a multi-media and multi-tasking "potentially distracted" driver

- How will the OEM cope with a new driver model?

A new driver:
Always connected or always distracted?
Acknowledge the Boundaries

Semi-Autonomous Driving means

- **Safety and Reliability**
  - No false detection
  - “Always” available
  - Rigorous safety development

- **Responsibility and Liability**
  - Driver is always responsible (Vienna Convention). Still true?
  - Demonstrate “best effort” and “state of art”
  - Protect against malicious attack
Automated Vehicle Model

Driver Fatigue
- Drowsiness camera
- Steering trend

Driver Fatigue

Driving Style
- RPM, gas pedal monitoring, etc.

Driver Attention
- Eye FoV camera
- TSR, LDW, etc.

360° & Driver Model

3D Context
- Surround See and Sense

Steer & Brake

Auto Navigation & Risk assessor

Vehicle Motion

HMI
Automated Vehicle: Disciplines Links & Relations

Automated Vehicles

- Open Platforms
- Dependable Safety
- Cooperative systems
- Big Data
- Vehicle Networking
- Security

Internet of Things

Cloud Computing

Big Data

Vehicle Networking
Multi-Dimensional Challenges

Multiple Disciplines
(Graphic, Video, Audio, Compute, Security, Safety, Biometrics)

Heterogeneous Task Specific Components
(HW, FW, SW)

Open & Interoperable Standards
(Protocols, Language, I/F)
Self-Driving Platform – Open and Flexible

Sensor Fusion Platform

- Sensor Raw Data Distribution & Handling
- Feature Detection & Taxonomy
- Data Fusion & Risk Assessment
- HMI Self-Action
- Tracking 3D Model

App Spec Computing (ICP, CV, Radar, GPS)

“Image” Signal Processing

Graphic Processing Unit

Digital Signal Processing

Computing Processing Unit

“Image” Signal Processing

Graphic Processing Unit

Digital Signal Processing
Leveraging an Open Standards Framework

Develop Ecosystem

Strong Data Network

Scalable Integration

Open Software Model

Ecosystem to deliver a safe, secure and open architecture supported by standards

OpenVX

OpenCV

OpenCL

OpenGL/ES

ISO 26262

Open Alliance

AUTOSAR
Freescale Automotive ADAS Innovation

Robust –
Safe, secure, dependable.
Combination of hardware features and intelligent software to provide high ASIL performance.

Efficient –
Highly abstracted, programmable intelligent accelerators
Multicore architecture providing optimal MIPS / mW

Open – Tools, drivers and middleware that enables a fast, safe and efficient software development path
The Road Ahead: Possible, Probable & Plausible

Safety, Security, Data Transportability

Safety with security ⇒
Multiple simpler units within one package
Protected fabrics
Easier configurability and data transport

Technology Trends

Beyond tradition ⇒ Hybrid technology, packaging
Be first in adoption. Leverage available technology

Development Models

Big data and open standard ⇒ new model for business
Database, open SW & applications for intelligent systems enabling tiers/OEMs to develop in faster and more creative ways

Architectural Options

Large clusters and distributed domains
XXL computational performance
Neural networks – flexibility and adaptability
Power at the service of performance

Automotive Networking

Beyond LIN, CAN or FlexRay
⇒ Ethernet as data-robust highway for ADAS and up-scalable data distribution
Digitalize and manage network
ISO26262 Fault Prevention and Control Measures

... implemented as **product features**
against random faults (architecture, function)

- Triple voted flip flops
- ECC on memories
- Radiation ‘hard’ flip flops
- Redundant vias
- Ultra low alpha mould compound to reduce effect of radiation

... to **prevent faults**
(robustness)

- ISO design process
- Proven technology
- Design margin
- Process margin
- Automotive process package

... to **control faults**
(detect and react)

- Independent compute engines – 2 x MP2 cluster
- Independent checker engine – Safe State engine
- EDC on memory and buses
- Logic BIST/memory BIST
- Voltage/temperature monitors

- Wafer level stress testing
- Burn-In
- Iddq testing
- AECQ100 qualification

... during **development** and **production**
against systematic faults (process, procedures)

**ISO26262 can NOT be retro-fitted !!!**
Design Margin

- Silicon designs must be simulated to ensure correct timing (timing closure) at all extremes of silicon process, temperature & voltage (PVT)
- Temperature and voltage are documented in the data sheet (0.9V +/-10%; -40º C to 125º C junction)
- Silicon manufacturing process yields a standard distribution between slow low power transistors & fast leaky transistors

Automotive simulates based on +/-3 sigma silicon process and defines spec limits based on this data. Data sheet is “guaranteed by design”

Consumer simulates based on +/-2.5 sigma silicon process and defines faster spec limit based on characterisation. Data sheet is “tested”
A **Safe** Eye on the Road

You can’t connect the dots looking backwards – S. Jobs
Example: Semi-Autonomous Vehicles and Processor Implications

Of the 1.24 million road deaths in 2013, 50% of road traffic deaths are vulnerable road users:  
(pedestrians, cyclists, motorcyclists)  
Source: WHO 2013.

- Radar-based systems already established for several generations
  - Reliably detect longitudinal moving objects
  - For example: Adaptive cruise control

- However, for laterally moving objects, camera based technology is adopted

**2013 Mercedes S Class stereo camera system**
- Active braking assistant
- Pedestrian collision avoidance up to 50 km/h
- Lane keeping up to 200 km/h
- Autonomous driving at low speed in traffic jam

**Mandate for mass market...**
1. Computational efficiency
2. Robustness
3. Open ecosystem
The Market – Freescale & Analyst view

- Market dominated by front view cameras
- Significant growth in smart peripheral view cameras (27% CAGR) and surround view (15% CAGR)

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<th>Peripheral Sensing</th>
<th>Data Fusion</th>
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<td><strong>Safe Architecture</strong></td>
<td>ASIL B (min) quad cores @ ≥800 MHz</td>
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<td>ASIL D quad cores @ ≥1000 MHz + 2nd SOC</td>
</tr>
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<td><strong>Sensor Proc.</strong></td>
<td>Massively parallel image processor for detection</td>
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<td>N/A</td>
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<td><strong>HMI</strong></td>
<td>2D GFx for debug &amp; HMI</td>
<td>3D GFX for HD display</td>
<td>N/A</td>
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<td><strong>Connectivity</strong></td>
<td>PCIe, MIPI-CSI2</td>
<td>PCIe, ENET, MIPI-CSI2</td>
<td>FD-CAN, FlexRay, ENET</td>
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## Assumed Safety Goals for Target Applications

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<tr>
<th>Application / safety goals</th>
<th>ASIL</th>
<th>Behavior in case of fault</th>
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| Adaptive headlight control | False positive: ASIL B  
False negative: QM | Fail-safe  
(Fail-silent or fail-indicate) |
| **Driver assist functions**  
(lane departure warning, blind spot detection, traffic sign recognition, obstacle/pedestrian detection, collision warning) | False positive: ASIL A  
False negative: ASIL A | |
| Mirror replacement | QM (redundant mirrors) /  
ASIL A (single mirror) | |
| **Emergency brake**  
(obstacle detection and emergency brake request) | False positive: ASIL B / ASIL C  
False negative: QM | |
| **Collision avoidance**  
(obstacle detection and active steering) | False positive: ASIL D  
False negative: QM | |
| Lane keeping | False positive: ASIL C  
False negative: ASIL C | |
| **(Semi-) autonomous driving** | False positive: ASIL D  
False negative: ASIL D  
(graceful degradation: maintain limited operation in case of a fault) | Failure-tolerant system  
(high availability system) |
The Market – Freescale & Analyst view

- Market dominated by front view cameras
- Significant growth in smart peripheral view cameras (27% CAGR) and surround view (15% CAGR)
Freescale Automotive ADAS Innovation

Safe and Secure – Combination of hardware features and intelligent software to provide high ASIL performance. Secure engine to protect boot and communication.

Scalability – Multicore architecture, robust network, combined with highly abstracted, programmable intelligent accelerators to enable all major ADAS application integration.

Software – Tools, drivers and middleware that enables a fast, safe and efficient software develop path.