ADAS to Autonomous Driving: IMG IP

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Automotive industry in transition

An industry facing up to new realities

- New & increasing mobility challenges (pollution, congestion, infrastructure)
- Rise of processing in the car (AI/ADAS/Autonomous)
- Increasing Government Legislation covering emissions, safety standards, fuel consumption
- Need to differentiate through electronics and software features
- Have to meet new safety standards (ISO26262)
- New driving markets, new business models new entrants (Tesla, Faraday, NextEV, Didi, BlaBlaCar, Lyft, Uber, CaaS)

‘There’s likely to be more auto-industry change in the next five years than in the last 50’

GM CEO Mary Barra, World Economic Forum Jan 2015
Automotive Market

A few stats and trends

$350*

Average silicon content/car 2020

~5bn units

Silicon TAM (AP/ECUs) in 2020

Total Five-Year (2015-2020) CAGR 29%
Big Market Influences/Pressures on ADAS

Governments

Car Manufacturer

Liability, litigation, accountability

New Entrants

Consumer Confidence/Trust
Autonomous Driving and ADAS

ADAS is the backbone for Autonomous Driving

- Reduce road deaths/GDP costs WW. 1.2m in 2015
- Increase road utilisation – 2x with 80% Autonomous cars
- Reduce pollution, congestion & parking time
- US/EU/China/Japan already driving legislation to support the ADAS market
- Issues of liability, safety, security will have to be resolved before wide adoption
- Complex vision processing (deep learning/AI) needs increasing rapidly
- Rollout: Platooning -> autotaxi/lift -> Semi -> fully autonomous
The Path to Autonomous Driving

Levels of Autonomy

- **Level 0**: Driver in constant control
- **Level 1**: Driver constantly monitors longitudinal OR lateral assistance
- **Level 2**: Driver constantly monitors longitudinal AND lateral assistance
- **Level 3**: Driver in a position to retake control, isn't required to constantly monitor
- **Level 4**: No driver required in certain scenarios
- **Level 5**: No driver required

Source: ABI Research
Autonomous Driving and ADAS
Leveraging massively parallel GPU for complex computation

- **PowerVR GPU** for infotainment system and cluster rendering
- **PowerVR GPU Compute** for ADAS image/video processing
- **PowerVR Video**: multistandard enc/dec, multi camera input,
- **MIPS CPU** Lockstep/threaded– device failsafe; Device Failure detect for fall-back
- **Ensigma WiFi** for V2I and In car Bluetooth LE
- **PowerVR Vision** Imaging Pipeline
ADAS: Levels of Processing

From Sensor to Actuator

- **Pixel Processing**
  - 100s Millions of pixels per second
  - Similar processing per pixel

- **Object Processing**
  - Thousands of objects per second
  - Similar processing per object

- **Object Recognition**
  - Dozens of objects per second

- **Sensor Fusion**
  - Decision Making
  - Application Control

- **Prop HWA/CNN/VPU**

- **GPU Compute**

- **MIPS**

As complexity increases, specifically designed hardware acceleration allow for best performance and most power efficiency.
ADAS Machine Vision Processor

Leveraging Imagination’s IP

- Processing and IP Unit control
- Vision Processing (GPU Compute / CNN/ VPU)
- DDR Controller
  - DDR4/3/3L
  - LPPR4/3
  - ECC Support
- Cache With ECC
- System control
- High Speed I/O
  - Display Port
  - USB 3.0
  - SATA 3.0
  - PCIe Gen 2.0
  - PS-GTR
- Proprietary IP
- General Connectivity
  - Ethernet
  - CAN, I2C, SPI
  - UART, USB2
  - NAND, SD, eMCC
- Real-Time Processing Unit – 2 x InterAptiv
  - Fast Boot and OS
- Security
  - HW based security
- ISP
  - Camera Processing
- Video
  - Video Processing
- Real-Time Processing Unit – 2 x InterAptiv
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  - Camera Processing
- Video
  - Video Processing
- Proprietary IP
PowerVR GPU Compute for ADAS

Taking the driver error out of the equation

- Leverages massively parallel nature of GPUs
- Much more power efficient than CPU
- Offloads CPU for decision/control
- Leverages IMG Zero Copy Framework to increase performance

Lane departure warning
Traffic sign recognition
Night vision
Intelligent high-beam control
Adaptive cruise control
Headway monitoring and collision avoidance
Surround view / Parking aid
Pedestrian detection

- Sensor acquisition
- Defective pixel correction
- Auto white balance
- Lens shading

PowerVR Video VPU
Encode, Decode

- Headlight detection
- Bilateral control algorithm
- Heuristics
- Object recognition

MIPS CPU
Compute

PowerVR GPU
Graphics and compute

- Fish-eye
- Image segmentation
- HoG calculation
- Kalman smoothing
- Panoramic stitching

- Ransac detection
- Turn analysis
- Spatial post-processing
- Markov random field
- Bilateral filter

- Camera
- Radar
- Infrared / thermal
- Ultrasonic
- ToF / depth

ENSIGMA
Wi-Fi, Bluetooth, sensors connectivity

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GPU Compute – Neural Networks

Demonstration Available – SDK in Development

- Neural Networks for Vision
  - State-of-the-art performance
  - Rapid development cycles (just training)
  - Range of vision tasks
    - Classification, Localisation, …

- PowerVR Focus:
  - In-house R&D and GPU Optimisations
  - Caffe Based offline training (Deep Learning)
  - AlexNet and GoogleNet on PowerVR GPU
  - Demonstration available (see right)
  - SDK in development

- Next: HW Efficiency Improvements (8XTP)
MIPS Multi-Threaded CPU in ADAS

The Auto world is looking for a Mobileye ‘killer’

- Deep Learning on Convolution Neural Networks on Vector Engines (VMP, PMA and MPC)
- Vector engines can be serviced by Threads
- MIPS H/W Multithreading efficient handling and improved Instructions per Clock (IPC) 600% vs non-threaded version.
  - 0.3 IPC (No MT) → 0.9 IPC(MT)
  - 1.8IPC (MT + Multi-Core)

Thus **600%** Increase in Performance using MIPS Multi-thread Multi Core
Threads can execute until there is a cache miss.

Thread 1
- load
- load
- add
- store
- load
- miss
- miss
- miss
- miss

Thread 2
- load
- load
- add
- store

Thread 3
- load
- load
- load
- load
- load
- sub
- store
- store

Common pipeline
- load
- load
- load
- load
- add
- load
- store
- load
- load
- add
- sub
- store
- store

Time
Safety and Security

Must be considered from the ground up in all systems

First Tesla Autopilot Fatality

- White tractor trailer pulling across road
- Overcast conditions
- Driver watching a video on phone
- What did the technology actually detect
- Who is responsible? - Tesla vs Mobileye (Tesla now ‘cleared’ of any error)

Wired Magazine: Jeep Hack

- Initially hacked through the Cars Diagnostic port as part of a WIRED magazine article
- Second trial - remotely hacked from a hotel room
- Showcased vulnerability of wireless connections in the car
Security is fundamental to the new Auto Market

Securing the car and its connections

- Up to 11 different wireless/cellular systems will be used to connect cars internally/externally each of which is open to attack.
- EU backed initiatives - Evita/Preserve – identifying attack use cases
- Few car companies, today, have considered security from the bottom up
- Need to be cognisant of the wider infrastructure it can be connected to. Highway, infrastructure, internet.
  - Ensigma 802.11p, BT LE (Whisper) – V2V/V2I, in car entertainment
  - Flow – updates, car/device management
  - Security - OmniSheild
  - Functional Safety – ASIL B/C/D
- IMG can establish a total root of trust upon which a secure end to end car network can be established.
MIPS - hardware virtualization highlights

Rich set of Trusted Execution Environment features and benefits

- Secure
  - Root is the secure hypervisor/kernel
  - Guest access rights controlled by Root
- Reliable
  - Corrupted/crashed OS1 cannot affect OS2
- Supports up to 31 Guest domains
- Shadow Register Sets can be used for each guest – no context switching overhead
- Interrupts and most exceptions can be dealt with entirely in the Guest
- No modification of Guest OS required
- Same Virtualization scheme is used all MIPS R5 and R6 cores (M-, I-, P-Class)
Automotive Ecosystem
Expanding Network of Leadership Partners

- Partners deliver a range of leadership products and services

- AutoSAR/AGL
- HMI/UX/Navi
- Hypervisors/Secure OS
- Automotive integration services
- Software solutions
- Infotainment/GenIVI
- Safety Stds
- Tools
Connectivity for Automotive

Fully Connected – With Imagination MIPS & Ensigma IP

Addressed with two classes of devices – Explorer (WiFi) and Whisper (BT LE)

Underpinned by OmniShield
Processes to address ISO26262 requirements

QMS Processes & Guidelines
- SW Coding guidelines
- Design Process
- Document Control
- Design guidelines

Safety organisation & Culture
- Safety organisation
- Safety culture
- Safety Training
- 26262
- ISO
- 61508

Standardising project execution
- Consistent process for projects
- Systematic Failure
  - HW/SW design failures
  - Verification failures
- Standard audit reviews
- Verification reviews

-established processes or best practice can significantly reduce systematic failures, increase efficiency & reduce time to market

Design safety methodology & processes
- Consistency in design approach
- Consistency in verification approach
- Consistency in design monitoring
- Safety work products safety analysis
- Formal safety confirmation reviews

Strict design processes with design for safety, traceability of work products and formal safety analysis will address random safety failures

Safety organisation & Culture
- Embedded into QMS processes
- Work product traceability
- Engineering competence
- Accountability for safety activity
- Safety work product Auditing
- Control & quality measures

Safety processes, guidelines & training will establish safety organisation, safety competence & culture
Imagination Innovating in Automotive
Creating Technology that matters for Vehicles

Dashboard

Autonomous Driving

DAB Radio

MCU in Car Body

Connectivity

PowerVR

RENESAS

MIPS

MIPS

MIPS

Ensigna

Mobileye

STI

MIPS

Valens

First in HDBaseT
Conclusions

*Imagination’s Automotive Advantage*

- Able to deliver **high value multimedia solutions** dedicated to safety, ADAS, security and infotainment
- IMG has a long history working with **world leading partners** throughout automotive ecosystem
- IMG IP **already deployed with leading car manufacturers** in most areas of the car
- Best placed of all IP vendors to deliver **total car/infrastructure solutions** incorporating both safety and security
Imagination: A global technology leader

A technology powerhouse for multimedia, processors, and communications IP

Developing innovative IP

- Recognised leader in graphics, GPU compute and video IP
- Established mainstream MIPS CPU processor IP
- Leader in communications IP market

A World Leader

- More than 10bn units shipped to date, over 3m per day
- FY16: £120m (US$ 158m)
- 1,400 people world-wide, >80% of staff are engineers
- 20+ offices; HQ in UK

Focus

- Accelerating investment in PowerVR, MIPS and Ensigma BU’s
- Divestment of Pure
- IMGWorks acquisition by a strategic partner
Thank You
**MIPS SAFETY**

**QMS Requirement:**
Quality process and procedure which allow for robust quality management of projects, including:

- QMS compliant processes
- Safety processes & guidelines
  - Configuration Management
  - Change management & control

**ISO26262 Requirements:**

For ASIL A, minimum requirements is evidence of quality process are required and these would be normally done by

For ASIL B to D, Safety compliance and evidence of safety processes and work product will need to be determined based on

- Safety Methodology
- Safety analysis

**Requirement for compliance**

- Evidence of safety cases
- Traceability of work products
- Technical safety analysis for random failures
- Safety process compliance audit

### MIPS Core & Automotive safety critical applications

<table>
<thead>
<tr>
<th>ASIL D</th>
<th>System</th>
<th>ISO26262 ASIL Levels</th>
<th>ASIL C</th>
<th>ASIL B</th>
<th>ASIL A</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Autonomous Systems</td>
<td>Engine Management</td>
<td>Body (Switch/Sensors)</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Airbag</td>
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<td></td>
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<td>EPS Power Steering</td>
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<td>Gearbox Transmission</td>
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<td>ABS / Brake by Wire</td>
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<td>Traction &amp; Stability</td>
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<td></td>
<td>Body Central Gateway</td>
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<td>Surround View Camera</td>
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<td>ADAS Sensors (Radar, Lidar, Camera)</td>
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ADAS Systems (Radar, Lidar, Camera)

Airbag

ADAS Systems

Engine Management

Gearbox Transmission

Traction & Stability

Surround View Camera

Body Central Gateway

Body (Switch/Sensors)