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

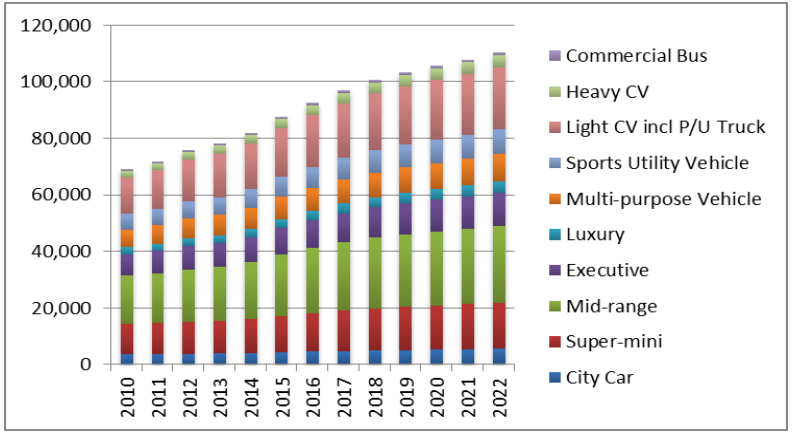
A few stats and trends

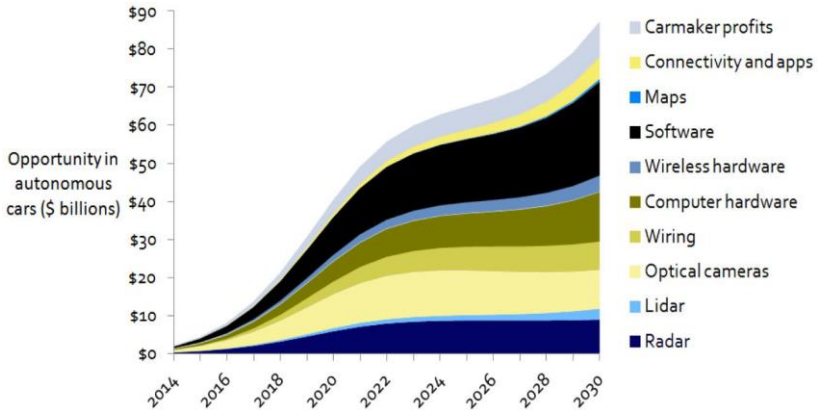
$350*

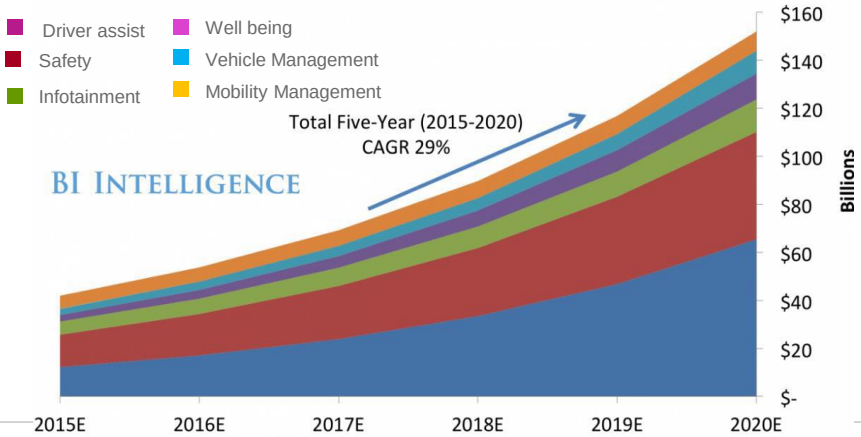
Average silicon content/car 2020

~5bn units

Silicon TAM (AP/ECUs) in 2020







Big Market Influences/Pressures on ADAS

Governments

Consumer Confidence/ Trust

Car Manufacturer

Liability, litigation, accountability

New Entrants

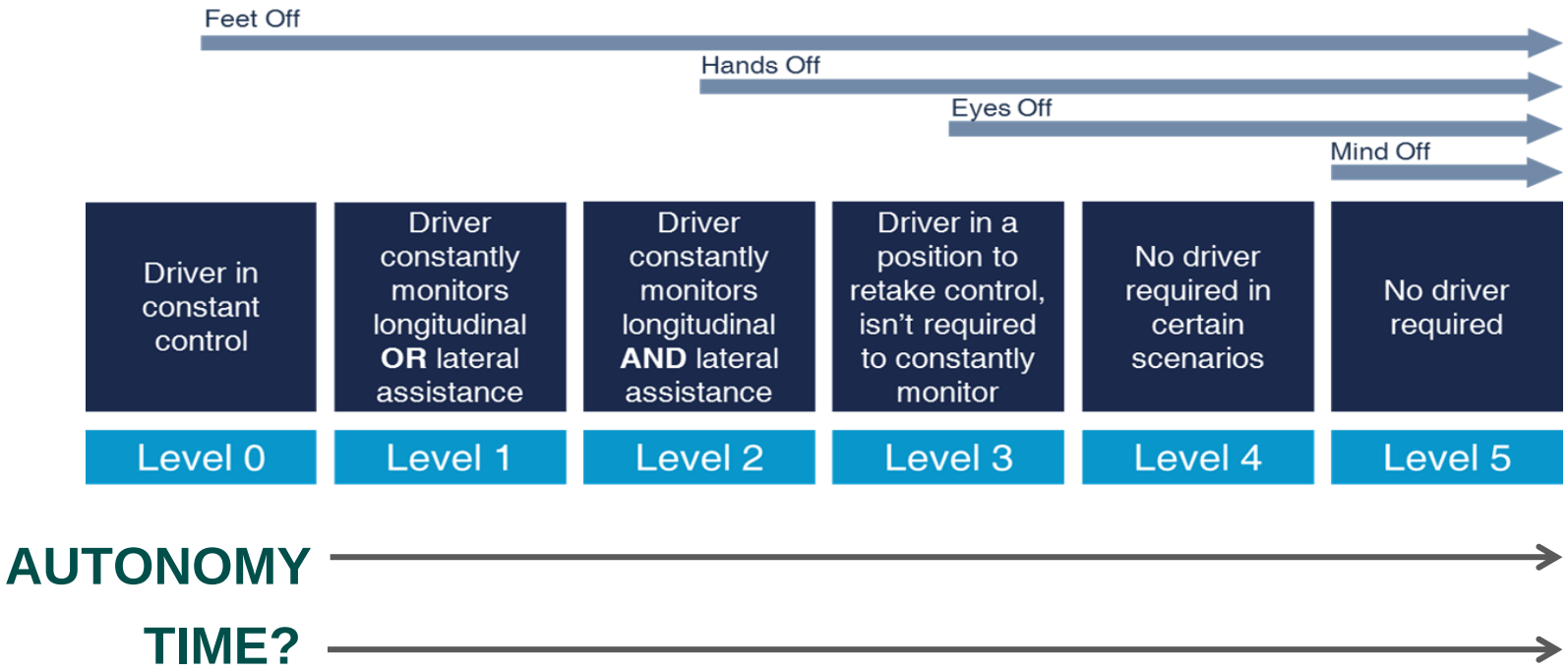
Autonomous Driving and ADAS

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

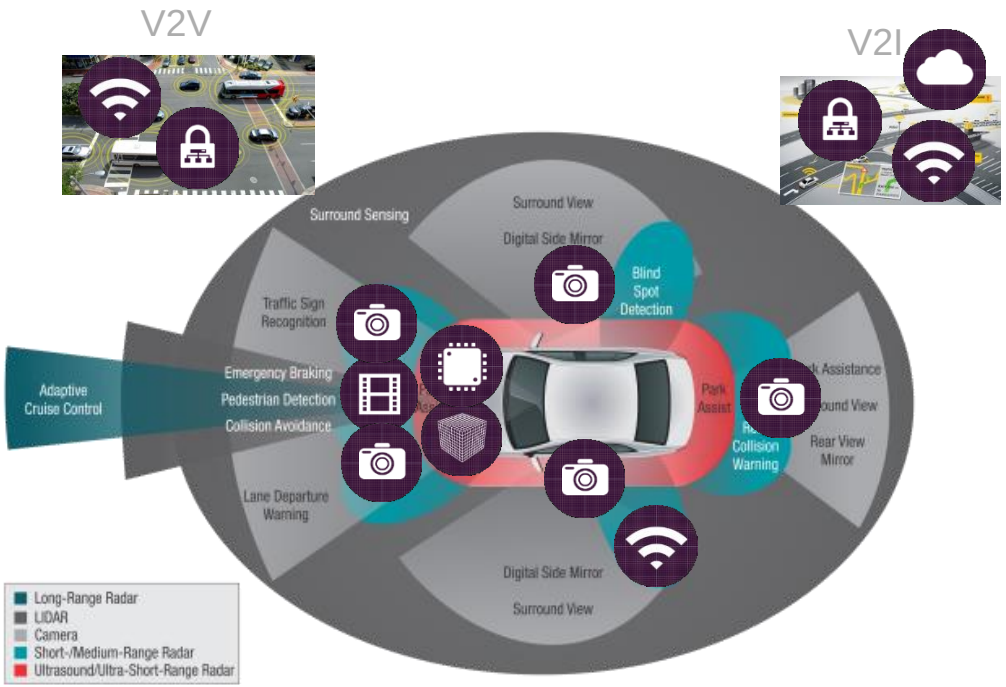
Levels of Autonomy



Source: ABI Research

Autonomous Driving and ADAS

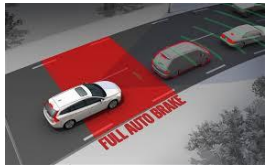
Leveraging massively parallel GPU for complex computation



- **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



Sensor Data → Low Level Processing → Intermediate Level Processing → High Level Processing → Control Logic → Action → Visual / 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

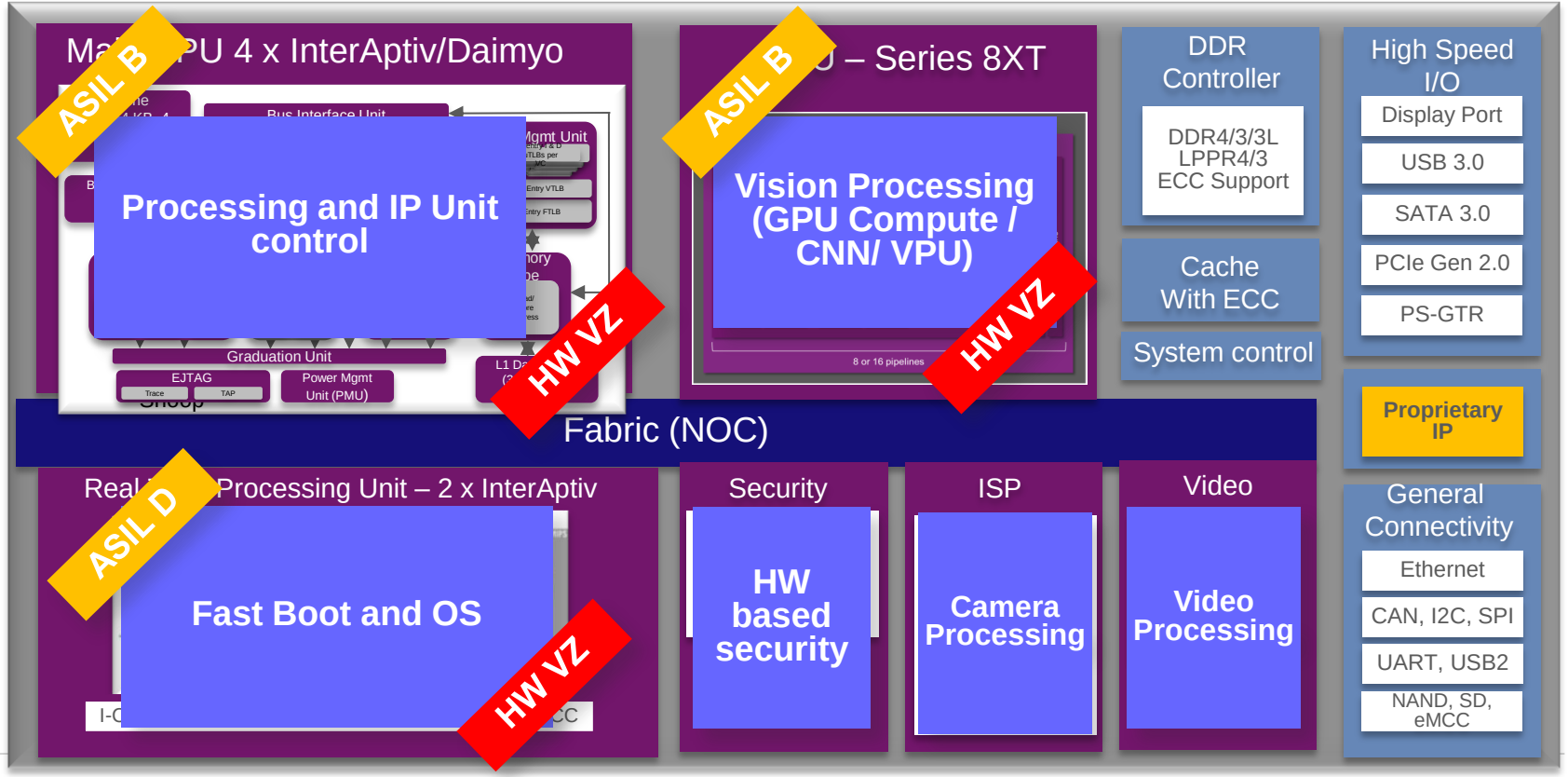
MIPS

ADAS to Fully autonomous : 10/100x processing power required

As complexity increases, specifically designed hardware acceleration allow for best performance and most power efficiency

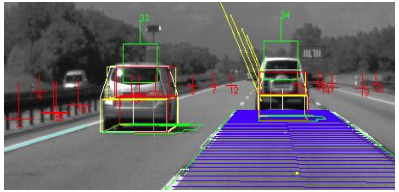
ADAS Machine Vision Processor

Leveraging Imagination's IP



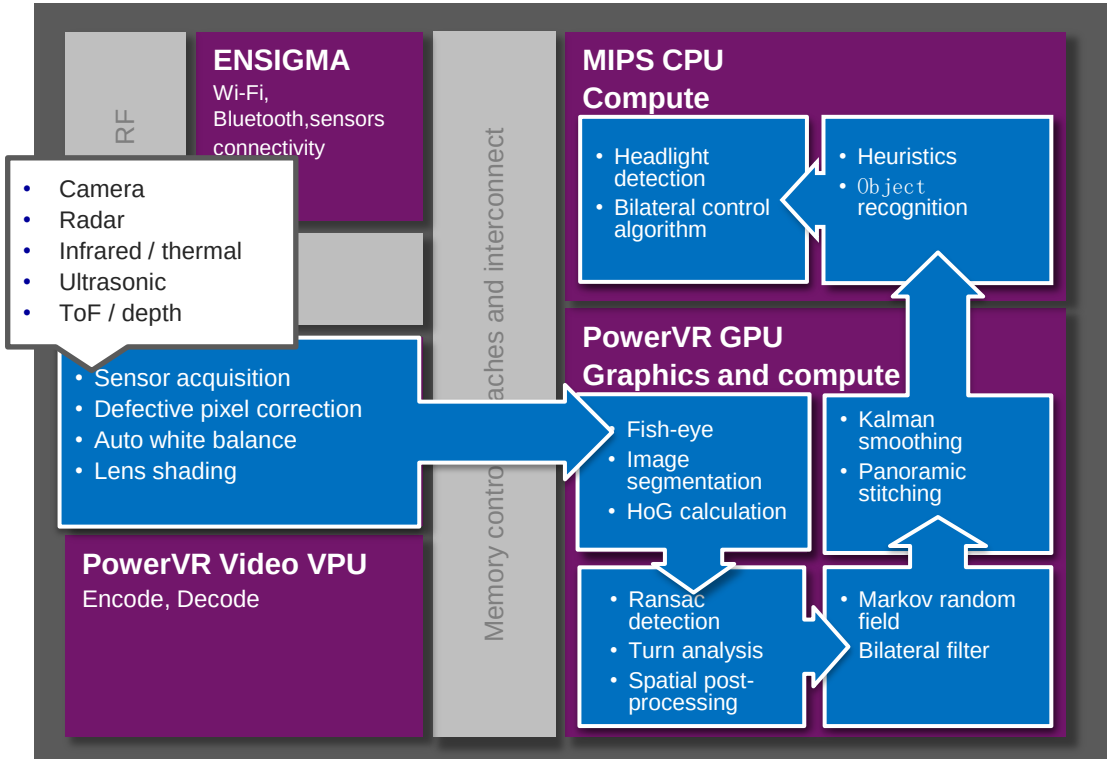
PowerVR GPU Compute for ADAS

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



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)**

CNN Object Detection/Recognition Demo
1000 different object classes
AlexNet Based Implementation
8 FPS on PowerVR G6430 at 533MHz(*)

(*) Subject to additional optimisations e.g. FFT

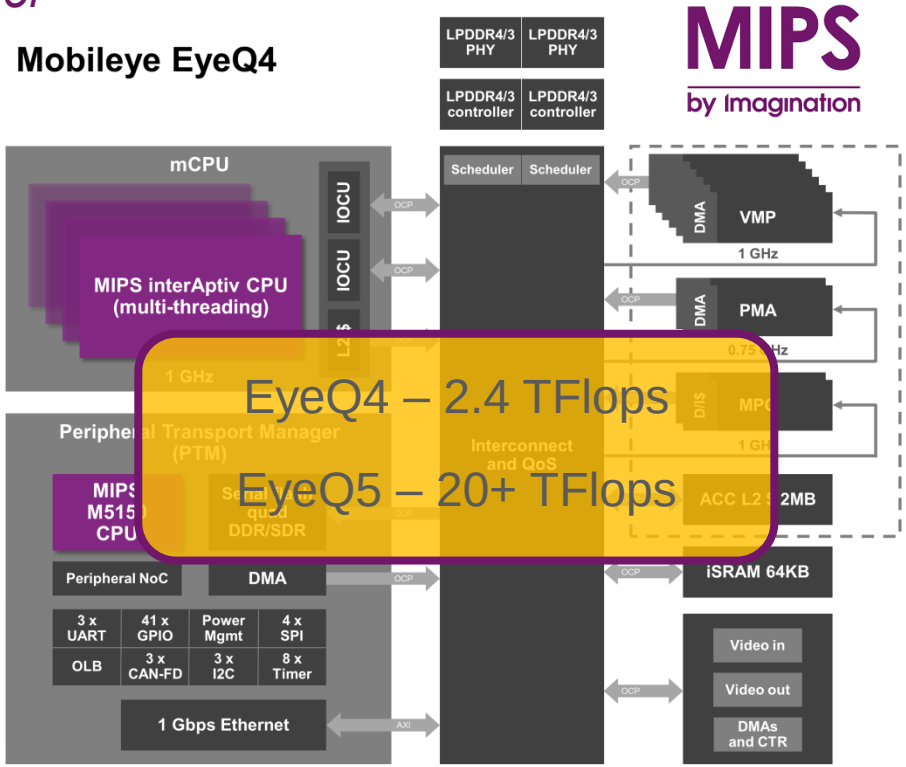
MIPS Multi-Threaded CPU in ADAS

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

Mobileye EyeQ4



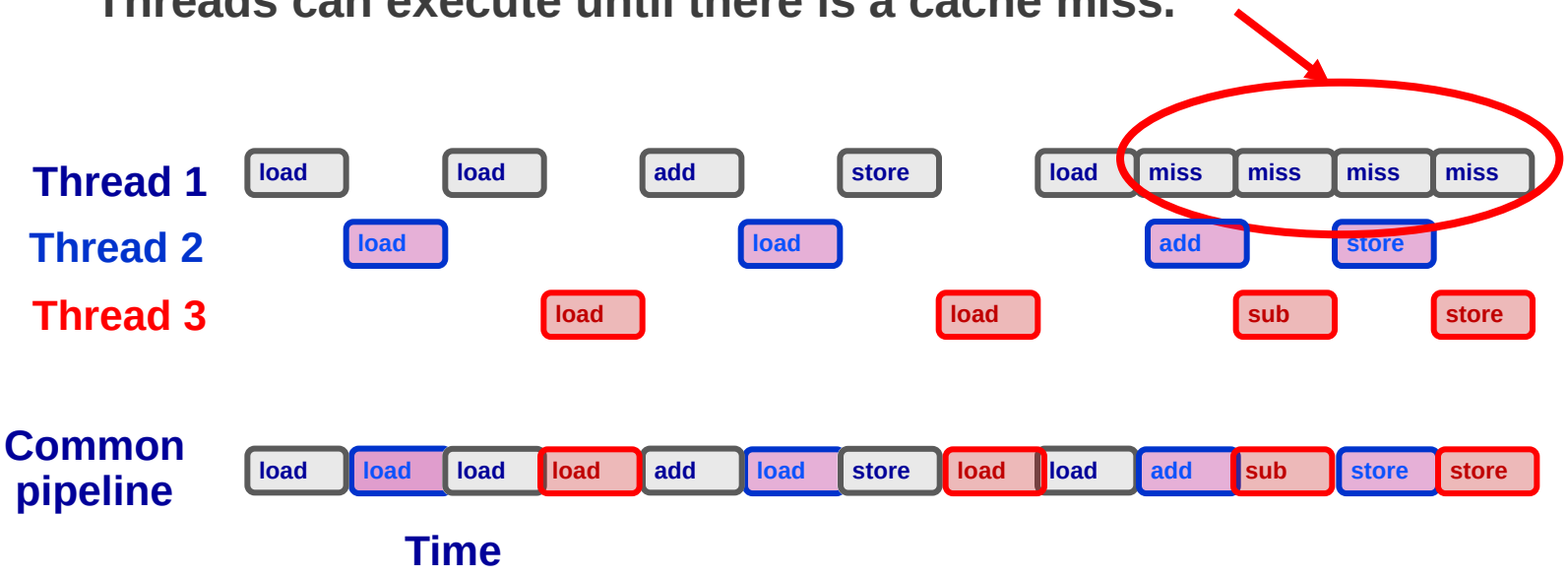
EyeQ4 – 2.4 TFlops

EyeQ5 – 20+ TFlops

Fine Grain MT on MIPS core

Maximizing execution pipeline utilization

Threads can execute until there is a cache miss.



Safety and Security

Must be considered from the ground up in all systems

First Tesla <u>Autopilot</u> 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

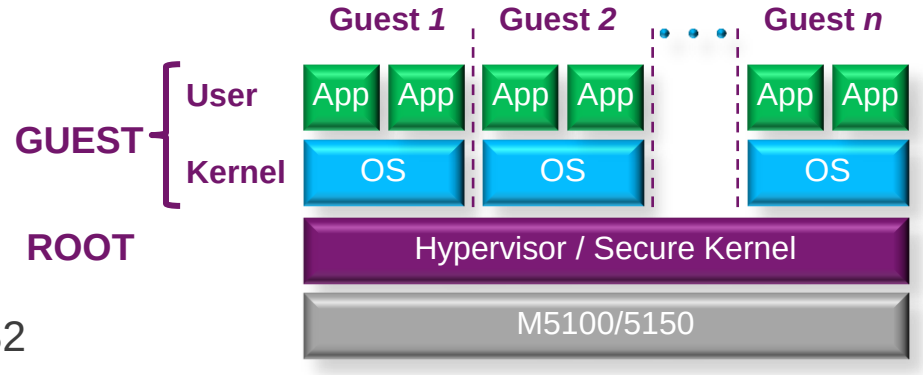
Security is fundamental to the new Auto Market

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

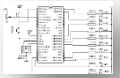
Underpinned by OmniShield

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

MIPS in LTE/5G Modem

Processes to address ISO26262 requirements

QMS Processes & Guidelines



Design Process

Document Control

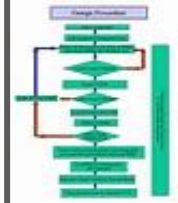
MISRA

SW Coding guidelines

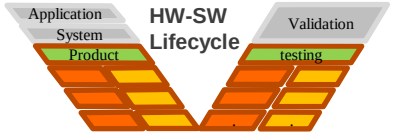
C++

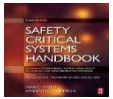
Design guidelines

Design procedure & safety lifecycle



Design & Verification Procedures





Safety Analysis

Design Traceability

Safety Lifecycle

Safety Processes & Guidelines

Safety Process

ISO 26262

IEC 61508

Safety guidelines

Safety Organisation

Safety Training

Safety culture

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

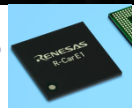
Imagination Innovating in Automotive

Creating Technology that matters for Vehicles

Dashboard

PowerVR

RENESAS



DAB Radio

Ensigma

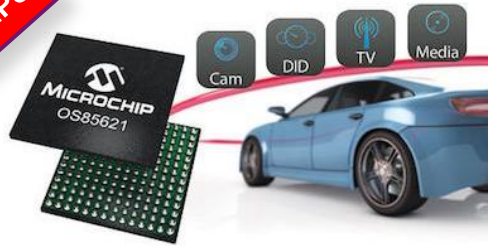
Autonomous Driving

MIPS

MOBILEYE®

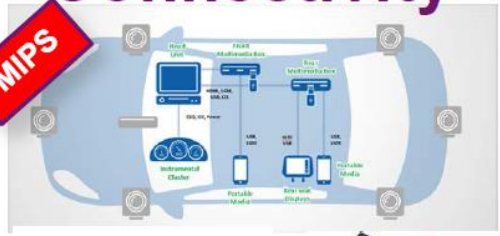
MCU in Car Body

MIPS



Connectivity

MIPS

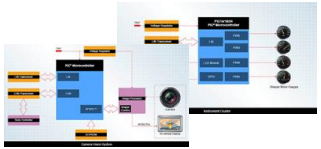


Valens
First in HDBaseT

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

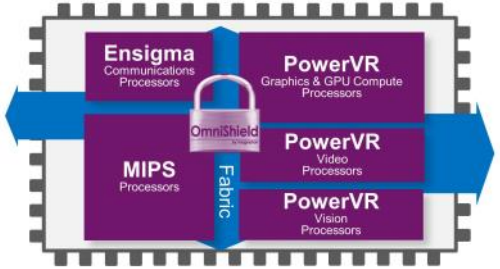
A technology powerhouse for multimedia, processors, and communications IP

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

Imagination

Thank You

www.imgtec.com

MIPS Core & Automotive safety critical applications

System ISO26262 ASIL Levels

ASIL D	ASIL C	ASIL B	ASIL A
Autonomous Systems		Body (Switch/ Sensors)	
	Engine Management		
Airbag			
ADAS Systems			Infotainment & Head Unit
EPS Power Steering		Gearbox Transmission	
	Traction & Stability		
ABS / Brake by Wire			
		Surround View Camera	
	Body Central Gateway		
	ADAS Sensors (Radar, Lidar, Camera)		

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