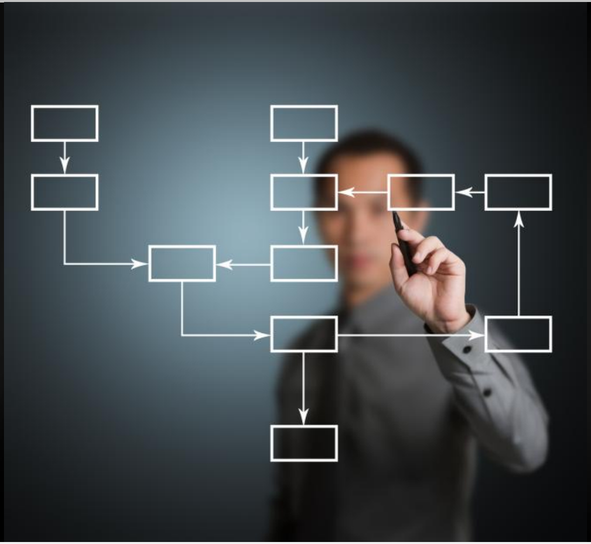
Autonomous Driving:
And the Impact of People, Process & Technology

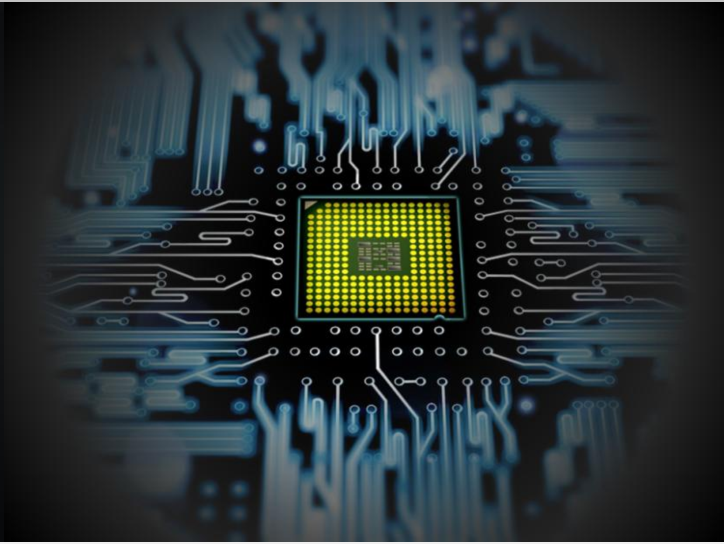
WIND

Marques McCammon
Automotive Solutions

July 16, 2015

Roadmap to Autonomy





For more than 30 years, when industry sets out to build something that **must work**, they've turned to Wind River

Pedigree

Spirit/Opportunity, 2004

Curiosity, 2012

Sojourner, 1997

Wind River has been a part of <u>every</u> Mars Lander since 1997


caps lock
change
alt

Mars Teams

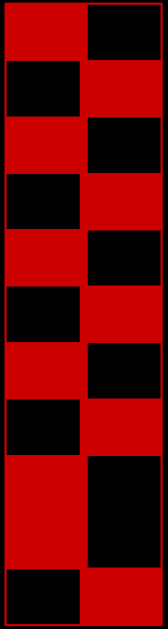
NASA / JPL

+ Academia

+ Industry (component)

+ Silicon Valley

JPL



Disaggregate supply chain

Shift to systems integration

Inter-corporate Design and Release

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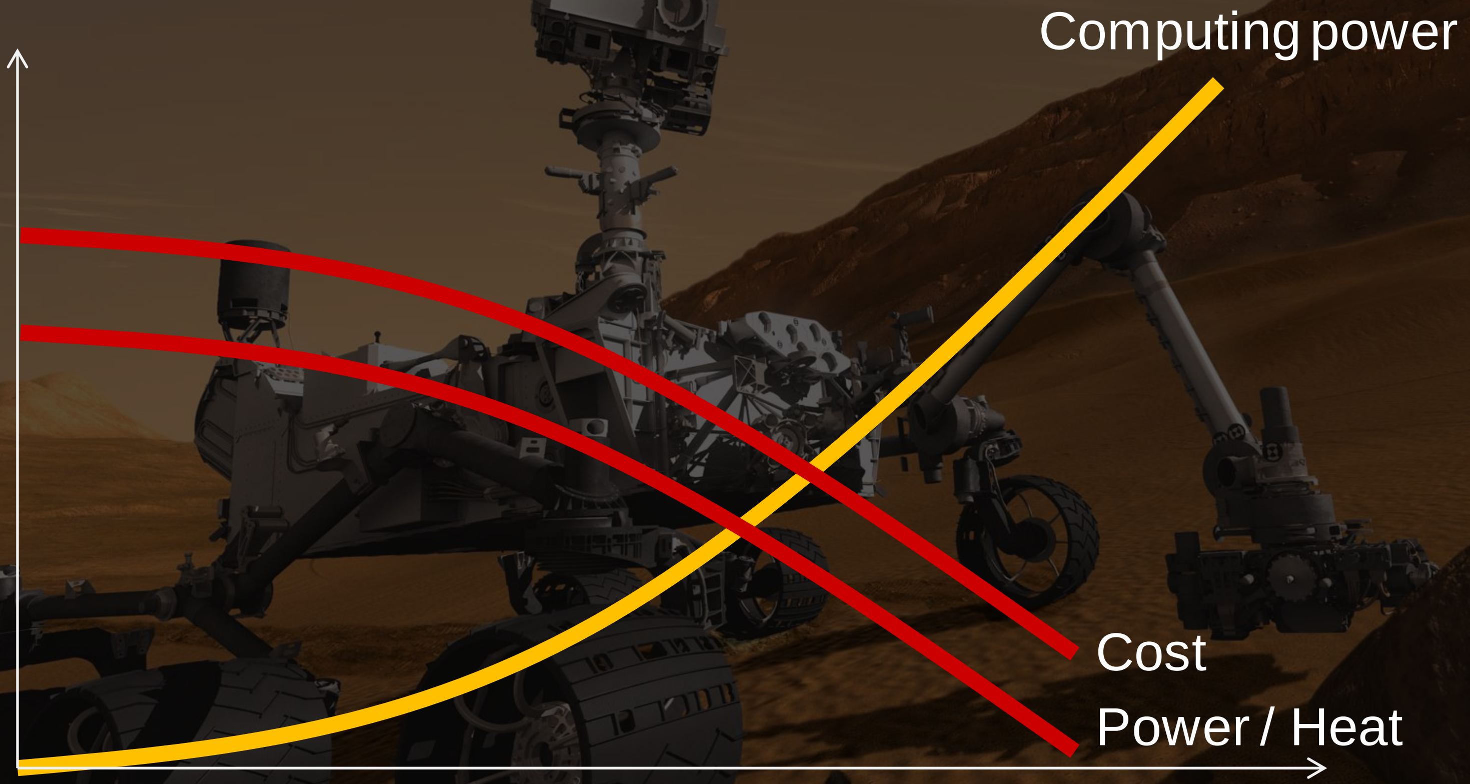
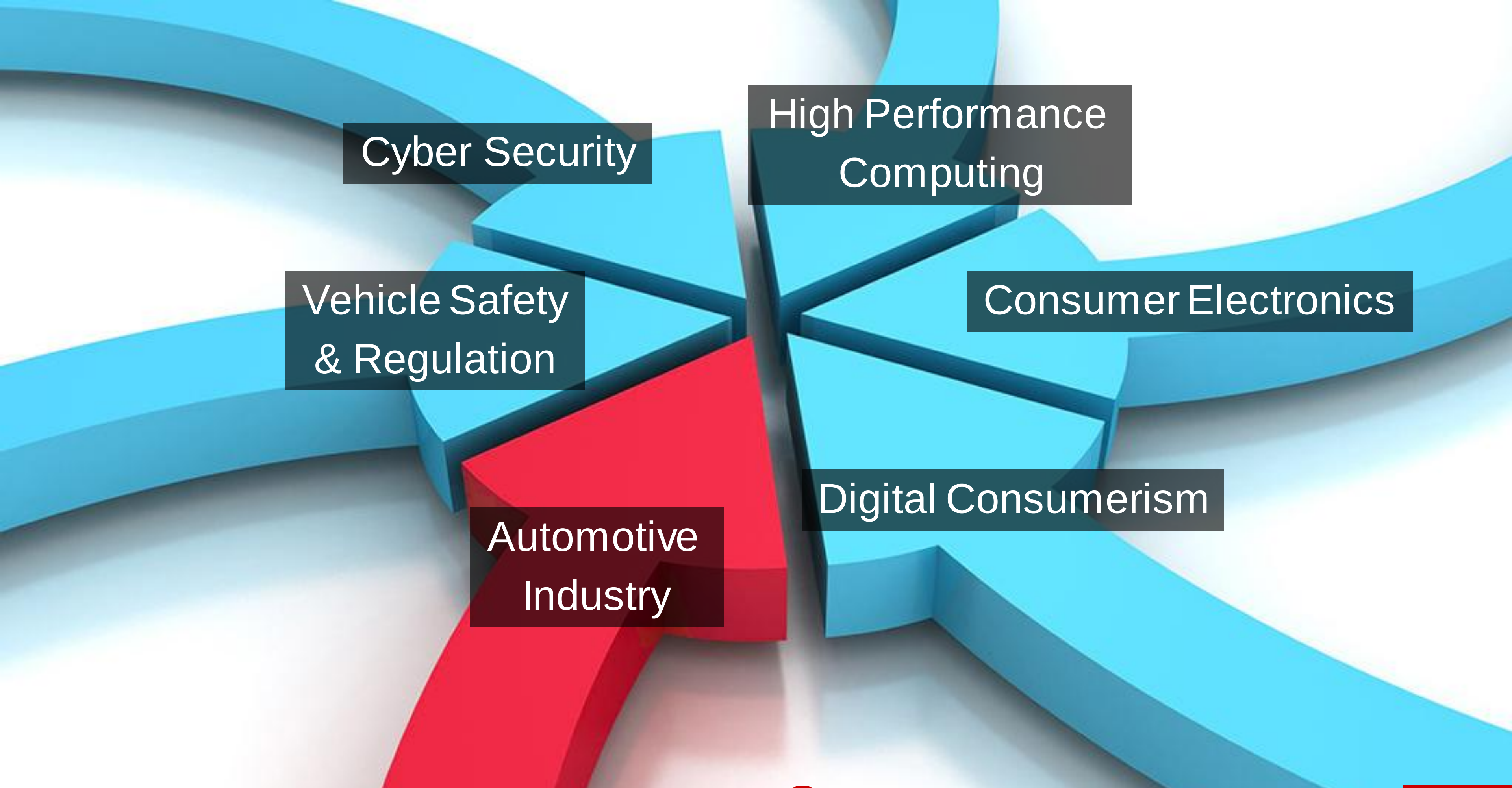
Technology - Moore’s Law

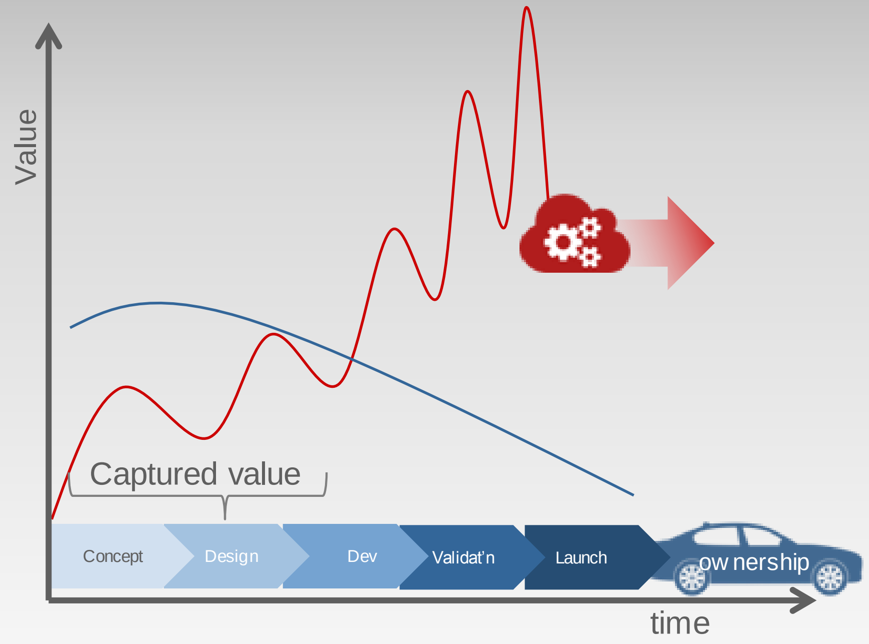



Cyber Security
High Performance Computing
Vehicle Safety & Regulation
Consumer Electronics
Digital Consumerism
Automotive Industry

Key Questions?

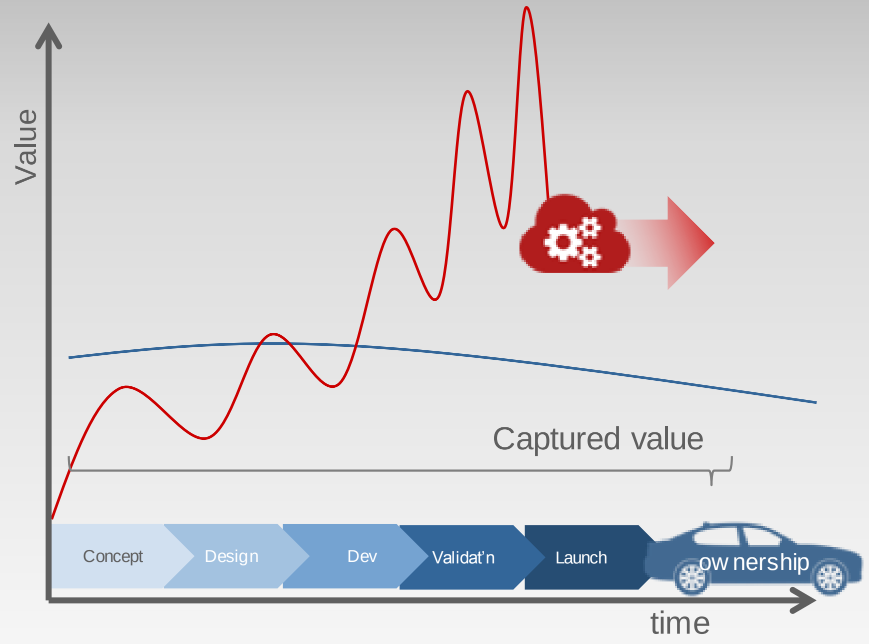
- What is the model for software in the future of Automotive?
- How is the ownership divided?
- Where does the value live?
- Can Automotive move at the pace of innovation?
- How will the fundamental business of Automotive change?
- How do you protect the consumer and enable the consumer at the same time?
- Who accepts the risks?
- How do you make money?

The Goal: Automotive Software Integration at the Speed of Innovation



Automotive development cycles are grossly out paced by the speed of software innovation leaving cars obsolete even before they are shipped

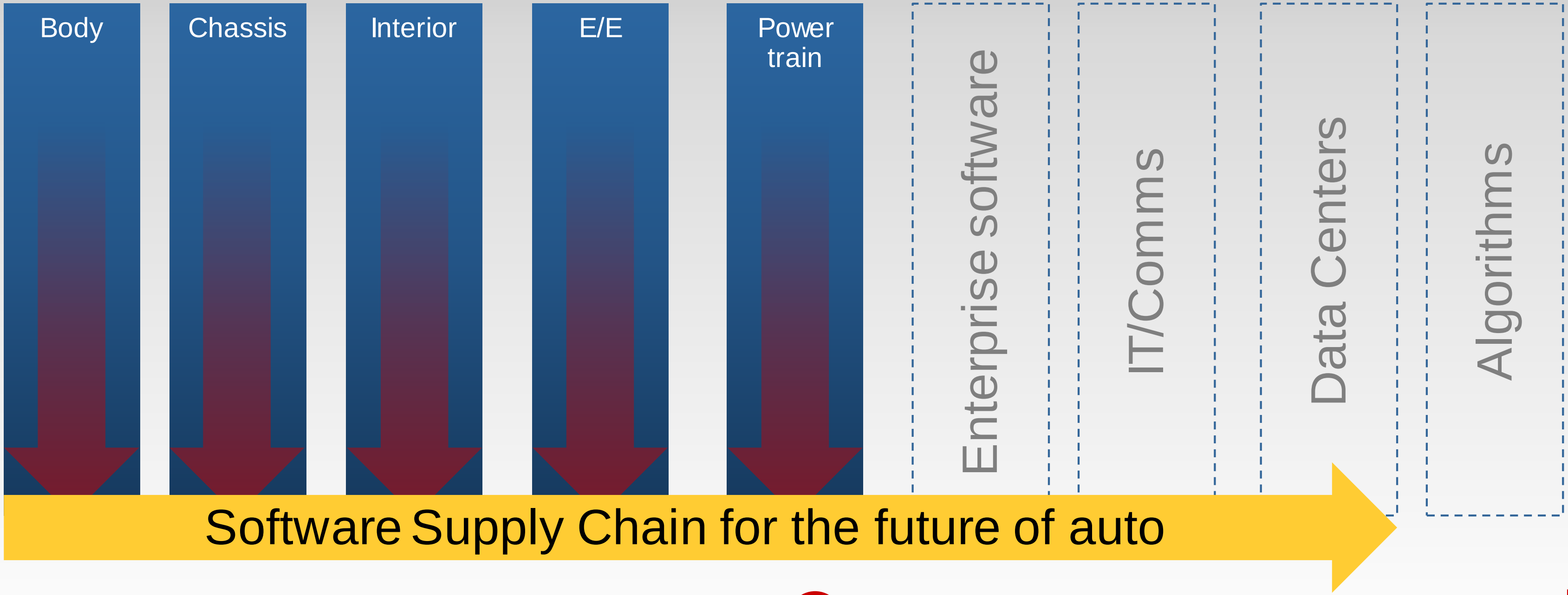
The Goal: Automotive Software Integration at the Speed of Innovation



Automotive needs a mechanism to capture the increasing software value across the vehicle lifecycle without creating risk to the function of the underlying architecture

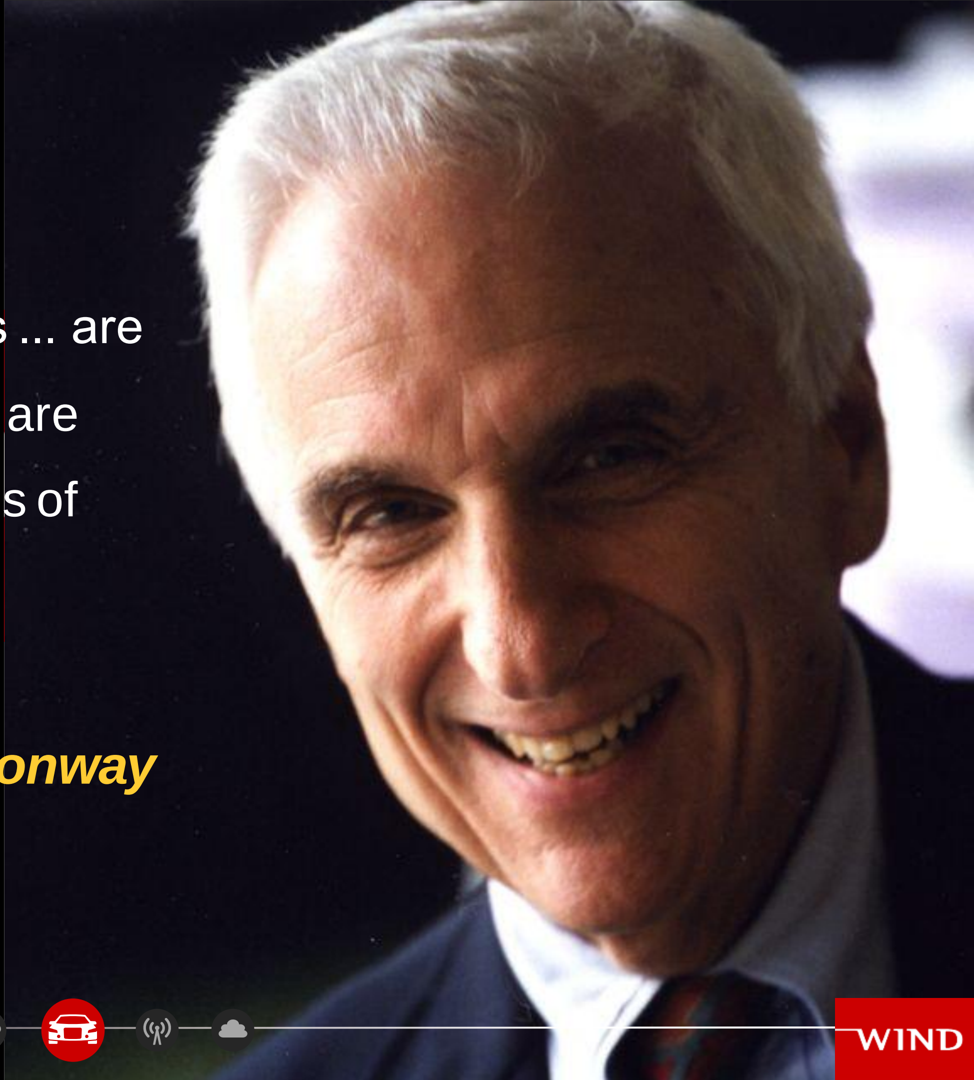
New Supply Models

Conventional Supply Chain Alignment



"…organizations which design systems … are constrained to produce designs which are copies of the communication structures of these organizations"

Melvin Conway



Content x Context = Value

Content:
- Traffic
- Maps
- News
- Media
- Agenda
- Social
- Communication

Context:
- Drive state
- Vehicle position
- User ID
- Geo-location
- Driver Condition
- Weather

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Bottom line:

1. Cost
2. Speed
3. Extensibility
4. Risk Management
5. Innovation

The Era of Autonomous Driving…

and its Implications for Electronics System Designers

Wind River Webinar, July 15, 2015

Michael Hendricks, Automotive & Consumer PLM
Clive Davies, Automotive System Architect

Automotive Electronics

- Electronic proliferation in vehicles creating a boom market for automotive semiconductors
  - **In 2005** electronics comprised **15 percent** total cost of vehicle*
  - In **modern hybrid vehicles** electronics represent **45 percent** of cost*
    - Up to 50 percent of standard vehicles in near future
    - Up to 80 percent of hybrids in near future
- Processing requirements skyrocket
  - Up to 100 electronic control units (ECUs) in today's vehicles
    - Trend toward sensor fusion and ADAS centralized architectures
  - Processor performance in vehicles to **increase 100x by 2024**
- Software complexity
  - Modern premium automobiles now have ~100 million lines of code

Sources: IEEE Spectrum – This Car Runs on Code
ARM Holdings

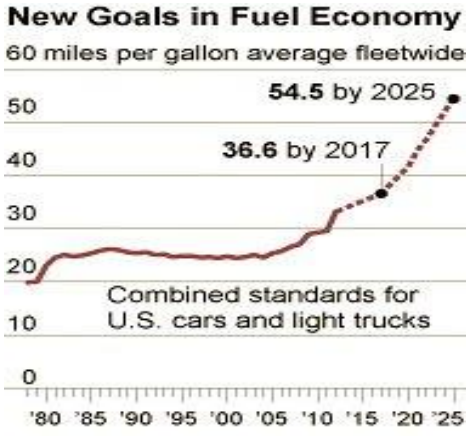
What is Driving Electronics Growth in Automotive?

- Consumer Demand
  - Audi's electronics enabled features responsible for $9,600 increase in average transaction prices for Audi U.S. over last five years
    - **"Our cars are the grandest and most beautiful electronic devices on the planet,"** Prof. Dr. Ulrich Hackenberg, Audi Board Member Tech Development

Audi Digital Instrument Cluster

- Safety
  - 1.2 million road fatalities each year
  - 90% caused by human error

- Efficiency / Environment
  - "A hybrid electric vehicle demands **ten times more semiconductor content** in powertrain"
    - Ahad Buksh, IHS analyst, automotive semiconductors



Source: National Highway Traffic Safety Administration

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Automotive Mega Trends & Key Requirements

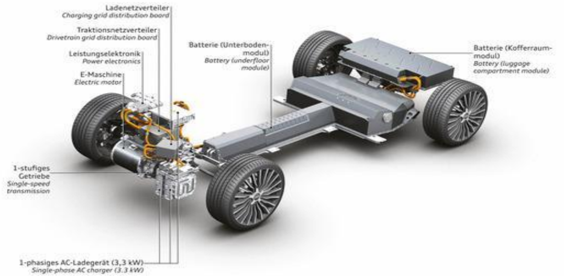
Cockpit Evolution
Cluster, HUD, HMI, CID

- **Why FPGA:**
  - Special feature / function
  - IO expansion
  - Video connectivity

Self-Driving Car
Camera, Radar, Laser

- **Why FPGA:**
  - Evolving algorithms
  - Performance / Watt
  - Differentiation vs. ASSP
  - Scalability

EV / Powertrain
BMS, Motor Control, ECU



- **Why FPGA:**
  - Real-time parallel processing
  - Faster control loops
  - Enables better motors

ISO 26262 Functional Safety

Video & Vision Processing

SW Development Flows

Infotainment & Driver Information | **ADAS** | **EV & Powertrain**

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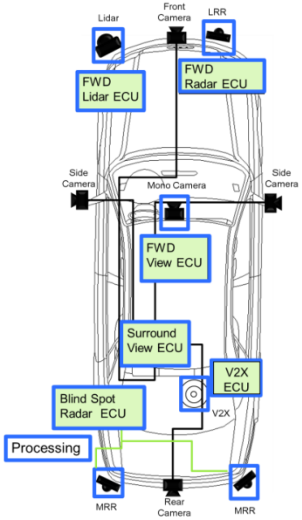
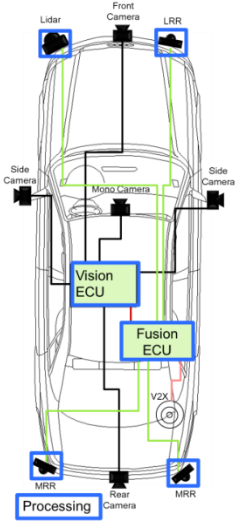
ADAS Architecture Trends – Scalable Platform Required

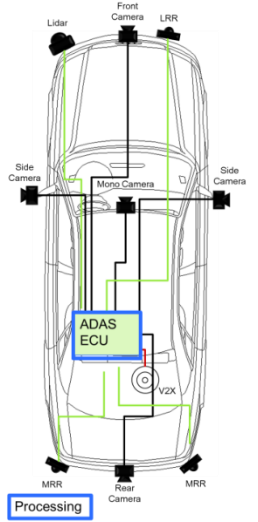
Distributed



Partially Centralized



Centralized



~3K DMIPS/ECU

~10K DMIPS/ECU

~15K+ DMIPS/ECU

ASSP, GPU, CPU

MCU, ASSP

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Scalable FPGA Platform

(Spans all architectures)

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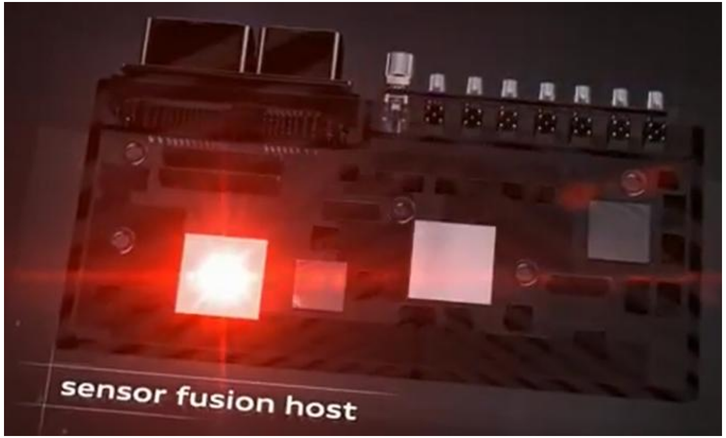
Audi & TTTech Select Cyclone V SoC for Audi zFAS Piloted Driving ADAS

Altera's SoC FPGAs integrate a ***flexible fabric and CPU*** *that enable us to deliver leading-edge* ***communication safety and a vastly accelerated, yet very robust software integration*** *process to Audi on their way towards the vision of piloted driving.* ***FPGAs are well-suited to manage this type of complex computing and networking****. They still remain an* ***affordable and low-power solution.***

—Dr. Stefan Poledna, TTTech co-founder and board member

Audi zFAS Block Diagram



- Why Altera
  - ISO 26262 Support
    - Functional Safety Data Pack
    - ECC on memory
  - Integrated transceivers
    - Communication to GPU
  - Highest logic density Automotive SoC-FPGA

Audi zFAS PCB

Sources: Green Car Congress, Altera, TTTech
Video: Audi - Piloted Driving. zFAS - All functions, one unit

Functional Safety – Priority

- Functional safety is to prevent the risk of injury or death as a result of **random, systematic,** or **common-cause failures** in safety-relevant systems

Functional Safety Data Package (FSDP)

Save ≈18-24 months! TTM

Methodology → Tools → IP → PLDs

SUPPORT RESOURCES

QUALITY

- ISO/TS 16949
- AEC Q100
- ISO 9001

DOCUMENTATION

Functional Safety Data Package (FSDP)

APP Notes, REL Reports

CERTIFICATION

- Devices
- IP (Dia., µC, IP)
- Design Flow
- Tools

STANDARDS

- IEC61508 Industrial
- ISO26262 Auto

TÜVRheinland®
Precisely Right.

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Technological Changes

The Need For Change

- Moving to a smaller process node gets you
  - More performance
  - Better power efficiency
  - Lower cost
- These assumptions are no longer valid!
  - Getting harder and harder to scale down process geometry
  - Costs are rising
- We need to find other ways to improve system performance
  - New ways of thinking
  - Not just "like the last version, but faster"
- Huge increase in processing while maintaining power envelope
  - Microsoft whitepaper shows FPGA significantly more power efficient than GPU for Convolutional Neural Networks (CNNs)

New Ways of Thinking

- Changes for system developers
  - Move to heterogeneous solutions
  - Re-think system partitioning
  - Adopt new platform technologies
- Changes for technology suppliers
  - Think about system programmability
  - Address new classes of developers
  - Develop system programming tools
- Example: Altera's OpenCL compiler
  - Bringing FPGA performance to software engineers

Programming FPGAs : SDK for OpenCL

OpenCL Host Program + OpenCL Kernels

Users write software

Altera OpenCL host library → C compiler

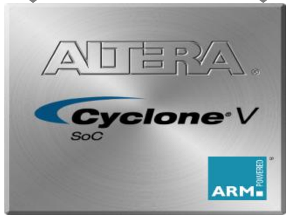
Altera Kernel Compiler

FPGA specific compilation target

VxWorks®

Host Binary

Device Binary



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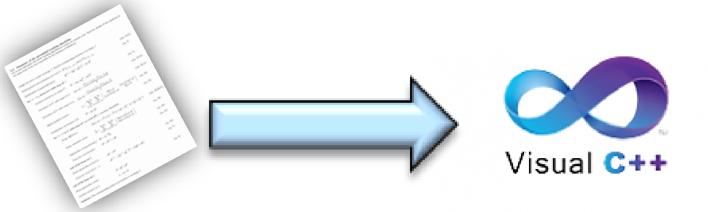
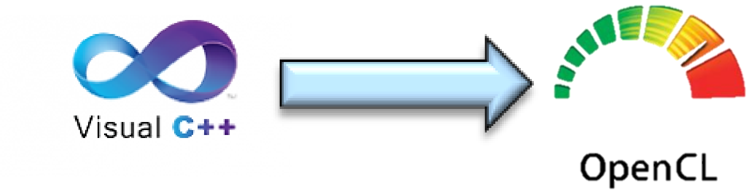
OpenCL Design Approach for Dense Optical Flow

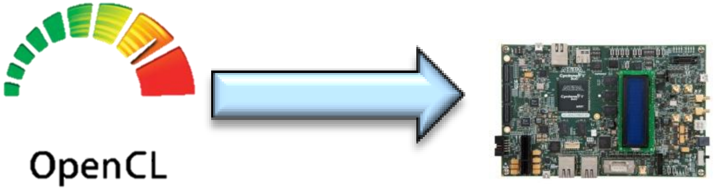
- Step 1: Whitepaper to C implementation
  - Pyramidal Lucas Kanade optical flow
  - Easy to check implementation
  - Prove C implementation



- Step 2: C implementation to OpenCL
  - Optimisation stage
  - Port linear C implementation to parallel OpenCL implementation
  - C model allows checking of OpenCL output



- Step 3: OpenCL to hardware
  - Final stage to target OpenCL to hardware
  - Dealing with board/video startup



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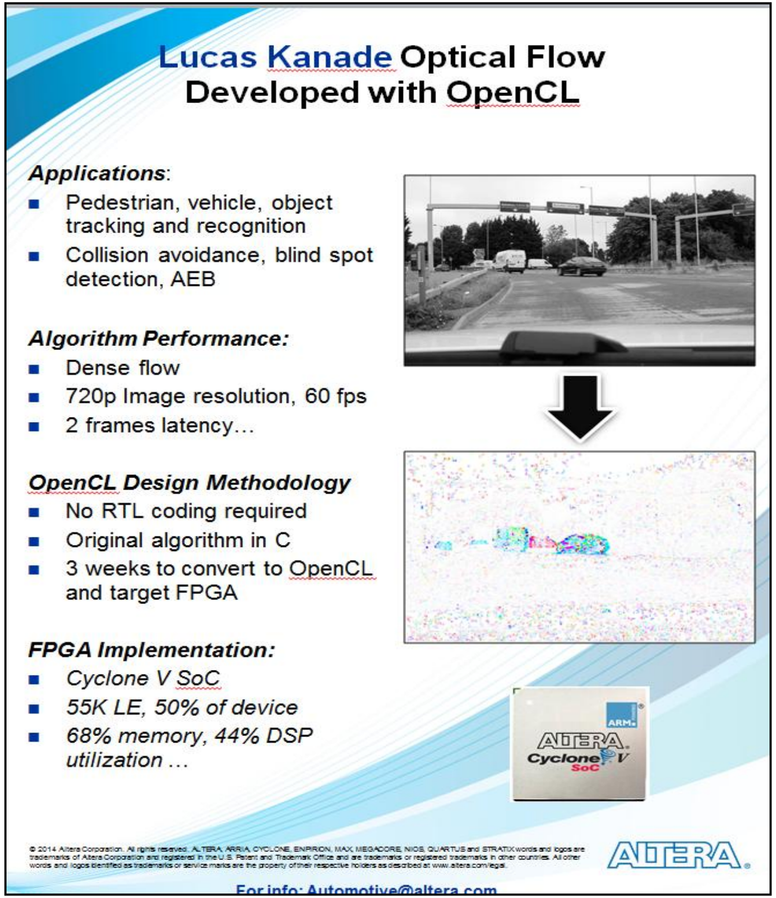
Example Design



Lucas Kanade Optical Flow Developed with OpenCL

Applications:

- Pedestrian, vehicle, object tracking and recognition
- Collision avoidance, blind spot detection, AEB

Algorithm Performance:

- Dense flow
- 720p Image resolution, 60 fps
- 2 frames latency…

OpenCL Design Methodology

- No RTL coding required
- Original algorithm in C
- 3 weeks to convert to OpenCL and target FPGA

FPGA Implementation:

- *Cyclone V SoC*
- *55K LE, 50% of device*
- *68% memory, 44% DSP utilization …*

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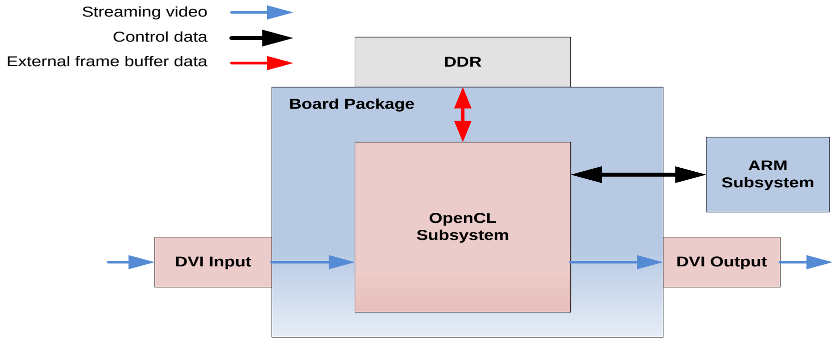
For info: Automotive@altera.com



[Optical Flow Design Example]

Summary

- Rapid increase in electronic content of vehicles
- Processing requirements increasing rapidly
  - Existing architectural approaches can't keep pace
- Design cycles getting shorter and shorter
- Need new ways of thinking to address these issues

Additional resources:

Altera's OpenCL SDK: https://www.altera.com/products/design-software/embedded-software-developers/opencl/overview.html

OpenCL Optical flow example: https://www.altera.com/support/support-resources/design-examples/design-software/opencl/optical-flow.html

Microsoft whitepaper on CNNs in FPGA: http://research.microsoft.com/pubs/240715/CNN%20Whitepaper.pdf

Q & A