Peeking into the Car of the Future

Luis Basto
Sep 25, 2019
Agenda

Cost of Automotive Electronics
Architecting the Car of the Future
Domain Based Architecture
- Connectivity
- ADAS & Highly Automated Driving
- Powertrain & Vehicle Dynamics
- Body & Comfort
- Infotainment & In-Vehicle Experience
Safety & Security
Some terms use in automotive electronics

- CAN bus – Controller Area Network
- DSRC – Dedicated short range communication (802.11p)
- V2X – V2V, V2I, V2X (vehicle-vehicle, infrastructure)
- ADAS – Advanced Driver Assist System
- ASIL – Automotive Safety Integrity Level
- LIDAR – Light Detection and Ranging
- EPS – electronic power steering
- ESP – electronic stability program
- ISO -26262 Functional Safety Standard
Safe and Secure Mobility
More than tripling the semi value per car – today’s standard car at $380
Autonomy

- **Full Automation** ($+700)
- **High Automation** ($+600)
- **Conditional Automation** ($+400)
- **Partial Automation** ($+100)
- **Driver Assistance** ($+50)
- **No Automation**

**Levels**

1. **Level 0-2 Human Driver**
   - Performs part of dynamic driving task
   - Monitors environment

2. **Level 3-5 Automated Driving System**
   - Performs entire dynamic driving task
   - Monitors environment

**Source:** Strategy Analystics; IHS; Evercore; ABI Research; NXP

Semi Content per Car increase (TAM) vs Level 0
Electrification

- **Pure Electric Vehicle**: +$450
- **Range Extended Electric Vehicle**: +$425
- **Plug-in Hybrid**: +$400
- **Full Hybrid**: +$350
- **Mild Hybrid**: +$200
- **Combustion Engine**: E0

Semi Content per Car increase (TAM) vs Level 0
Source: Strategy Analytics; IHS; Evercore; ABI Research; NXP
# Vehicle Electrification: Diversity of Approaches

<table>
<thead>
<tr>
<th>Electrification Levels</th>
<th>E0</th>
<th>E1</th>
<th>E2</th>
<th>E3</th>
<th>E4</th>
<th>E5</th>
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<tbody>
<tr>
<td>Common Name</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Combustion Engine (ICE)</td>
<td>Ford Mustang</td>
<td>Honda Insight</td>
<td>Toyota Prius</td>
<td>FCA Pacifica</td>
<td>BMW i3</td>
<td>Nissan Leaf</td>
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<tr>
<td>Mild Hybrid (M-HV)</td>
<td></td>
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<tr>
<td>Full Hybrid (F-HV)</td>
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<tr>
<td>Plug-in Hybrid (PHEV)</td>
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<td></td>
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<tr>
<td>Range Extended EV</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Pure Electric Vehicle</td>
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<td></td>
</tr>
<tr>
<td>Example</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Battery System</td>
<td>![12V]</td>
<td>![12V,48V]</td>
<td>![LV, HV]</td>
<td>![LV, HV]</td>
<td>![LV, HV]</td>
<td>![LV, HV]</td>
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<tr>
<td>Mains Charging</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>![plug]</td>
<td>![plug]</td>
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<tr>
<td>Electric Traction</td>
<td>-</td>
<td>![10-20kW]</td>
<td>![15-60kW]</td>
<td>![40-80kW]</td>
<td>![40-80kW]</td>
<td>![&gt;80kW]</td>
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## Connectivity

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
<th>Connectivity Features</th>
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<tbody>
<tr>
<td>$100</td>
<td>Fully Connected Car</td>
<td>+ Fully Connected Car, + 4G-LTE Advanced, V2X Security, + 4G-LTE Digital, + WiFi, + Bluetooth</td>
</tr>
<tr>
<td>$80</td>
<td>4G-LTE Advanced, V2X Security</td>
<td>+ Digital Radio, + 4G</td>
</tr>
<tr>
<td>$50</td>
<td>Digital Radio, 4G</td>
<td>+ Connectivity</td>
</tr>
<tr>
<td>$30</td>
<td>Connectivity</td>
<td>+ Analog Radio</td>
</tr>
<tr>
<td>$10</td>
<td>Analog Radio</td>
<td>No Connectivity</td>
</tr>
</tbody>
</table>

*Source: Strategy Analytics; IHS; Evercore; ABI Research; NXP*
Architecting the Car of The Future
Mega Trends Force Vehicle Architecture Transformation

**T O D A Y : F L A T**
- Low bandwidth, flat network
- One MCU per application

**U n f i t t o f u t u r e M o b i l i t y**

**T O M O R R O W : D O M A I N S**
- High bandwidth network
- Gateway key to communication between domains

**S t e p t o A u t o n o m o u s C a r**

**A F T E R T O M O R R O W : Z O N E S**
- Domains virtualized by SW – enabling high flexibility
- Easy enable/disable or update functions

**S t e p t o U s e r - D e f i n e d C a r**

- Wires go virtual

- Flat to hierarchical

- Gateway key to communication between domains
Domain-based Architecture

- Connectivity
- ADAS & Highly Automated Driving
- Powertrain & Vehicle Dynamics
- Body & Comfort
- Infotainment & In-Vehicle Experience

Diagram:
- Connectivity
  - DC
  - Gateway
- Powertrain & Vehicle Dynamics
  - DC
- Infotainment & In-Vehicle Experience
  - DC
Domain Architecture

Connectivity
- V2X
- Cellular
- WiFi, BT, GNSS, NFC
- Smart Car Access
- Radio Reception

ADAS & Highly Automated Driving
- Radar
- Camera
- Lidar

Powertrain & Vehicle Dynamics
- Motion & Pressure
- Speed
- Ultrasonic

Body & Comfort
- Temp, Light, Humidity
- Switch Panels

Infotainment & In-Vehicle Experience
- Touch Displays & Gesture
- Voice Recognition & Audio

Sense

Think
- Connectivity Domain Controller
- Safe Central Compute & Planning Domain Controller
- Powertrain Domain Controller
- Body Domain Controller
- eCockpit Domain Controller

Act
- eCockpit
- Audio & Amplifiers
- HVAC, Interior Lighting
- Doors, seats, steering wheel, mirrors, wipers, sunroof
- Engine Transmission Brake
- Battery Cell Management
- Steering Airbag Suspension
- Vehicle Networks

Domain MPUs
Edge Nodes & Sensors
High Bandwidth
Gateway
Safety & Security
1. Based on analysis of existing NXP Software code in existing customers’ applications
2. Based on publicly available competitor roadmap performance statements versus today’s best safe auto platform
Connectivity
# A Look Inside the Connectivity Domain – All in a single ECU

<table>
<thead>
<tr>
<th>Broadcast Reception</th>
<th>Car Access – Base Station</th>
<th>Security</th>
<th>Consumer Connectivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analog Radio</td>
<td>Long Range</td>
<td>Crypto µC</td>
<td>Bluetooth</td>
</tr>
<tr>
<td>Digital Radio</td>
<td>Passive Keyless Entry</td>
<td></td>
<td>Wifi</td>
</tr>
<tr>
<td>Satellite Radio</td>
<td></td>
<td></td>
<td>GPS / GNSS</td>
</tr>
<tr>
<td>Modem</td>
<td></td>
<td></td>
<td>NFC &amp; WPC</td>
</tr>
<tr>
<td>2G / 3G / 4G / 5G</td>
<td></td>
<td></td>
<td>Connectivity Stack</td>
</tr>
<tr>
<td>V2X / DSRC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IEEE 802.11p</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Secure V2X Sensors

Seeing around Corners

Sees objects up to 1km, around corners
Proven IEEE 802.11p standards
Highest security
Scalable architecture

NXP RoadLINK
In volume production
1st to market with secure 1-chip modem
ADAS & Highly Automated Driving
Radar
Evolves to 360° view with high-performance integration

- **Short range/Medium range RADAR**
  - Park Assist
  - Cross-Traffic Alert
  - Junction Assist

- **Long Range RADAR**
  - Adaptive Cruise Control
  - Automatic Emergency Braking
  - Forward Collision Warning

**Medium Range RADAR**
- Blind Side Detection

**TOMORROW**
**TODAY**

Field tested by Google
Enabling A/D Perception & Sensing Requirements in Radar

Detection & Tracking
Resolve cluttered, hidden objects & track directionality

Classification & Segmentation
Pedestrians, Cars, Trucks, Motorcycles

Mapping
Static and Dynamic Object & Free Space detection (L4 functions)
3D Shapes (images) with classification (Deep Learning)

Localization
Ego motion and pin-point position via map correlation or SLAM

SOP 2021
for L3-4 vehicles
High-performance Vision Sensors

Improve Safety on the Road

Front View  Surround View  Driver Monitor  Perception

NXP S32V
Supports demand for open, safe, scalable solutions, and AI
Vision Today and Tomorrow

Market leading performance

Surround View
VISION
3D Segmentation
Highway Autopilot Assist
Park Assist
Pedestrian Detection

Driver Monitor
Camera
3D Positioning
Driver Alertness
Driver Awareness

Safe Central Compute
Camera / RADAR
Safe Decision Making

NCAP Camera
VISION
Pedestrian Detection, Lateral Tracking
Automatic Emergency Braking
Collision Avoidance
Rear View
Powertrain & Vehicle Dynamics
SENSE

Connectivity
- V2X
- Cellular
- WiFi, BT, GNSS, NFC
- Smart Car Access
- Radio Reception

ADAS & Highly Automated Driving
- Radar
- Camera
- Lidar

Powertrain & Vehicle Dynamics
- Motion & Pressure
- Speed
- Ultrasonic

Body & Comfort
- Temp, Light, Humidity
- Switch Panels

Infotainment & In-Vehicle Experience
- Touch Displays & Gesture
- Voice Recognition & Audio

THINK

Connectivity Domain Controller

Safe Central Compute & Planning Domain Controller

ACT

Vehicle Networks
- Engine
- Transmission
- Brake
- Battery Cell Management

Steering
- Airbag
- Suspension

HVAC, Interior Lighting
- Doors, seats, steering wheel, mirrors, wipers, sunroof

eCockpit

Audio & Amplifiers
- eCockpit

Motion & Pressure

Speed

Ultrasonic

Temp, Light, Humidity

Switch Panels

Touch Displays & Gesture

Voice Recognition & Audio

Vehicle Networks
NXP Provides Leading Powertrain Control Solutions
System optimized, scalable, secure and safe
Battery Management System

Internal Combustion Engine

Traction Motor

Hybrid Vehicle Control Unit

Traction Motor

Integrated DC/DC Converter

Traction Motor

Internal Combustion Engine

NXP GreenBox Development Platform

Target Applications
Vehicle Dynamics “Start, Stop and Steer”
Safe Dynamic Control Using S32S MCUs and MPUs
Sensors in Automotive Applications

- Vehicle movement Tracking Unit 6DOF
- Radar beam orientation & stabilization
- Tire Monitoring Sensor
- Suspension monitors
- Comfort seat Air Bladder Sensor
- Airbag Pressure Satellite Sensor
- Airbag Inertial Satellite Sensor
- Electric Parking Brake Hill start control
- Car Alarm
- Airbag Central Crash sensor
- Night Vision Infrared sensing
- Electronic Stability Control sensors
- Engine Mgt - Air Pressure, Turbo CNG/LPG Gas pressure
- Engine Mgt - Electronic Throttle Exhaust Gas Recirculation
- Brake booster vacuum pressure
- Pedestrian Impact protection PSAT and/or Low g
- Pedal Position Sensor
- Wheel Speed Sensor (ABS)
- Steering Angle, Torque Sensor
- Keyfob motion detection
- Navigation Dead Reckoning
- Roll Over detection
Body & Comfort
MagniV – Applications

**Sensor Interface**
- Alarm sensors
- Ultrasonic sensors
- Rain / light sensor
- Particle sensor
- NOx sensor
- Urea sensor
- Airmass sensor
- Air quality sensor
- Passenger occupancy detection
- Steering wheel sensors (touch / hands off)

**Motor Control**
- Convertible or sliding roof
- Door closing
- Seat, headrest control
- Mirror adjustment
- Steering wheel adjustment
- Steering column lock
- Starter / alternator
- Water pump engine cooling
- Engine cooling fan
- Headlight cleaning, levelling
- Oil pump
- ABS pump
- Parking break
- Window lifter
- Seatbelt system
- Tailgate closing
- Throttle valve
- HVAC water pump
Infotainment & In-Vehicle Experience
Infotainment & In-vehicle Experience

- Cockpit
- Multimedia
- Media Source
- Radio
- Audio
## Connected Infotainment: Key Differentiator & Sales Driver for OEMs

<table>
<thead>
<tr>
<th>Component</th>
<th>Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cockpit</td>
<td>Full digital eCockpit</td>
</tr>
<tr>
<td>Multimedia</td>
<td>Multiple high resolution displays</td>
</tr>
<tr>
<td>Media Source</td>
<td>Smartphone content, apps &amp; services</td>
</tr>
<tr>
<td>Radio</td>
<td>Digital radio &amp; regional standards</td>
</tr>
<tr>
<td>Audio</td>
<td>Noise cancellation, engine sound …</td>
</tr>
</tbody>
</table>
Safety & Security
System Development Unlocks NXP’s Value Propositions

**Functional Safety and Security**

- **Looks at unintentional hazards**
  Predictable and regular

- **Looks at intentional hazards**
  Unpredictable and irregular

**Component Reliability & Robustness**

Maximum quality of components is mandatory for high-value system
Safety & Security Go Together

#1 Objective: no functional hazards on mission-critical ECUs

Only possible, if:
- System availability ensured
- Information received / processed trustworthy

Cyber-security is a prerequisite for availability and trust in the system

#1 Objective: no functional hazards on mission-critical ECUs

Only possible, if:
- System availability ensured
- Information received / processed trustworthy

Cyber-security is a prerequisite for availability and trust in the system
Functional Safety & Security – System-Level Concerns

IC-LEVEL SAFETY & SECURITY SOLUTIONS + SAFE & SECURE DOMAIN ARCHITECTURES = SAFE AND SECURE MOBILITY

- Resource isolation
- On-die monitoring
- Integrity & authenticity checks

- Domain isolation
- Firewalls
- Network intrusion detection

- Fail operational
- Resilient against cyber attacks

Connectivity
ADAS & Highly Automated Driving
Powertrain & Vehicle Dynamics
Body & Comfort
Infotainment & In-Vehicle Experience
Vehicle Networks
ISO 26262 : 2018 Part 11 – What’s New and Already Applicable

ISO 26262 Deliverables

<table>
<thead>
<tr>
<th>Impact Analysis</th>
<th>Reinforced</th>
<th>Applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>IP Management</td>
<td>New</td>
<td>Applicable</td>
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<tr>
<td>Safety Analysis- FTA</td>
<td>Reinforced</td>
<td>Applicable</td>
</tr>
<tr>
<td>Safety Analysis- DFA</td>
<td>Improved</td>
<td>Applicable</td>
</tr>
<tr>
<td>Safety Analysis- FMEDA</td>
<td>Improved</td>
<td>Applicable</td>
</tr>
<tr>
<td>Fault Injection</td>
<td>Reinforced</td>
<td>Applicable (or not)</td>
</tr>
<tr>
<td>Confirmation Measures</td>
<td>Improved</td>
<td>Yes and No</td>
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</tbody>
</table>

2018 Edition 2

Applicability
<table>
<thead>
<tr>
<th>Domain</th>
<th>Application</th>
<th>Hazardous Event (example)</th>
<th>ASIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active safety</td>
<td>Central Fusion</td>
<td>Inadvertent hard braking during driving</td>
<td>D</td>
</tr>
<tr>
<td>Passive Safety</td>
<td>AIRBAG</td>
<td>Inadvertent deployment during driving</td>
<td>D</td>
</tr>
<tr>
<td>Chassis</td>
<td>EPS</td>
<td>Self steer during driving</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>Stability control</td>
<td>One wheel lock during driving</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>ABS</td>
<td>One wheel lock during hard braking</td>
<td>C</td>
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<tr>
<td>HEV/EV</td>
<td>Motor control</td>
<td>Sudden Torque Up/Down</td>
<td>C</td>
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<tr>
<td>Power Train</td>
<td>Transmission</td>
<td>Speed down on express way</td>
<td>C</td>
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<tr>
<td></td>
<td>Engine control</td>
<td>Decreasing of engine torque</td>
<td>B</td>
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<tr>
<td>Body</td>
<td>Brake Lamp</td>
<td>No brake lighting during braking</td>
<td>B</td>
</tr>
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</table>

ASIL Level Examples For Different Solutions

- **ADAS/ RADAR: SAFE CENTRAL COMPUTE**
- **SECURE CAR ACCESS**
- **INFOTAINMENT**
- **POWERTRAIN ELECTRIFICATION**
- **SAFETY**
- **VEHICLE NETWORKING**
- **BODY**
- **CHASSIS**
Examples Of a System Dreaded Event and ASIL Levels

- **ADAS Sensor**
  - Phantom detection
  - ASIL B

- **Battery Management**
  - Fire
  - ASIL C

- **Power Steering**
  - Auto steering, lock, loss
  - ASIL D
NXP’s Safe Assure Program

**Simplify Customer Experience**
ISO26262 system compliance process

**Optimize Customer R&D Efficiency**
Reduces time and complexity required to develop ISO26262 safety systems

**Reduce Risk of Harm**
Supports the most stringent Automotive Safety Integrity Levels (ASILs)

**Safety Starts with Quality**
Zero defect methodology from design to manufacturing to help ensure our products meet the stringent demands of safety applications
Proven History in Driving Security

Mid 1990s
- Censorship
- Remote Keyless Entry

Early 2000s
- Enhanced Censorship
- Passive Keyless Entry

Mid 2000s
- High Assurance Boot & Fault Detection Sensors
- Keyless Entry RF Transceivers

Late 2000s
- Crypto Services Engine (SHE), Active Shields
- Keyless Entry RF Transceivers

2010s +
- Hardware Security Module (HSM)
- Secure Elements (SE)
- Gateway, CAN security
- NFC-based Smart Access

eGovernment
Bank Cards
Smart Mobility (MIFARE) Cards
Tags & Authentication
Readers
Mobile

Proven History in Driving Security
### What is at Risk and who is Affected?

<table>
<thead>
<tr>
<th>IMPACT</th>
<th>Car Users</th>
<th>Car Owners</th>
<th>Insurers</th>
<th>OEM &amp; Suppliers</th>
<th>Service Providers</th>
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</thead>
<tbody>
<tr>
<td>Safety</td>
<td>Injuries</td>
<td>Damage</td>
<td></td>
<td>Claims, brand damage</td>
<td></td>
</tr>
<tr>
<td>Financial</td>
<td>Vehicle theft</td>
<td>Insurance claims</td>
<td>IP theft</td>
<td>Loss of income (fraud, DoS, …)</td>
<td></td>
</tr>
<tr>
<td>Privacy</td>
<td>Loss of personal data (PII)</td>
<td></td>
<td>Claims, brand damage</td>
<td>Claims, brand damage</td>
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NXP’s Automotive Security Solutions

Automotive ICs with... …on-chip security subsystems

Infotainment & In-Vehicle Experience
Connectivity
ADAS & Highly Automated Driving
Vehicle Networking
Powertrain & Vehicle Dynamics
Body & Comfort

i.MX8

Security Controller (SECO)
- High performance
- Media content protection

CSE
- Ease-of-use
- Cost-optimized

Security Engine (SEC)
HSE (HSM)
- High performance
- Versatile feature set

Layerscape

S32x & MPC57xx

Security companions

Secure Element (SE)
- Tamper-resistant secure system ideal for M2M authentication (e.g. V2X)

Function-specific secure ICs

Secure CAN Transceiver (TJA115x)
- For enhanced IDS & IPS

Secure Ethernet Switch (SJA1110)
- Network frame analysis (L2/L3/L4)

Secure Car Access ICs
- For advanced RKE / PKE solutions

V2X DSRC Baseband (SAF5x00)
- Ultra-fast ECDSA verifications
SECURE CONNECTIONS
FOR A SMARTER WORLD
References

- http://www.nxp.com/automotive
- Cybersecurity for Dummies, Lawrence C. Miller, 2016
- Car Hacks & Mods for Dummies, David Vespremi, 2004