

Greetings from Georgia Tech PRC

Packaging for Autonomous Vehicle Electronics

Application and Market Projections
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3 Main Reasons for Automotive Electronics

1. Reducing Human Fatalities

- 94% of 33,000 Deaths in the U.S., and 1.3M globally due to human error

2. Improving Driving – Energy Efficiency

3. Improving Human Productivity

Many, Many more

Mercedes-Benz F 015 Luxury in Motion Research Car



Key Drivers for Automotive Electronics

**Computing
- Autonomous
Driving**

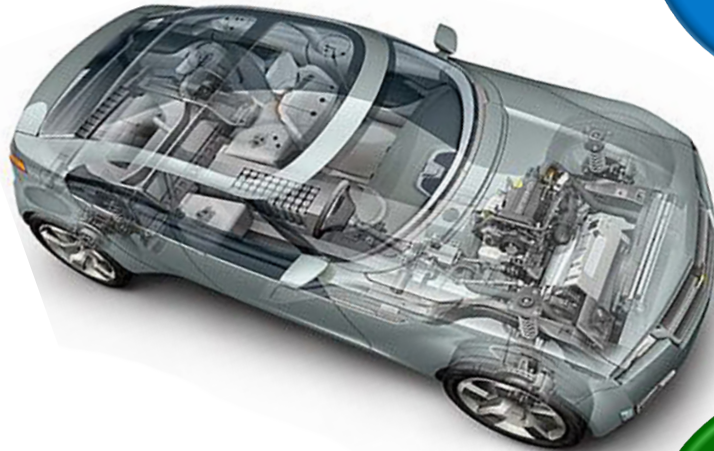
**Connectivity
(4G, 5G)**

**Sensing
Electronics**

- Radar
- Lidar
- Cameras

**Electric &
Hybrid
Drivetrains**

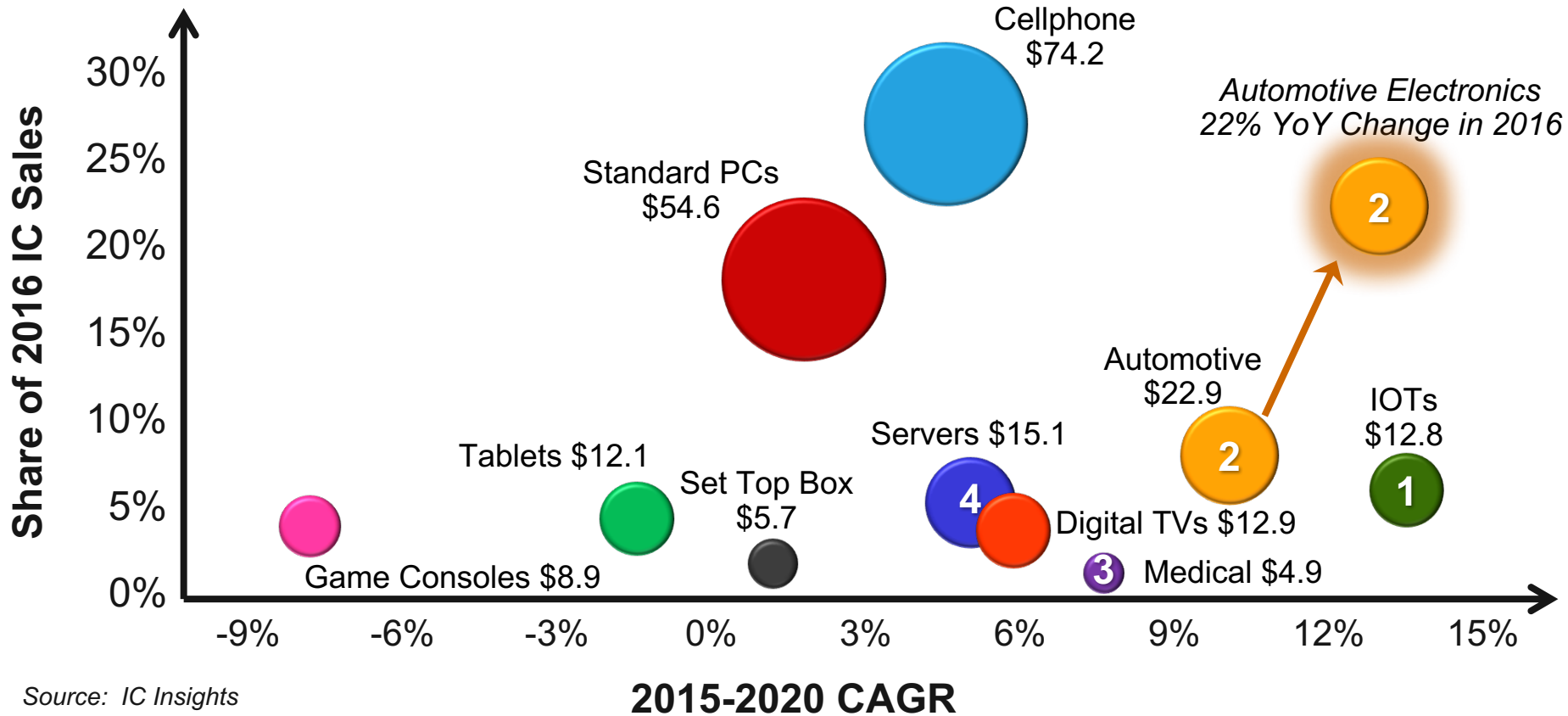
- Batteries
- Drive Train & Battery Charger
- Power Distribution & Power Conversion



Automotive Systems may be the first to introduce several new device and packaging technologies (e.g. LIDAR) in high volumes

Automotive Market Projections for IC consumption are Accelerating

IC End User Markets (\$B) and Growth Rates



Source: IC Insights

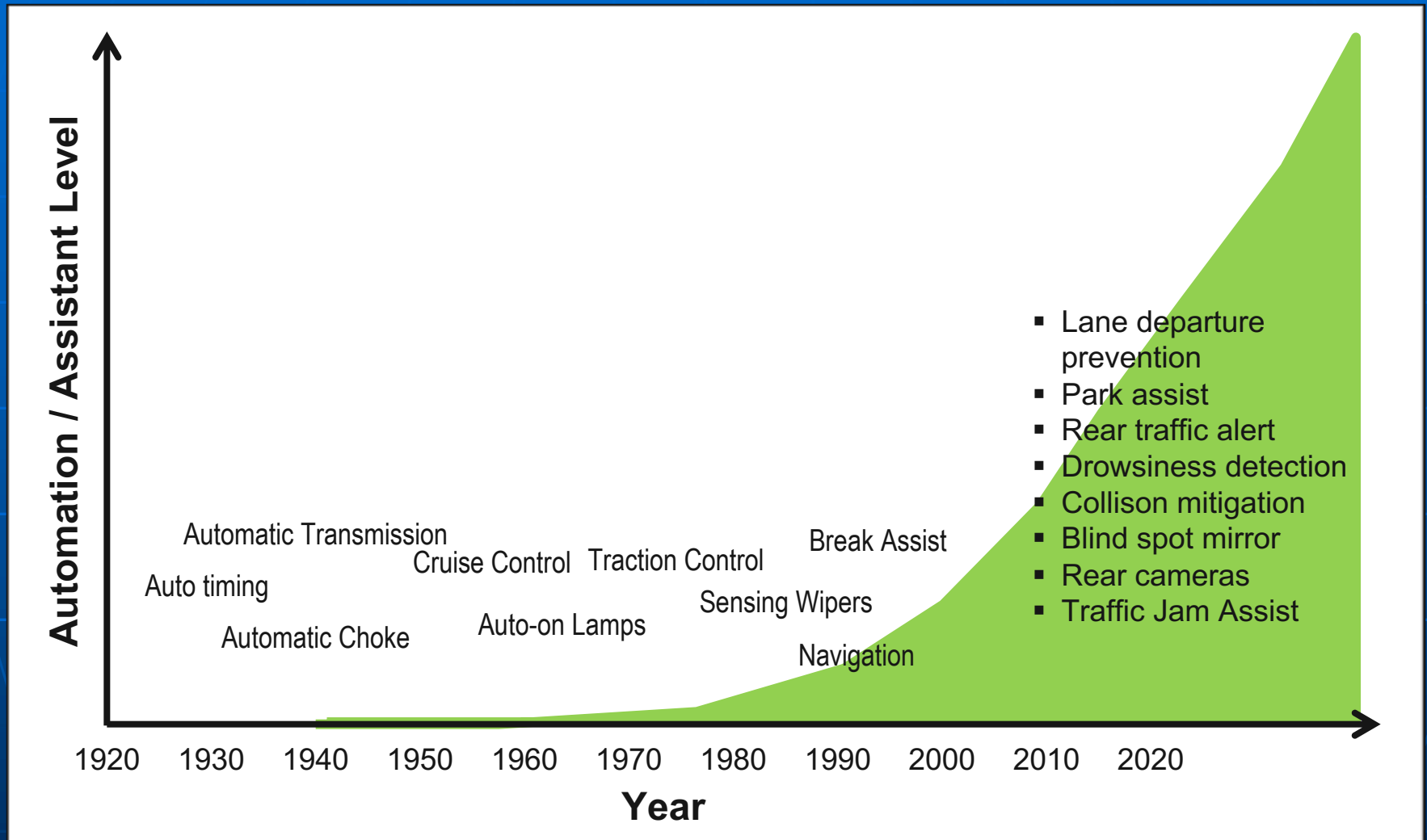
* Covers only the Internet connection portion of systems

Source: IC Insights

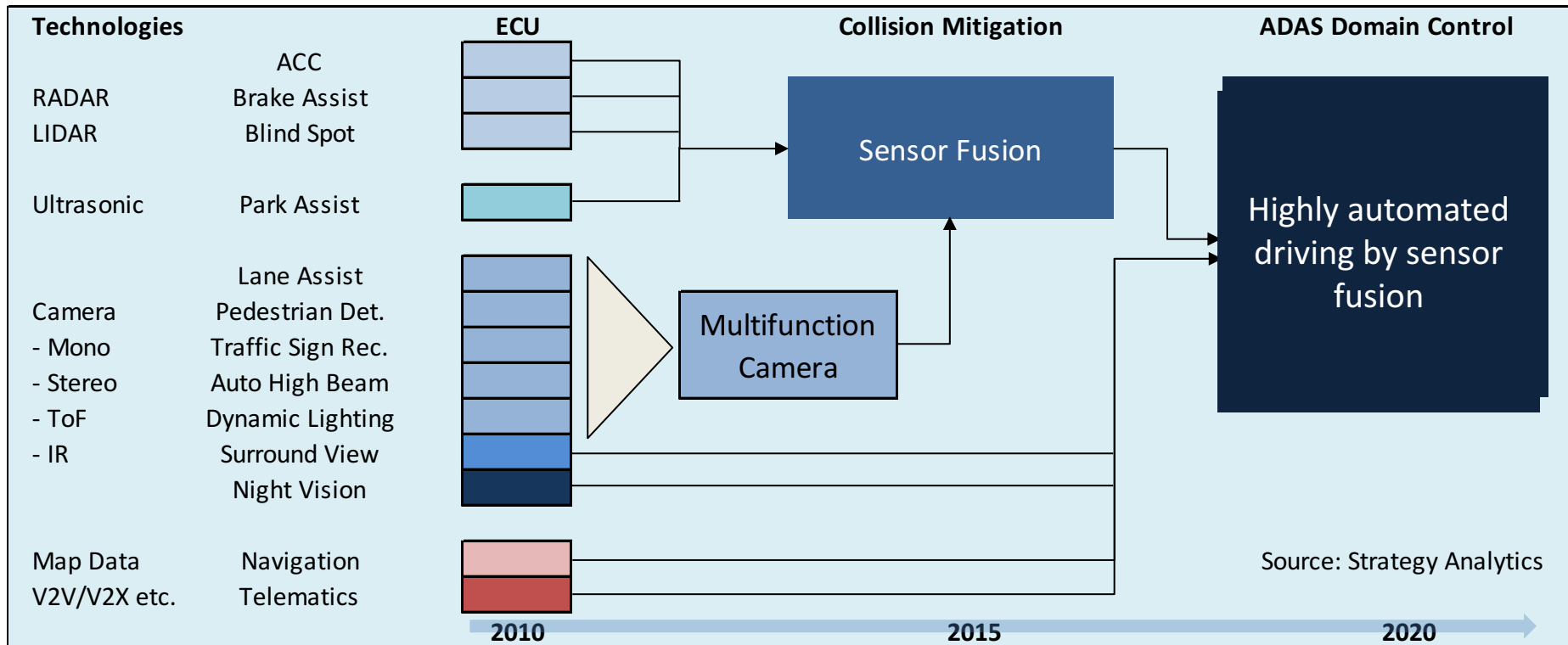
Levels of Autonomous Driving

- **Level 1** – Function-specific Automation: Automation of specific control functions, such as cruise control, lane guidance and automated parallel parking. Drivers are fully engaged and responsible for overall vehicle control (hands on the steering wheel and foot on the pedal at all times).
- **Level 2** - Combined Function Automation: Automation of multiple and integrated control functions, such as adaptive cruise control with lane centering. Drivers are responsible for monitoring the roadway and are expected to be available for control at all times, but under certain conditions can disengage from vehicle operation (hands off the steering wheel and foot off pedal simultaneously).
- **Level 3** - Limited Self-Driving Automation: Drivers can cede all safety-critical functions under certain conditions and rely on the vehicle to monitor when conditions require transition back to driver control.
- **Level 4** – Self-Driving Under Specified Conditions: Vehicles can perform all driving functions under specified conditions.
- **Level 5** - Full Self-Driving Automation: Vehicles can System performs all driving functions on all normal road types, speed ranges and environmental conditions.
- Several OEMs have pledged to include Level 1 Functions to be in all cars sold by 2022
- Level 2 available in most luxury vehicles in 2017 model year
- Level 2 as a Standard feature in several 2017 models

Move to Autonomy is Happening



ADAS is Highly Heterogeneous Requiring SOP Concept



Integration of Multiple Packaged Devices for Semi-Autonomous Functions

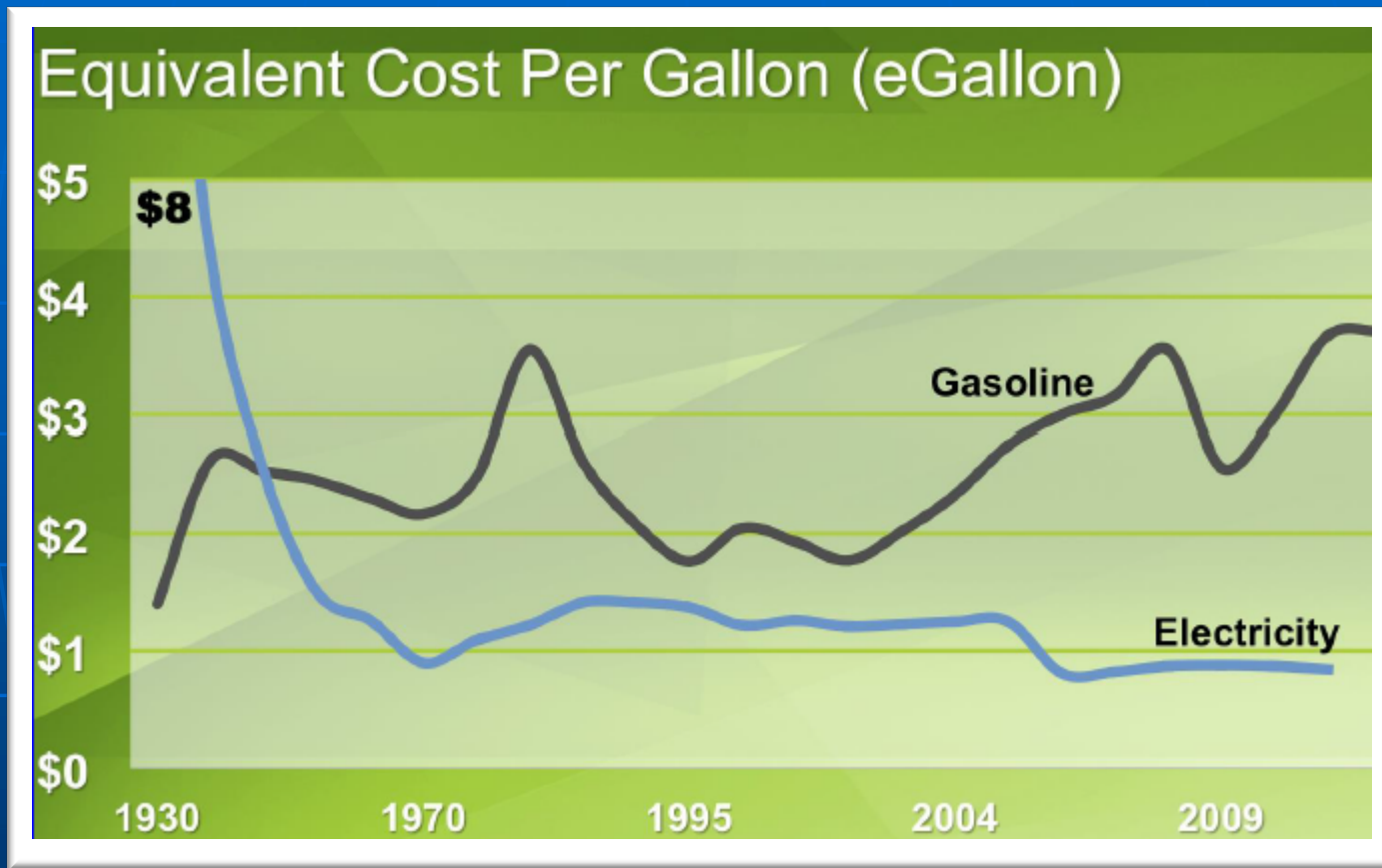
- Auto Emergency Braking
 - Front RADAR (packaged in FO WLP)
 - Front Camera (Ceramic or organic package with embedded ISP)
- Lane Keeping or Centering
 - Dual lane watch cameras (increasing to 3 or more in future)
 - Electric steering assist
- Adaptive Cruise Control
 - Front RADAR
 - Front Camera
- Self Parking System
 - 12 ultrasonic sensors
 - Surround view (4 cameras)
- More than 40 processors controlling Level 1 functions

Connectivity & Data Bandwidth

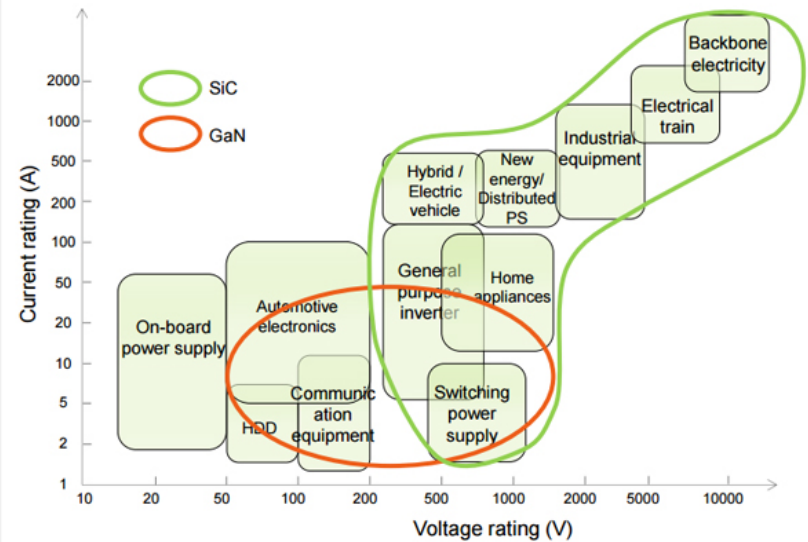
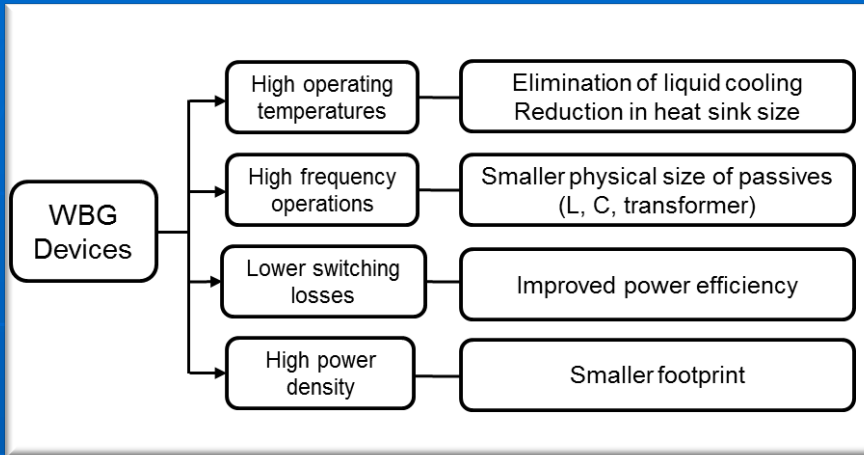
- Average Connected Car – 4000 GB per day
- Average Person (video, chat and internet usage)
 - 650 MB in 2016
 - Expected to grow to 1.5GB by 2020

Source: Brian Krzanich, Automotility 2016

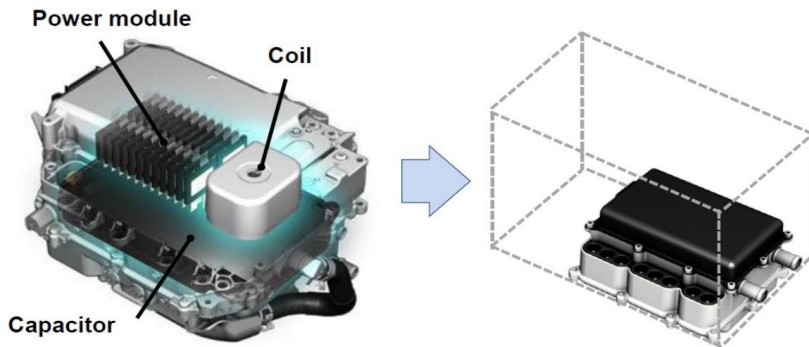
Two Reasons For Electric Cars: Sustainability and Efficiency



WBG Power Devices & Modules



Source: Keysight / APEC 2015



Source: Toyota

Toyota announced introduction of SiC Devices for drivetrain within the next five years

→ **Need packaging solutions FOR GaN / SiC**

Summary

- Automotive Electronics market introducing several new functions requiring new device and packaging technologies
- Driving functions are
 - Autonomous driving (sensors and computing/AI)
 - Connectivity and infotainment
 - Electric and Hybrid Drivetrains

Georgia Tech



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Thank you

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