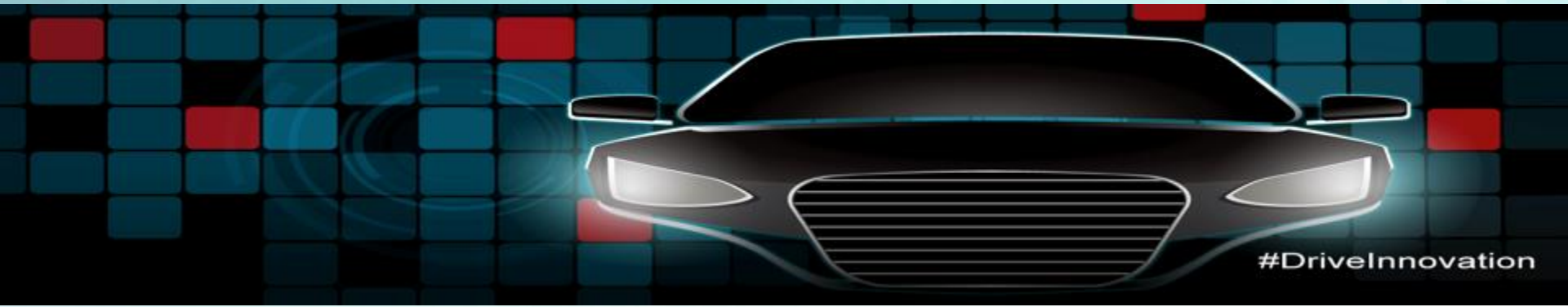
Accelerating the Driving Experience: The Semiconductor Point of View



Ron Nag - Texas Instruments

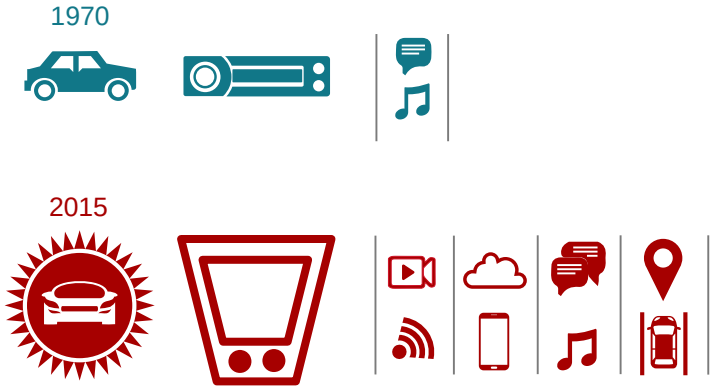
North Dallas Chamber of Commerce – Transportation Crossroads Conference- October 21, 2016

Automotive semiconductor content has boomed…

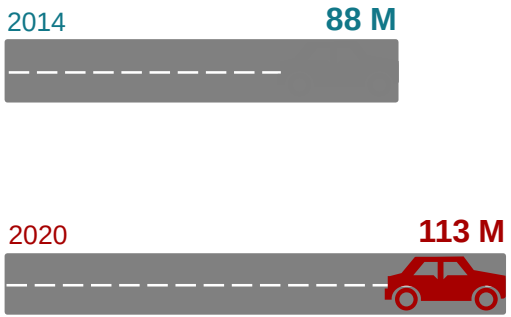
1990 — Average semiconductor content per car — 2015

~$62 → ~$309

Semiconductor content

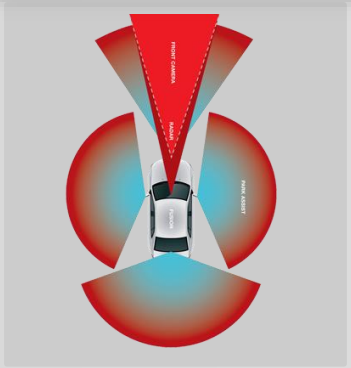


Worldwide vehicle production



Innovation across 5 market sectors

Advanced driver assistance systems

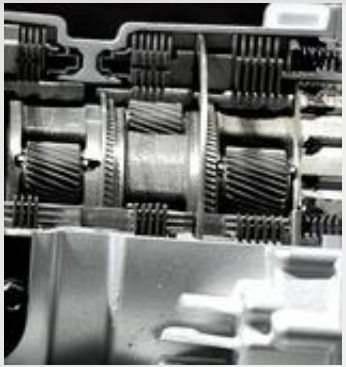


Adaptive cruise control
Night vision
Blindspot detection
Lane departure warning

Passive safety

Automatic braking
Airbag deployment
Antilock braking
Tire pressure monitoring

Hybrid/electric and powertrain systems



Automatic start/stop
Battery management
Electric power steering
Engine and transmission control

Body electronics & lighting

Security system
Seat position control
Remote keyless entry
Lighting

Infotainment & cluster

Entertainment system
Head-up display
Navigation system
eCall

and more…

Semiconductors enable capabilities you'd expect…

AIR BAG, INFOTAINMENT

NAVIGATION


STEERING


LIGHTING

…but also some that are not as obvious

WATER PUMPS

TAIL LIGHTS

TIRES

In automotive: Unlimited possibilities for electronics

SAFETY | POWERTRAIN | BODY ELECTRONICS | ADAS | INFOTAINMENT

night vision
driver alertness monitoring
auto-dimming mirror
active cabin noise suppression
windshield wiper control
head-up display
accident recorder
interior lighting
entertainment system
instrument cluster
voice/data communications
cabin environment controls
battery management
airbag deployment
engine control
adaptive front lighting
dedicated short-range communications
LED tail lights
adaptive cruise control
navigation system
LED headlights
automatic braking
security system
active exhaust noise suppression
electric power steering
antilock braking
active suspension
electronic throttle control
automatic start/stop
transmission control
hill-hold control
electronic valve timing
active vibration control
remote keyless entry
seat position control
electronic stability control
regenerative braking
cylinder de-activation
blindspot detection
lane departure warning
parking system
tire pressure monitoring

Key growth areas: Driving Innovation

- Hybrid/Electric Vehicles
- Autonomous Vehicles

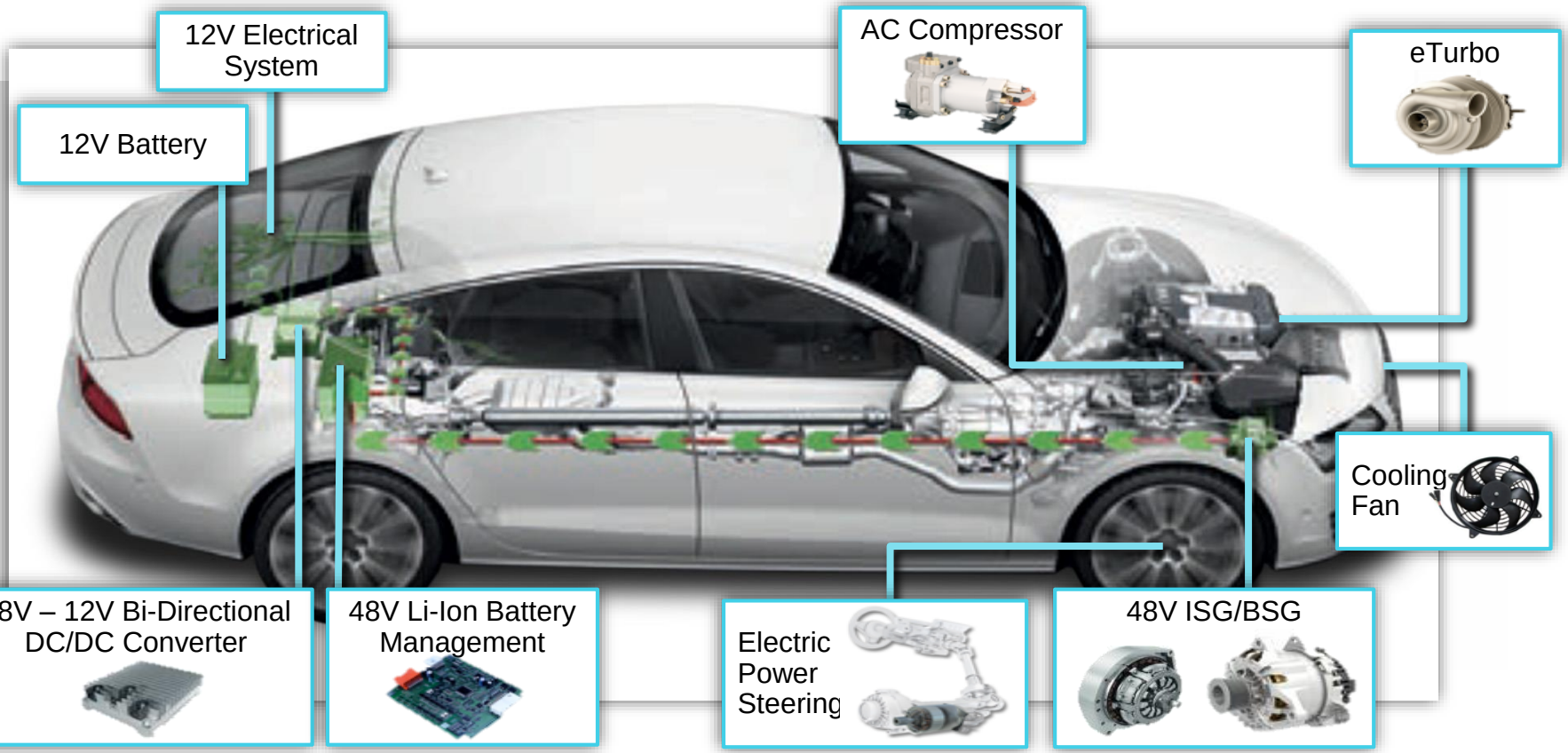
EV/Hybrid is an emerging market in China

- Electric vehicle and hybrid vehicle (EV/HEV) design interest grows.
  - IC demand with 30% annual growth in China through 2020 (Strategy Analytics).
- China continues to support EV and hybrid purchases.
  - Shipments of EVs expected to double in China from 300K in 2015 to 600K in 2016 (Strategy Analytics).
- Need for advanced EV charging piles (stations) in the home, office or public.
  - Growth expected in China and around the world. For example global EV charging stations installation base to grow to more than 12.7 million in 2020 (I.H.S. Research, 2015).

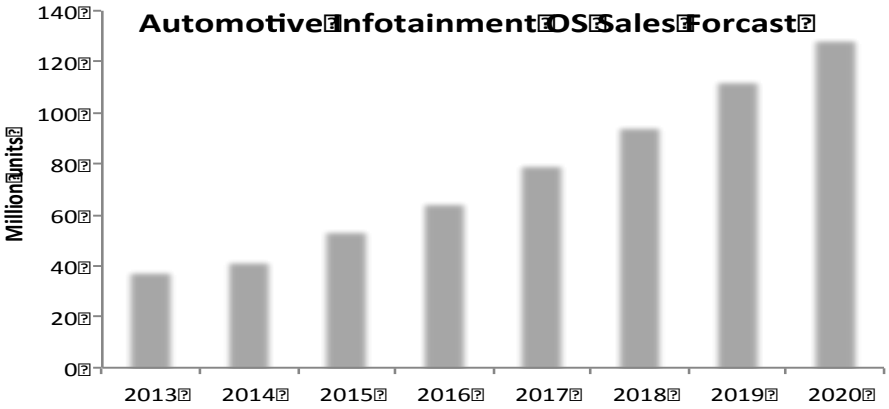
Market trends: Higher power semiconductors: 48V

- Fuel economy & CO_2 reduction
  - Enhancing Start-Stop operation – faster, less impact, more often
  - Energy recuperation – more efficient
- Increased electrical demand in vehicles
- Higher torque, higher speed motors

48V ecosystem in automotive



Infotainment & Cluster: High End Features Moving to Entry & Mid-Level Models



Source: HIS Automotive

- Customer demands for safer and smarter vehicle
- Mainstream In-Vehicle-Infotainment (IVI) system moving away from commodity **Rapidly**
- **Performance** & **Integration** matters for 2016 and beyond

ADAS: Levels of Autonomous Driving

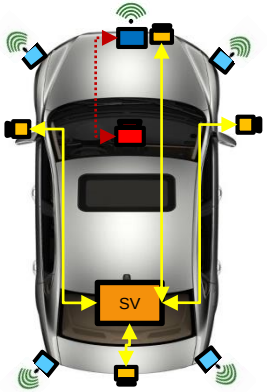
2014: Level 2 enabled through 10 processors in one vehicle, enabling front camera and radar with fusion for speed control, front camera for steering control, supported by 4 corner radars and 360 degree surround view.

SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/ Deceleration	*Monitoring* of Driving Environment	Fallback Performance of *Dynamic Driving Task*	System Capability *(Driving Modes)*
***Human driver* monitors the driving environment**						
0	**No Automation**	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	**Driver Assistance**	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes
2	**Partial Automation**	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/ deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes
***Automated driving system* ("system") monitors the driving environment**						
3	**Conditional Automation**	the *driving mode*-specific performance by an *automated driving system* of all aspects of the dynamic driving task with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes
4	**High Automation**	the *driving mode*-specific performance by an automated driving system of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes
5	**Full Automation**	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**

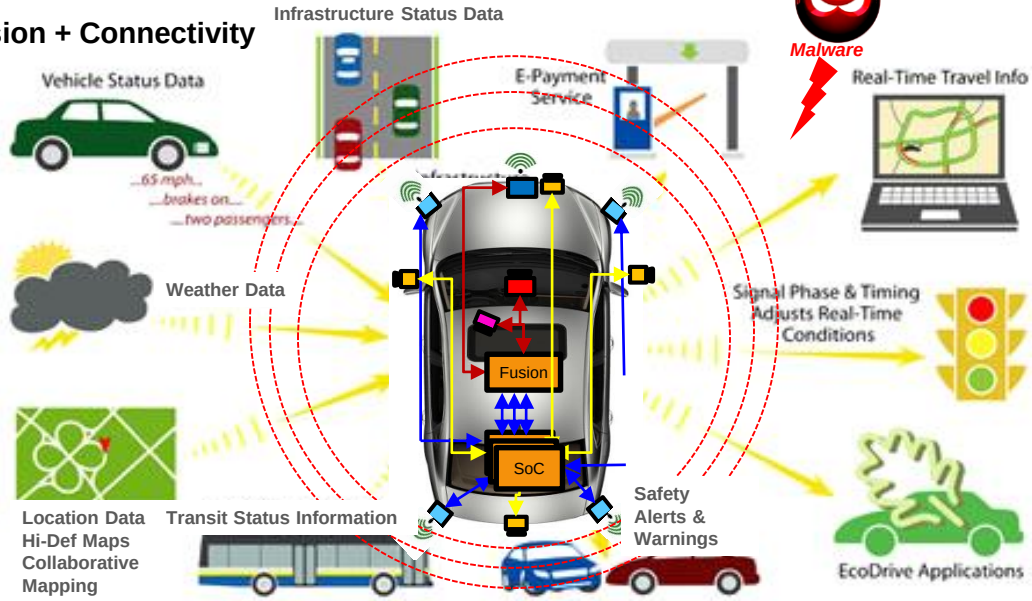
ADAS to Autonomous

Few sensors

More sensors



Fusion + Connectivity



ADAS – Driver Assist to Limited Driver Substitution

- Discrete signal processing with 1-4 sensors per SoC and limited fusion on highly integrated processor
- Traditional Detection and Classification moving to Deep Learning
- Isolated compute provides security

Autonomous driving through connected/collaborative technology

- Shift to centralized signal processing
- Multi-Modal Sensor Fusion provides Robustness and Redundancy
- Heavy use of Deep Learning
- Connected compute needs active security

ADAS → **Autonomous Driving**

Summary: Many innovations to come!

- The largest growth market for semiconductors is automotive
- Areas driving the grow are electric & autonomous vehicles
- Higher voltage electronics enabling next generation vehicles
- Vehicle security is key

Thank You