# Drive on: Where are the flying automobiles?

Tom Beckley – Senior VP & GM, Custom IC and PCB Group
MATLAB EXPO 2017;  San Jose, CA
November 7, 2017



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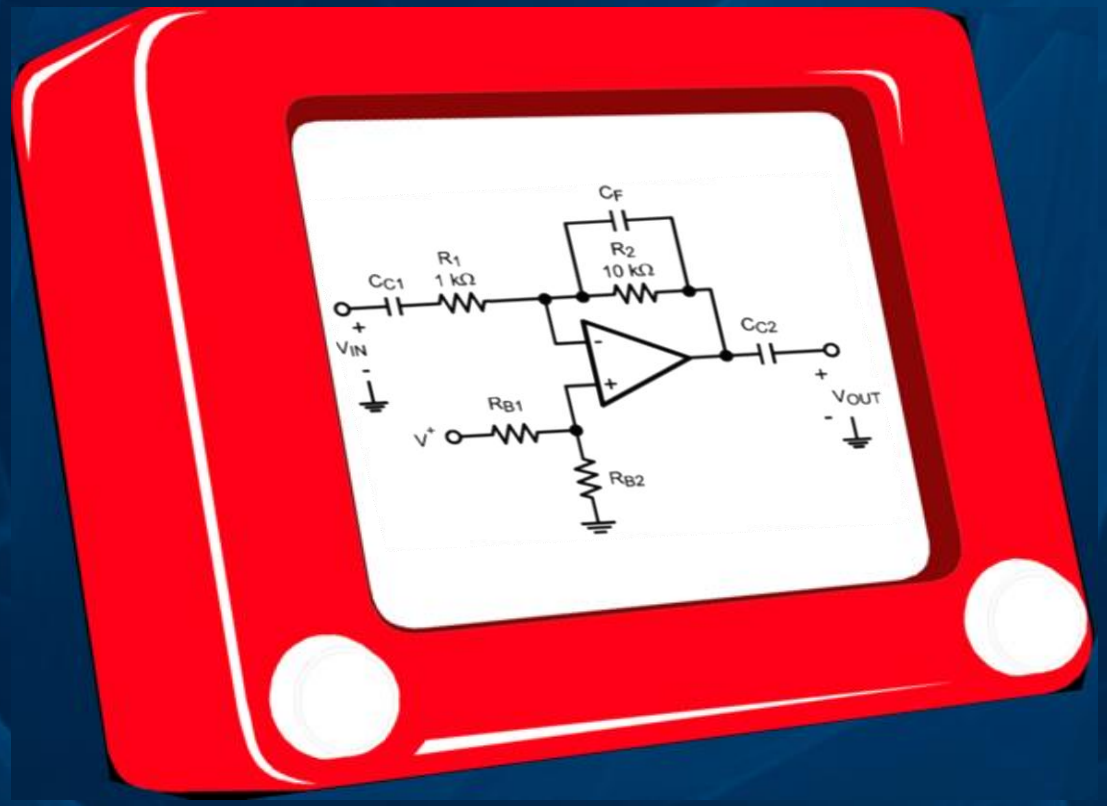
# Early 1960s



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# The Jetsons predicted the future

## American television early 1960s




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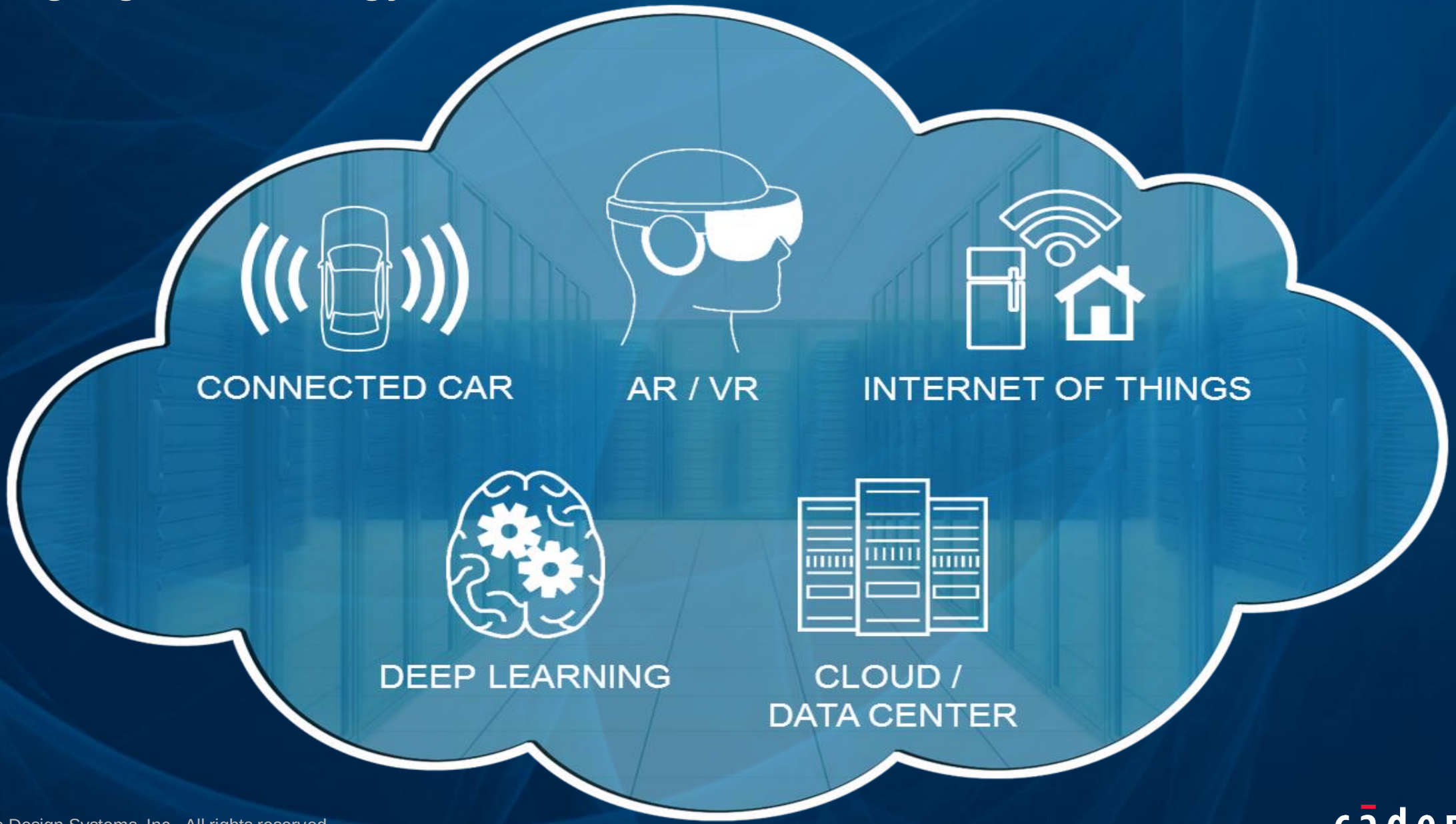
# Emerging technology trends



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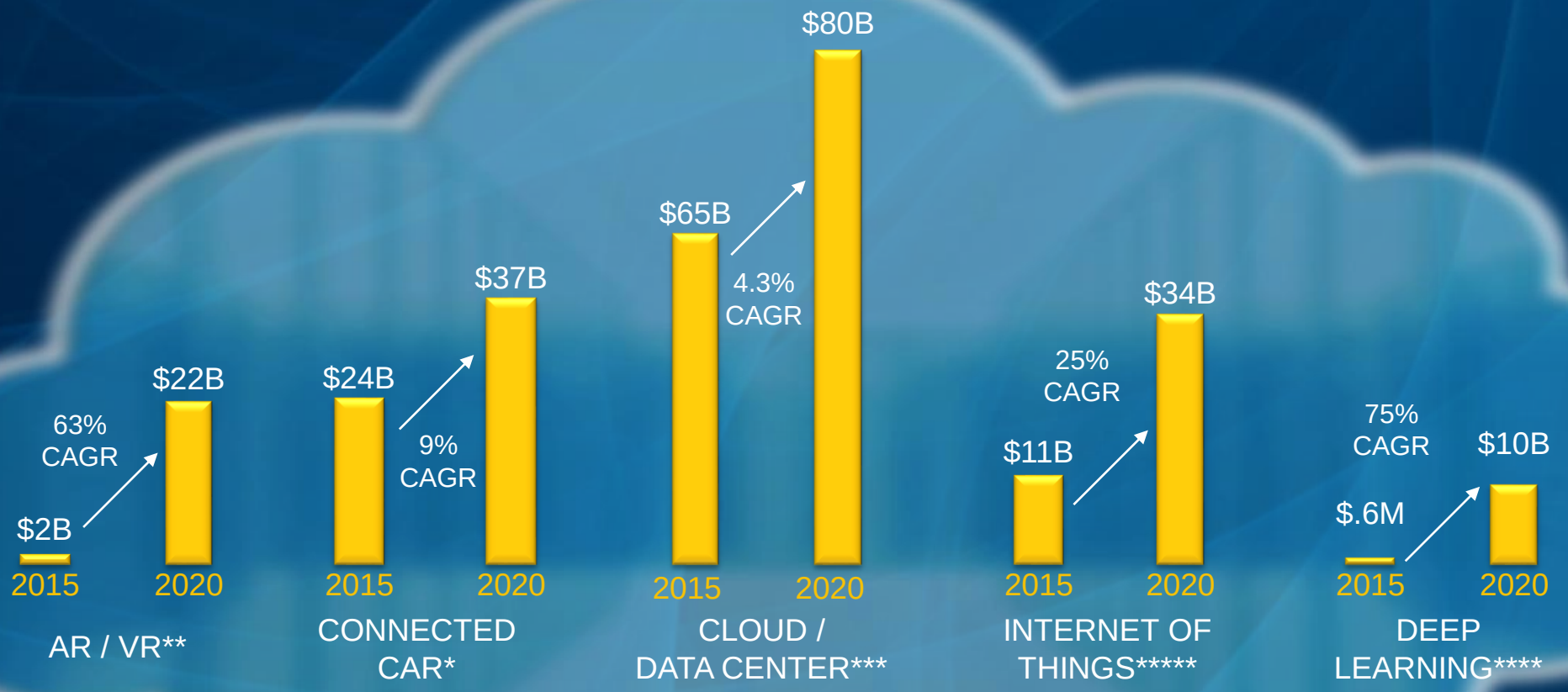
# Emerging technology trends




**The opportunities are massive**

* IBS Global Service Industry Report, Nov 2016
** MarketAndMarkets, AR/VR Market Forecast 2016
*** Gartner Semiconductor Forecast Q3'16
**** BofAMerrill Lynch Global Research estimates October 2016
***** Gartner Forecast – IoT Endpoints, Nov 2016



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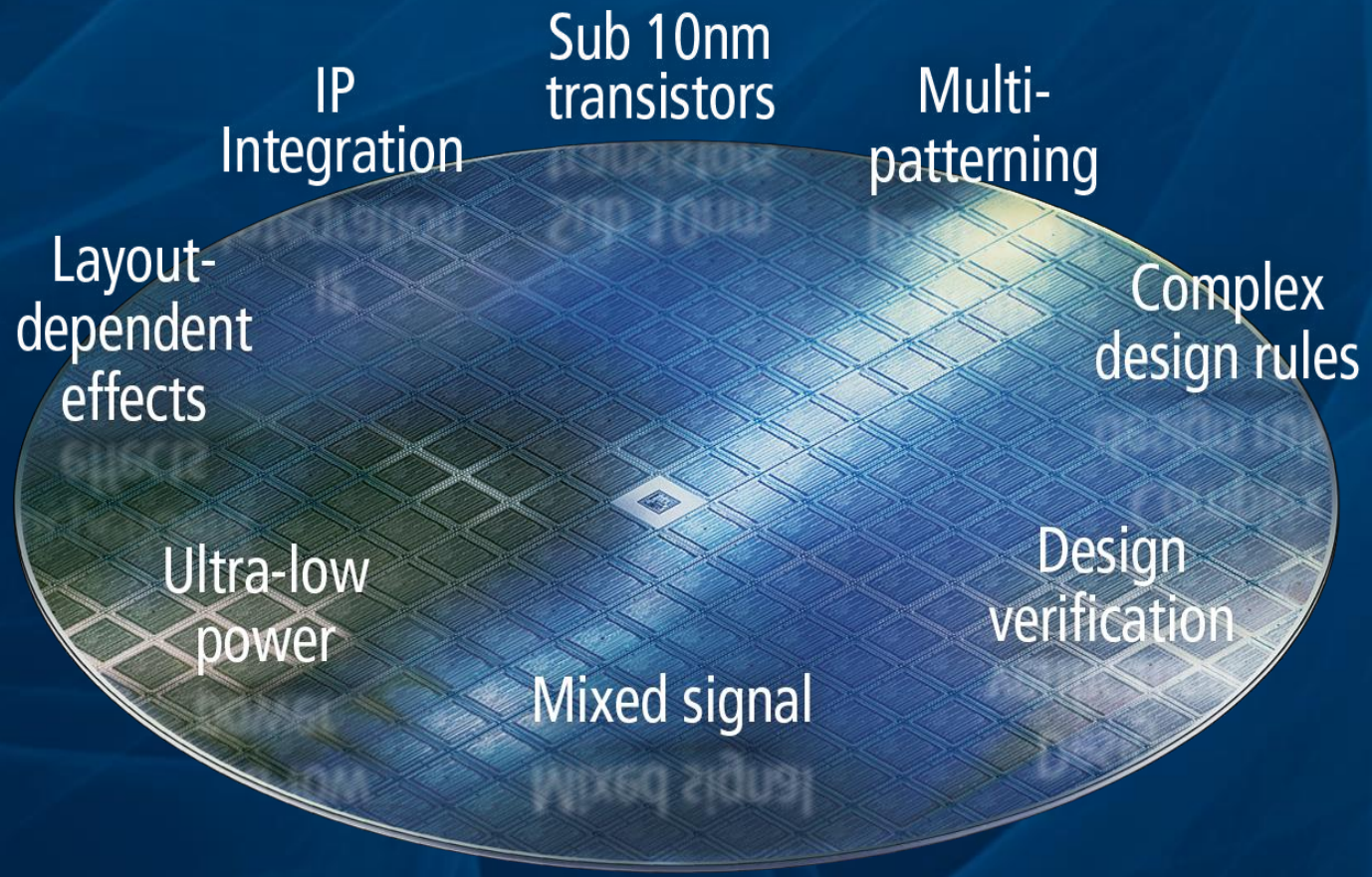
# Design challenges – Silicon



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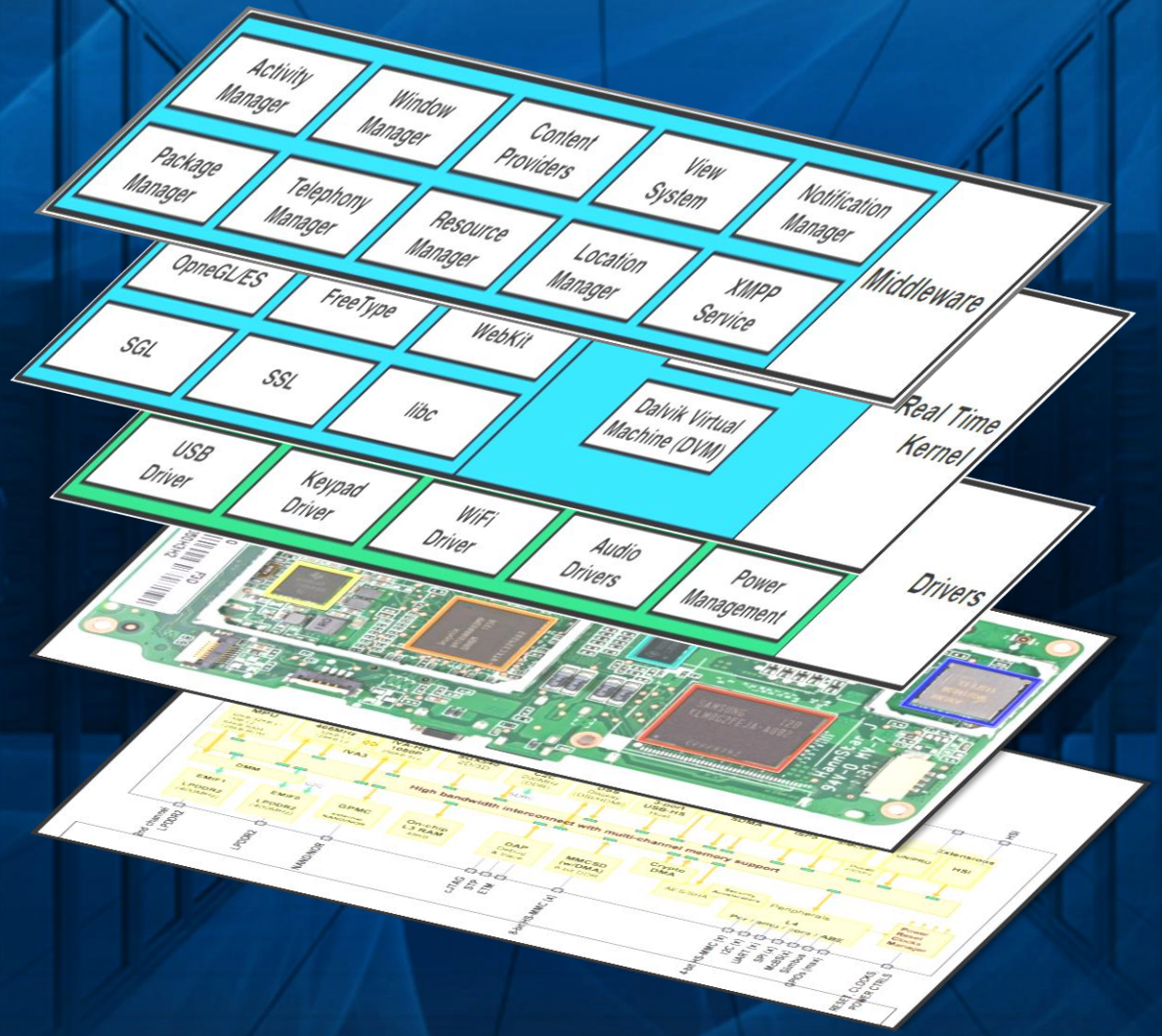
# Design challenges – Silicon and system design

System Modeling and Analysis

RF/Photonics /Mixed Signal

Fault Sim & Thermal Analysis

System-Level SI and PI




Integrated Chip, Packaging, and Board

System Prototyping

Metric-Driven Design and Verification

Flow-to-Enterprise PLM



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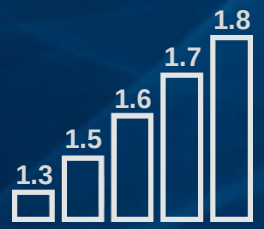
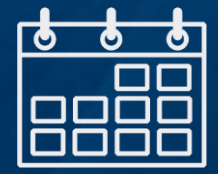
# Cadence at a glance

Tools, IP, hardware, solutions and services for electronics design - from IC design to IC packaging to boards to systems




FY12 – 16
Revenue ($B)

FORTUNE 100 BEST COMPANIES TO WORK FOR® 2017



1H FY17 revenue
$956M

4,250+ R&D engineers
1,535 field engineers

$735M R&D investment
in 2016

7,200+ employees



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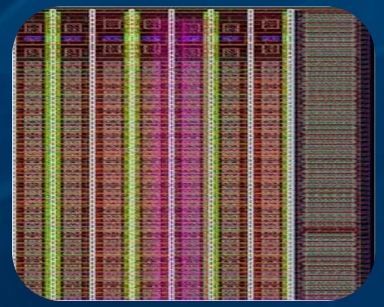
# Part of what we do is to work in “extremes”

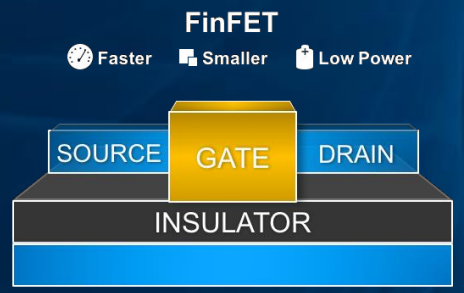
## Create, simulate and verify designs that use advanced nanometer transistors

~512 Billion Transistors

Living on a Flat Planet
about 1 inch in diameter

x 68




10nm Gate Size

A cat whisker

÷ 10,000



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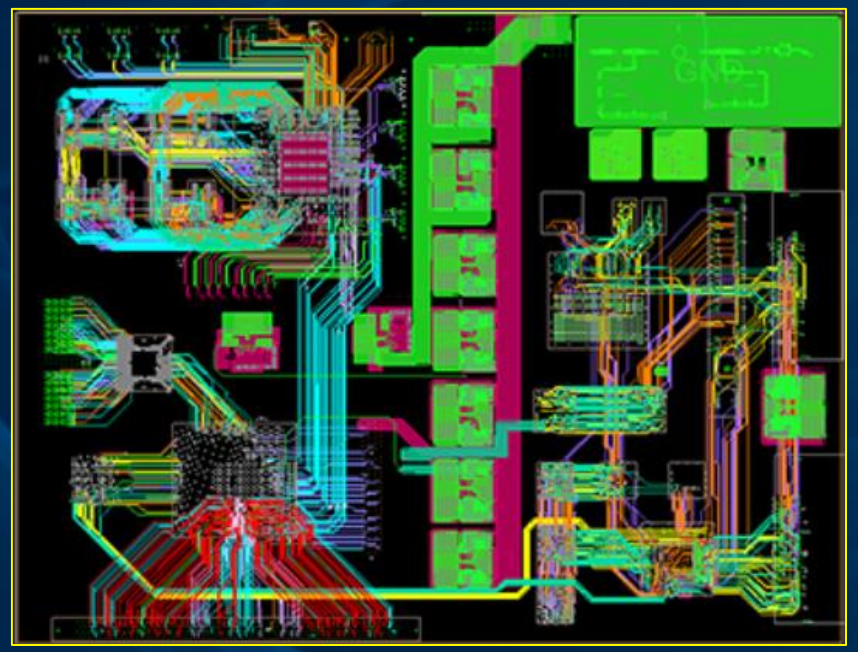
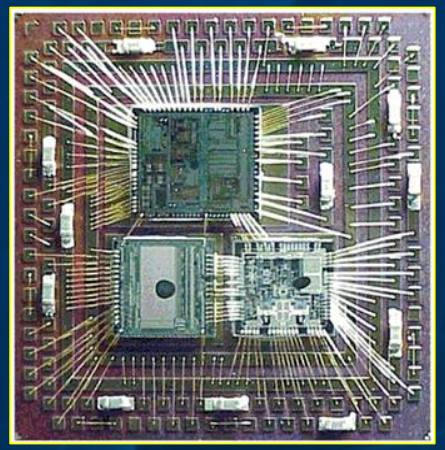
# Cadence system design environment

## Integrating IP, IC, package, PCB, and analysis

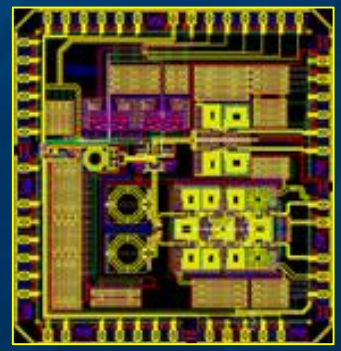
- Our software helps engineers move between various stages of electronic design so that your favorite electronic gadget is ready for the holiday rush!



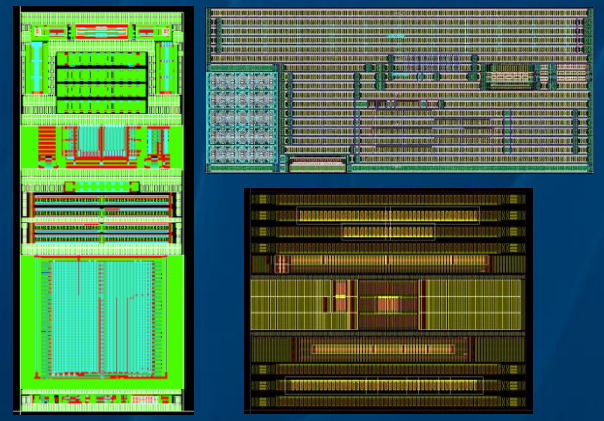
**Printed Circuit Board (PCB)**



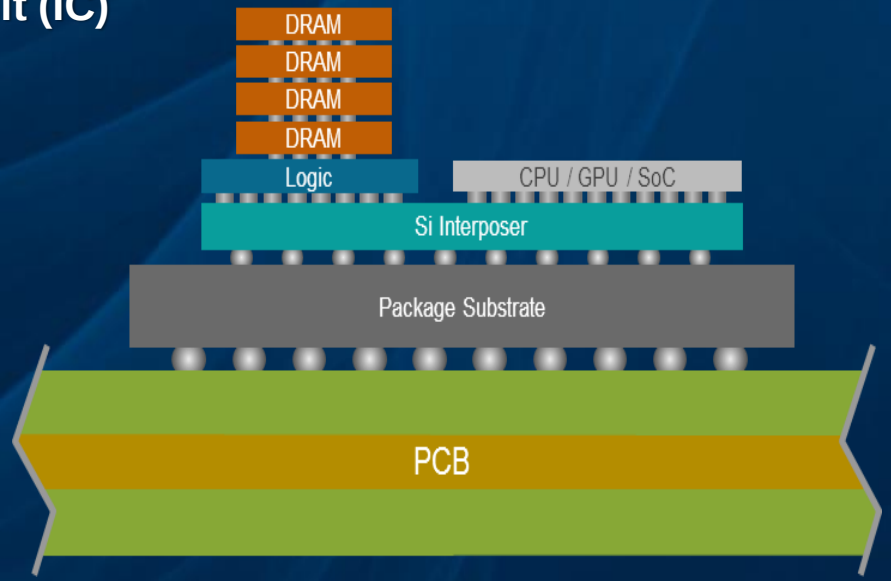
**Package**



**Integrated Circuit (IC)**



**Intellectual Property (IP)**



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# Bridging the divide between ICs and Systems

## MathWorks system design capabilities integrated with Cadence solutions

MathWorks

+

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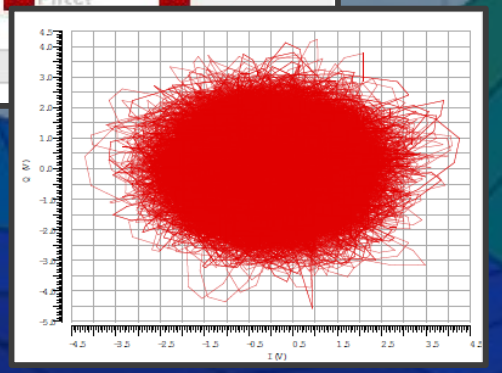

**High-performance IC data exchange and analysis**

PSpice® <> Simulink

**System-level simulation solutions for IoT and automotive applications**



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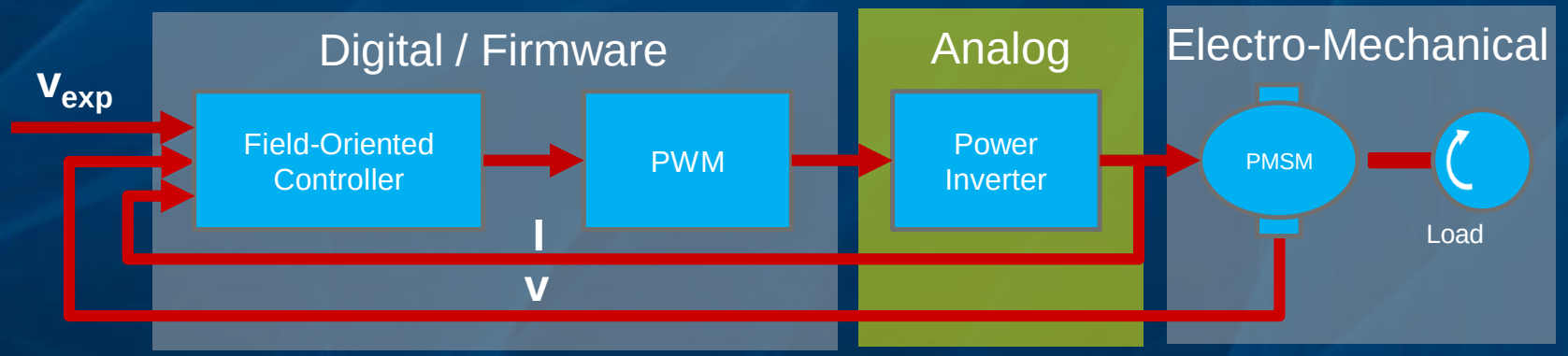
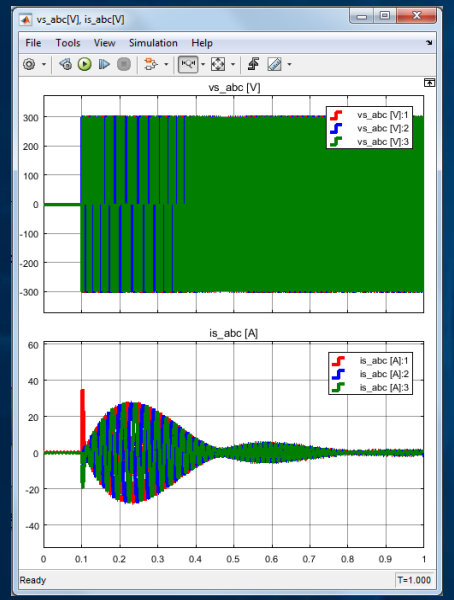
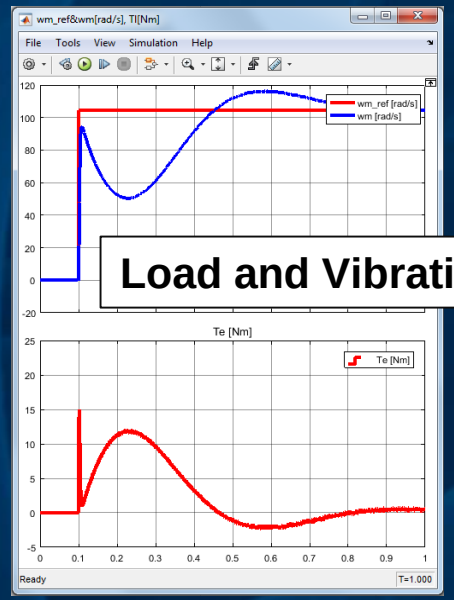
# Automotive system design for electric vehicles

## MATLAB / Simulink / PSpice integration

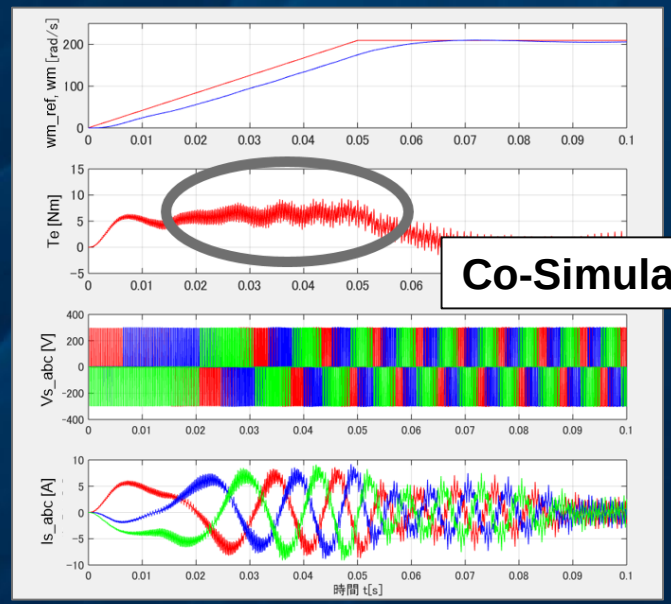
- From actuators to electric vehicle motors
- Acceleration of 0-60mph in 2.7 secs
- Example control of a permanent-magnet-synchrone-machine for motor powertrains




**Load and Vibration**




**Co-Simulation**



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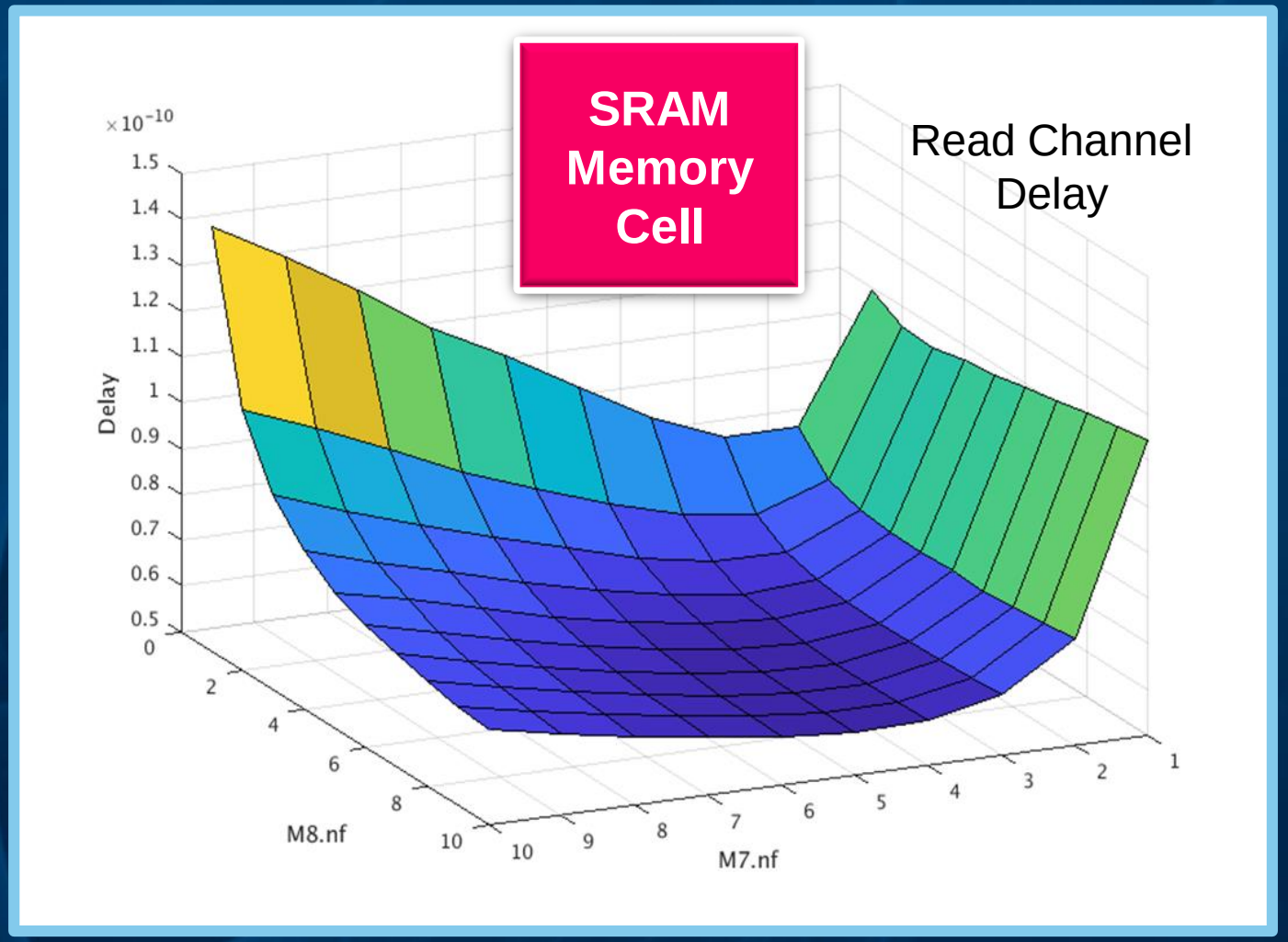
# Quickly determine trade-offs even when using gigabytes of data

## MATLAB / Virtuoso ADE Product Suite integration

*Q: What is the impact on the read channel delay if I change the size of my transistors?*

A: Simulate the design in Virtuoso ADE and visualize the trade-off results in MathWork's Matlab



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# Moving data at the *speed of light(ning)* in the cloud

## The science of ***Photonics*** and the impact on ICs and Boards


*Bringing modeling, design and data analysis all together to invent the future*



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# Intelligent design solutions = analytics + ML + optimization




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# Disruption and Opportunity

## Agility, Change, and New Fabrics within the Automotive Ecosystem

# Cars – we've come a long way in a short time


**1968 Ford Falcon**

The straight six Ford engine – a bear to keep running smoothly (carburetor adjustments, checking distributor/plugs, timing light, etc.)

# Early 21st century automobiles
## Electromechanical subsystems unfold

- A sophisticated platform of actuators
  - Anti-lock brakes
  - Traction control
  - Air suspension control
  - Electric power steering
  - Powertrain (air, fuel, exhaust, cooling, turbo, transmission)
- Dynamic stability control (DSC)
  - Driving automation for safety, synergistic control of actuators
  - Pedal-to-the-metal acceleration, foot-to-the-floor braking
  - Cornering, oversteer, understeer
- Engine management
  - ICE: Driving automation for efficiency, performance
  - EV: Inverter / converter for efficiency, performance

Dynamic stability control ECU

Courtesy of Bosch



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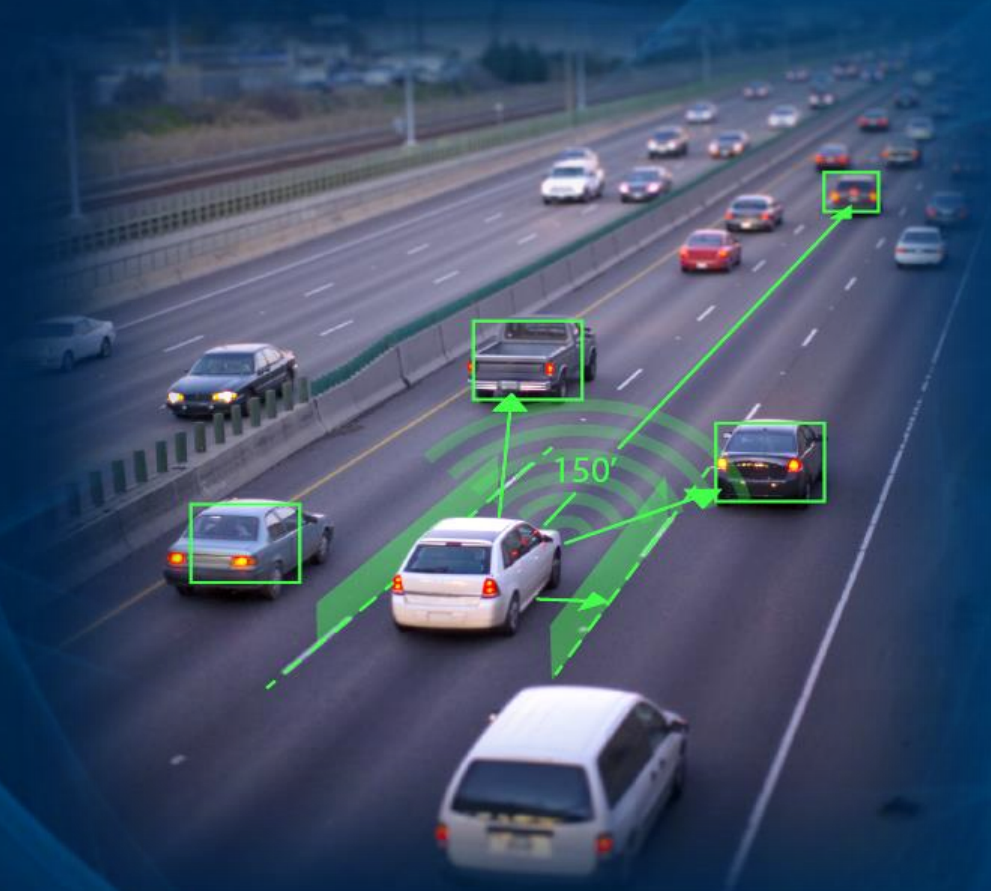
# Rapidly evolving driver mentality




Most cars today

| | Alone | Carpool / Ridesharing |
|---|---|---|
| Autonomous | **Ford** **GM** **BMW** | Lowest $$$ per mile |
| Manual | Highest $$$ per mile | **Uber** **Lyft** |



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# Automotive ecosystem disruption enroute to autonomous vehicles

- What we see
  - OEMs frustrated by 7-year product development cycle
  - OEMs challenged by 2-year consumer product development of new entrants
  - AV demands higher data rates and higher performance density
  - ECUs must be smaller, lighter, lower power and cost, more integrated and reliable

New ICs and packages decrease:
- ECU/board size
- ECU/board power
- ECU/board BOM
- ECU/board weight

New ICs and packages increase:
- Performance
- Differentiation
- Reliability, security
- Security of supply

MEMS, silicon photonics, and wireless create opportunities



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# Cadence automotive IP

## Digital radio and voice command

Multi-microphone voice command, and noise reduction


Multi-channel audio decode and advanced post processing

Acoustic noise cancellation

Digital Radio receiver: HD Radio, DAB, DAB+, DRM, T-DMB

## Embedded signal processing

**Battery management**

Regenerative power management

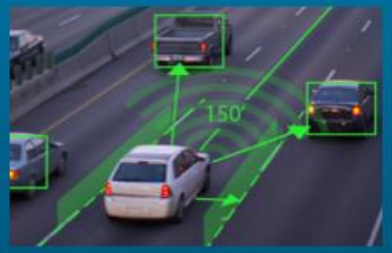
Engine control

Cabin environmental control

## ADAS Vision processing

**Advanced Driver Assistance Systems**

Traffic sign detection / recognition




Lane-departure warning

Front-collision warning

Automatic high beam

## Telematics connectivity / Radar

Emergency Services

GPS

Peer-to-peer smart car networking for intelligent vehicle highway control

Built-in LTE Modem and WiFi Access Point

Radar/Lidar



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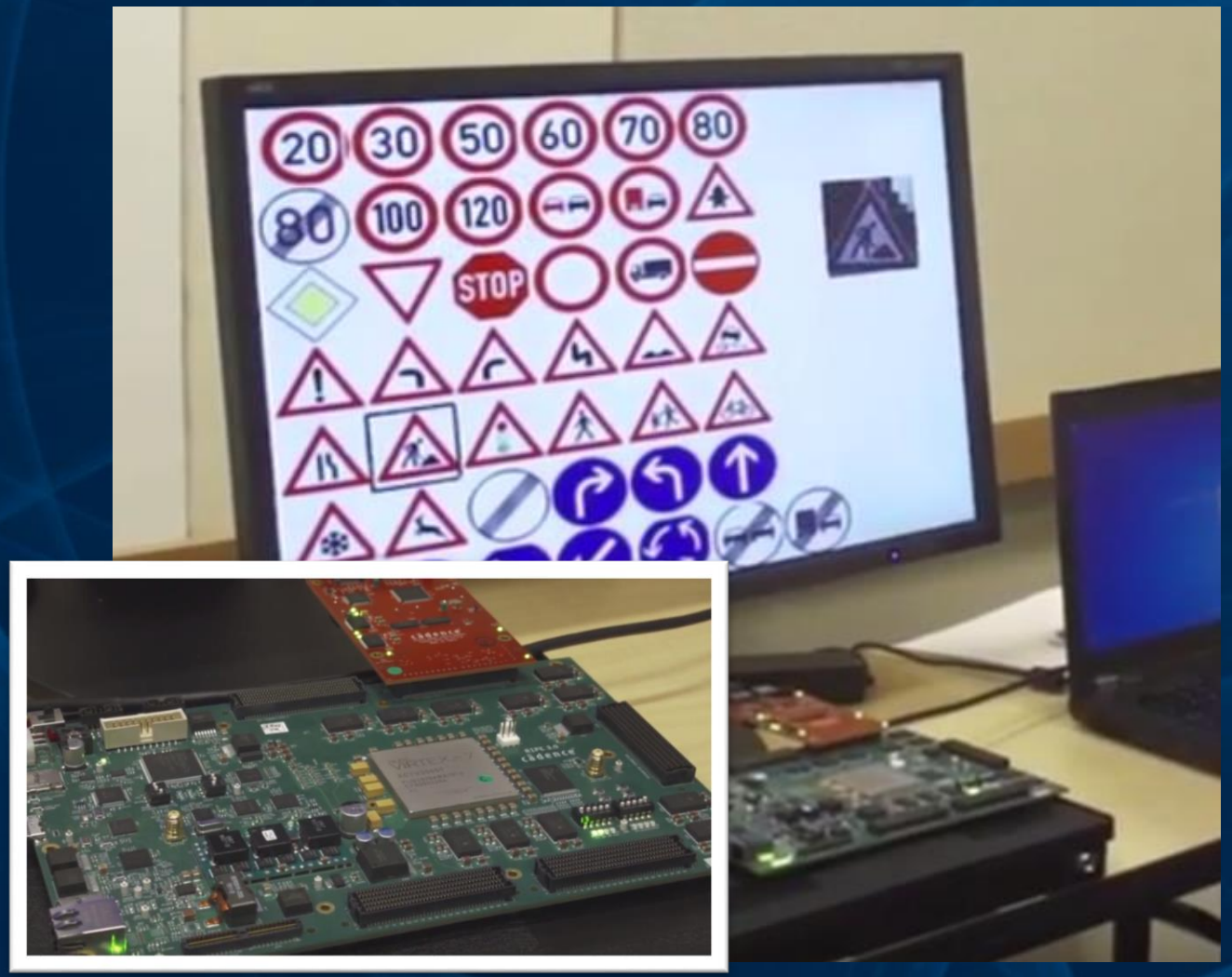
# Cadence – industry's highest scoring German traffic sign recognition




Artificial intelligence DSPs provided by Cadence Tensilica IP

- Machine learning
- Analyze big data
- High-performance computing
- Leverage statistical methods
- Pattern recognition
- Automated decision making

**German Traffic Sign Recognition Benchmark (GTSRB)**

CNN - compares 51840 input signs with 43 trained signs
→ 99.82% detection rate (human 99.22%)!

**CNN** Convolutional Neural Networks



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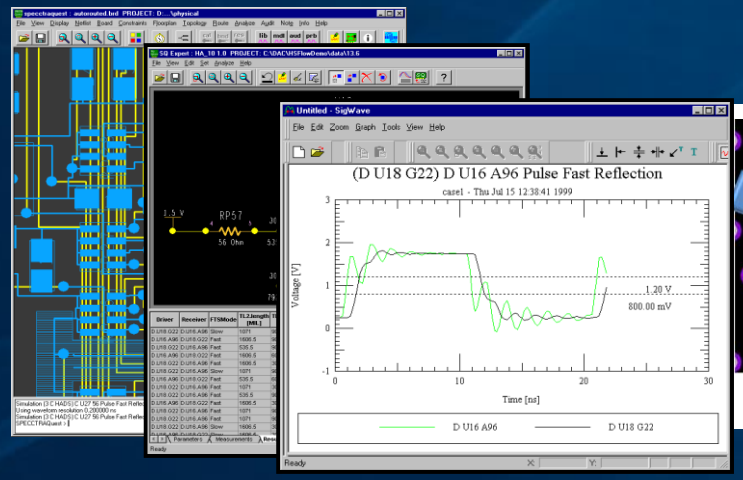
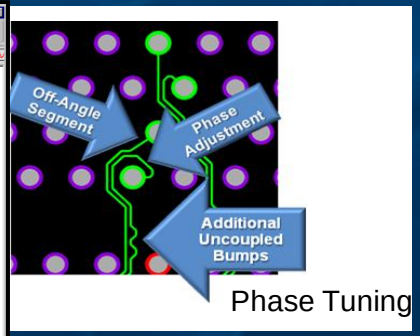
# Automotive PCB design and analysis

*MathWorks*

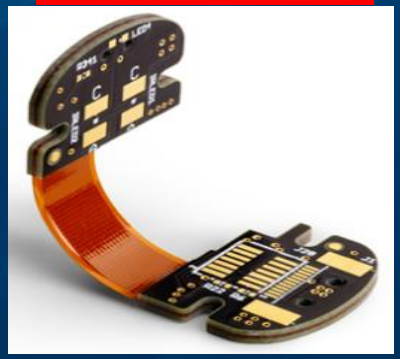



*ARROW*




Phase Tuning

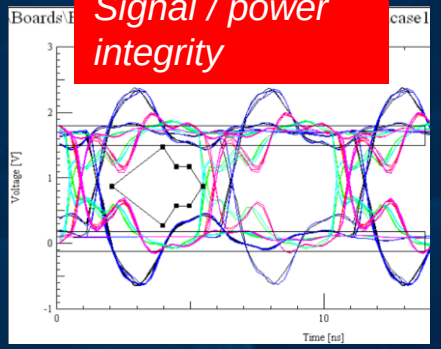
*Flexible design*



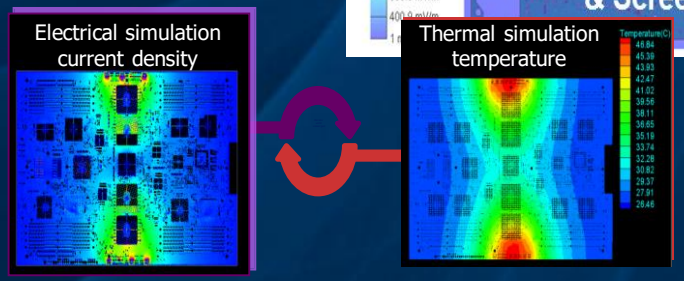
*ptc*
*Dassault-Systemes*
*SIEMENS PLM*

*Electromagnetics integrity*


*Signal / power integrity*




*Thermal integrity*





***"Cadence Sigrity™ technology dramatically reduced EMI/EMC testing time. And our product went to market much faster."*** **Imran Shak - Hyundai**



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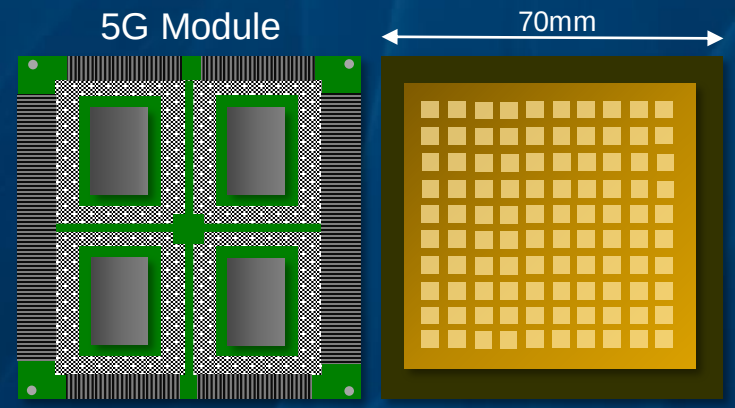
# Automotive 5G / wireless design technologies

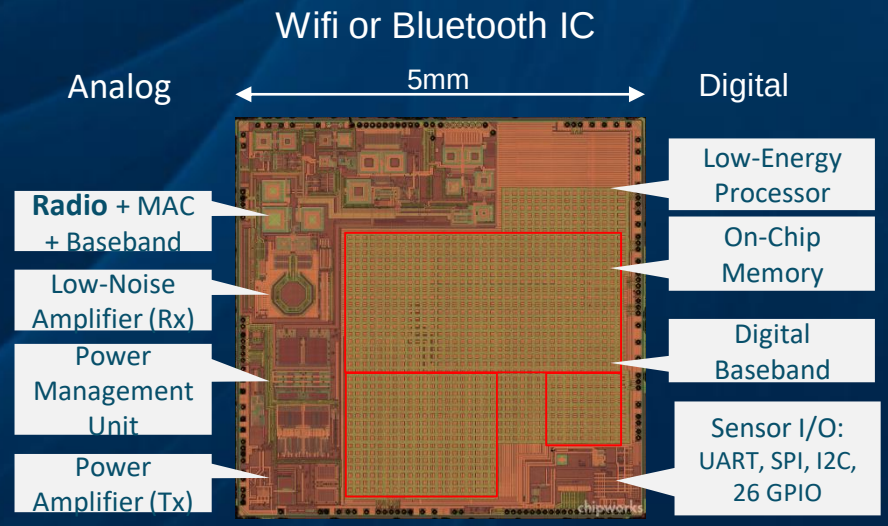
## Wireless is a rapidly emerging opportunity for suppliers

- V2X: for 25Gb of data per car per hour
  - Neural net training coefficients (1M-1B weights) download from data center
  - Sensor data upload to data center
  - HD maps download from data center
- WiFi: for in-car passenger streaming
- Drive-by-wireless: for lower cable weight and cost
  - Eliminate failure points associated with wire and connectors
  - Remove wiring installation costs
  - Simplify design of vehicle variants




4 monolithic silicon ICs on the bottom of the module

Dual-polarized antennas on the top of the module




Picture ©Chipworks



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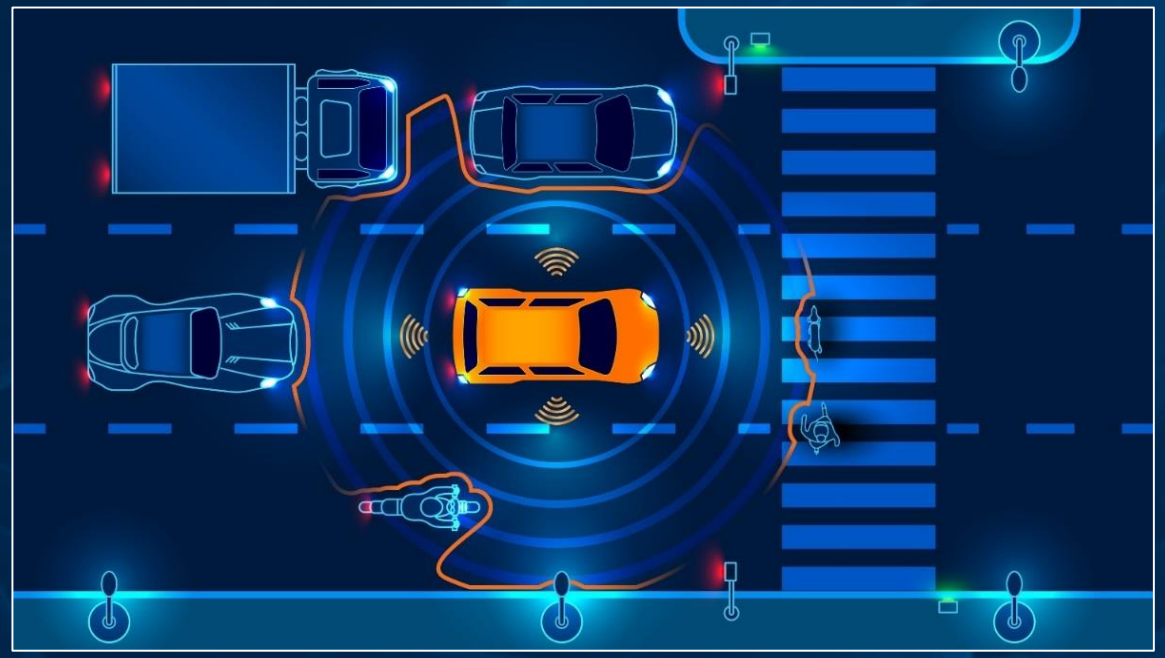
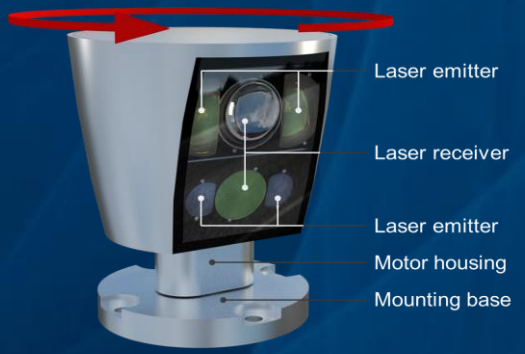
# Bringing it all together
## Example: Automotive ADAS/AV LiDAR

- Alternative / addition to cameras and radar

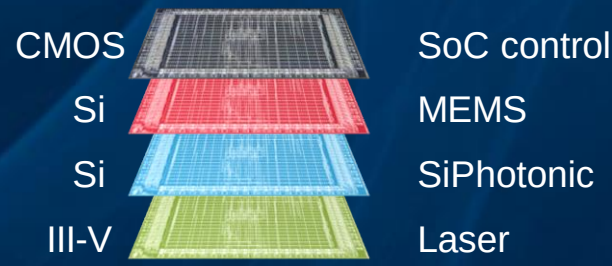


- Solution: Cadence integrated platform for multi-fabric design / DSP beamforming offload
  - MathWorks beamforming algorithm toolkit

Today: $80K rotating roof-top box




**Soon: <$100 solid-state technology**




**Example: 3/4-die SiP Lidar**



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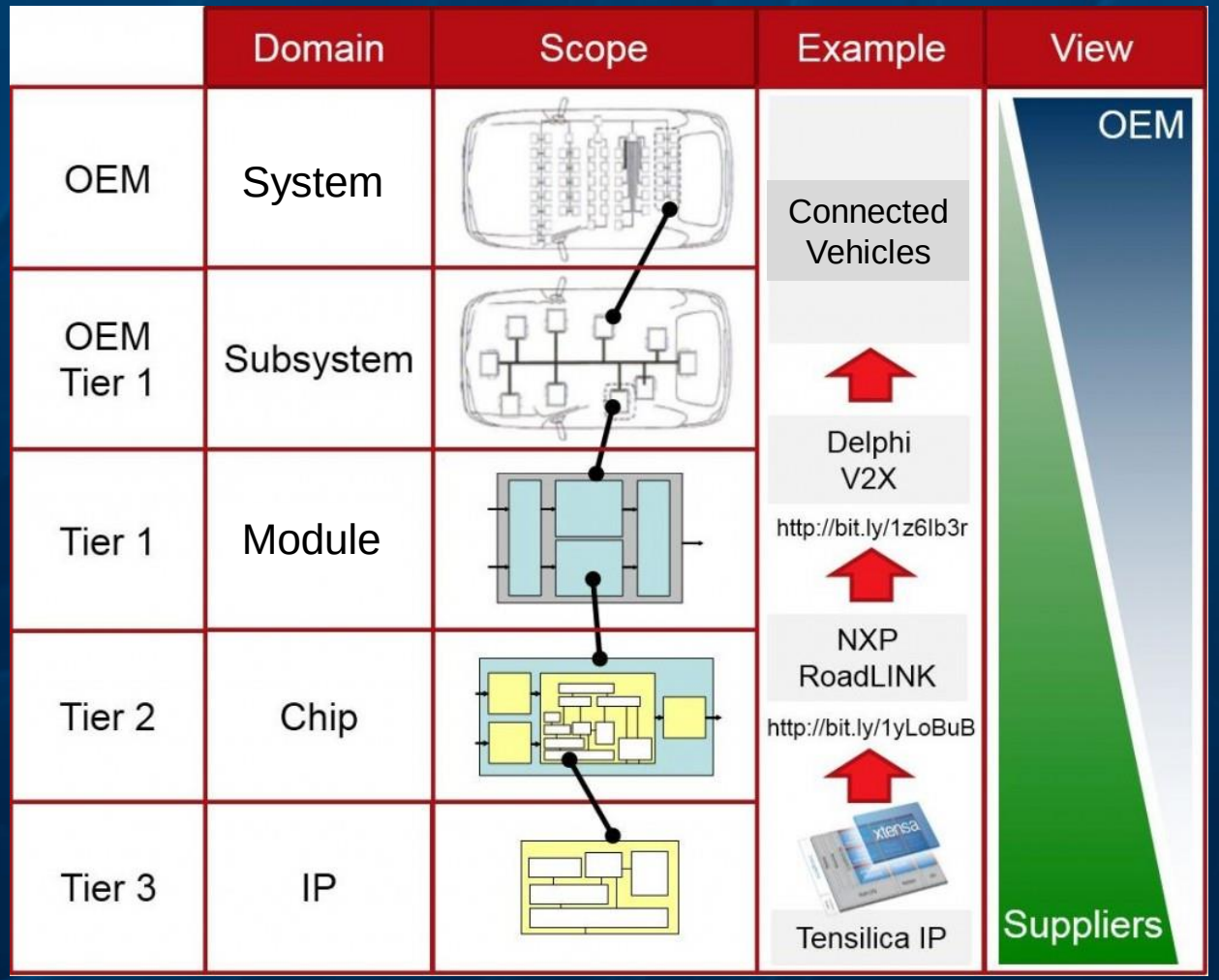
# Cadence System Design Enablement

## "Chips to systems"

- System design authoring
- Rules-driven design, metric-driven verification
- Power-aware budgeting, electrical verification and signoff
- Co-design / analysis across silicon/package/board
- MCAD/ECAD board, system assembly, connectivity and reliability co-design
- Design / supply chain collaboration
- WIP product design data management with enterprise PLM

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*“I shall be telling this with a sigh*

*Somewhere ages and ages hence:*

***Two roads diverged in a wood, and I —***

***I took the one less traveled by,***

***And that has made all the difference.”***

**The Road Not Taken, 1916**

**Robert Frost, American Poet**