ANALOG DEVICES

AHEAD OF WHAT'S POSSIBLE™

Sensing Technologies for an Autonomous Tomorrow

STEWART SELLARS

GENERAL MANAGER, LIDAR

Analog Devices Inc.

Nvidia GTC

March 18, 2019

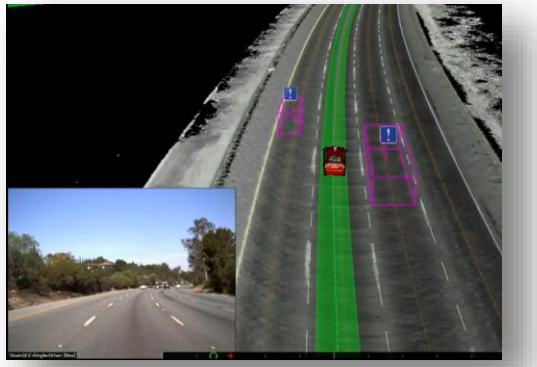
VISION ZERO

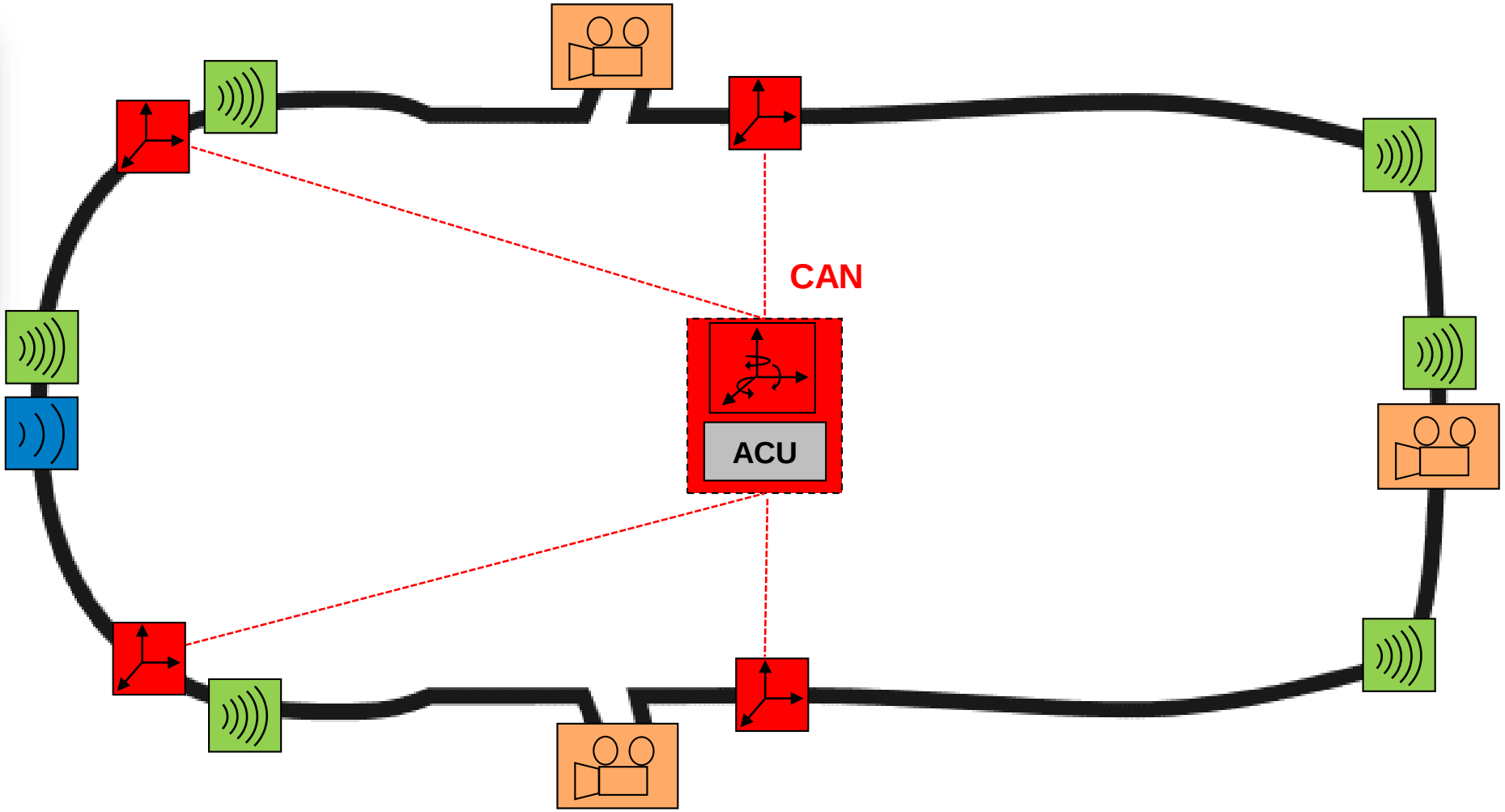
Ø Vehicle Occupants Killed or Seriously Injured in a Vehicle

Pedestrians Killed or Seriously Injured by a Vehicle

From ADAS…
Perception & Navigation Safety Sensing Systems **TODAY**

Drive360™
AUTONOMOUS DRIVING SOLUTIONS





- Camera
- MEMS/IMU
- LIDAR
- RADAR
- Ultrasound

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…to Autonomous Driving
Perception & Navigation Safety Sensing Systems **TOMORROW**

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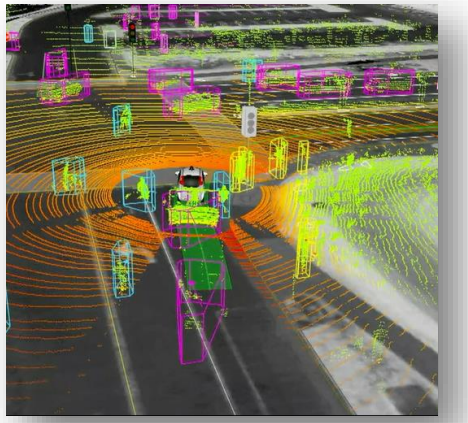
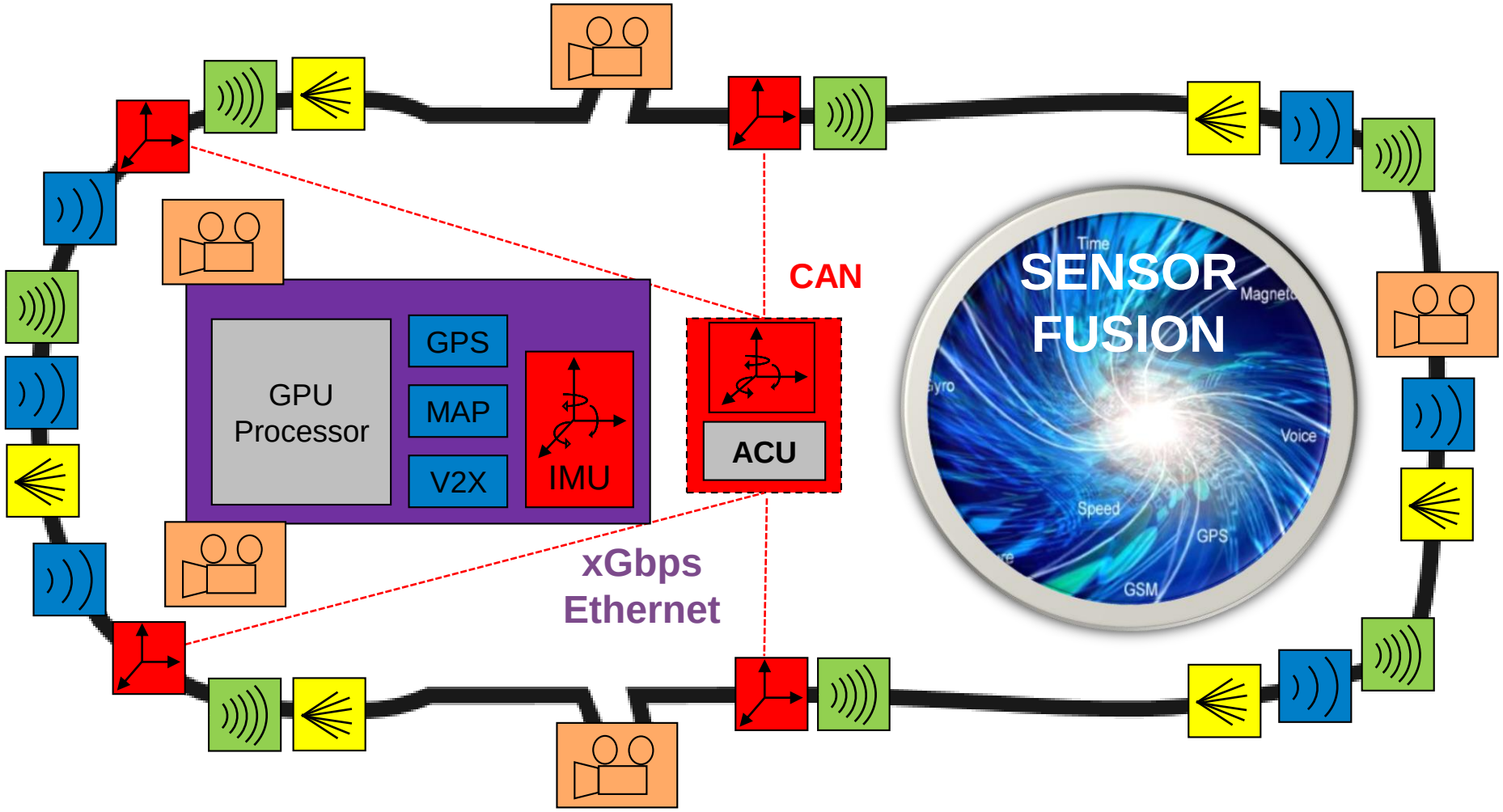
AUTONOMOUS DRIVING SOLUTIONS





- **Camera**
- **MEMS/IMU**
- **LIDAR**
- **RADAR**
- **Ultrasound**

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Consumer Sentiment towards Autonomous Driving

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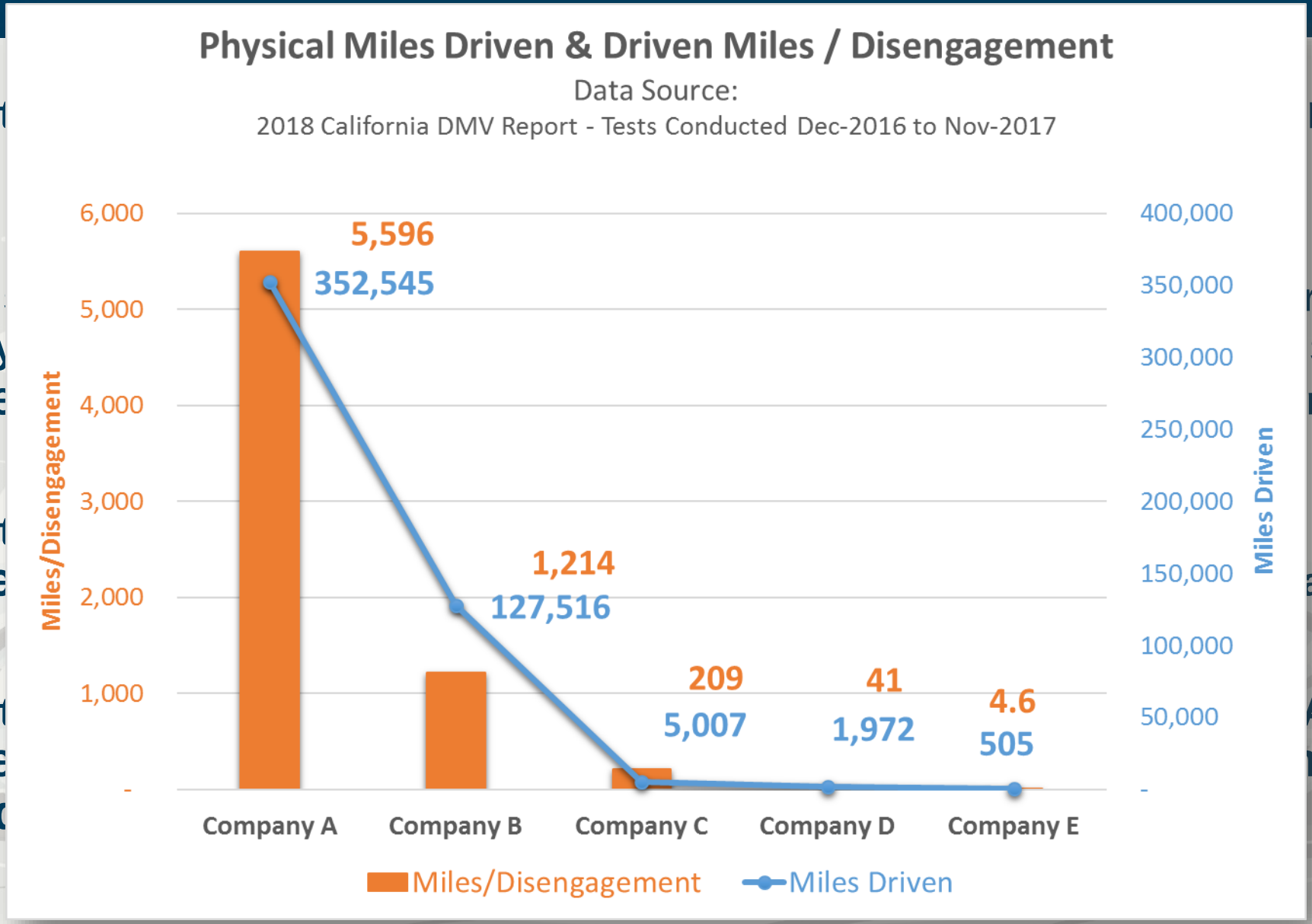
- According t… net users are likely …
- In a pair of … ry 2018) and Gallup (May … self-driving ve… ne.
- According t… 70% of pe… ars.
- According t… AHAS), 59% of pe… han-controlled …



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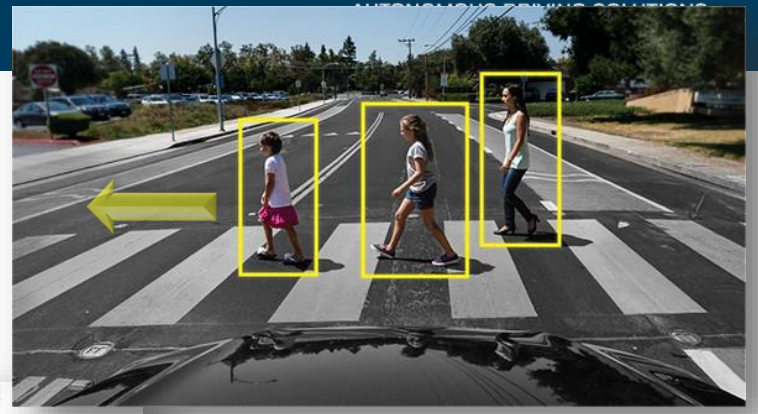
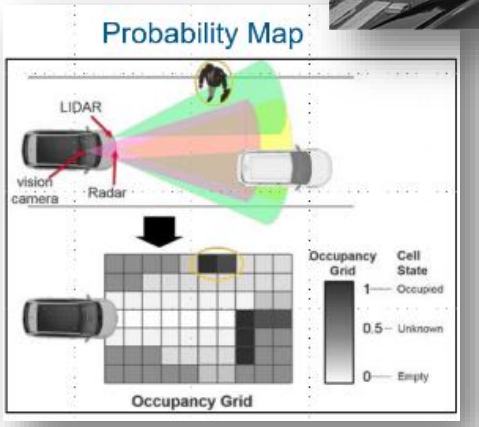
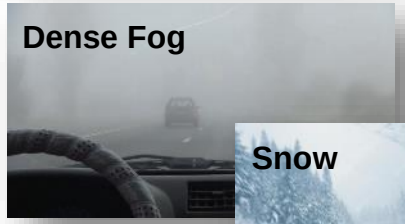
Some Key Use Case Problems
Sensing Technologies must address these Challenges

- **Reliably calculate Lateral Velocity at a Low Latency**
- **Creation of a 3D, Dense Occupancy Map**
- **Urban Canyon & Tunnel Navigation**
- **Reducing / Removing Effects of Weather on Driving**
- **Increasing the Speed Envelope of Use Cases**







Perception Sensors for Autonomous Driving

A single sensor cannot do the entire job!

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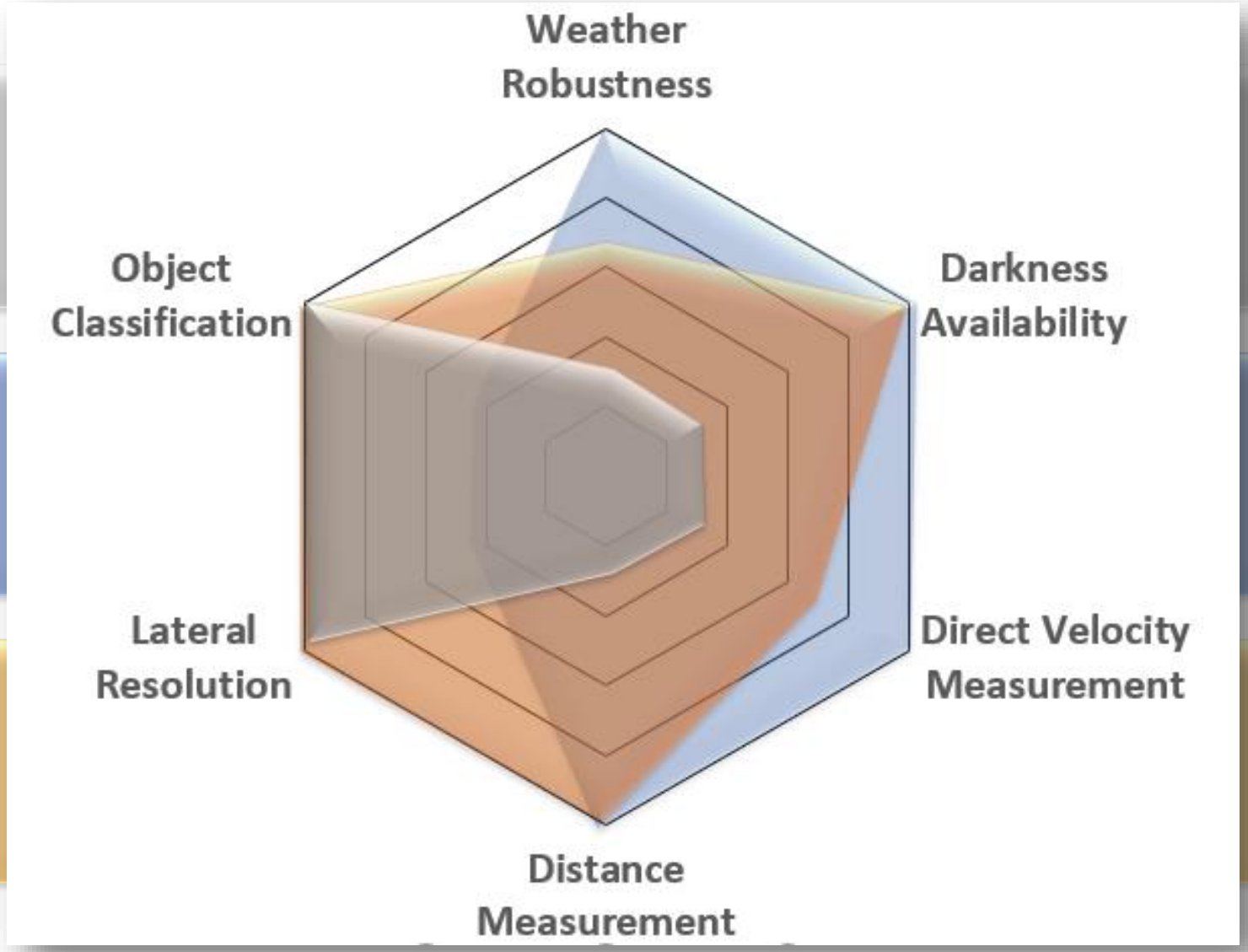

Vision
Cameras
& Software

RADAR
Radio Detection
and Ranging

LIDAR
Light Detection
and Ranging

* Source: dSPACE Technology Conference 2017

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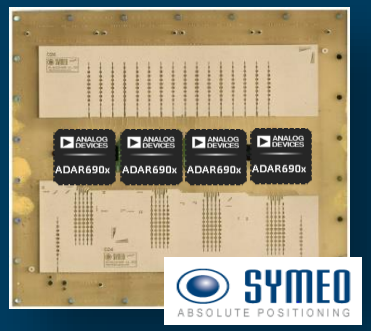
Automotive RADAR

28nm CMOS Technology Platform
for 77/79GHz Applications



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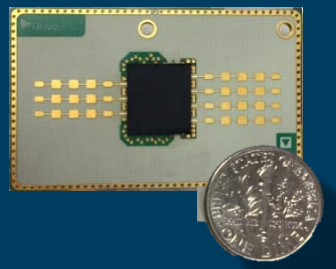
AUTONOMOUS DRIVING SOLUTIONS

Industry Leading RADAR Solutions
for ADAS and AV Applications

- ✓ **15+ YEAR OF HISTORY IN AUTOMOTIVE RADAR**
- ✓ **ADI CONTENT IN 50% OF WW RADAR MODULES**
- ✓ **OVER 6000 AUTO QUALIFIED & RELEASED PARTS:**

TX/RX, AMPS, ADCS, MEMS, DSPS, REGULATORS, CONVERTERS



Over 300 Million ADI components shipped into automotive RADARs

Enabling Autonomous Driving: Imaging RADAR

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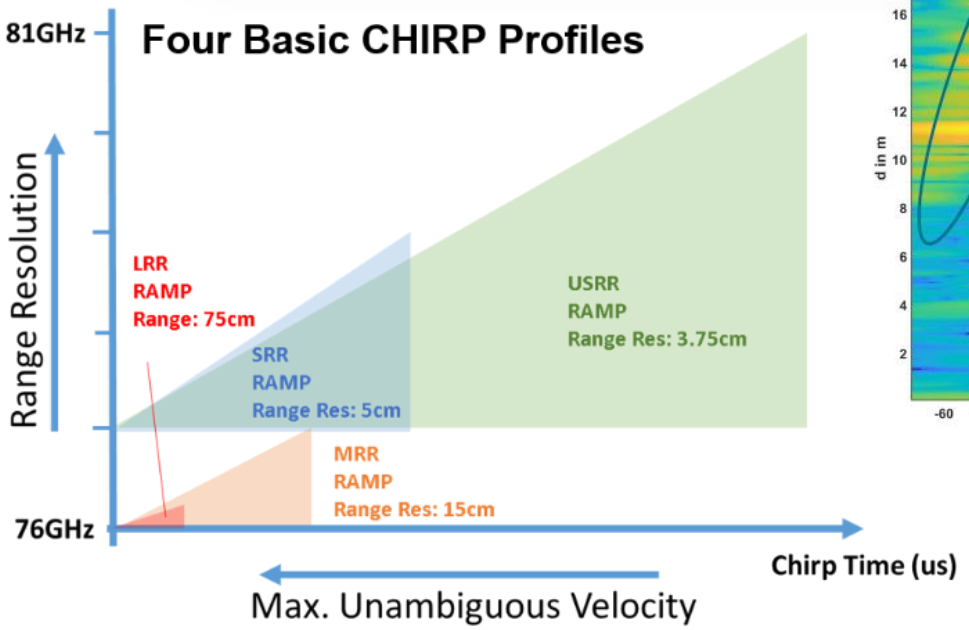
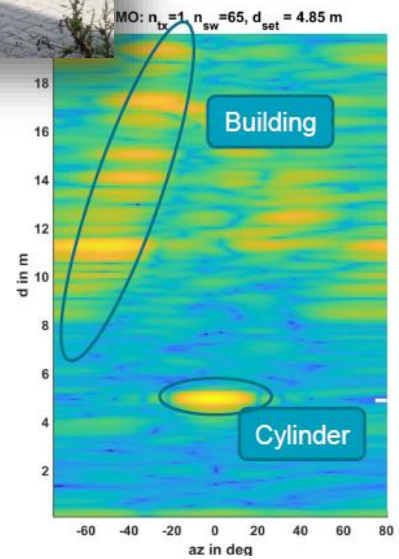
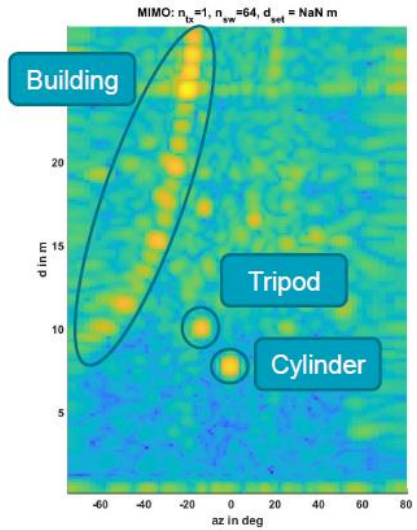
Imaging RADAR Requirements for Autonomous Driving:

- High resolution in both azimuth and elevation (push to 1° and beyond)
- Significant performance improvement by cascading multiple sensors together
- Fast, Configurable “Chirps”
- Scalable solution that works USRR→LRR







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Automotive Inertial MEMS

High Performance Navigation, Guidance & System Health

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HIGH PERFORMANCE INERTIAL MEMS
for Autonomous Driving

ADI *i*Sensor® portfolio of high performance IMUs achieve unrivaled performance:

<2°/hr gyro drift and up to 10 degrees of freedom

Sensor Fused Dead-Reckoning
Accurate, Dynamic Navigation Aid during GPS Blockage and Uncertainty

Enabling Autonomous Driving: Inertial Measurement Units

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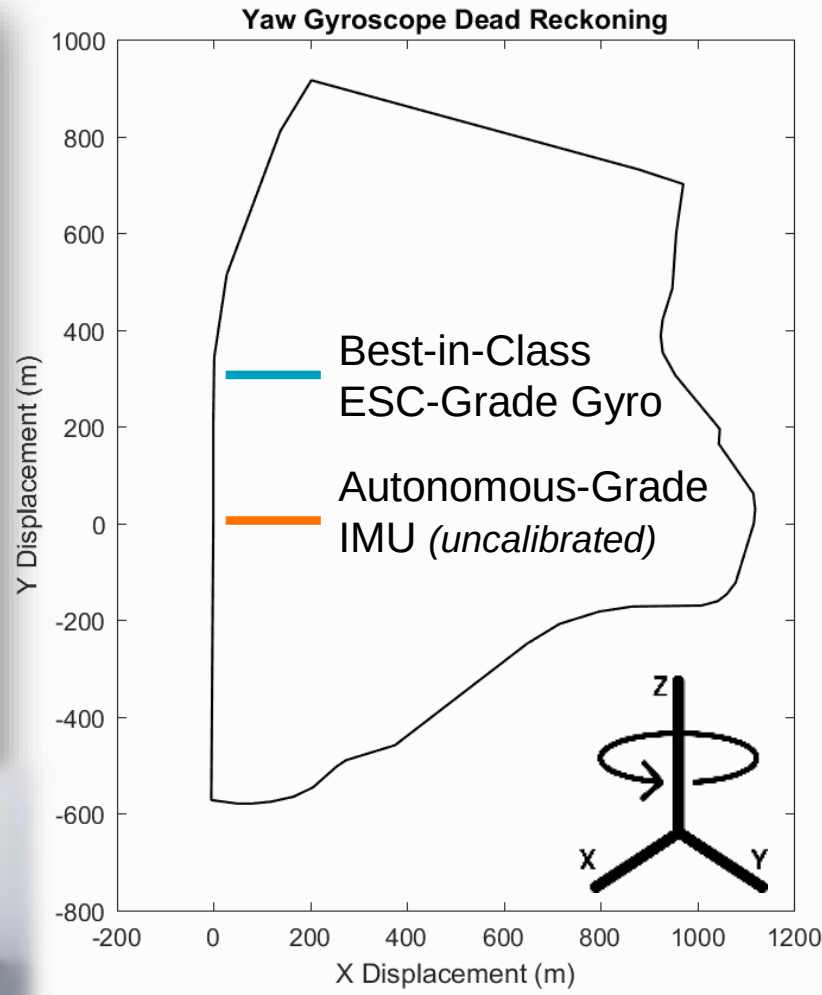
AUTONOMOUS DRIVING SOLUTIONS

- **IMU critical to autonomous-grade navigation and guidance systems**
- **Fuse with precision map, GPS, and perception sensors for SLAM**
- **Impervious to environmental conditions**
  ….*Gravity is Constant!*



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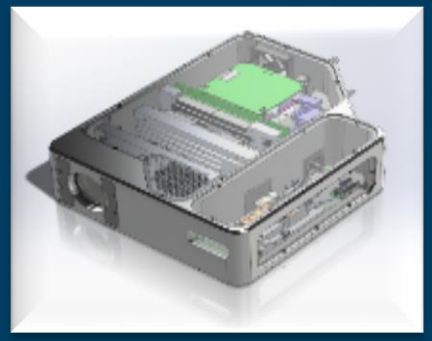
AUTOMOTIVE LIDAR

PERFORMANCE LEADING ELECTRONICS SUPPLIER FOR LIDAR APPLICATIONS



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Long Range LIDAR
for Autonomous Driving

System Level Expertise

- ✓ ***System Architecture Expertise - coherent, direct detect, 900 vs 1500nm***
- ✓ ***Component → Integrated Offerings – high resolution AFE, laser drivers, high performance ADCs, TIAs, power etc***

Short/Mid-Range (20-50m): Flash & ToF Solutions

- ✓ ***Integrated, High Performance, Low Power***
- ✓ ***Full System Solution***

Enabling Autonomous Driving: LIDAR

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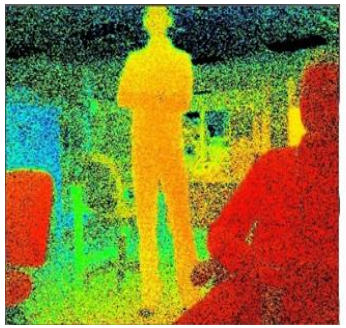
- **Variety of demo systems have been developed to showcase ADI technology**
  - Medium range low resolution
  - Medium range high resolution
  - Long range scanning

- **ADI approach is to use system understanding to offer components that provide system level differentiation**

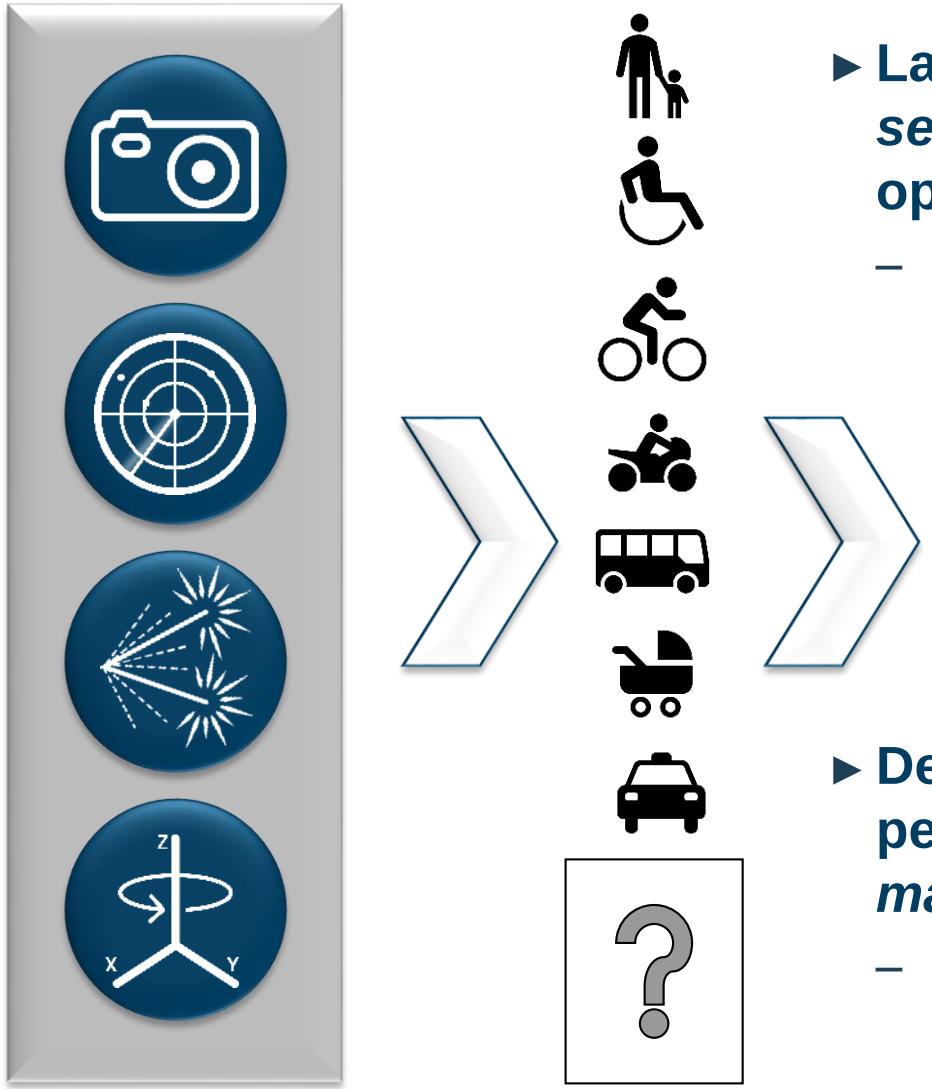


Depth Mapped Image

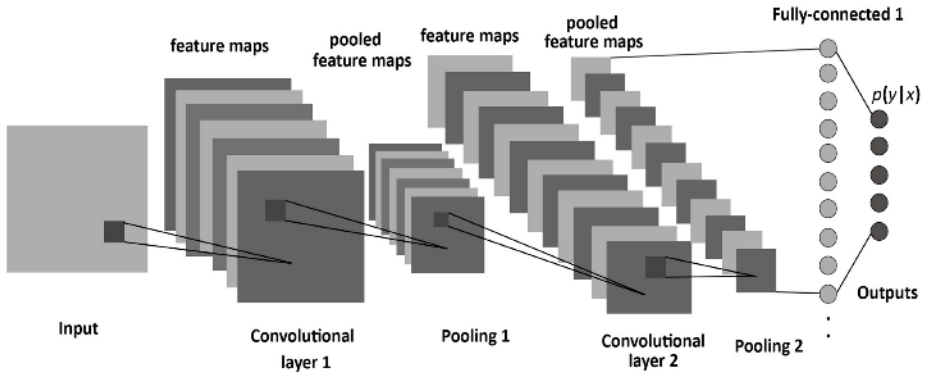
RGB Color Image

- **Product strategy that can support various LIDAR architectures**
  - Direct detect ay 9xxnm
  - Direct detect at 15xxnm
  - Coherent system at 15xxnm

Garbage-In → Garbage-Out
AI with High Performance Perception & Navigation Sensors



- **Large amounts of data collection with *high quality sensors* is a must for AI training and optimized operation**
  - Not all sensors can provide this level of fidelity



- **Deep Convolutional Neural Networks trained with high performance sensor data result in *more robust decision making* and *safer operation of the vehicle***
  - Higher resolution sensor data supports *more accuracy* in object detection, tracking and classification

A Changing Landscape

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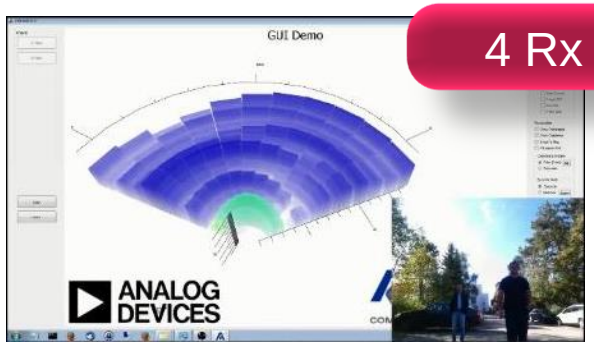
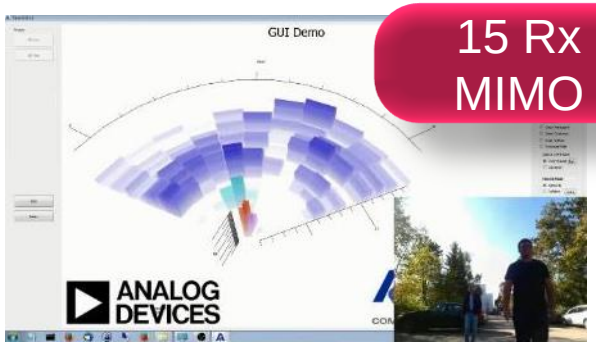
Performance is Needed!

Example:
7xGHz Imaging RADAR



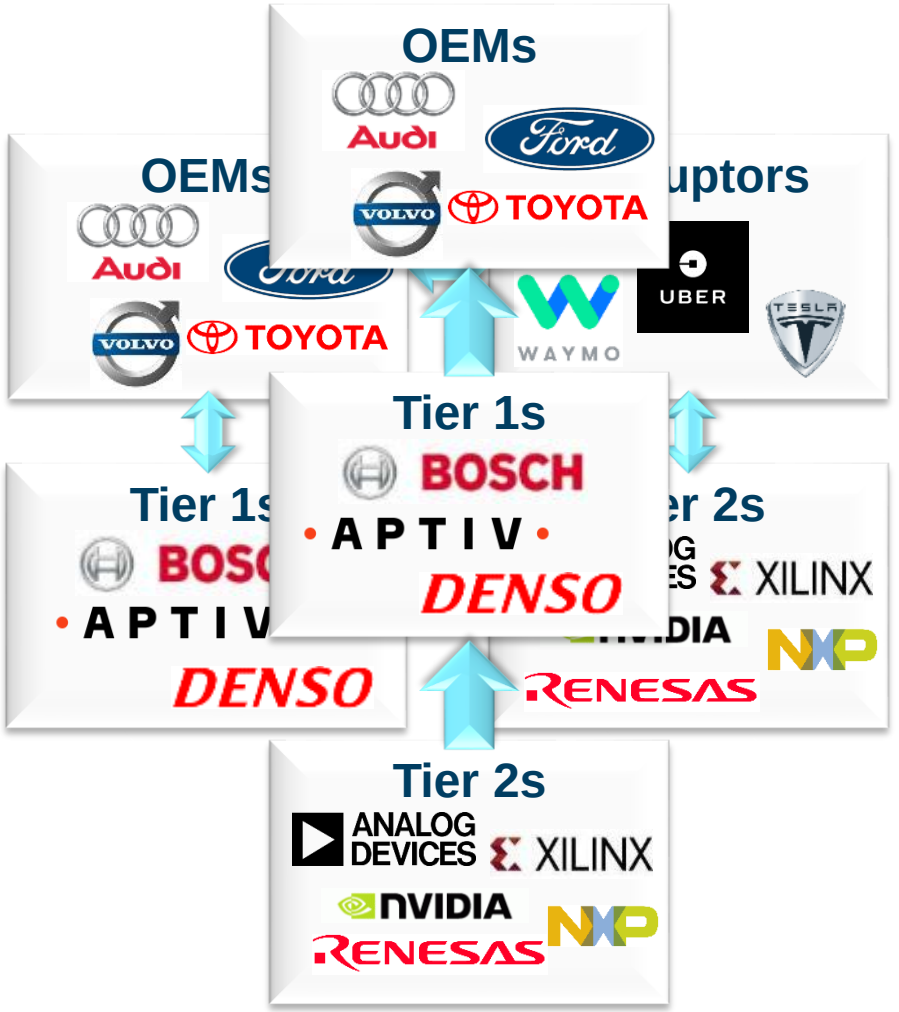
4 Rx



15 Rx MIMO

Micro-Doppler and System Level Features enable High Quality AI Algorithms

Industry is Evolving!



We Cannot Do It Alone!

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Thank You

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