CONNECTED AND AUTOMATED VEHICLES
Derek Caveney, Toyota Technical Center
Motivation for Automation

Zero casualties from traffic accidents.

The motivation and priorities differ by OEM.
Toyota develops technologies based on our “Integrated Safety Management Concept” to enable Zero Casualties.

- **Risk Avoidance**
  - Highly-automated Driving
  - Driver Education & Planning

- **Risk Reduction**
  - Pre-Collision Automation
  - Warning and Avoidance Automation

- **Injury Mitigation**
  - Structure & Restraints

- **Collision Mitigation**
  - Active-Passive
  - Advanced Driving Assist Systems a.k.a. Active Safety

- **Collision Avoidance**
  - Connected Automation
  - Human Machine Interface
Key Enablers for Zero Casualties

Automation and connected technologies reduce collision risks for drivers.

Driving Automation Technology

Cooperative Driving Technology

Increase lateral and longitudinal safety margins

Reduce driver’s workload and provide “Peace of Mind”
Why Automated Technologies?

Many enablers are available on today’s production vehicles

- Advanced Pre-Collision System
- All-speed Dynamic Cruise Control
- Active Ped. Detection with IR and Stereo Camera
- Lane Departure Alert
- Lane Keep Assist
- Blind Spot Monitor with Rear Cross Traffic Alert

Widely available through government and industry initiatives.

Japan NCAP

EuroNCAP

NHTSA NCAP

IIHS TSP+

NCAP = New Car Assessment Program

IIHS = Insurance Institute for Highway Safety

TSP = Top Safety Pick
Toyota Deploying Active Safety at Low Cost to Customers

Almost all models and all trim levels by end of 2017

- Automated Emergency Braking
- Lane Departure Warning
- Automated High Beams
- Pedestrian AEB
- Adaptive Cruise Control

$500
$300

Mar. 2015 Announcement
Why Connected Technologies?

Share information to avoid collisions

Collision Mitigation ➔ Collision Avoidance

Share decision making

Avoid Risk ➔ Coordinate Actions

…… longer range and non-line of sight detection and **cooperative** decision making

Feb. 2014 Announcement

TOYOTA
Dedicated Short Range Communications (DSRC) have been used in Japan V2I for over 5 years.

Using 5.8GHz

Ministry of Land, Infrastructure, Transport and Tourism (MLIT)

DSRC for low-latency V2I-safety applications
Intersection V2I products available today in Japan.

From IR
- "Red light" warning
- Probability of running a red light detected
- Warning red light
- Traffic signal information received

From 760MHz
- Vehicle detection sensor
- Pedestrian detection sensor
- ITS wireless device
- National Police Agency (NPA)

National Police Agency (NPA)
V2V (760MHz) will be deployed by Toyota in 2015.

Communicating Radar Cruise Control
NHTSA plans to mandate V2V installation to new cars.

2001-2004
CAMP VSC
DSRC Safety

2006-2009
CAMP VSC2
V2V & V2I Safety

2006-2008
VII Consortium
V2I Mobility

2010-2014
CAMP VSC3
V2V Safety

2011-2013
Driver Acceptance Clinic
Model Deployment

Ann Arbor MI
Safety Pilot

8/20/2014
NHTSA issued
ANPRM for
FMVSS 150

5.9GHz DSRC
Device for All New
Vehicles
(no application
requirements)

Research
Ford, GM, Honda, Hyundai, Mercedes-Benz, Nissan, Toyota, and VW prepared test 64 vehicles (8 each).

2,836 DSRC Vehicles
- 64 OEM vehicles
- 2000 Awareness Devices
- 300 Aftermarket Devices
- 100 University Vehicles
- 103 Transit Buses
- 72 Commercial Trucks

29 Roadside DSRC
- 21 intersections
- 3 curves
- 5 freeways
University of Michigan Mobility Transformation Center will be a leader in US testing and deployment for next 7 years.

2014~ : Ann Arbor Connected Vehicle Test Environment
9,000 equipped vehicles

2015~ : Southeast Michigan Connected Vehicle Deployment
20,000 equipped vehicles

2016~ : Ann Arbor Automated Vehicle Field Operational Test
2,000 connected and automated vehicles

MTC Leadership Circle companies are Delphi, Denso, Econolite, Ford, General Motors, Honda, Iteris, Nissan, Bosch, State Farm, Toyota, Verizon and Xerox
DSRC and 4G LTE soon built into North America vehicles.

5.9GHz V2V (with OnStar 4G LTE, from AT&T)

2017 Cadillac CTS will introduce 5.9GHz V2V

GM CEO Mary Barra Sept. 7th 2014

4G LTE Share: Global Embedded Telematics Sales

Ref: IHS Sept. 2014

4G LTE enables Software OTA updates, including V2X security certificates.
Connected: More than just DSRC….

Continental working with IBM, Cisco, and HERE to provide dynamic e-horizon and OTA updates.

4G LTE for longer-range (>1km)

dynamic information
Connected: Traffic lights are already coming online

ConnectedSignals working with cities to publish their traffic light phase and timing

City Servers
↓
Connected Signals Servers
↓
Vehicle

Mobile Device

In-vehicle Display

Portland, Oregon

Competing technology for DSRC
Combining Automated and Connected – The competition is on!

Tesla already provides OTA software updates to their Autopilot features. Release 7.0 to have Highway Autopilot

Tesla sells sensor hardware to enable Autopilot features and then releases software updates for adaptive cruise control, lane centering, blind spot monitoring, and Valet parking

Model S Meter Display with Surrounding Vehicles and Autopilot Status

Model S has forward camera, forward radar, and 12 ultrasonics
GM’s automated highway driving system “Super Cruise” and Audi’s traffic jam pilot to be introduced in the US.

Super Cruise

2017 Cadillac CT6 will introduce Super Cruise

Traffic Jam Pilot

2018 Audi A8 will introduce Traffic Jam Pilot

Both technologies allow hands-free driving on the highway. Both technologies likely to use interior cameras to monitor the driver state.
Automated: Toyota’s Prototype

Automated Highway Driving Assist (AHDA) will come to the US market soon.
Automated: Toyota’s Prototype

Production-ready sensors and maps are used.

1. **Fusion of forward radar and forward camera**
   that supports both steering and speed control

- [Image of cameras]
- [Image of radars]
- [Image of Toyota Safety Sense (TSS) Sensors]
Automated: Preview Challenging Scenes

Preview scenes that might require manual steering. Allow ample time for the driver to take action calmly.

Concept

Map + GPS + Historical Database + Camera

Lane-specific preview of challenging scenes

Examples of challenging scenes

- Faded lane markers
- Exit Only lanes
- Merging traffic from left
Smooth transitions between automated and manual highway driving are enabled by Predictive HMI.

Prototype Display for Demonstration
NHTSA asked to define automation levels and test methods. US locations are being leased for autonomous vehicle tests.

1) Automation Level
2) Test Scenario

US is an international competition field. Ford, GM, Honda, Mercedes, Nissan, Toyota, VW, Bosch, Delphi, Continental are testing in US

NHTSA = National Highway Traffic Safety Administration
## Automated: Trend

**Competition shifted from research and advanced development to production**

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- **2015-2017 Production**: Tesla, GM, Mercedes Highway Autopilot
- **2017-2020 Production**: Tesla, Audi, Nissan Future Product Demonstration

*GM, Audi, Auto Valet Park, Ford, Others, Google, Nissan, BMW*
What does this mean to Powertrain Innovation?

Slope and curvature maps, high-resolution traffic, and real-time traffic signals information should be available.

1. In manual and automated driving, powertrain demands should be more predictable and less erratic
   - Known destinations can have a trip plan.
   - Known routes (e.g., commute) can be learnt, regardless if the destination is set by the human.
   - Unknown destinations will have good prediction on the short-term demand.

2. Car-sharing might lead to less knowledge about manual driving behaviors of an individual vehicle.

3. When in an automated mode, the demands should be smoother than when a human is driving.
Thank You