Future Infrastructure & Interstates

For TRB Future Interstate Study Panel on
Automated & Autonomous Passenger vehicles

Toyota Motor North America, R&D
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Our Goals

Provide joy and happiness through our automobiles to everyone.

Toyota Global Vision: Toyota will lead the way to the future of mobility, enriching lives around the world with the safest and most responsible ways of moving people.

Ultimate Goal: Zero casualties from traffic accidents.

And Beyond

New enabling technologies help create a better society.

A new mobility-based society

— A New Relationship Between People and Vehicle —

Automated Driving Technologies

AI

BIG DATA

Communications

Our Challenges

Better mobility with advanced driving assist systems

Safety

Aging Society

Environment

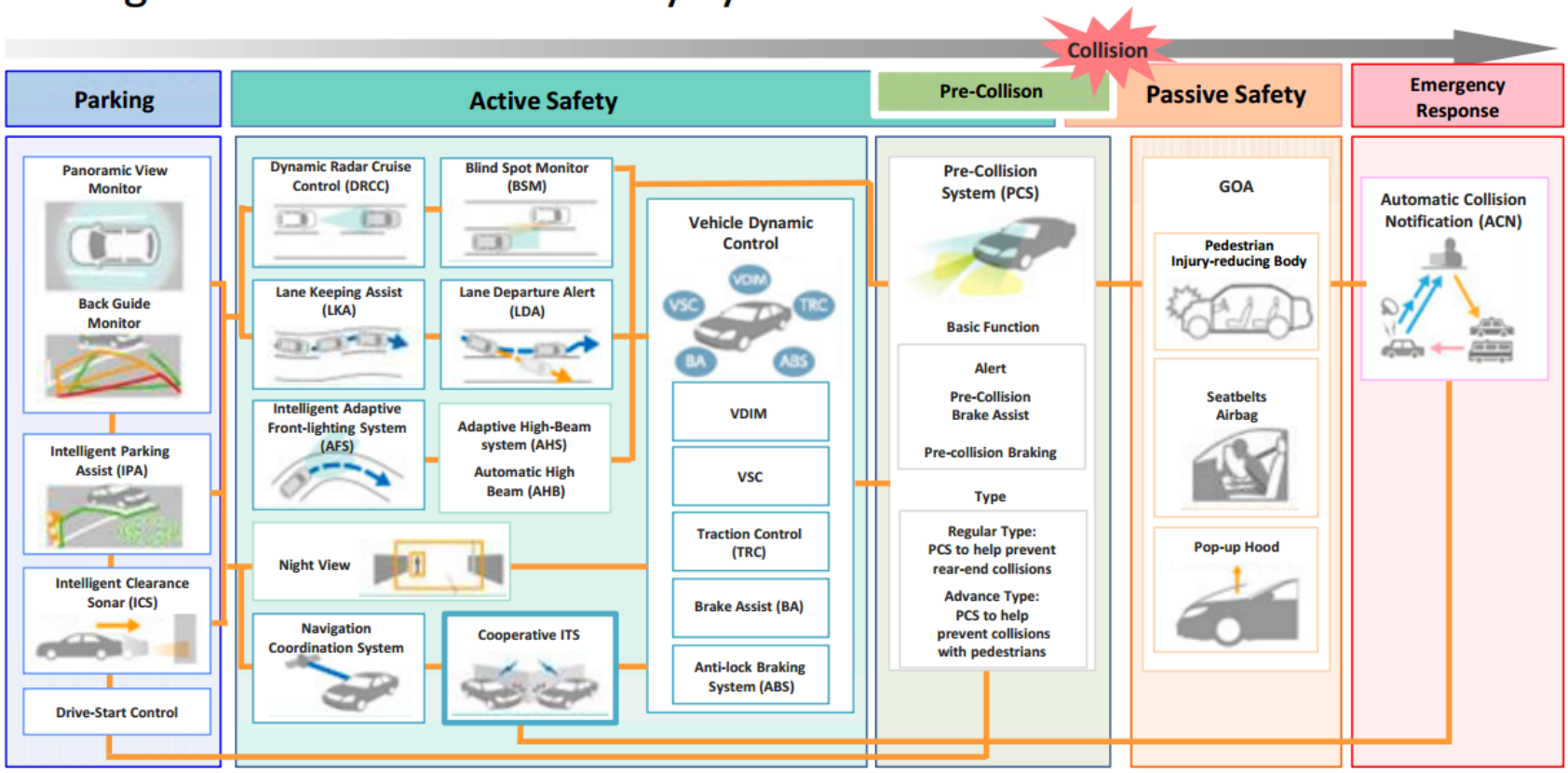
Realizing a society in which all people can enjoy safe and smooth freedom of movement

Integrated Safety Management

Apply multiple technical solutions to different stages of a crash

Optimal support for all driving situations

Integration of individual safety systems



ITS: Intelligent Transport Systems

VDIM: Vehicle Dynamics Integrated Management
VSC: Vehicle Stability Control
BA: Break Assist
ABS: Antilock Brake System

PCS: Pre-Collision System

GOA : Global Outstanding Assessment

http://www.toyota-global.com/innovation/safety_technology/pdf/toyota_integrated_safety_management_concept.pdf

Toyota Safety Sense

Five key ADAS features as standard on almost all models

Lexus and Toyota Will Make Automated Braking Standard on Nearly Every Model and Trim Level by End of 2017

http://corporatenews.pressroom.toyota.com/releases/lexus+toyota+automated+braking+standard+2017.htm

Advanced automatic safety technology that was once available on only the most expensive new vehicles is about to be included as standard equipment on almost every Lexus and Toyota model and trim level in the United States. Announced today at the New York Auto Show, Toyota will begin to include the ***Lexus Safety System +***™ and ***Toyota Safety Sense***™ packages, anchored by automatic emergency braking (AEB), on almost every new vehicle by the end of 2017.

Vehicle & Pedestrian Pre-Collision System

Dynamic Radar Cruise Control

Lane Departure Alert

Auto High Beam

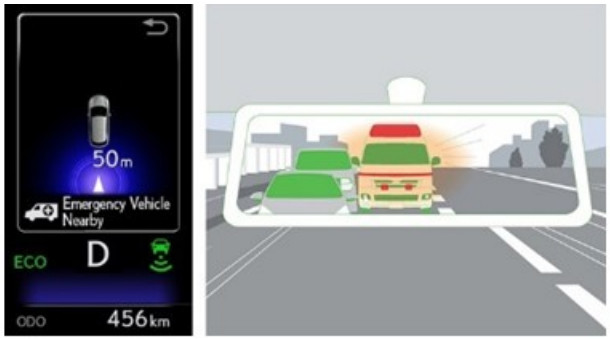
V2X Cooperative Systems

V2X product introduction has already started

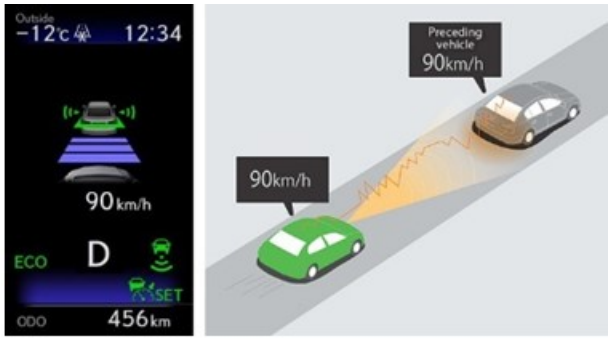
Examples of Toyota's V2X products (available in Japan since 2015)

iTS CONNECT

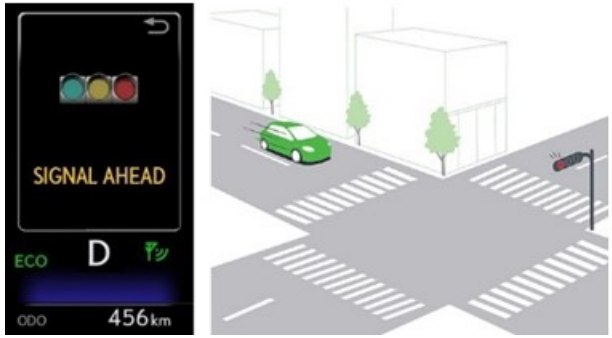
V2V Information



V2V Control Assist



V2I Alert



V2I Signal Info.

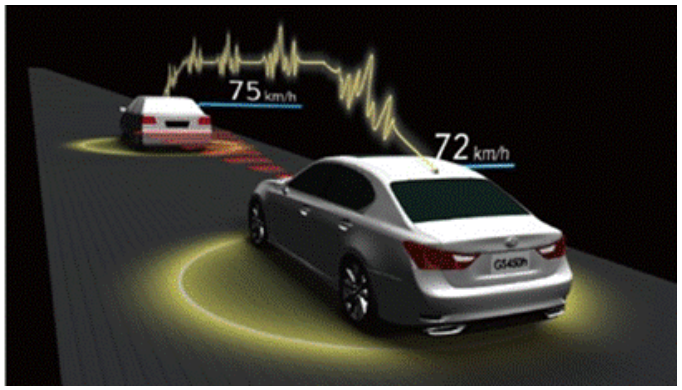
V2I Alert

http://toyota.jp/technology/safety/itsconnect/
http://www.toyota-global.com/innovation/intelligent_transport_systems/infrastructure/

V2X Cooperative Systems: C-ACC

"Connected technology helps the performance of driving assist.

"Communicating Radar Cruise Control" in Toyota/Lexus products (Japan)
Radar + Camera + V2V = Foundation for "Connected Automation"

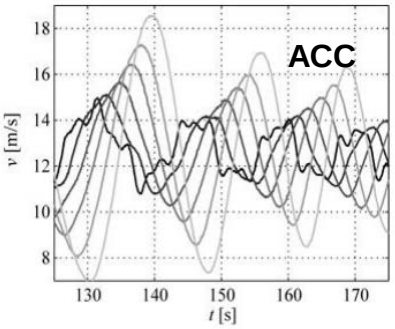


Cooperative Truck Platooning using V2V DSRC (US)
https://tti.tamu.edu/2016/12/01/follow-the-leader-two-truck-automated-platoon-test-is-a-winner-2/

USDOT Video
https://www.youtube.com/watch?v=D_2DPm9v-Lw

TNO Report

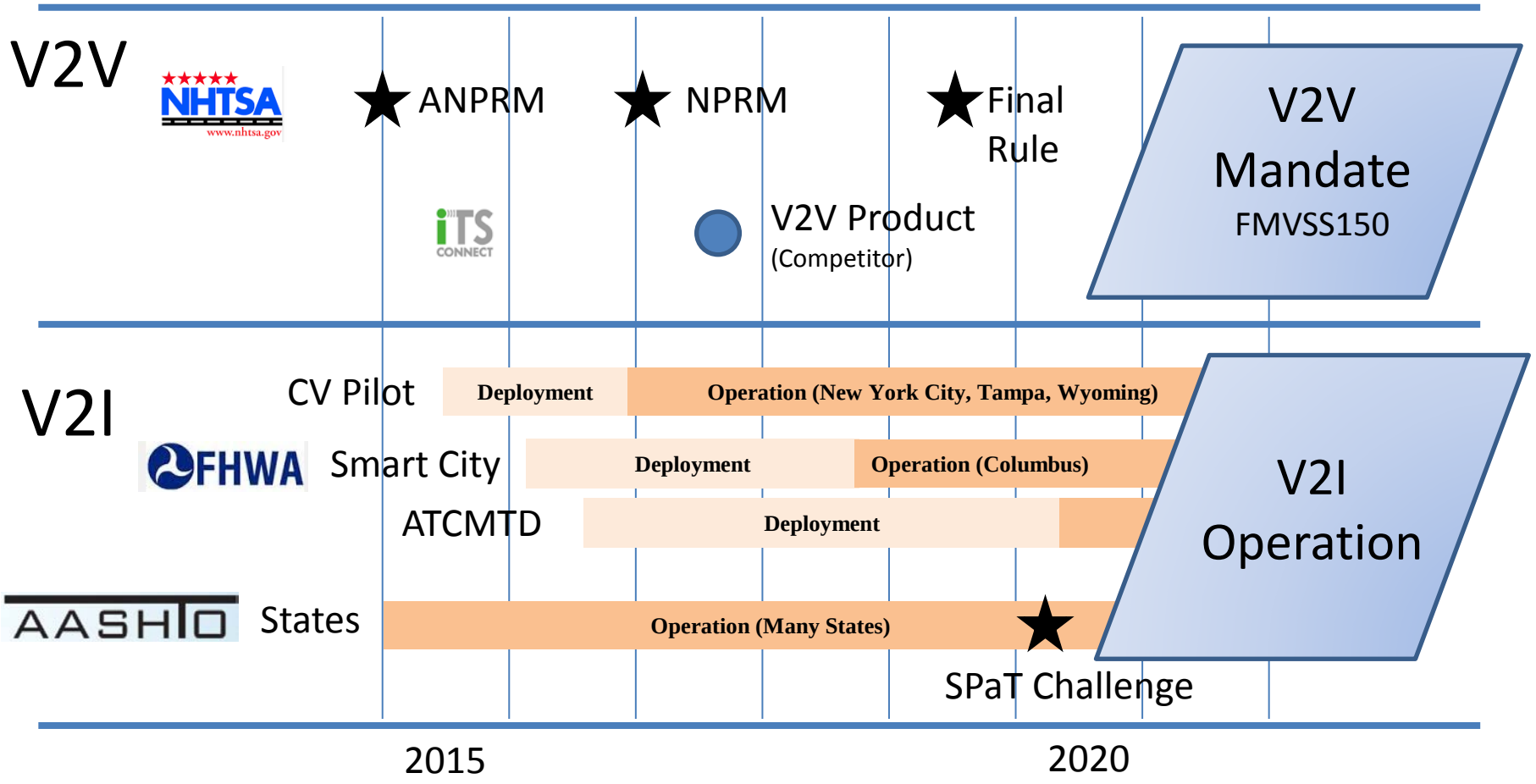
V2V communication enabled smoother car following



http://www.dct.tue.nl/New/Wouw/phdthesisploeg2014.pdf

V2X Cooperative Systems

Coordinated V2V & V2I deployment efforts are underway



Next Step: Automated Driving

Two enabling technologies for driving automation

Automated
(On-Board Systems)

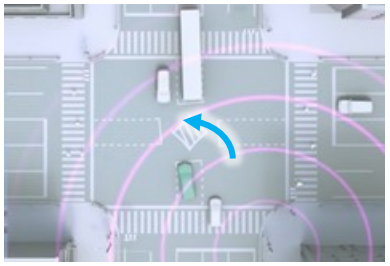
Improvement of decision-making technology to improve safety and support automated driving

Control systems

Recognition, accident prevention and mitigation

Cooperative
(Using Communication)

Wireless communication is particularly well-suited to situations in which it is difficult to detect hazards with onboard systems alone.



Intersection V2X,
ITS Connect

Intelligence

Automated Driving

Mobility Teammate Concept

Our concept for automated driving assist

Creating a mutually-supportive partnership between driver and vehicle.

The vehicle system senses driving environment needs and driver's capabilities and provide adaptive support to the driver in a way that the driver can operate the vehicle sufficiently.

MOBILITY TEAMMATE CONCEPT
Automated Driving Tech.

Key Technologies

Technology focus and organizational efforts

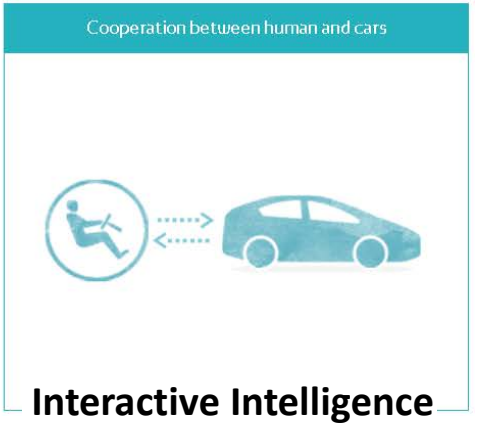
MOBILITY TEAMMATE CONCEPT
Automated Driving Tech.

TOYOTA RESEARCH INSTITUTE

http://www.tri.global/

Driving Intelligence

Connected Intelligence



Interactive Intelligence

TOYOTA connected

http://www.toyotaconnected.com/

CSRC Collaborative Safety Research Center TOYOTA

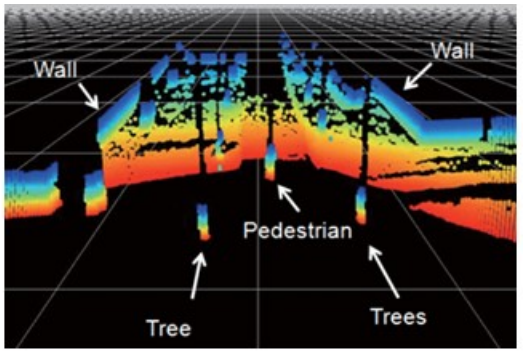
https://www.toyota.com/csrc/

http://www.toyota-global.com/innovation/automated_driving/

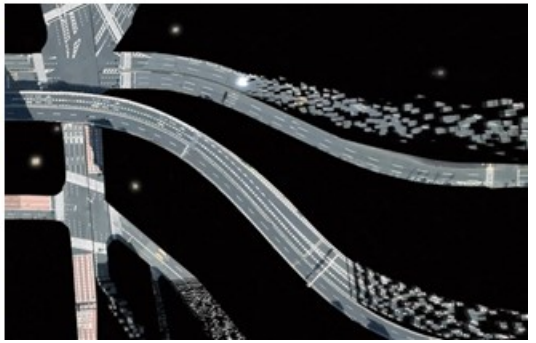
Driving Intelligence

“Driving Intelligence” for determining safe driving path

Using AI, cars create and accumulate knowledge and plan safe driving routes.



SPAD LIDAR



Automatic map-creation technology (PRECISE)

Toyota Central R&D Lab.

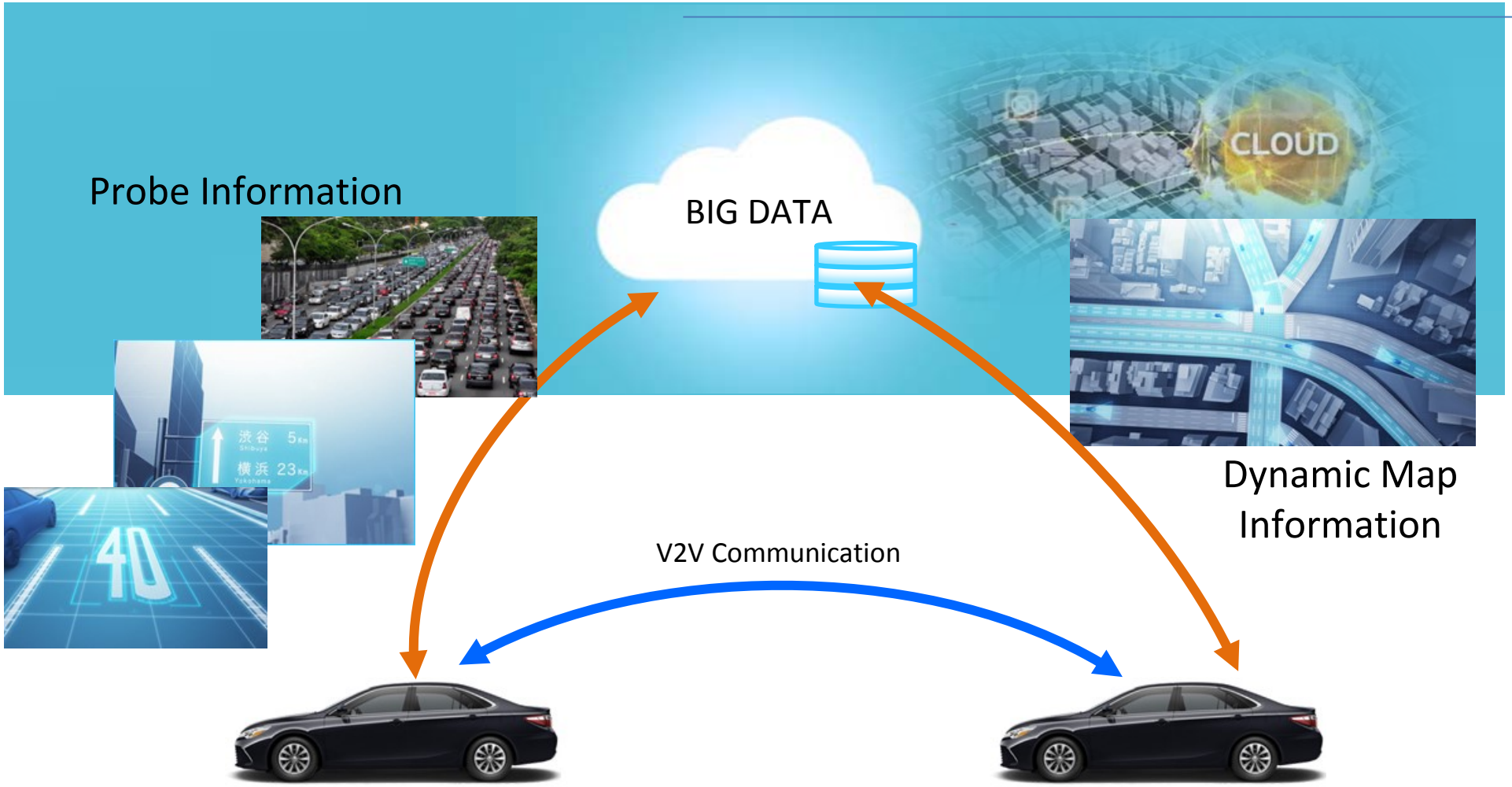
SPAD: Single Photon Avalanche Diode Light Detection And Ranging

PRECISE: Positioning with Reliability Enhancement by Coupling IMU Satellites with External sensors

Connected Intelligence

"Connected Intelligence" to obtain information from outside.

Enhanced Safety and Creation of New Services



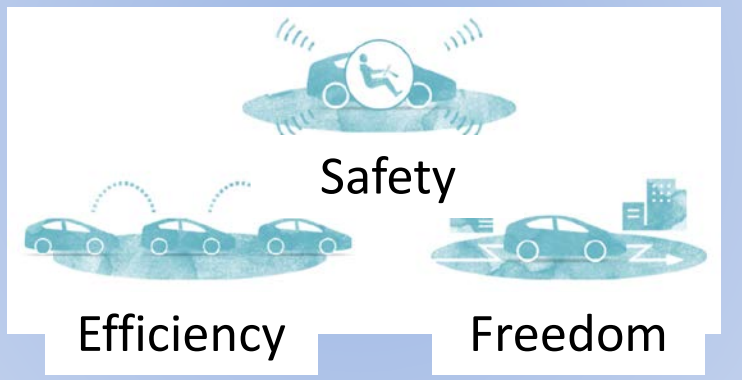
Interactive Intelligence

“Interactive Intelligence” for best driver-vehicle relationship

Automated driving systems interact with the driver like a chauffeur and guardian

Chauffeur

Artificial Intelligence



Guardian

Full Automated Driving
New Mobility

Advanced Driving Intelligence

Driving Support
Enjoyable Driving

Building relationships between people and cars that share the same goal, like close friends who watch over each other, and when in need, help each other out.

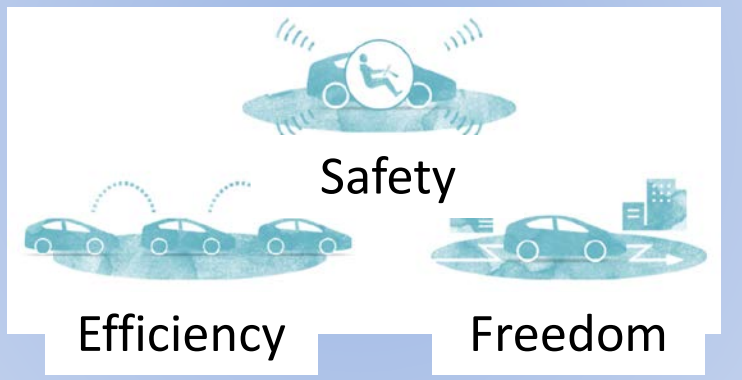
Chauffeur and Guardian Concept

Automated driving systems interact with the driver like a chauffeur and guardian

Chauffeur

Artificial Intelligence

Guardian



Full Automated Driving
New Mobility

Advanced Driving
Intelligence

Driving Support
Enjoyable Driving

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Summary

Toyota sees automated driving as a way to contribute to a better society, rather than just to make things easier for people.

- Driver and vehicle should mutually support each other like friends watch over and help each other when needed.

- Three types of intelligence (driving, connected and interactive) are key enablers for automated driving systems.

Road-vehicle interaction is an important factor therefore road and vehicle designers should become teammates to create more mutually-supporting transportation systems.