Toyota’s Approach Toward the Realization of Sustainable Mobility

The 2008 Toyota Sustainable Mobility Seminar
September 23-24
Portland, Or

Chris Tinto - Vice President
Technical and Regulatory Affairs, Safety
Toyota Motor North America, Inc.
**Toyota’s Approach Towards the Realization of Sustainable Mobility**

- **Agenda**
  - Toyota’s Safety Approach
  - Intelligent Transportation Systems (ITS)
    - ITS – Safety
    - ITS – Environment
  - Summary
1. Safety
   Traffic accident
2. Environment
   Traffic Congestion, Environmental impact
3. Comfort
   Fun, Excitement, Comfort

“Minimize”

“Maximize”

Foundation

Safety

Environment

Comfort

Human-Centered
Toyota’s Safety Approach
Toyota Safety

In Pursuit of Real World Safety

Accident Investigation/Analysis

Development/Evaluation

Computer Simulation/Analysis
Toyota Safety

Passive Safety

Energy Absorbing Body Structure

Occupant Restraint System

GOA (1995)

Seat belt with pre-tensioner & force limiter (1997)

SRS Curtain shield airbag (1998)

SRS Knee airbag (2002)
Passenger Twin-Chamber Airbag

**LS460 (2007)**

**IS250/350 (2006)**
Toyota Safety

Active Systems

Vehicle Stability Enhancement

Accident Avoidance
Operation Support / Control

ABS (1971)
TRC (Traction control) (1987)
VSC (1995)
Pre-crash Safety (2003)
Toyoita Safety

Active Systems – Evolution of Vehicle Dynamic Control System

VDIM: Vehicle Dynamics Integrated Management

VDIM + Steering Control

Safety & Fun to drive

VSC
TRC
ABS

Stand Alone Control

TODAY for TOMORROW
TOYOTA
Toyota Safety

Pre-Crash Systems – Evolution

2004 Lexus LS430
(2003 Harrier in Japan)

Front
Millimeter-wave radar
Toyota Safety

Pre-Crash Systems – Evolution

2006 Lexus LS460
(2004 Crown Majesta in Japan)

Front camera

2004 Lexus LS430
(2003 Harrier in Japan)

Front Millimeter-wave Radar

Improved Warning & Control
Toyota Safety

Pre-Crash Systems – Evolution

2006 Lexus LS460
(2004 Crown Majesta in Japan)

Driver monitoring camera

Lexus LS460/600H
(2006 Lexus GS450h in Japan)

Front Camera

2004 Lexus LS430
(2003 Harrier in Japan)

Front Millimeter-wave Radar

2006 Lexus LS450

Improved Warning & Control

TOYOTA

TODAY for TOMORROW
Toyota Safety

Pre-Crash Systems – Evolution

2006 Lexus LS460
(2004 Crown Majesta in Japan)

Front Camera

2004 Lexus LS430
(2003 Harrier in Japan)

Front Millimeter-Wave Radar

2006 Lexus LS460
(2004 Lexus GS450h in Japan)

Driver Monitoring camera

'08 Lexus LS460/600H
(2006 Lexus LS460 in Japan)

Front Stereo Camera

Rear Millimeter-Wave Radar

Detection of Pedestrian
Evolution to Omni-Directional Detection & Higher Level
Toyota Safety

Parking  Active Safety  Pre-Crash Safety  Passive Safety  Rescue

All Driving Stages

Integration and Cooperation of Safety Systems

Integrated Safety Management Concept
Toyota Safety

Integrated Safety Management Concept

Recognition

- Driver’s Condition (drowsy, etc.)
- Vehicle Condition (Vehicle behavior)
- Traffic Environment (Inter-vehicle distance, pedestrians, etc.)

Judgment

- DSS computer

Action

- Driver Alert (Displays, sounds, vibrations, etc.)
- Vehicle Control Support
- Traffic Environment (Communication, lights, sounds, etc.)
Toyota Safety

Integrated Safety Management Concept

- Stereo camera
- Yaw rate and acceleration sensor
- Steering angle sensor
- DSS (Driver Support System) ECU
- Driver-monitoring camera
- Brake pedal stroke sensor
- Millimeter-wave radar

Recognition

- Wheel speed sensor (on each wheel)
- Rear millimeter-wave radar
- Steering torque sensor
- Brake pressure sensor
- Steering torque sensor
Wheel speed sensor (on each wheel)
Brake pressure sensor
Stereo camera
Yaw rate and acceleration sensor
Steering angle sensor
Brake pedal stroke sensor
Millimeter-wave radar
DSS (Driver Support System) ECU
Driver-monitoring camera
Rear millimeter-wave radar
Wheel speed sensor (on each wheel)
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Toyota Safety

Integrated Safety Management Concept

- Stereo camera
- Yaw rate and acceleration sensor
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- Millimeter-wave radar
- DSS (Driver Support System) ECU
- Driver-monitoring camera

Action

- Pre-crash Intelligent Headrest
- Pre-crash Seatbelt
- Suspension control
- Steering control (VGRS)
- Electric power steering
- Brake actuator
Toyota Safety

Pre-Crash Systems

Driver assistance through recognition technology

An Earlier Warning Becomes Possible for the Driver

- Danger
- High Danger
- Unavoidable
- Collision

With Face Direction Sensor

Warning Brake
Warning (When looking away)

With Stereo Camera

Warning Brake
Warning (When looking away)

Intervention
Warning
Suspension
Brake Assist
Seat belt

Steering Assist

TOYOTA
Toyota Safety

Rescue Systems

Automatic Notification upon Airbag Deployment
Toyota Safety
Integrated Management Safety Concept

- Active Safety:
  - Accident avoidance operation support/control
  - Vehicle distance alarm
  - Lane-deviation alarm
  - VDIM, BA (Brake Assist)
  - VSC, ABS (Anti-lock Brake System)

- Pre-crash Safety System:
  - PC-BA, PC-VGRS (Pre-crash Brake Assist, Pre-crash Variable Gear Ratio Steering)

- Rear-end Pre-crash Safety System:
  - PC-BA, PC-VGRS

- Passive Safety:
  - Passenger safety
  - Seatbelts, airbags
  - GOA (Global Outstanding Assessment)

- Rescue:
  - HELPNET/Lexus Link
  - Vehicle Infrastructure Cooperative Systems

- Reduction of driving burden:
  - Radar cruise control
  - Lane Keeping Assist
  - PA, IPA (Parking Assist, Intelligent Parking Assist)

- Damage reduction:
  - Network linked Navigation system
  - Blind corner monitor

- Accident avoidance operation support/control:
  - Back guide monitor
  - Network linked Navigation system

- Reducing driving burden:
  - Collision Avoidance

- GOA (Global Outstanding Assessment):
  - HELPNET/Lexus Link

- Vehicle Infrastructure Cooperative Systems:
  - G-Book

- TODAY for TOMORROW
ITS-Safety
ITS Safety

Autonomous Safety Systems and Vehicle-Infrastructure Cooperative Systems

Autonomous safety systems

Vehicle-Infrastructure Cooperative Systems that support safe driving

Increased awareness of people

Accident reduction

≈

20XX
Vehicle’s and Driver’s Eyes

i.e. The power to perceive things that are not present to the senses

“Clairvoyance”

Autonomous Cooperative
In-vehicle signage
(curve ahead, etc)

Off-board navigation
completes on-board maps

Electronic payments for
parking, gasoline, and toll roads

Traveler information
(work zones, travel times, etc)

Ramp metering

Pothole detection

Infer travel times, volumes, etc from probe data
for corridor planning assist and load balancing

Curve speed warning

In-vehicle signage
(curve ahead, etc)

Off-board navigation
completes on-board maps

Network management and
probe data collection

Lead vehicle emergency
brake warning

Traffic signal
violation warning

Electronic payments for
parking, gasoline, and toll roads

Stop sign
violation warning

Weather information (traveler notification,
 improved forecasting, winter maintenance, etc)

Signal timing optimization

Pothole detection

Infer travel times, volumes, etc from probe data
for corridor planning assist and load balancing

Curve speed warning

In-vehicle signage
(curve ahead, etc)

Office navigation
completes on-board maps

Network management and
probe data collection

Lead vehicle emergency
brake warning

Traffic signal
violation warning

Electronic payments for
parking, gasoline, and toll roads

Stop sign
violation warning

(*) VII program is sponsored by US DOT
References: "VII POC Applications Concept of Operations" document

Vehicle Infrastructure Integration (VII) Vision

Application type legend:

Safety
Mobility
Commercial

Wireless communication
(DSRC)

Road-Side
Unit

TODAY for TOMORROW
ITS Safety
Effects of Vehicle-Infrastructure Cooperative Systems

Autonomous safety systems
Vehicle-Infrastructure Cooperative Systems that support safe driving

Frontal collisions
Rear-end collisions
Solo vehicle accidents
Accidents at intersections
Accidents involving motorcycles/motorbikes
Accidents involving bicycles
Accidents involving pedestrians

Reduction of deaths and injuries
ITS Safety

Communication Sensors

V-I System
- Road-sensing data unit
- Vehicle/Pedestrian recognition

V-I System
- Traffic control unit
- Light/Restriction recognition

V-V System
- Communication unit
- Hazardous vehicle recognition

Communication sensors

Situation recognition
ITS Safety
Vehicle-Infrastructure Cooperative System – Vehicle to Vehicle
ITS Safety

Vehicle-Infrastructure Cooperative System – Vehicle to Infrastructure

Detected pedestrian on crosswalk and warns car that is turning left

Prevents collision with an oncoming vehicle

Early lane change based on information about fallen object
ITS Safety

Vehicle-Infrastructure Cooperative System – Vehicle to Infrastructure
Government-Industry Collaboration

DSSS Project (with National Police Agency)

Location: Toyota City, Japan

5 Dangerous Intersections

Vehicles: 100 Vehicles
(50 are equipped with IR-DSRC)

Phase 1: Warning Only
- Signal Violation
- Stop Sign Violation

Phase 2: Control Intervention

May be in Tokyo with OEMs
ITS Safety

Vehicle-Infrastructure Cooperative System Programs – ASV Project (Japan)

Government-Industry Project

Ministry of Land, Infrastructure and Transport & 14 OEMs (cars, trucks, motorcycles)

• Stop Sign Movement Assist
• Pedestrian Present
• Blind Spot Warning
• Lane Change Assist
• On-Coming Vehicle Warning

Inter-OEM Validation of V-V Safety Applications

• Common: Communication Media & Messages, Scenarios
• OEM-Unique Implementation, HMI, Algorithms
ITS Safety

U.S. Department of Transportation (DOT) ITS Projects

<table>
<thead>
<tr>
<th>98-04</th>
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Public-Private Projects for Cooperative ITS Systems

USDOT’s RITA and automakers are conducting POC tests to assess 5.9GHz DSRC for V-I by using a network in Michigan.

Test item example:
  - Signal Violation Warning
  - Traveler Information
  - Electronic Toll System etc

RITA will summarize the test result as part of its ‘Viability Assessment’ in late 2008.

Consortium Participants: GM, Ford, Chrysler, Mercedes, VW, BMW, Toyota, Honda, Nissan (9)
This application provides geometric data and signal phase info to vehicles via 5.9GHz DSRC and warns the vehicle when a possible violation is detected.

Proving the functionality of V-I communications via 5.9GHz DSRC within CICAS-V–enabled intersections in MI.

Next Step: a full-scale field test will be conducted later than this Fall.

CAMP Participants: GM, Ford, Mercedes, Toyota, Honda
ITS Safety

Test Scenarios

Traffic Signal Violation

Stop Sign Violation

Vehicle & Pedestrian Present

V-I Video Share
ITS Safety

Potential Casualty Reductions with Cooperative Safety Systems

Towards “Minimize”

Passive Safety

Autonomous Systems

Vehicle-Infrastructure Cooperative Systems
ITS Environment
ITS Environment

Relationship between Travel Speed and Exhaust Emissions

**CO₂ emissions**
- (CO₂ emissions ratio)
- Base value for emissions at 10 km/h is 100

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<tr>
<th>Speed (km/h)</th>
<th>Emissions</th>
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<td>30</td>
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**NOx emissions**
- (NOx emissions ratio)
- Base value for emissions at 10 km/h is 100

<table>
<thead>
<tr>
<th>Speed (km/h)</th>
<th>Emissions</th>
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<td>10</td>
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<td>30</td>
<td>48</td>
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<td>60</td>
<td>21</td>
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*Speed measured in a state close to actual traveling conditions
Source: Japan Automobile Research Institute
Traffic Flow Improvement (examples)

1. Smoother Flow
   Causes: Delayed start at intersection
   - Merging bottleneck
   - Lane departure / passing other vehicles
   - Congestion at ‘sag’ points
   measure: Assist driver with smooth operation

2. Density Management
   Causes: staggered driving
   measure: Running in line by ACC, forming a ‘group’

3. Crowd Dispersion
   Causes: Temporarily crowded area / time / season
   measure: Provide traffic information to vehicle, with “TDM”

“TDM”: Traffic Demand Management
ITS Environment

Probe Technology
Summary
Summary

Safety Systems

Minimize
(Safety & Environment)

Maximize
(User-friendliness)

Passive Safety
Active Safety

Evolution I

201X ~

Evolution II

Vehicle-Infrastructure Cooperative System

Sustainable Mobility

Probe Information System

Navigation Cooperation

Integrated HMI

Information and Telecommunication System

TODAY for TOMORROW
The 15th ITS World Congress Exhibitions and Demonstrations

http://www.itsworldcongress.org/about-world-congress.html

Summary

VII Bus Tours: Focus on Infrastructure-based demo (Test bed & the future Transportation Management Center (TMC))

Participants take a trip around the Center and experience cooperative demo on a closed public road (bus sends probe data to TMC)

11th Avenue Theater

Demonstrations by 6 automakers (Toyota will join)

11th Avenue Theater Participating OEMs: GM, Daimler, VW, Toyota, Nissan, Honda
Thank you for your attention!
Toyota Safety
ITS Environment

CO₂ and NOₓ emission reduction by congestion improvement

**CO₂ Emission**

- 10km/h
- 20km/h
- 30km/h

**NOₓ Emission**

- 10km/h
- 20km/h
- 30km/h

Source: JARI

TODAY for TOMORROW
Cooperative Education, Road Maintenance

ITS Safety
Casualty Reduction with Cooperative Safety Systems

Autonomous

Cooperative

Education, Road Maintenance
The world’s first 5.9GHz DSRC infrastructure is deployed for VII projects.

VII POC created a common foundation for 5.9GHz DSRC cooperative infrastructure. Demonstrations utilizing this framework are expected during the 2008 ITS World Congress in New York.
ITS Safety

DOT ITS Projects – VII System at a Glance

VII Operation Center

Telematics Service Providers

Traffic Management Center

VII Private Businesses

VII Coalition

VII Consortium

Cooperative ITS Services (VII Applications)

ITS Network

WiFi

Cell Phone Network

Satellite

DSRC Mobility

Payment System

V-I

VII Public Applications

POC Test

CICAS-V

CAMP VSC-2 Consortium

VII Private Businesses

VII Public Applications

POC Test

VII Coalition

VII Consortium

Business Deployment
• VII business Model
• VII Operation
• Partnership with related entities

System R&D and Testing
• VII Architecture
• VII Network
• Interoperatability among mobility applications

Technological R&D and Testing
• Standardizing System Specifications
• DSRC Communications Protocol
• Interoperatability among safety applications

TOYOTA
“Minimize” symbolizes the vision and philosophy of our persistent efforts to minimize the negative aspects vehicles may have, such as traffic accidents, traffic congestion and environmental impact.
Toyota Safety

Active Systems – Direction

- Supports Series of Driver Behaviors as Much as Possible
- Attempts to Prevent Drivers from Approaching Critical Conditions

Monitoring of Surroundings
Omni-directional supervision / Driver monitor

Error types in Accidents with Injury
- Recognition
- Judgment
- Action

N = 825,683 persons
Source: 2002 ITARDA

Vehicle Infrastructure Cooperation System

VSC · VDIM
Vehicle Dynamics Control

Driving support by autonomous system
Driving support by vehicle & road cooperation

Pre-crash safety
Accident Avoidance Support

Recognition
Action
Judgment

Source: 2002 ITARDA