先進安全自動車

ADVANCED SAFETY VEHICLE

情報交換型運転支援システム　国際シンポジウム

International Symposium on Inter-Vehicle Communication (IVC) Driving Support System

日　時：　平成17年10月14日（金）

会　場：　グランドホテルニュー王子　芙蓉の間

主　催：　国土交通省

Date:　Friday, October 14, 2005

Venue:　Banquet Room “Fuyo”, Grand Hotel New Oji

Organizer:　Ministry of Land, Infrastructure and Transport

情報交換型運転支援システム
国際シンポジウム

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International Symposium on
Inter-Vehicle Communication (IVC) Driving Support System

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ご挨拶

主催者挨拶

国土交通省自動車交通局

本日ここに、「情報交換型運転支援システム国際シンポジウム」を開催するにあたり、国土交通省を代表いたしまして、一言御挨拶を申し上げます。

現在、昨年の交通事故死者数は７，３５８人と平成４年以降減少傾向となっておりますが、依然として交通事故件数、交通事故死傷者数は 高い水準となっております。

また、小泉内閣総理大臣は、平成１６年１月１９日、「今後10年間で交通事故死者数を５，０００人以下にすることを目指す」との目標を設定しており、これまでにも増して交通安全対策を推進する必要性があると認識しております。

このような状況の中で先進安全自動車（ＡＳＶ）については、交通安全対策の重要な役割を担うものと考えており、ＡＳＶの開発・普及の促進を進めるため、平成３年度以来、産・学・官の協力体制のもと検討を進めてまいりました。

その結果、衝突軽減ブレーキやレーンキープシステムといった各種のＡＳＶ技術が次々と実用化されてきております。

現在進めております第３期ＡＳＶプロジェクトでは、実用化段階に入ったＡＳＶ技術の普及促進のための検討とともに、次世代技術による更なる安全性の向上を目指して、情報支援型運転支援システムの技術開発に取り組んでおります。通信を活用した情報交換型運転支援システムは、自律検知型運転支援システムでは対応しきれない出会い頭事故、右折事故等にも対処できる可能性があり、将来的な発展が期待されます。これまでＡＳＶプロジェクトは、事故実態の分析に基づき、情報交換型運転支援システムに期待される機能や仕様についての調査・研究に取り組んできました。これらを踏まえ、今年７月よりは、この苫小牧市にてシステムの有効性や限界についての確認を行う検証実験が４ヶ月にわたって実施しているところであります。また、前日、前々日とその一部をご覧いただくための公開実験が行われたところであります。

さらに、本日は、日米欧において情報交換型運転支援システムに取り組まれている方の参加を得て、国内外での取組状況や課題等に関する意見交換の場として本国際シンポジウムを開催することとなりました。このシンポジウムでＡＳＶプロジェクト及び各国における情報交換型運転支援システムの今後の発展にとって、有意義なものになるよう期待しております。

最後になりましたが、本国際シンポジウムの開催にあたりましてご尽力いただきました関係者の皆様に感謝申し上げ、また、本日ご参集いただいております皆様に御礼申し上げまして、開会の挨拶とさせていただきます。

Greeting from the Organizer

In opening this International Symposium on Inter-Vehicle Communication (IVC) Driving Support System here today, I would like to say a few words on behalf of the Ministry of Land, Infrastructure and Transport.

The number of fatalities resulting from traffic accidents in Japan totaled 7,358 last year, continuing the downward trend observed since 1992. However, the number of traffic accidents and resulting injuries remain high.

On January 19, 2004, Prime Minister Junichiro Koizumi set the goal of reducing the number of deaths in traffic accidents to no more than 5,000 a year within 10 years and we keenly recognize the necessity to further promote measures to enhance traffic safety.

In such a circumstances, we think that advanced safety vehicle (ASVs) will play a significant role in enhancing traffic safety in the future. To promote the development and use of ASV, we have been working a research and studies since 1991 under the framework of the three-way cooperation of industry, academia and government. Our efforts have resulted in the development and commercialization of various ASV technologies such as the collision mitigation brake system and the lane keep system.

In the ongoing third phase of the ASV project (ASV-3), we are working on measures to promote the use of ASV technologies that have reached the commercial stage. At the same time, we are striving to develop new technologies for inter-vehicle communication systems in order to further enhance safety through next-generation technologies. High hopes are placed on the future development of inter-vehicle communication systems as they offer the possibility of preventing head-on collisions and right-turn accidents, both of which autonomous detection systems cannot cope with. The ASV project has been conducting studies and research on the prospective functions and specifications of inter-vehicle communication systems based on the analysis of traffic accidents. For the past four months since July this year, we have been conducting verification experiments here in Tomakomai city to confirm the effectiveness and limitations of these systems. Just yesterday and the day before yesterday, we carried out experimental demonstrations to show these future technologies.

Today, we are holding this international symposium to discuss and exchange opinions on the efforts undertaken and challenges faced both in Japan and abroad, with the attendance of all of you who are working on the development of inter-vehicle communication systems in Japan, the United States and Europe. I greatly hope that the outcome of this symposium will contribute in a meaningful way to the ASV project as well as to the future development of inter-vehicle communication systems in each country.

Finally, I would like to express my appreciation for the efforts of all those who have worked so hard to realize this symposium and my gratitude to all the participants gathered here today.

Road Transport Bureau, Ministry of Land, Infrastructure and Transport

プログラム

プログラム

10:30	開会
10:30-10:40	主催者挨拶
10:40-12:00	日米欧における通信技術の現状
	(1) 10:40-11:00 芝浦工業大学　古川　修
	(2) 11:00-11:20 Ygomi LLC　T. Russell Shields
	(3) 11:20-11:40 DaimlerChrysler AG Dr. Ralf Guido Herrtwich
	(4) 11:40-12:00 質疑応答
12:00-13:10	休憩
13:10-14:40	先進安全自動車（ＡＳＶ）における取組状況
	(1) 13:10-13:30「情報交換型運転支援システムの考え方」 株式会社本田技術研究所　櫛田　和光
	(2) 13:30-13:50「システムコンセプトと技術的検討」 トヨタ自動車株式会社　金光　寛幸
	(3) 13:50-14:10「システム検証実験の内容と実施状況」 日産自動車株式会社　高田　雅司
	(4) 14:10-14:40 質疑応答
14:40-15:10	休憩
15:10-16:40	「車車間通信を使った運転支援の実現に向けて」をテーマとしたフリー討論
	(壇　上　者)
	①コーディネータ：芝浦工業大学　古川　修
	②株式会社　日立製作所　小山　敏
	③ Ygomi LLC　T. Russell Shields
	④ DaimlerChrysler AG　Ralf Guido Herrtwich
	⑤株式会社本田技術研究所　櫛田　和光
	⑥トヨタ自動車株式会社　金光　寛幸
	⑦日産自動車株式会社　高田　雅司
	⑧国土交通省自動車交通局　和迩　健二
16:40-16:50	まとめ、閉会挨拶
16:50	閉会

PROGRAM

10:30	Opening
10:30 - 10:40	Opening address from the organizer
10:40 - 12:00	Current status of communications technology in Japan, the United States and Europe (1) Japan: Yoshimi Furukawa, Shibaura Institute of Technology (2) U.S.A.: T. Russell Shields, Ygomi LLC (3) Europe: Dr. Ralf Guido Herrtwich, DaimlerChrysler AG (4) Questions and answers
12:00 - 13:10	Break
13:10 - 14:40	Initiatives being pursued for the promotion of Advanced Safety Vehicles (ASVs) (1) “Concept of IVC Driving Support System”: Kazumitsu Kushida, Honda R&D Co., Ltd. (2) “System Concept and Technological Examination”: Hiroyuki Kanemitsu, Toyota Motor Corporation (3) “System Verification Tests – Their Features and Implementation Status”: Masashi Takada, Nissan Motor Co., Ltd. (4) Questions and answers
14:40 - 15:10	Break
15:10 - 16:40	Free discussion on the theme “Toward the realization of IVC-based driving support system” (Panelists on stage) (1) Coordinator: Yoshimi Furukawa, Shibaura Institute of Technology (2) Satoshi Oyama, Hitachi, Ltd. (3) T. Russell Shields, Ygomi LLC (4) Dr. Ralf Guido Herrtwich, DaimlerChrysler AG (5) Kazumitsu Kushida, Honda R&D Co., Ltd. (6) Hiroyuki Kanemitsu, Toyota Motor Corporation (7) Masashi Takada, Nissan Motor Co., Ltd. (8) Kenji Wani, Road Transport Bureau, Ministry of Land, Infrastructure and Transport
16:40 - 16:50	Concluding summary and closing address
16:50	Closing

講演資料

古川　修

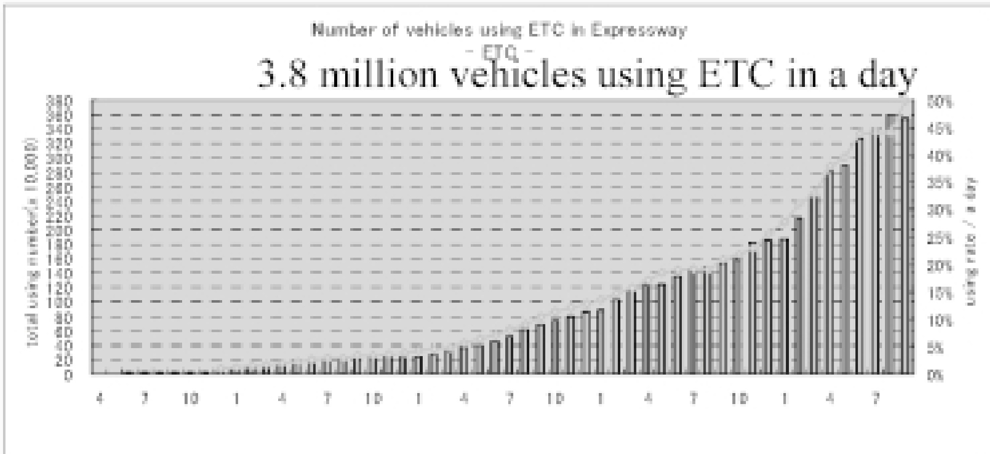
Status of Vehicle Communication Technology in Japan

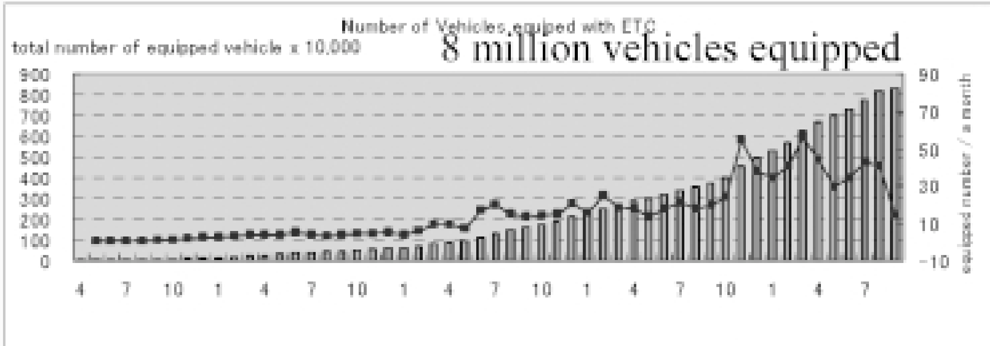
Yoshimi Furukawa
Shibaura Institute of Technology
Working Leader of

Contents

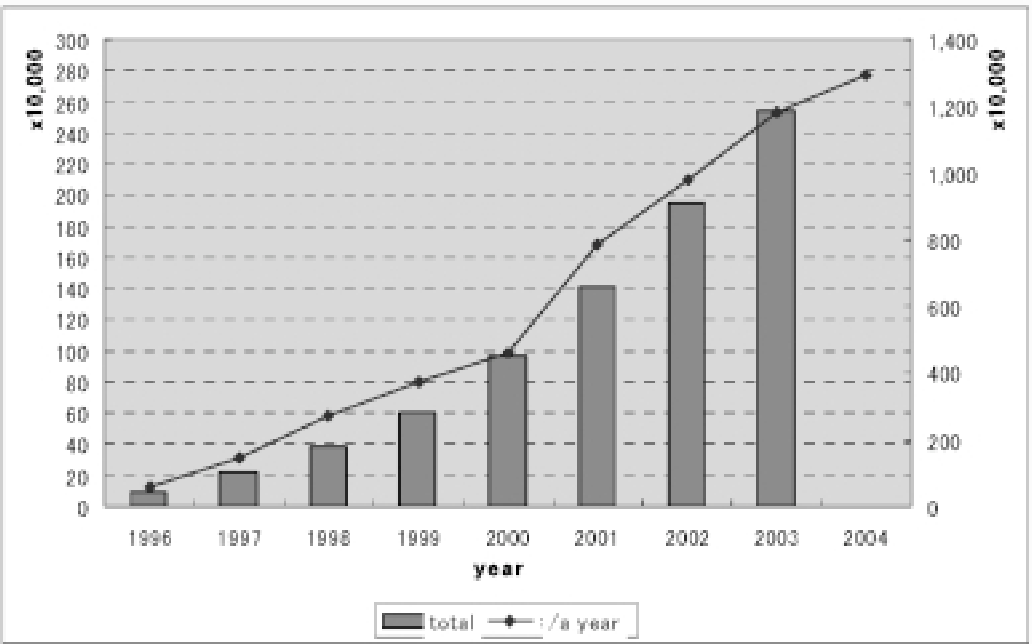
- ETC & VICS on the market - statistics in Japan
- Related organization & histories of C2C and R2C communication
- ASV activities
- AHS activities
- Cooperative driving
- Inter Driver Communication System
- Conclusion

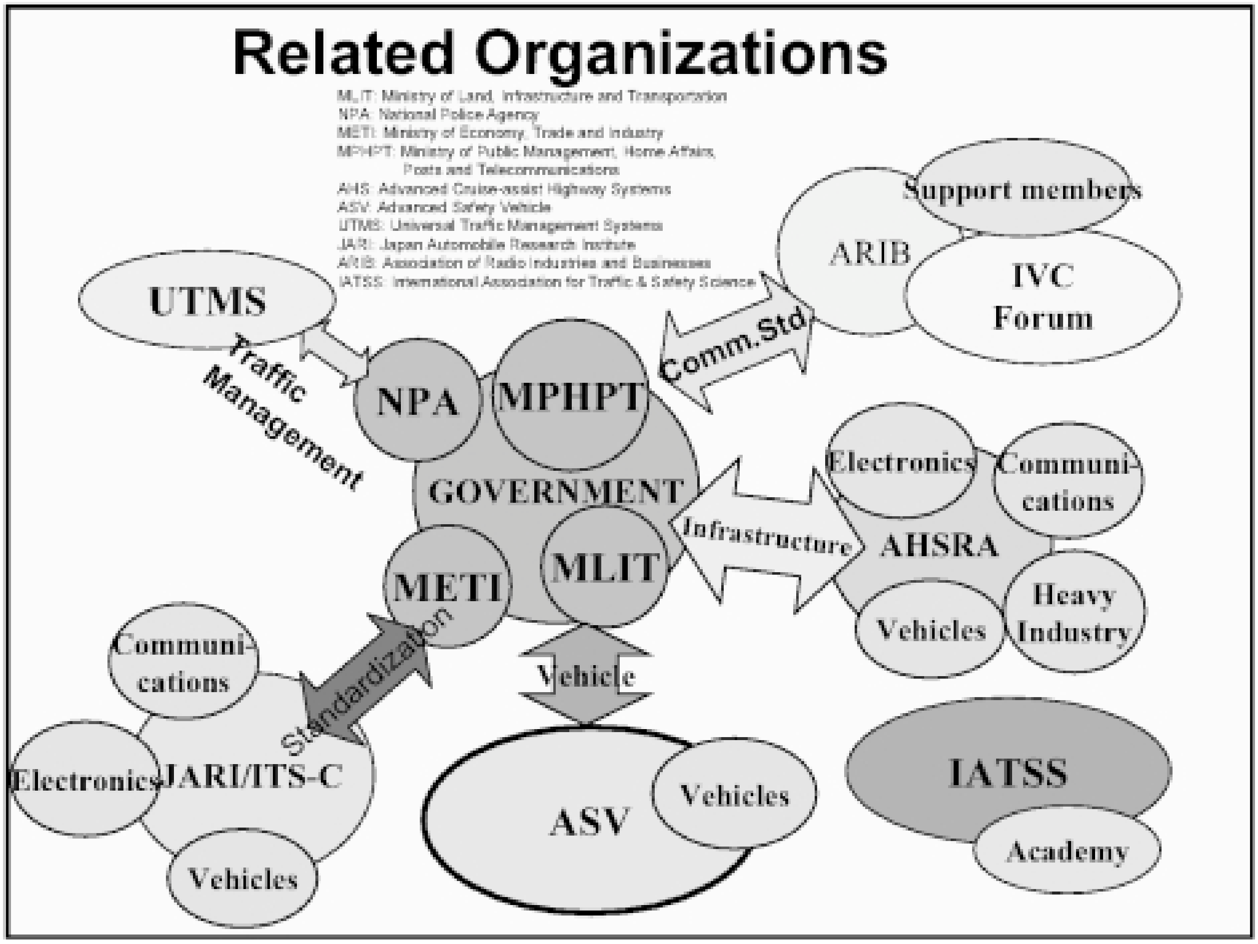
ETC systems on the market - statistics in Japan

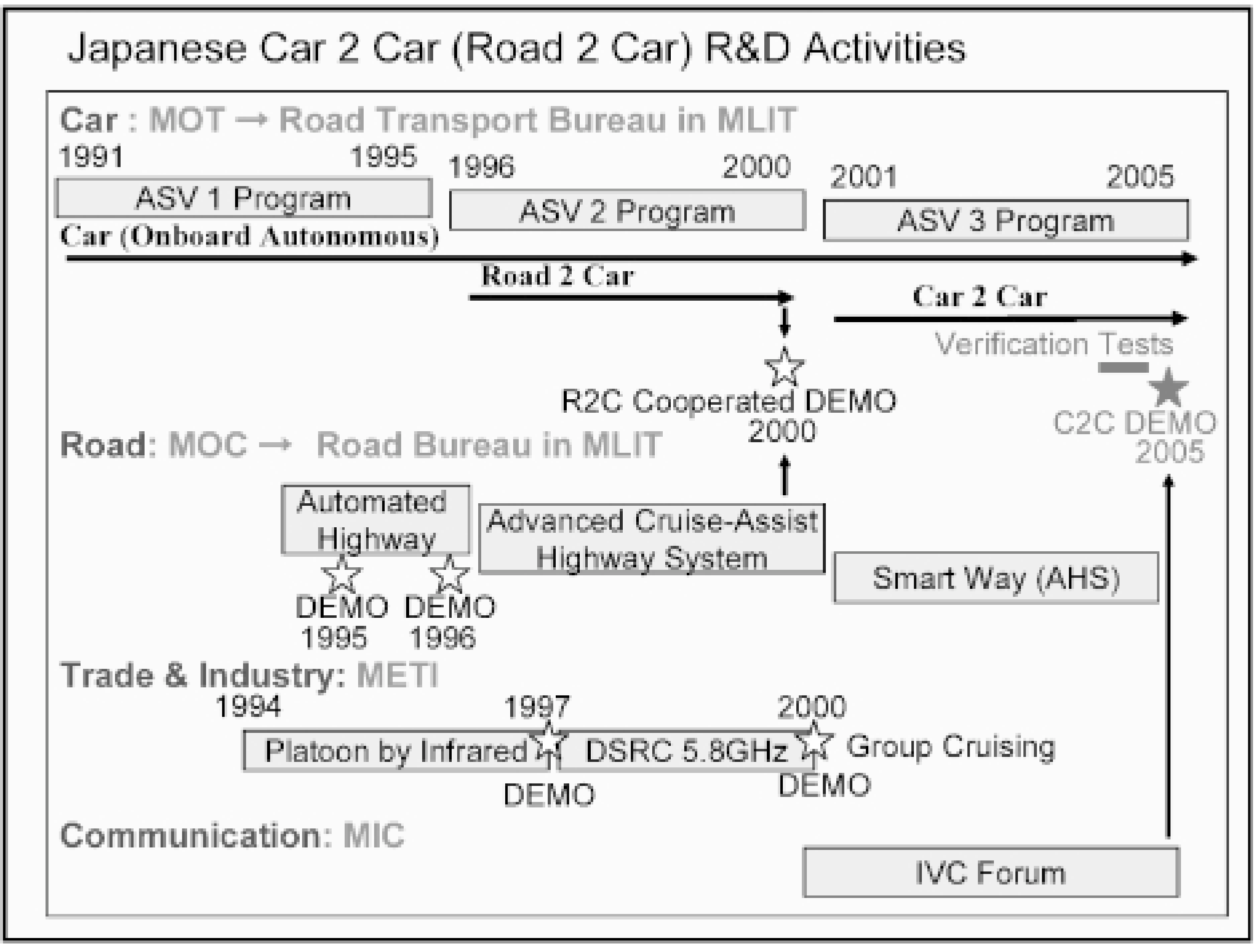


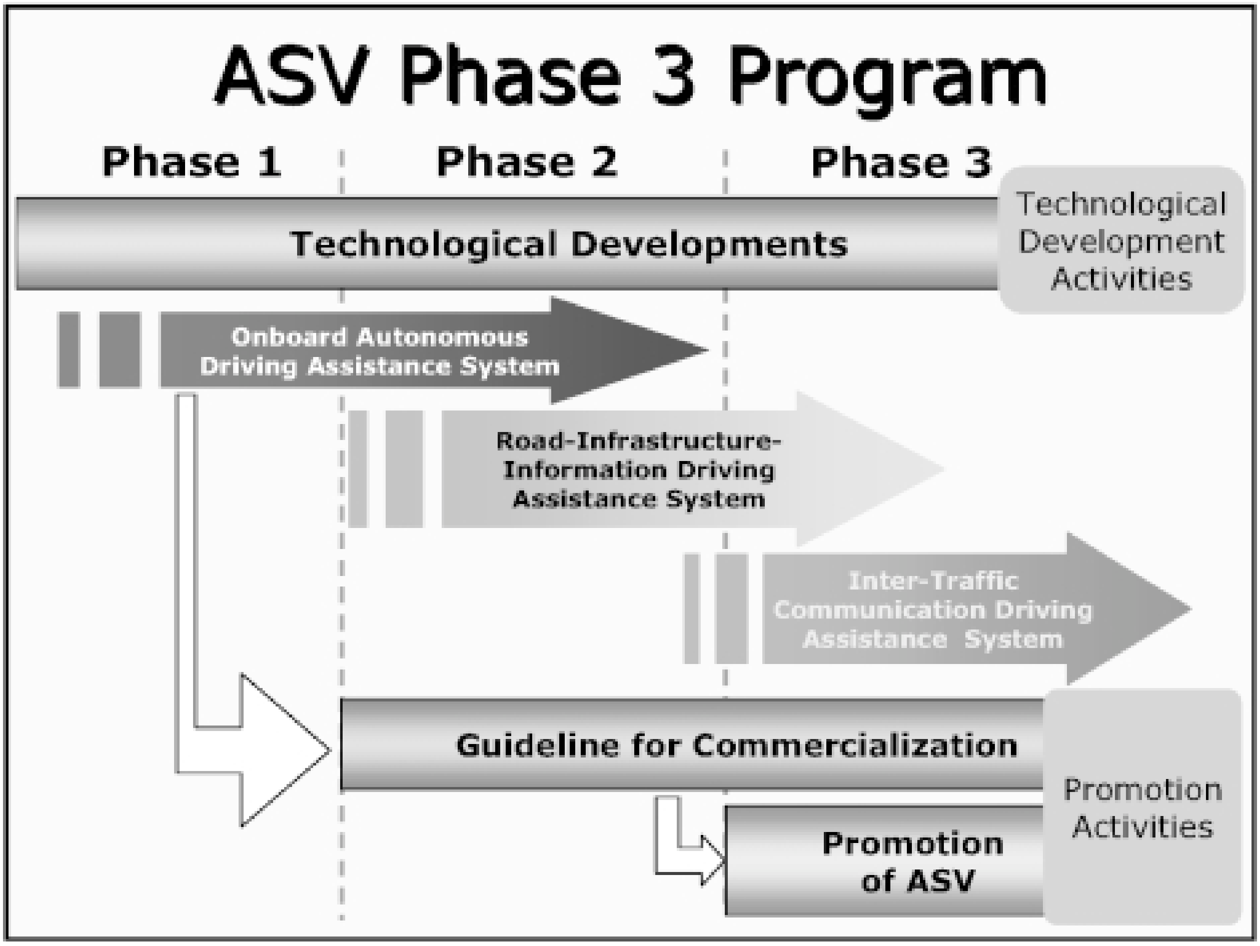


VICS on the market - statistics in Japan




Related Organizations
MLIT: Ministry of Land, Infrastructure and Transportation
NPA: National Police Agency
METI: Ministry of Economy, Trade and Industry
MPHPT: Ministry of Public Management, Home Affairs, Posts and Telecommunications
AHS: Advanced Cruise-assist Highway Systems
ASV: Advanced Safety Vehicle
UTMS: Universal Traffic Management Systems
JARI: Japan Automobile Research Institute
ARIB: Association of Radio Industries and Businesses
IATSS: International Association for Traffic & Safety Science
UTMS
Traffic Management
NPA
MPHPT
GOVERNMENT
METI
MLIT
Comm.Std
ARIB
Support members
IVC Forum
Infrastructure
AHSRA
Electronics
Communi-cations
Vehicles
Heavy Industry
Standardization
Communi-cations
Electronics
JARI/ITS-C
Vehicles
Vehicle
ASV
Vehicles
IATSS
Academy


Japanese Car 2 Car (Road 2 Car) R&D Activities
Car : MOT → Road Transport Bureau in MLIT
1991 1995
ASV 1 Program
1996 2000
ASV 2 Program
2001 2005
ASV 3 Program
Car (Onboard Autonomous)
Road 2 Car
Car 2 Car
Verification Tests
R2C Cooperated DEMO 2000
C2C DEMO 2005
Road: MOC → Road Bureau in MLIT
Automated Highway
DEMO 1995
DEMO 1996
Advanced Cruise-Assist Highway System
Smart Way (AHS)
Trade & Industry: METI
1994
1997
2000
Platoon by Infrared
DSRC 5.8GHz
Group Cruising
DEMO
DEMO
Communication: MIC
IVC Forum


ASV Phase 3 Program
Phase 1
Phase 2
Phase 3
Technological Developments
Technological Development Activities
Onboard Autonomous Driving Assistance System
Road-Infrastructure-Information Driving Assistance System
Inter-Traffic Communication Driving Assistance System
Guideline for Commercialization
Promotion of ASV
Promotion Activities


Car 2 Car Safety Drive Assist System in ASV 3 Program
Safety driving assistance system by communication among automobiles, motorcycles, bicycles and pedestrians.
Bicycle, vehicles Approaching!
One-way Communication
Two-way Communication
Right turning vehicle ahead!
Motorcycle, Pedestrians Approaching!
One-way Communication
Two-way Communication
Oncoming vehicle!
Oncoming vehicle
Two-way Communication

Objectives in ASV Phase 3 program

1.Decision of requirements for communication system

In order to decide the requirement, following objectives are set.

- Decision of system definition
- Verification of system application concept by experiments
- Proposal of recommended communication frequency

2.Conditions

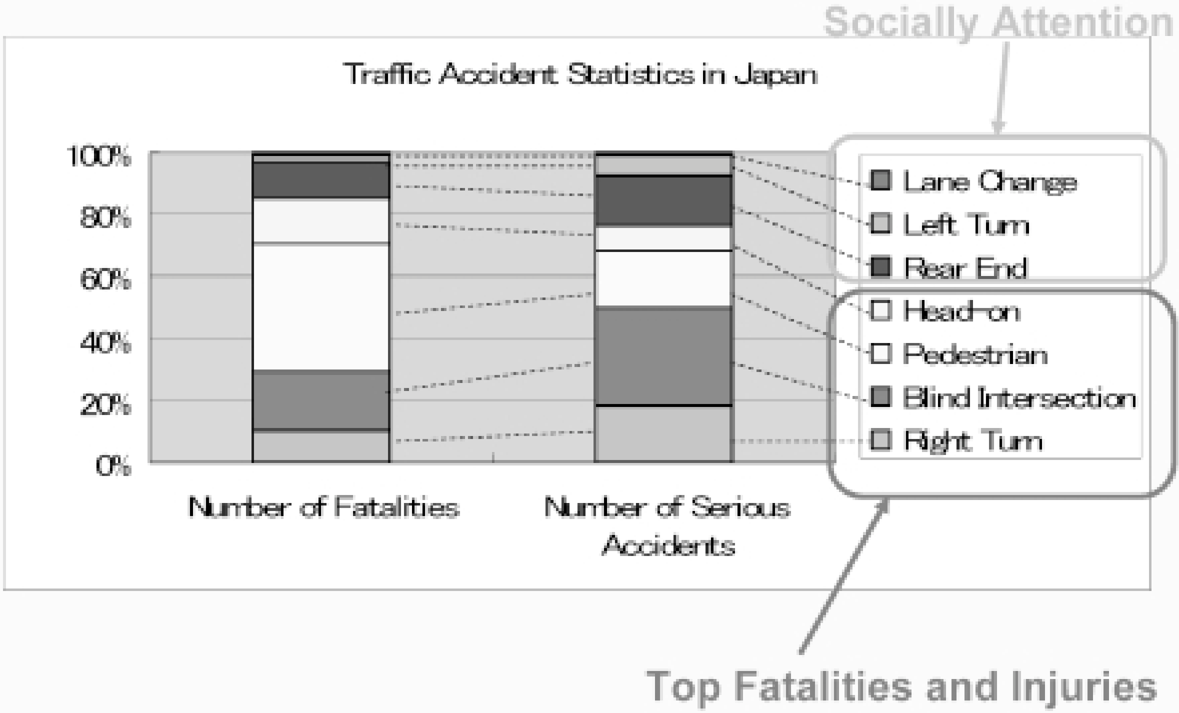
- The level of the technology composing the system is realized by a year of **2008**. (not the system realization target)
- Utilization of the road infrastructure should be kept to a minimum

Basic philosophy

- Promotion of System
  System is designed to be effective, **even if the user rate is far below 100%.**
- Objectives in service
  Accident patterns that have **a significant number of fatalities and injuries** as well as other types of accidents that **attract social attention** are selected.
- Verification of effects
  Verification of effectiveness of the systems should be judged by the reduction of specified accidents.
- Communication objects
  Heavy duty vehicle, Passenger Car, Motorcycle, Bicycle and Pedestrian etc.
- Structure of communication system
  It should be **adaptive to advance technology** of onboard equipments and communication systems, and to multi-modality of system applications.

System Applications for Reduction of Accidents

Extracting objective accident patterns
by the analysis of accident statistics in Japan.



System Applications for Reduction of Accidents

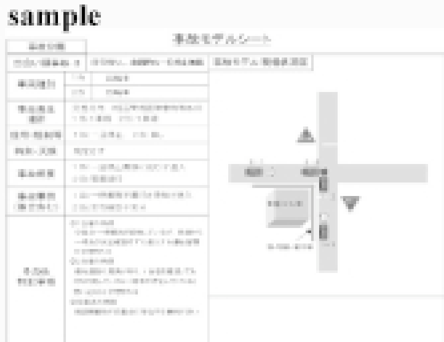
Extracting objective accident patterns
by the analysis of accident statistics in Japan.

Top fatalities and injuries
- ①right turn collision
- ②blind corner collision
- ③pedestrian collision
- ④head-on collision

Social attention
- ⑤rear end collision
- ⑥left turn collision
- ⑦lane change collision

Investigating functions and effects of the system, by categorizing accident statistics to some patterns of collision models

sample



Accidents reduction estimation by Inter-traffic Communication Type Drive Assist Systems

- ●fatalities: about 2,500 (total 9,220 / a year)
- ●serious injuries: about 25,000
  (total 72,000 / a year)

*averaged accident number in 1995 ~ 2000

Cooperative Drive Assistance System

Real-time Drive Assistance
by Road & Vehicle cooperation

ASV : Advanced Safety Vehicle
R&D on Intelligent Vehicle

AHS : Advanced cruise-assist Highway System
R&D on Intelligent Road

2000: Feasibility Tests of AHS/ASV and Demo 2000

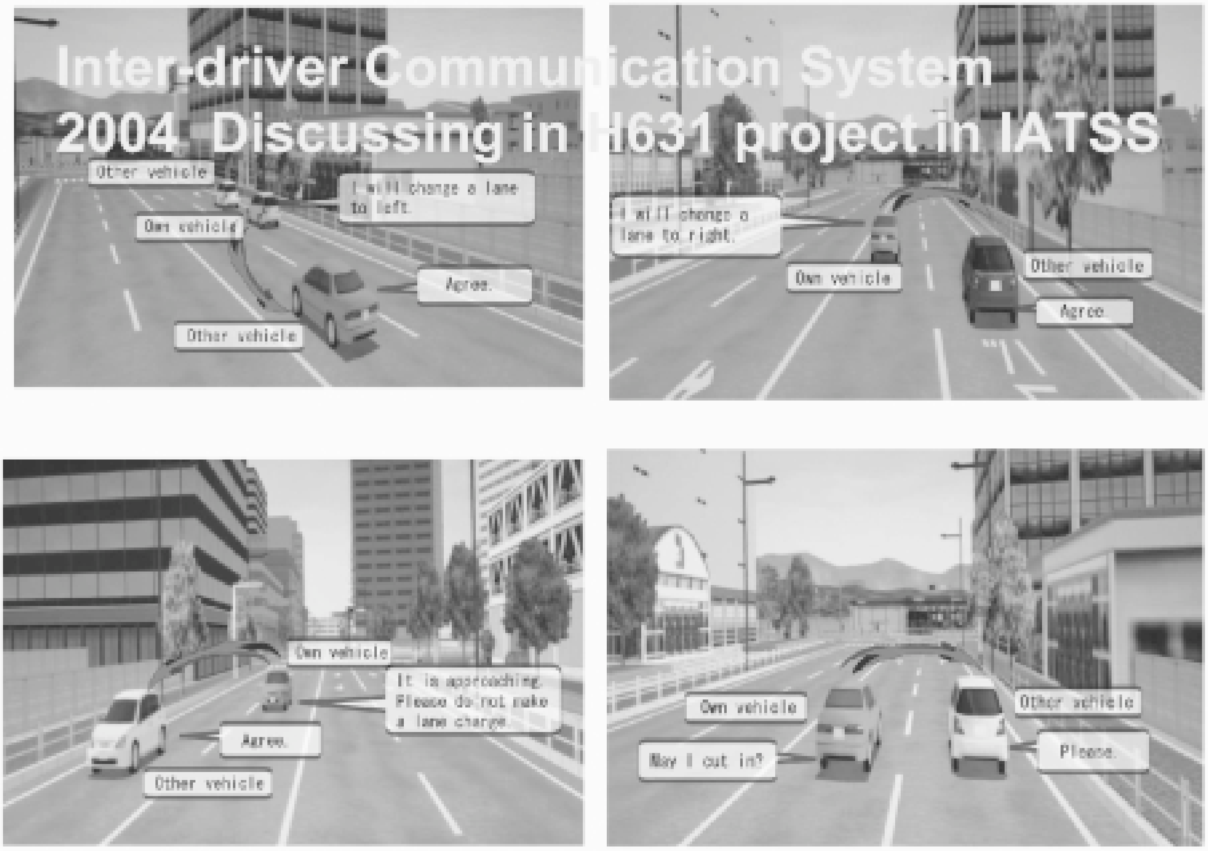
2002: Proving Tests (Field Operation Tests)

Cooperative Driving

- Cooperative Driving
  - Cooperation among automated vehicles
  - Flexible platooning
  - Merging & de-merging
- Functions of Automated Vehicle
  - Sensing
    - Localization: DGPS, within 2 cm
    - Obstacle: laser radar, over 100 m
  - Lateral & Longitudinal Vehicle Control
  - Inter-vehicle Communications: 5.8GHz, DSRC

Movie of Cooperative Driving

Merging3n.mpg



Merit of IDCS

- vehicles smooth merging in intersection
- smooth lane change
- smooth cutting in
- giving way
- showing gratitude
- alerting possible hazardous situation
- group generation
- sharing information
- communicating either mind
- game
- constructing community in vehicles' traffic

Conclusion

Status of C2C and R2C communication technology in Japan is introduced.

More detail information of ASV activities will be introduced in the following session.

T. Russell Shields

Activities and Technologies in Vehicle-Vehicle and Vehicle-Infrastructure Communications in the United States

Advanced Safety Vehicle International Symposium

Overview of Intelligent Vehicle Systems

October 14, 2005

T. Russell Shields, Chair, Ygomi LLC
shields@ygomi.com

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Standards Activities: Probe Processing

- Data from sensors in vehicles can improve the performance of crash avoidance systems of following vehicles
  - This information can be transmitted vehicle to vehicle and vehicle to infrastructure to vehicle
- Probe standards are important so that all vehicle makes can share data with one another
  - Important to collect/analyze data centrally to ensure quality
  - Probably implies a single probe center operating as a utility providing all probe processing for a given area
- The Society of Automotive Engineers has initiated a probe standards initiative that is working cooperatively with ISO/TC204/WG16
  - Common messages format/content
  - Privacy issues

3

ITS Standards: Mobile Wireless Broadband

- Mobile Wireless Broadband (MWB) is one good approach for supporting public safety vehicle fleets both for routine operations and major emergencies
- Standards crucial for interoperability across jurisdictions
- One MWB approach – HC-SDMA – was made a U.S. ANSI standard by the Alliance for Telecommunications Industry Solutions (ATIS) in September 2005
  - Only current MWB standard that meets needs of public authorities and emergency responders
- HC-SDMA now moving toward European and international standardization
  - Project MESA (founded by TIA and ETSI) established groundwork for use of MWB for public authorities
  - Standards work in progress in ETSI and ISO

4

Software Reconfigurable Radios

- Safety systems must work for the life of the vehicle
- This requires the in-vehicle data communications unit (DCU) to remain functional for two decades, through multiple generations of radio technology
- Software based radios can help by allowing the DCU to adapt to new radio technology
- To be serviceable in the vehicle, they must have...
  - Software controlled antenna filters – to enable DCUs to work on newly authorized frequencies without a hardware change
  - The ability to download and install updated software – to minimize need for physical equipment updates over the vehicle's service life
  - This defines a "software reconfigurable radio" (SRR)
- The international radio technology community is working to develop SRRs for in-vehicle use

5

US Government Activities in ITS

The transportation reauthorization bill passed in August 2005*

- Moves ITS from a niche program to the mainstream of transportation funding
- Provides significant new funding for ITS-related projects including vehicle infrastructure integration
- Prohibits unauthorized sale/use of traffic signal preemption transmitters
- Widens ITS access to funding of motor carrier safety research
- Funds Multiple ITS-related efforts including
  - National ITS Program Plan
  - National Architecture and Standards Program
  - Road Weather Research and Development Program
  - Centers for Surface Transportation Excellence
- Adds safety labeling requirements for new vehicles
- Creates ITS Research Advisory Committee

* ***"Safe, Accountable, Flexible, and Efficient Transportation Equity Act: A Legacy for Users" (SAFETEA-LU)***

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Vehicle Infrastructure Integration (VII) at U.S. Department of Transportation

- Vision: Significant reduction in highway fatalities and dramatic improvements in transportation mobility
- Goal: Equip every vehicle manufactured in U.S. with a communications device including GPS so that data can be exchanged effectively with a nationwide, instrumented roadway system
- Builds on vehicle safety technology trialed in the Intelligent Vehicle Initiative
- Uses 5.9 GHz band, specifically allocated for DSRC with public safety emphasis
- Progress is slow
  - Deployment of a national communications infrastructure at 5.9GHz is awaiting a business case being built in VII tests
  - Existing DSRC Industry Consortium is focused on commercial/tolling applications
  - Standards completion has proven difficult

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VII Initiative – Concurrent Tracks

- **Technical Implementation** – Complete definition of architecture and project cost to implement
- **DSRC Prototype** – Complete prototype testing of DSRC – make prototypes available for VII test program
- **Business Model** – Create a business plan, including requirements for deployment, public-sector and public-private financing options, expenditure justifications
- **Policy Issues** – Define privacy policies for public and private sector, and develop policies to protect privacy, minimize liability, and define who owns data
- **Outreach** – Conduct VII workshops and develop a plan to provide outreach to other potential stakeholders
- **Test Program** – Conduct vehicle, roadside, and network management subsystem tests, work on application integration, and do field tests

8

Cooperative Intersection Collision Avoidance Systems (CICAS) Initiative

- U.S. DOT partnership with vehicle manufacturers and states to examine intelligent systems to enhance driver decision-making at intersections to avoid crashes, including
  - Vehicle-based technologies – sensors, processors, driver interfaces within each vehicle
  - Infrastructure technologies – roadside sensors/processors to detect vehicles and identify hazards, signal systems, messaging signs, etc.
  - Communications systems – uses DSRC to communicate warnings and data between infrastructure and equipped vehicles
- CAMP is developing the vehicle-based framework for CICAS
  - CAMP includes BMW, DaimlerChrysler, Ford, GM, Nissan, Toyota, and Volkswagen
- Several states will conduct field tests
- Will integrate prototype WAVE roadside beacons to establish communication between intersection infrastructure and vehicles
- Participants and partners for initial projects expected to be announced at ITS World Congress in November

9

Integrated Vehicle Based Safety Systems Initiative (IVBSS)

- U.S. DOT partnership with automotive, commercial, and transit vehicle industries will expedite integrated vehicle-based safety systems in the U.S.
- Goal: to equip all new vehicles with advanced driver assistance systems to help drivers avoid common deadly crashes (rear-end, road departure, and lane change)
- Projects and studies to be conducted on private passenger vehicles, freight-carrying trucks, and transit buses to develop
  - Information on how best to communicate integrated warnings to drivers
  - Tests/criteria for performance of systems that simultaneously address the most common deadly crashes
  - Integrated vehicle-based systems tested on the road with prototype vehicles and real drivers to understand safety benefits
- Could potentially result in creation of active safety "star ratings" for crashworthiness
- Participants and partners for initial projects expected to be announced at ITS World Congress in November

10

General Approach for Vehicle Safety Communications Not Yet in Place

Telematics has not provided the communications necessary for safety

- Emphasis has been on user-oriented services, which are not intrinsically vehicle-related
- Communications-based safety systems including automatic crash notification (ACN) stop working if the vehicle owner/user stops making periodic payments
- Current telematics pathways do not provide confidentiality of customer relationships and critical vehicle data

11

Requirements for a New Safety-Oriented Approach

- Data-only communications
  - Simpler, more robust/crash resistant, less expensive than data and voice
  - More likely to get through in fringe areas and under difficult circumstances
- Safety systems must benefit all drivers, not only the owners of relatively new vehicles
  - In-vehicle data communications unit (DCU) must remain functional (i.e., able to be updated to current communications technology) for up to 20 years without charge after the initial vehicle purchase
  - Owner/driver must not be required to pay ongoing fees for safety functions after the initial vehicle purchase
- Vehicle safety requires very high transmission reliability
  - Must be able to send critical messages simultaneously over multiple communications media to maximize probability of getting through
- Automotive-grade reliability (when the vehicle is sold, the communications works without any set up activity and keeps working until a physical failure)

12

Thank you!

- Questions?

Dr. Ralf Guido Herrtwich

DAIMLERCHRYSLER

Vehicle IT and Services Research
Berlin · Stuttgart · Ulm · Palo Alto
driving connectivity

Car-2-X Communication in Europe

Dr. Ralf Herrtwich

Vehicle IT and Services Research
(REI/V)

September 19, 2005

DAIMLERCHRYSLER

Car-2-X Communication in Europe in the Past

PROMETHEUS

Car-2-X Communication has its roots in the PROMETHEUS Programme!

First work 1988-1989 in the subproject Copdrive CED4

Technology: Radio location/orientation and communication

The Mercedes-Benz demo vehicle!

Photo taken at the Munich Test Track in preparation for the first PROMETHEUS Board Members Meeting 1989

CED4 presentation: radio location and communication. Exchange of the intention of maneuvers and exchange of actual maneuvers. Display of the state for external observers through 2 lamps on the roof. No GPS!

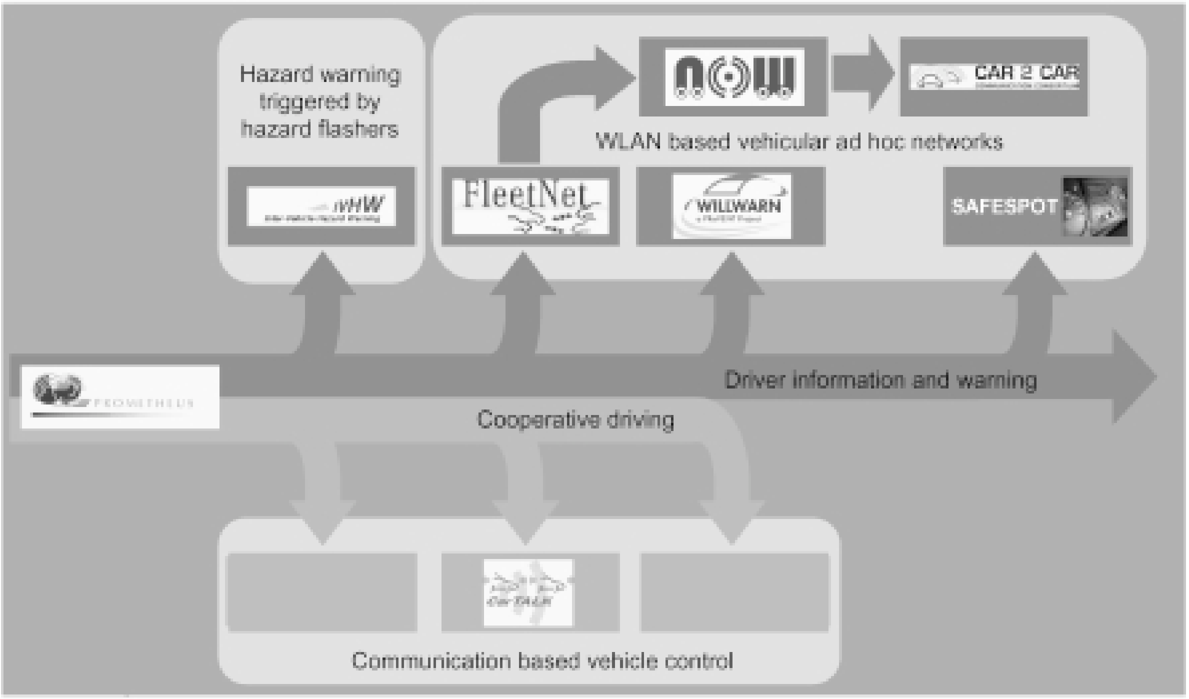
During the course of the project, the focus shifted from co-operative driving applications towards registration and communication of warning messages.

However, technology in location and communication has changed dramatically since then!

DaimlerChrysler Confidential　September 19, 2005　2

DAIMLERCHRYSLER

Car-2-X Communication in Europe after PROMETHEUS



DAIMLERCHRYSLER

More Recent Activities

EU research projects:

- Inter-Vehicle Hazard Warning
- CarTALK 2000

German research projects:

- FleetNet – Internet on the Road

DaimlerChrysler Confidential　　September 19, 2005　　4

DAIMLERCHRYSLER

Inter Vehicle Hazard Warning
2001-2003

IVHW Inter-Vehicle Hazard Warning

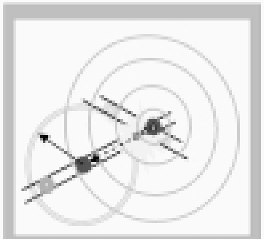
French-German Telematics Research Project funded under the DEUFRAKO framework

Partners:
- Robert Bosch GmbH, **DaimlerChrysler AG**, BASt, Renault, PSA, Cofiroute, INRETS, ISIS, Estar

Objective:
- Vehicle-to-vehicle communications to advance danger awareness of the driver by about 4 to 8 seconds and thus, to enable "comfortable" safe driver reactions

IVHW-Approach:
- Expand range of hazard flashers optical signaling by superposing radio messaging

Results:
- Developed a warning system specific for hazard warning in the 869 MHz spectrum
- Dedicated application/communication was deemed unfeasible for market introduction because of penetration issues



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CarTALK 2000
2001 - 2004

CarTALK

European research project funded by EC within the 5th Framework Programme

Partners:
- **DaimlerChrysler AG**, Centro Ricerche Fiat, Robert Bosch GmbH, Siemens AG, Netherlands Organisation for Applied Scientific Research (TNO), University of Cologne, University of Stuttgart

Objective:
- Communication protocols and application development for safe and comfortable driving

CarTALK 2000-Approach:
- Use of inter-vehicle communication technology for driver information, longitudinal control of vehicles and cooperatve driving assistance

Results:
- Identified and validated automotive applications based on communication

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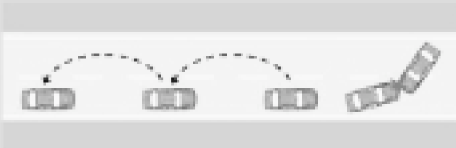
DaimlerChrysler

CarTALK 2000
2001 - 2004

IWF – Information and Warning Functions



- Accident ahead, car break down
- Congestion
- Road condition monitoring
- Extended blind spot (e.g. lane merging)

CBLC – Communication-Based Longitudinal Control Systems

- Stop and go traffic
- Advanced distance keeping: anticipated driving, early braking
- Advanced flow control and throughput

CODA – Co-Operative Driver Assistance Systems

- Merging at highway ramps, merging two lanes
- Crossover merging

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FleetNet – Internet on the Road
2000 - 2003

German research project funded by Ministry of Education and Research

Partners:

- **DaimlerChrysler AG,** Fraunhofer Institut Fokus, NEC Europe Ltd., Robert Bosch GmbH, Siemens AG, TEMIC Speech Dialog Systems GmbH
- Subcontractors: TU Braunschweig, TU Hamburg-Harburg, University of Hannover, University of Mannheim

Objective:

- Development and demonstration of vehicular ad hoc networks for inter-vehicle communications to support active safety applications and information applications

Fleetnet-Approach:

- Use of existing communication technology to prove feasibility of ad hoc networks for inter-vehicle communication

Results:

- Communication protocols at the network layer for vehicle-to-vehicle communication

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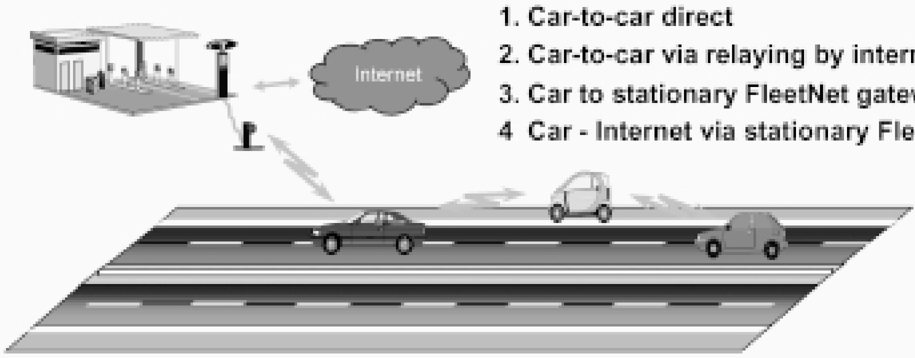
DaimlerChrysler

FleetNet – Internet on the Road
2000 - 2003

FleetNet

Inter-Vehicle Communications Platform

1. Car-to-car direct
2. Car-to-car via relaying by intermediate cars
3. Car to stationary FleetNet gateway
4 Car - Internet via stationary FleetNet gateway



Applications
- Cooperative Driver Assistance
  - Emergency notifications
  - Platooning
- Decentralized Floating Car Data
  - Dynamic navigation
  - Route weather forecast
- User Communication & Information Services
  - Internet access
  - Mobile office

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Ongoing projects

EU research projects:
- PReVENT WILLWARN

German research projects:
- NOW – Network on Wheels

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PReVENT WILLWARN
2004 - 2007

WILLWARN a PReVENT Project

European research project funded by EC within the 6th Framework Programme as part of the PReVENT Integrated Project

Partners:

- **DaimlerChrysler AG**, TNO Automotive, BMW Forschung und Technik GmbH, Philips, National Technical University of Athens, CNRS – Ile de France Est, HTW Forgis

Objective:

- Development of driver information and warning system using oncoming traffic as information carrier

WILLWARN-Approach:

- Hazard detection algorithms based on CAN data, GPS, and optional environment sensors e.g. radar
- Warning Message Management with messaging and forwarding strategies
- On-board relevance checks and warning evaluation
- System architecture and protocols for routing and application

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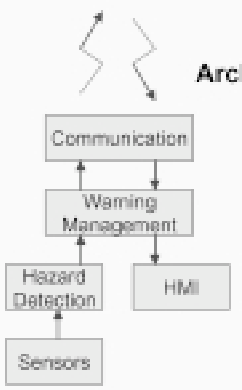
PReVENT WILLWARN
2004 - 2007

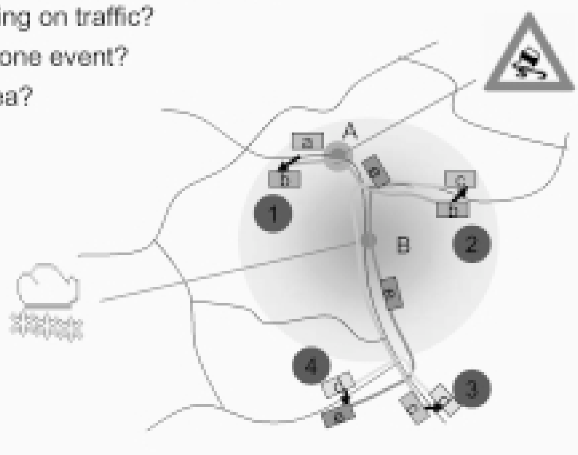
WILLWARN a PReVENT Project

Important Questions

- What happens in road networks depending on equipment rate?
- How long do messages survive depending on traffic?
- How to handle multiple messages from one event?
- Different types of messages: spot or area?

Architecture





Message transport: 1 -> 2 -> 3 -> 4

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DAIMLERCHRYSLER

NOW - Network on Wheels
2004 - 2008

German research project funded by Ministry of Education and Research

Partners:
- BMW Forschung und Technik GmbH, **DaimlerChrysler AG,** Fraunhofer Institut Fokus, NEC Deutschland GmbH, Siemens AG, Volkswagen AG
- Subcontractors: TU Braunschweig, TU Hamburg-Harburg, University of Hannover, University of Mannheim

Objective:
- Development of VANET (vehicle ad hoc network)-demonstrator from Proof-of-Concept system towards a reference system of the Car-2-Car-Communication Consortium (C2C-CC) standard

NOW-Approach:
- Use of Fleetnet results as basis for realization and demonstration of reference system for vehicular ad hoc networks.
- Adoption of US protocols to Europe

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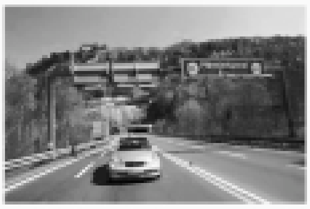
DAIMLERCHRYSLER

NOW - Network on Wheels
2004 - 2008

Technical challenges:
- Scaleable Geo-Broadcast:
  - reliable delivery of data packets
  - scaling in situations with low, medium and high numbers of vehicles
  - radio transmission combined with physical data transport by vehicles
- Data security in vehicular ad hoc networks:
  - authentication and integrity of exchanged safety related data
  - taking into account anonymity and privacy concerns of users
- Architecture to support simultaneously active safety and deployment applications by enabling car to car and car to infrastructure communication



Demonstrator:
- Implementation of a demonstrator system according the C2C CC standardization progress as basis for the C2C CC demonstrations

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Activities to start soon

EU research projects:

- SAFESPOT Integrated Project

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SAFESPOT IP
2006 - 2008

Integrated Project (IP) funded by EC within the 6th Framework Programme

Partners:

- **CRF,** DaimlerChrysler AG, Renault, Volvo, Piaggio, Bosch, Conti-Teves, Siemens VDO, IBEO, Navteq, Teleatlas, Siemens, Kapsch, Lacroix, ptv, Telefonica, MIZAR, Qfree, Sodit
  + various road operators, research institutes and universities

Objective:

- Creation of extended horizon in space/time through cooperation with other vehicles and infrastructure
- Definition of conditions, that guarantee the safety, without affecting efficiency (safety margin)

SAFESPOT-Approach:

- Create solutions for relative, accurate localisation between vehicles based on cooperation between vehicles and between vehicles and infrastructure
- Generate local dynamic maps through merging of digital maps with information coming from vehicles and infrastructure (e.g. road status, presence of obstacle,…)
- Algorithms for routing in ad hoc networks

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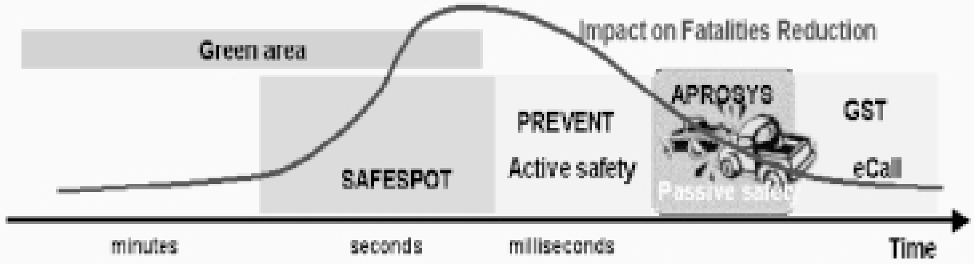
SAFESPOT IP
2006 - 2008



Extended horizon in space/time through cooperation of other vehicles and the infrastructure

Define conditions that guarantee safety without affecting efficiency (safety margin)

Help the driver to stay in these conditions

Manage any dangerous situation, as often as possible with normal driving maneuvers

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To Dos

Joint initiatives are needed in Europe to address three top issues:

Frequency allocation:
- Agreement on a frequency spectrum for vehicular safety applications similar to the US
- Initiatives are underway, but slow
- ETSI TG 37 has developed draft technical document to be submitted to CEPT

Protocol definition:
- Adoption of US / international protocols wherever possible

Infrastructure deployment:
- Investigation of infrastructure deployment similar to the US and Japan
- The only way to reach penetration quickly

Out of the NOW project, the European Car-2-Car Communication Consortium (C2C-CC) has been set up, that takes care of these issues.

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CAR 2 CAR
COMMUNICATION CONSORTIUM

Car 2 Car Communication Consortium

Objectives & Organisational Structure

September 2004 Objectives & Organisation 19

CAR 2 CAR
COMMUNICATION CONSORTIUM

The Consortium

- The Car2Car Communication Consortium is a non-profit organisation initiated by European vehicle manufacturers
- open for suppliers, research organisations and other partners
- working on an open system supporting active safety applications as well as a broad range of information services

September 2004 Objectives & Organisation 20

CAR 2 CAR
COMMUNICATION CONSORTIUM

MISSION

- is to bring out the idea of working together for more safety on the road
- is to establish an open European industry standard for Car2Car Communication systems
- is to promote the allocation of a royalty-free European-wide frequency band for Car2Car applications
- is to force the harmonisation of the Car2Car Communication standard worldwide

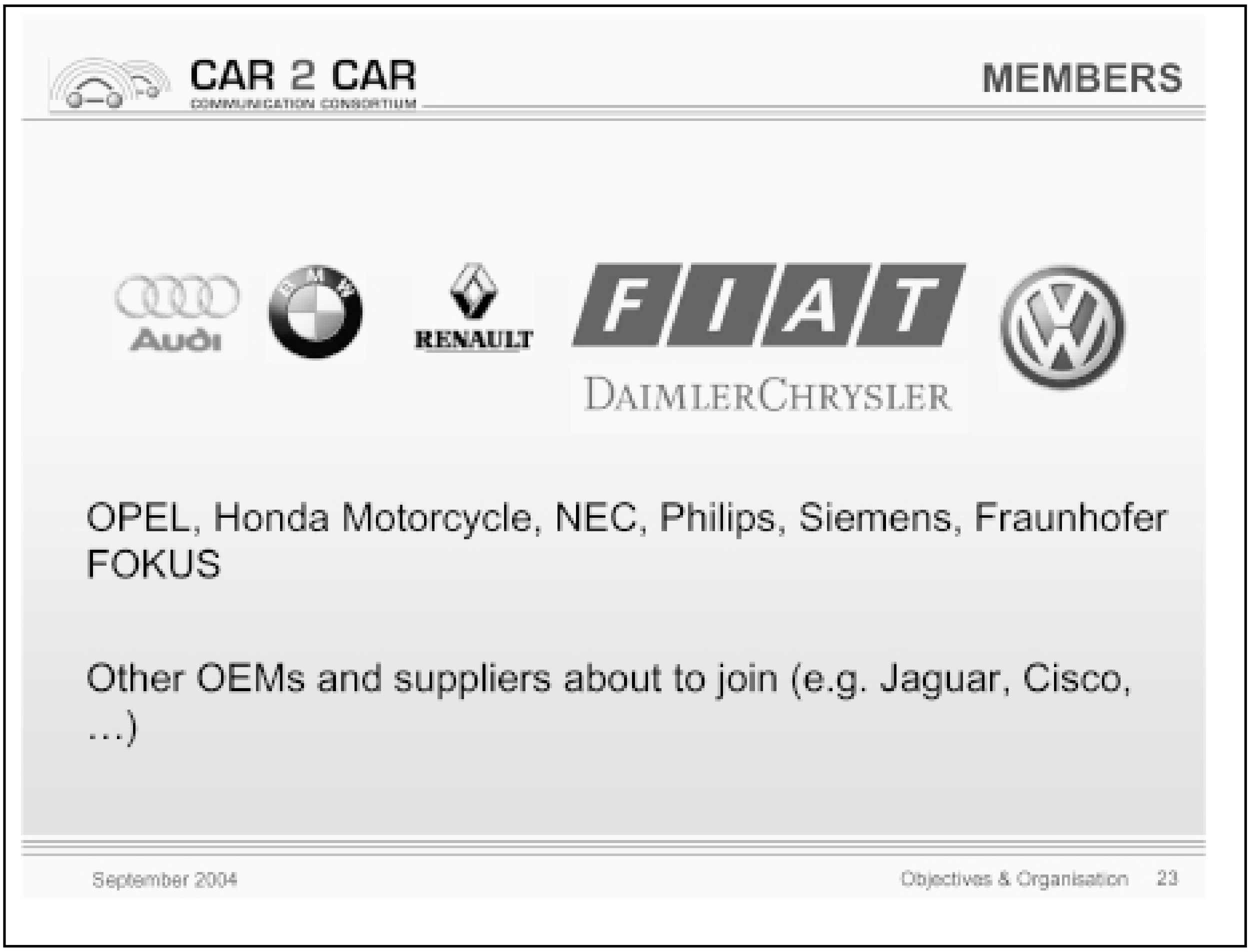
September 2004 Objectives & Organisation 21

CAR 2 CAR
COMMUNICATION CONSORTIUM

OBJECTIVES

- Creating an open European industry standard for inter-vehicle-communication systems based on wireless LAN components off-the-shelf to guarantee European-wide inter-vehicle operability
- Ensuring high availability, reliability and the necessary data security and anonymity of the C2C system
- Enabling the development of active safety applications by specifying, prototyping and demonstrating the C2C system
- Developing realistic deployment strategies and business models to speed-up the market penetration
- Taking into consideration worldwide related activities

September 2004 Objectives & Organisation 22


CAR 2 CAR
COMMUNICATION CONSORTIUM
MEMBERS
Audi
BMW
RENAULT
FIAT
DAIMLERCHRYSLER
OPEL, Honda Motorcycle, NEC, Philips, Siemens, Fraunhofer FOKUS
Other OEMs and suppliers about to join (e.g. Jaguar, Cisco, …)
September 2004
Objectives & Organisation 23

櫛田　和光

Concept of Inter-vehicle Communication type Driving Support System

ASV3 Inter-vehicle Communication
System Technology WG
Honda R&D Co.,ltd. Asaka R&D center
Research Engineering Dep. S
Kazumitsu Kushida
kazumitsu.kushida@mail.a.rd.honda.co.jp

Contents

- Fundamental philosophy of ASV
- Basic Concept for Driving Support Technology in ASV
  - ✓ Basic concept
  - ✓ Past efforts utilizing communication technology
  - ✓ Future view
- Concept making procedure
- Fundamental radio wave propagation test
  - ✓ Open road condition
  - ✓ Poor visibility condition

Fundamental philosophy of ASV

- Fundamental principle of driver assistance
  - ✓The system respect driver's will
  - ✓Driver always drive with responsibility as a precondition
- Driver acceptance
  - ✓Well designed Human-machine Interface can be used in comfort
- Social acceptance
  - ✓The right understanding for the system is accepted from other traffic users

Basic Concept for Driving Support Technology

Basic concept

Object is "in the driver's field of view"

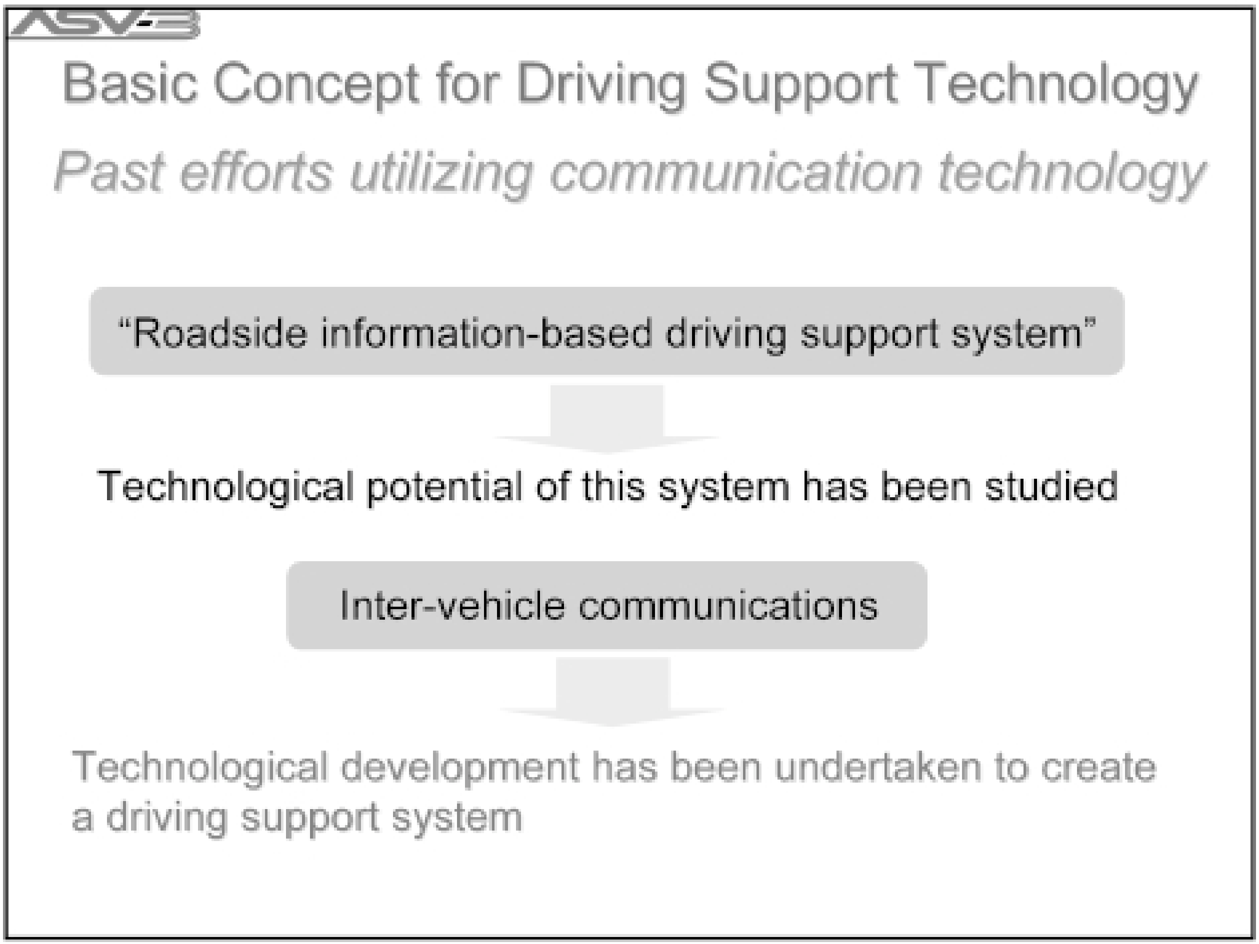
↓

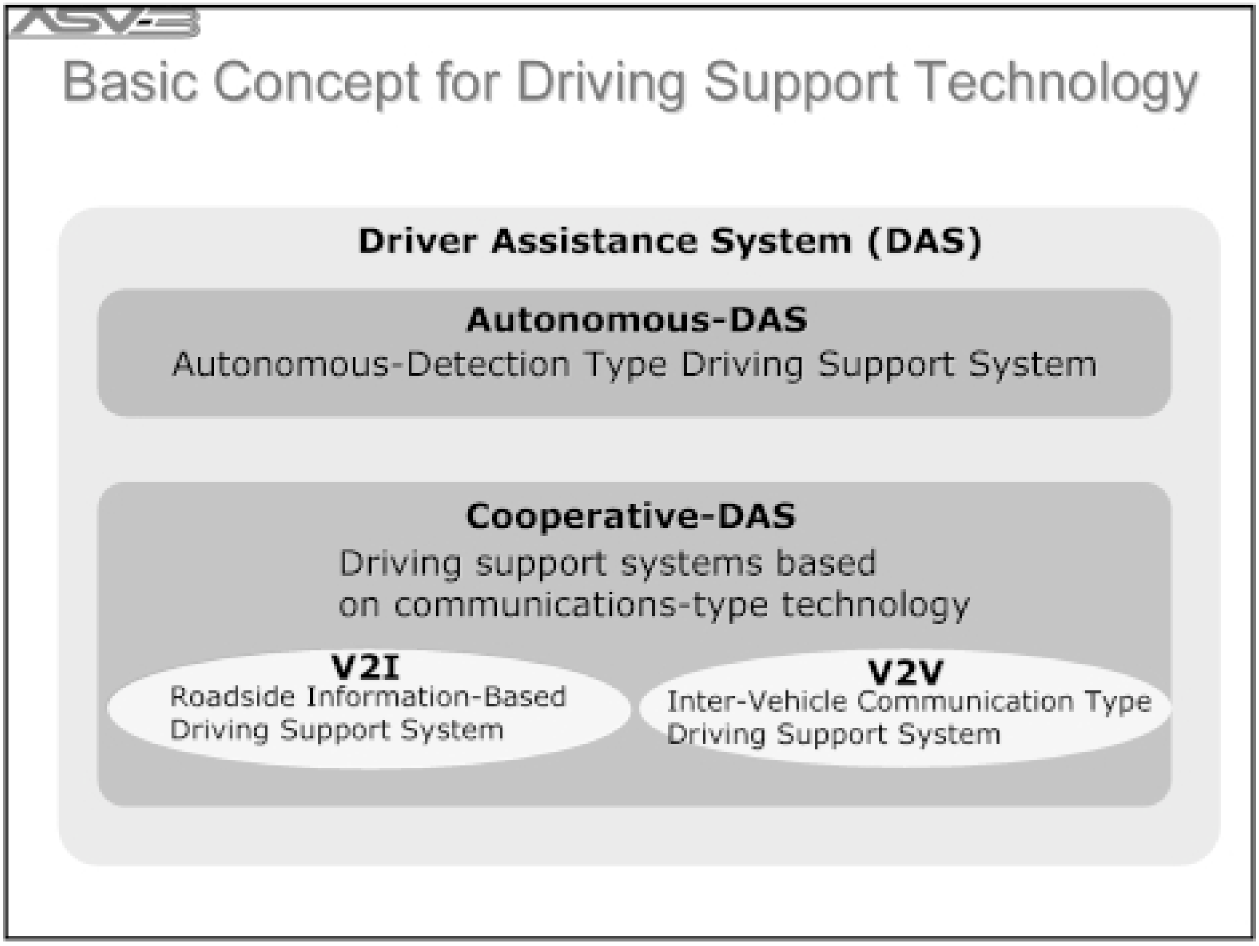
"Autonomous-detection type driving support system"

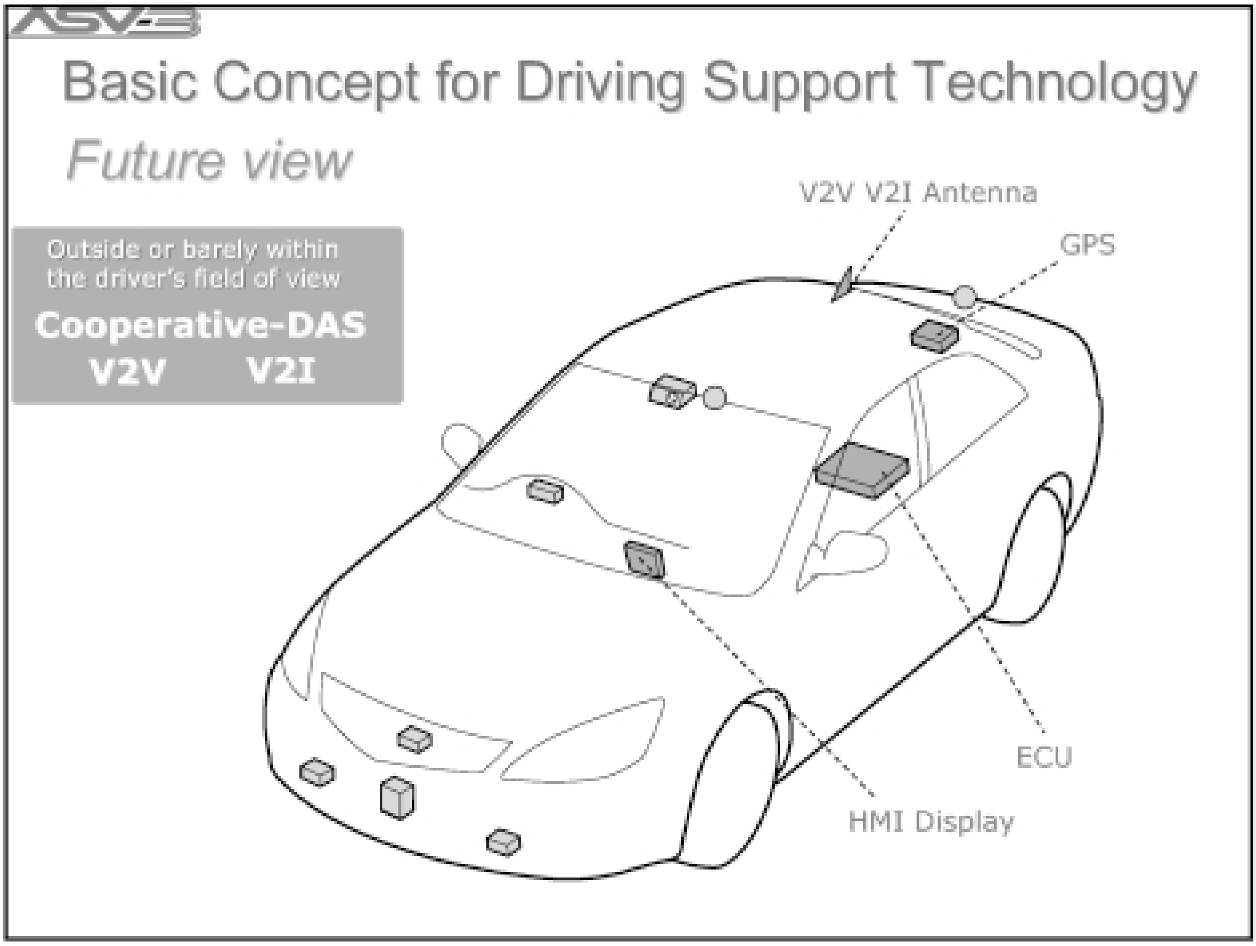
Object is "outside or barely within the driver's field of view"

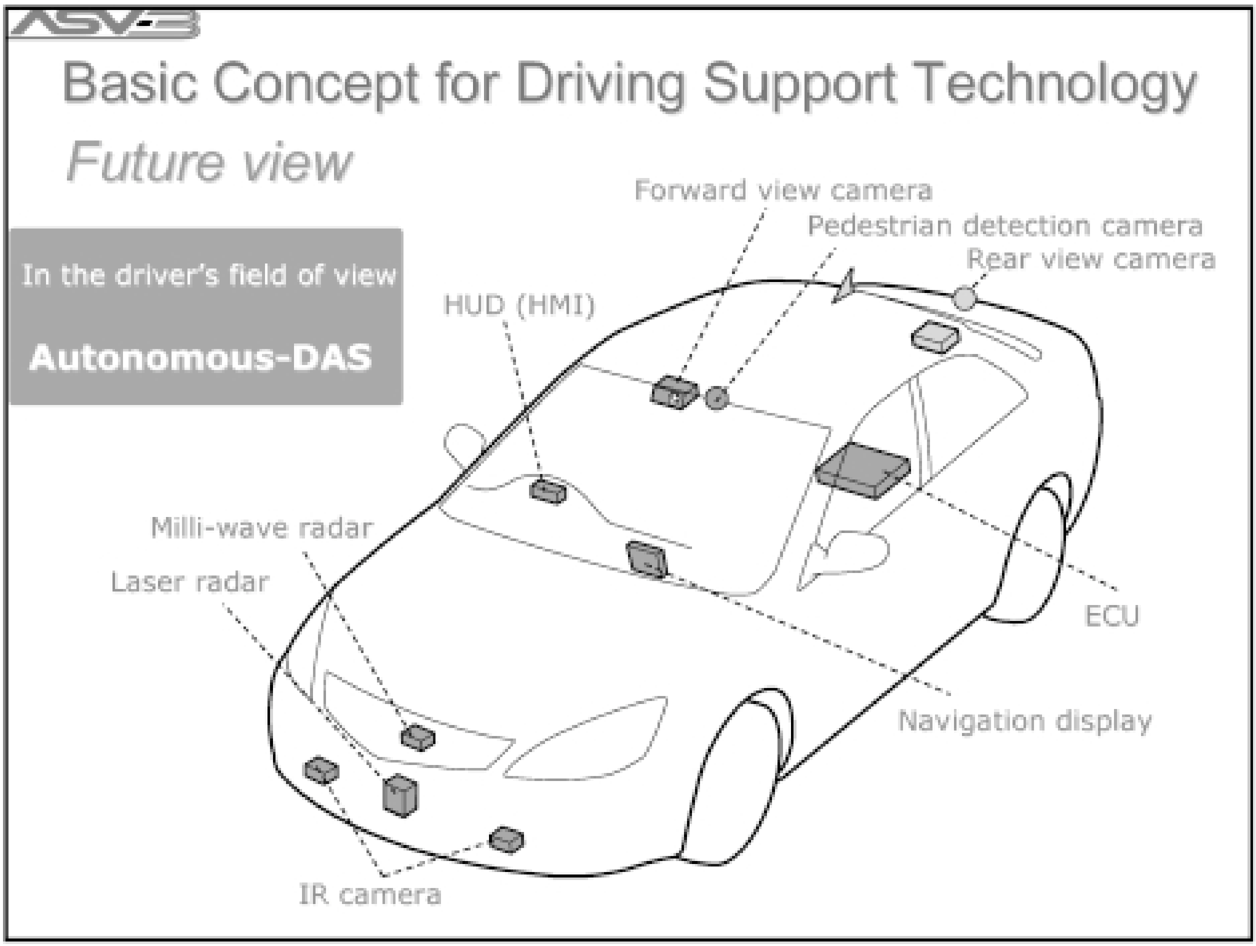
↓

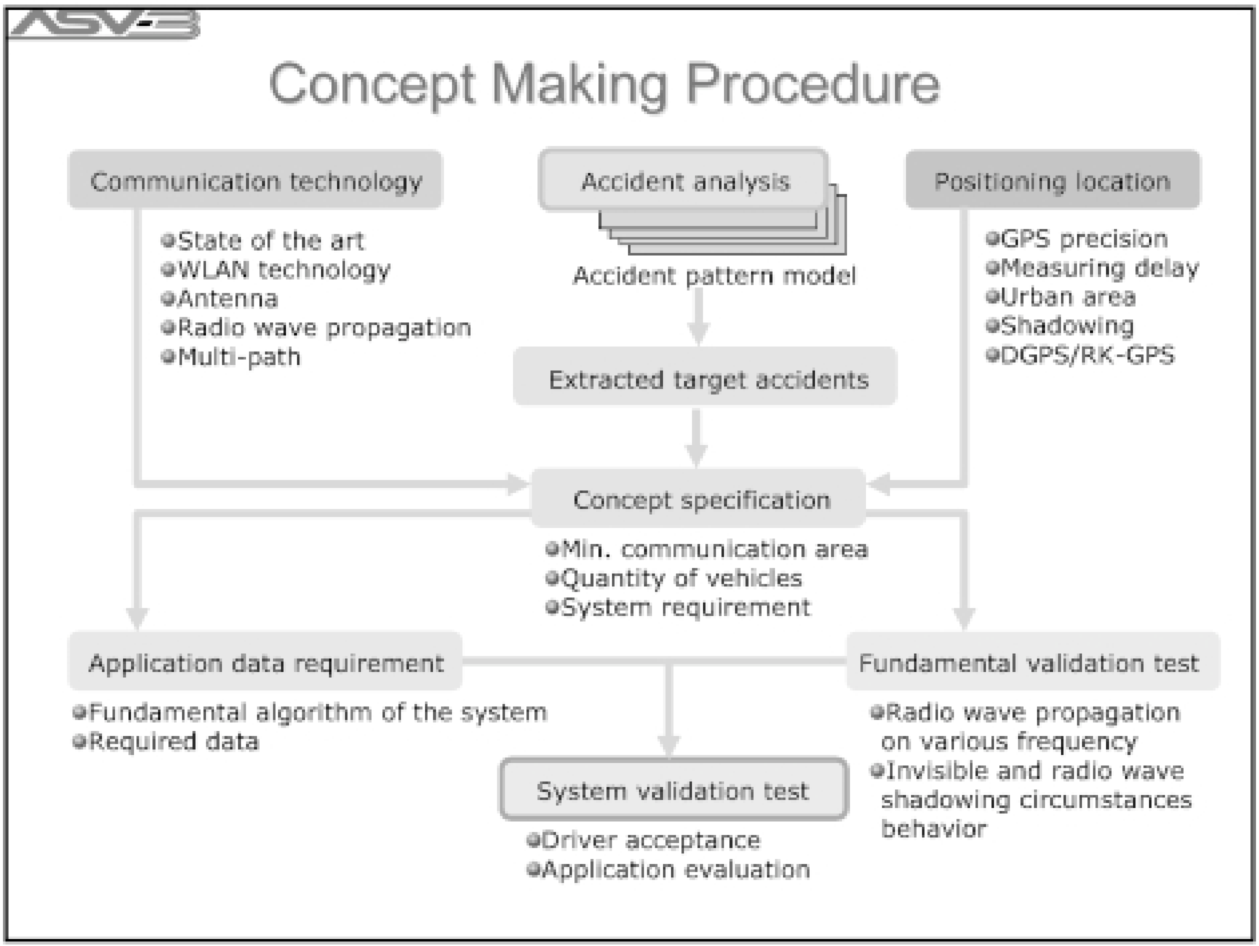
"Communications-type technology"

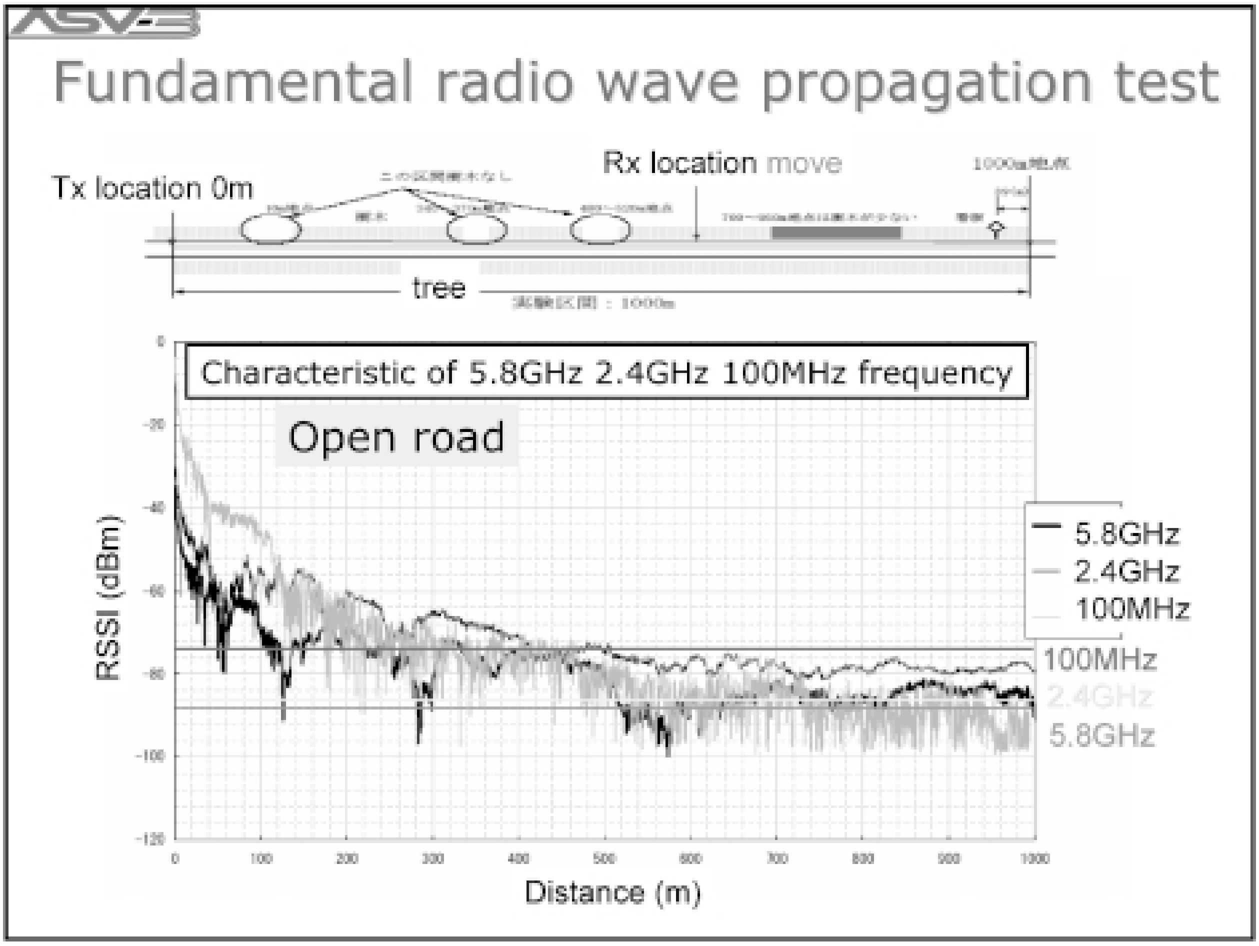

Basic Concept for Driving Support Technology
Past efforts utilizing communication technology
"Roadside information-based driving support system"
Technological potential of this system has been studied
Inter-vehicle communications
Technological development has been undertaken to create a driving support system

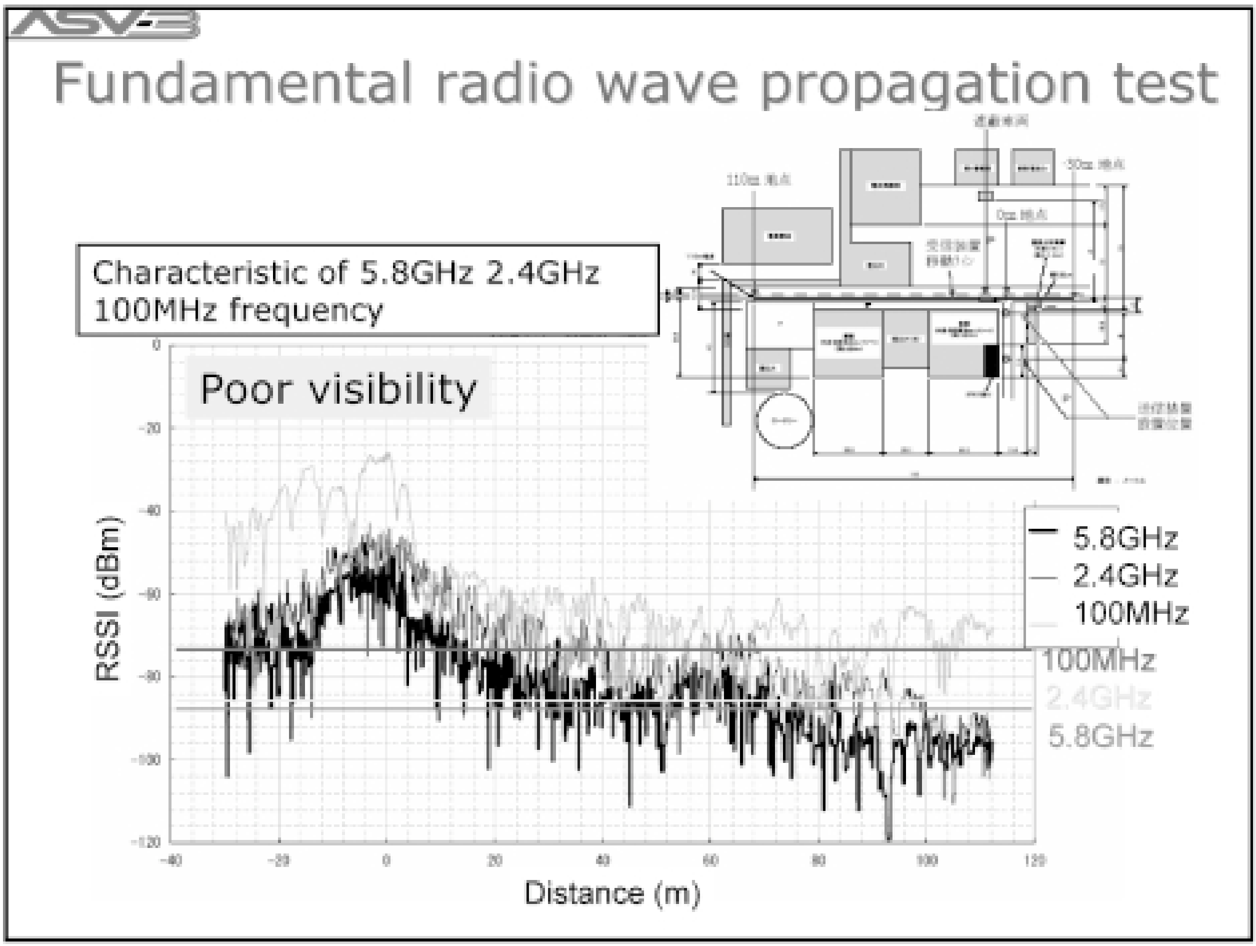

Basic Concept for Driving Support Technology
Driver Assistance System (DAS)
Autonomous-DAS
Autonomous-Detection Type Driving Support System
Cooperative-DAS
Driving support systems based on communications-type technology
V2I
Roadside Information-Based Driving Support System
V2V
Inter-Vehicle Communication Type Driving Support System


Basic Concept for Driving Support Technology
Future view
Outside or barely within the driver's field of view
Cooperative-DAS
V2V V2I
V2V V2I Antenna
GPS
ECU
HMI Display


Basic Concept for Driving Support Technology
Future view
In the driver's field of view
Autonomous-DAS
Forward view camera
Pedestrian detection camera
Rear view camera
HUD (HMI)
Milli-wave radar
Laser radar
ECU
Navigation display
IR camera


ASV-3
Concept Making Procedure
Communication technology
●State of the art
●WLAN technology
●Antenna
●Radio wave propagation
●Multi-path
Accident analysis
Accident pattern model
Extracted target accidents
Positioning location
●GPS precision
●Measuring delay
●Urban area
●Shadowing
●DGPS/RK-GPS
Concept specification
●Min. communication area
●Quantity of vehicles
●System requirement
Application data requirement
●Fundamental algorithm of the system
●Required data
Fundamental validation test
●Radio wave propagation on various frequency
●Invisible and radio wave shadowing circumstances behavior
System validation test
●Driver acceptance
●Application evaluation


ASV-3
Fundamental radio wave propagation test
Tx location 0m
Rx location move
tree
Characteristic of 5.8GHz 2.4GHz 100MHz frequency
Open road
RSSI (dBm)
Distance (m)
5.8GHz
2.4GHz
100MHz
100MHz
2.4GHz
5.8GHz


Fundamental radio wave propagation test
Characteristic of 5.8GHz 2.4GHz 100MHz frequency
Poor visibility
RSSI (dBm)
Distance (m)
5.8GHz
2.4GHz
100MHz
100MHz
2.4GHz
5.8GHz
110m 地点
30m 地点
0m 地点

金光　寛幸

2

A Concept and a Study on Inter-vehicle Communication type Driving Support System

ASV3 Inter-vehicle Communication System
Technology WG, Concept SWG leader
Toyota Motor Corporation
Integrated System Engineering Div.
Hiroyuki Kanemitsu

3

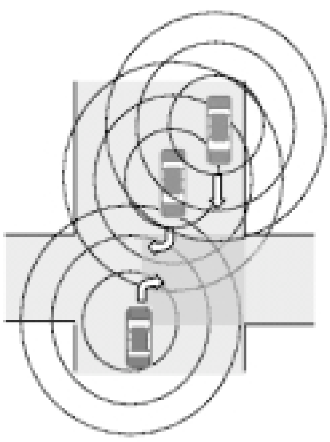
Contents

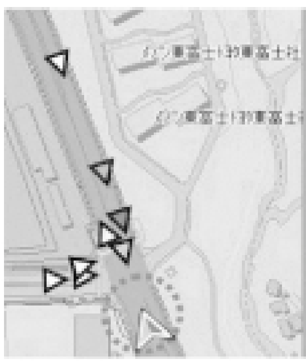
- Concept of ASV3 Inter-vehicle Communication type Driving Support System.
  - ✓ Target collision patterns and potential benefits
  - ✓ System Functionalities
  - ✓ Technical Challenges
- Common specifications for inter-vehicle communication.
  - ✓ Communication range
  - ✓ Frequency and transmission power

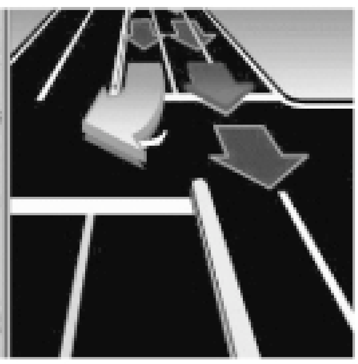
4

What is Inter-vehicle Communication?

- Each vehicle periodically transmits own speed, position and other vehicle status information.
- Information from the other vehicles enables the better understanding of the surrounding traffic situation.



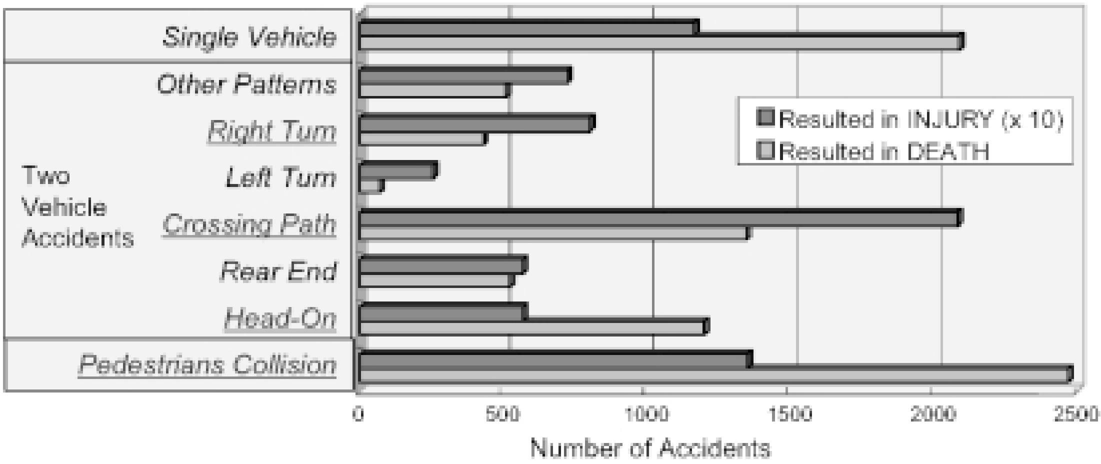




5

Accident Analysis

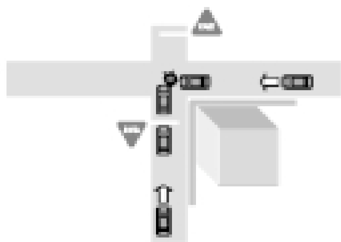
- Target collision patterns are identified through detailed analysis of accident statistics.



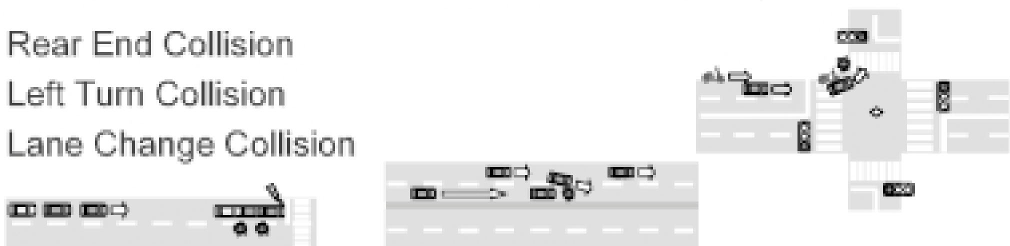
6

Target Collision Patterns

- "Miss Detection" is the leading cause of many high occurrence accidents patterns.
  - ✓ Right Turn Collision
  - ✓ Head-On Collision
  - ✓ Crossing Path Collision
  - ✓ Pedestrian Collision



- Regardless of the frequency of occurrence, the society needs to develop countermeasures for these collision patterns that tend to result in severe consequences.
  - ✓ Rear End Collision
  - ✓ Left Turn Collision
  - ✓ Lane Change Collision

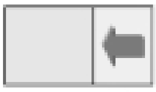


ASV-3 7

Potential Accident Reduction

- Premises
  - ✓ Selected 7 target collision patterns
  - ✓ All vehicles are equipped with OBE (=100%)
  - ✓ ASV systems prevent all accidents.

- Reduction of 2,500 death accident / year (-28%)



From
9,192 accidents

To 6,700 accidents

- Reduction of 25,000 injury accidents / year (-36%)

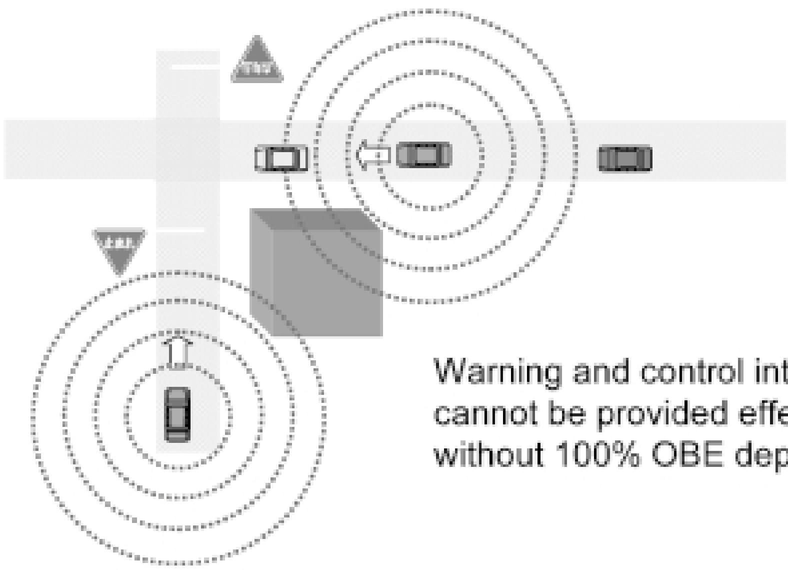
From
72,212 accidents

To 47,000 accidents

ASV-3 8

System Functionality

- There will be vehicles without OBE on the road. Therefore the system functionality should be limited to services that ask for driver's attention.

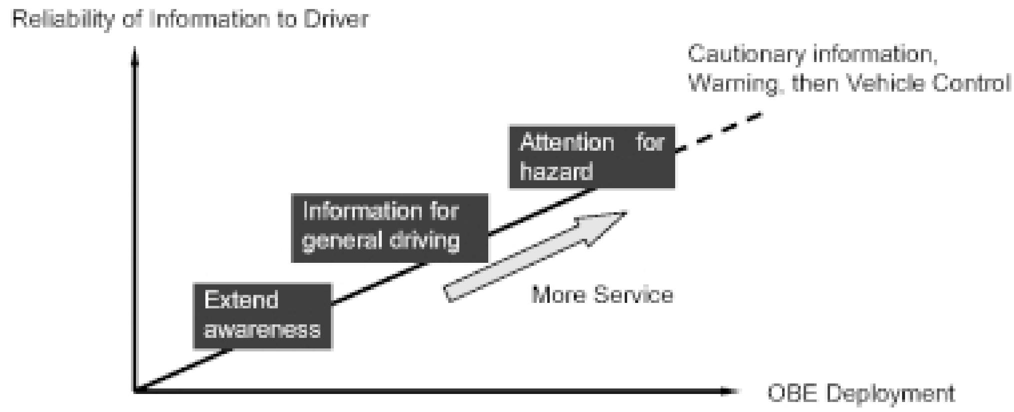


Warning and control intervention cannot be provided effectively without 100% OBE deployment.

9

Escalation of System Functionality Along with OBE Deployment

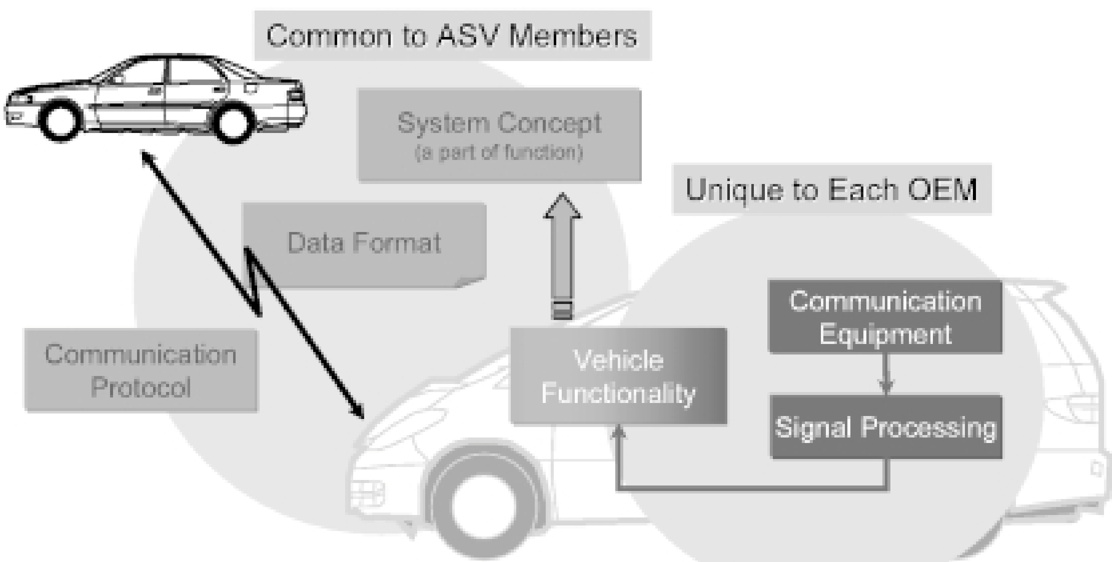
- Systems can provide more functionalities as the number of vehicle with OBE increases.



10

ASV Project Boundary

- ASV members developed common specifications where industry de-facto standards are required.



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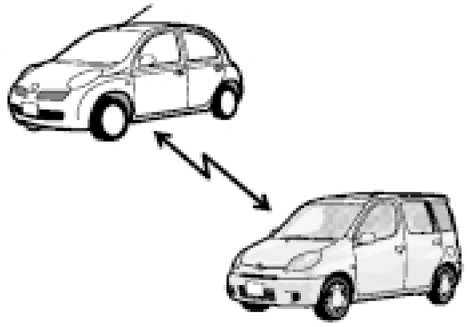
Data Format



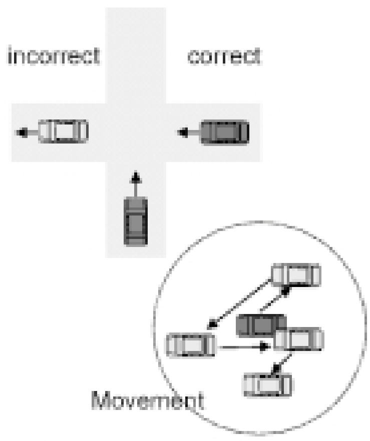
Data Structure

- **Application Data BODY**
  - **Administration FIELD**
  - **Standard Info FIELD**
    - Vehicle ID
    - Destination ID
    - Vehicle Class
    - Position UNIT
    - Motion UNIT
  - **Equipment Status FIELD**
    - Gear Position
    - Brake
    - Turn Signal
    - Hazard Switch
  - **Vehicle Status FIELD**
  - **Message FIELD**
  - **Individual Data FIELD**

ASV-3 12

Technical Challenges

- **Positioning Error**
  Inaccurate position determination due to GPS signal errors & internal data processing errors.
- **Path Prediction Error**
  Misinterpretation of vehicle heading due to varying location signals from the other cars.



↑ **Common Issues to ASV Members**

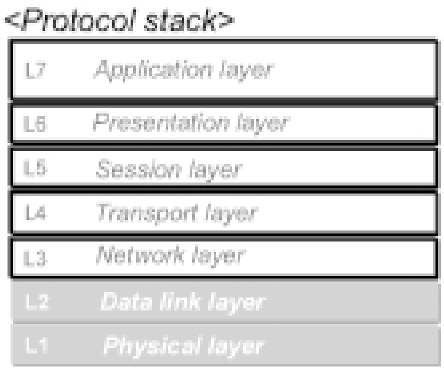
Unique Issues to Each Member ↓

- **Signal Processing Burden**
  Can we identify the potentially hazardous vehicles among many vehicles in the communication range?
- **HMI**

13

Development of Common Specifications

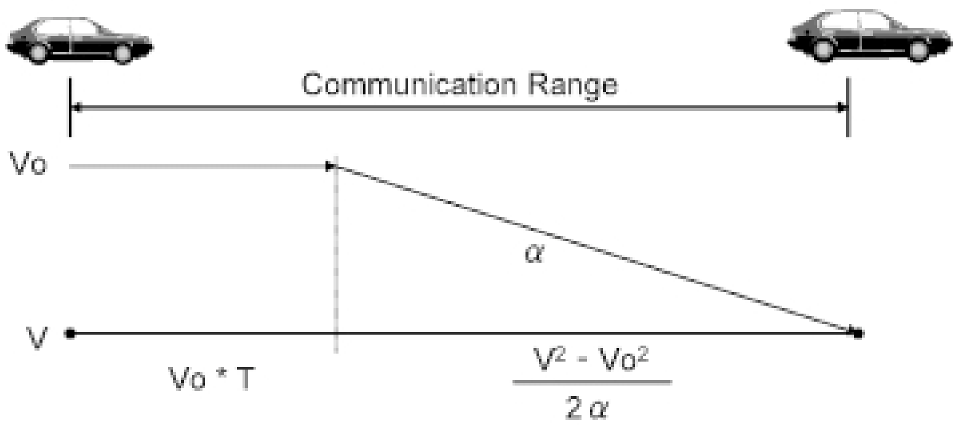
- ASV members determined the common specifications for the Layer 1 & 2 through analyses on:
  - ✓ Necessary Communication Range
  - ✓ Radio Wave Propagation
  - ✓ Data Transfer Speed



14

Thoughts about Communication Range

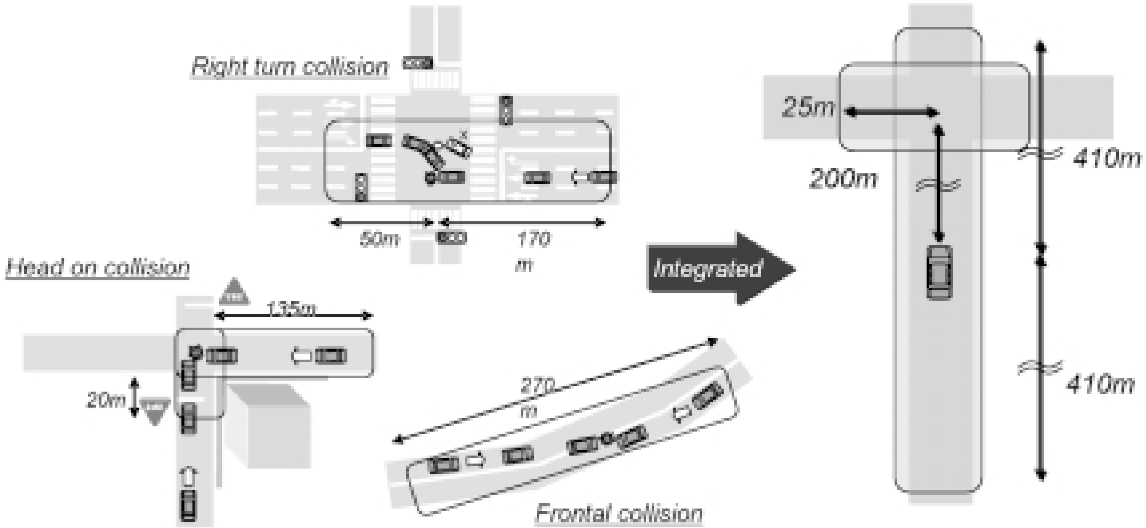
- **Vo**: 90%-ile value in initial speed when drivers recognized dangerous situation (based on accident statistics).
- α : Longitudinal Deceleration $\geq$ -2 m/s^2 - passenger car (for trucks $\geq$ -1 m/s^2)
- **T**: Time lag until the driver takes an action = 4 sec.
- **V**: Final vehicle speed is 0 m/s.



ASV-3 15

Required Communication Area

- Necessary communication areas for attention services to cover target collision patterns were determined.



ASV-3 16

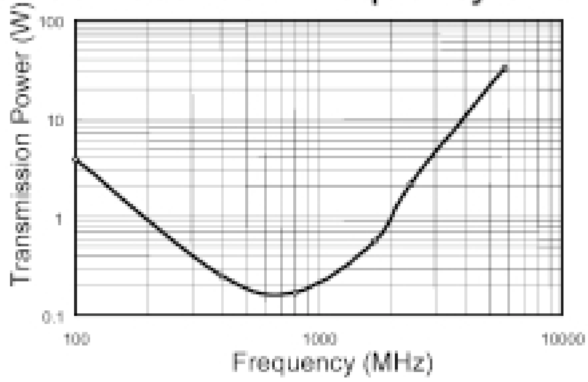
Radio Frequency & Transmission Power

- Appropriate radio characteristics were identified based on propagation characteristics.

✓ Premise Condition

Antenna gain	*0dB*
Antenna feeder loss	*2dB*
Antenna directional pattern	*Omni-directional*

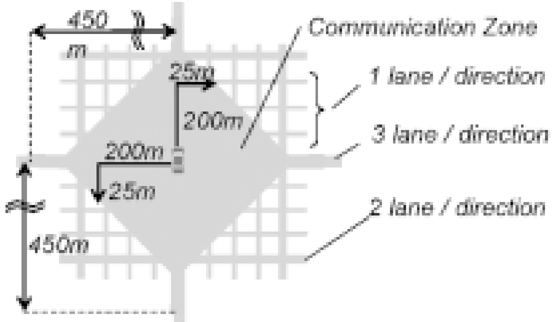
✓ Correlation between Frequency and Required Power



17

Communication Capacity

■ Premise Condition

Data size	*200 bytes (including redundancy)*
Number of vehicles	*Max. 1780 (assuming 1 second as inter-vehicle gap)*
Road Configuration & Communication Zone	
Medium access control	*CSMA*
Communication establishment rate	*≧80%*
Transmission period	*Controlled by vehicle speed*

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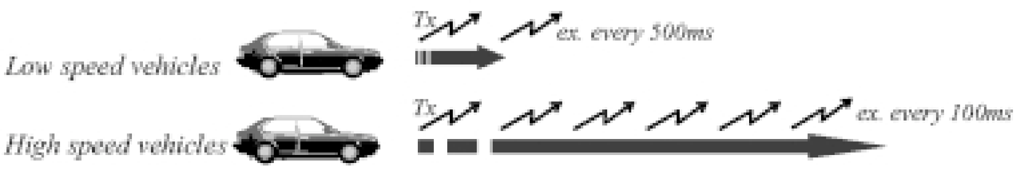
Transmission Period Control

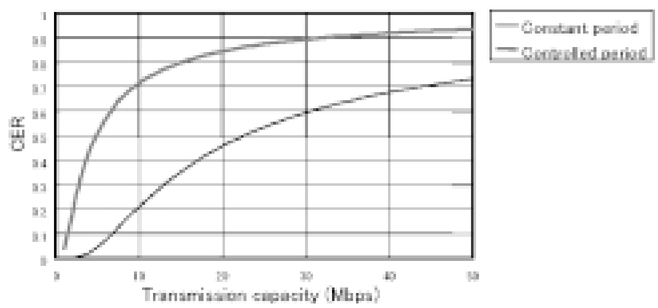
■ Change signal transmission intervals based on vehicle speed to reduce communication traffic.



Controlled Period (ex.)

Vehicle Speed	*Tx Period*
> 100km/h	*100ms*
80-100km/h	*120ms*
60-80km/h	*150ms*
40-60km/h	*200ms*
20-40km/h	*300ms*
10-20km/h	*600ms*
< 10km/h	*1200ms*

Correlation between Capacity and CER



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Modulation Method / Channel Control

- Multi carrier method is more applicable than single carrier method.

Modulation Method	Channel Capacity	Channel Control	Advantage	Disadvantage
Single Carrier	Small(100kbps order)	Necessary	Simple demodulator	Complex L2 protocol
Multi Carrier	Large (10MHz order)	Not always necessary	Simple L2 protocol	Complex demodulator

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Ideal L1 / L2 Protocol

		Deployment Practicality
Frequency	From hundreds of MHz to a few GHz	△
Transmission Power	Less than 1W (30dBm)	△
Polarization	Vertical polarization	○
Capacity	About 20Mbps	○
Modulation method	OFDM-QPSK	○
Countermeasure to multi-path fading	Forward error correction ex. Reed-Solomon & Punctured coding etc.	○
Medium access control	CSMA/CA	○
Channel control	Single channel	○
Transmission period	Controlled on vehicle speed	○

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Conclusions

- Target collision patterns for ASV information-sharing systems are identified.
- The ASV systems are limited to services that ask for driver’s attention.
- Communication ranges for target collision patterns are determined.
- Ideal requirements for L1 / L2 layer are identified.

高田　雅司

IVC(Inter-Vehicle Communication) System Validation Test Concept & Progress Report

October 14 2005

ASV System Validation SWG leader
NISSAN MOTOR CO., LTD.
Advanced Vehicle Engineering Division
Masashi Takada

Purpose of Validation Test

To qualify, in a realistic environment, the efficiency of a driving support system based on the collection of information from surrounding vehicles.

Main validation items:

- suitability of the position measurement accuracy that can be reached with today's measurement technologies.
- absence of adverse effects (driver confusion, misinterpretation, mishandling of the situation) when the system is used in an environment that includes non IVC-equipped vehicles.

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Validation Test Place

Civil Engineering Research Institute of Hokkaido

Cold-region Test Track in Tomakomai

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Validation Test Term

- Preliminary Test
  July 2005

- Validation Test
  August to October 2005

ASV-3 5

Test Accidents

（１）Right turn collision

（２）Crossing path collision

（３）Pedestrian collision

（４）Head-on collision

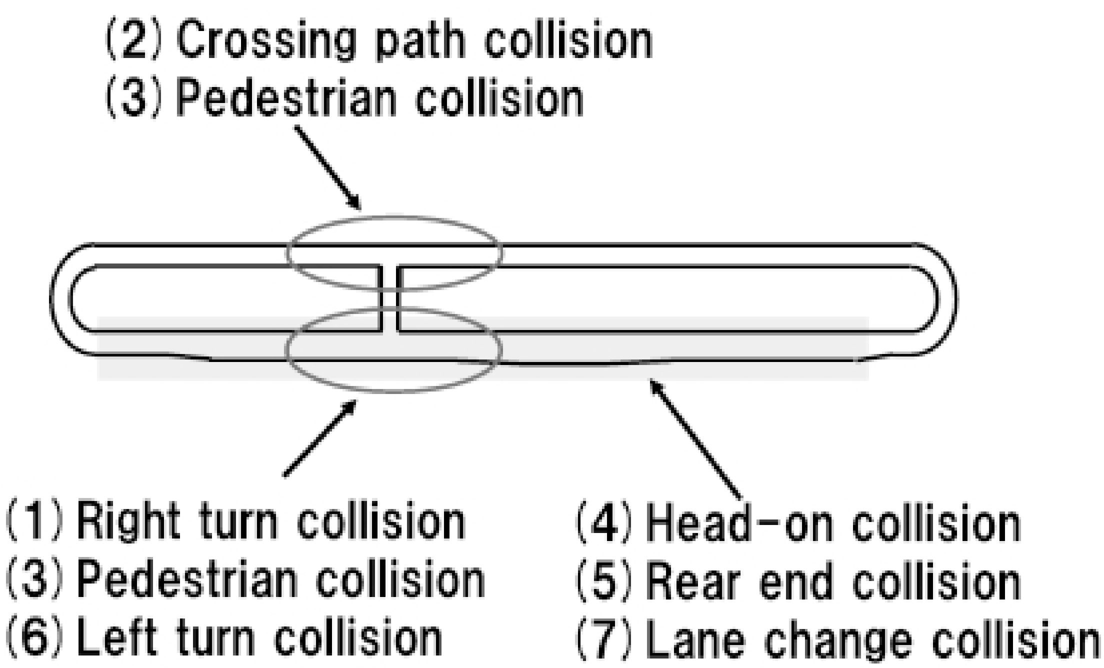
（５）Rear end collision

（６）Left turn collision

（７）Lane change collision

ASV-3 6

Test Aria



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Test Companies and Accidents

	Right Turn collision	Crossing collision	Pedestrian collision	Head-on collision	Rear end collision	Left turn collision	Lane change collision
Isuzu		C			C	C	
Kawasaki	M	M				M	
Suzuki	PM	PM				PM	
Daihatsu		P			P		
Toyota	P	P		P	P		
Nissan	P	P			P	P	P
Nissan Diesel					C	C	
Hino	C				C		
Honda	M	PM	P	M	PM	M	P
Subaru	P	P		P	P		P
Mazda	P	P	P	P	P	P	P
Mitsubishi		P			P		
Mitsubishi Fuso					C	C	
Yamaha	M	M	M		M		M

P:Passenger Vehicle　C:Consumer Vehicle　M:Motor Cycle

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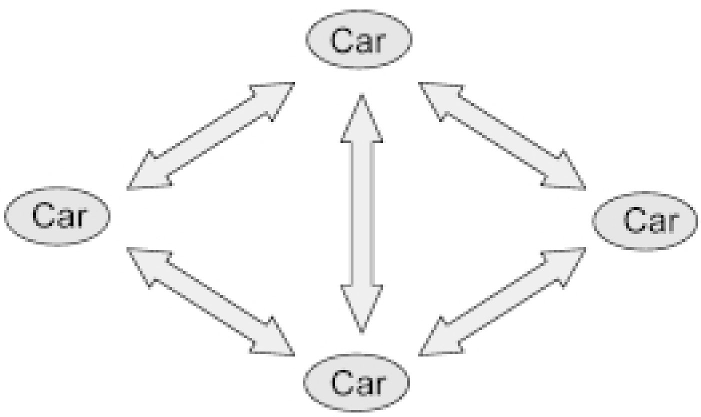
Communication System



Information

■Standard Information
- -Vehicle ID
- -Vehicle type
- -Current position
- -Vehicle speed
- -Direction

■Equipment Status
- -Gear shift position
- -Brake lamp
- -Direction indicator lamp
- -Hazard lamp

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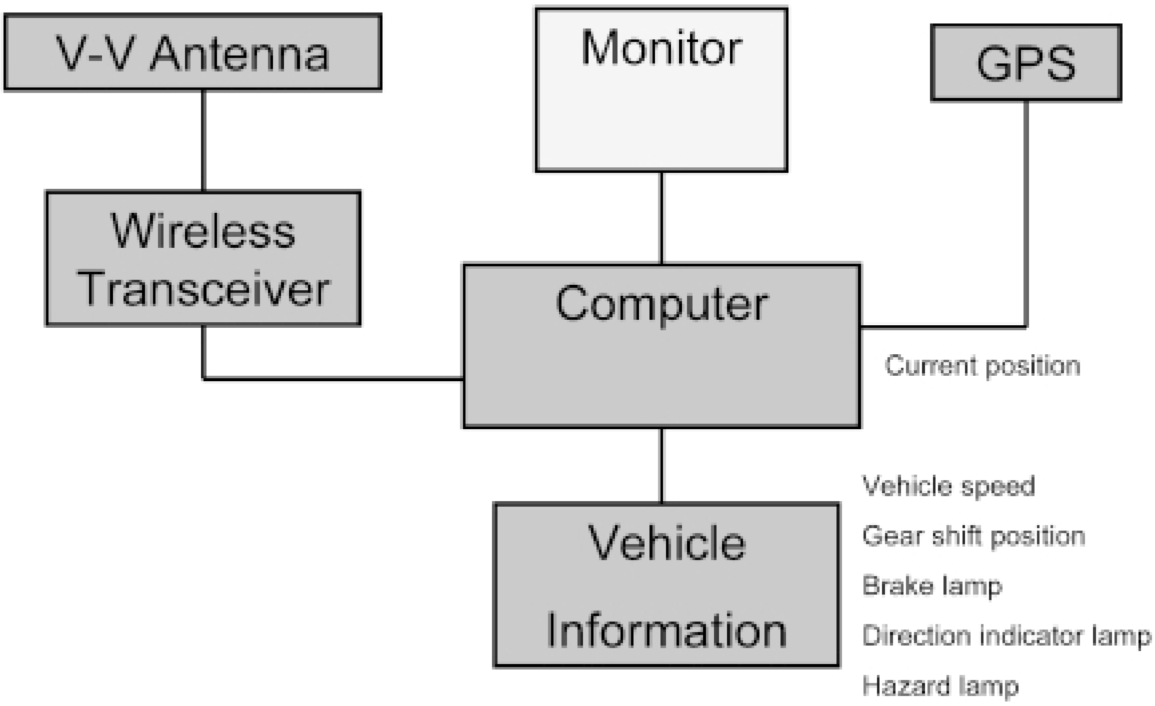
System Structure in Vehicle



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System Functions

(Example: NISSAN Right Turn Collision)

- Display an icon representating the other car on the monitor.
- Based on the other car's data, calculate the probability of a collision and modify the colour of the icon if the probability is high.
- Alert the driver if he doesn't decelerate despite a high probability of collision

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Confirmation Items

- Is the timing for conveying information to the driver optimal ?
- Is the information easily understandable to the driver ?
- Is the driver's understanding of the situation correct ?
- Is the driver able to derive a proper course of action ?
- Is the information well accepted（i.e not perceived as annoying）?
- Is the current communication range suitable ?
- Are all the expected functions realized ?

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Video
Right turn collision

ASV-3

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Video
Crossing path collision

ASV-3

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Video
Rear end collision

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Conclusion

- Encouraging results. The system seems to efficiently help preventing accidents.
- Significant results can already be achieved with today's level of position measurement accuracy.
- The presence of non IVC-equipped vehicles in the surroundings may not hinder the efficiency of the system.
- The communication range that was set during the system concept phase was proven suitable in 7 types of accidents.

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Issues

- Study necessity to develop accuracy of position. （accuracy of GPS is improper for some application）
- Decide about the communication system of IVC （frequency, protocol）.
- Measure against communication delay.