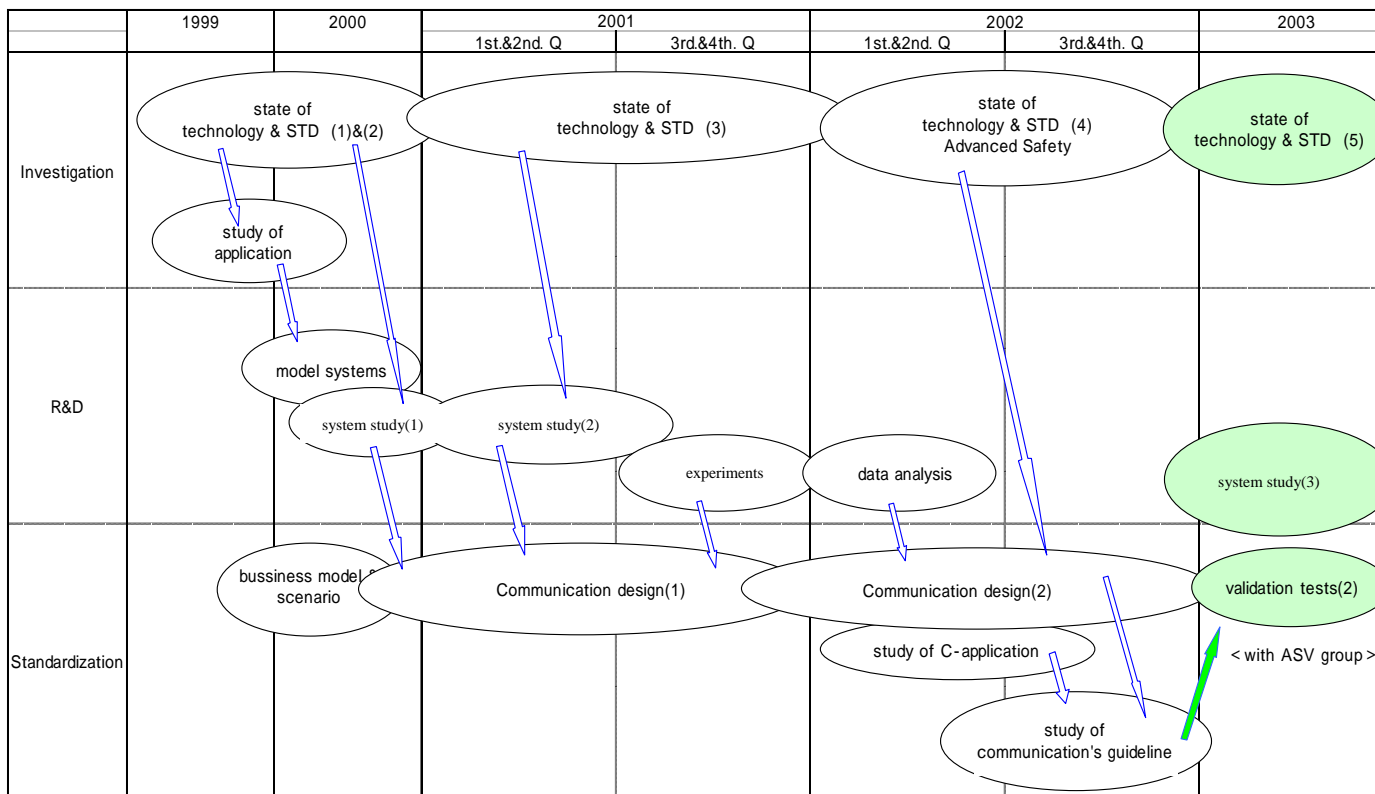
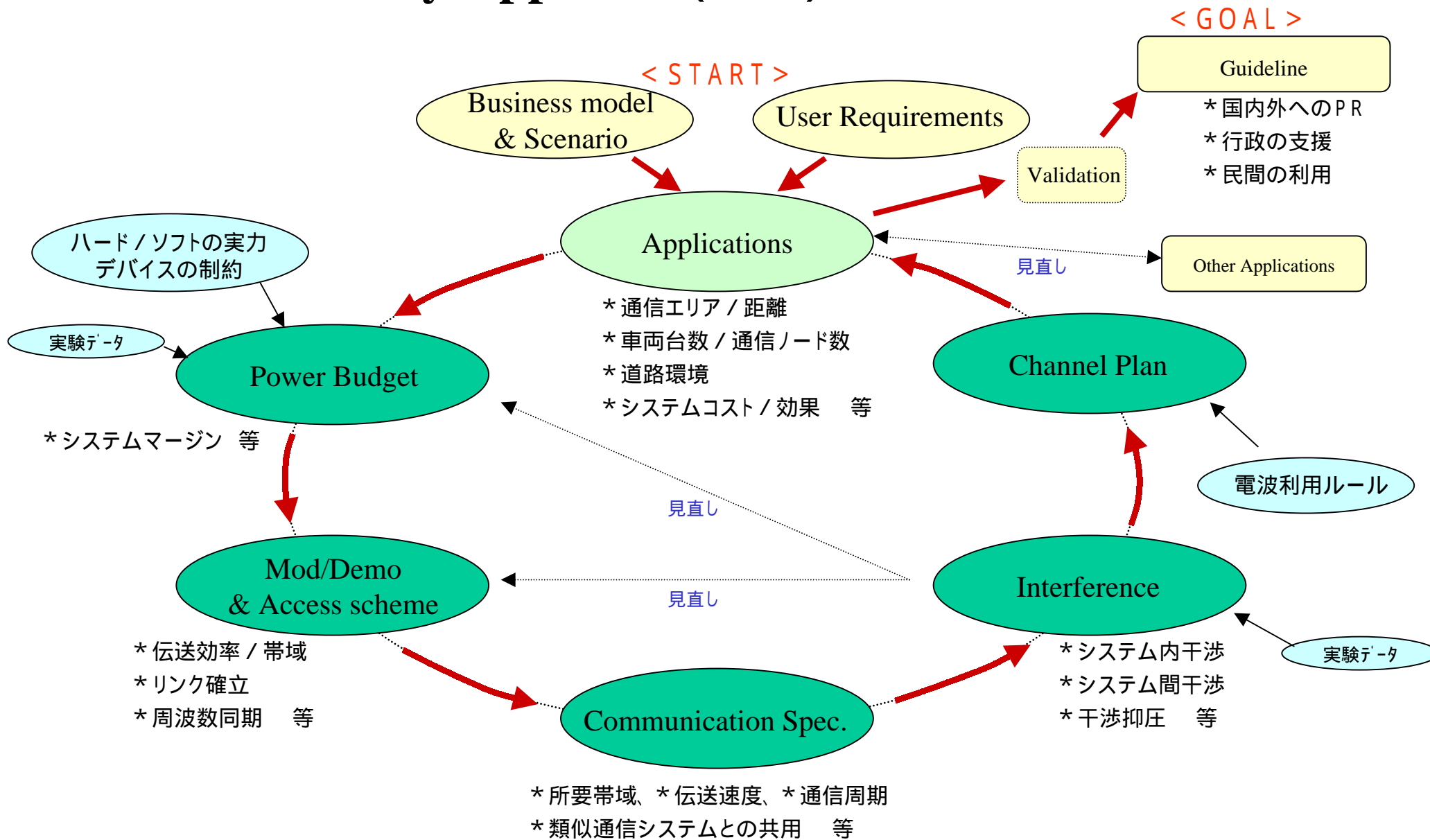


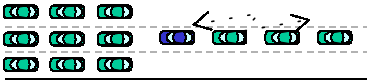
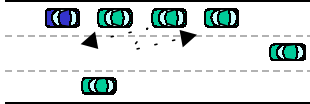

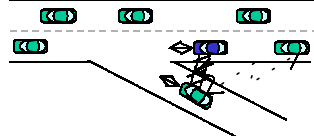
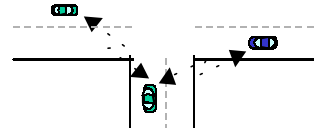
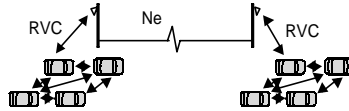
< Study Approach of Vehicle-to-Vehicle Communications >



Study Approach (v1.3)



Example of Inter-vehicle Communication Systems

No.	Applicatio	Services	Service band		Discussion	
			Microwave	Millimeter-wave		
1	Adaptive cruise Stop & Go	Automatically stop and go smoothly, when cars are in traffic jam.				(1st.)
2	Cooperative driving	Cooperative driving by exchanging respective cruising data				
3	Hazard warning	Obstacle warning Stopped vehicle waring Slowing down vehicle warning				
4	Merging & lane change warning	Cars of main line and a car merging communicate for safe and smooth line change				
5	Intersection & winding curve collision warning	Cars out of sight communicate for safe and smooth cruise				(1st.)
6	Inter/intra-platoon communication	Ad Hoc communication between cars				

S - Appli.

IVC mapping

C - Appli.

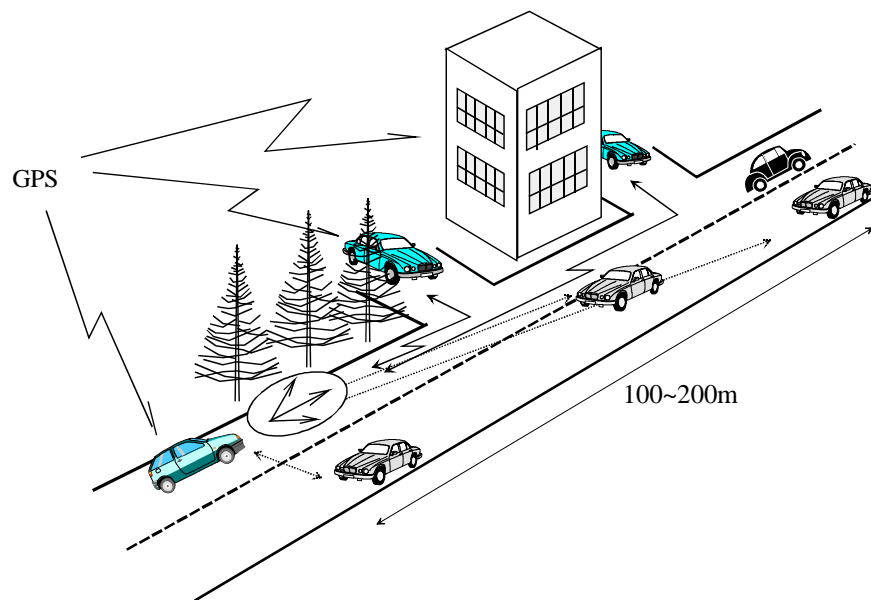
		for	
type		Safety	Convenience
1:1		<p>< Our Forum ></p> <p>Stop & Go</p>	<p>< EU ></p> <p>Schauffeur</p>
1:n		<p>Intersection Collision Warning</p>	<p>WARN</p>
n:n		<p>< North America ></p>	<p>CarTalk2000</p> <p>FleetNet</p>

IVC: Inter-Vehicle Communication

AVCSS: Advanced Vehicle Control and Safety Systems

出会い頭衝突警報システム

Intersection Collision Warning



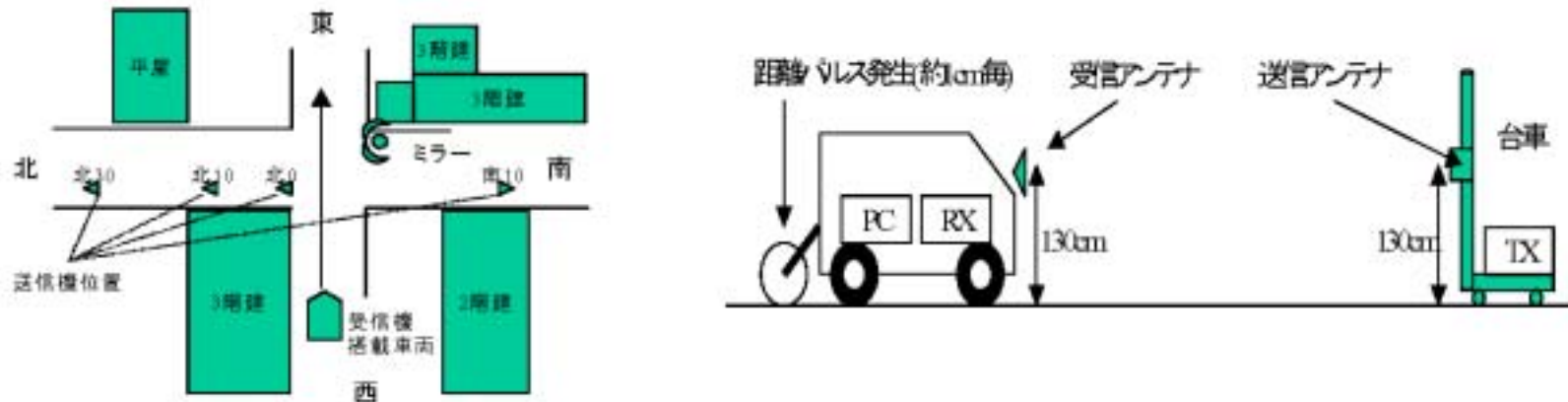
Communication Range 100 -200 m

Message set 40 byte

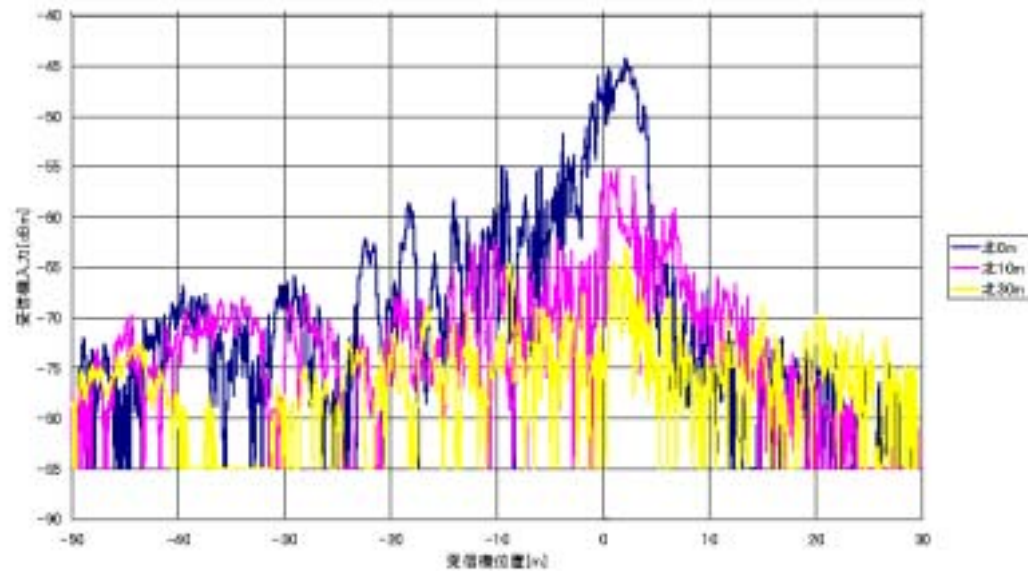
Allowable latency less than 100 msec

Experiments-2: Propagation at an Intersection

電波伝搬実験-2 : 5.8 GHz 見通し外電波伝搬



実験1 送信機位置による伝搬の違い



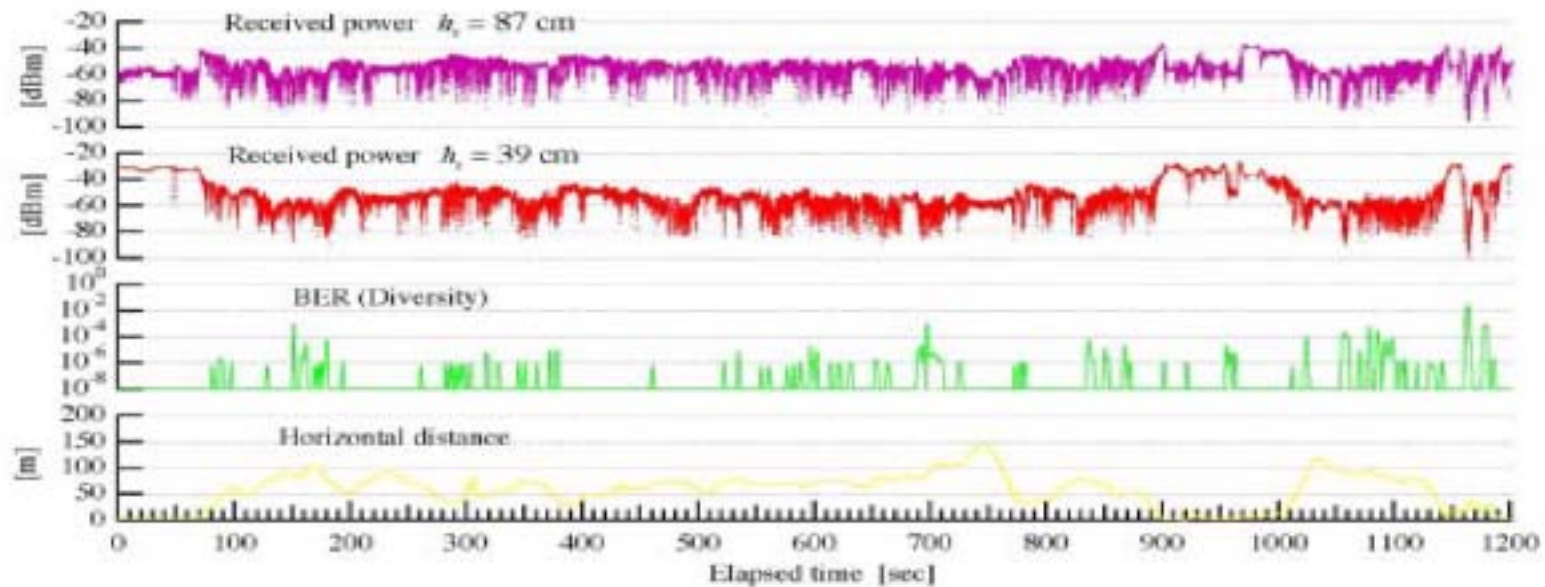
▲ Corner of the Intersection

Experiments-1: Received Power in High-Speed Drive Condition

電波伝搬実験－1：高速道路走行時の受信電力変動

車間距離：約 80m, 走行速度：約 80 km/h

59.1 GHz

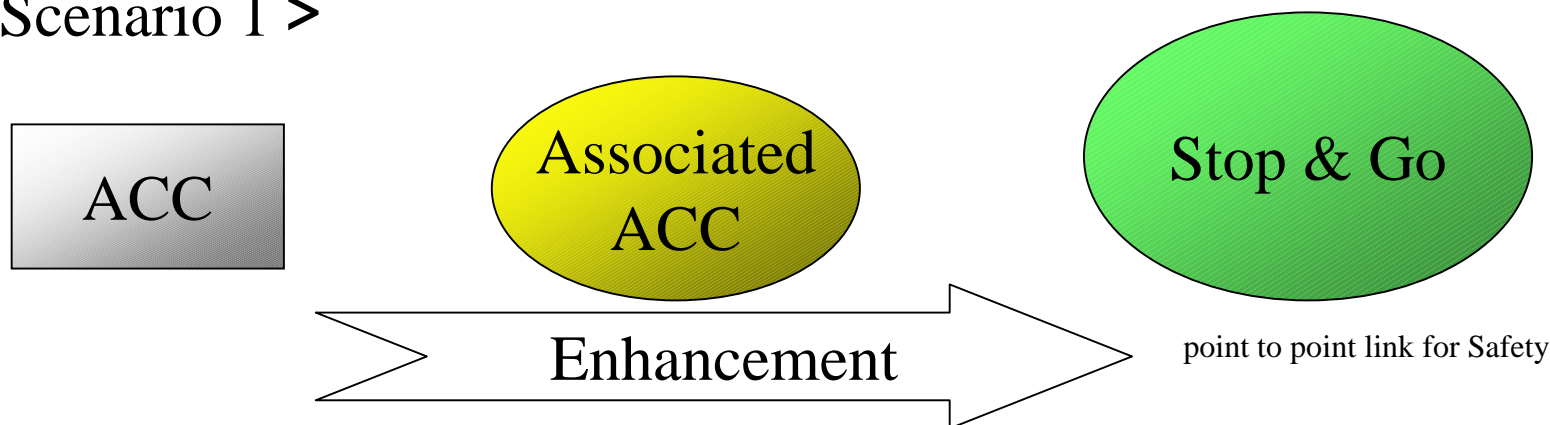


Communication Spec. (Example)

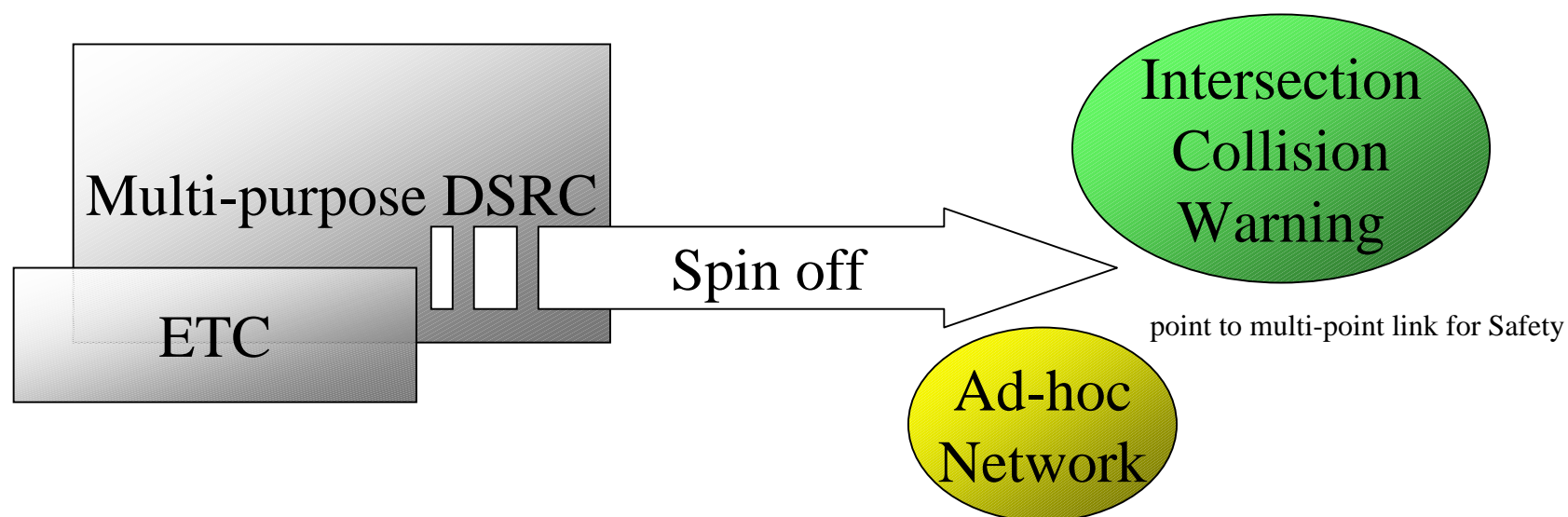
	Stop & Go	Intersection Collision Warning
Frequency Band	60 GHz	5.8 GHz
Modulation	FSK	/4-QPSK(ASK)
Modulation Speed	512 Kbps/128 kbps	640 kbps/4 Mbps
Media Access	CSMA	CSMA
Emission Power	less than 10 mW	less than 10 mW

IVC Deployment Scenarios

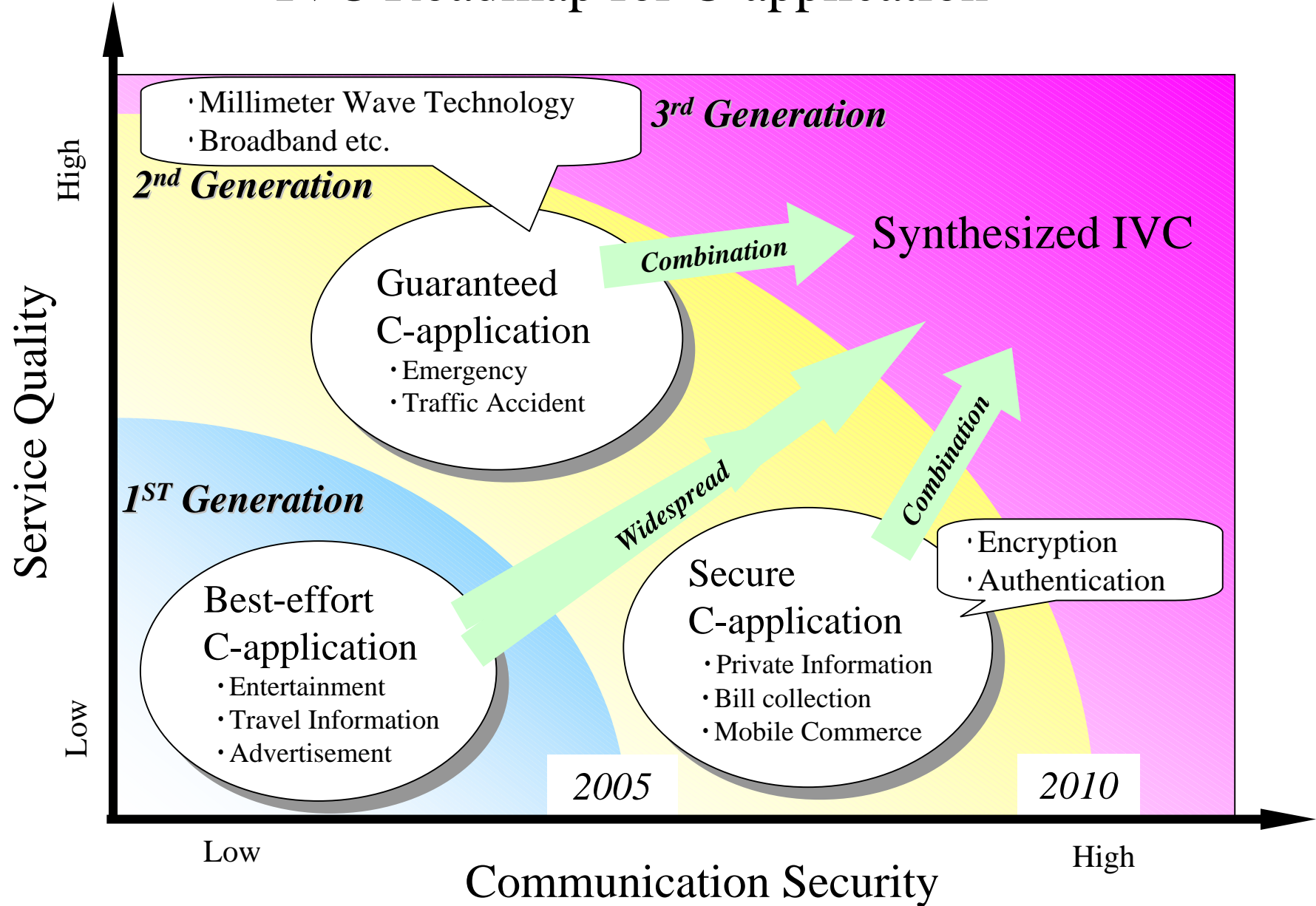
< Scenario 1 >



< Scenario 2 >



IVC Roadmap for C-application

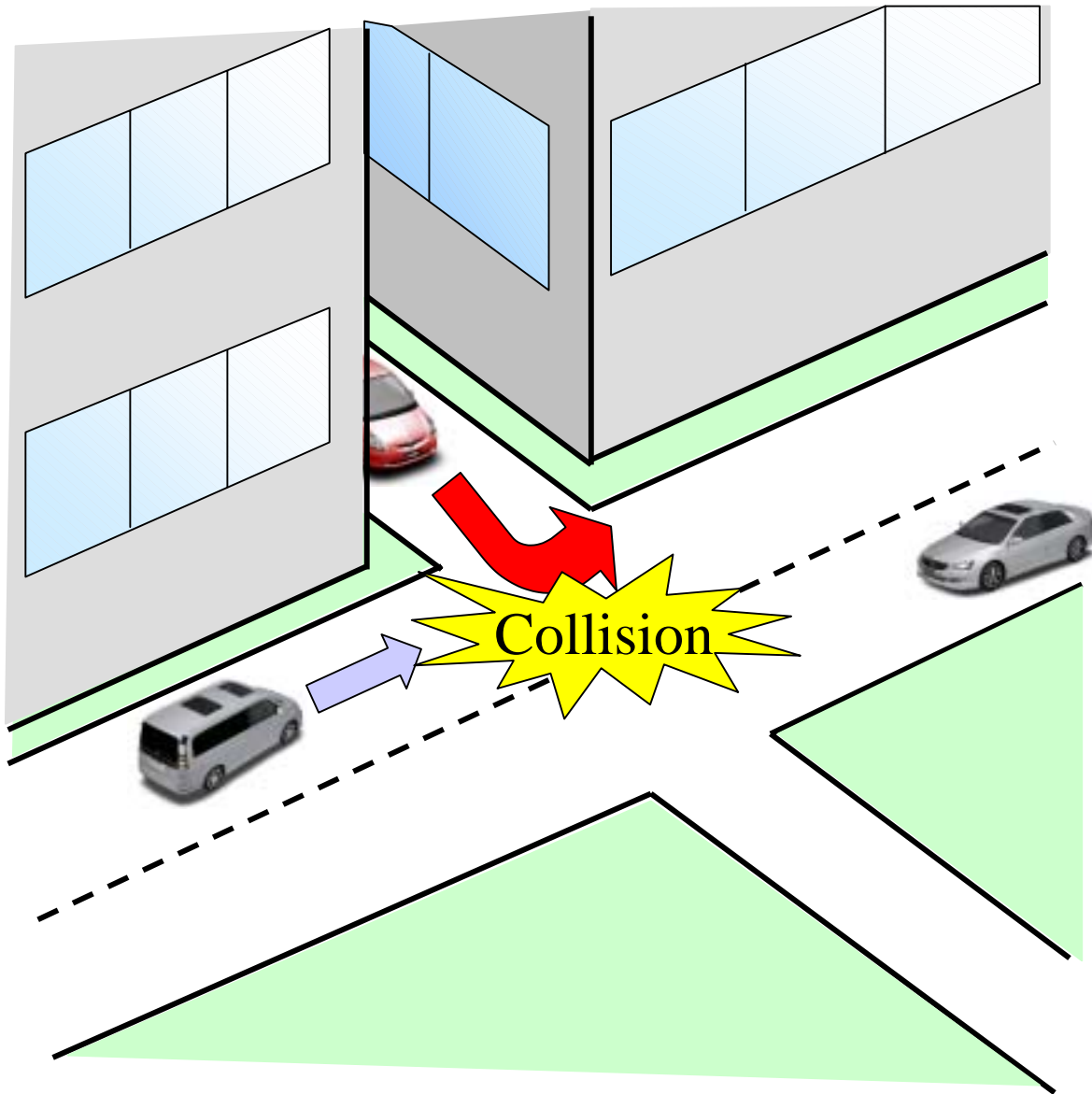


Inter-Vehicular Communications for Intersection Collision Warning System

September 4, 2003

Inter-Vehicular Communications System Expert Group

Intersection Collision Warning



Intersection Collision

25.7% of all traffic accidents
in 2001 Japan

Challenge

- reduce/mitigate collision
- without infrastructure
- out-of-sight communication

Purpose

- Avoid or mitigate
the collision at intersection
through inter-vehicle communication

Trial condition

- Frequency: 5.8 GHz

- Band: 5 MHz

(same as DSRC ARIB STD-T75)

- Vehicle in non-priority road:

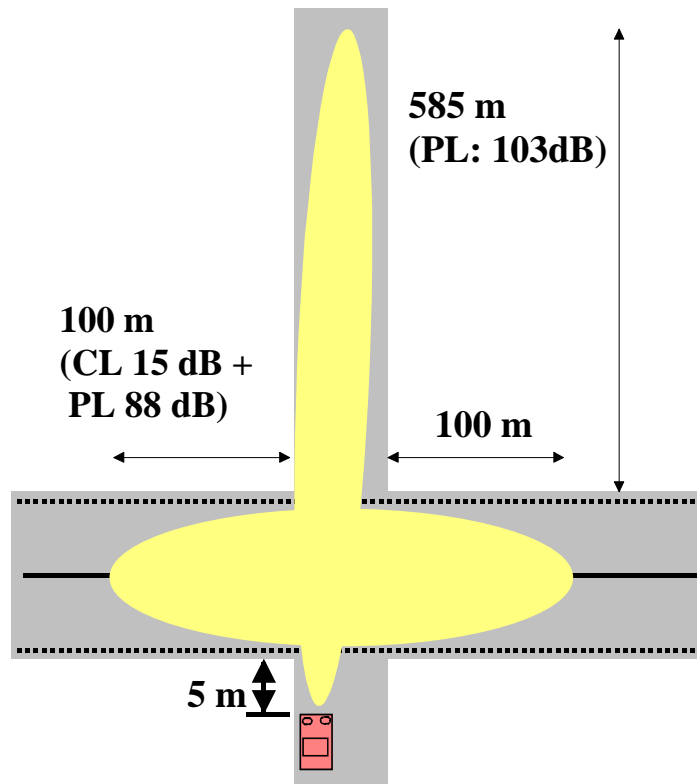
stops at 5 m before intersection

(Because of corner loss at 5.8GHz)

Communication area:

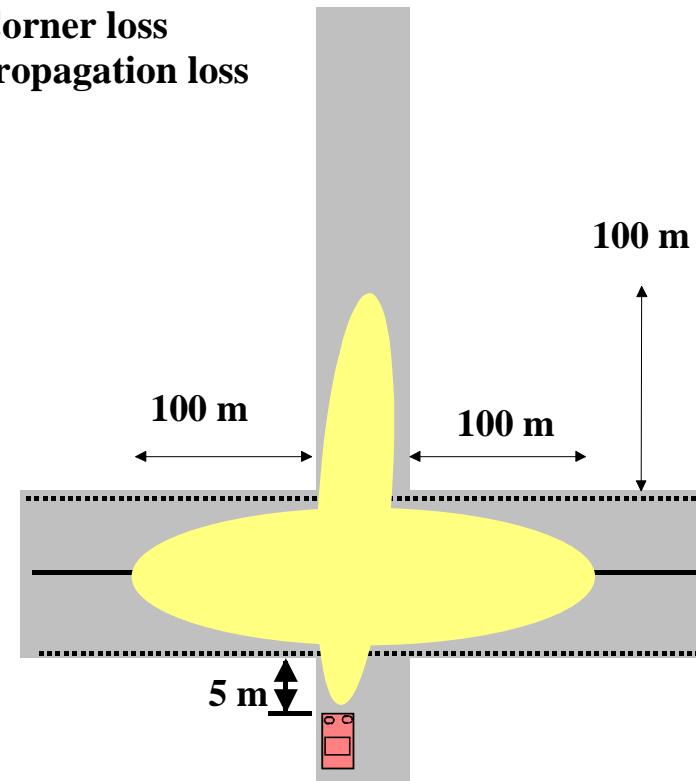
Drawback of single channel:

- unnecessary vehicles on straight road
- low level signal for vehicles on cross-road against on straight road



(a) Area by single channel

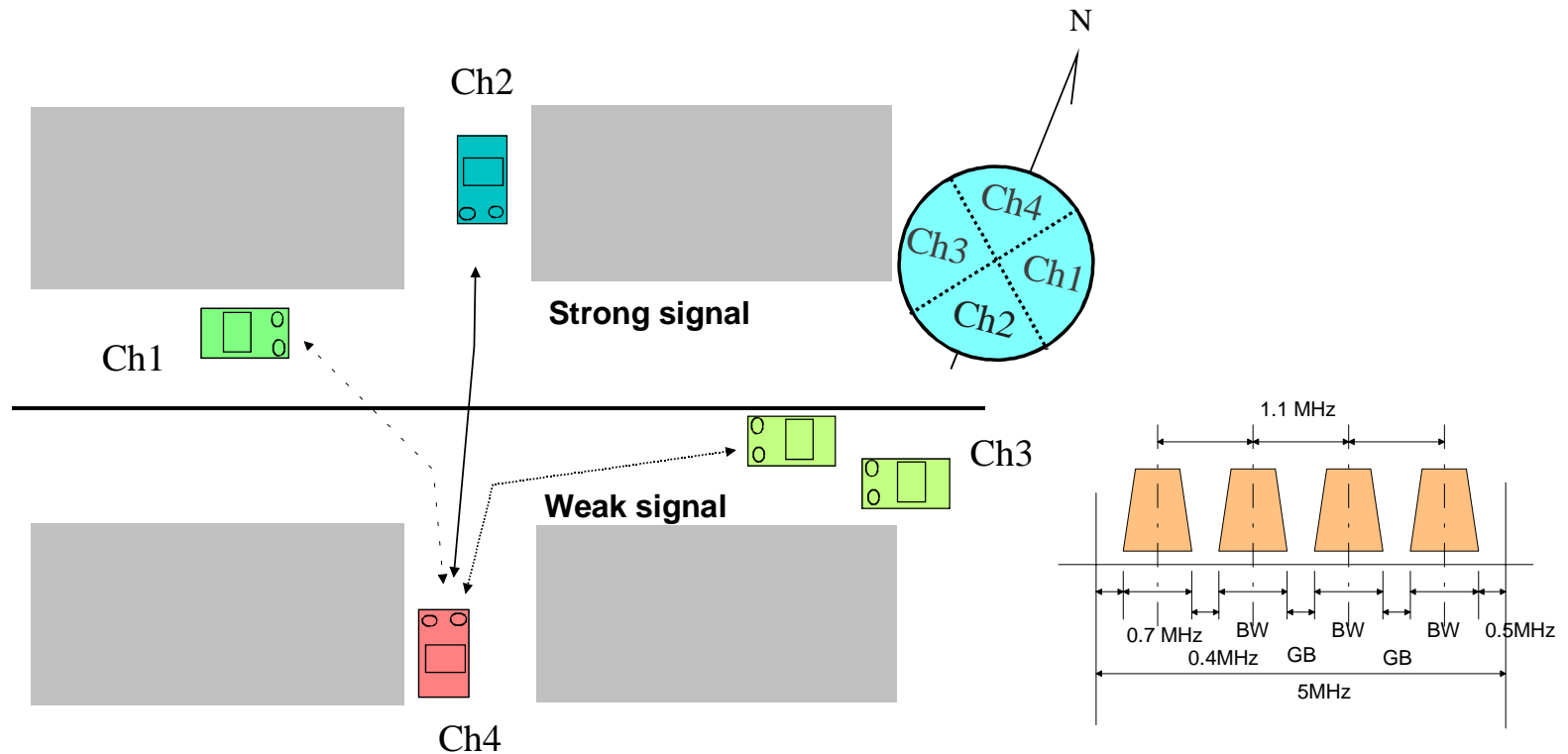
CL: Corner loss
PL: Propagation loss



(b) Ideal area

Proposal for communication system

- **Running direction based frequency multi-channels (RDBFM)*)** -



- Frequency band: divided into 4
- Transmitting frequency: pre-determined based on direction

*) proposed by Shunji Miyahara, Visteon Asia Pacific, Inc.

Advantages of RDBFM

-Separation between

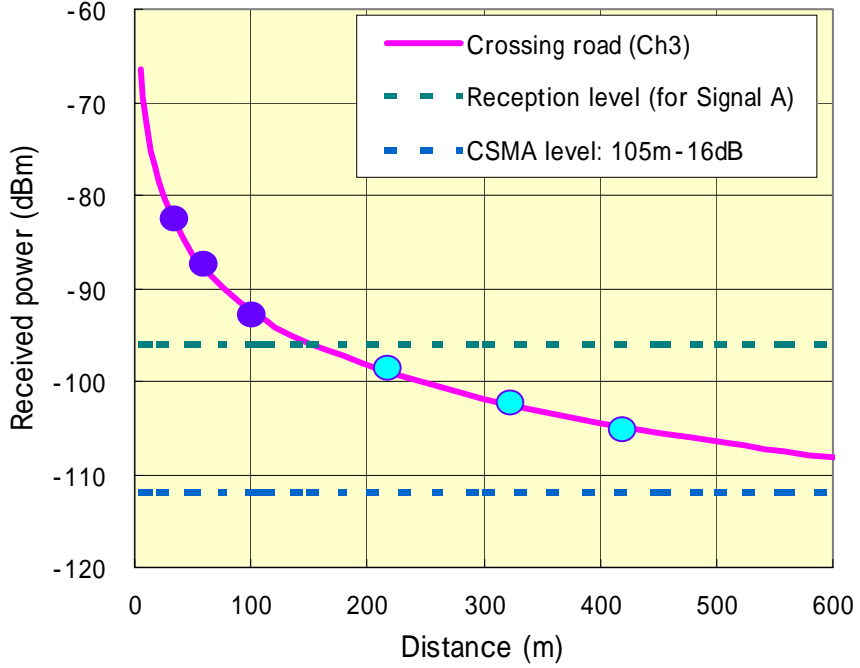
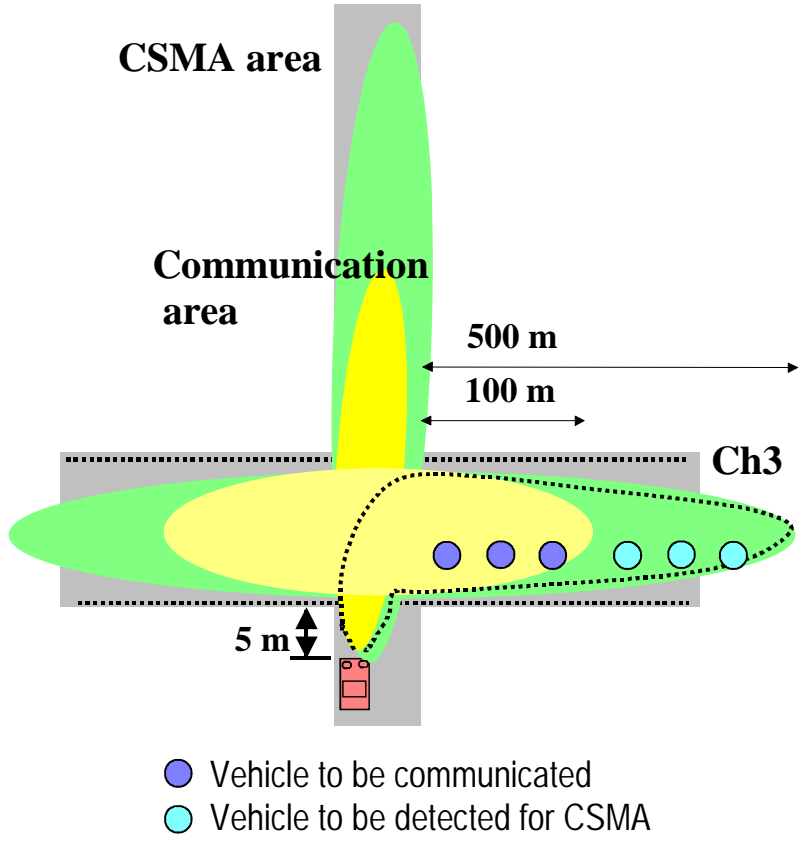
strong signal from straight road, and

weak signal (target) from cross road

-Dominance of target signal:

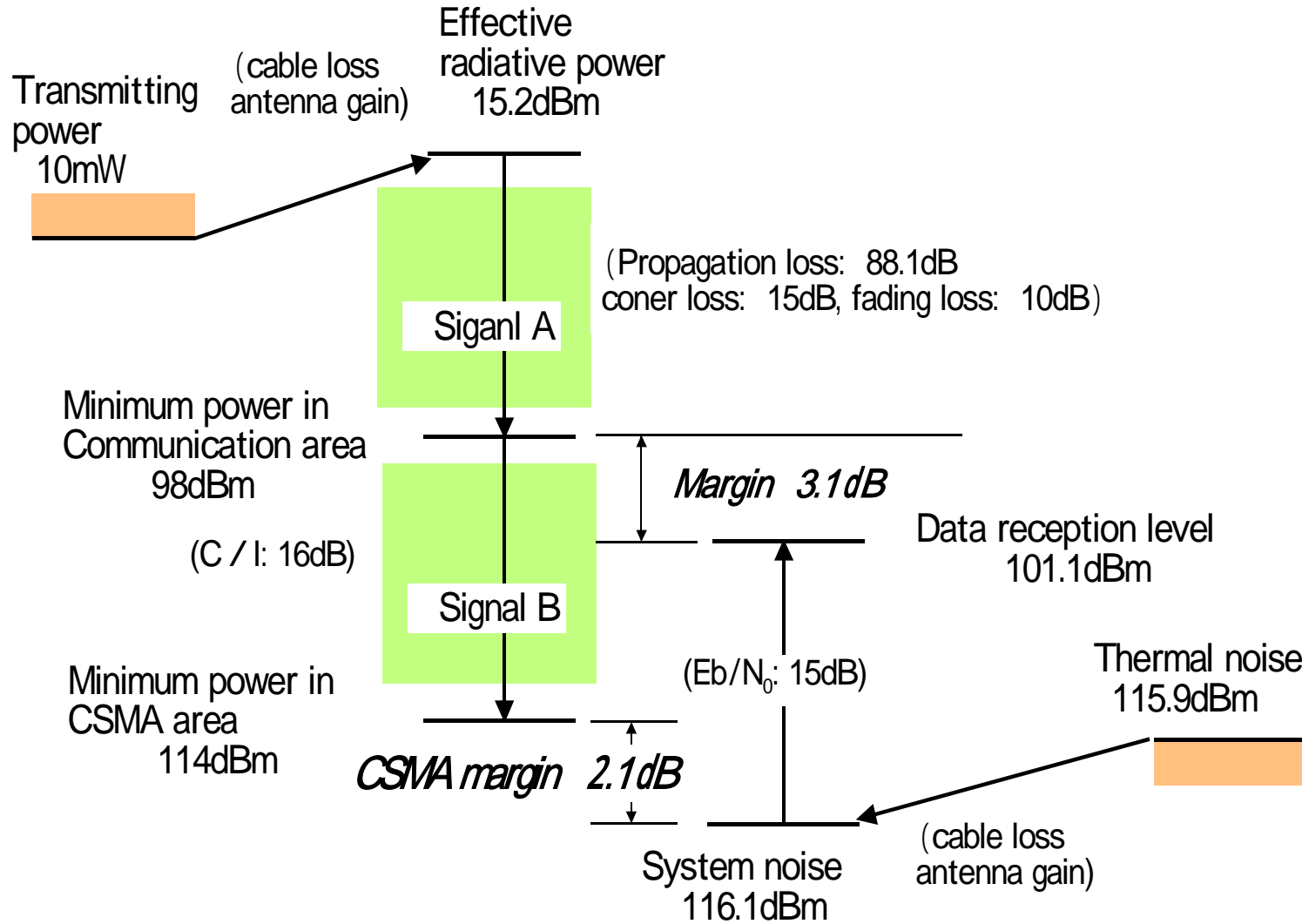
target signal is the strongest in each channel

Access in RDBFM

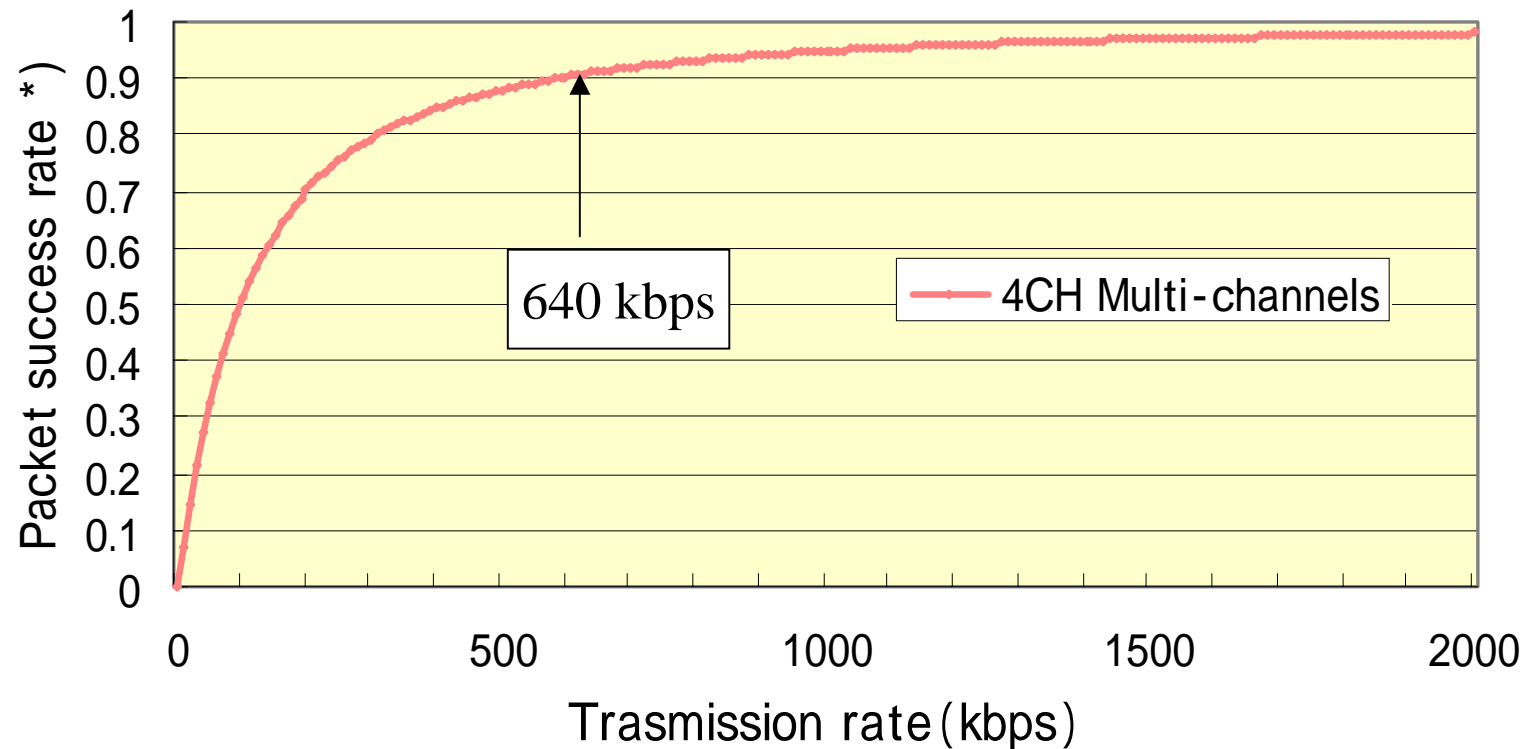


- Transmitter: 10dBm, Corner loss: 15 dB, Fading 10 dB, 640kbps, BER=10E-5

Example of power budget



Example of packet success rate



- Packet success rate: *> 90 % at 640 kbps*
(*Transmitting rate-10Hz, velocity -60km/h, vehicle pitch-26.6m, Channel: Ch3*
Evaluation^{}): success for travel of 2.5 [m]*)

Summary of specification

Application	Intersection Collision Warning
Specification	
· Modulation	p / 4 - QPSK
· Amount of information	40 Byte (Position, velocity, ID, direction, ...)
· Information stransmission rate	160 kb _i t/s
· Transmission rate	640 kbit/s
· Access	CSMA
· Carrier / band width	5.8 GHz / 5 MHz
· Bandwidth for each channel	0.7 MHz (Pitch= 1.1 MHz)
· Number of channels	4 (RDBFM)
· Pitch of transmission	100 msec
· BER	1 E-5
· Transmitting power	10 dBm
· Power budget	3.1 dB (Corner loss : 15dB, Fading : 10dB)

Conclusion

- To avoid collision at intersection,
Inter-vehicle communication system is proposed
- Signal level compensation:
Running direction based frequency multi-channels
- Possibility of out-of-sight communication:
Not impossible, worth continuing investigation
 - Power budget
 - Packet success rate

Member's list of Communication Design Group

Company
Clarion Co., Ltd
DENSO CORPORATION
FUJITSU LIMITED
HONDA R&D CO., LTD
Japan Automobile Research Institute
TOKAI RIKA CO., LTD.
TOYOTA MOTOR CORPORATION
Visteon Asia Pacific, Inc.