Issue Survey Report

Advanced ITS Driving Automation
Using Cellular Communication Technology

Supplementary Material: Issue Survey for SIP Use Cases for Cooperative Driving Automation

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ITS Info-communications Forum

Cellular System TG

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Revision History

Version	Date	Chapter/ Section	Reason	Revised Content
1.0	May 31, 2022	Establishment	Newly established	

The ITS Info-communications Forum plans to update the content of this document through further investigation, and if revisions are made, will issue a revised document including the version number and the details of the revisions.

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Introduction

The Cross-ministerial Strategic Innovation Promotion Program (SIP) Use Cases for Cooperative Driving Automation were formulated by the Task Force on V2X Communication for Cooperative Driving Automation (hereinafter, SIP TF) to study the communication protocols required for cooperative driving automation in the future. The SIP TF had the activity to create the roadmap for the suitable communication system for cooperative driving automation. The following four activities were mainly carried out.

(1) To identify the use cases* in which autonomous vehicles require communication
*: SIP use cases for cooperative driving automation [1]

(2) To specify the communication requirements for SIP use cases for cooperative driving automation

(3) To evaluate the feasibility of existing/new communication system for SIP use cases and its identification of issues

(4) To establish the roadmap for cooperative driving automation and its communication systems

The ITS Info-communications Forum established a cooperative workflow with SIP TF and decided that the Task Groups in ITS Info-communications Forum studies the above (2) and (3) in collaboration with SIP TF. Regarding (3), Cellular System Task Group (hereinafter referred to as TG) studied the cellular technology as one of the options for new communication system, in order to identify the specific issues of cellular technology to SIP use cases for cooperative driving automation.

Services for cooperative driving automation and safety driving need to be investigated from a wide range of perspectives, including not only communication technology such as whether they can meet the performance complaint to the requirements of safety and reliability but also business feasibility and regulations, such as whether they can be commercialized with the agreed responsibility, rules, and costs with many stakeholders like service operators, manufacturers, and traffic participants, etc. The TG has investigated the issues from both technical and non-technical perspectives and has published "Issue Survey Report on Advanced ITS and Driving automation Using Cellular Communications Technologies". This report is a supplementary material of the previous report, where the specific issues from SIP use cases for cooperative driving automation are identified for the respective use case with analyzing the requirement, involving stakeholders and business relations.

Chapter 1 Arrangement of use cases to analyze issues

1.1 Target use cases

The TG investigated 25 SIP use cases for cooperative driving automation published by the SIP TF. Each use case assumes communication methods (V2V, V2I, V2N). In order to identify the issues for cellular V2X, this study assumes that PC5 is used for V2V and V2I, and Uu is used for V2N.

1.2 Examination Methods of Issues

In the first edition of the report published by this TG, the use cases in the report were categorized based on the update rate of the information i.e., static, semi-static, semi-dynamic and dynamic layers. The issues were identified accordingly. In this document, the SIP use cases for cooperative driving automation were also categorized based on the update rate of information. The result is shown in Table 1.1.

Table 1.1 Categorization results based on the update rate of information on SIP use case for cooperative driving automation.

	Utilizing V2V/I		Utilizing V2N	
update frequency	Classification by function	Name of the use case	Classification by function	Name of the use case
Utilizing dynamic information	a. Merging/lane change assistance	a-1-1. Merging assistance by preliminary acceleration and deceleration	-	
		a-1-2. Merging assistance by targeting the gap on the main lane		
	b. Traffic signal information	b-1-1. Driving assistance by using traffic signal information (V2I)	b. Traffic signal information	b-1-2. Driving assistance by using traffic signal information (V2N)*
	c. Lookahead information: collision avoidance	c-1. Collision avoidance assistance when a vehicle ahead stops or decelerates suddenly	-	
		c-2-1. Driving assistance based on intersection information (V2V)		
		c-2-2. Driving assistance based on intersection information (V2I)		
		c-3. Collision avoidance assistance by using hazard information		
	a. Merging/lane change assistance	a-1-3. Cooperative merging assistance with vehicles on the main lane by roadside control		
		a-1-4. Merging assistance based on negotiations between vehicles		
		a-2. Lane change assistance when the traffic is heavy		
		a-3. Entry assistance from non-priority roads to priority roads during traffic congestion		
	g. Platooning/ adaptive cruise control	g-1. Unmanned platooning of following vehicles by electronic towbar		
		g-2. Adaptive cruise control and manned platooning of following vehicles using adaptive cruise control		
	-		h. Teleoperation	h-1. Operation and management of mobility service cars
Utilizing semi-dynamic information	-		d. Lookahead information: trajectory change	d-1. Driving assistance by notification of abnormal vehicles
				d-2. Driving assistance by notification of wrong-way vehicles
				d-3. Driving assistance based on traffic congestion information
				d-4. Traffic congestion assistance at branches and exits
				d-5. Driving assistance based on hazard information
	e. Lookahead information: emergency vehicle notification	e-1. Driving assistance based on emergency vehicle information	e. Lookahead information: emergency vehicle notification	e-1. Driving assistance based on emergency vehicle information
Utilizing semi-static information	-		f. Information collection/ distribution by infrastructure	f-1. Request for rescue (e-Call)
	f. Information collection/ distribution by infrastructure	f-2. Gathering information for optimizing traffic flow		f-2. Collection of information to optimize the traffic flow
	-			f-3. Update and automatic generation of maps
				f-4. Distribution of dynamic map information

* In the SIP use cases for cooperative driving automation, the driving assistance by using traffic signal information (V2N) is described to provide only traffic signal cycle information. Therefore, it may be categorized as semi-dynamic information, however, when an abnormality happens, abnormality notification is assumed to be necessarily informed within the same cycle with the driving assistance by using traffic signal information (V2I), hence this use case is categorized into use cases utilizing dynamic information.

For the SIP use cases for cooperative driving automation, from the viewpoint of communication methods, issues are categorized to 3 areas: common to the use case of V2V/I, common to the use case of V2N, and common to both communication methods. For the use case of V2N utilization, the issues are further categorized to three areas of use cases dealing with dynamic information, with semi-dynamic information, and with semi-static information according to update rate of the information. For the use case of V2V/I utilization, it was not necessary to categorize the use case based on the update rate of the information. Therefore, total of six areas were identified.

The relationship among the above six areas is shown in Figure 1.1.

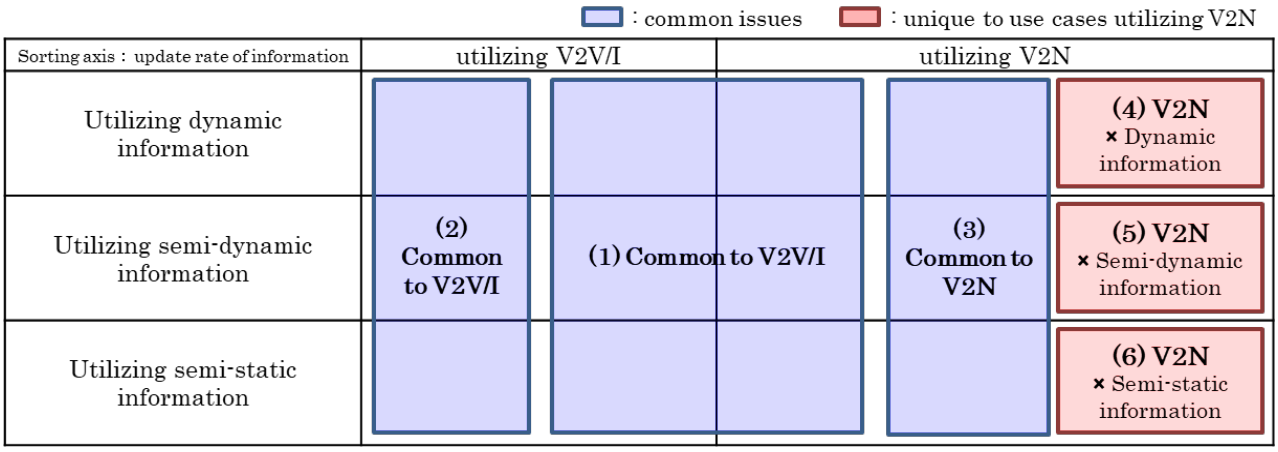

Figure 1.1 Examination axis and concept for sorting out issues

Chapter 2 Organizing issues

2.1 Issue categorization based on the subject

In order to investigate the issues broadly including non-technical ones, the following six categories are used.

a. Issues that need to be investigated holistically,

b. Issues related to technology,

c. Issues related to the regulation,

d. Issues related to the infrastructure,

e. Issues related to business feasibility,

f. Issues other than categorized.

2.2 Issues Arrangement Result

Issues were investigated from the angle of the examination methods in Chapter 1 and from the angle of the subject in 2.1. The relationship with SIP cooperative driving automation use cases was also clarified. The relation with individual use cases is shown in the attached table. The issues based on the categorization are described below.

(1) Issues common to V2V/I and V2N use cases

a. Issues that need to be investigated holistically

Category	Organizing issues
Service definition	**(1) a.1 Outline of the issue** To define the service (what to do for what kind of issues in what scenes, whether communication is necessary, etc.) and to define the overall architecture, features, etc. required for the service realization, and the formulation of guidelines. ● **Details (Challenges, etc.)** • To have the agreement among all the stakeholders clarifying how to assign roles and functions to autonomous systems and communications, roads and regulations, etc. • To specify service definition assuming actual control method and service level of the vehicle, coexistence of automatic operation and communication, abnormal case, etc. Different car OEMs would have different design policies regarding vehicle control need to take into account.
Requirements setting and verification	**(1) a.2 Outline of the issue** • To investigate requirements (e.g., delay, reliability) necessary for service realization, the criteria to verify their applicability and verifying. • To specify communication requirements for each environment/use case and to determine verification conditions (model cases). ● **Details (Challenges, etc.)** To clarify a service level agreement (SLA) regarding required communication quality.
	(1) a.3 Outline of the issue To investigate how to assign roles, functions, cost sharing, etc. for the stakeholders and systems in order to achieve the service requirements and to investigate business feasibility with how the cost is shared among users.

b. Issues related to technology

Category	Organizing issues
Communication standardization	(1) b.1 Outline of the issue • To specify communication protocol (including message format), performance requirements, and test specifications with the consideration of performance, applicability, business model, business continuity, privacy, security, and global harmonization. • To establish a framework and system, operation method for standardization (including maintenance and enhancement after specification release).

c. Issues related to the regulation

Category	Organizing issues
Privacy protection	(1) c.1 Outline of the issue • To have an agreement to aquisite original information from the organizations, and to determine the necessity of agreement to collect the location information of the vehicle and so on with the owner or user. If the agreement is necessary, to investigate how the agreement can be made. • To decide how to use the obtained information aligned with the Personal Information Protection Law and other laws. ● Details (Challenges, etc.) To determine what privacy information is stored in servers that provide information, and if not stored, to investigate how to cooperate with the servers of other organizations storing privacy information.

d. Issues related to Infrastructure

Category	Organizing issues
Development of terminals and infrastructure	(1) d.1 Outline of the issue • To investigate how to increase the penetration rate of terminals and how to deploy the infrastructure such as roadside unit and server with the consideration of the business models including how the cost is shared among users. • The systems using existing infrastructure facilities (traffic signal controllers, servers, etc.) need to modify the equipment or adding interface devices to have the communication. ● Details (Challenges, etc.) • There are related issues in "technical issues" and "business feasibility." • The entity that leads issue solving is necessary.
Operational specifications of terminals and infrastructure	(1) d.2 Outline of the issue To study systems and frameworks for monitoring and operating service-related equipment, infrastructure, and networks.
Sophistication of terminals and infrastructure	(1) d.3 Outline of the issue To design initial services with the capability to allow new service realization while maintaining compatibility with deployed services.

e. Issues related to Business feasibility

Category	Organizing issues
Business model	**(1) e.1 Outline of the issue** To establish business models and to clarify the entities with the consideration of users, terminals, development and operating of the infrastructure, and communication costs. ● **Details (Challenges, etc.)** To study how to achieve initial investment in spite that quicker penetration is not expected unlike smartphones. Note: Smartphones are shipped at a scale of about 30 million units a year [2] and are replaced in about 4 years on average [3]. New cars are sold at a scale of about 5 million units a year [4] and retired on average in about 15 years and sometimes up more than 25 years in the longer case [5]. So, the penetration rate is slow.

f. Issues other than categorized

Category	Organizing issues
Security measures	**(1) f.1 Outline of the issue** • To ensure the reliability of communication information (security of communication paths), to prevent spoofing, and false information. • To establish a framework to prevent the location information of the vehicle from being misused.
Relationships between use cases	**(1) f.2 Outline of the issue** To investigate which parts of the business model, protocols and servers are common and which parts are independent considering commercial timelines for different use cases and different communication methods (V2N/I/V).
Relationships between organizations	**(1) f.3 Outline of the issue** To assign what part is investigated in the collaboration among various government, private sector projects, and the standard related organizations.

(2) Issues common to the use cases of V2V/I

a. Issues that need to be investigated holistically

Category	Organizing issues
Measures to increased costs caused by quality improvements to meet requirements	**(2) a.1 Outline of the issue** To investigate business feasibility with the consideration of the increased cost because performance and network quality improvement are required to satisfy the delay, packet arrival rate, and information accuracy requirements. ● **Issues specific to communication methods** To investigate business feasibility and product deliverability of OEM, equipment and infrastructure manufacturers taking into account the cost and volume increase required for modifications as modification would be required for on-board unit and roadside unit.

b. Issues related to technology

Category	Organizing issues
Communication standardization	(2) b.1 Outline of the issue Same as (1) b.1 ● Issues specific to communication methods • To ensure a frequency bandwidth according to the amount of communication traffic, and to specify communication channel and QoS according to a communication content. • To have the investigation, study, verification and standardization of congestion control methods.
Equipment and infrastructure specifications	(2) b.2 Outline of the issue • To specify service-related equipment and infrastructure (including fail-safe functions) and guidelines. • To develop specification and/or guideline for equipment modification or interface device to acquisite and distribute information by connecting to networks and communication devices for the systems using existing infrastructure facilities (traffic signal controllers, servers, etc.). ● Issues specific to communication methods To develop specifications and guidelines for equipments such as roadside unit and on-board unit.

c. Issues related to the regulation

Category	Organizing issues
Providing services for the equipments of different manufacturers and MNOs	(2) c.1 Outline of the issue To develop a system and policy that can provide services correctly connecting all communication vehicles and communication infrastructure. ● Issues specific to communication methods To establish a system and a management method in which all of the vehicles and roadside units can be connected with each other regardless of vehicle type and manufacturer.
Equipment certification/ verification	(2) c.2 Outline of the issue To clarify the scope of authentication and inspection, and to realize and operate them. ● Issues specific to communication methods To investigate how authentication and verification of on-board unit and roadside unit are carried out.

e. Issues related to Business feasibility

Category	Organizing issues
Business continuity	(2) e.1 Outline of the issue To investigate whether the system can be continuously operated based on the life cycle of the car, model development, and the lifetime of the car and infrastructure, and to establish a scheme to update it without service interruption. ● Issues specific to communication methods To investigate operation method in advance to achieve continuous operation of the on-board unit and roadside unit with the consideration of the life cycle of the car, model development, and the lifetime infrastructure.

(3) Issues common to use cases of V2N

a. Issues that need to be investigated holistically

Category	Organizing issues
Requirements setting, verification	**(3) a.1 Outline of the issue** Same as **(1) a.3** ● **Issues specific to communication methods** Since there are more stakeholders and systems, the coordination will be complex considering various options, and it takes time to agree. ● **Details (Challenges, etc.)** • It is particularly difficult to agree on the responsibility and cost sharing because different roles are realized by different entities. The roles could be information sources, information acquisition, collection and aggregation, distribution of information, and distribution to vehicles. In addition, depending on the functionality of each server or the systems, the scale of installation and modification of facilities and equipment varies. Therefore, even technical requirements would take time to specify. • An entity that leads the solution of these issues is necessary.
Advantages of V2V/I and V2N	**(3) a.2 Outline of the issue** To investigate the advantages of such as cost and quality and to select service realization method, if V2V/I and V2N are used for the same service. ● **Issues specific to communication methods** To investigate whether it is possible to find an advantage of V2N over V2V/V2I in terms of cost merit while satisfying the service requirements. ● **Details (Challenges, etc.)** • In order to realize a V2N service, it costs to modify equipments for connection with an information source or develop and introduce an interface device (e.g., for traffic signal information distribution, modification of a traffic signal controller and implementation of a fail-safe function are required), the construction and operation of a server for information acquisition, collection, aggregation, and distribution, and also the communication cost is required to use a mobile communication network. Is there an advantage in terms of cost? • Whether the delay is within the acceptable range in consideration of the upload rate of information and the processing time in each server, etc. in the case through various servers, etc.

b. Issues related to technology

Category	Organizing issues
Communication standardization	**(3) b.1 Outline of the issue** Same as **(1) b.1** ● **Issues specific to communication methods** To specify the communication protocols and the server functions related to whether a vehicle requests information stored in the server or the server decides a target vehicle to provide the information, and what information should be transmitted and received in such cases.
Equipment and infrastructure specifications	**(3) b.2 Outline of the issue** Same as **(2) b.2** Issue 1 ● **Issues specific to communication methods** To develop the specification of equipment for servers to acquire, collect, and distribute information (such as obstacles) from information sources. Issue 2 ● **Issues specific to communication methods** To investigate a mechanism to verify whether information obtained through a network matches the actual situation, and to investigate a fail-safe function for the abnormal event such as malfunction and failure.

c. Issues related to the regulation

Category	Organizing issues
Providing services for the equipments of different manufacturers and MNOs	**(3) c.1 Outline of the issue** Same as **(2) c.1** Issue 1 ● **Issues specific to communication methods** To establish a system and a management method in which all vehicles can be connected with each other regardless of the vehicle type and manufacturer, MNO, etc. Issue 2 ● **Issues specific to communication methods** To examine how to continue providing the service when a user is out of coverage of serving MNO. ● **Details (Challenges, etc.)** • If the V2N service can't obtain information from other vehicles, it also affects the service provision to its own user. In order to prevent the disruption of the V2N service, to investigate how MNOs should collaborate (roaming, etc.), and to investigate the need of a third-party organization, and to develop operational rules including the cost sharing • In the case of cooperation among MNOs, when the MNO service are unavailable, other MNOs need to accommodate more users than the users compared with situation the cell was designed. Therefore, it is necessary to investigate the feasibility and the possible impact on the communication quality of the assisting MNOs and to investigate the mechanism for settlement among the assisted MNOs.

Abnormal case handing	**(3) c.2 Outline of the issue** To construct the system from acquisition of original information to distribution to the vehicle, and to investigate the responsibility sharing and granularity of the demarcation point (I/F) need to be clarified. ● **Issues specific to communication methods** Detailed and complex coordination are required due to more stakeholders and system assets. ● **Details (Challenges, etc.)** It is necessary to agree in advance whether there are operators who operate information sources, MNO networks, servers, etc., roles among those operators, sharing of responsibilities, sharing of costs in the event of fault or failure, etc.
	(3) c.3 Outline of the issue To establish of policy in the event of service outages due to equipment failure, etc. ● **Issues specific to communication methods** Since there are more stakeholders and systems, it is necessary to consider a system and a policy to deal with them, which can analyze the causes of faults and failures, and clarify responsibilities. ● **Details (Challenges, etc.)** It is necessary to investigate in advance methods and systems for monitoring the entire system including information source, MNO network, server, etc., to consider the expected faults and failures, and to specify the time to service recovery for failed equipment and infrastructure repair, the definition of the deterioration of acceptable service levels, and who will recover.
	(3) c.4 Outline of the issue To develop policy for the case of service down due to communication problems, etc. ● **Issues specific to communication methods** To investigate how to continue providing the service in the event that the serving MNO becomes unavailable due to a communication failure, etc. ● **Details (Challenges, etc.)** • If the V2N service can't obtain information from other vehicles, it also affects the service provision to its own user. It is necessary to consider systems such as transfer transportation by railway. Even existing smartphone services have not yet implemented a mechanism to help other MNO users who have communication problems. For V2N, it is necessary to investigate how MNOs should cooperate with each other (roaming, etc.) so as not to stop the service, establish a third-party organization, develop operational rules, and arrange the cost sharing. • In the case of cooperation between MNOs, when the service of serving MNO becomes unavailable, other MNOs will accommodate the users, and it is necessary to accommodate more users than expected in the cell design. Therefore, it is necessary to evaluate the impact on the communication quality of the assisting MNOs and whether it is acceptable or not and to investigate the mechanism for settling the assisted MNOs.

Equipment certification/ verification	**(3) c.5 Outline of the issue** Same as **(2) c.2** ● **Issues specific to communication methods** To investigate whether it is necessary to certificate servers beyond a mobile communication network, etc., in addition to on-board unit. ● **Details (Challenges, etc.)** Existing vehicle safety standards and telecommunications business act may not be sufficient for the service. Develop industry standards and to establish a certification system if required.

e. Issues related to Business feasibility

Category	Organizing issues
Business model	**(3) e.1 Outline of the issue** Same as **(1) e.1** Issue 1 ● **Issues specific to communication methods** Organizing who bears the communication cost using a mobile communication network from what viewpoint. ● **Details (Challenges, etc.)** For the use case that entity provide the information and the entity to use the information are different, the entity who provide the more information should not be sacrificed. Issue 2 ● **Issues specific to communication methods** The construction of a business model becomes more complicated because there is a plurality of systems and stakeholders. ● **Details (Challenges, etc.)** An entity that leads issue solving is necessary.
Ensuring business continuity	**(3) e.2 Outline of the issue** Same as **(1) e.1** ● **Issues specific to communication methods** To investigate operation method to serve continuously V2N service based on the life cycle and model development of the vehicle, and the lifetime of the vehicle and infrastructure in advance (consideration of MNO's facility operation policy and business model for continuing to use communication of a specific generation). ● **Details (Challenges, etc.)** In order to continue using communications of a specific generation, the current business models and operations of MNOs, base station vendors, chip manufacturers, etc. are affected. Considering how to serve several generations-old communication services for V2N services and maintain a system for manufacturing and supplying equipment and parts while the generation of communications utilized by Smartphone and others continues to advance. Note: After the first car with a feature is released [y=0], it is y=5～10 years to complete installing it to other car models, y=15～20 years to end the production of the last car model, and about y=35 years to the end of the car. On the other hand, Japan's mobile communication systems have terminated mobile services for 1G and 2G in about 20 years for each, and 3G is planned to be terminated in the future.

(4) Issues common to use case of V2N with dynamic information.

a. Issues that need to be examined holistically

Category	Organizing issues
Measure to increased costs caused by quality improvements to meet requirements	**(4) a.1 Outline of the issue** Same as **(2) a.1** Issue 1 ● **Issues specific to communication methods** To investigate business feasibility in cases where the cost is expected to increase by improving the quality of a mobile communication network in order to satisfy requirements such as delay and packet reachability according to the application. ● **Details (Challenges, etc.)** To investigate whether it is possible to control the communication state, set QoS control, and set radio communication parameters differently from those of other ordinary terminals to achieve low latency. (The communication delay time may vary greatly depending on whether the communication terminal is in IDLE state or Connected state.) Issue 2 ● **Issues specific to communication methods** To investigate improving the quality of devices involved in the acquisition, processing, and distribution of information, improving the quality of networks between servers, and business feasibility based on the increase in costs as well as improving the quality of mobile communication networks since lower latency and more accurate information distribution are required. ● **Details (Challenges, etc.)** • In order to meet the requirements of low latency, it is necessary to consider the improvement of information sources, servers, inter-server networks, etc. for real-time information acquisition, collection, aggregation, and distribution from information sources. Furthermore, in order to satisfy the requirement [6][7] that the gap between the traffic signal information to be provided to the vehicle and the actual light color is ±300 ms or less, it is necessary to consider the improvement of the time accuracy of the traffic signal controller and the modification of the traffic signal controller that can acquire the traffic signal information more frequently. • When improving or modifying networks among devices and servers, it is necessary to widely consider and agree with various entities on who will bear the cost and establish the business.

b. Issues related to technology

Category	Organizing issues
Equipment and infrastructure specifications	**(4) b.1 Outline of the issue** Same as **(2) b.2** Issue 1 ● **Issues specific to communication methods** To investigate whether abnormality occurrence can be immediately detected and whether it can be notified to the vehicle with acceptable delay, when handling information used for vehicle control. ● **Details (Challenges, etc.)**

	Since V2N transmits information via an information source, a mobile communication network, a server, etc., it is difficult to provide information with acceptable delay after detecting failure. (Example: In the case of traffic signal information distribution, it is necessary to have a function to match the traffic signal information provided to the vehicle with the physical traffic signal light color to determine the failure, and a mechanism to quickly notify the vehicle when an abnormality is detected [6][7].) It is necessary to conduct technical verification to realize this, and to consider what to do about the cost in that case. Issue 2 ● **Issues specific to communication methods** Compared with conventional usage for infotainment via networks, the usage for vehicle control requires modification of vehicle equipment and in-vehicle networks, and reinforcement of security in order to achieve reliability and the like necessary for control. Therefore, it is necessary to consider whether the use will be established as a product including cost. ● **Details (Challenges, etc.)** This is because it is necessary to consider not only the network that connects with the outside of the vehicle and its communication message side, but also the modification of the equipment and the network configuration of the vehicle and security.

(5) Issues common to use case of V2N with semi-dynamic information.

a. Issues that need to be investigated holistically

Category	Organizing issues
Measure to increased costs caused by quality improvements to meet requirements	**(5) a.1 Outline of the issue** Same as **(2) a.1** ● **Issues specific to communication methods** Same as **(4) a.1** Issue 1 ● **Details (Challenges, etc.)** Same as **(4) a.1** Issue 1

(6) Issues common to use case of V2N with semi-static information

No issues were identified in this categorization.

Chapter 3 Discussion

Based on the results of the previous chapter, the characteristics and observation are described in this chapter for each communication method.

3.1 Issues common to V2V/I and V2N use cases.

As similar to the previous reports compiled by this TG, it was reconfirmed that there are many issues not only related to technology but also related to the regulation, availability of the infrastructure, business feasibility, etc., and these many issues need to be solved. The biggest recognized issue among them is the identification/assignment of entities (e.g., companies, organizations, government agencies, prefectures, municipalities, local governments, etc.) who specifically lead the activity like who launches the service with what role and responsibility and who bears the cost to establish the business. TG discussed this issue, but TG were not able to conclude this.

3.2 Issues common to the use cases of V2V/I

For many use cases using V2V/I, most of the service content and realization technologies are the same as those of the services have already been providing in Japan for driving safety support or their information contents can be reused. Thus, not many new issues were identified other than those outlined in the previous reports. The experience/knowledge obtained from existing system could be utilized for the realization of these use cases.

There are three ways to realize a communication system: to extend the existing system, to replace the existing system by a new one, and to use both the existing one and a new one. The pros and cons need to be analyzed carefully. When extending the existing system, it is necessary to evaluate whether there is room for future extension. When replacing by a new system, it is necessary to evaluate whether cost advantages could be obtained even with the consideration of replacement cost, on-board unit sales cost, etc., and whether existing users can be migrated smoothly or not. When using both the existing system and a new system, it is necessary to evaluate whether the business could be feasible even with the increasing cost and the circuit size of the equipment, and whether OEMs, equipment and infrastructure manufacturers can provide them as products.

As identified above, who provides the services with what roles and what responsibility and who will bear the cost are essential issue.

Regarding on-board unit and roadside unit, it is necessary to evaluate whether it can be provided as a product by automobile manufacturers and roadside unit manufacturers and to evaluate whether business is feasible in consideration of size, increased features, increased cost,

etc. when developing the specification of the equipments and considering improvement/modification of the equipments to satisfy the requirements. At that time, for business continuity, it is also very important to consider in advance how to continuously operate the system of the on-board unit and roadside unit in consideration of the life cycle or update cycle of the vehicle, and the update cycle of the infrastructure.

3.3 Issues common to use case of V2N

The use case of V2N requires the information source, the communication with vehicles for information acquisition, collection, aggregation and distribution, and the vehicle itself with communication capability. The roles of each function, the measure and the responsibility for the fault or failure and the cost sharing need to be concluded among various parties. Therefore, the V2N use case requires complex coordination in general. It is essential to have a leading entity to guide these complex coordinations.

When a vehicle moves out of a service area of a serving MNO, or when a V2N cannot be operated due to a fault or the like, the vehicle needs to recognize it rapidly, and the vehicle must have a fail-safe function to continue safety vehicle control. In addition, for the full-time operation of V2N, the discussion on the rules, framework, cost sharing, etc. is necessary. Furthermore, it is required to consider the necessity and the way to cooperate among MNOs for the full-time operation of V2N.

It is necessary to be able to continuously operate the service with the consideration of the life cycle or update cycle of the vehicles and the update cycle of the infrastructure. On the other hand, the generation of communication technology utilized by the smartphone are advanced like 5G, 6G and so on. Therefore, it is necessary to consider in advance how to continuously provide the V2N use case communication service for several communication generations. This issue may affect the business model and operation of MNOs, base station vendors, chip manufacturers, etc. as it is different from the one for the smartphones.

For use cases that handle dynamic information, vehicle control information can be sent is assumed. In order to meet high reliability and low latency requirements, end to end consideration and the improvement would be necessary such as not only the quality of mobile communication networks, but also the equipment related to the acquisition, processing, and distribution of information, and the quality of inter-server networks. In addition, it is necessary to investigate a mechanism that enables the immediate detection of abnormality occurrence and notification to the vehicle within the required latency. These issues need to be addressed not only by technical considerations, but also by a number of parties to agree on the roles and requirements of related servers and other equipment, and who will bear the costs of the new

installation or modification of facilities and equipment required to fulfill those roles and requirements, thereby required especially complex coordination. In addition, the vehicle side that receives dynamic information also needs to change the equipment within the vehicle and the in-vehicle network and strengthen the security for the necessary reliability of the control, etc. in the utilization in the vehicle control, compared to the conventional utilization for infotainment, etc. via the network.

Traffic signal information distribution, one of the use cases for handling dynamic information, has been confirmed to be technically established by SIP [8] for information distribution for autonomous driving vehicles by V2I. However, in order to establish a service equivalent to V2I by V2N, it is necessary to thoroughly investigate the functions necessary for providing the service, the performance, quality*, reliability of the entire system, etc., which are equal to or more than that of V2I, and whether the cost benefit will come out.

* Note that delay characteristics need to be investigated whether the value similar to that for V2I is necessary or not. In order to provide traffic signal distribution service, comparison of V2I and V2N (classification of further detailed use cases, requirements, performance, cost, etc.) should be further continued.

Chapter 4 Summary

In this report, in order to classify the issues when using cellular V2X for the advanced ITS and driving automation, detailed issues are investigated from a wide point of view including non-technical issues for SIP cooperative driving automation use cases, and they are categorized by communication methods and information update rate. As in the previous reports, the report also summarizes a number of issues related to not only technology but also regulation, infrastructure development, business feasibility, etc., reaffirming that there are many issues that need to be solved other than technology related issues, rather than just being implemented in society once the standardization of radio communication is completed. In particular, the use cases that use V2N to handle dynamic information need to be discussed and agreed with a wide range of stakeholders from a comprehensive perspective in order to satisfy the required quality, which is higher than that of the information used for the driving plan, etc. This implies that the hurdles to practical use of dynamic information are higher compared to the practical use of semi-dynamic or semi-static information.

It was not able to conclude the role and responsibility of many stakeholders in building a system, and who pays the costs to establish a business. The major issue to realize the system would be whether it is possible to determine the main entities who lead these activities.

Conclusion

Based on the issues that have been summarized in this TG for the use of cellular technology for ITS and driving automation, we investigated more detailed issues for the SIP use cases for cooperative driving automation.

In order to commercialize new services such as the SIP cooperative driving automation use case, it is necessary to decide entities that will lead the discussion such as roles and responsibilities among stakeholders and who will pay the cost. We hope that this study would be utilized effectively, and the ITS Info-communications Forum would contribute based on the knowledge obtained in this study.

Appendix Table 1: Relationship between each issue and SIP use cases for cooperative driving automation

					Use cases that utilize V2V/I			Use cases that utilize V2N						
					Dynamic information	Semi-dynamic information	Semi-static information	Dynamic information		Semi-dynamic information		Semi-static information		
Perspective of issue arrangement	Category	Outline of the issue	Examination area of the issue	Issues specific to communication methods	a-1-1. Merging assistance by preliminary acceleration and deceleration a-1-2. Merging assistance by targeting the gap on the main lane b-1-1. Driving assistance by using traffic signal information (V2I) c-1. Collision avoidance assistance when a vehicle ahead stops or decelerates suddenly c-2-1. Driving assistance based on intersection information (V2V) c-2-2. Driving assistance based on intersection information (V2I) c-3. Collision avoidance assistance by using hazard information a-1-3. Cooperative merging assistance with vehicles on the main lane by roadside control a-1-4. Merging assistance based on negotiations between vehicles a-2. Lane change assistance when the traffic is heavy a-3. Entry assistance from non-priority roads to priority roads during traffic congestion g-1. Unmanned platooning of following vehicles by electronic towbar g-2. Adaptive cruise control and manned platooning of following vehicles using adaptive cruise control	e-1. Driving assistance based on emergency vehicle information	f-2. Gathering information for optimizing traffic flow	b-1-2. Driving assistance by using traffic signal information (V2N)	h-1. Operation and management of mobility service cars	d-1. Driving assistance by notification of abnormal vehicles d-2. Driving assistance by notification of wrong-way vehicles d-3. Driving assistance based on traffic congestion information d-4. Traffic congestion assistance at branches and exits d-5. Driving support based on hazard information	e-1. Driving assistance based on emergency vehicle information	f-2. Collection of information to optimize the traffic flow	f-3. Update and automatic generation of maps	f-4. Distribution of dynamic map information
a. Issues that need to be investigated holistically	Service definition	To define the service (what to do for what kind of issues in what scenes, whether communication is necessary, etc.) and to define the overall architecture, features, etc. required for the service realization, and the formulation of guidelines.	① Common to V2V/I and V2N	-	●	●	●	●	●	●	●	●	●	●
	Requirements setting, verification	• To investigate requirements (e.g., delay, reliability) necessary for service realization, the criteria to verify their applicability and verifying. • To specify communication requirements for each environment/use case and to determine verification conditions (model cases).	① Common to V2V/I and V2N	-	●	●	●	●	●	●	●	●	●	●
		To investigate how to assign roles, functions, cost sharing, etc. for the stakeholders and systems in order to achieve the service requirements and to investigate business feasibility with how the cost is shared among users.	① Common to V2V/I and V2N	-	●	●	●	●	●	●	●	●	●	●
			③ Common to V2N	Since there are more stakeholders and systems, the coordination will be complex considering various options, and it takes time to agree.				●	●	●	●	●	●	●
	Advantages of V2V/I and V2N	To investigate the advantages of such as cost and quality and to selelc service realization method, if V2V/I and V2N are used for the same service.	③ Common to V2N	To investigate whether it is possible to find an advantage of V2N over V2V/V2I in terms of cost merit while satisfying the service requirements.				●			* V2V/I and V2N are separated as services, so there is no need to compare them.	●		
	Measures to increased costs caused by quality improvements to meet requirements	To investigate business feasibility with the consideration of the increased cost because performance and network quality improvement are required to satisfy the delay, packet arrival rate, and information accuracy requirements.	② Common to V2V/I	To investigate business feasibility and product deliverability of OEM, equipment and infrastructure manufacturers taking into account the cost and volume increase required for modifications as modification would be required for on-board unit and roadside unit.	●	●	●							
			④ V2N × dynamic information ⑤V2N ×Semi-dynamic information	To investigate business feasibility in cases where the cost is expected to increase by improving the quality of a mobile communication network in order to satisfy requirements such as delay and packet reachability according to the application.				●	●	●	●			
			④ V2N × dynamic information	To investigate improving the quality of devices involved in the acquisition, processing, and distribution of information, improving the quality of networks between servers, and business feasibility based on the increase in costs as well as improving the quality of mobile communication networks since lower latency and more accurate information distribution are required.				●	●					

Perspective of issue arrangement	Category	Outline of the issue	Examination area of the issue	Issues specific to communication methods	Use cases that utilize V2V/I			Use cases that utilize V2N						
					Dynamic information	Semi-dynamic information	Semi-static information	Dynamic information		Semi-dynamic information		Semi-static information		
					a-1-1. Merging assistance by preliminary acceleration and deceleration a-1-2. Merging assistance by targeting the gap on the main lane b-1-1. Driving assistance by using traffic signal information (V2I) c-1. Collision avoidance assistance when a vehicle ahead stops or decelerates suddenly c-2-1. Driving assistance based on intersection information (V2V) c-2-2. Driving assistance based on intersection information (V2I) c-3. Collision avoidance assistance by using hazard information a-1-3. Cooperative merging assistance with vehicles on the main lane by roadside control a-1-4. Merging assistance based on negotiations between vehicles a-2. Lane change assistance when the traffic is heavy a-3. Entry assistance from non-priority roads to priority roads during traffic congestion g-1. Unmanned platooning of following vehicles by electronic towbar g-2. Adaptive cruise control and manned platooning of following vehicles using adaptive cruise control	e-1. Driving assistance based on emergency vehicle information	f-2. Gathering information for optimizing traffic flow	b-1-2. Driving assistance by using traffic signal information (V2N)	h-1. Operation and management of mobility service cars	d-1. Driving assistance by notification of abnormal vehicles d-2. Driving assistance by notification of wrong-way vehicles d-3. Driving assistance based on traffic congestion information d-4. Traffic congestion assistance at branches and exits d-5. Driving support based on hazard information	e-1. Driving assistance based on emergency vehicle information	f-2. Collection of information to optimize the traffic flow	f-3. Update and automatic generation of maps	f-4. Distribution of dynamic map information
b. Issues related to technology	Communication standardization	• To specify communication protocol (including message format), performance requirements, and test specifications with the consideration of performance, applicability, business model, business continuity, privacy, security, and global harmonization. • To establish a framework and system, opereation method for standardization (including maintenance and enhancment after specification release).	① Common to V2V/I and V2N	-	●	●	●	●	●	●	●	●	●	●
			② Common to V2V/I	• To ensure a frequency bandwidth according to the amount of communication traffic, and to specify communication channel and QoS according to a communication content. • To have the investigation, study, verification and standardization of congestion control methods.	●	●	●							
			③ Common to V2N	To specify the communication protocols and the server functions related to whether a vehicle requests information stored in a server or the server decides a target vehicle to provide the information, and what information should be transmitted and received in such cases.				●	●	●	●	●	●	●
	Equipment and infrastructure specifications	• To specify service-related equipment and infrastructure (including fail-safe functions) and guidelines. • To develope specification and/or guideline for equipment modification or interface deveice to acquisite and distribute information by connecting to networks and communication devices for the systems using existing infrastructure facilities (traffic signal controllers, servers, etc.).	② Common to V2V/I	To develop specifications and guidelines for equipments such as roadside unit and on-board unit.	●	●	●							
			③ Common to V2N	To develop the specification of equipment for servers to acquire, collect, and distribute information (such as obstacles) from information sources.				●	●	●	●	●	●	●
			③ Common to V2N	To investigate a mechanism to verify whether information obtained through a network matches the actual situation, and to investigate a fail-safe function for the abnormal event such as malfunction and failure.				●	●	●	●	●	●	●
			④ V2N × dynamic information	To investigate whether abnormality occurrence can be immediately detected and whether it can be notified to the vehicle with acceptable delay, when handling information used for vehicle control.				●	●					
			④ V2N × dynamic information	Compared with conventional usage for infotainment via networks, the usage for vehicle control requires modification of vehicle equipment and in-vehicle networks, and reinforcement of security in order to achieve reliability and the like necessary for control. Therefore, it is necessary to consider whether the use will be established as a product including cost.				●	●					
c. Issues related to the regulation	Providing services for the equipments of different manufacturers and MNOs	To develop a system and policy that can provide services correctly connecting all communication vehicles and communication infrastructure.	② Common to V2V/I	To establish a system and a management method in which all of the vehicles and roadside units can be connected with each other regardless of vehicle type and manufacturer.	●	●	●							
			③ Common to V2N	To establish a system and a management method in which all vehicles can be connected with each other regardless of the vehicle type and manufacturer, MNO, etc.				●	●	●	●	●	▲	
			③ Common to V2N	To examine how to continue providing the service when a user is out of coverage of serving MNO.				●	●	●	●	●	●	●
	Abnormal case handing	To construct the system from acquisition of original information to distribution to the vehicle, and to investigate the responsibility sharing and granularity of the demarcation point (I/F) need to be clarified.	③ Common to V2N	Detailed and complex coordination are required due to more stakeholders and system assets.				●	●	●	●	●	●	●
		To establish of policy in the event of service outages due to equipment failure, etc.	③ Common to V2N	Since there are more stakeholders and systems, it is necessary to consider a system and a policy to deal with them, which can analyze the causes of faults and failures, and clarify responsibilities.				●	●	●	●	●	●	●
		To develop policy for the case of service down due to communication problems, etc.	③ Common to V2N	To investigate how to continue providing the service in the event that the serving MNO becomes unavailable due to a communication failure, etc.				●	●	●	●	●	●	●
	Equipment certification/verification	Clarifying the scope of authentication and inspection, and establishing and operating a system and system for this.	② Common to V2V/I	To clarify the scope of authentication and inspection, and to realize and operate them.	●	●	●							
			③ Common to V2N	To investigate whether it is necessary to certificate servers beyond a mobile communication network, etc., in addition to on-board unit.				●	●	●	●	●	●	●
	Privacy protection	• To have an agreement to aquisite original information from the organizations, and to determine the necessity of agreement to collect the location inforamtion of the vehicle and so on with the owner or user. If the agreement is necessary, to investigate how the agreement can be made. • To decide how to use the obtained information aligned with the Personal Information Protection Law and other laws.	① Common to V2V/I and V2N	-			●	●	●	●	●	●	●	●

Perspective of issue arrangement	Category	Outline of the issue	Examination area of the issue	Issues specific to communication methods	Use cases that utilize V2V/I			Use cases that utilize V2N						
					Dynamic information	Semi-dynamic information	Semi-static information	Dynamic information		Semi-dynamic information		Semi-static information		
					a-1-1. Merging assistance by preliminary acceleration and deceleration a-1-2. Merging assistance by targeting the gap on the main lane b-1-1. Driving assistance by using traffic signal information (V2I) c-1. Collision avoidance assistance when a vehicle ahead stops or decelerates suddenly c-2-1. Driving assistance based on intersection information (V2V) c-2-2. Driving assistance based on intersection information (V2I) c-3. Collision avoidance assistance by using hazard information a-1-3. Cooperative merging assistance with vehicles on the main lane by roadside control a-1-4. Merging assistance based on negotiations between vehicles a-2. Lane change assistance when the traffic is heavy a-3. Entry assistance from non-priority roads to priority roads during traffic congestion g-1. Unmanned platooning of following vehicles by electronic towbar g-2. Adaptive cruise control and manned platooning of following vehicles using adaptive cruise control	e-1. Driving assistance based on emergency vehicle information	f-2. Gathering information for optimizing traffic flow	b-1-2. Driving assistance by using traffic signal information (V2N)	h-1. Operation and management of mobility service cars	d-1. Driving assistance by notification of abnormal vehicles d-2. Driving assistance by notification of wrong-way vehicles d-3. Driving assistance based on traffic congestion information d-4. Traffic congestion assistance at branches and exits d-5. Driving support based on hazard information	e-1. Driving assistance based on emergency vehicle information	f-2. Collection of information to optimize the traffic flow	f-3. Update and automatic generation of maps	f-4. Distribution of dynamic map information
d. Issues related to Infrastructure	Development of terminals and infrastructure	• To investigate how to increase the penetration rate of terminals and how to deploy the infrastructure such as roadside unit and server with the consideration of the business models including how the cost is shared among users. • The systems using existing infrastructure facilities (traffic signal controllers, servers, etc.) need to modify the equipment or adding interface devices to have the communication.	① Common to V2V/I and V2N	-	●	●	●	●	●	●	●	●	●	●
	Operational specifications of terminals and infrastructure	To study systems and frameworks for monitoring and operating service-related equipment, infrastructure, and networks.	① Common to V2V/I and V2N	-	●	●	●	●	●	●	●	●	●	●
	Sophistication of terminals and infrastructure	To design initial services with the capability to allow new service realization while maintaining compatibility with deployed services.	① Common to V2V/I and V2N	-	●	●	●	●	●	●	●	●	●	●
e. Issues related to Business feasibility	Business model	To establish business models and to clarify the entities with the consideration of users, terminals, development and operating of the infrastructure, and communication costs.	① Common to V2V/I and V2N	-	●	●	●	●	●	●	●	●	●	●
			③ Common to V2N	Organizing who bears the communication cost using a mobile communication network from what viewpoint.				●	●	●		●	●	
			③ Common to V2N	The construction of a business model becomes more complicated because there is a plurality of systems and stakeholders.				●	●	●	●	●	●	●
	Business continuity	To investigate whether the system can be continuously operated based on the life cycle of the car, model development, and the lifetime of the car and infrastructure, and to establish a scheme to update it without service interruption.	② Common to V2V/I	To investigate operation method in advance to achieve continuous operation of the on-board unit and roadside unit with the consideration of the life cycle of the car, model development, and the lifetime infrastructure.	●	●	●							
			③ Common to V2N	To investigate operation method to serve continuously V2N service based on the life cycle and model development of the vehicle, and the lifetime of the vehicle and infrastructure in advance (consideration of MNO's facility operation policy and business model for continuing to use communication of a specific generation).				●	●	●	●	●	●	●
f. Issues other than categorized	Security measures	• To ensure the reliability of communication information (security of communication paths), to prevent spoofing, and false information. • To esbablish a framework to prevent the location information of the vehicle from being misused.	① Common to V2V/I and V2N	-	●	●	●	●	●	●	●	●	●	●
	Relationships between use cases	To investigate which parts of the business model, protocols and servers are common and which parts are independent considering commercial timelines for different use cases and different communication methods (V2N/I/V).	① Common to V2V/I and V2N	-	●	●	●	●	●	●	●	●	●	●
	Relationships between organizations	To assigne what part is investigated in the collaboration among various goverment, private sector projects, and the standard related organizations.	① Common to V2V/I and V2N	-	●	●	●	●	●	●	●	●	●	●

Appendix Table 2: Use Cases Not Considered for issue survey

Communication methods	Function classification	Use case name	Reasons for "Not considered"
V2I	d. Look-ahead information: trajectory plan change	d-1. Driving assistance by notification of abnormal vehicles	The method of implementing V2I and V2N is summarized in the SIP-TF report. However, it is appropriate to implement V2N for the reasons that responsiveness will not be required in information distribution because of the application to be utilized for the trajectory plan change, and V2I will require many roadside units to cover the roads to avoid service interruption.
V2I	d. Look-ahead information: trajectory change	d-2. Driving assistance by notification of wrong-way vehicles	Same as d-1.
V2I	d. Look-ahead information: trajectory change	d-3. Driving assistance based on traffic congestion information	Same as d-1.
V2I	d. Look-ahead information: trajectory change	d-4. Traffic congestion assistance at branches and exits	Same as d-1.
V2I	d. Look-ahead information: trajectory change	d-5. Driving assistance based on hazard information	Same as d-1.
V2N	f. Information collection/ distribution by infrastructure	f-1. Request for rescue (e-Call)	The HELPNET service has already been put into practical use using the Emergency Notification System (HELP).

References

[1] SIP Cooperative Automatic Operation Communication System Study TF, SIP Cooperative Automatic Operation Use Case FY2019 Cooperative Automatic Operation Communication System Study TF Activity Report - September 2020, https://www.sip-adus.go.jp/rd/rddata/usecase.pdf (Japanese version) https://en.sip-adus.go.jp/rd/rddata/usecase.pdf (English version)

[2] K.K. MM Soken, 2021 Domestic Mobile Phone Terminal Shipment Count Survey, https://www.m2ri.jp/release/detail.html?id=526

[3] The Cabinet Office's Consumption Trend Survey, conducted in March 2021, published by https://www.esri.cao.go.jp/jp/stat/shouhi/shouhi.html

[4] Japan Automobile Manufacturers Association, 2021 edition Japanese automobile industry, https://www.jama.or.jp/library/publish/mioj/ebook/2021/MIoJ2021_j.pdf

[5] Automobile Recycling Promotion Center, Automobile Recycling Data Book2020, https://www.jarc.or.jp/data/databook/

[6] SIP Phase 2/Automated Operation (Expansion of Systems and Services)/Research and Development Results Report on Advancement of Signal Information Provision Technology for Automated Operation, November 2020, https://www.sip-adus.go.jp/rd/rddata/rd04/204.pdf

[7] SIP Phase 2/Automated Operation (Expansion of Systems and Services)/Research and Development Overview Edition on Advancement of Signal Information Provision Technology for Automated Operation, November 2020, https://www.sip-adus.go.jp/rd/rddata/rd04/204s.pdf

[8] SIP Phase 2/Automated Operation (Expansion of Systems and Services)/Tokyo Waterfront Demonstration Test Conducted, May 2021, https://www.sip-adus.go.jp/rd/rddata/rd04/103.pdf