A Study of the Usable Concept of Transportation Information Services for the High Value Added Railway Transportation Infrastructure

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Abstract--**In urban areas, the railway systems and these transportation services are indispensable for the social infrastructure to ensure the safe, punctual and comfortable transportation for a large number of passengers. In order to perceive a whole railway service, we need to evaluate hospitality of staffs and crews, and provide the information during train delays such as the train schedule and the conditions of equipment of vehicles and stations. In these studies, the train information in Japanese transportation service is focused on, and an appropriate effect of transport information for the passenger's behavior is analyzed and an appropriate concept of information service is presented for the railway transportation system.**

The properties of railway service are reviewed by the SSM-IA analysis and the train information services which can elevate the railway service values are pointed out.

Next, the usability of information items such as passenger's congestion state and the train position inside lane are suggested by the analysis of the user's preferences survey. In addition, the relations between the customer's satisfaction and information services are viewed from the effect on passenger's behavior in the transportation infrastructure. Finally, an expected information service model is suggested in order to improve the passenger's transportation value.

I. INTRODUCTION

The core service of rail operation lies in provision of the reliable punctuality in rail operation. In Japan, there have been various efforts to add values to this initiative amongst rail service operators. The successful example includes the introduction of through operation wherein railway tracks of different operators are connected to expand the rail network, leveraging mutually on the existing infrastructure and facilities to increase the ridership and the passenger convenience. Recent changes to the operating environment such as the demographic structure, technological advances and different work styles have put the rail transportation under pressure to achieve more convenience such as high-speed and connection-free travel, enhanced comfort and reliability, thus increasing demands in broader range of different quality services both in the hard and the soft aspects.

This study will observe comprehensively the whole rail service and discuss the value-adding innovation field, in particular, the information service, examining the urban rail service as the carrier of the mass transportation in the metropolitan area, whereby ideal services will be identified to support user mobility. The field survey conducted will clarify that it is a useful rail-user service to feed them with the information on on-board congestion and on-rail location (the position and/or location of a currently running train) as the TOPIC information in addition to the already practiced information service, followed by further examination to achieve the service which allows the majority of rail users to gather information strategically and efficiently.

II. PREVIOUS STUDIES ON RAIL SERVICE

Studies on rail service in Japan are broadly categorized in the transportation planning as in service planning diagram and train operation, and the information service, putting aside hardware development including rail carriage and station facilities. The majority of them address the theme of the element technology and the evaluation method whereas some of them attempt an approach to the system technology in a comprehensive examination of the whole rail service, the example being a new mode of train operation control system such as *Advanced Train Administration and Communications System (ATACS)* developed by *East Japan Railway* (2015). As for the information service for passengers, some studies deal with the information service in the event of transportation disruption [1], [2], [3]. However, amidst the complicity of the impact arising from the disruption, none of them has yet to offer the information that rail users would truly appreciate. The information currently supplied by rail operators includes brief data on train operation in the event of disruption (the type of disruption, expected delay time etc.) and the programmed information on arrival and departure at the time of normal service, and thus very limited.

This study will examine the whole picture of rail service which constitutes the core of urban traffic and, based on the analysis of the findings, conceptualize the information service that enhances the service value. Embracing the idea that rail operators should be able to offer more of the topic information on the normal operation, the currently feasible and practicable information service will be argued.

Recent studies show that the service sector has grown to represent approximately 70 % of the Japanese national economy, and studies on the rail service have shifted to focus on innovative value creation and customer value. Recently Vargo and Lush [4] proposed the theoretical framework of customer values as called the service dominant logic. In this paper, goods and services are not dichotomized. Rather, it will be considered that the whole service sustained by the good can constitute the value to be offered to consumers: the good is not the final product but projected as the medium or the method to provide service, thus attaching importance to consumers.

A. Distinctive elements and services in the rail transportation

Restricting the target of the service to people and adding an element, ¨stimuli to time use¨ to the nature of the service, the rail service is classified, taking into consideration the distinctive elements in the rail transportation. For reference, below indicated is the matrix developed with ¨target of service¨ and ¨target of nature¨ as presented by Lovelock [5]. As shown in the Table 1, it is considered that at the core of the basic function lies the reliability that availability of rail service is impliedly or implicitly offered at all times, and provision of comfortable time is required as the value added to time.

Lately, there have been increasing studies on the framework of service value structure to reinvigorate the innovation in the service sector. Kohtsuki and Sato [6] conducted research and studies on the service from the perspective of technology management, wherein they analysed the process in the field of the medical care, education and IT service from the viewpoint of service science to elucidate that the service values in those sectors consists of customer-related elements.

Amongst values that consumers appreciate, added values such as brand, safety and reliability have weighed more in their mind, which gives rise to focusing on added values not less than the product and service values per se. This concept of component elements, if applied to the rail service with emphasis on services to people, is illustrated in the Figure 1, wherein the transportation service is positioned as principle service coupled with the station and carriage facilities, the customer service by train staff and the safety-and-security-based reliability to constitute the total value. It follows from this that, let alone the means of transportation, the rail service is expected to offer the soft and hard services and the reliability which lies in safety and security to enhance additional values.

B. The whole picture of logical structure of the existing rail service –analysis by SSME-IA

This section places in the comprehensive perspective the whole logical structure that allows the rail service provision. As a visualizing tool to examine the innovation field in the rail service, SSM-IA is applied to illuminate the complicity and mutuality that lie in the present rail service, and thus, visualize the whole system.

Soft System Methodology, (hereinafter SSM) [7], advocated by Checkland, is the methodology for problem solution. This method, often practiced in the management field, allows stakeholders to take a soft approach to facilitate their understanding of problems and learning process in a situation where various values are operating. Innovation Architecture (hereinafter IA) [8], [9], championed by Tschirky [8] is one of graphic tools and an excellent methodology which allows businesses to formulate innovation strategies efficiently. Kamagata [10] attempted the fusion of IA with SSM, looking at the applicability of IA to the service sector, to propose the SSM-applied Innovation Architecture (hereinafter SSM-IA) as a tool to analyse complicated and involved business environment. The table 2 shows comparison of elements between SSM-IA and IA. It has been proven in some case studies that SSM-IA can facilitate an effort to explore new knowledge to develop descriptive framework of the service [10], [11].

TABLE 1 CLASSIFICATION OF DISTINCTIVE SERVICES IN THE RAIL TRANSPORTATION WITH REFERENCE TO THE LOVELOCK´S CLASSIFICATION.

<table>
<tr><td colspan="2" rowspan="2"></td><td colspan="2">Target of services</td></tr>
<tr><td colspan="2">People</td></tr>
<tr><td rowspan="3">Nature of service</td><td>Stimuli to tangible element</td><td colspan="2">Service to the human body</td></tr>
<tr><td>Stimuli to intangible element</td><td>Service to the human mind
Customer service, Information service</td><td rowspan="2">Service of reliability
Safety, security</td></tr>
<tr><td>Stimuli to time use</td><td>Provision of comfortable time
Punctuality, Rapidity, Real-time operation, Comfortableness</td></tr>
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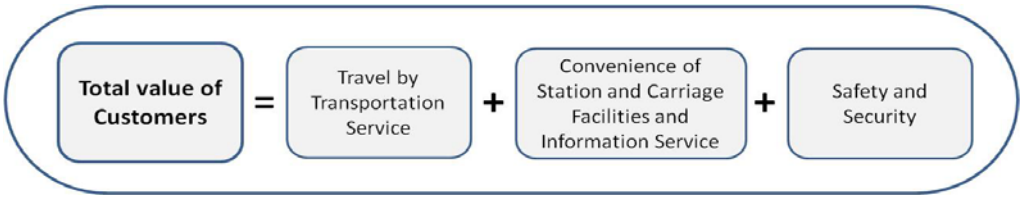

Fig. 1 Component elements that constitute values of rail value

TABLE 2 COMPARISON OF ELEMENTS BETWEEN IA AND SSM-IA

Methodology	IA	SSM-IA
Target	Manufacturing	Service
Architecture	Innovation field/Market needs	Targets
		Market Needs
	Product systems/Services	Services
	Modules	-
	Functions	Functions
	Technology/Applied knowledge	Technology, Working knowledge, Service infrastructure
	Science knowledge	Science knowledge

Iwasaki, et al. [12] modified by the author

III. DESCRIPTION OF THE RAIL SERVICE BY SSM-IA

This section will attempt to visualize the whole system to examine the innovation field of the rail service addressed in this study. We conducted an overhead descriptive analysis of the entire rail service by SSM-IA, extracted the key elements, and proposed value enhancement of the rail service.

Based on the six-layered object knowledge as indicated by the previous studies and in line with first-hand professionally knowledge gained by the co-author, this study attempted to develop six-layered architecture on the rail service, including "target", "market needs", "services", "functions", "technology, working knowledge, service infrastructure", and "science knowledge" to describe the framework as the whole system which provides services[12]. Figure 2 illustrates the whole framework which allows for the existing rail service as a snapshot of the present situation.

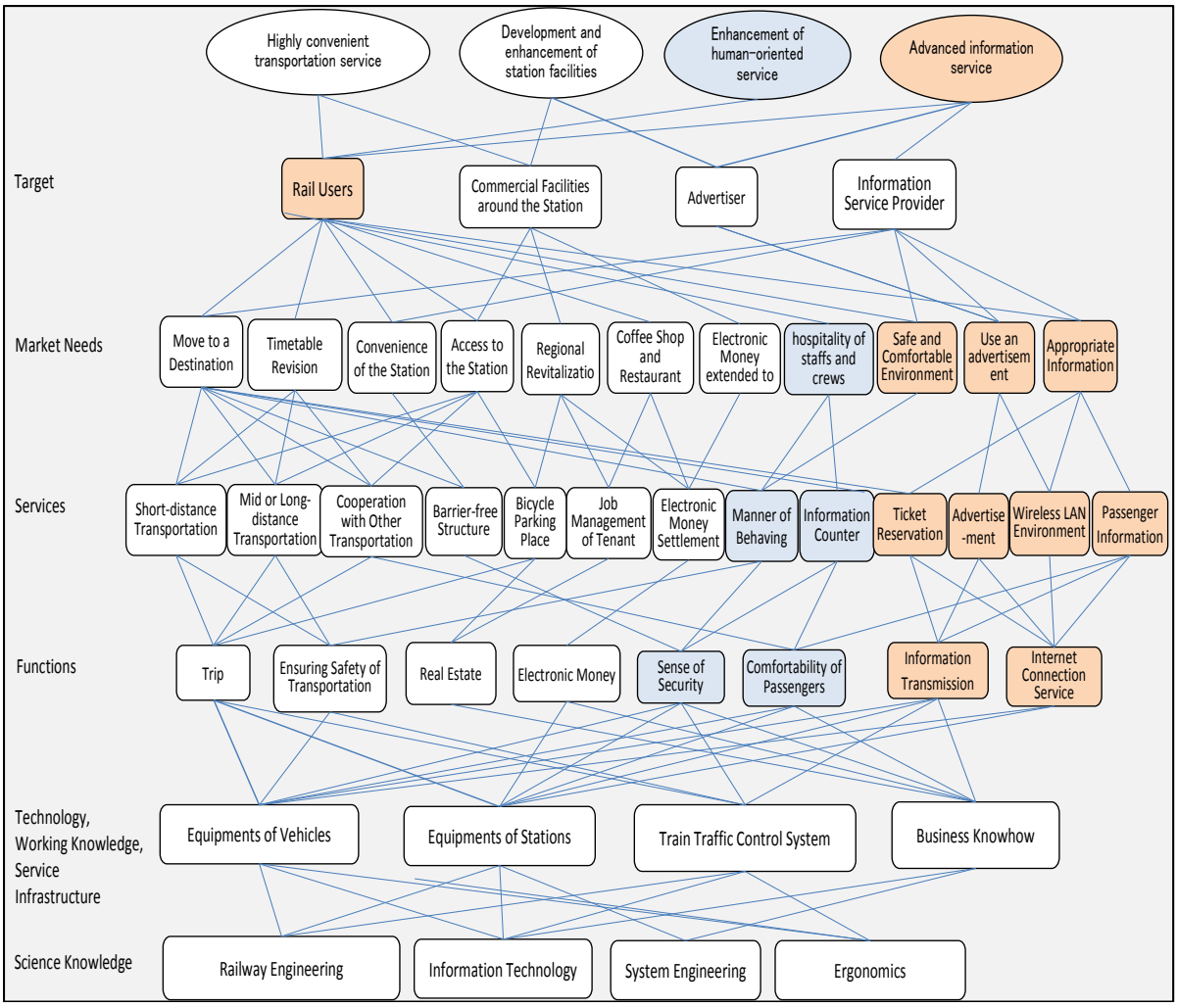

Fig. 2 Description of the rail service by SSM-IA

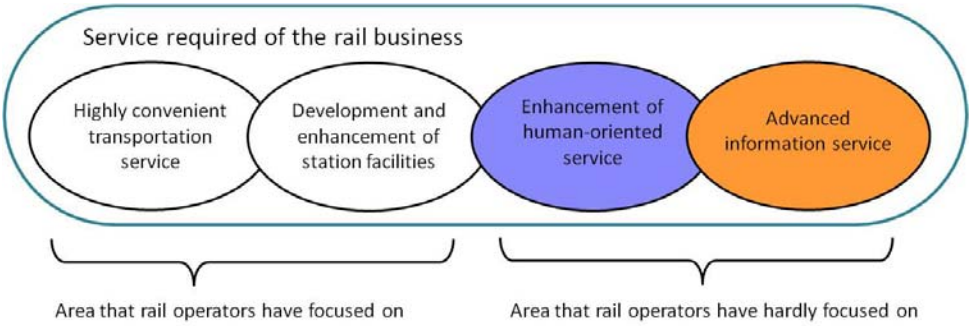

Fig. 3 Services required of the rail service and expected innovation field

Adding to the "transportation service" and "station facility development and enhancement, "human service" and "enhanced information service" are included in the innovation field of the rail service as shown in the Figure 3. Compared to the service planning diagram and station facilities, the human service and the information service have been largely neglected, thus leaving much to be improved.

In these four innovation fields "Move to a Destination" and "Timetable Revision", "Convenience of the Station", " Access to the Station", Regional Revitalization", " Safe and comfortable Environment", Appropriate Information" as shown in market needs are effective service factors for users. If the appropriate information related to Key functions as "Trip" and " Ensuring Safety , Security of Transportation" , Comfort ability" are provided to passengers, the service values of Rail transportation in passengers will have enhancement.

IV. ANALYSIS OF INFORMATION SERVICE - OUTGOING INFORMATION FROM THE OPERATOR

At the level of rail operation, supplied is the static information planned in advance. This type of information is herein called *the static information*, which is widely distributed as the commercially available timetable and on the display at a station. On the other hand, the dynamic information on a real-time situation provided for passengers is defined as *the TOPIC information.* As shown in the Figure 4, the information available for the rail service provider has been increasing in quantity and quality. However, much of the increased information is left unused by the passengers to become *STOCK information*.

- STATIC information: Timetable (arrival/departure time, carriage number, information in the context of connections and transfer)
- TOPIC information: Train operation (information on running train by route, information on each train service)
- STOCK information: Gathered by train operator and but left undistributed (carriage capacity, move-in and -out)

The rail operator takes charge of information service to a large number of the general and the information provider to individuals. That being said, there has not been any coordination forged yet between those service providers in providing information.

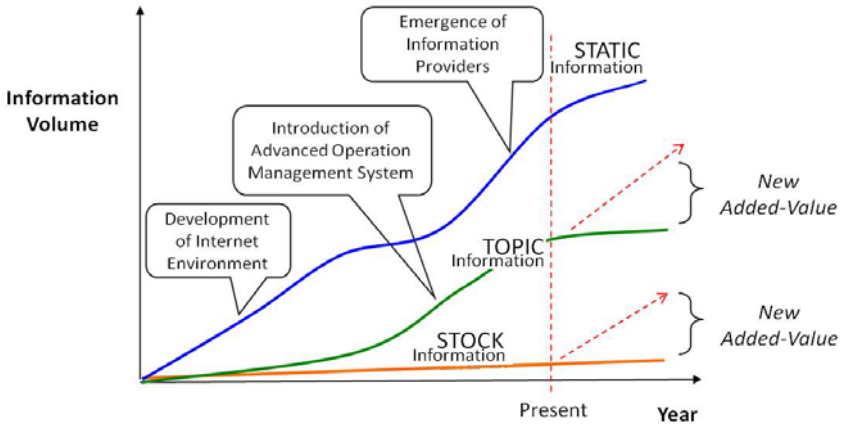

Fig.4 Trend of Information quantity by type

(Note) The information provider refers to a business which commercially provides traffic information to support individual travels. The passenger rail services users receives possible route options and expected arrival time calculated by the provider. The business runs a service model in which the proprietary database channels the requested information through an application of a search engine. Service users receive the information on their PC, smart phones and mobile phones. The service is provided for fee or free, depending on the range of information available.

V. NEW INFORMATION SERVICE AND UTILITY IN THE RAIL SERVICE

Obviously, current rail users want real-time information on schedule disturbances. This user survey investigates the acceptability of the real-time information provision concept, and indicates the importance of providing real-time information as well as the benefits of this concept during normal times.

Provision of information valued by rail users requires service development driven by a new concept, using unexplored information resources and contents. Amongst the untapped resources is the data available only to the rail operators, which can be fed to forecast and calculate the ongoing and expected levels of on-board congestion, or provide the information on the current on-rail location of a running train. This will allow users to choose the right train service that suits their behaviour whereas enabling the rail operator to provide passengers a comfortable environment on board, thus enhancing the service value. Fig. 5 outlines the expected utility arising from the information provision.

- **Information on congestion** refers to the congestion rate "by carriage".
  - Forecast the congestion rate at the time of boarding and provide it for passengers waiting at a station in addition to the actual congestion rate observed upon arrival (Extremely full, full, no seat available, seats available)
  - Allow passengers to choose a less congested carriage before the train arrival.
- **On-rail location** refers to the information on the position of upcoming trains (multiple numbers) currently running or at halt on the rail, which is called "on-rail location".
  - Allow passengers to know if the next train is arriving soon or not, facilitating their choice of a train.

To put it in an illustration, here assumed is an information service system in which data on the congestion is collected, processed and provided for passengers, indicating the change of the number of passengers on board by disembarking station. Coupled with the passenger flow data daily collected and the passenger behaviour simulated, the on-board congestion rate is calculated by carriage[13]. The information serviced by this method has contributed to even distribution congestion amongst carriages of a train as in.

Currently, the rail operator has the on-board conductor works out the number of on-board passengers visually. The value found is not accurate. However, the rail operator does factor this value into the service planning, and hence, it is redeemed not to be far off from the reality. Comparing the estimated value with the observational value, the correlation coefficient was found at the high end of 0.85 to 0.94.

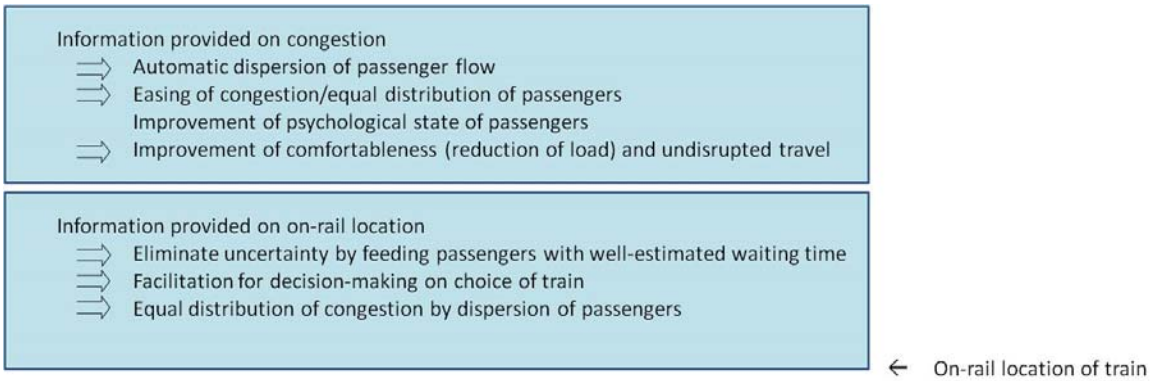

Fig.5 Expected utility arising from providing a variety of information

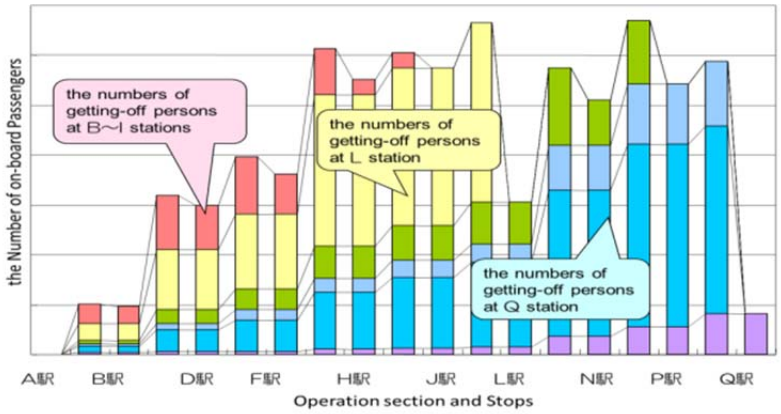

Fig. 6 Analysis of data on boarding

We know from internal surveys that the users of some railway lines want relaxation of congestion. However, increasing transport capacity by increasing the number of trains, etc. is not practical. By at least providing users with information on congestion in advance, it can relieve their psychological burden. It can also be expected to even distribution congestion amongst carriages of a train.

VI. USER OPINION SURVEY ON THE INFORMATION SERVICE

For development of the information service in the rail operation, it is essential for value enhancement of the rail service to clarify how passengers appreciate the information provided, what type of information passengers want and find to be useful and how useful it is for them.

In this study, that the passenger finds the information provided desirable and benefits from it is defined as "Information Acceptability", and conducted a survey to elucidate the reality of it. The type of information surveyed are limited to the following three categories: *"Route guidance* and *Connection guidance"*, *"Congestion"* , *"On-rail location of a train"*. The survey was conducted online in December, 2011, targeting a total of 450 JR and other rail users, including workers, housewives and students who resided in the Kanto and Kansai metropolitan areas.

The survey first focused on "Congestion" and 'On-rail location', which was the information yet to be provided. It was followed by utility analysis and economic evaluation to illustrate the information acceptability in this regard. Then the survey on the information medium was performed.

A. Satisfaction with information providers

The evaluation by the Likert scale shows that users are not highly satisfied with the current information service on the rail operation by the information provider, the negative feed-back being high user charges and lack of data that captures the real-time train operation.

This survey indicates that the information on congestion and on-rail location is deemed not as useful as the route and connections information. However, this type of information, already provided, is indeed positively evaluated, and hence the information acceptability is recognized.

As for the real-time information on train operation and the improved user charges, users consider it "the quality to be guaranteed regardless", because of which these services should be improved with priority[14],[15],[16],[17], [18].

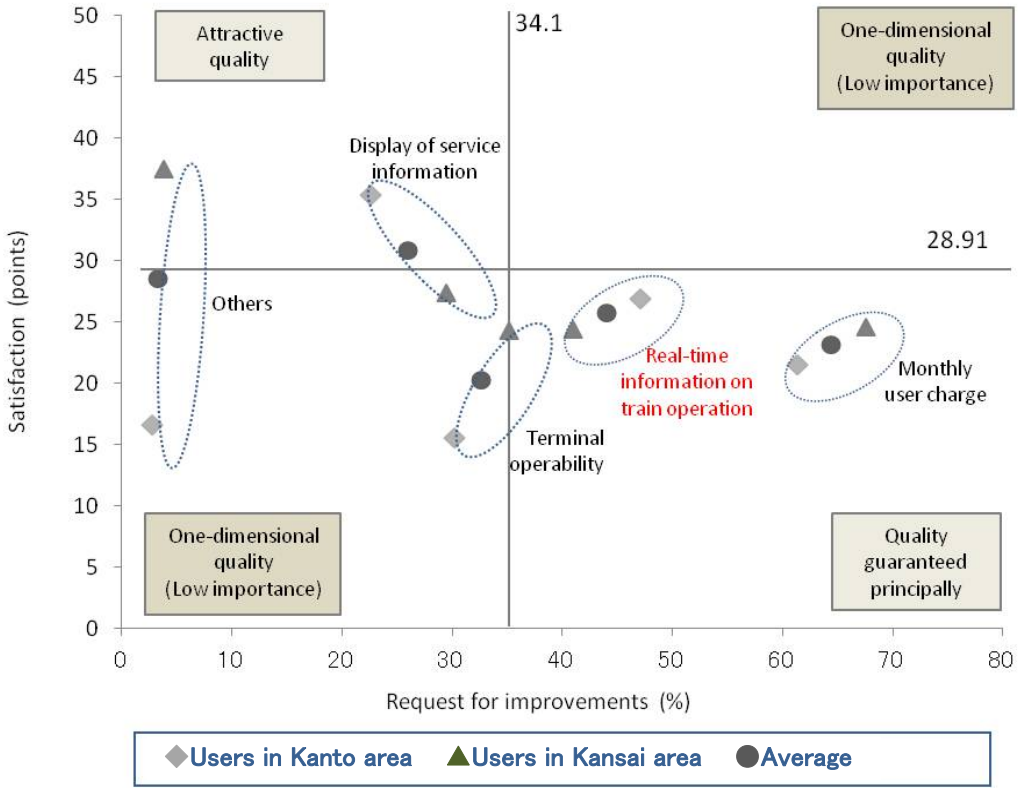

Fig. 7 User satisfaction and request for improvements

B. Utility of the information

Utility of information for users is evaluated, focusing on the location where the information is provided. Rail users find themselves in various situations. If evaluated by "the purpose of use", the utility of the information is appreciated with varying degrees as in a case of a "travel against more restrictions in time" such as commuters to the office and school, "a travel against less restriction in time" such as those back from the office and school or "a non-routine travel on holiday".

The utility can be also evaluated by the medium through which the users receive the information, the medium being categorized in:

- Mobile terminal such as phones
- Announcement on display at a station
- Public Address in a station
- Web pages of a rail service provider
- Others

The route information is mostly accessed on mobile terminals such as phones and positively evaluated as "the most useful information" available before outing. As for the information on congestion and "on-rail location" of trains in service (multiple numbers), there is a strong request that it should also be available on mobile phones and terminals and displays at a station. Apparently, deep down inside users would like to assess the situation against the information on on-rail location to see how much the expected train service is behind the schedule and prepare themselves for ongoing delays when running against the clock.

As described above, it is considered that the information required by users is well utilized through the medium that is available to them, and it is made clear that the mobile terminal and the display at a station are their favourite options.

VII. CONCLUSION-PROPOSAL OF A CONCEPT OF A NEW INFORMATION SERVICE IN THE RAIL INFRASTRUCTURE

In this study the survey and research were conducted with the hypothesis that the information provided only by the rail service operator shall be useful and high in information acceptability from the users' perspective and evaluated that the information both on congestion and on-rail location was well-accepted.

Lately, there has been rapidly-growing interest in the service sector whereas innovative services which were not available before have emerged, using the internet as an open platform owing to rapid development of ICT technology. This new trend has prompted a shift at the core of business operations from the product to the service. Nowadays, there are technologies available whereby the service previously catered only to a large number of the general can be tailored to make it personal to individual needs. Against this backdrop, a system is expected to come ahead that will enable to sort individual data out from the mass data, link them up and add significance to it to offer scientifically-verified information. Driven by this expected system, we would like to propose a concept to enhance the information service that facilitates the decision-making.

The information on "congestion" and "on-rail location of trains" can be processed in such a way to satisfy the user's request to achieve an information service of high values added. This information service, whose realization still owes much to further efforts in research and development yet to come, will come at the core of the whole service information provided, from which users expect to benefit ardently. From the perspective of rail operators which own core infrastructure for rail transportation, it will serve the purpose of creating new services of values added to their core infrastructure to leverage on a large volume of data arising daily as essential resources. Rail technology caters only to limited market, which requires its research and development to be aligned to a purpose-driven direction. The possible direction of this information service development is identified as structured in the Fig. 8 where SSM-IA is applied to illustrate information service concepts in the rail service. Capturing the information service in a structure allows the issues to be well articulated, and the related technological development, when further advanced, can strengthen the function expected of the information service. From the viewpoint of its feasibility, the outcome of this study is deemed to hold practical significance.

Equally from the academic prospective, the logical structuring of service model and individual analysis of values offered to users is beneficial in verifying approach to the service and its descriptive framework.

It is our intention to plan to establish the information services and confirm their effectiveness for users in order to realize this model in the future. It is important for rail service operators to cooperate with information providers and realize services while considering the economic efficiency for both parties. We will convert data that can only be held by rail service operators into data meaningful for users. This will lead to improved added value of the railway.

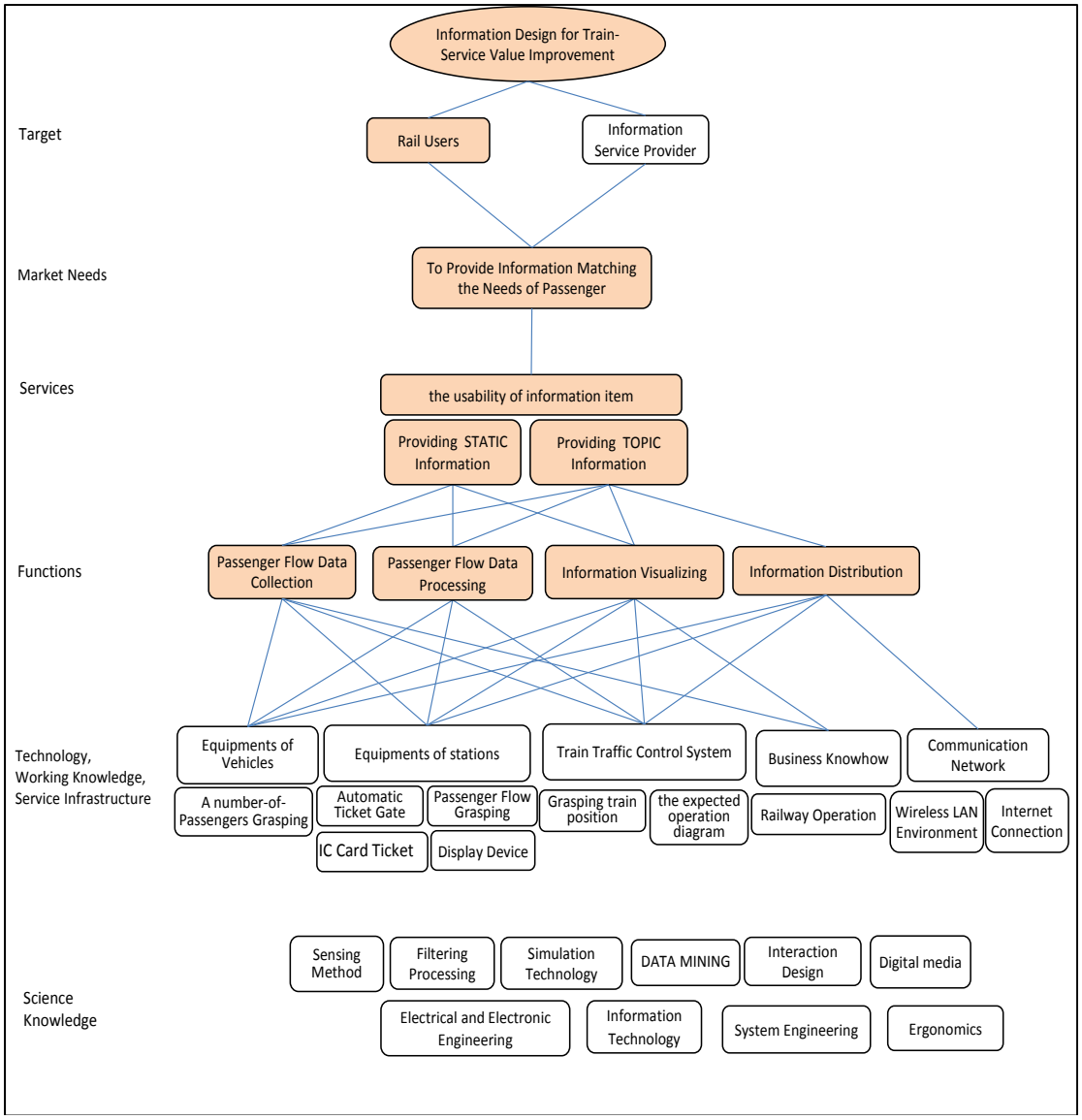

Fig. 8 Structure of Information Service in the rail service by SSM-IA

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