People- and Environment-friendly Urban Development Utilizing Geospatial Information

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OVERVIEW: Hitachi aims to create safe urban spaces in which people can have a sense of security, including enhancing emergency call and dispatching systems and implementing systems that can watch over the infirm from new vantage points through the use of core technologies for geospatial information. These include pedestrian flow analysis that can utilize positioning as well as maps and other location information in a seamless way both indoors and outdoors. Hitachi is also working to create city spaces that take account of the environment through the implementation of new transport systems such as environmental road pricing. Its aim is to accelerate social innovation and undertake urban development in a way that is kind to both people and the environment.

INTRODUCTION

"GEOSPATIAL INFORMATION" is the general term for both geographic information and location information including time information.

The widespread use of satellite positioning systems, particularly GPS (global positioning system), and the publication and distribution of electronic maps via the Internet and other media have made it much easier to identify the location of people, objects, and vehicles and display this information on a map. Also, geospatial information is now used by many different people in a wide range of fields from service businesses through to social infrastructure businesses such as power and other utilities, telecommunications, and transport.

Hitachi recognizes geospatial information as an up-and-coming aspect of IT (information technology)

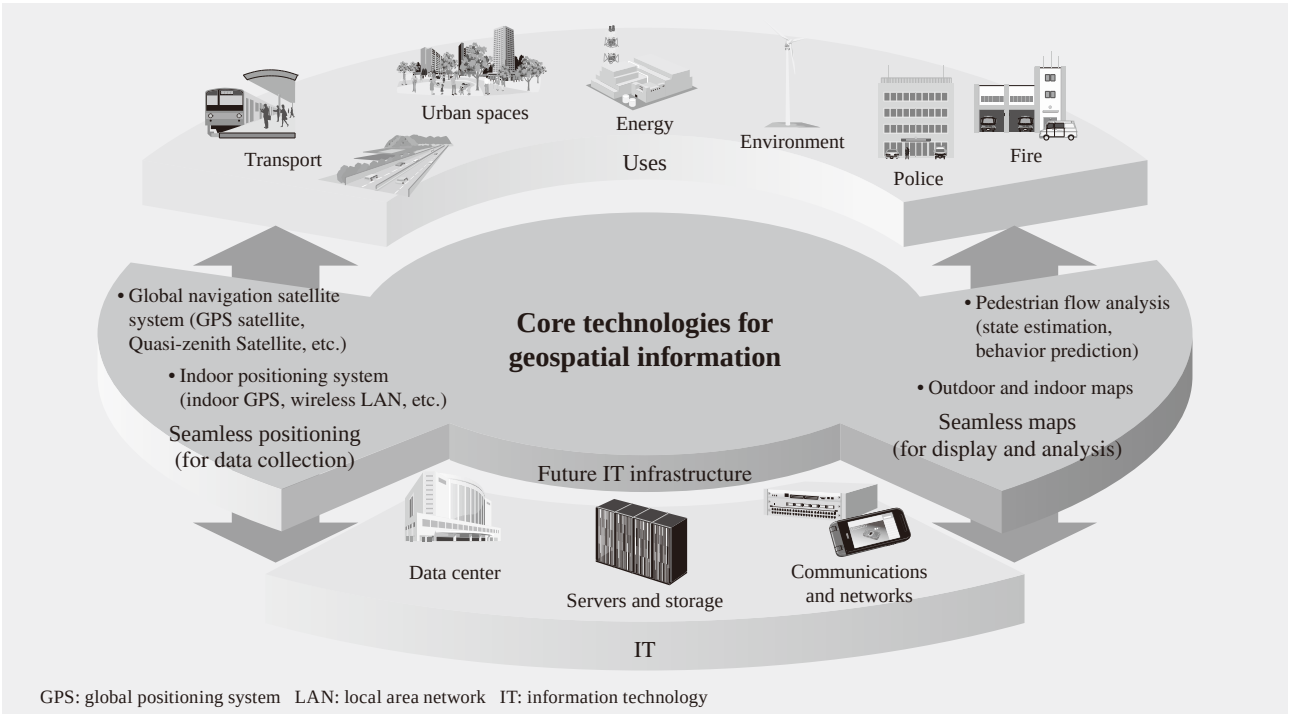

Fig. 1—Overview of Geospatial Information that Supports Social Infrastructure.
Geospatial information consists of location and geographic information including time information. Hitachi recognizes the role of geospatial information as an up-and-coming form of IT for supporting social infrastructure and is working on research and development of core technologies that can be used as the basis for geospatial information technology.

infrastructure and is working on R&D (research and development), practical trials, and other initiatives that deal with core technologies for geospatial information. These include seamless positioning using GNSS (global navigation satellite systems) and indoor positioning systems as well as seamless maps and pedestrian flow analysis for both indoor and outdoor spaces (see Fig. 1).

EXISTING USES AND CHALLENGES FOR GEOSPATIAL INFORMATION

Outdoors, geospatial information is used in a wide range of applications such as car navigation, pedestrian flow, and logistics. Indoors, meanwhile, it is anticipated that greater use will be made of geospatial information in industrial systems such as inventory management and tracking staff movements.

The challenges that need to be overcome to improve outdoor applications for geospatial information include achieving better positioning accuracy and expanding the range of areas in which these applications are available. For indoor applications, the challenges include the provision of indoor positioning system infrastructure and indoor maps.

Hitachi believes that new social innovations can be achieved by developing infrastructure and technologies that make advanced use of geospatial information (see Fig. 2).

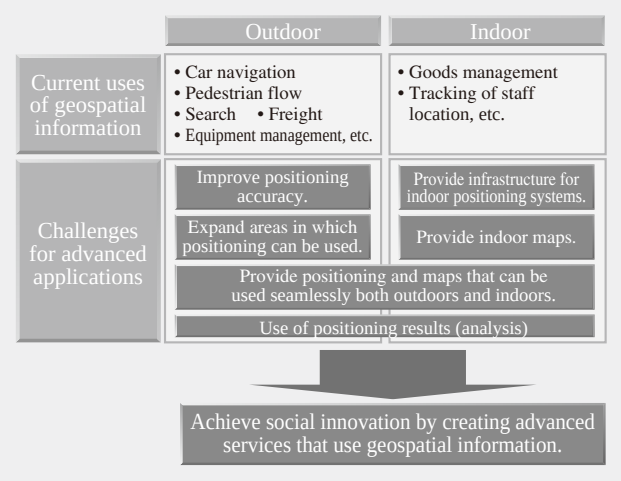

Fig. 2—Existing Uses and Challenges for Geospatial Information.
More advanced uses of geospatial information face a number of challenges. Resolving these will promote social innovation.

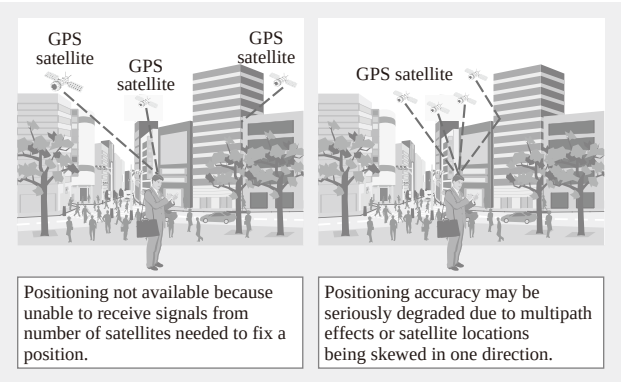

Fig. 3—Difficulties of GPS Positioning in Urban Areas.
Positioning may be seriously degraded in urban areas because the presence of many high-rise buildings may block the GPS signals.

POSITIONING ACCURACY IMPROVEMENT USING MULTI-GLOBAL NAVIGATION SATELLITE SYSTEMS

GPS receivers determine their positions by receiving signals from four or more GPS satellites. In urban areas, however, positioning does not always work because the presence of many high-rise buildings can make it impossible to receive signals from the number of satellites needed to fix a position. Also, even if enough signals can be acquired, positioning accuracy may be seriously degraded due to multipath effects such as reflection by buildings or if the satellite locations are skewed in one direction (see Fig. 3).

In addition to the USA's GPS satellites, various countries are developing GNSSs including the Russian GLONASS (global navigation satellite system) and European Galileo systems. In September 2010, Japan launched Michibiki, the first satellite for its QZSS (Quasi-zenith Satellite System) satellite navigation system. As of October 2010, GPS has 31 satellites including backups and GLONASS has 26. Ultimately, the number of GPS, GLONASS, and other satellites orbiting the Earth will exceed 100. Multi-GNSS will bring benefits including better accuracy and greater availability[(1)] (see Fig. 4).

SEAMLESS OUTDOOR AND INDOOR USE OF POSITIONING AND MAPS

Seamless Positioning

GNSSs such as GPS cannot work indoors, underground, and in other environments where the satellite signals are blocked.

One proposal to resolve this problem is the Indoor Messaging System, referred to in this article as "indoor GPS." Indoor GPS transmits GPS-like signals containing information about the transmitter location. This similarity makes it easy to add support for this system to GPS receivers which are already widely

used and also makes it possible for the same receiver to work seamlessly both outdoors and indoors.

Hitachi intends to introduce indoor GPS infrastructure and is working on R&D aimed at commercializing indoor GPS transmitters[2), (3)] (see Fig. 5).

Hitachi also participated in demonstrations funded by the Ministry of Economy, Trade and Industry which used a prototype GPS-equipped mobile phone to test seamless positioning using GPS positioning outdoors and indoor GPS positioning indoors. The demonstrations showed the feasibility of this system.

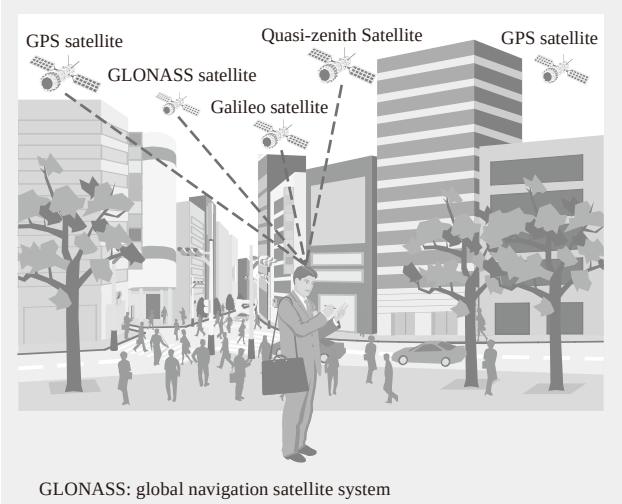

Fig. 4—Image of Multi-global Navigation Satellite System. The areas in which positioning can be performed can be enlarged and its accuracy improved and made more consistent by augmenting positioning by GPS satellites (USA) with signals from the Quasi-zenith Satellite System (Japan), GLONASS (Russia), Galileo (Europe), and other satellite systems.

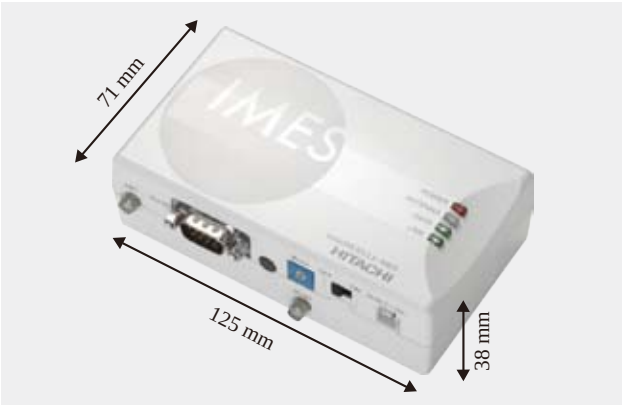

Fig. 5—Indoor GPS Transmitter (Hitachi Industrial Equipment Systems Co., Ltd.).
The installation of indoor GPS transmitters can make GPS positioning available in indoor, underground, and other environments where GPS signals cannot be received.

Seamless Maps

To implement map-based applications such as navigation, it is necessary in addition to digitizing the maps themselves to provide network data indicating paths that people and goods can follow. This network data consists of lines that represent paths (links) and points that represent branches (nodes). Outdoors, greater use will be made of these maps and the associated network data as car navigation and pedestrian flow applications enter wider use.

However, maps and network data for indoor locations have yet to be provided. Because indoor spaces may be made up of a number of floors or a single floor may be divided up into separate compartments, they require a different approach to network data than that used outdoors. Another requirement is that the way the indoor map and network data is provided must take adequate account of the need for compatibility with existing outdoor maps.

With the aim of creating maps and services that work seamlessly outdoors and indoors, Hitachi has participated in R&D and demonstrations funded by the Ministry of Internal Affairs and Communications. Specifically, this work includes how to handle two-dimensional plans in a three-dimensional way, how to define the connections between floors provided by stairways, elevators, and other facilities, and how to build models for situations in which the spatial extent of entities like floors and rooms is such that network data cannot be defined simply as a combination of lines (see Fig. 6). In December 2010, Hitachi conducted

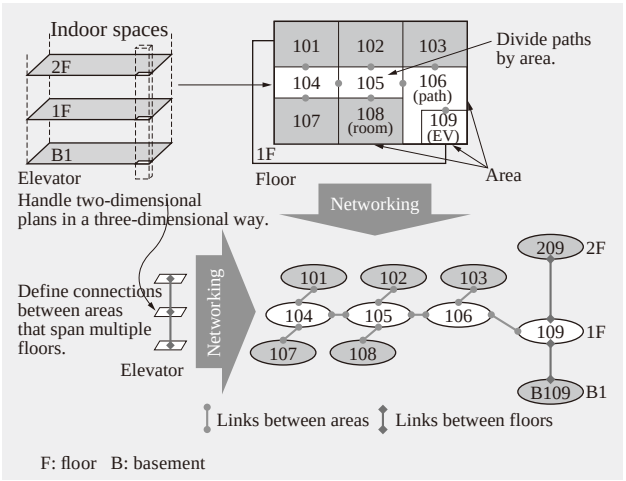

Fig. 6—Indoor Map Management and Network Data. Indoor applications require measures such as network modeling and managing maps in a way that suits the characteristics of indoor spaces while still maintaining compatibility with outdoor applications.

demonstrations in a commercial space that included outdoor and indoor walkways. The demonstrations showed the feasibility of this technology.

USE OF PEDESTRIAN FLOW ANALYSIS TO STUDY CHARACTERISTICS OF USER BEHAVIOR

Applications such as marketing and value-added information delivery based on location information are currently being produced by accumulating and analyzing information about people's location. Hitachi has been conducting R&D on pedestrian flow analysis for applications such as creating value-added information and predicting what people will do next based on an analysis of their behavior characteristics. This pedestrian flow analysis uses a probability model to represent changes from one state to another based on accumulated location information. The term "state" is used here to mean things like people's location and activity (such as walking, being lost, or remaining in one place). Because state changes are represented using a probability model, it is possible to obtain the probability percentages for changes from the current state to each new state and thereby to predict the person's next action.

The pedestrian flow analysis can be applied not only to individuals but also used to produce behavior models for group attributes (such as age, gender, interests and preferences, and so on). Accordingly, it is possible to predict a person's next action from this group behavior model even if no details are known about that person[4].

UTILIZATION OF GEOSPATIAL INFORMATION FOR SOCIAL INNOVATION

In addition to seamless positioning and seamless maps, Hitachi believes that pedestrian flow analysis will accelerate social innovation.

For example, because it is so difficult to determine the current position of conventional mobile phones, mobile phones are now required to incorporate a function that can report the phone's position when used to make a police, ambulance, fire, or other emergency call. Mobile phones with GPS receivers are now in common use[5]. However, because the positioning accuracy of GPS can be poor in urban environments and GPS may not work when used indoors, it is important to provide the infrastructure for services such as seamless positioning using indoor GPS. By providing this infrastructure, the phone's

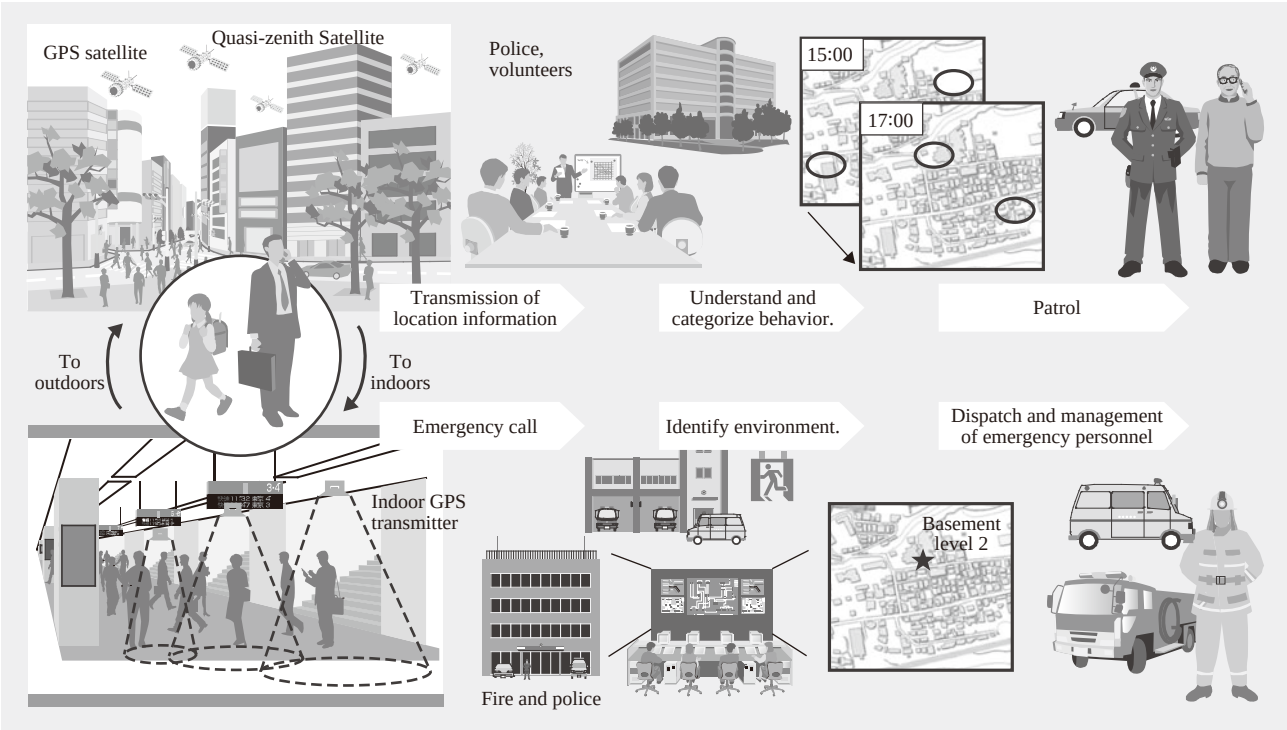

Fig. 7—Overview of Security and Safety Solutions.
Use of multi-GNSS and indoor GPS can provide seamless location solutions and help minimize harm during emergencies by allowing emergency services to arrive on the scene more quickly. Also, use of pedestrian flow analysis can make safety and security services more effective.

location can be rapidly determined when used to make an emergency call. This shortens the time taken for emergency personnel to reach the scene, helps achieve a rapid emergency response, and minimizes the harm resulting from the emergency.

Also, recent times have seen a series of major crimes in which vulnerable people such as children or the elderly were the victims. An effective approach to reducing crime is to understand the behavior of vulnerable people who are likely to become victims and focus crime prevention on times and places where large numbers of such people congregate[6]. Systems such as multi-GNSSs and indoor positioning systems are effective in situations like these and can be utilized to help understand the behavior of vulnerable people and implement crime prevention measures even in urban, indoor, and other environments where GPS signals are difficult to receive. By using pedestrian flow analysis to identify places where people congregate, it is also possible to do things like identifying spatial and temporal changes in people's situations and ascertaining behaviors based on the attributes of groups such as elementary school students, junior high school students, high school students, and the elderly. Other possibilities from outside the field of crime prevention include utilizing a better understanding of the behavior of disabled people, for example, to produce a map of barrier-free transport options (such as for walking sticks, wheelchairs, and prams), providing routes to suit different means of transport, and using behavior prediction to issue cautions.

With the aim of creating secure and safe urban spaces, Hitachi intends to use public trials and other methods to evaluate the effectiveness of multi-GNSS, seamless outdoor and indoor positioning systems, and pedestrian flow analysis, as well as investigating their application in security and safety solutions such as emergency calls and protecting the vulnerable. Hitachi also intends to work with relevant government agencies and other bodies both to encourage making indoor GPS transmitters part of the infrastructure of society and to investigate interoperation with police, fire, civil defense, and other related systems (see Fig. 7).

Providing the infrastructure for multi-GNSS also makes possible the implementation of environmental road pricing. Environmental road pricing can alleviate traffic congestion and reduce the burden on the environment by charging a fee for vehicles that enter a particular urban district to limit traffic inflows. However, because of the large number of roads servicing urban areas, the sort of payment methods currently used on toll roads would incur a high cost for the installation and maintenance of the associated facilities. Alternatively, if every car were to be fitted with a terminal equipped with communication capabilities and a multi-GNSS able to determine the vehicle's location with a high degree of accuracy, a flexible billing system based on data such as the time, day-of-week, and distance traveled could be implemented by having the terminal transmit the vehicle's location to a center system.

Hitachi has already successfully researched and developed a probe car system which collects location information from vehicle-mounted units at a center to generate and distribute information about traffic congestion. Now it intends to draw on this experience to work with relevant organizations and test the effectiveness of using a multi-GNSS to determine vehicle locations with aims that include reducing urban traffic congestion and reducing the burden on the environment. Hitachi is also working on deploying its environment and transport solutions overseas, particularly in emerging nations where work on establishing urban transport infrastructure is ongoing.

CONCLUSIONS

Hitachi believes that the seamless enhancement of positioning and map technology for both outdoor and indoor use together with the development of pedestrian flow analysis will accelerate social innovation based on geospatial information. In addition to the Hitachi activities described in this article which include making urban spaces safe and secure and reducing the impact that traffic has on the environment, Hitachi is also working on the development of solutions that include improving convenience for city residents and improving services and enhancing competitiveness for industry and logistics based on sophisticated uses of geospatial information. Through these initiatives, Hitachi will continue to support the creation of a safe and comfortable society.

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