

# Naviewn — Handset with Enhanced GPS Technology

## — The Development of a New Global Positioning System —

Naviewn is a handset with enhanced GPS technology, which has been on sale since January 2000. This mobile handset for position information services was the first to adopt enhanced GPS and has effectively expanded the frontiers of mobile multimedia.

This article reviews the development of its positioning technology and describes its functions.

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### 1. Introduction

Enhanced GPS<sup>\*1</sup> is a comprehensive positioning technology that enables a handset with an internal GPS receiver and a compatible server to exchange various data required to share calculation processes over a mobile phone network. The positioning sequence of enhanced GPS is shown in Figure 1.

Traditionally, GPS receivers had to receive signals from the satellites, calculate positions and display the results all by itself.

In contrast, enhanced GPS allows the server and the handset share the calculation processes, to achieve advanced positioning capabilities in terms of both function and performance.

Naviewn also is capable of downloading electronic maps and information about restaurants and public facilities in town with the positioning results, to provide a map guidance service. It can additionally link the coordinates of the handset (latitude and longitude data) with URLs, and display maps in coordination with map websites. Moreover, it has the functions of a mobile multimedia device, including e-mail, browser, PIM<sup>\*2</sup> and PC-synchronized functions.

This article describes the handset's functions and outlines its development.

### 2. Development Concept

GPS has been successfully applied to Car Navigation

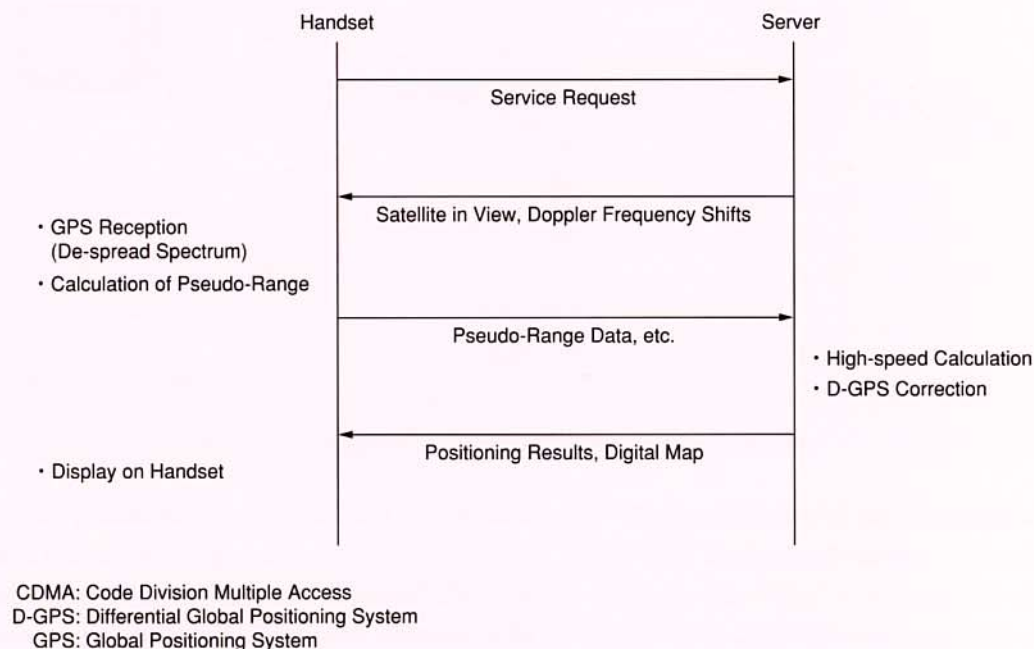


Figure 1 Positioning Sequence



Photo 1 Exterior Appearance of the Naviewn

Systems and land surveys, but the technology had too many problems to be applied to location information services for ordinary consumer use.

Specifically, the power consumption was enormous and it took too long to locate objects because of the need to constantly receive navigation messages (e.g., ephemeris) at speeds as slow as 50 bit/s from more than 4 satellites. It was not suitable for use in downtown areas because of the time difference in the arrival of the satellite signals caused by tall buildings, which create a multipath environment that leads to large errors.

The solution to these problems was found in the positioning technology of enhanced GPS, on which we decided to base the development and design of our next-generation handset.

The name "Naviewn" is a combination of the words Navigation, VIEWer and Network. The name represents a navigator that is used and carried around by people on the move. The appearance and specifications of Naviewn are presented in Photo 1 and Table 1, respectively.

### 3. GPS Function

#### 3.1 Conventional GPS Problems

Conventional GPS receivers suffer from the following weaknesses.

##### (1) Sensitivity

Conventional GPS receivers cannot be used unless there is a sufficiently strong line-of-sight receiving path between

Table 1 The Naviewn Specifications

Shape/Dimensions (Measurements)	Approx. 82 × 153 × 18 mm (width × height × thickness) Thickness of antenna section is approx. 22 mm (Cubic volume: Approx. 230 cc)
Weight	Approx. 220 g (inc. batteries)
Power Consumption	Max. 2.0 W (During GPS Positioning)
Battery Unit	SUM-4dry battery (Alkaline) × 4
Memory	User memory: Approx. 6.5 MB
Operational Temperature	0 to 45 degrees C
Interfaces	PDC 16-core interface × 1 PC-Link interface × 1
Main Functions	GPS Positioning - Sensitivity: -150 dBm - Time to First Fix: Approx. 30 seconds - Built-in antenna/GPS adjustment Map Guidance Service - Around current location - Designated area map - Route guidance for short-cuts Data Communication - Internet mail (POP/SMTP) - WWW browser PIM - Address book - Scheduler - Calculator - Dictionaries (Japanese, English-Japanese, Japanese-English) - Memo pad PC Synchronized Function

GPS: Global Positioning System

PIM: Personal Information Manager

themselves and the satellites.

Most conventional Car Navigation Systems require an input level of approximately -130 dBm to achieve S/N 15 dB (i.e., the probability of being able to execute positioning is 50%). The smaller the required input level, the greater the system's ability to execute positioning in difficult wireless conditions.

##### (2) Accuracy

The errors are so large that they often make the receivers useless without correction by D-GPS<sup>\*3</sup>, or other means. Accuracy is a few meters following error correction, compared with 50 to 100 meters in normal conditions.

##### (3) Multipath

Between tall buildings or on narrow roads, a multipath environment causes a time difference in the arrival of the satellites signals. This makes it impossible to accurately calculate the pseudo-range to the satellites, and results objects from to large errors.

##### (4) Time to First Fix

It takes a long time to locate in "cold start"<sup>\*4</sup>.

##### (5) Power Consumption

Unless the receiver has access to a constant power supply

as in Car Navigation Systems, it cannot be used for long periods with only dry batteries or other small portable power supplies.

(6) Volume and Weight

The receivers are too large and heavy for people to carry around.

(7) Price

Most of the products are relatively expensive.

### 3.2 Solutions

DoCoMo analyzed the priority technologies for developing a system for location information services and decided to take the following approach:

(1) Adopt an Architecture that Raises the Overall Positioning Efficiency and use an Effective Calculation Algorithm

DoCoMo decided to design sequences and data formats, and develop positioning technologies.

(2) Install the GPS Antenna inside the Main Unit and Pursue a Structure that Minimizes Volume and Weight

Technology to eliminate the noise inside the unit while maintaining portability is important for improving sensitivity

and making the GPS receiver practicable.

(3) Develop a Device Configuration for High-speed Calculation and Low Power Consumption

Efforts were focused on achieving high-speed calculation and low power consumption based on the introduction of Gate Arrays (G/A) and a Digital Signal Processor (DSP) in the GPS receiver.

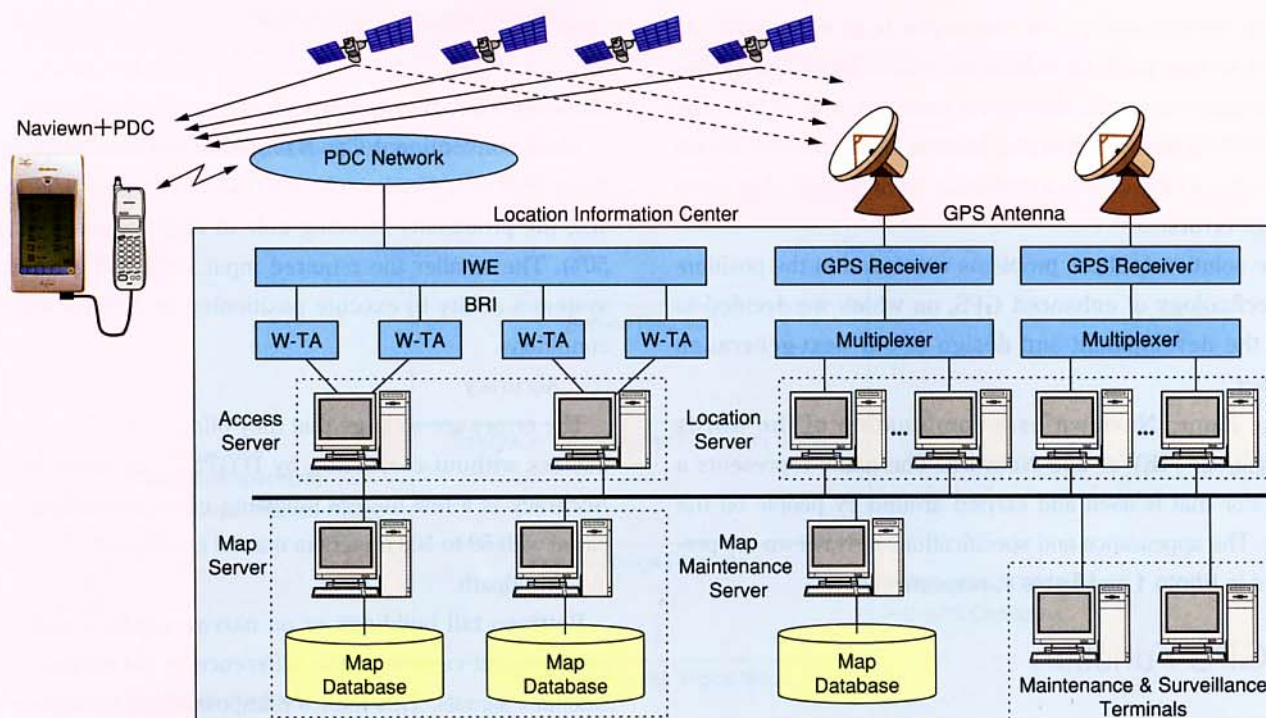
(4) Diversify Product Configurations and Develop General-Purpose Products

The PDA model was chosen from a range of product configurations, including models designed for installation in vehicles and those that were integrated with mobile phones. The decision was based on the ease of standardizing the functional module configuration and the model's versatility as a mobile computing product.

### 3.3 Development Results and Features

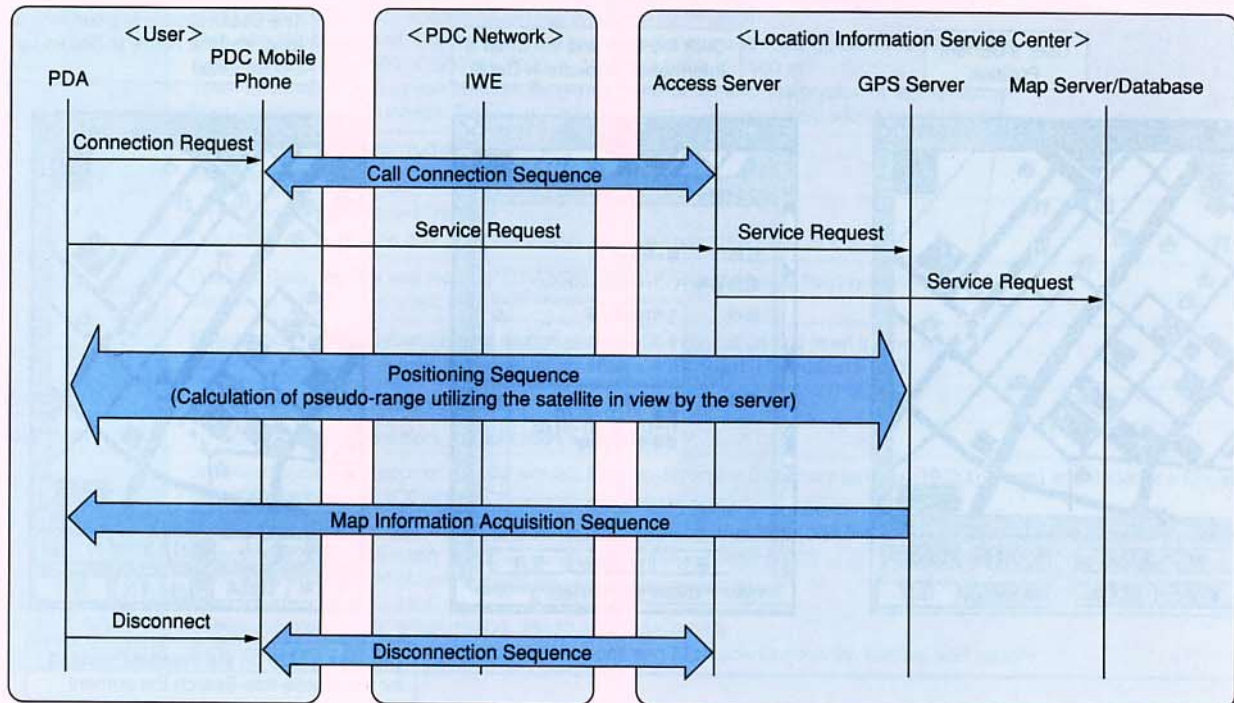
Development started in 1997 and the commercial service was launched in January 2000. The system configuration and service sequence are shown in Figures 2 and 3, respectively.

The positioning functions have the following features:



BRI: Basic Rate Interface  
 CDMA: Code Division Multiple Access  
 GPS: Global Positioning System  
 IWE: Inter Work Equipment  
 W-TA: Worm-Terminal Adapter

Figure 2 System Configuration



PDA: Personal Digital Assistant  
 PDC: Personal Digital Cellular Telecommunication System  
 GPS: Global Positioning System  
 IWE: Inter Work Equipment

Figure 3 Service Sequence

#### (1) High Sensitivity

Sensitivity is  $-150$  dBm, which is 100 times greater than conventional GPS. The unit can be used not only in cars but also near windows and in wooden houses, conditions which are too difficult for conventional GPS to handle.

#### (2) High Accuracy

Accuracy is within a few meters in an Open-Sky environment<sup>\*3</sup> following correction.

#### (3) Low Power Consumption

The power consumption of the handset was dramatically reduced. For example, using four SUM-4 dry batteries, it can be operated for two weeks, assuming the use of GPS positioning twice, e-mail and other transmission tasks for 10 minutes and PIM functions for 30 minutes per day.

#### (4) Fast Calculation

In contrast to conventional GPS, which required a few minutes to locate objects in from a "cold start", enhanced GPS can complete the same task within 30 seconds or so. The calculation process in the handset is extremely fast, completed in about a second.

#### (5) Low Noise in a Portable Design

Handsets have many technical issues that need to be

addressed. The impact of harmonic distortion depends on whether the handset's antenna is installed inside or outside the main unit, and the GPS signals are blocked by the human body when the handset is too close. We managed to solve these issues by installing the GPS antenna inside the main unit without sacrificing the handset's portability, and established the basic technology to eliminate noise for introducing GPS functions into PCs and mobile phones in the future.

#### (6) Local Oscillator's Stability

We chose the most stable local oscillator that could be used in the handset. As oscillator accuracy deteriorates over time and therefore lowers positioning precision, a special function was added to enable users to adjust errors arising from accuracy deterioration.

### 3.4 Technical Points

#### (1) How Sensitivity and Accuracy were Improved

In conventional GPS, the handset passes complex calculation processes over to the server via the communications. The server constantly receives data from the satellite and executes various software processes at high speed. Factors adversely affecting the terminal's reception environ-

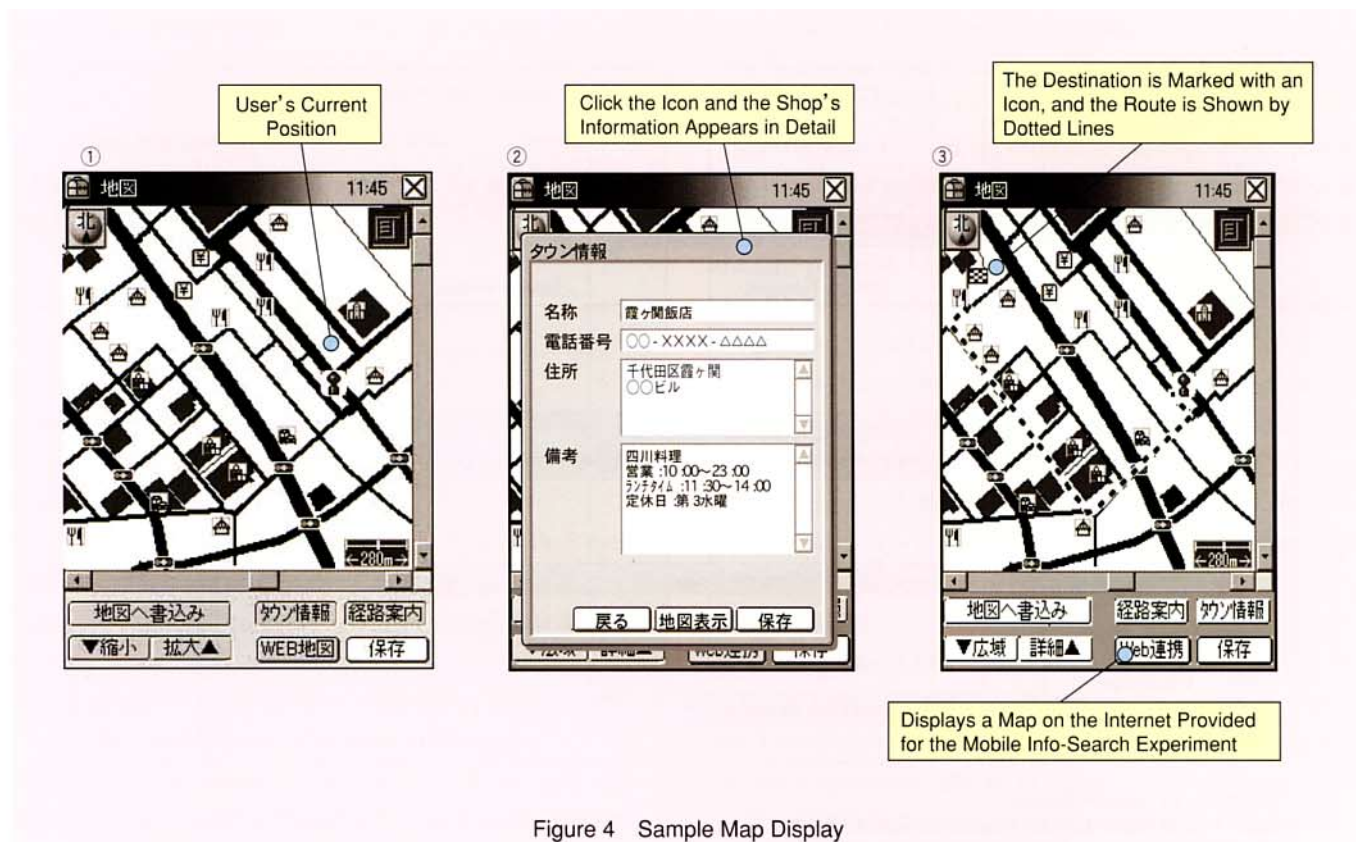


Figure 4 Sample Map Display

ment were minimized and the parameters for calculation were optimized.

## (2) How Time to Fix was Shortened and Power Consumption Reduced

- ① The server receives almanac<sup>\*6</sup> and ephemeris<sup>\*7</sup> data from the satellite and keeps the data for a certain period. Thus, the RF section in the handset does not have to continually operate to receive such data.
- ② Conventional GPS calculated the pseudo-range to the satellites<sup>\*8</sup> based on a hardware correlator (which calculated the correlation with all satellites). High-speed calculation was realized by adopting an electronic device configuration based on an Application Specific IC (ASIC) + DSP.
- ③ The need to demodulate Frequency Modulation (FM) on the handset side for D-GPS correction was eliminated.

## 4. Map Function

Naviewn doesn't store any maps within itself. Instead, it downloads latest digital maps from the center.

Practical map acquisition and mobility were pursued from the following three points of view:

- ① For the user, it is inconvenient to have to update map information stored in the handset. Old map information also affects the quality of the service.

- ② The memory is too small to store a map covering the entire nation. The relatively high cost of maps might directly push up the product price.

- ③ It is impossible to centralize the management of updating/improving all the information attached to maps.

Another factor that had to be taken into account was the time required for the user to download maps. Although people have different degrees of "patience", we aimed at completing the downloading process within 30 seconds — from connection to disconnection. Considering the throughput of circuit exchange in the Personal Digital Cellular (PDC) unit, we compress the map data at the center and convert it into a simple vector map before sending it to the handset.

### 4.1 Map Guidance Service Function

A sample map display is shown in Figure 4. The outline is as follows:

- ① Acquisition of map: Displays a map showing the user's position and any designated area.
- ② Acquisition of town information: Displays the user's position, shops and restaurants around the destination and supplementary information (e.g, phone number and business hours) on the map.
- ③ Route search: Displays the shortest route from the user's current position to the next destination.

Table 2 Software Specifications

Map	Map Guidance Service: Acquisition of map and town information Map Acquisition Method: Current position, designated areas and route guidance for short-cuts Acquired Map Size: 500 × 500 m / 1000 × 1000 m / 1500 × 1500 m Town Information Acquisition Method: By genre, detailed list and designation of facility name Map Administration Function: Saving and management of acquired map and town information
E-mail	E-mail protocol: POP3, SMTP Storage capacity: Up to 200 e-mail transmission/reception
Browser	HTML version: Based on HTML3.2 Display function: Frame and graphics display (GIF, animated GIF and JPEG)
Schedule Manager	Display: Daily, weekly and monthly schedules, special occasions and holiday setup Maximum number of entries: 600
Address Book	Registration, editing, browsing and search of personal information and town information Maximum number of entries: Personal information = 400; Town Information = 200
Memo Pad	Handwritten memos, entry into maps
Calculator	10 digit addition, subtraction, multiplication and division
Dictionary	Japanese dictionary (approx. 42,000 words), English-Japanese dictionary (approx. 19,000 words) and Japanese-English dictionary (approx. 12,000 words)
PC Link	System requirements: IBM PC/AT and compatible systems, Pentium 133 MHz or faster, 32 MB of main memory or more Operating System: Microsoft Windows 95/98 (Japanese version for PC) Necessary software: Microsoft Outlook 98 Interface standard: RS-232C Communication speed: 9600, 19200, 38400 and 115200 bit/s Synchronization: Terminal schedule/address book and Microsoft Outlook 98, backup and restore

#### 4.2 Synchronicity with Web Maps (Mobile Info-Search Experiment)

In order to analyze the ways in which map information might be used in the future, we added a function that enables users to participate in an experiment for using maps published on the Internet, with the cooperation of a number of map companies.

It retrieves and displays maps on the Internet that match the handset's coordinates and other input data by linking the coordinates with the Uniform Resource Locator (URL). (Refer to <http://www.kokono.net>.)

## 5. Other Functions

### (1) Shape

We decided to make the handset tall and narrow for the following reasons:

- ① It would be difficult to hold a wide handset and simultaneously look at a map while walking outside. Considering the center of gravity, a handset with such a shape would tire the user after long periods of use.
- ② As users walk forward, they would prefer to see a map displayed on a tall and narrow handset, which requires less scrolling.

### (2) Design

The design takes the following factors into account:

- ① The upper part of the LCD (Liquid Crystal Display) in

the main unit is uniquely designed to provide a wider display area.

- ② Parts that come into contact with the palm and fingers are rounded to eliminate any discomfort. The indentations run diagonally to prevent fingers from slipping while eliminating the need to use expensive non-slip materials.
- ③ The 16 - core L-shaped connector on the right hand side of the handset connects with the PDC and is designed in such a way as to avoid contact with the hand or to be affected by impacts during operation.

### (3) Mobile Applications

We aimed to encourage the widespread use of this product by including an Internet browser, PIM, PC-link and other mobile applications. The software specifications are listed in Table 2.

## 6. Conclusion

Enhanced GPS is a key technology for mobile multimedia, and further technological developments are anticipated in the future. We expect to see developments not only in navigation systems but also in fleet management systems security. We intend to continue contributing to the expansion of the mobile market through new positioning technologies.

## Terminology

### ★1 Global Positioning System (GPS)

A system that determines the position of an object with the use of signals emitted from 24 U.S. military satellites (NAVSTARs) that orbit at 20,000 km above the Earth. Originally developed for military purposes. Part of the satellite system was released for free public access after a decision by the U.S. Senate. Uses a public code called C/A and nonpublic, military-purpose codes named P code and Y code. The center frequency of the carrier is 1575.42 MHz. Multiple access technology is CDMA.

### ★2 Personal Information Manager (PIM)

Software for managing electronic personal information, consisting of a schedule manager, address book, calculator, dictionary and memo pad.

### ★3 Differential GPS (D-GPS)

In differential GPS, a point whose correct coordinates are already known is located and the errors found in the positioning results are passed on to an unknown point at a certain time. Through this, the results of locating the unknown point can be adjusted to achieve the correct coordinates. A service that provides nationwide adjustment information based on a sub-carrier of FM radio is available.

### ★4 Cold Start

Refers to the situation in which the GPS receiver is switched on for the first time or after a long break.

### ★5 Open Sky

A place where there are no obstacles to reception, where more than 4 GPS satellites are constantly in view (e.g. school playgrounds).

### ★6 Almanac

Basically orbit information of all the satellites.

### ★7 Ephemeris

Accurate orbit information of all the satellites and information regarding signal transmission time. Detailed information required for position calculation.

### ★8 Pseudo-range to the Satellites

Clocks in GPS receivers are less accurate than atomic clocks in satellites. Thus, their time is adjusted based on the time kept by the satellite, in other words, a "pseudo-time". In the strict sense, the calculation of the distance between the positioning point and the satellite is called a "pseudo-range", rather than a "precision range".