

GPS Safety Monitoring System for Takasu Proving Ground

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ABSTRACT

A GPS safety monitoring system that uses receiving stations to receive GPS position data, transmitted by vehicles on a test course, has been developed. Data processing by computer enables real time display of vehicle status on monitor screens. At the same time, the system uses vehicle data to judge whether an accident has occurred, specify the location of the accident, and send out an emergency alarm. Honda's Takasu Proving Ground covers a large area of undulating ground, making direct monitoring by camera a challenge. A monitoring system based on transponders and sensors embedded in test courses has therefore been utilized in the proving ground. The number of Takasu test courses has recently been increased, and there have also been increases in the number of vehicles using the courses, bringing the former system to its functional limits. The monitoring system discussed in this paper was therefore introduced. This has enabled monitoring of the entire area of the Takasu Proving Ground, including connecting roads. The new system has increased the safety of the courses and done away with the necessity for inspection tours. The initial cost of introducing the system was one-tenth of the projected cost of extending the previous system.

1. Introduction

Honda's Takasu Proving Ground is a course used mainly for framework performance tests and cold climate tests for cars, motorcycles and ATVs. Takasu covers more than four times the area of the company's Tochigi Proving Ground, and contains an unparalleled range of undulating low-, medium-, and high-speed test courses (Fig. 1). This makes it challenging to directly monitor the courses using cameras. Previously, test vehicles were fitted with transponders^{*1}, and sensors embedded in the courses were used to measure the positions of the vehicles. This system judged that an accident had occurred if a vehicle was stationary on a course for a specified period of time. However, the number of test courses has recently been increased, and the number of motorcycles, cars, and ATVs being tested has also increased, bringing this system to its limits in terms of performance and cost. A new safety monitoring system using the global positioning system (GPS) was therefore developed, enabling monitoring of safety across all the Takasu courses.

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*1 The term transponder is formed from the words TRANSmitter and resPONDER, and refers to a device that is able to relay and return a response to electrical signals it receives.

2. Development Goals

(1) Increased safety

Transponder sensors are only embedded in two courses on which high-speed tests are conducted, but the aim for the introduction of the GPS safety monitoring system was to enable safety to be monitored on all the courses within the Takasu Proving Ground. In addition, real-time monitoring of all vehicles in the proving ground would not only enable accidents to be detected, but would also enable speed infringements and dangerous driving to be monitored and controlled, thus contributing to the prevention of accidents. Linkage with existing equipment would also enable:

- Preventive strategies for secondary accidents (by means of emergency warning lights and electronic signs)

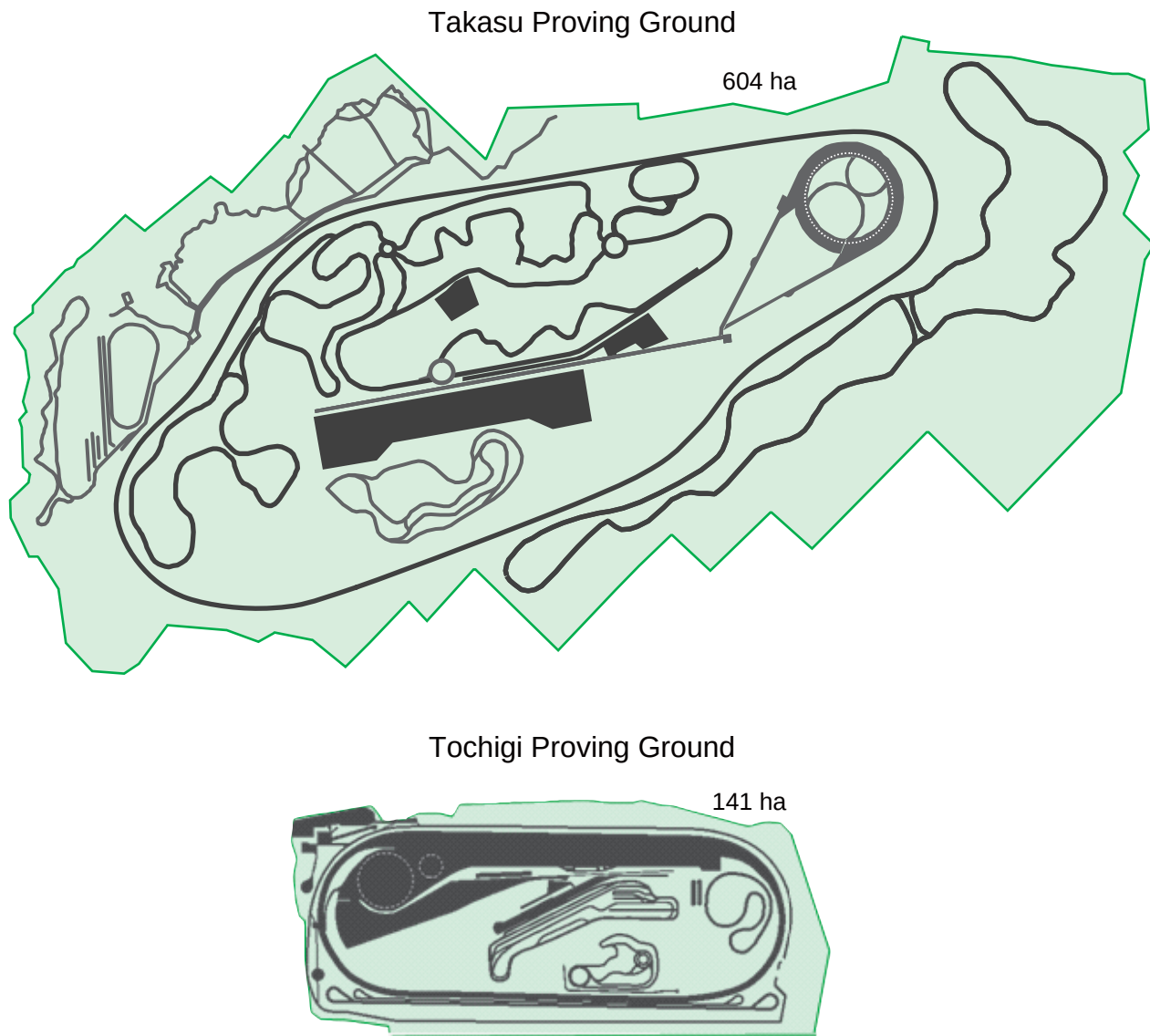


Fig. 1 Honda proving grounds

- Management of vehicle numbers (restriction of vehicle numbers by means of counters and gates)
- Management of motorcycle and car schedules (control by means of electronic displays at course entrances)

In this way, the system would enable the realization of total safety management.

- (2) Reduction of size and weight of transmitting stations
To enable fitting on two-wheeled vehicles, the aim for the transmitting stations was set at a total weight of 200 g or less and a size of 120 mm or less per side.
- (3) Accuracy and reliability of measurements
Snow drifts would affect the performance of the sensors in the previous system, necessitating inspection tours of

the courses during winter. The aim for the GPS safety monitoring system was to function without any issues and to display a high level of reliability in all seasons, and to work as a fully automatic monitoring system, without any need for inspection tours.

- (4) Reduction of initial costs and operating costs
The target for reduction of initial costs was set at implementation of the system at a cost of less than one-tenth of the projected cost, assuming expansion of the use of sensors to a further five courses. The target for operating costs (maintenance, etc.) was set at approximately one-half.

3. System Configuration

Vehicle position and other data transmitted by each of the transmitting stations fitted in test vehicles is received by the nearest receiving station, enabling real-time monitoring of vehicle behavior by the main PC (the safety

monitoring server) (Fig. 2). Data processing enables warnings to be sent out if an accident has occurred, and rescue crews on standby are able to determine where the accident has occurred on a display (Fig. 3) and scramble to the scene. At the same time, the entrance gates to the course are automatically closed, and electronic signs

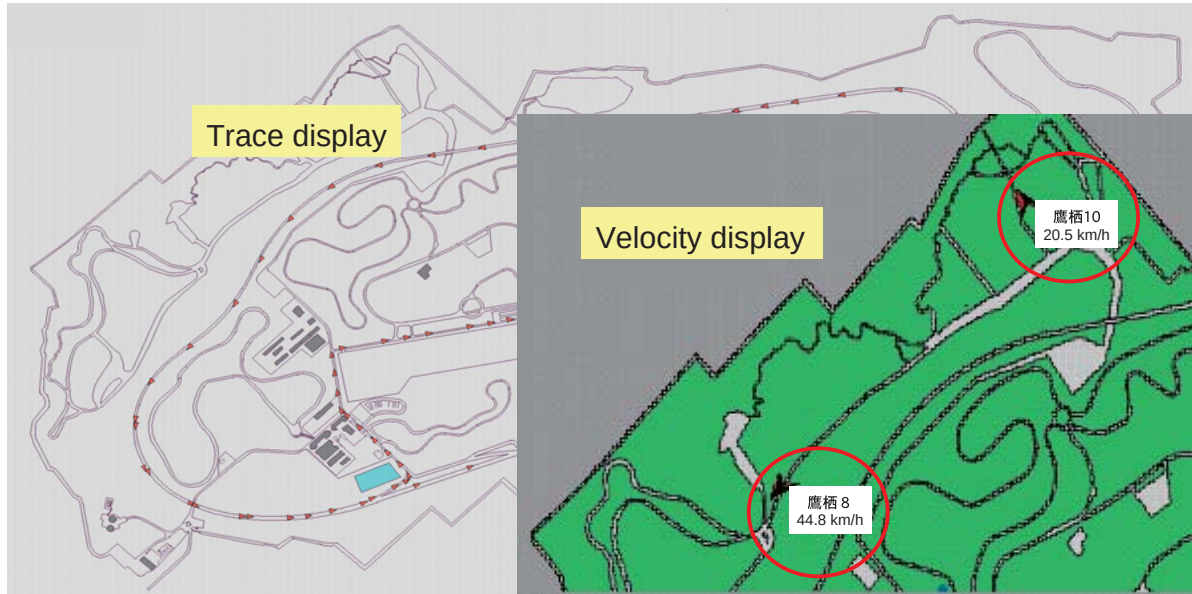


Fig. 2 PC monitor: Trace and velocity display

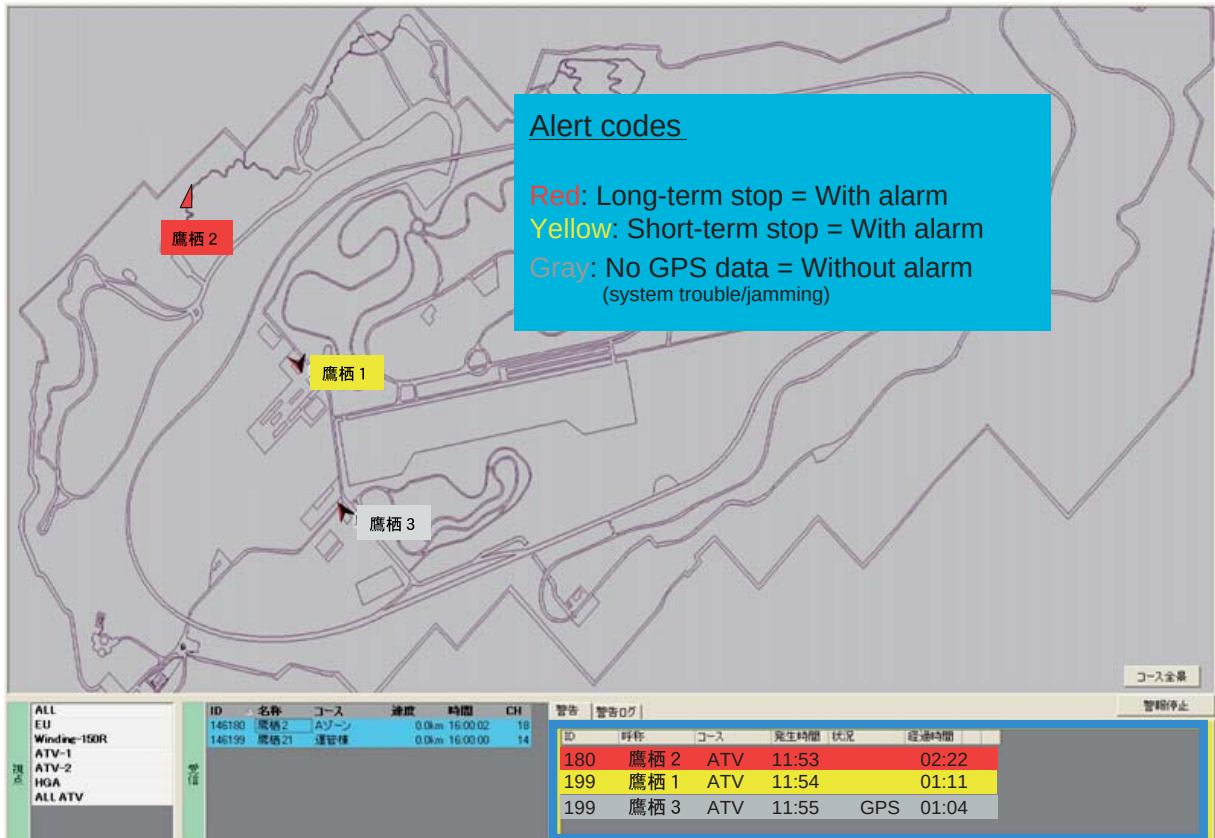


Fig. 3 PC monitor: Warning display

Table 1 Types of wireless transmitter

Type	Access speed	Size	Investment	Transmitting cost per unite
Wireless LAN	54 Mbps	Big	Large	¥0
Cellular phone	7.2 Mbps	Big	Large	¥10,500/month
Land mobile radio	2400 bps	Compact	Small	¥400/year

The specifications of the land mobile radio transmitting stations are as follows:

- Frequency: 400 MHz band; Output: 1 W
- System weight: 190 g (including battery)
- Size: H25 x W108 x D65 (mm)

3.2. Receiving Stations

The system features four receiving stations, a main antenna on a 30 m tower and three sub-antennas. Each of these receiving stations is provided with a control terminal, radio transmitters, a distributor, an amplifier, and an RS232C extension board (Fig. 6).

Private radio is prone to interference, and the positioning of antennas with consideration of the specific area and its geomorphology is therefore important. Interference tests showed that for the area in question, the combination of one main antenna tower and three sub-antennas would provide the optimum transmission environment.

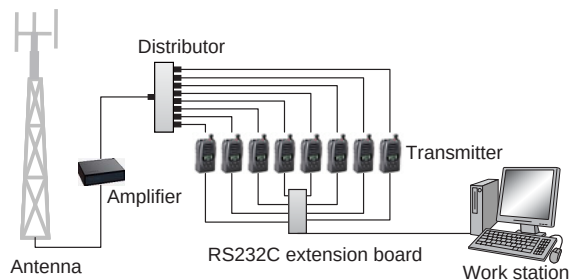
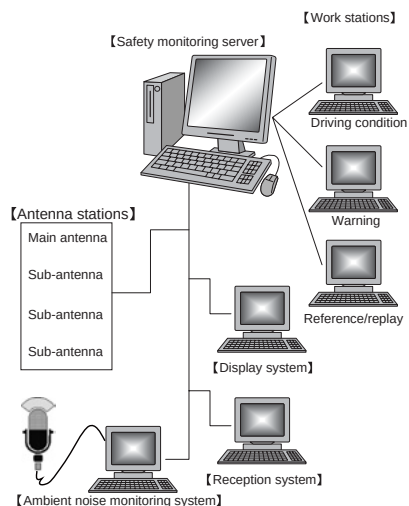


Fig. 6 Receiving stations



(a) Hardware

3.3. Data Processing System

3.3.1. Hardware

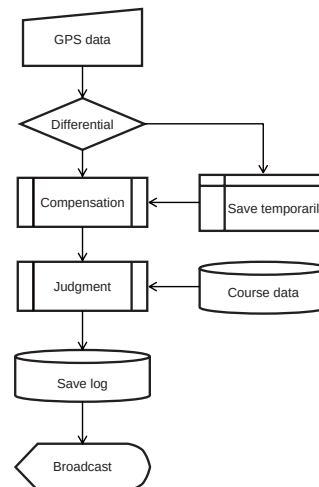
Figure 7(a) shows the configuration of the hardware making up the data processing system.

- (1) Safety monitoring server
- (2) Display system
- (3) Reception system
- (4) Ambient noise monitoring system
- (5) Antenna stations

3.3.2. Main program

Figure 7(b) shows the data processing flow of the main program in the data processing system.

- (1) Data received from the transmitting stations
ID, position data (latitude and longitude), speed, direction, elevation, date, time
- (2) Compensation of position data by post-processing
- (3) Judgment on test course
 - a Judgment on course and area
Judgment on which course the vehicle is using, specification of area
 - b Prioritization of approximate values (historical data) for decision on course
In areas in which multiple courses are contiguous, use of historical data for judgment on course in use
- (4) Logging of course data
- (5) Saving of log
- (6) Broadcast of data



(b) Main program

Fig. 7 Data processing system

4. Technological Issues and Applied Technologies

4.1. Data Transmission Capacity and Number of Transmitting Stations

In order to help ensure sufficient land mobile radio transmission capacity based on the assumption of multiple transmitting stations transmitting data simultaneously, two types of firmware, for low- and medium-speed transmission at 0.1 Hz and fast transmission at 0.2 Hz, have been employed, making it possible to set ten or five transmitting stations for each channel. Data transmission from a maximum of 100-200 transmitting stations is therefore possible. This provides a margin for the growth of the current vehicle capacity of the Takasu Proving Ground by two- to four-fold. In addition, unnecessary transmissions have been avoided through the use of firmware, which reduces the amount of transmissions when a transmitting station has judged from GPS data that a vehicle has stopped.

4.2. Accuracy of GPS Measurements and Judgment of Accidents

GPS normally has an error of around two meters, and accuracy can decline even further depending on the angle of the satellite and other factors. Because of this, judgment on whether a vehicle has left a course is challenging when courses are contiguous. Data processing is therefore used to judge whether a vehicle has left a course from immediately prior historical data and speed data. In order to increase reliability even further, G sensors have been added to the transmitting stations to provide vehicle behavior data, enabling accidents to be judged with a high degree of accuracy.

5. System Reliability and Effects

5.1. Results of Reliability Tests

5.1.1. Suitability of transmitting station units to environment

(1) Temperature tests

The temperature of transmitting station units was increased from -20°C to +60°C in a thermostatic chamber, and the units were left for an hour at each 10°C increment.

(2) Waterproof tests

Leak tests were conducted using a differential pressure sensor. After 30 sec at a negative pressure of 4.9 kpa, the differential pressure leak tester recorded figures of less than 0.05 kpa.

(3) Static electricity tests

When the units were powered up and turned off, ±20 kV was impressed at the antenna, and ±15 kV was impressed on the unit.

(4) Vibration tests

- Vibration frequencies: 5-8 Hz / 8-30 Hz
- Total amplitude: 3 mm / 1 mm

- Test time (each test): 15 min x 3 directions x 2 waveforms (Total: 90 min)

(5) Impact tests

Units were dropped onto a concrete floor from a height of 120 cm, one time per side for five sides of each unit.

The results of the temperature, water, static electricity, vibration, and impact tests cleared benchmark figures.

5.1.2. Tracking of vehicle speed

No decline in reception was recorded at vehicle speeds of 250 km/h and above.

5.1.3. Operation of alarm and response time

High-speed driving: Alert within 5 sec after vehicle stopped, alarm raised within 10 sec.

Low-speed driving: Alert within 10 sec after vehicle stopped, alarm raised within 20 sec.

Target figures were achieved in both cases.

5.2. Performance in Operation

The system has been in operation for 4 years in the case of ATVs. It has enabled the realization of fully automatic monitoring in all seasons, and done away with the necessity for inspection tours during winter.

6. Conclusion

The expansion of the test courses in the large area of the Takasu Proving Grounds is continuing today, and further expansion plans are projected for the future. The system discussed in this paper can be made to cover any amount of extension of test courses simply by overwriting software. This is the initial application of the system, and Honda expects to enhance safety management by extending its use to other test courses and training courses. The introduction of the GPS monitoring system discussed here enhances safety management, and test riders and drivers have placed high expectations on it. Test course safety is an ongoing concern in automotive test course management. At the Takasu Proving Ground Honda is putting in place a comprehensive safety management system, which extends from preventive safety to emergency accident response, aiming to achieve the world's highest standard of safety for an automotive test course.

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