"Gensai Communication System": Development of the terminal device

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[Summary] We developed "Gensai Communication System" to collect and replay information in a disaster. Since a key point of the development is maintaining communications, we developed a wireless ad-hoc network system whereby terminals reconstruct the network independently.

1 Introduction

Recently introduced town and village emergency radio systems operate in the 60-MHz band and aim to provide local residents with information for disaster reduction. However, recent disaster training drills have shown an increasing need to provide residents with methods for transferring accurate information and for collecting information on people's safety.

The GENSAI (Disaster reduction) Communication System (Figure 1 and GENSAI CS hereafter) is being developed to meet such needs and this article describes a communications terminal (Figure 2) forming the core of such systems. We compare general household receivers in disaster wireless systems starting with the municipal radio communication system for disaster prevention and administration with GENSAI CS terminals.

Figure 2 Communications Terminal

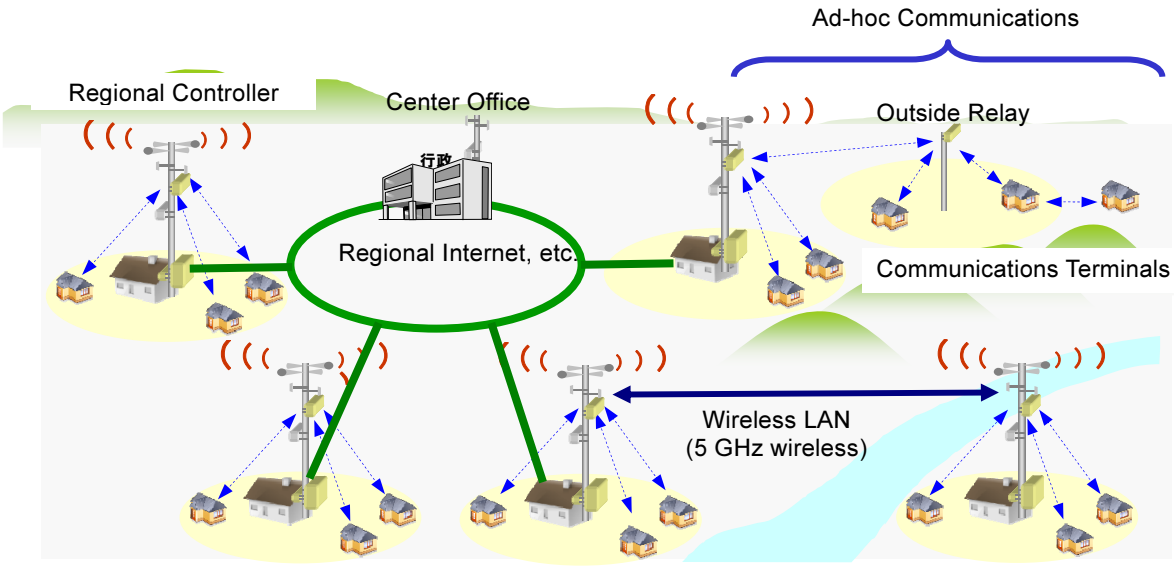


Figure 1 Diagram of Gensai Communication System

2 Development Concept

2.1 Background

The current government wireless communications for disaster prevention and administration widely installed in Japanese cities, towns and villages (Figure 3) is a one-way system that only broadcasts information in one direction from the local government office to a public address system in parks, etc. However, the spoken public announcements can be hard to hear by people indoors and even introducing household receivers that can be used inside have problems with knowing whether they are operating normally, and whether the broadcast information has been understood.

Future disaster wireless systems must not only transfer information to residents but must also be able to confirm the residents' safety as well as determine the disaster conditions to support fast and responsive provision of assistance and recovery efforts.

As a result, in addition to installing receivers in every household for provision of information, the system must be setup to support two-way communications for obtaining responses from residents. Additionally, it is also necessary to keep down the costs of the household receivers and operations.

Our aim is to build a complete GENSAI CS service meeting the above needs by using communications terminals as household receivers in combination with master base stations.

This work is a joint development project between Anritsu and NTT Data who developed the system server control software. We developed the other equipment such as the communications terminals and base stations.

2.2 Key Concepts

The key development concepts for the GENSAI CS communications terminals are listed below:

(1) Two-way Communications

The previous government wireless communications for disaster prevention and administration system using the 60-MHz band is only a one-way service for broadcasting information to residents, whereas the household receiver is a dedicated receiver; to improve the system as a disaster wireless system requires a two-way communications function. A key development concept for the GENSAI CS was support for two-way communications. Achieving two-way communications would make it possible to support the following services.

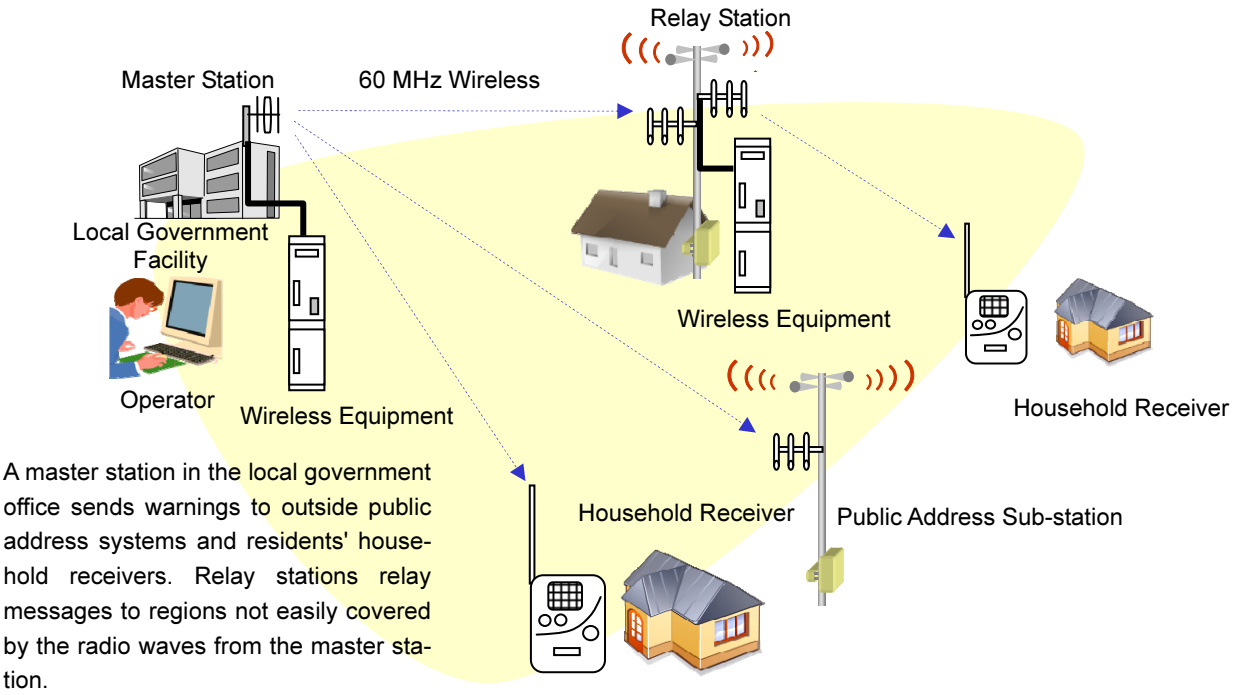


Figure 3 Diagram of "Bousai Gyousei" radio system

[1] Confirming Residents' Safety

Two-way communications plus household receivers makes it possible to collect responses from residents. By offering a GENSAI CS system with a means for residents to respond, it is possible to determine whether residents have heard the evacuation order, have started evacuation, whether they require assistance, and whether they are safe, etc.

[2] Equipment Monitoring

Since the previous type of household receivers was located in residents' homes, the government side could not understand the installation conditions. In addition, we must assume a variety of different operating conditions such as loss of power due to power cuts and discharged batteries etc. Consequently, sometimes household receivers may not be working when an evacuation order is issued in an emergency and there may be cases when residents are unable to obtain the information they need. With the GENSAI CS system, if the status of the communications terminal can be constantly monitored, there is less risk of the information not being received by residents, and residents not receiving information can be identified.

(2) Low Operation Cost

In the previous system using 60-MHz band wireless, the household receivers are dedicated receivers. Consequently, under the current wireless law, if the household receiver has a transmit function, it requires some form of license charges. Supplying household receivers with the transmit function to every household, would require considering license charges for every unit, greatly increasing the operation costs. The GENSAI CS system uses a two-way wireless method that does not incur license charges.

(3) Simple Operation

Since every resident will use the household receiver, it will be unacceptable if it is a high-function device requiring complex operations. In addition it must not require complex operations to access the required information in an emergency. The GENSAI CS communication terminal must be sufficiently simple to enable correct operation by anyone.

Additionally, since it may be handled by very old people as well as people who have been injured, it should be designed giving consideration to the following ideas.

[1] Two notification methods by voice and LED

[2] Big, easy to see buttons

[3] Easy to operate displays

(4) Ad-hoc Communications

One problem of wireless communications systems is the "reachability" of the wireless wave. In hilly or densely populated urban environments, the wireless wave from the base station may be obstructed preventing normal reception. This problem is solved by using an ad-hoc wireless communications*1 method for the GENSAI CS System. Using this method, communications terminals that are unable to receive the wireless waves from the base station, receive the wireless wave from a nearby communications terminal acting as a relay station. A unique aspect of this ad-hoc wireless communications method, is that the wireless network is composed of several hundred multiple hops.

*1: Ad-hoc wireless communications technology in a multi-hop network environment, each wireless terminal itself performs autonomous routing. The wireless terminal can establish an autonomous network by establishing connection with nearby devices.

(5) Countermeasures to Power Cuts

We designed the system to be able to operate for more than 20 hours on battery power even when the commercial power supply has been cut.

(6) Voice Messaging in Non-Emergencies

Although the primary purpose of the communications terminal is to transfer emergency information, it can also be used for other contacts from local government during non-emergency times.

3 Key Design Points

3.1 Disaster Reduction CS Structure

As shown in figure 1, the GENSAI CS is composed of a base station installed in a government facility such as an evacuation center and communications terminals installed in the houses of local residents; this system both distributes and collects information. The communication between the city town or village office and each base station is performed using TCP/IP over any infrastructure such as the area-intranet with optical fibers and wireless LAN.

3.2 Two-Way Communications

Communications between the base station and communications terminals in each household is a one-to-many wireless system using restricted wireless channels. Achieving two-way communications under these conditions requires considering technical approaches, such as polling from the base station and competition between terminals. Since the GENSAI CS system uses communications between one base station and several hundred communications terminals, we used the polling method because all communication terminals must be treated as equal peers.

In this method, the base station polls the communications terminals one-by-one to collect responses from each household as well as information on the operation status of each terminal. The design time required to poll 200 communications terminals was set to about 2 minutes.

Table 1 lists the information returned by each terminal in response to the polling request. Collecting this information confirms successful receipt of warning information by the residents while also monitoring the daily status of the system appliances.

Table 1 Responses from communications terminal

No.	Item	Response Type	Objective
1	Button press data	Resident response	Confirm resident safety
2	Message reception status	Message transfer confirmation	Confirm message received from local government office
3	Message replay status	Message transfer confirmation	Confirm replay of message from local government office
4	Equipment power status	Operation status	Monitor equipment daily status
5	Equipment battery status	Operation status	Monitor equipment daily status

3.3 Ad-Hoc Network

Wireless communication systems sometimes suffer from problems with regions where the wireless waves cannot be received easily. The GENSAI CS solves this problem by configuring an ad-hoc network in which communications terminals act as relays for the signal from the base station (Figure 4).

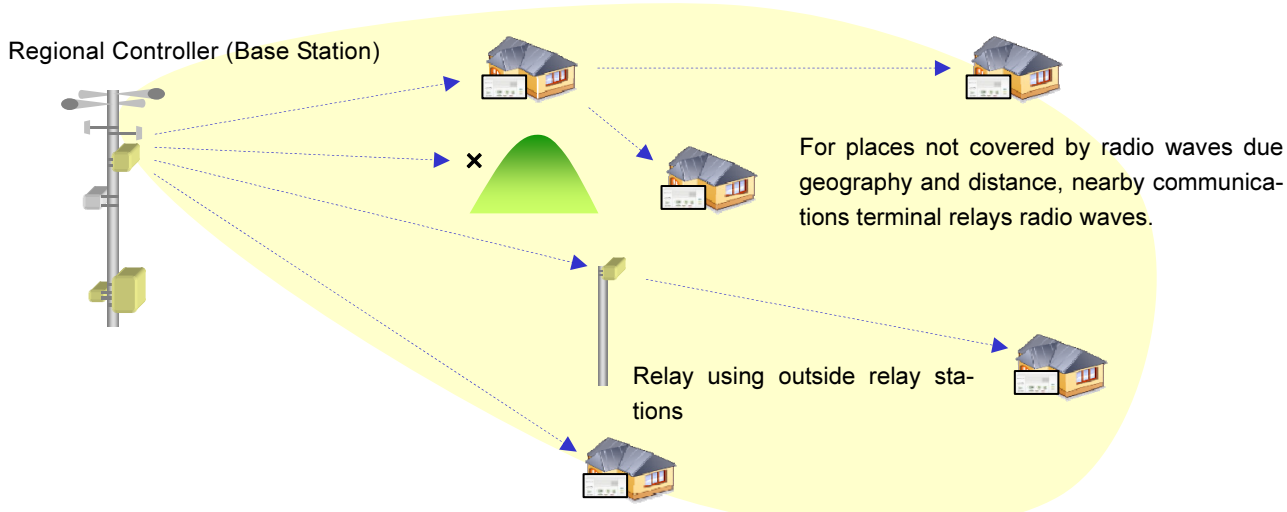


Figure 4 Structure of ad-hoc network using communication terminal

(1) Ad-hoc Network Setup

An ad-hoc network using the communications terminals achieves connections using two phases: scanning, and negotiation.

[1] Scanning

In this phase, after the communication terminal starts, a connection request packet is broadcast at a fixed interval and responses from nearby terminals to this broadcast are collected.

This scanning operation determines the presence of neighborhood terminals that are able to communicate and simultaneously collects the following information (Figure 5 [1]－[2]).

・ Level of wireless wave when response received from each terminal

・ Number of relays of each terminal from base station

・ Type of equipment (base station, relay, communications terminal)

[2] Negotiation

After collecting information from terminals that are able to communicate, this phase selects the best terminal for communications and establishes communications by using the information from scanning to find the terminal closest to the base station with the highest wireless wave level. Negotiation sends a connection request to the specified partner terminal, and completes the connection when the response to the connection request is received from the partner (Figure 5 [3]－[4]).

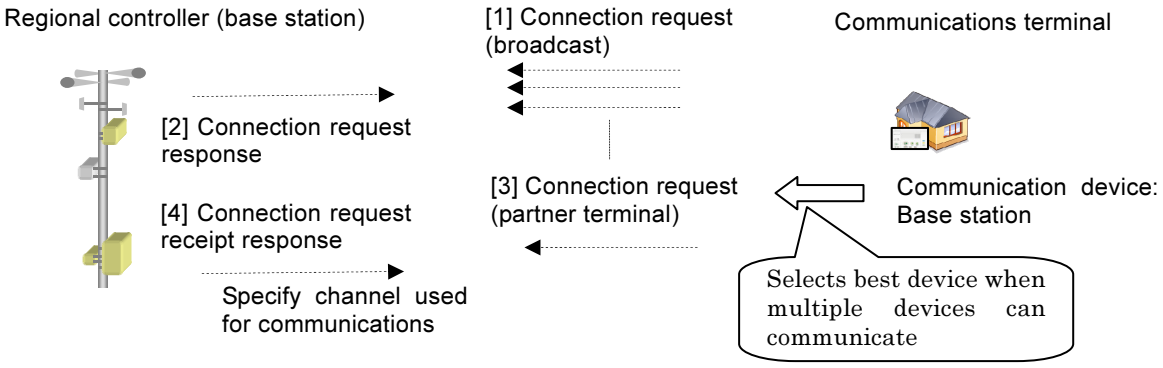


Figure 5 Structure of ad hoc network (scan and negotiation)

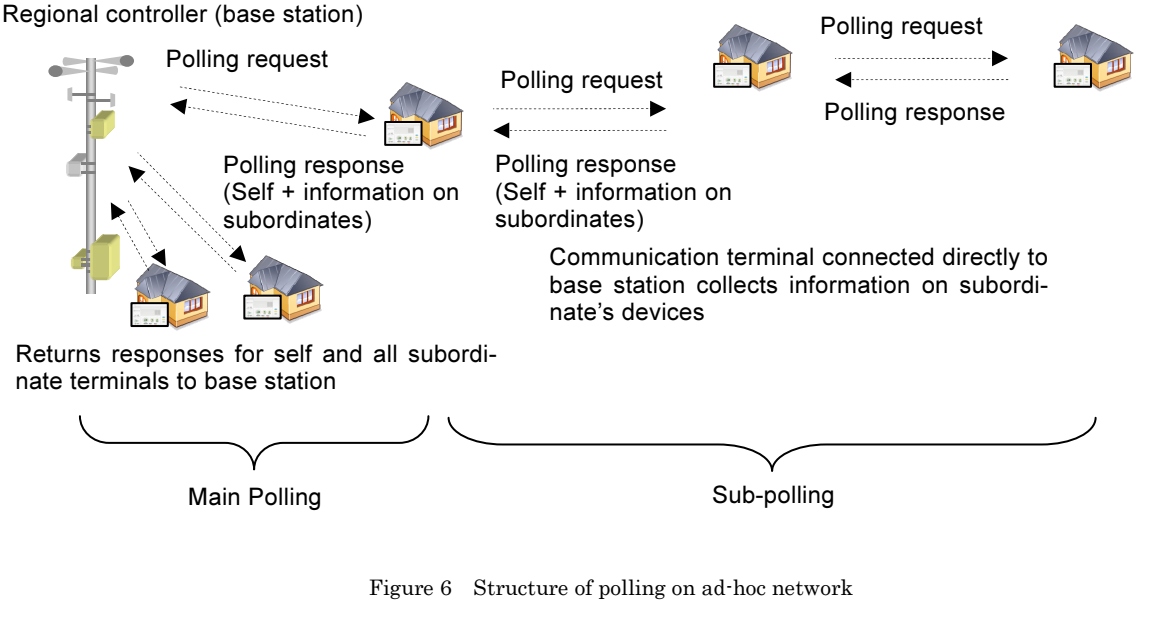


Figure 6 Structure of polling on ad-hoc network

After receiving the connection requests from the partner, the communication channel is allocated automatically to the communication terminal. This negotiation procedure makes it possible to communicate at any locality even if settings have not been premade at the communication terminal.

An ad-hoc network is configured by all the communications terminals performing the above two procedures.

(2) Polling on Ad-Hoc Network

As previously described, in a GENSAI CS two-way communications are achieved by polling from the base station, in an ad-hoc network environment communications terminals relay the communications, but in simple terms not all communications terminals can be polled from a base station.

Consequently, in the GENSAI CS, we have achieved an ad-hoc network environment by using a unique method composed of two polling types called main polling and sub-polling. These methods are outlined below.

[1] Main Polling

This polling is performed by the base station directly contacting connected communication terminals. Like the normal polling operation, responses are received from communication terminals one-by-one.

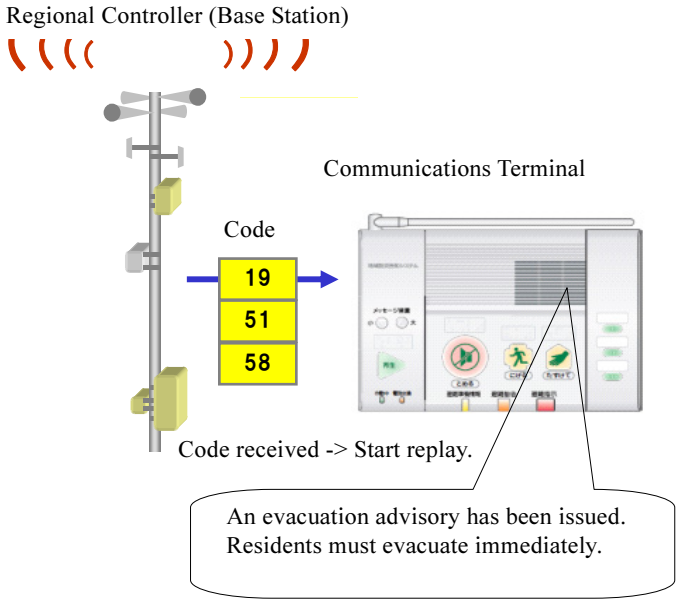
In the example shown in Figure 6, three communications terminals are connected directly to the base station which gathers information by polling these three communications terminals in sequence.

As described below in the sub-polling section, information for the two terminals that are not directly connected to the base station is received by requests from and responses to the directly connected terminals performing the main polling.

[2] Sub-polling

In this method, communications terminals that are not directly connected to a base station can be polled by using the directly connected communications terminals as base stations. As shown in the example in Figure 7, when there are multiple layers of connections, polling requests are forwarded to unconnected terminals with each communication terminal collecting responses and returning them to the request originator.

Using a combination of the above two polling methods, the base station can collect information from all communications terminals ultimately.



Built-in Announcements

19	**An evacuation advisory has been issued.**
20	A warning has been issued.
21	A precautionary notice has been issued.
・・・	・・・
51	Residents ...
52	People hearing this broadcast ...
53	People near the coast ...
・・・	・・・
58	must evacuate immediately.
59	must take safety precautions.
60	must take appropriate action without panicking.

Figure 7 Structure of fixed announcements (Japanese only)

3.4 Fixed Phrase and Voice Announcements

The communications terminals have two types of audio replay function.

(1) Fixed Phrases

More than 100 voice phrases about warnings and cautions such as earthquakes and tsunami are stored in the communications terminal for replay when the corresponding code number is sent from the base station. In an emergency, all the communications terminals can receive the replay code from the base station within 1 minute.

(2) Voice Information

To broadcast detailed information that cannot be transferred using predetermined phrases, the communications terminals have a function for receiving and replaying voice recordings made at the local government office. A vocoder is used for the recording and replay of voice compressed at up to 2 Kbit/s.

3.5 Easy Operation

Since various local residents will be using the communications terminals, they must be easy to use (Figure 8).

(1) Operability

The GENSAI CS base station collects information by residents pressing buttons. As a result, the buttons are large and easy to use even by elderly people, and can be operated simply by pressing any one of the three center buttons.

(2) Universal design

The button markings use universal designs that are intuitively recognized and understood.

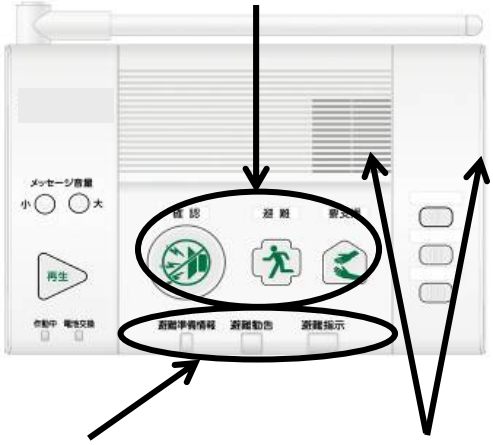
(3) Visibility

There are three types of emergency orders: "Evacuation Preparation", "Evacuation Recommendation", and "Evacuation Order". The warning types are indicated by LEDs to assure visibility wherever the communication terminal is installed.

(4) Easy-to-hear

The built-in speaker is mounted behind a grill so that the audio is easy to hear from any direction.

(1) For simplicity there are only three buttons for responses.
(2) The buttons have an intuitive universal design.



(3) LEDs light in accordance with the alarm type. Visibility is improved using an L-shaped panel that can be viewed from the top and both sides of the front panel.

(4) Grilles in the front and side panels allow the audio from the internal speaker to be heard easily from any direction.

Figure 8 Operability of communication terminal

3.6 Operation at Power Cut

The communications terminals can operate for more than 20 hours on battery power in the event of a power cut. The batteries are the common AA alkaline type that can be bought almost anywhere.

3.7 Low Operation Cost

The wireless system linking the base station with the communications terminals uses the low-power 429-MHz band, which does not require any license fee, helping keep down running costs to just the cost of the electricity for power. The power consumption at normal operation is about 1 W, totaling about 20 yen per month, which is not a heavy financial burden on residents.

4 Functions

The basic functions of the communications terminal are listed in the following table.

Table 2 Communication terminal specifications

No.	Item	Specification	
1	Wireless Specification	ARIB STD-T67	
2	Wireless Frequency	429 MHz	
3	Tx Power	10 mW max	
4	Communications Speed	2.4 kbit/s max	
5	Wireless Communications Method	Simplex	
6	Modulation Method	FSK	
7	External I/F	Voice Output ×1 (3.4-mm mini-jack) RS-232C×1 (RJ-11)	
8	Power Supply	100 Vac (50/60 Hz, AC adapter) 6 Vdc (four alkaline AA batteries)	
9	Operation at Power Cut	20 h min	
10	Mass	0.5 kg approx. (excluding AC adapter and batteries)	
11	Operation Temperature	−5° to 40℃	
12	External Dimensions	40 (H)×155 (W)×120 (D) approx (antenna folded and excluding projections)	
13	LED/Button Specifications	Operating LED	Green/Red
		Battery Change LED	Red
		Prepare to Evacuate LED	Yellow
		Recommend Evacuate LED	Orange
		Order Evacuate LED	Red
		Volume Button	1 large and small each, no LED
		Replay/Stop Button	Green
		Warning Confirmation Button	Red
		Start Evacuation Button	Yellow
		Assistance Required Button	Yellow
		Option Button I	Blue
		Option Button II	Yellow
		Option Button III	Green

5 Conclusion

Future wireless disaster reduction systems for cities, towns and villages not only must be able to transfer disaster information during a disaster, but must also have various functions for confirming the safety of residents and comprehending the disaster conditions. Following the Hanshin Awaji Earthquake in the Osaka-Kobe region, Japanese disaster prevention changed to disaster reduction. As clarified by the Great East Japan Earthquake and subsequent tsunami, evacuating residents to safety can greatly reduce the damage from a disaster. The damage from unavoidable disasters cannot be prevented—it can only be reduced. We have developed this GENSAI CS model as a way to help with this. We intend to continue developing equipment helping to assure people's security and safety.

Acknowledgments

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