

Airborne Telemetry Network Technology



The flight test is conducted for final performance verification during aircraft development. At the flight test, data is transmitted to the ground with telemetry technology to monitor safety and determine whether the test is successful. We work on applying the technology of the telemetry network equipped with high-capacity communication and bidirectional communication functions to the flight test in order to address an increase in measurement data in line with advancements made in onboard airborne systems and communication from the ground to the aircraft. We are now demonstrating this technology using helicopters and will apply it to fixed-wing aircraft in the future.

Introduction

In the development and improvement of aircraft, flight tests are conducted to verify the final performance, functionality and safety. During a flight test, data is transmitted from the aircraft to the ground with telemetry technology to monitor safety and determine whether the test is successful.

1 Background

During flight test, it is critical to acquire information such as stress and vibration data to evaluate the aircraft's structure, inter-equipment communication data to evaluate the onboard systems, and image data to capture the operating status of the equipment. And since aircraft structure, onboard systems and equipment are becoming increasingly sophisticated every year, the amount of data required is increasing.

However, only selected data is actually transmitted out of the data acquired because of restrictions to the volume of data that can be transmitted with telemetry technology 1). Moreover, as the amount of data required continues to grow, it is predicted that it will be difficult for conventional telemetry technology to handle flight tests.

In addition, from the viewpoint of improving flight-test efficiency, various other requirements are expected to place an increasing burden on telemetry systems such as data transmission from the ground to the aircraft, controlling onboard measurement equipment, and retransmission data that could not be transmitted due to the radio interference. These all require bidirectional communication, which also is not supported by

conventional telemetry technology.

To solve these problems, we have launched research into telemetry network technology to realize a faster communication rate as well as bidirectional communication.

2 Overview of telemetry network technology

Telemetry network technology acquires data with ethernet-based measurement equipment, and as shown in **Fig. 1** illustrates how each piece of equipment is connected via network switches. This technology consists of three networks: an onboard network installed on the aircraft, a bidirectional RF radio communication network, and a ground network. The RF network provides communication between the onboard network and ground network via network transceivers.

The telemetry network led by the US Department of Defense (DoD) is called iNET (integrated Network Enhanced Telemetry), which was added in 2017 to IRIG 106, a telemetry technology standard.

iNET will be the standard going forward in-flight tests conducted by the DoD. The DoD has a large number of flight-test areas and plans to apply this iNET technology to conduct flight tests over a wide range covering each area.

Figure 2 shows an overview of iNET, where bidirectional communication takes place between airborne aircraft; on the other hand, communication between aircraft and the ground is performed in combination of bidirectional and unidirectional communication.

Our telemetry network technology conforms to this standard.

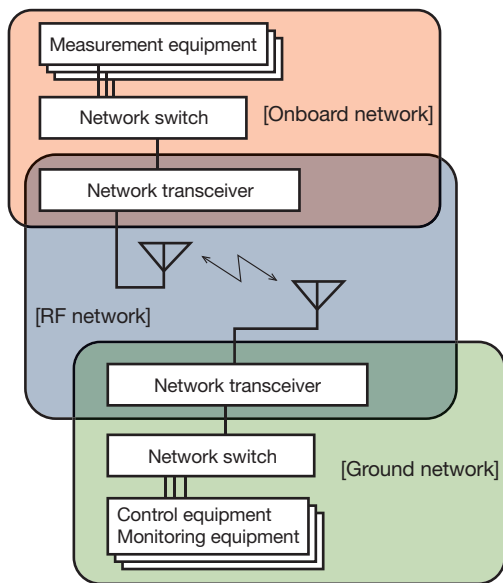


Fig. 1 Overview of the telemetry network technology

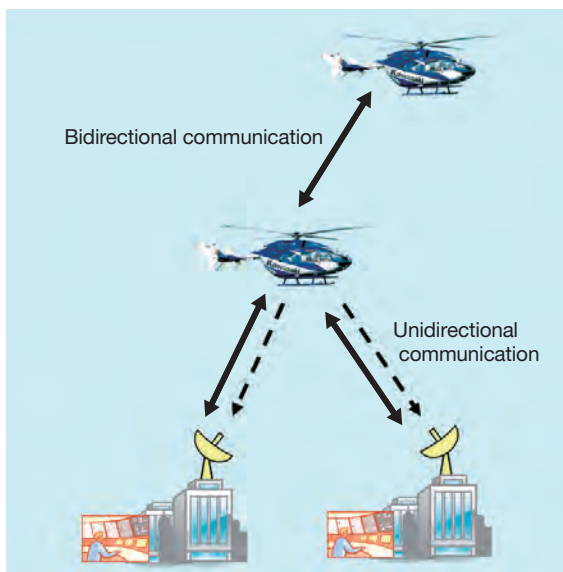


Fig. 2 Overview of iNET

3 Comparison with conventional technology

In conventional telemetry technology, data is transmitted unidirectionally from the aircraft to the ground. The data acquired onboard is converted to serial data (PCM data) and frequency or phase-modulated, then finally transmitted. The communication speed achieved in

our company is up to around 3 Mbps in S-band telemetry¹⁾.

On the other hand, telemetry network technology enables bidirectional communication. It packetizes data acquired onboard according to the ethernet standard and transmits the packets via network transceivers using OFDM (Orthogonal Frequency Division Multiplexing), compliant with the wireless LAN standard IEEE802.11a. Furthermore, it automatically switches the modulation method to 16QAM, QPSK, or BPSK depending on the radio signal reception strength. The estimated maximum communication speeds are about 20 Mbps, 10 Mbps, and 5 Mbps, respectively - much faster than the conventional system. Moreover, its bidirectional communication functions allow onboard equipment to be remotely controlled and interrupted data to be retransmitted - functions that the conventional technology does not support. The new technology also makes it possible to connect ethernet-based equipment such as a network camera, or add various other functions by developing software for them.

Figure 3 shows the appearance of the network transceiver we are using, and Table 1 lists its specifications.



Fig. 3 Appearance of network transceiver

Table 1 Specifications of network transceiver

Center frequency (MHz)	2,200 ~ 2,400
Occupied band (MHz)	20 or less
Transmission output power (W)	80 (peak)
Modulation system	OFDM (802.11a)
Interface	Ethernet
Dimensions (mm)	W 159 × D 168 × H 74
Weight (g)	2,903

4 Telemetry network technology applied in this company

Among the three networks mentioned above, we have already demonstrated the onboard network, and are now preparing to demonstrate the RF network. Specifically, we are working on applying the RF network to flight tests to demonstrate the communication range, communication rates and bidirectional communication functions. We are also accumulating knowledge on various settings to demonstrate these functions and how equipment should be installed in aircraft.

(1) Securing efficient and stable communication rates

As radio signal strength constantly fluctuates during a flight test, securing an efficient and stable communication rate is essential. Since the communication rate varies depending on the modulation method, we are testing settings such as for the procedure to switch between modulation systems and on the reception-level threshold for the switching under various reception conditions during flight tests.

(2) Optimizing time allocation for communication

This telemetry network technology uses TDMA (Time Division Multiple Access) to allocate time for communication, and the downlink from the aircraft to the ground and the uplink from the ground to the aircraft are allocated different periods of time. Since the way time should be allocated between the ground and the aircraft is also important, we are trying various ratios during flight tests to find the optimal allocation.

(3) Checking data retransmission functions from aircraft

We are also working on adding a new function that utilizes the characteristics of bidirectional communication. When communicating by telemetry technology, there may be some instances where obstacles between the aircraft and ground facility or the aircraft's attitude variations may disrupt communication between antennas. In such a case,

retesting is required due to the deficiency in the received data caused by radio disruption. To address this problem, we have developed a function that sends a data retransmission command from the ground to the aircraft for the data to be transmitted again, by taking advantage of the bidirectional communication features of the telemetry network technology. This function is also being demonstrated under various conditions of radio disruption in flight tests.

Table 2 presents a list of tests conducted so far regarding the above. In a communication test conducted in 2015, we demonstrated telecommunication using a moored airship at the Taiki Aerospace Research Field in Hokkaido. We established communication speeds up to approx. 20 Mbps with the airship at an altitude of 120 m and a distance of 34 km.

5 Demonstration by a flight test using a helicopter

In FY2016, we started in-flight demonstrations using a helicopter. These tests are to confirm whether the communication range, communication rates, and the overall functions are applicable to aircraft flight tests. The following describes the FY2016 demonstrations.

(1) Equipment and facilities

Flight test vehicle: Kawasaki BK117 C-2 helicopter.

(i) Equipment installed in the aircraft

Since the measurement equipment was to be used temporarily for the study, it was installed in a simplified way as shown in **Fig. 4** to minimize modifications. Major pieces of equipment were fixed in the cabin, a telemetry antenna to an existing stay, and a GPS antenna to an entrance handgrip.

The GPS antenna is equipment needed to synchronize communication between the aircraft and the ground.

(ii) Facilities on the ground

Figure 5 shows the ground facilities, comprising an antenna placed on a roof of our Gifu Works building, a

Table 2 Details of test conducted

Year	Contents
2007	Investigation into telemetry network technology
2014	Introduction of telemetry facilities for flight tests
2015	Bidirectional telemetry communication test using a moored airship
2016 2017	Demonstration of bidirectional telemetry using a helicopter



Fig. 4 Equipment in fuselage

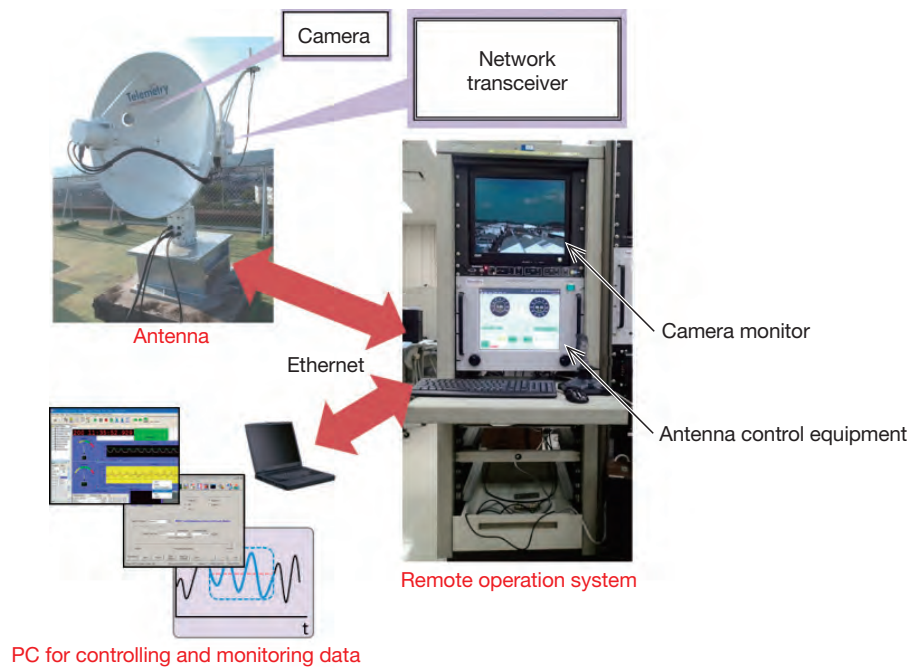


Fig. 5 Ground facilities

remote-operation system, and a PC for controlling and monitoring data installed in the monitoring room.

The antenna can automatically track the aircraft by obtaining the location information from the network transceiver installed in the aircraft. With the PC for controlling and monitoring, we measured communication parameters such as communication rates.

(2) Overview and results of the flight test

We tested the following items while flying the aircraft between our Gifu Works and a place within 50 km of the Works as shown in **Fig. 6** : checking the communication range and rates, controlling onboard measurement

equipment from the ground, and retransmitting data following radio signal interruptions.

In conclusion, we achieved a communication rate of 5 Mbps at a communication range of 50 km, and confirmed onboard measurement equipment could be controlled from the ground, and data could be retransmitted when the radio signal had been interrupted.

Regarding the communication rate, we now see the prospect of establishing 10 Mbps in subsequent analysis.

Testing is still underway with different settings of the onboard measurement equipment, and we are obtaining better results in terms of communication range and speeds.

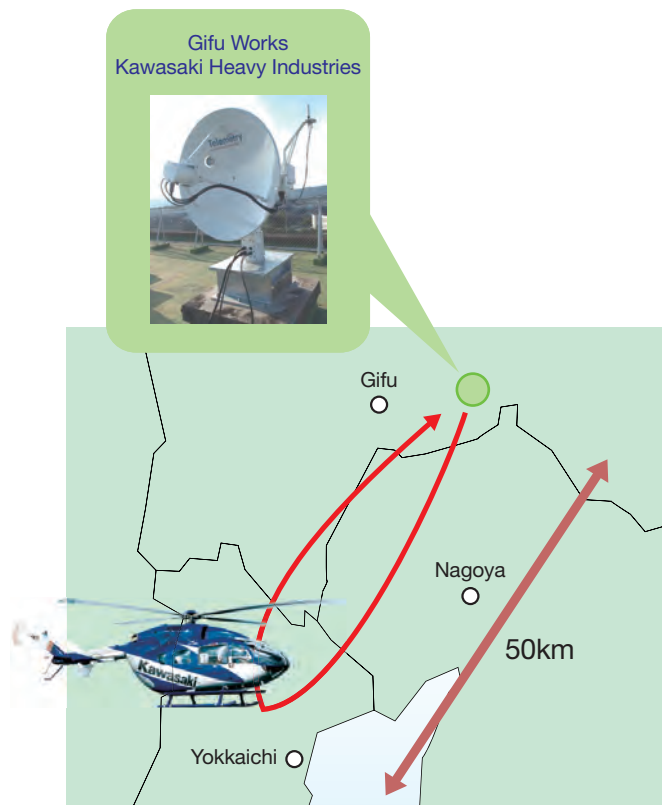


Fig. 6 Overview of test

Conclusion

Telemetry network technology is a system that has not been used in Japan to date, but will become a standard for flight tests going forward, so we will continue our research to put into practical use. Our goals are to further extend the maximum communication range and demonstrate the technology using faster aircraft, such as a fixed-wing one.

Furthermore, we will work on applying this technology to systems for transmitting data, such as image data, to assist information sharing among search-and-rescue aircraft dispatched in a disaster.

Reference

- 1) Ito: "Flight Test Real-Time Monitoring System," Kawasaki Heavy Industries Technical Review No. 171 pp.52-53 (2011)



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