

Successful Transmission of High-Resolution Live Video from a Drone in Flight Using VHF-Band Narrowband IoT Communication System: Wi-SUN FAN

—Achieving High-Quality Real-Time Video Transmission over Narrowband, Long-Range IoT Communications—

Overview

A research group led by Professor Hiroshi Harada of the Graduate School of Informatics at Kyoto University (hereinafter “Kyoto University”) has developed a wireless communication system compliant with the international wireless communication standard “Wi-SUN FAN” for VHF-band (170 MHz and 220 MHz bands) narrowband IoT communication systems (hereinafter “VHF-IoT”), for which the Information and Communications Council of the Ministry of Internal Affairs and Communications issued a partial report in December 2025. The developed system is expected to achieve long-distance transmission over more than 10 km. The group also developed a highly efficient video compression and transmission system capable of transmitting video at the limited data rates available with VHF-IoT. By installing these systems on a drone, the group successfully demonstrated wireless transmission of live HD (1,280 × 720 pixels) camera video at 10 fps from a drone in actual flight.

Key Points

- Developed a wireless communication system compliant with the international wireless communication standard Wi-SUN FAN, which uses OFDM, for VHF-IoT in the 170 MHz and 220 MHz bands, which are well suited to long-distance communication. The system achieves high-speed transmission at 600 kbit/s with an occupied bandwidth of 400 kHz and 2,400 kbit/s with an occupied bandwidth of 1,200 kHz.
- Successfully transmitted live HD (1,280 × 720 pixels) camera video at 10 fps from a drone in flight using an occupied bandwidth of 400 kHz.
- In addition to highly efficient video compression, developed packet aggregation for efficiently transmitting multiple video packets and proprietary communication control technology for transmitting important video frames with high quality and efficiency, thereby achieving stable live video transmission even at limited data rates.
- Applied Wi-SUN FAN, which supports autonomous network formation and multi-stage multi-hop communication, to the VHF band and demonstrated live video transmission from a drone in flight to a ground station, with a view to deployment for wide-area communications during disasters and in mountainous areas.

1. Background

In recent years, drones have increasingly been used for a wide range of applications, including assessing

damage during large-scale disasters, searching for survivors, and transporting supplies to mountainous areas and remote islands. Wireless LAN (Wi-Fi) and cellular systems are currently the primary means of communication with drones. However, Wi-Fi communication is generally limited to ranges of several hundred meters. In addition, because Wi-Fi uses frequencies in the several-gigahertz range, signals are susceptible to blockage by forests and terrain, making it difficult to maintain stable communications when drones fly in mountainous areas. For logistics drones and similar applications, cellular networks are also being considered as a means of continuously monitoring the aircraft's status and surroundings from a remote location during flight. However, communications may be interrupted when a drone flies outside cellular coverage, such as in mountainous areas, or when cellular networks become unavailable because of a large-scale disaster. To address these challenges, narrowband IoT wireless communication systems using the VHF band (hereinafter "VHF-IoT") are being studied. The VHF band is lower in frequency than the bands primarily used by Wi-Fi and cellular systems, is less susceptible to blockage by forests and terrain, and can provide long-range, wide-area coverage. In December 2025, the Information and Communications Council of the Ministry of Internal Affairs and Communications issued a partial report on the technical requirements for VHF-IoT, specifying the use of the lower frequency band from 170.0 to 177.5 MHz and the upper frequency band from 217.5 to 222.0 MHz, as well as operation with antenna power of up to 5 W. By taking advantage of the propagation characteristics of the VHF band, VHF-IoT is expected to support wide-area IoT communications as a private communication network for public and public-interest organizations, including in mountainous areas where cellular networks are unavailable and during disasters. Kyoto University has previously developed wireless transmission equipment compatible with VHF-IoT and, in May 2026, successfully demonstrated long-distance wireless transmission over more than 30 km. However, that demonstration focused primarily on point-to-point transmission and used FSK modulation over the limited 400 kHz bandwidth available in the upper VHF-IoT frequency band, resulting in a data rate of only 150 kbit/s. For practical applications such as disaster-site monitoring and search operations and logistics drones, technology was therefore needed that could leverage the long-range propagation characteristics of the VHF band to enable network communications among multiple radios while also stably transmitting smoother live video from drones in flight over limited frequency bandwidth.

2. Research Results

To achieve high-speed, high-quality data transmission within the limited frequency bandwidth available in the VHF band while autonomously establishing wireless connections with drones in flight, Kyoto University developed a wireless communication system compliant with the international wireless communication standard "Wi-SUN FAN," which uses OFDM, and supporting VHF-IoT in the 170 MHz and 220 MHz bands. The system achieves a data rate of 600 kbit/s with an occupied bandwidth of 400 kHz and up to 2,400 kbit/s—the maximum data rate specified by Wi-SUN FAN—with an occupied bandwidth of 1,200 kHz. In addition, the networking capabilities of Wi-SUN FAN enable the ground station and drone to autonomously establish a wireless connection and perform IP-based data communications.

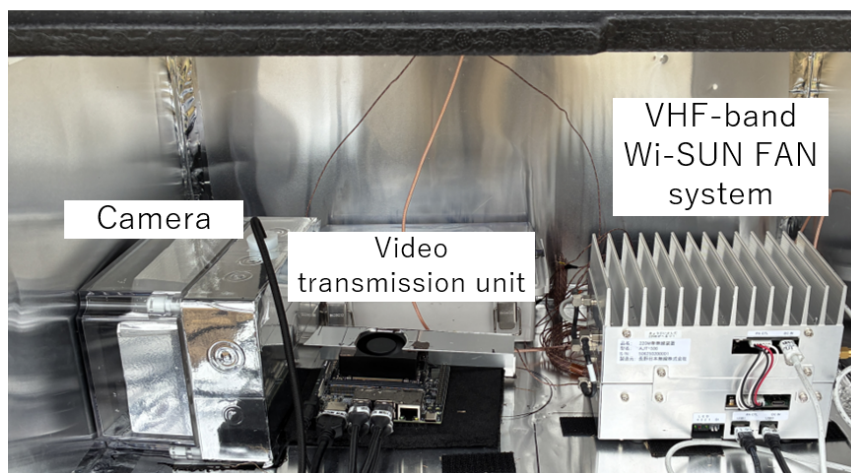
The radio propagation environment between a drone in flight and a ground station changes continuously depending on factors such as distance, relative position, and surrounding terrain. To maintain stable live

video transmission even under such time-varying wireless conditions, the group developed packet aggregation, which efficiently combines multiple video packets for transmission, together with a proprietary video compression and transmission method that controls transmission according to the importance of individual video frames so that important frames can be transmitted with high quality and efficiency. By combining Wi-SUN FAN technology with this highly efficient video compression and transmission method, the group realized a wireless video transmission system capable of stably transmitting high-quality live video even at the limited data rates available in the VHF band.

Using the developed system, the group conducted drone flight experiments assuming wide-area monitoring during disasters and similar situations. The drone was equipped with a VHF-band Wi-SUN FAN radio (router), a camera, and a video transmission system transmitter, and transmitted live camera video while flying at altitudes of 25 m and 50 m above ground. On the ground, data received by a VHF-band Wi-SUN FAN radio (border router) were decoded by the video transmission system receiver, and the video was displayed and recorded in real time. The experiments confirmed that, despite the use of narrowband VHF communications, clear live HD video ($1,280 \times 720$ pixels) at 10 fps could be transmitted stably from the drone in flight for more than 10 minutes. In addition to video transmission with an occupied bandwidth of 400 kHz, the group also successfully transmitted video with an occupied bandwidth of 1,200 kHz at a data rate of 2,400 kbit/s. Figure 1 shows the transmitting equipment mounted on the drone, Figure 2 shows the receiving equipment, and Figure 3 shows video received from the drone. Table 1 lists the main specifications of the VHF-band Wi-SUN FAN radios used in this experiment.



(a) A drone in flight that is transmitting VHF signals

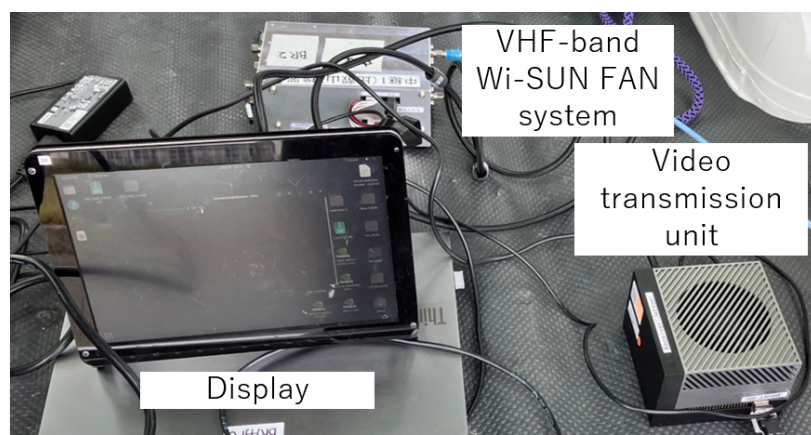


(b) Equipment mounted on the drone

Figure 1: Transmitting Equipment



(a) Receiving Equipment



(b) Receiving Equipment

Figure 2: Receiving Equipment



Figure 3: Video received from a drone in the 220 MHz band

Table 1: Main Specifications of the VHF-Band Wi-SUN FAN Radios

Frequency	Transmit Power	Occupied Bandwidth	Modulation	Data Rate
170 MHz	250 mW	1,200 kHz	OFDM	2,400 kbit/s
220 MHz	1 W	400 kHz	OFDM	600 kbit/s

3. Future Developments

In this demonstration, basic transmission tests using VHF-band Wi-SUN FAN confirmed that HD live video could be transmitted stably from a drone in actual flight. Although the transmission distance in this test was approximately 50 m, future work will take advantage of the long-range propagation characteristics of the VHF band and target transmission distances of several kilometers. Drone flight and video transmission tests will be conducted in real-world environments while varying conditions such as flight altitude, transmission distance, terrain, and obstructions. In addition, by leveraging Wi-SUN FAN's autonomous network formation capability and multi-hop communication capability supporting more than 20 relay hops, the group will propose and demonstrate a new communication system for drone delivery management in which multiple ground stations and drones communicate with one another to form a wide-area communication network. The goal is to realize a highly reliable communication system capable of continuously monitoring the position and status of drones in flight and their surroundings from a remote location, even across wide areas that include mountainous regions without cellular coverage and areas where communication infrastructure has been damaged by disasters. The group will also further advance its video compression, packet aggregation, and video transmission control methods to make effective use of the limited data rates available in the VHF band and develop and demonstrate a video compression and transmission system capable of delivering smoother live video at frame rates higher than the currently

demonstrated 10 fps while maintaining HD resolution. By integrating these technologies, the group aims to advance applications including disaster assessment, search and rescue, infrastructure monitoring in mountainous areas, and supply transport, ultimately realizing a wide-area, highly reliable next-generation drone communication system using VHF-band Wi-SUN FAN.

4. Acknowledgments

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<Glossary>

1. Wi-SUN FAN (Field Area Network)

Wi-SUN FAN is a communication standard established by the Wi-SUN Alliance for wirelessly implementing smart grids that support smart metering and distribution automation, as well as smart-city applications such as infrastructure management, intelligent transportation systems, and smart lighting. It is an IPv6-compatible multi-hop communication specification for sensors, meters, and other devices and is characterized by its ability to build wide-area, highly reliable IoT networks. Version 1.0 was established in 2016, and Version 1.1, which supports higher-speed communications and lower power consumption, is currently in effect.

2. VHF-IoT

VHF-IoT is a narrowband IoT communication system introduced in the guard bands between the public broadband communication system and other systems in the V-High band (170–222 MHz). A regulatory framework has been established to enable public safety agencies and other organizations to share information during disasters and for other purposes. The system can be used both on the ground and in the air. It uses the lower frequency band (170.0–177.5 MHz) and the upper frequency band (217.5–222.0 MHz), and permits operation in the air with antenna power of up to 1 W.

(Reference)

Report of the Information and Communications Council, Ministry of Internal Affairs and Communications:

https://www.soumu.go.jp/menu_news/s-news/01kiban13_02000131.html