and distance for avoidance maneuvers. Additionally, if turbulence is anticipated, proactively activating the seatbelt sign is essential to enhance passenger and crew safety.

- Regarding clear air turbulence (CAT), which remains difficult to predict with current technology, further advancements in meteorological analysis systems and improvements in forecasting capabilities are expected to enable more precise turbulence predictions before flight operations commence.

Practical implementation of aircraft-mounted Doppler Lidar

- Utilization of aircraft-mounted Doppler Lidar for flight control

By utilizing laser light and the Doppler effect of scattered light from aerosols in the atmosphere, it is possible to measure wind speed and other atmospheric conditions ahead of the aircraft even in the absence of precipitation particles, unlike conventional onboard weather radar. Based on this data, a technology development initiative led by JAXA (Japan Aerospace Exploration Agency) is underway to automatically control the aircraft and reduce turbulence. Through flight experiments, the capability to observe wind conditions at high altitudes has already been demonstrated. However, research is ongoing to extend the detection range further. Enhancing detection range requires higher output power and improved performance of observation equipment, which contradicts the need for miniaturization and weight reduction for aircraft installation. To overcome this challenge, efforts are being made to integrate new technologies to achieve both goals, and its practical implementation is eagerly anticipated.

Utilization of EDR and other turbulence information

- Sharing of turbulence information using EDR and other data

Currently, real-time turbulence information relies almost entirely on PIREP submitted by flight crews during flights. However, the reported turbulence intensity is largely influenced by the size of the aircraft and the subjective perception of the flight crew, making it less objective. By utilizing the automated reporting system developed with EDR turbulence information can be obtained in real-time, providing a more objective and quantitative assessment of turbulence intensity while also considering the aircraft's size. This enables aircraft to take appropriate actions based on the severity of the turbulence indicated by EDR values. Efforts to forecast and share turbulence information using EDR and other data are being officially recognized and integrated as standard indicators within various frameworks, including ICAO and IATA, where data is collected, stored, and shared systematically.

Column "Efforts to share real-time turbulence information utilizing new technologies"

Understanding where and what kind of turbulence is occurring is crucial for preventing turbulence-related accidents. However, the current system for sharing turbulence information faces challenges in terms of objectivity and timeliness. Japan Airlines (JAL) is working on utilizing real-time information-sharing systems that leverage EDR and services provided by private meteorological companies. The airline's Flight Operations Standards & Technology Department has contributed an article on this initiative.

"JAL's initiatives for preventing accidents caused by sudden aircraft turbulence"

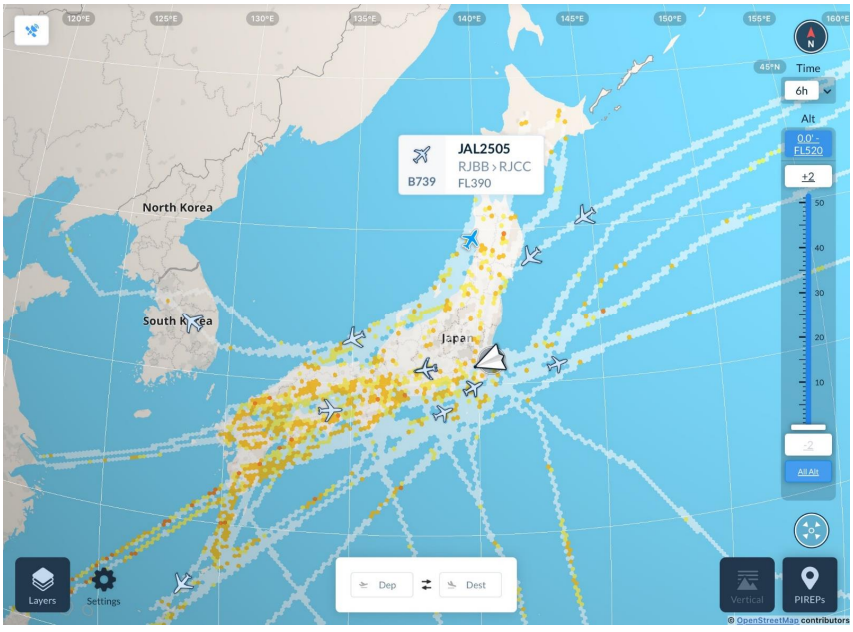
For airlines, it is essential to anticipate areas of sudden turbulence during flight and take measures to avoid its impact, ensuring a smooth in-flight experience and preventing injuries to passengers and crew.

To achieve this, airlines develop safe flight plans and corresponding service plans by making full use of the latest meteorological charts and weather data. However, supplementing weather information with reports from pilots who have actually encountered turbulence is extremely effective. When reporting turbulence encounters, key factors include the accuracy of location (latitude, longitude, altitude), turbulence intensity, and the exact time of occurrence. Additionally, the real-time nature of the reports is critical. However, the current C-PIREP (Collaborative Pilot Report) system, which enables airlines to share information, relies on pilots manually or verbally reporting turbulence intensity based on their subjective experience—often only after they have finished responding to the turbulence. This method presents challenges regarding the objectivity and timeliness of turbulence information.

EDR (Eddy Dissipation Rate) has gained attention as a technology to address the challenges of C-PIREP. EDR is an indicator of airflow turbulence recommended by ICAO as a turbulence standard. It is automatically calculated by a computation program installed in an aircraft's computer using sensor data from the aircraft and is reported to the ground in real-time. Theoretically, this eliminates ambiguity and time lag.

In January 2021, the JAL Group became the first in Japan to implement EDR, launching a system that automatically reports turbulence information to the ground in real-time. At the same time, the airline also introduced a system, jointly developed with a private meteorological company, which utilizes AI to rapidly process the automatically reported turbulence data and immediately notify aircraft in flight. As a result, there is now almost no time lag between turbulence occurrence and information sharing.

Currently, the EDR program is installed on some Boeing 737 and 767 aircraft, covering approximately 35% of the JAL Group's fleet. However, technical challenges remain in expanding its installation to more aircraft models, and increasing the volume of turbulence data will take time.



Turbulence information observed over Japan and surrounding areas

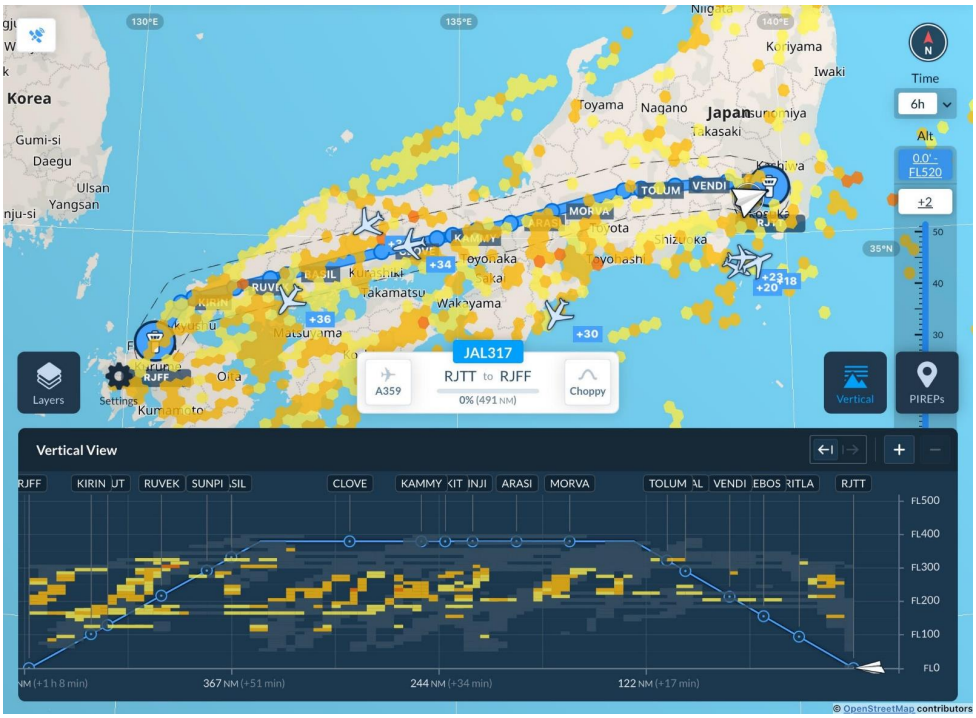
As one approach to overcoming the challenges of the existing EDR system, the JAL Group has been exploring the adoption

of the latest technology that allows for easier access to turbulence information from a greater number of aircraft. A trial operation of this technology began in fiscal year 2023.

This technology utilizes an application installed on tablet devices used by pilots during flight. The application automatically measures turbulence intensity at five levels using the tablet's GPS data and accelerometer sensors. The measured data is then transmitted in real-time to a ground server via in-flight Wi-Fi. The turbulence data collected from JAL flights and other airlines is sent to the ground server and can be accessed via the application on the tablet through in-flight Wi-Fi.

By registering the aircraft type in the application, the turbulence intensity is automatically adjusted based on the size of each aircraft. This ensures that turbulence information reflects an objective measure that closely matches the pilot's actual experience, regardless of the aircraft size. Additionally, the viewer function allows pilots to check turbulence data along their flight route in both horizontal and vertical cross-sections, as well as to visually grasp the distribution of turbulence information reported by other aircraft.

For aircraft where GPS reception and Wi-Fi communication are available in the cockpit, simply bringing a tablet device with the installed application into the cockpit enables both the transmission and reception of turbulence information. When used in combination with EDR, therefore, this system has the potential to enhance flight safety by adding another layer of protection. However, since real-time data transmission and reception require a stable in-flight Wi-Fi connection, airlines must carefully assess their own operational circumstances and determine the appropriate balance between EDR and this new technology.



Turbulence information along flight routes (vertical turbulence distribution)