

Aircraft flight is greatly affected by meteorological phenomena. Currently, a fully functional system comprising people and technologies is being used to minimize the impact of weather. Technology has been researched to more actively utilize weather information and has been put into operation to further reduce the effects of weather. In fact, this is also a field in which JAXA specializes. Here, we will introduce cutting-edge aircraft operation technology focusing on wind.

Airborne turbulence detection system

Detecting turbulence before it is encountered

In February of this year, Hamaki Inokuchi and others on the Operation and Safety Technology Team completed the world's first successful advanced detection of clear air turbulence 6 km in front of an aircraft in flight at an altitude of 3.2 km by using the turbulence detection system under development. With this, the practical application of an airborne turbulence detection system is finally becoming a reality.

Systems that can be mounted on aircraft

Inokuchi and his team developed a turbulence detection system that uses Doppler LIDAR. By emitting laser light to detect remote wind turbulence, the system can let us know when turbulence occurs. Large-sized Doppler LIDAR that is used on the ground is already in operation, but we still don't have one that can be mounted on aircraft. Currently, with weather radar mounted on aircraft, we can detect, in mid-air, rain and cumulonimbuses, which can cause turbulence, and take special precautions to avoid them or ensure that seatbelts are buckled. However, we cannot use radar to detect "clear air turbulence", which is not accompanied by raindrops. If Doppler LIDAR can be mounted on aircraft, we would be able to detect turbulence in clear weather before it is encountered, making it

possible to detect turbulence in all weather conditions when used together with weather radar.

The idea of a turbulence detection system using Doppler LIDAR dates back to around 1990. At that time, Inokuchi and his team had been tackling development of equipment using lasers to measure the position of high-speed projectiles from the ground. By calculating the time that emitted laser light reflects back to the aircraft, the aircraft's position could be known; however, because light scattering before reaching the aircraft was the cause of some error, trial and error was applied to determine how to cut the scattered light. Aerosol was identified as what causes light to scatter. It was believed that if we knew the speed of the aerosol suspended in the atmosphere, we could understand the movement of the airflow, which could be used in the

detection of turbulence. By applying optical communication technology (fiber amplifiers), they could see that a relatively small device could be made, and they started development of an airborne turbulence detection system in collaboration with manufacturers. During a flight test in 2002, they succeeded in measuring remote airflow with a prototype. They had demonstrated for the first time in the world that a system can be made small enough to be mounted on an aircraft. At the time, it was able to measure 1.5 km ahead, but as the output of the fiber amplifier has since gradually increased and the signal processing method of the measured data was further improved, we can now boast the world's highest performance of measuring wind 30 km ahead on the ground and 5 to 9 km ahead at high altitudes.

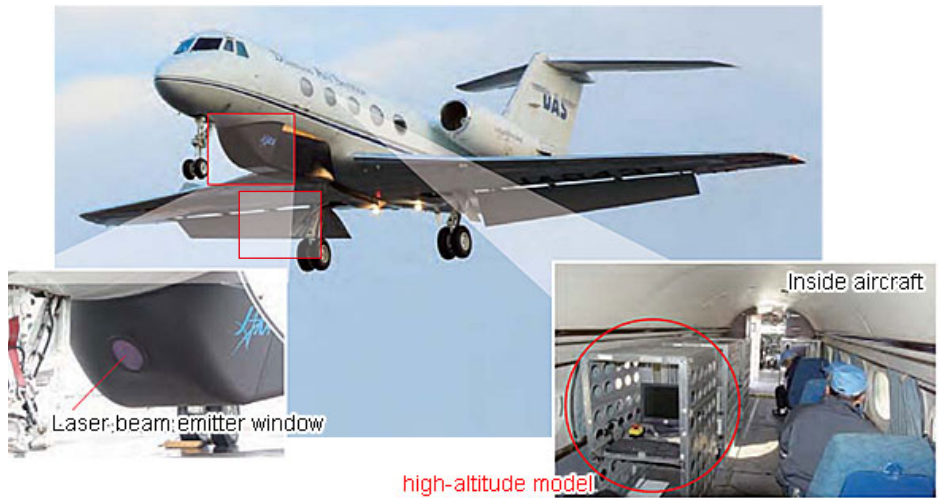
■ If an airborne turbulence detection system could be realized (visualization)

Detection phase	Response method
During takeoff	Aircraft waits to take off until turbulence decreases
During altitude changes	Ascend/descend where turbulence is weaker
During cruising	1. Light up the fasten seatbelt sign, and discontinue passenger services 2. Automatic control of aircraft helm
During landing approach	Redo landing

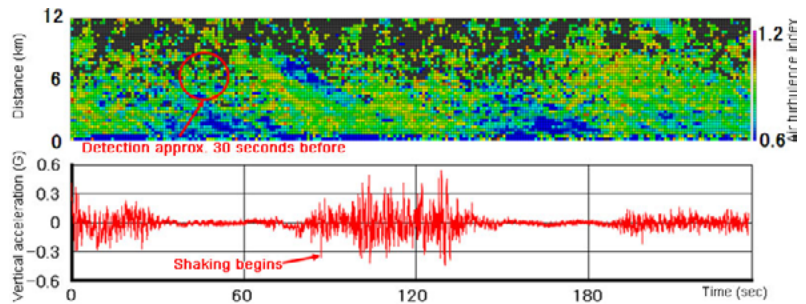
Preparing for sudden shaking

The system can already measure from a long distance at low altitudes, reaching the level for practical application. However, the device measures only short distances at high altitudes and must be enlarged in order to increase the output to extend the distance. In the future, we plan to study technology for relaying the data on turbulence detected at high altitudes to the autopilot system in order to control the aircraft and reduce shaking.

We have already begun collaborative research with foreign and domestic aircraft and electrical component manufacturers for practical application. With the aim of demonstrating the technology in about five years, commercialization is expected to follow.



- System installed for flight testing (high-altitude model)
This system can detect not only clear air turbulence, but nearly all turbulence during clear weather, such as low-level wind shear and mountain waves.



- Sample of clear air turbulence detection
Clear air turbulence detected 6 km ahead at an altitude of 3.2 km on Feb. 2, 2012



Research team members
Operation and Safety
Technology Team



Low-level turbulence advisory system

Predicting landing difficulty from wind

Naoki Matayoshi and his section members of the DREAMS Project Team have been tackling development of a low-level turbulence advisory system to support pilots in making landing decisions. By estimating aircraft movements from wind monitoring data along the landing path, the system can assess in real time whether or not landing is possible. Since the trend in wind changes as much as 10 minutes later is also predicted and shown, the system is useful to pilots in making a decision on landing. With this system, we aim to halve the number of cases where landing is not possible as a result of wind.

Last year, through assessment testing of a prototype system at Shonai Airport in Yamagata Prefecture, they confirmed that cases where landing was impossible could be correctly predicted. This year, they will enter into verification tests with improved easy-to-read screens as well as further enhanced prediction accuracy.

Supporting pilot decisions

If there are buildings or topographical formations such as small hills close to the airport, the surrounding airflow changes, and wind shear (sudden changes in wind

speed or direction) or turbulence will easily occur. These types of atmospheric disturbance (low-level turbulence) disrupt the speed and attitude of aircraft flying at low speeds and low altitudes for takeoff and landing, which become difficult to perform. In some cases, a go-around or return to the departure point are necessary. This will not only upset passengers, but cause delays and, therefore, is a situation to be avoided from an economic perspective. Since Japan has very little level ground, many airports were constructed on rough terrain, creating numerous cases where low-level

Special feature Capturing wind changes to optimize operation

turbulences cause a problem.

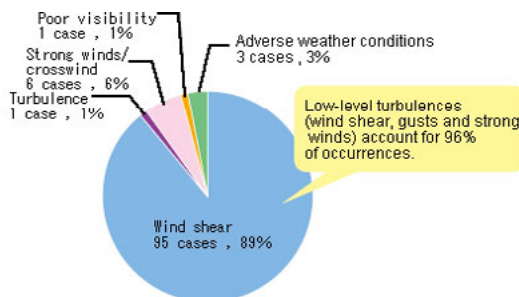
Currently, the weather stations set up around airports transmit the wind direction and speed on runways to aircraft and, at some major airports, provide information on the amount of change in the wind speed when changes above a certain level are detected over the takeoff/landing paths. In addition, equipment warning when wind shear has been encountered is being installed on aircraft. Referring to this wind information, the pilot determines whether or not to land, mainly based on prior experience.

A feature of the low-level turbulence advisory system is that it not only provides wind information, but goes a step further and determines whether or not landing is possible with the observed wind conditions. In addition to detecting and warning about winds presenting danger of an operation failure such as with a go-around, the wind status in 10 minutes is also predicted so that aircraft can wait in the air, without beginning approach, for the next opportunity to land where it was previously unknown if approach should be attempted. The system is operated and referred to by an aircraft dispatcher and transmits the above mentioned information to the pilot via radio.

Wind changes → Aircraft movements → Evaluating landing difficulty

Through collaborative research with Osaka University, Matayoshi and his team have been conducting detailed observation of low-level turbulence at Shonai Airport since 2009. They have been able to reveal several patterns of wind changes that adversely affect landing. Based on the obtained knowledge, technology has been established to predict short-term wind changes as well as estimate aircraft movements from these wind changes by using flight simulation technology, in which JAXA specializes.

The degree of difficulty in landing is



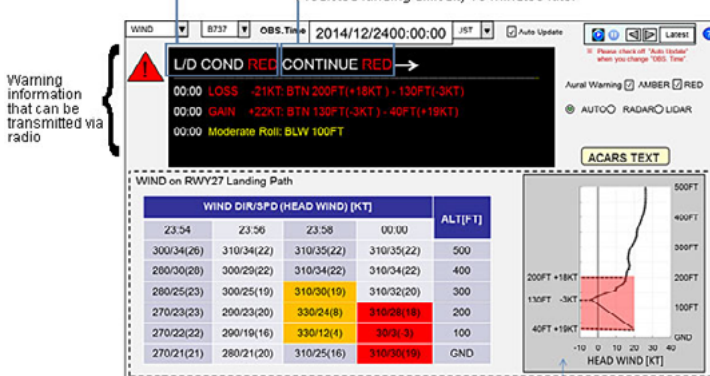
● Occurrences of go-around at Narita International Airport (2008)



Aircraft dispatcher

Current status of the degree of difficulty in landing

Predicted landing difficulty 10 minutes later



Shows observed values for wind direction and wind speed on the landing path. Altitude ranges where warnings have been issued appear in color. Updated every two minutes.

● Tentative advisory screen

predicted based on the estimated aircraft movements, but the issue is that, in an actual flight, a pilot in the same aircraft subjected to the same wind may make a different decision. The decision to land differs depending on experience. Therefore, they collected data on winds that actually did not allow landing at Shonai Airport as well as aircraft flight data and surveys of pilots, analyzed what movements pilots felt in determining danger and abandoning landing as well as what wind changes caused what aircraft movements, then modeled the pilot's decision process. They adopted a method of predicting the pilot's decision as a probability. As a result, the

"XX% probability of the pilot deciding to land" was derived. This is replaced with the degree of difficulty in landing (possibility of operation failure) and indicated in three intuitively easy-to-understand levels (red, amber and green). This is technology that contributes to improving service rates in addition to reducing the burden on the pilot.

Through collaborative research with the Meteorological Agency, evaluation of the low-level turbulence advisory system is being planned for next year on flights at other domestic airports. They expect airlines to put this system into practical application three to five years later.

Research team members
DREAMS Project Team
Weather Information Technology



Naoki Matayoshi



Tomoko Iijima



Eiichi Yoshikawa

Research and development in reducing wake turbulence separation

How much can the interval with preceding aircraft be reduced?

Air traffic control technology is also being changed with more active use of weather information. Matayoshi and his team are tackling research and development to reduce aircraft separation. They are developing technology that can flexibly set aircraft separations according to weather conditions, aiming at world standards in air traffic control technology.

Aircraft also produce turbulence

The strong air vortices emitted backwards from the wings of aircraft in flight are called wake turbulence. Since wake turbulence produced by aircraft taking off or landing remains near the ground at airports for a while, following aircraft may encounter such wake turbulence and experience attitude upsets that compromise flight safety. The aircraft therefore must keep a certain separation in takeoff and landing phases.

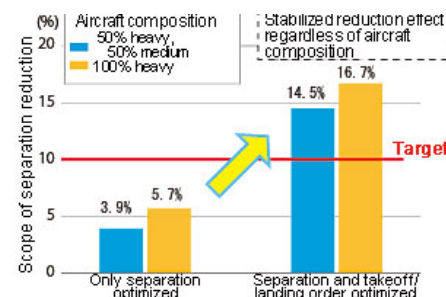
In fact, the length of time that wake turbulence remains is not always the same. The strength of the generated vortex differs depending on the aircraft weight and speed, and the behavior changes depending on the weather conditions (wind, atmospheric stability, etc.). For example, if there is a crosswind, the vortex will be blown away so that it doesn't remain on the takeoff/landing path very long. While there are differences in the weight of each aircraft, current separation is a fixed interval with an excessive safety margin, in relation to the weather, assuming the worst-case scenario of easily remaining wake turbulence. If this separation could be set flexibly according to weather conditions, more aircraft than at present would be able to fly.

Matayoshi and his team also propose a method that can further enlarge the scope of separation reduction by changing the takeoff/landing order of aircraft and changing the flight path according to weather information. They have developed two algorithms that can reduce the current separation by 10% (annual average).

One algorithm, the "wake turbulence prediction function", predicts how long wake turbulence generated by each aircraft will remain on flight paths based on weather monitoring /forecasting information and calculates the minimum safe separation. The other, the "traffic optimization function", optimizes the order in which aircraft take off and land as well as their flight paths in order to minimize the separations.

Creating technology to safely reduce separation

The amount of reduction in the aircraft separation is being determined by performing a risk assessment to ensure that "the wake turbulence encounter risk (probability that aircraft encounters wake turbulence) with the reduced separation exceeds the averaged encounter risk with the current separation with a probability of 10-3 or less". This method assures safety with reduced separation at a level equal or better than that with current separation. Furthermore, while quantitatively estimating errors in wake turbulence behavior predictions and weather monitoring/forecasting, we are able to reasonably reduce



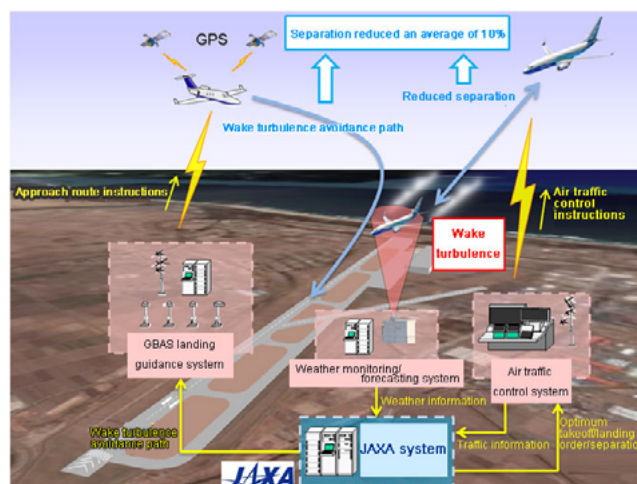
● Expected separation reduction (simulation of Tokyo International Airport)

the safety margin. Consequently, the optimally reduced aircraft separations can be calculated by considering weather conditions, flight paths and the takeoff/landing order.

So far, nearly 1,000 flights at Tokyo International Airport have been simulated to assess the "wake turbulence prediction function" and the "traffic optimization function" so that the separation could be reduced by 10% while maintaining safety. Similar technology developments are being carried out in Europe and the United States, but our method produces greater separation reduction. Next year, we have a plan to observe wake turbulence in over 3,000 cases at domestic airports and verify the prediction functions. In 2014, we will be reporting our research results to ICAO (International Civil Aviation Organization) as well as devising a proposal for standards to reduce wake turbulence separation.

Leading aircraft \ Following aircraft	Heavy	Medium	Light
Heavy (≥ 136 tons)	4NM	5NM	6NM
Medium (≥ 7 tons)	3NM	3NM	5NM
Light (< 7 tons)	3NM	3NM	3NM

● Current standards for wake turbulence separation
Classified according to aircraft weight. 1 NM is approx. 1.8 km.



● Conceptual view of system operations

Developing “usable” impact simulation

- Research and Development of Water-Landing Impact Analysis Technology for Aircraft Design -

From the research field

Environmentally Compatible Airframe Technology Team

In June 2012, JAXA performed a water landing test using an aircraft model in Yokohama National University's large test water tank. As part of the research and development of the analysis technology for estimating forces on an aircraft fuselage making a water landing, this test was performed with the purpose of obtaining data for verifying analysis methods. Since 2011, water landing tests have been performed through collaborative research with Yokohama National University.

Accelerating high-accuracy analyses

In aircraft development, we have something called the necessary ditching requirements. Ditching, meaning an emergency water landing, requires that aircraft be constructed to minimize the possibility of injury to occupants should it make an emergency landing on water. Through this collaborative research, Hirokazu Shoji and others

on the Environmentally Compatible Airframe Technology Team of the Structures and Materials Technology Section have tackled creating analysis technology useful for studying safe aircraft structural design that meets these requirements. Team leader Shoji describes it as “aiming for analysis technology that provides reasonably accurate results, even with a rather coarse mesh (computational grid)”.

Analysis technology can provide a computer simulation of the acceleration and skin surface pressure applied to an aircraft fuselage from the water surface. In order to perform calculations on a computer, a method called the finite element method (which is often used to calculate the strength of structures) is used. Specified method, which creates a computational grid for each fluid (water and air) to estimate the forces acting on the aircraft structure, is used so that the forces that change according to the motions of the object and the fluid can be simultaneously estimated. By performing the

calculations using these methods, the same results as if tests were performed can be estimated. High-accuracy results at the scale of the finite elements and a fine computational grid are produced, but it takes some time to obtain the results since there are an enormous amount of calculations. With “useable” simulation technology, it is necessary “to quickly be able to perform reasonably fine and accurate analyses”.

Tests simulating a water landing

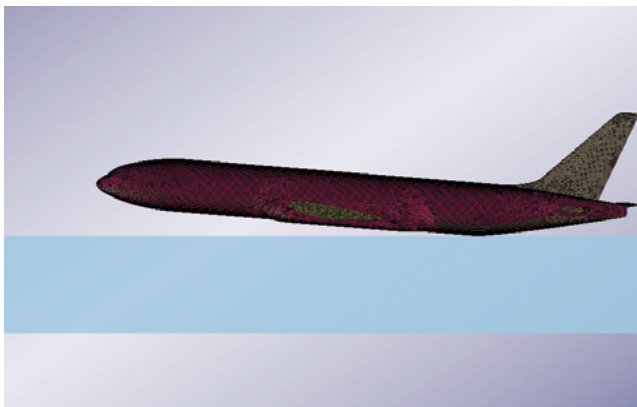
In order to polish the analysis technology, work is needed to compare the data obtained in the tests and verify its accuracy. Last year, we conducted water landing tests using a cylindrical model simulating only the outmold of the aircraft's rear



Flying wing model

Analysis diagram

(For the airframe configuration, the aircraft shape of the CRM, developed by NASA for researching aerodynamic relationships, was used.)



Structures and Materials Technology Section
Section leader
Hirokazu Shoji



fuselage, but this time we wanted to perform the test after manufacturing a model of the entire aircraft, with the wings and engine attached. We obtained data from tests performed under various conditions in order to study the effects of configuration differences (with/without the tail, with/without wings and with/without the engine) in addition to differences such as when making a water landing on the crest of a wave or landing on the trough or side of a wave. In order to verify whether the analysis technology can be further applied to aircraft structures of other shapes, we conducted water landing tests on flying wing models in October.

Currently, we are verifying the analysis technology based on the obtained data. Team leader Shoji hopes that “the technology can be applied not

only to the development of passenger aircraft but also to landing impact simulations of manned reusable vehicles”.

Necessary ditching requirements for airworthiness certification of aircraft

- Minimize the possibility of injury to occupants in an emergency landing on water.
- Under reasonable water conditions, the aircraft will float while occupants can escape, assuming there is also damage to the aircraft.
- If the effect of damage to windows and doors during a water landing is not taken into account, the windows and doors must be designed to withstand local pressures.
- The behavior of aircraft during a water landing must exhibit stability in water landing tests with scale models or a similarity analysis from test data of a similar configuration with behavior that is well known.

(Summary of important points from FAR 25.801 and Airworthiness Inspection Procedures III, section 4-7-1)



Conducting the Water landing test



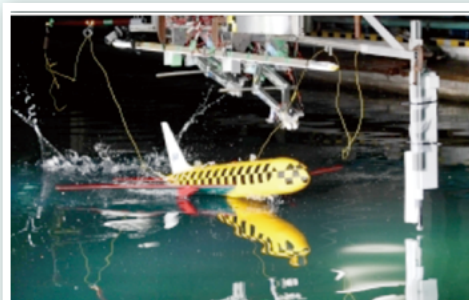
1. Aircraft assembly-This time, it was the actual configuration, with the engines also attached.



2. Test model passed to student and professor of the Yokohama National University ready and waiting at the large test water tank.



3. Set up in the suspension device. It is towed here at the start.



4. Water landing test performed - the aircraft model released and landed on the water.

How can we build up our future society and communication through a family aircraft transportation system?

From personal cars to personal planes [Part 1]

Do you know that there are people who use airplanes as a means of transportation, just like a personal car? They are not celebrities who jet-set across the world in private jets with a pilot. There are people who say that only airplane can provide mobility because of the surplus of space, for example, the lack of roads. What would it be like if we could use personal airplanes on a daily basis in our future society? JAXA's young professional researchers in the aviation technology field developed an interesting discussion on a future society with personal airplanes using future technology. This issue and the next one feature what they discussed.

Realizing a society that can respond to diverse values

Susuki If you think of the 20th century as the era when personal cars have rapidly become prevalent, the 21st century may become the era when personal planes become prevalent to form society's infrastructure. What future aircraft technology is necessary for realizing an era in which we develop a two-dimensional transportation network into a three-dimensional transportation network and when a wide variety and large number of airplanes will fly around at high speeds? We have gathered here today to talk about what research we should be pursuing toward that goal. Why don't we start our discussion with each of you taking a turn introducing your perspectives?

Kobayashi If planes were to be used for

personal applications, I don't believe that they would become prevalent unless they are more relevant than cars and are simple and beneficial. Operation, refueling and maintenance should be simple, and the purchase and maintenance costs should be affordable. With a user image of a couple who has reached retirement age using it on 2- or 3-day trips or a company employee with many domestic business trips-if this range was targeted, I think many could be sold. As for the performance requirements, the weight that can be carried on a two seater is 200 kg (including occupants and luggage). It must be able to travel between Tokyo and Osaka in one hour. It would be best if it flew on electricity, and was the size of a car when not flying. It would take off and land using highways, instead of from houses. In that case, the STOL (short takeoff and landing) and VTOL (vertical takeoff

and landing) technologies are necessary. Otherwise, being extremely concerned with disaster prevention, so, from the viewpoint of disaster prevention, normally an airplane would not fly in an emergency, but it would be great if you could press a button to make the airplane fly off, like a grasshopper, to go to a predetermined location. I have four concerns about trying to achieve this. 1) Is there an airframe configuration and engine that meets the requirements? 2) What fuel would be used? 3) If there was autopilot, how much can errors, such as incorrectly entering the destination, be reduced? and 4) How can collision avoidance technology be used?

Kubo In fact, I think the problem of airspace is extremely difficult. In addition, human operators may not be eliminated in the future. Autonomy is associated with artificial intelligence, where something makes a

Moderator

**SUSUKI Ippei**

Former Senior Chief Officer of Aviation Engineering and Research, JAXA. Joined the National Aerospace Laboratory of Japan (now JAXA) in 1977. Specializing in structures and materials.

**TSUDA Hiroka**

Joined JAXA in 2004. Pursuing Crew Resource Management (CRM) and Synthetic/Enhanced Vision System (S/EVS).

**NISHIZAWA Akira**

Joined the National Aerospace Laboratory (now JAXA) in 2002. Pursuing research of electric aircraft. Has flight experience piloting small airplanes.

**HIRANO Yoshiyasu**

Joined JAXA in 2005. Pursuing research of composite materials and structural design. In charge of structural design of experimental aircraft for the Supersonic Transport Team since 2008.

**KUBO Daisuke**

Joined JAXA in 2008. Pursuing research and development of Unmanned Aircraft Systems (UAS).

**KOBAYASHI Keiji**

After working in the industry, joined JAXA in 2009. Pursuing research and development of the Disaster Relief Aircraft Management System Network (D-NET).

decision on its own and does something, but this is still something that technically cannot be done, and we have just now reached the point where flying is done automatically as programmed in advance. The difficulty is: how will something unexpected be responded to, and wouldn't a human pilot also have a part in bearing the responsibility in such a situation? For this reason, in order for a system to operate in the extremely wide environment of airplanes, I think that people will not be removed so easily. On the other hand, I think it would be best to automate planes that are only handling cargo. If airplanes were to become like personal cars, I think it would be necessary to create an environment where nothing is unexpected and you can ride without doing anything. Since we cannot fly unless traffic is tightly controlled so that it does not become crowded when numerous airplanes are in the sky, I think that the fun in flying by operating the airplane yourself would be lost. Therefore, we may be flying in limited situations where it is increasingly automated.

Tsuda I thought about this on the premise that there will be one in every home, instead of a car. For that, circumstances are required where it would be better to have an airplane than a car. In Japan, although the driver's license for a car is in the range of about 300,000 yen, getting a pilot's license for an airplane, since it requires many hours of training, is about 10 times more expensive. So, the license for an airplane must be brought to the same level as for a car to achieve good cost performance as a means of transportation. We must have an environment different than it is now so that flights can be safe even with an increasing number of vehicles. The risks are two-fold: one is the risk of the plane coming down while you are flying or while someone is riding on it, and the other is the risk of the plane coming down over people living on the ground. How will these risks be managed? We also have environmental issues such as noise and exhaust, and we must change the fact that airplanes are

so expensive in the first place that they cannot be purchased by individuals. I have considered measures for these issues. For example, if we improved the efficiency of the airplane system and advanced automation, we could expect to decrease the training time. There is a way of flying, called instrument flight rules (IFR), where the plane is flown using its instruments when visibility is poor and nothing can be seen or information cannot be obtained through the window. Currently, in Japan, this is a separate license. Therefore, using an HMD (Helmet Mounted Display, a display mounted on the head), for example, the pilot can see and get information instead of the outside landscape (refer to "SAVERH" in Explanation of terms.) and is able to fly with only basic flight training, in other words, without a separate license. If the training time could be shortened, the costs should also be further reduced.

How can flights be safe in the midst of an increasing traffic volume? If the airplane was made smaller and equipped with mechanisms that blow out air to correct attitude like Gundam's system, it should be possible to set narrow traffic routes. Instead of a flight method where air traffic controllers give permission for each airplane like current flight control, I think it is also necessary for airplane pilots to be able to fly by communicating with each other. In addition, this may be an extreme measure, but if we want it to spread, unless we eliminate railroads and prohibit cars, it may be difficult to achieve this in Japan.

Hirano I think that the biggest obstacle to realizing one airplane per household is the image that aircraft easily cause fatal accidents. To dispel this, I wonder if it must first become a means of moving among set locations. Conversely, the reason why personal aircraft are not realized is that it is necessary to innovate technology. I think



that they would more likely be used if we took a path of first using them like buses at determined altitudes, and beyond that, if there are technological innovations, they will be gradually developed.

Nishizawa First of all, what will change, and how, if aircraft are popularized? I think that the biggest thing is that lifestyles will change. The number one advantage of airplanes is that you can move over long distances in a short period of time. I think that the concept of the living area will become larger than now, making the living area a very wide area. If there will be one aircraft for each household, it would be better if the living location and working location were further apart. Most people now cannot make those choices independently, but I think there is a greater sense that it is no longer relevant. Some people who are doing just that are those working in Silicon Valley in the United States and getting there by airplane from far away. But, they are not going every day. One reason is the weather, but also they can work from home, so they do not need to go to work every day. Actually, we too do not need to go to work every day. Since I think that this trend is continuing more in the future, if airplanes were like personal cars, we could go anywhere, even from far away, at any time, whenever necessary. Then we can choose an even better environment. I think the next step to this would be for aircraft to become popularized. Most Japanese now have traveled overseas by airplane. This is the first step to popularizing aircraft. I think the next step would be changing from public vehicles to private vehicles. This

Explanation of terms

【SAVERH】

SAVERH (Situational Awareness and Visual Enhancer for Rescue Helicopter) is research in visual information support technology for pilots of rescue helicopters. This technology combines sensor information, for example, from infrared cameras, with three-dimensional information of topographical and natural features generated from a database, and displays the information on the instrument panel display or HMD (helmet-mounted display). SAVERH aims to improve the pilot's situational awareness as well as enable safe operation, even during bad weather or at night.



External view of HMD



Sample HMD display (composite)

should be visited again in the future and would be technically possible.

There is the issue of eliminating railroads and cars, as Ms Tsuda said. Looking at it from the other side, there are countries, other than Japan, that have poor railways and roads, but are said to have a very large population. If airplanes could be inexpensively available in those places and could be operated easily, I think they would spread. In terms of the technology to realize that, it is necessary to automate operation and make getting a license simple and easy. If the flight control system was similar to that of a car, I think something like that could be possible.

Susuki I found that your ideas have covered very interesting topics. Inexpensive planes may be an opportunity for countries without well-developed railway networks and roads to develop rapidly. For example, I wonder if there wouldn't be a possibility of personal planes from Japan to be used like that in the world.

Nishizawa Unfortunately, the chances are small that a new transportation system using planes could be developed in Japan and spread to the world. There is a feeling that Japan takes the lead, but when an existing transportation system has been developed this much, there is no strong need to introduce a new system. However, if we could create technology that will lead to the popularization of airplanes, that would be a great advantage.

Hirano There is also the issue of cost-effectiveness. I have heard that mobile phones in China spread before the landline network was developed. The reason is that, since the country is so wide, it was cheaper to expand the mobile phone network, instead of developing the landline infrastructure. In areas, in Japan too, that are depopulated and where railways have been abandoned, it would be possible with a higher cost-effectiveness.

Nishizawa With an advancing

depopulation, those municipalities will no longer be able to maintain the minimum required infrastructure for living. Hospitals are a good example. If the hospital is far away, it would be most efficient to transport by plane. Like from a remote island. These new uses for airplanes may spread more.

Susuki If the living area becomes larger than it is now, travelling by air is faster.

Nishizawa That's right. Let's say that if there were affordable airplanes that can be easily operated by anyone, highly capable human resources could be brought together if businesses would make their own airfields that could be used by anyone from anywhere. If airfields are made, facilities such as hospitals and schools would be placed around them. People would come from various places and the value of the city, or social infrastructure, would increase with the presence of the airfield, and then there would be a motivation to make many more airfields. If there are economic benefits, more companies and local governments will do these things, and since there will be an increase in the choices of where you can go, that will become the lifestyle.

Hirano The reverse is also true. As opposed to living where land is inexpensive and commuting by airplane, there is a pattern of companies, for example, securing vast pieces of land where it is cheap so employees can commute from anywhere.

Nishizawa Some people want to live in the country, and some people want to live in the city. I think that personal aircraft will enable us to realize a social system that can respond to diverse values.

Coexisting with the existing transportation system

Susuki If "growing rice in a field in Fukushima while living in Aichi" can be realized, the structure of industries, such as agriculture, will also change. I wonder if the delivery of cargo will also be replaced by airplanes.

Nishizawa High value-added items, such as perishables, are already transported by air.

Hirano There is an appropriate means of transport depending on demand. I think that we should transport items where it is worth taking advantage of the speed and transporting them on a new aircraft system, but items where it is not worth it should use the transportation system that

has been used until now.

Susuki If the road network is used for taking off and landing, wouldn't they disturb cars?

Nishizawa I think it is better to make new airfields. Aircraft will require STOL capability. But, with airfields having runways 20 m wide × 400 m long, for example, the land area is tens of thousands of square meters. This is comparable to the size of a distribution center for a courier service. I think that could hold a company, if one were so inclined.

Susuki What size of airplane would fly there?

Nishizawa About four people. The convenience of VTOL is highly desirable, but since it consumes a large amount of fuel, one that takes off using a runway should first be realized. I think gradually there will be different ones for different purposes.

Susuki VTOL is small and safe, but is a path likely where it can be used by the masses?

Kubo A tilt rotor civil aircraft (aircraft that can take off vertically and fly forward by changing the angle of the rotor blades) is at the testing stage for the practical operations. I think we will be able to achieve it in the near future, but its price is high, compared to ordinary aircraft. Eventually, the choice will be determined by where it can be marketed. Even if one aircraft per house is difficult, I think that will differ considerably if it is seen from the sense of a rich person driving a luxury car. I feel that it should go faster if I was looking down on a road that is congested.

Susuki Are there regions overseas where personal aircraft are becoming prevalent?

Kubo About how much do they cost overseas?

Nishizawa A license can be obtained for several hundred thousand yen. The aircraft would be from several million yen for an inexpensive one if it is second-hand. Its maintenance costs are in the range of 2 to 3 million yen a year.

Kubo If that is the situation and the costs are also reasonably low, it would be possible. There is the concept of the air taxi (small aircraft that operate whenever necessary), but what about the weather? I would want to fly at any time.

Nishizawa Any time would be difficult with only visual flight rules (VFR). Since you cannot fly on days with bad weather, the service rates would go down tremendously and it would not work out as a business. If the instrument flight rules (IFR) were more fine-tuned, you would not be affected by weather. I think that will be



resolved since such research is progressing now.

Is technology necessary for enhancing human capabilities?

Susuki What are some of the technologies now?

Kubo There is the instrument landing system (refer to "ILS" in Explanation of terms), which enables landing even in bad weather, but the conditions are quite strict for introducing CAT3 (refer to Explanation of terms), and there are only few airports in Japan that have it. The reality is that this type of system to reduce cancellation rates requires a considerable cost. I guess, even with the technology, the cost is so high that there is still room for a better solution.

Kobayashi With CAT3, the maintenance costs of facilities set up beside airports are high. Since large equipment must be mounted on the aircraft to make use of this system, which only large airports have, it can only be placed on large airliners. Let's just classify VFR and IFR a little here. Basically, flying under the pilot's responsibility in conditions where the weather is good and objects in the distance can be seen (good visibility) is VFR. In contrast, flight using autopilot or ground installations because there is poor visibility and the pilot can no longer fly on their own power is called IFR, and the responsibility basically does not lie with the pilot. SAVERH, which is being researched by Ms Tsuda, is such a technology that increases the pilot's capacity under poor weather conditions.

Tsuda Under bad weather conditions, that is, IMC (Instrument Meteorological Conditions), you can fly only with IFR. In order to attempt flying with IFR, the aircraft must first be compatible with IFR, and the pilot must have a license for IFR. This aircraft is expensive, and the pilot also requires more training hours, in other words, it is costly. With SAVERH providing new information to the pilot, they can attempt VFR flight, even in IFR weather conditions (IMC).

Susuki Is that information such things as topographical information?

Tsuda Yes. The pilot would be able to fly

with information equivalent to that obtained from the outside view. There are various methods of providing information to pilots. For example, at night, even when obstacles are not visible to the human eye, they are visible by infrared cameras. If those obstacles seen by the camera are displayed, pilots would know where things like mountains are. Because SAVERH also knows the location of the aircraft, you would know where and how you are currently flying.

Susuki I see. So, what is detected is translated so that the pilot understands it.

Tsuda That's right. Here, it is thinking like a human pilot. But, how would that be? Technically, we must consider if there is enough technology to allow landing, even with no people involved.

Susuki You're right. Now a pilot who has trained a lot is necessary, but isn't a direction conceivable for research where information detected by machines could be directly processed by a computer, specifically without human involvement, so that we can disembark safely.

Kobayashi In other words, you mean do we need research in technology to enhance human capabilities?

Susuki Right. It would be the concept of the pilot of the future.

Kobayashi From the perspective of disaster prevention, it is absolutely necessary. Because, in search and rescue, there are things that can only be found by people. If, in the distant future, computers become extremely advanced and everything can be collected through multi-sensing, people may no longer be necessary, but I don't think that can be realized in the near future. So, in the meantime, I think research like SAVERH is needed. Since there are major labor-saving benefits for certain operations, I think we are also going in the direction of more and more automation.

Susuki What do you mean by things that can only be found by humans?

Kobayashi For example, situations where people are lost in the mountains. Where a person will go cannot be found by machines, no matter how much their sensing performance is advanced. The reason is that

a pattern of searching here, then going there must be created from experience.

Susuki But, chess and shogi can be played with modern computers. So, if they could be crammed with the vast amount of previous patterns, wouldn't they be able to search for a hit. When I think about it, choosing where a person will climb seems easy for a machine, so wouldn't they be able to do it easily.

Kobayashi They should be able to operate within a scope of assumptions, but I think it is absolutely impossible with machines where various factors are conceivable or it is not known what, such as a disaster, will happen.

Susuki For example, if a multiphase flow, where sand and water are mixed, occurred, wouldn't it be efficient for a computer to analyze where people will go so that, according to those results, that location can be searched first?

Kobayashi Even if you could find 80% quickly, it's not that good if 80% of people in rescues were found. There are times when machines triumph and times when only people can do something. Therefore, it's necessary to improve human capabilities by using technology. I am not against humans using them to make predictions. Naturally, automation is necessary, but it will never be where everything is done by autopilot.

Nishizawa This is a difficult conversation to clarify as black and white at the moment. Imagining it from a general user's perspective, if operation was automated, I would certainly like for it to be available. That said, for those who say it would be best not to have to do anything after selecting the destination and pressing a button, I don't think that this will be the case.

Kobayashi It seems contradictory, but I am not against autopilot. I think it is best to simplify the operation. It would be simpler if tasks could be made into routines. There is a different scene than that, and I think that might be VFR or IFR.

(Continued in the next issue)

【 ILS / CAT 】

The ILS (instrument landing system) is wireless landing support equipment that emits radio waves from the sides of the runway for aircraft on landing approach to indicate the course for approaching the runway. This safely guides the aircraft to the runway, even during poor visibility such as with bad weather. ILS is divided into five levels, according to the weather conditions. These levels, called categories, are CAT1, CAT2, CAT3a, CAT3b and CAT3c.

Explanation of terms