

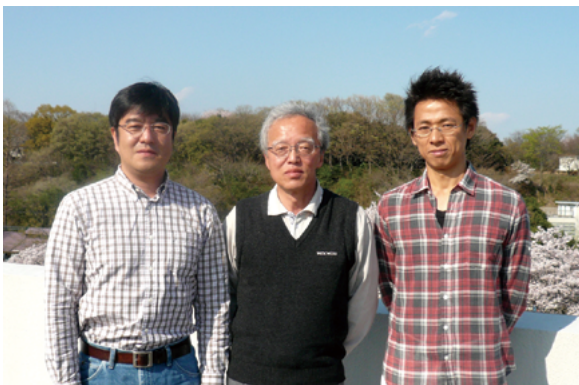
3D animation of aircraft operation from flight data DRAP software to support pilot training

Human factors have been considered one of the most critical problems that have recently threatened flight safety. In order to attain a significant reduction in the number of accidents, prevention of human errors caused by flight crews should be one of the most crucial subjects. To maintain and improve high-level flight safety, pilots frequently perform various training activities on a daily basis—one of these consisting in reviewing their own flight data. To provide support in this activity, DRAP was developed in collaboration between JAXA and airline companies. Below, members of the Operation and Safety Technology Team who participated in the software development explain how this JAXA technology is related to safe operation of aircraft. So, next time you take a plane, we hope that you may remember DRAP.

Q Could you first explain the pilot's activity of "reviewing their flights"?

Operation and Safety Technology Team Human Factors Section

(From left) Koji Muraoka, Noriaki Okada, Ryuji Yamamoto
Hoping that DRAP will be used by more airline companies to improve flight safety



A All of the airlines operating medium and large aircraft implement an FDM (Flight Data Monitoring) (*) program as one of the activities performed within the airline. An FDM program uses flight data collected during daily airline operations to improve flight safety and operational efficiency. A typical FDM program activity is to analyze flight parameter deviations from specified limits (e.g., a high descent rate during final approach), which are called exceedance events, and to feed back the results to pilots as safety information. In addition to the exceedance analysis, Japanese airlines feed back flight data sets of normal operation to pilots when they request to review their own flights for the purpose of enhancing their skills for safe flights in the future.

(*) This on-board flight recorder is called the QAR (Quick Access Recorder). It is different from the flight data recorder (FDR), known as the black box, which must be installed and is analyzed in case of an accident. The QAR features a high number of recorded parameters, a high data recording frequency, a long recording time, easy



DRAP Window

data downloading as well as impact-resistance and heat-resistance in the event of an accident.

Q What type of software is DRAP?

A DRAP (Data Review and Analysis Program) is software that converts this data so that it can be played back as a 3D animation.

In the past, data recorded on aircraft was presented to pilots as numbers, graphs and text. By using DRAP, information such as instrument readings and the pilot's outside view during maneuvers as well as how much the control wheel was moved can be visually recreated in chronological order. (However, the pilot does not appear in these animations.) As compared with reviewing the flight as numbers and graphs, pilots can gain a quick and, therefore, intuitive understanding of their flights.

Main functions/features of DRAP

- A three-dimensional animation of flight data is

displayed in the pilot view (from the cockpit), God's eye view and flight instruments view. In addition, there is a function for displaying a two-dimensional map showing the flight trajectory on a



horizontal plane and a function for displaying control operations.

- Since Japanese topographical and runway parameters have been collected into a database, animations for takeoff and landing can be viewed for specific runways.
- Algorithms reconstruct airframe position data at takeoff, landing, cruising and go-around based on the recorded flight data.
- Aircraft aerodynamic coefficients are used to accurately extrapolate vertical/horizontal winds. With this function, more precise wind information, which does not appear in aircraft instruments, can be reviewed.

Q What are the more interesting features of DRAP?

A Compared to previous software with similar functions, it is easy to use. There is flight data analysis software with a 3D animation display function available on the market. However, most of them were developed for users having knowledge of computers and flight data analysis, and it is not so easy for general users, including pilots, to become familiarized with the software.

Therefore, with the main aim of allowing pilots to use DRAP from computers installed with it in order to quickly review their flights, we designed it according

to the following basic ideas. (1) Simplifying flight data downloading and the user interface. (2) Reducing as much as possible the amount of time necessary to convert the original data to DRAP data.(3) Allowing pilots to review data from various points of view.

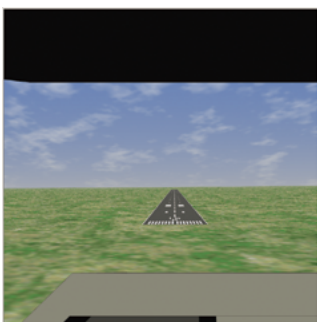
Q How did DRAP come about?

A Based on wishes expressed by airline companies, DRAP was developed using technology for "flight measurement", "experiment data management", "data processing", "flight simulation" and the "cockpit interface", accumulated by National Aerospace Laboratory of Japan (NAL), one of the organizations preceding JAXA.

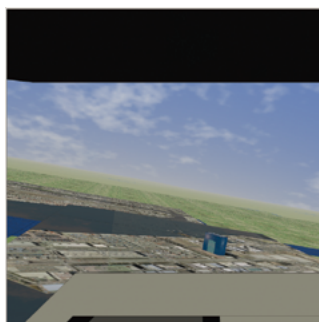
Software development in collaboration with Japan Airlines (JAL) began in 1999. Its practical application was evaluated by JAL in 2000, then by All Nippon Airways (ANA) and Japan Air System (JAS) in 2001. At first, it was compatible with B747-400, B777 and B767 aircraft, but now DRAP version 2.4 (running on Microsoft Windows 2000, XP, Vista and 7) is compatible with nearly all large aircraft operating in Japan and is being used by numerous airline companies.

Q How much is DRAP contributing to improved flight

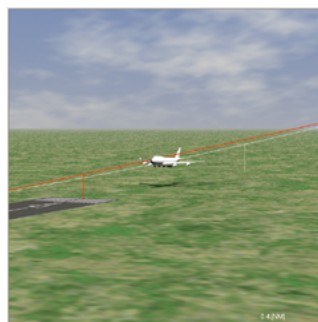
Example of data display functions



Pilot view ● Final approach (runway from left seat viewpoint)



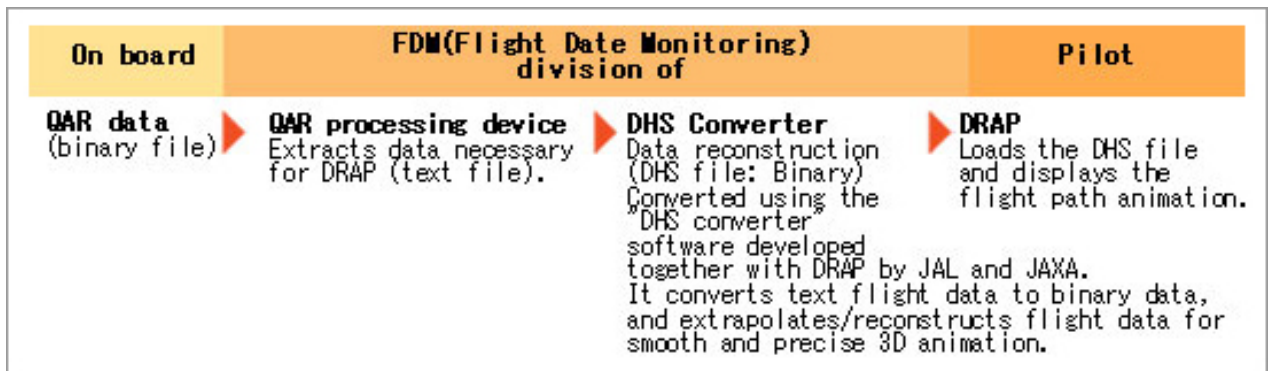
Pilot view ● Turning to final approach leg (buildings near the airport)



God's eye view
Red line: Standard course;
White line: Actual flight path



2D view
To review approach flight path compared with a standard approach pattern.



Process of displaying in DRAP the data obtained from aircraft

safety?

A Flight safety has been maintained and improved through the overall efforts and activities of airlines, aircraft manufacturers, authorities, and so on. We cannot measure in numerical terms what percentage is DRAP's contribution or how many accidents have been avoided from the use of DRAP; however, we would like to believe that it is certainly being used to maintain flight safety on a daily basis.

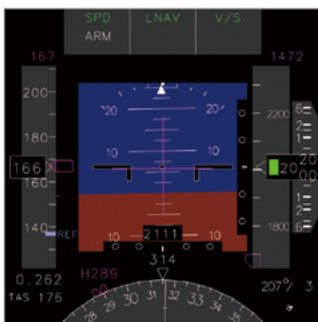
Q What were the main difficulties during development?

A How to configure the display in a way that makes

sense to pilots. Appropriately displaying the desired information was determined through trial and error. Improvements were incorporated while referring to the opinions of pilots who had used it.

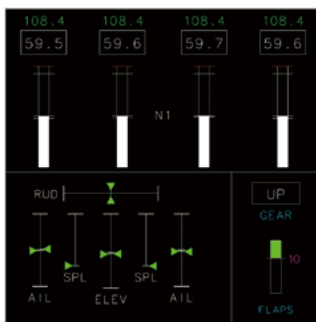
Q What are your future goals?

A We would like to enhance its functionality by making it compatible with new aircraft models and further expanding the application of DRAP. DRAP continues to evolve according to changes in the data handling environment.

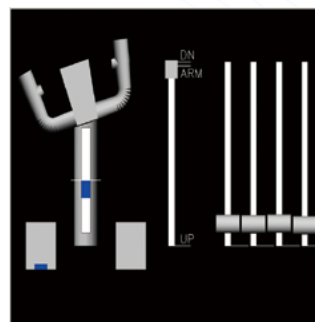


Instruments ● PFD: Primary flight display (B747-400)

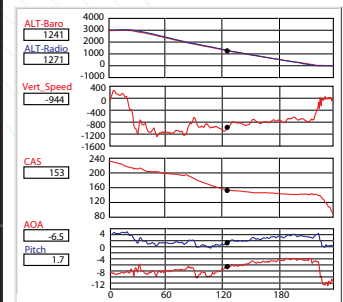
The cockpit instruments appear differently for each aircraft model.



Instruments ● Engine/flight control display (B747-400)



Controls ● B747
Shows how much the control wheel, rudder pedals, thrust levers and brake lever were moved.



Time history
The black dots move in the graphs as the animation progresses in order to show the current values.

Small-scale wind shears make landing difficult

Wind shears can easily occur if there are buildings or topographical formations around the airport. If there are small-scale wind shears (on a scale between tens and hundreds of meters) at low altitude, it may be difficult for an airplane to land since its attitude is affected immediately before landing (fig. 1).

Doppler radar, which monitors wind from the movement of water drops by using radio waves, is a device used to monitor wind shear from the ground. Already introduced at some hub airports in Japan, these are being used to monitor large-scale wind shears (on a scale of about 1 km or more), which are suspected to be directly connected to accidents. However, currently, they are not able to monitor small-scale wind shears as shown in fig. 1.

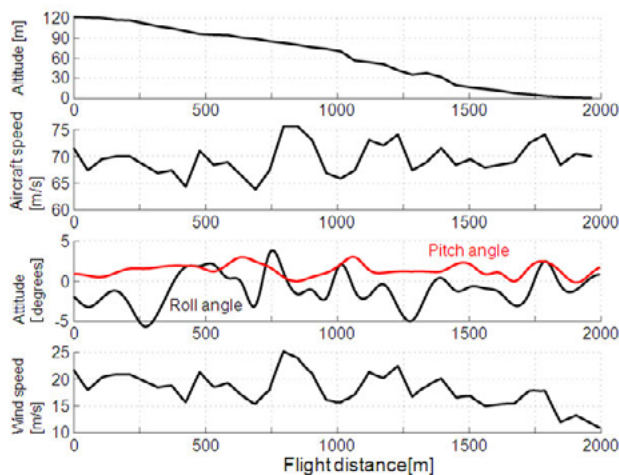


Fig.1 ● Sample of landing data in low-level wind shear (provided by All Nippon Airways Co., Ltd.)

This is a sample of flight data for a passenger aircraft that landed during a wind shear at a low altitude. The wind changed on a scale between tens and hundreds of meters, which caused changes in the attitude and speed of the airplane. The pilot commented that it was difficult to stabilize the aircraft attitude.

Accurately measuring wind shears with high-resolution radar

At JAXA, we have been developing a technology for monitoring small-scale wind shears by using the newest high-resolution Doppler radar. Originally developed at Osaka University to monitor micro-scale meteorological phenomena, such as "guerrilla" downpours, this radar is compact and inexpensive (a fraction of conventional radar) while featuring the capability to monitor small-scale wind shears at an extremely high resolution. (Table 1 and Fig. 2)

This high-resolution radar was installed at Shonai Airport in Yamagata prefecture (an airport where wind shear tends to occur), and the wind on the landing path was monitored. At this airport, the service rate for scheduled flights is reduced by 5% during the winter, when seasonal winds are strong, as shown in fig. 3. The objective of monitoring was to determine

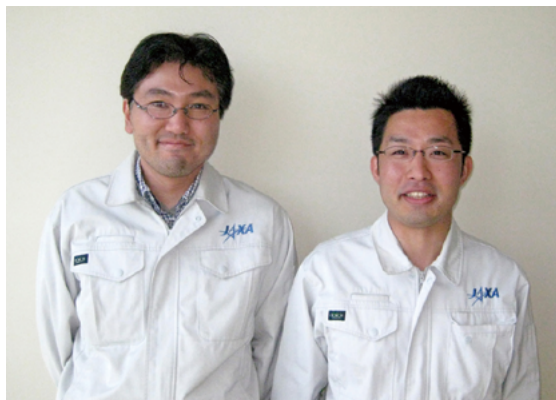
Table 1 ● Comparison of high-resolution radar and conventional radar

	High-resolution radar	Conventional radar
Monitoring range	Approx. 15 km	Approx. 120 km
Resolution	Approx. 10 m	Approx. 150 m



Fig.2 ● High-resolution radar installed at Shonai Airport

Weather Information Technology Section
 (From left) Naoki Matayoshi, Masahiko Sugiura



the cause of this. It was the first attempt worldwide to monitor wind shear around an airport using such a high-resolution radar.

A sample of the obtained wind data is shown in fig. 4. An area of a few hundred meters on the landing path containing a combination of high wind areas and low wind areas was monitored (fig. 4 (1)). We concluded that wind shears of a small scale of about 150 m was the cause of airplane attitude disruption at an altitude of 60 m or less (fig. 4 (2)).

This monitoring was the first quantitative clarification of small-scale wind shears at low altitudes, which make landing difficult for passenger aircraft. It further demonstrated that high-resolution radar, which was originally developed to monitor "guerrilla" downpours, is also useful to improve the operation of passenger aircraft.

Now, we will continue with research of a low-level wind shear advisory system that, in an easy-to-understand manner, provides pilots with information on wind shears monitored by high-resolution radar. We hope that, if pilots are aware of wind conditions on the landing path, we can reduce situations where landing is impossible and improve the winter service rate.

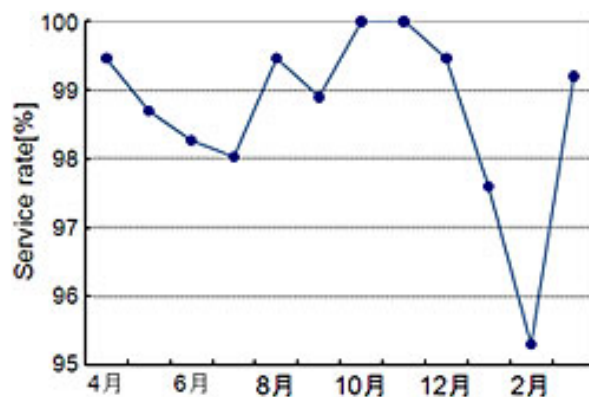
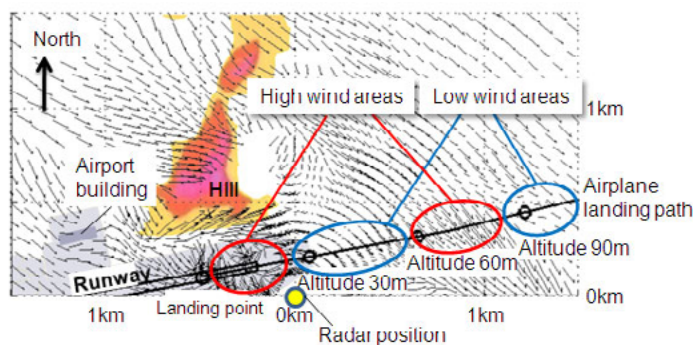


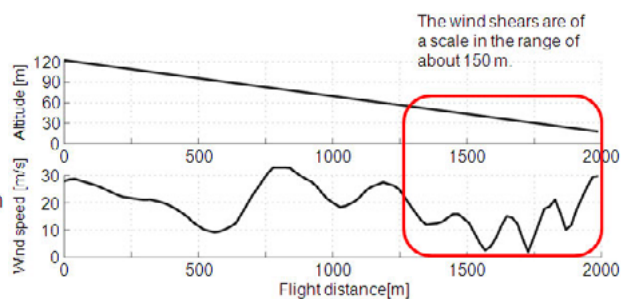
Fig.3 ● Service rate for scheduled flights at Shonai Airport
 (Average values over the three-year period between 2006 and 2008; provided by All Nippon Airways Co., Ltd.)

In conclusion, we would like to thank everyone at Shonai Airport who cooperated in this wind monitoring test.

(Naoki Matayoshi)



(1) Wind distribution (top view)



(2) Wind speed variations on landing path

Fig.4 ● Sample of wind monitoring results (with strong west-northwest wind)
 In the wind distribution diagram, the arrows indicate momentary one-second wind vectors (wind direction and speed).



Interview
People who fly dreams
Vol.16

Revolutionizing the world of air transportation with personal electric airvehicles

Powering aircraft electrically!

Unmanned and Innovative Aircraft Team
Akira Nishizawa

✈️ Do you think aircraft can be powered electrically like cars!—The answer is yes. Some aircraft lovers are already using them for leisure, but it shouldn't be a surprise if they become a common mode of transportation, much like a car, in the near future. We can hardly wait for the day when we can get our hands on this "innovative aircraft" that will greatly transform our way of life!

Significance of electric-powered aircraft

✈️ What is the Innovative Aircraft Technology Section researching?

Nishizawa We are tackling research and development of technology necessary for creating electric-powered aircraft that seat one or two people. Normal aircraft operate by burning fossil fuel, but we are aiming to replace this with an electric propulsion system.

✈️ What are the applications for a single- or double-seated plane?

Nishizawa Ordinarily, they are used for sport and leisure. In our research for the electric propulsion system, we are first attempting to achieve this in a small airplane as a flying test bed.

✈️ What stage has the research advanced to?

Nishizawa We have designed and

built a prototype of an electric motor system with a maximum output of 20 kW, checked its performance, and have obtained reasonable results. It provides an output that allows a single-person ultralight plane to fly.

✈️ What were the main difficulties?

Nishizawa Rechargeable batteries are installed as the power source; however, if we are to assume that the batteries should hold enough energy required for flight, the airplane will become seriously heavier than standard ones with fuel engines and, therefore, the batteries pose a low performance issue to for the airplane. The constraints of a large output and a light weight represent strict conditions that cannot be compared with other vehicles such as an electric car. However, we are not performing research on batteries themselves; instead, our job is to understand the various aircraft-specific issues that arise if existing technology, such as batteries and electric motors, is applied to aircraft.

Historically, battery systems have been changing rapidly, and each time, their efficiency has improved exponentially. I think it would be ideal if the demand for strong efficiency in aircraft applications further influenced battery development. Therefore, I believe it is also our role to demonstrate the significance of electric-powered aircraft.

✈️ What is the significance of electric flight?

Nishizawa One is that CO₂ is not exhausted. Another is that the energy efficiency is increased and the running costs are decreased. With current technology, it is impossible for large passenger aircraft to suddenly become powered electrically, and I don't think anyone can predict when it will become

possible.

However, although it is difficult to operate aircraft solely with electric power, since hybrid technology—which it combines with fossil fuels—is possible, I think that by following this step, we are going in the direction of reducing fossil fuel consumption as much as possible and, therefore, greatly increasing efficiency. Actually, various parts of newly released passenger aircraft will be electric. Energy is not only needed by aircraft engines, but also consumed in various areas, including cabin pressurization, air conditioning, flight control, cabin lighting and the galley. There are hydraulic, pneumatic and electric methods to produce these, but the future trend is to replace most of them with electric ones. By running everything electrically, energy efficiency is increased and overall aircraft energy consumption is reduced. In addition, there are other large advantages such as a reduced number of parts as well as easier design and maintenance.

Meanwhile, one- to two-seater electric aircraft have been actively developed over the past two to three years, mainly in the U.S. and Europe, and some are already being sold. Currently, sports and leisure are the main applications for those being purchased. Previously, electric flight in itself was a new concept, but the present conditions are changing considerably so that they could be sold on a small scale.

✈️ What is the status of Japanese research on small electric aircraft?

Nishizawa In Japan, there are few companies that manufacture and sell small aircraft. Because the demand for sky sports is comparatively small, there is no foundation from which it can develop. Although motor and



Akira Nishizawa
Innovative Aircraft Technology Section
Specialized in mechanical engineering in graduate school



Just going shopping in a personal airvehicle. This is how it will most certainly be like once innovative aircraft are realized. Nishizawa operating a (non-electric) ultralight plane in flight school

motor control technologies as well as component technologies, such as batteries, are trailing, Japan holds the most advanced technologies in the world.

Replacing engines in small aircraft with electric ones provides a system that is extremely easy to use. Since there is a definite movement to use these in the U.S. and Europe, where air sports are popular, due to the many big advantages such as fewer malfunctions, nearly no maintenance in addition to reduced noise and vibration, various businesses are taking on the challenge of development. Since, from the point of view of production, design and manufacturing will also become easier, I think they will be made by manufacturers who, until now, had never envisioned making such aircraft.

✈ However, passenger aircraft, have a significant hurdle to overcome.

Nishizawa For this reason, it is essential that we accumulate technology for small aircraft. This is not necessarily for the aircraft propulsion system itself. Instead, I think that, while maintaining a mutual relationship where it can be incorporated in some aircraft systems, both can continue to progress.

Lifestyles also to change completely

✈ When you say that it is easy to use, do you mean like a car?

Nishizawa I think it will naturally go in that direction. Compared with cars, aircraft still do not seem like an everyday

vehicle. However, in the future, possibly 10 or 20 years from now, I think they could become an everyday means of transportation. For that reason alone, it should be possible that they become extremely easy to operate.

✈ By powering them electrically?

Nishizawa Making them electric only partly contributes to that, but the largest part is incorporating a computer into the flight control system.

If that technology progressed, the computer could automatically perform a considerable part of the operations, allowing aircraft to be operated as easily as driving a car. If this were the case, aircraft that anyone can operate might become available. Currently, in the United States and Australia, there are people using aircraft as frequently as cars. I think that, instead of simply being a local occurrence, there will be a time when it will expand globally as an everyday means of transportation. This should significantly increase the number of aircraft. However, they would be small electric aircraft.

I think that making aircraft easily operated by anyone is extremely compatible with making them electrically powered, and that electric flight is significant as a system to meet that objective.

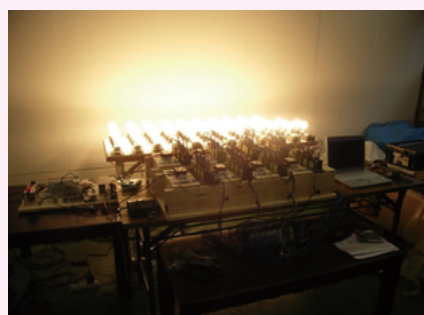
Therefore, it is our utmost obligation to show the overwhelming benefits of electric flight, not the least to advance component technologies related to reducing fossil fuel consumption of

passenger aircraft.

I think that you can get the sense of it by means of the familiar example of how rice used to be cooked on a hearth long ago. Later still, the gas stove was replaced with the electric rice cooker. This change has certainly progressed in the direction of increased convenience and efficiency, and is closely tied to a lifestyle change. Long ago, we had to wake up early to start a fire, but now rice is ready to be eaten when we wake up in the morning if we have prepared it before going to bed. Once you have obtained this convenience, you cannot let go of it. Maybe this will be the same for vehicles—after they become electric, we will no longer have the trouble of refueling or getting dirty with maintenance. In other words, the significance of being powered electrically is that hassles will gradually disappear. If so, the impressions we have of aircraft will change considerably. I believe that electric flight tends to offer that possibility.

✈ Finally, could you explain what your goals are?

Nishizawa Actually, I would like to research technology that is usable all over the world. It happens only once every few decades that various values, including those relating to lifestyle, change as a result of technological innovations. I would like to create such technology with the impact to dramatically change the world. Therefore, I hope for that honor while continuing to actively fulfill my obligations. There may be times when I hit a wall and just can't solve a problem, but I think it is important to be persistent.



Battery charging/discharging test



Wind tunnel test of electric propeller