Special feature

# Novel navigation systems ensuring the safety of satellite navigation

Against a backdrop of increased demand for air transportation, a transition to a new flight operation system is required to be able to maintain air safety with an even larger than the current number of aircraft in the air. Satellite navigation is one such system. Although this has begun to be utilized in recent years, enhanced accuracy and reliability are key issues in realizing safer and more efficient operation. At JAXA, we are conducting research and development of a high-precision satellite navigation system that combines INS (inertial navigation system) with GPS. With INS supplementing when signals from GPS satellites cannot be used temporarily, continuous high-precision navigation is possible. There are several factors causing satellite signals to no longer be usable; even solar activity is said to have an unexpected impact. Understanding how each factor affects aircraft and devising technical solutions for them are essential for developing a high-precision satellite navigation system. In this Special feature, we will explain how the research and development of the high-precision satellite navigation system is advancing.

## Introduction

Although worldwide air transportation demand has frequently declined due to global unrest such as synchronized terrorist attacks, epidemics of infectious diseases such as SARS (severe acute respiratory syndrome) as well as the global economic recession originating with the financial crisis, it has continued to increase over the long term. A steady increase in demand has been forecasted for the future with the Asia-Pacific region as the driving force, and the air passenger traffic volume in 20 years is expected to be more than double what it is now. However, if we continue to use the current operation system as some congested airports and airspaces already come close to saturation, various problems may arise, including a loss of convenience due to delays, constraints in efficient operation in addition to a threat to safety due to the increased load on air traffic controllers.

In reaction to these concerns, ICAO (International Civil Aviation Organization) is focused on transforming the operation system with new technology and establishing a global ATM (air traffic management) operational concept. In response, the United States and Europe have begun programs called NextGen and SESAR, respectively, and the Civil Aviation Bureau of Japan has established CARATS (Collaborative Actions for Renovation of Air Traffic Systems), its long-term vision for the future air traffic system.

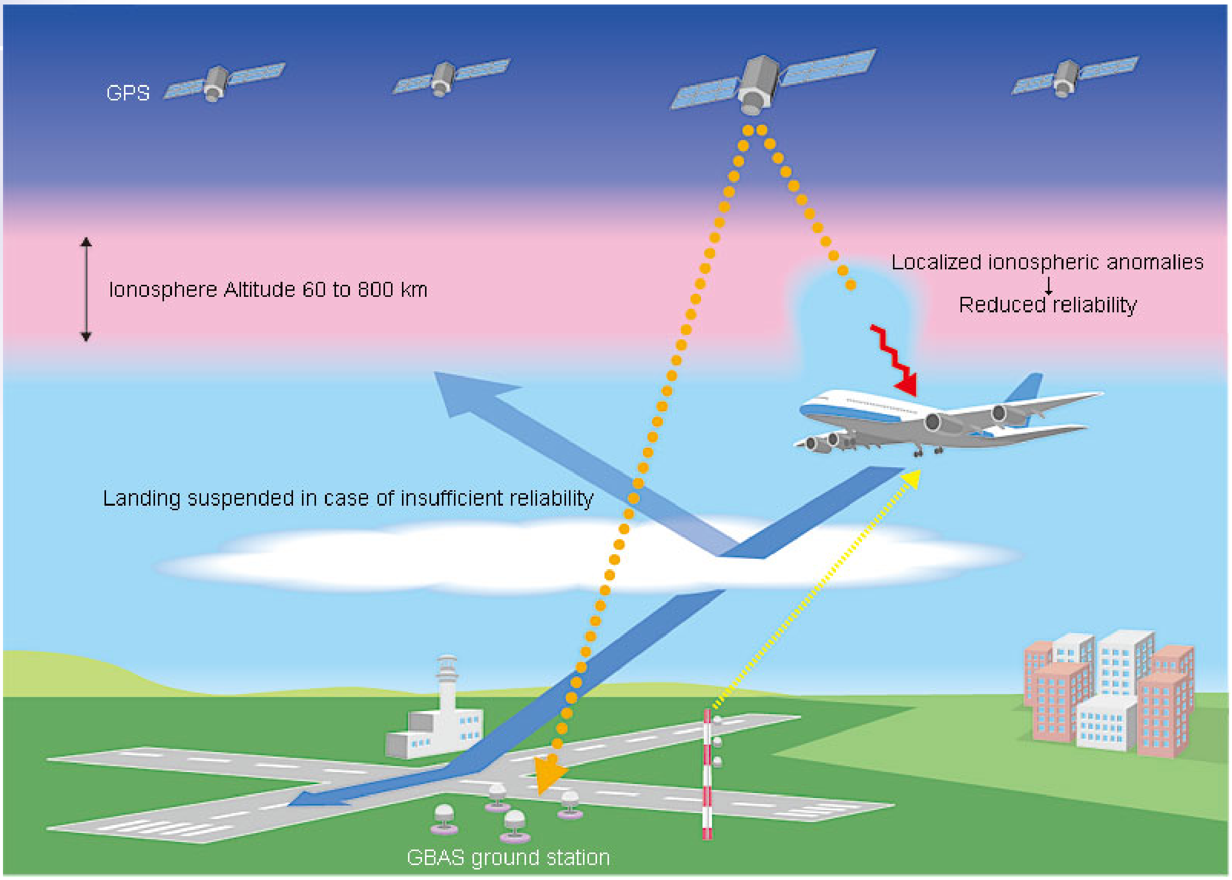
JAXA established its next-generation flight operation system research and development project DREAMS (Distributed and Revolutionarily Efficient Air-traffic Management System) in collaboration with CARATS and is vigorously continuing research and development of five key technologies for the realization of the ICAO global ATM operational concept. Research of high-accuracy satellite navigation technology, one of the five key technologies of DREAMS, is vital to "realizing satellite-based navigation for all flight phases", one of the renovation paths established by CARATS, in order to overcome the technical issues in realizing a precision approach utilizing satellite navigation.

## Flying changes with satellite navigation

The route to a destination is determined before the aircraft takes off. The technology for guiding the aircraft from the point of departure to the destination as well as the technology for observing the aircraft position and speed at every minute are called navigation.

Conventional aircraft primarily use navigation called radio navigation. Although it is possible to recognize where you are flying when the view of the ground in good weather is well visible (called geographical navigation), radio navigation relies on radio waves emitted from ground facilities (aeronautical radio navigation aids) to provide for cases when the view is unreliable such as above the clouds. However, because radio facilities are limited to emitting radio waves from the ground, they cannot be used in places out of reach of radio waves from land or in places where radio waves are blocked such as behind mountains.

Therefore, in recent years, satellite navigation using GPS, known as the



Precision approach using satellite navigation with GBAS and ionospheric threats

built-in function of car navigation and cell phones, is being used. GPS (global positioning system) is a system operated by the United States and mainly consists of about 30 artificial satellites in orbits around the earth. It can measure your position nearly anywhere on the earth by receiving signals emitted from multiple GPS satellites.

Since the limitations of ground radio facilities do not apply to satellite navigation, the flight path can be selected more flexibly, and it is expected to contribute to operational optimization as well as the expansion of airspace capacity.

If satellite navigation is to be employed during landing on runways, higher accuracy and reliability, compared with mid-air use, is required. In order to use satellite navigation to realize high-category precision approach (in this category, approach is permitted if conditions are met, even in weather conditions that do not allow the runway to be visible until reaching the ground, for example, due to fog), which has particularly high safety requirements, an augmentation system, called GBAS (ground-based augmentation system), to supplement GPS accuracy and reliability has been proposed. GBAS is a system that, based on the signals received by three or four GPS ground stations installed near the runway, generates GPS error correction information as well as integrity information and transmits it to nearby aircraft.

Compared with ILS (instrument landing system), which is the conventional aeronautical radio navigation aid for approach, GBAS has the advantages that the navigation system error is small, multiple runways can be accommodated with one system, and the approach path can be flexibly established.

## GBAS and the ionosphere

With received correction information, aircraft using GBAS perform high-precision positioning by compensating for a number of common errors between the GPS signal received by the ground station and that received on the aircraft. A characteristic of the method to compensate for common errors is that, since the GBAS ground station generating the correction information is separated from the aircraft that uses the correction information, as the commonality of errors contained in the GPS signals received by each decreases, the navigational accuracy decreases.

Of the errors contained in the GPS signals, the amount of delay (ionospheric delay) occurring while passing through the ionosphere, a part of the signal propagation path, is one of the major sources of error. Since the normally calm ionosphere is spatially homogeneous and its temporal changes are gradual,

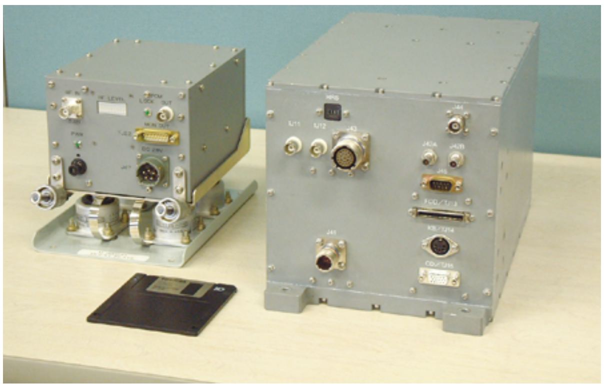


Fig. 1 ●"GAIA", GPS-Aided Inertial navigation Avionics, developed by JAXA (for unmanned vehicles)
Based on the GAIA technology, we are aiming at civil transport applications with this research and development.

## Ionospheric anomalies that decrease navigation accuracy

SED: Ionospheric disturbances accompanying magnetic storms

Plasma bubbles: Phenomenon of a localized reduction in the electron density distribution of the equatorial ionosphere Asia is greatly affected by this, compared to Europe and the United States.

## Impairment of satellite navigation

Scintillation: Waveforms of the GPS signal are interrupted, making continuous signal reception difficult.

Ionospheric delay gradient: The spatial correlation of the GPS ranging error is reduced by the ionosphere, making GBAS correction difficult.

there is a high commonality in the ionospheric delay observed from the ground station and the aircraft so that adequate navigational accuracy can be obtained for precision approach. However, once localized anomalies occur in the electron density distribution of the ionosphere, the commonality of ionospheric delay observed from the ground station and the aircraft decreases, and not only can the navigational accuracy necessary for precision approach be unmaintainable, but safety is also not guaranteed. Therefore, various monitoring algorithms for detecting these types of ionospheric threats are studied around the world.

In fact, this ionospheric condition is greatly affected by solar activity. High and low solar activities repeat periodically over an approximately 11-year cycle, and we will enter the most active period from this year on to next year. When solar activity is vigorous, it is said that the Aurora can be observed other than at the North and South Poles, power transmission systems fail, causing blackouts, and aviation as well as maritime long-distance radio communications are disrupted. In addition, the ionosphere becomes active due to solar activity and the following ionospheric disturbances, which are a threat to satellite navigation, are likely to occur.

## Ionospheric threats

Ionospheric disturbances accompanying magnetic storms, called SED (storm-enhanced density), have been thoroughly studied as ionospheric threats to satellite navigation. In Japan, where the magnetic latitude is low compared to Europe and the United States, there are also concerns about the effects of ionospheric anomalies called plasma bubbles, where the plasma density in the equatorial ionosphere is locally reduced. While the impact of plasma bubbles on positioning accuracy is smaller than that of SED, the occurrence frequency of plasma bubbles in particular seasons is significantly higher than that of SED.

The mechanism of how these ionospheric disturbances affect satellite navigation is mainly based on the following two principles. The first is that scintillation (fluctuations in phase and reception strength) occurs in the received GPS signal passing through the ionosphere, due to the irregular structure of the various scales occurring in the disturbance. If this scintillation is intensified, phase tracking of the signal by the GPS receiver lags behind, and eventually the signal can no longer be received.

The second is that the plasma density in the ionosphere varies locally, and a spatial gradient (ionospheric delay gradient) occurs in the ionospheric delay. Even if the GPS signal is continuously received, such a gradient may be a threat to the safety of the precision approach. Against such a threat, the monitoring algorithm called CCD (code carrier divergence) monitor was developed and implemented. If a sudden change in the ionospheric delay is detected by the CCD monitor, safety is ensured by excluding the corresponding GPS signal.

Therefore, if a strong ionospheric disturbance is encountered, the GPS signal can no longer be received due to scintillation, or the GPS signal is excluded by the CCD monitor, and the number of GPS signals that can be used for positioning is reduced. As a result, there are concerns that positioning may not be possible or the reliability of the positioning result

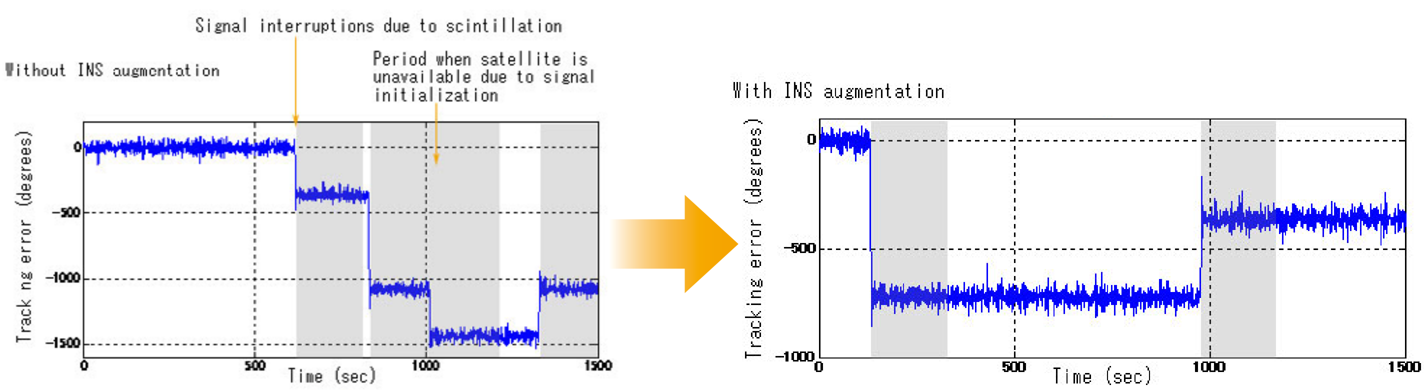



Fig.2 ● Reduction of GPS signal reception interruptions by integrating INS (simulation) is reduced, making it impossible to continue precision approach with satellite navigation.

## Improvement through INS integration

In order to mitigate the effects of ionospheric anomalies on precision approach using GBAS, we are investigating a method that combines the on-board equipment installed on aircraft. JAXA has developed an integrated navigation system that uses GPS and INS (inertial navigation system) to compensate for each other's shortcomings (fig. 1). We are continuing research of the following two technologies to improve that technology.

One is the technology for improving signal tracking performance in the GPS receiver by supplementing aircraft motion information measured with INS. By eliminating phase fluctuations caused by aircraft movement, it is expected that an even larger signal tracking margin can be ensured and signal interruptions will be reduced, even if there are large fluctuations in the GPS signal strength and phase from the effects of scintillation. In order to verify this function, we conducted numerical simulations where simulated fluctuations were added artificially to the GPS signal and we confirmed that the phase tracking error was significantly reduced. As a result, we could reduce reception interruptions (discontinuity in figure 2) and shorten the amount of time that the GPS signal cannot be used.

The second is the technology for alleviating surges in the protection level (accuracy ensured by a high degree of reliability) when the number of usable satellites is reduced due to reception interruptions or satellite exclusion by the CCD monitor, by switching to coasting (continuing inertial navigation without compensation by GPS), using INS to take over for the previous protection level of GPS/GBAS. A GBAS working group in the United States assessed the proportion of increase in the vertical protection level during coasting, and reported that a maximum of 1.5 m in 30 seconds would be sufficient. Based on this result, we conducted numerical simulations to evaluate the function of alleviating the effects of plasma bubbles and confirmed that there was a greater advantage in cases where reception was frequently interrupted.

Fig.3 ●GPS ground station set up in Thailand (front left)

Fig.4 ●JAXA experimental aircraft MuPAL-$\alpha$

In order to evaluate the performance of these proposed technologies, we are simultaneously developing a numerical simulation tool that can accurately assess the results. Although plasma bubbles occur more frequently than magnetic storms, assessment in practice is difficult under actual plasma bubbles since they are a phenomenon limited by region, season and time of day. Therefore, by constructing a numerical analysis model on the computer as an evaluation tool and performing numerical simulations, evaluations can be conducted. In order to increase the reliability of the numerical analysis model, a large amount of observation data is essential. Currently, continuous observation is being conducted at GPS ground stations set up in Bangkok, Thailand as well as Ishigaki city in Okinawa prefecture (fig. 3). In addition, we are planning several flight tests around Ishigaki to study the effects of aircraft movement on the signal tracking function of GPS receivers as well as confirm the results of the signal tracking augmentation algorithm using INS. This March, we conducted a preliminary flight test (6 flights) using experimental aircraft MuPAL-$\alpha$ (fig. 4). An assessment of the system simultaneously recording detailed GPS signals on the ground and on the aircraft confirmed that it functioned as expected. Unfortunately, plasma bubbles were not observed during this period. However, since solar activity will become more vigorous from now on, we look forward to upcoming flight tests planned this autumn and beyond.

## Conclusion

When considering a next-generation flight operation system as a measure for the future increased demand in air transportation, the realization of precision approach using satellite navigation is an essential issue; however, ionospheric anomalies have become a major threat. While the currently vigorous solar activity is a major threat, it can also be considered perfect timing for conducting research and development for improving reliability. During this period, we hope to continue to collect sufficient observation data and apply it to the numerical analysis model in order to improve the functionality of the INS integration technology.

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Research Report

From the research field

# Research in fan noise reduction technology

## — Aiming at quiet jet engines—

Clean Engine Team

### Sound generated by a jet engine

We hear various sounds during our daily lives-the sound of the wind rustling the trees, the voices of passers-by, the sound of cars driving by, and the sound of airplanes flying overhead. Some are pleasant sounds, some are noisy. For most people, aircraft sounds are considered noisy. Because the loudest sounds are produced during takeoff and because aircraft fly at low altitudes around airports, aircraft noise is becoming a major social issue. While aircraft noise can be divided into that from the airframe and that from the engine, the Clean Engine Team is conducting research related to the noise produced by the jet engine. There are two main noise sources in a jet engine: fan noise, which is produced by the fan, and jet noise, produced by exhaust. The fan is an impeller, as shown in figure 1, composed of a rotor (rotating) and a stator (stationary), which function as a single element. Figure 1 shows that air taken into the jet engine is divided in two. One part flows to the core engine, passes through the compressor, combustor and turbine to be exhausted from the rear of the engine (core exhaust). The other passes through the fan duct to be exhausted from the rear of the engine (bypass exhaust). The ratio of the volume of air passing through the core engine to the volume of air passing through the fan duct is called the bypass ratio. Since the higher the bypass ratio, the better the jet engine fuel efficiency, there has been a trend toward higher bypass ratios for jet engines of commercial aircraft in recent years. If the bypass ratio can be increased, the volume of air passing through the fan duct increases, resulting in increased fan noise. Therefore, in order to realize a quiet jet engine with good fuel efficiency, the development of fan noise reduction technology is extremely important.

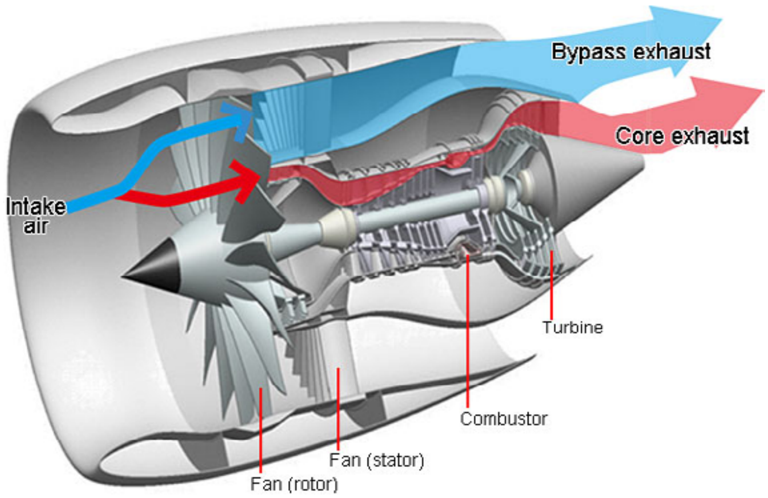


Fig.1 : Bypass exhaust and core

### If only just the noise could be reduced

There are various factors that affect the noise produced by the fan, but our team is currently researching the reduction of the noise from the interaction of the rotor and stator (hereafter, called interaction noise). As shown in figure 2, interaction noise occurs when the low flow (wake) generated by the rotor hits the stator. Depending on the wake properties as well as where the wake hits the stator, the level of the interaction noise emitted to the

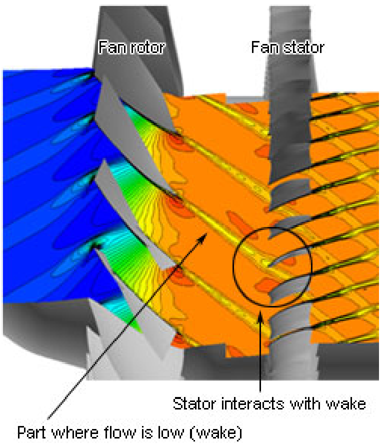


Fig.2 : Flow field around the fan

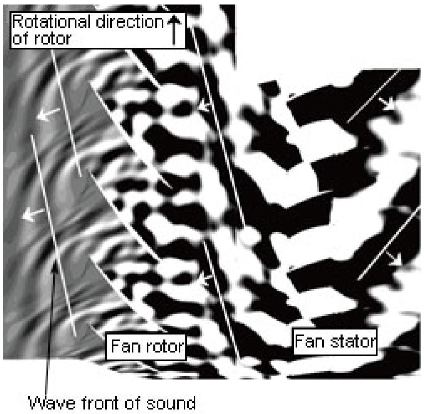
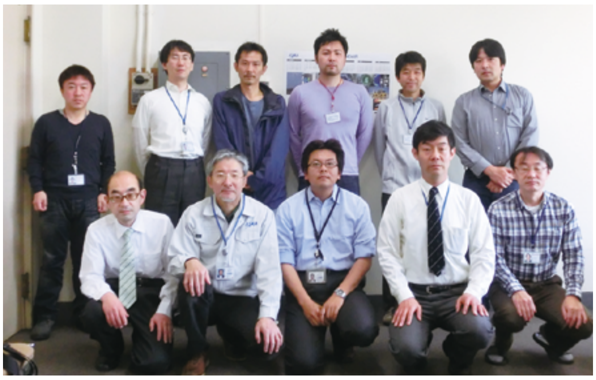


Fig.3 : Sound propagation obtained through CFD



Research team members,The author is seated at the center of the front row.

outside of the engine differs. The wake properties change depending on the rotor shape, and where the wake hits the stator is determined by the shapes of both the rotor and stator. Therefore, suitably changing the shapes of the rotor and stator may reduce the noise. However, by doing so, the efficiency of the fan itself may decrease considerably, possibly resulting in a fan that is quiet but performs poorly. Therefore, it is necessary to research how to realize a quiet fan without reducing its efficiency.

## Seeing sound

Computational fluid dynamics (CFD) has proven useful to this research. With this method, the flow of air (flow field) is simulated on a computer. Figure 2 shows the flow field around a fan as obtained through CFD. One advantage of CFD is that the flow field can be closely understood since detailed data can be obtained. In addition, interaction noise can be captured by using CFD. Figure 3 shows a sample visualization of the interaction noise after the results obtained through CFD have been processed. The lines in the diagram are the wave fronts of the interaction noise captured through CFD. Since sound propagates through air as waves, these wave fronts move in the direction of the arrows in this diagram, radiate to the outside of the engine, then arrive at our ears, where it is recognized as noise. Figure 4 shows a comparison between data actually measured through experiments and the results obtained with CFD. We can see that interaction noise can be accurately predicted with CFD. By predicting fan noise with CFD, we can simultaneously predict the fan efficiency from the flow field information in addition to the size of the generated interaction noise as well as how it is generated. In other words, by watching the flow field, we can "see sound". By being able to see sound, we can see how sound is produced and how it is propagated when the shapes of the rotor and stator are changed. Therefore, when a method for reducing fan noise is proposed, it can first be studied with CFD. As an example, we are using CFD to study the reduction in fan noise by angling the stator more than usual in the circumferential direction; this is called a lean stator (fig. 5). Although the lean stator technology has not yet been put into practical use because of many issues such as structural strength and reduced fan efficiency, we plan to examine the possibility of resolving these issues by utilizing CFD. I hope to continue this research in the future to aid in the development of reduced-noise fan technology.

(Junichi Kazawa)

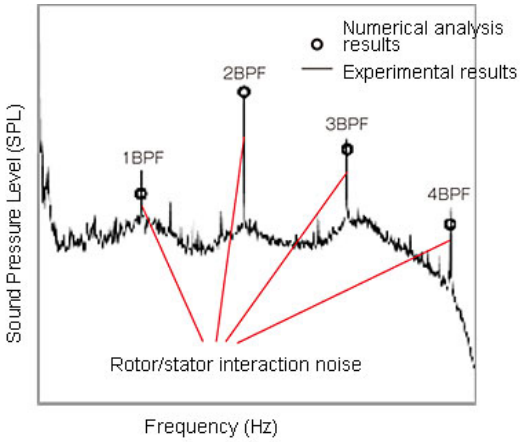



Fig.4 : Comparison of test results and CFD results

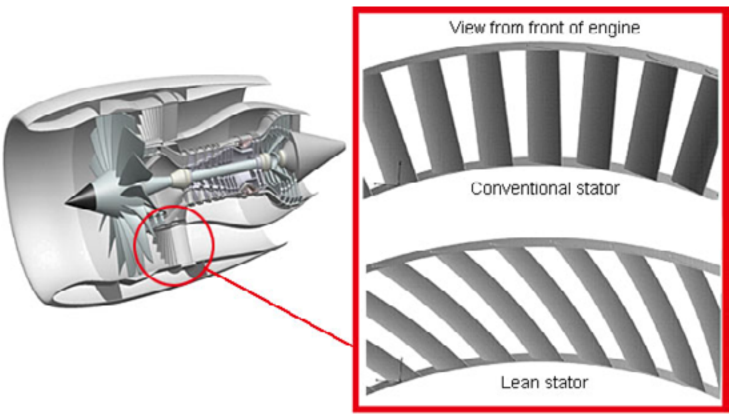



Fig.5 : Lean stator

Research Report

From the research field

# Research in weight reduction of jet engines

Clean Engine Team

## Using composite materials in civil aircraft

The newest civil aircraft, Boeing 787, is said to utilize nearly 50% composite materials by weight. Carbon fiber reinforced plastics, known as the typical composite material, is a plastic-reinforced material with bundles of thin fibers of 10 microns or less. Since it is lighter (lower density) than aluminum or titanium alloys, it is a lightweight, high-strength material being used in many fields, not only aircraft, but also sports equipment such as golf clubs and car bodies. Since civil aircraft become lighter through the use of composite materials, fuel consumption is reduced, in other words, $CO_2$ emissions are reduced, making civil aircraft economical and environmentally friendly.

## Weight reduction of jet engines

It was reported that the fuel consumption of large aircraft could be reduced by 1% if the jet engine weight is lowered by approximately 68 kg. Although not as much as in airframe structural materials, some jet engine parts, such as fan blades and the fan casing, have already begun to be made of composite materials to reduce engine weight, and research for using composite materials in other parts is widely being conducted. To increase engine efficiency, in particular, an increased bypass ratio or fan flow rateis necessary, which makes the fan diameter larger; therefore, weight reduction of jet engine parts, such as through the use of composite materials, is required in order to maintain engine weight down. In addition, as weight reduction of the jet engine would result in reduced airframe structural strength for supporting the engine, weight reduction of airframes can also be expected.

## Making lightweight compressor casings

The Clean Engine Team is conducting research on using composite materials for the jet engine compressor casing (fig. 1). The compressor assumes the role of compressing air taken in by the fan at the engine intake and discharging the compressed air into the combustor. In large engines, the air is compressed to 1/50 or more; in small engines, to 1/20 or more. Therefore, the compressor casing requires the structural strength to withstand high-pressure air. High-strength titanium alloys and stainless steel are being used for compressor casings. If this could be replaced by a high-strength,

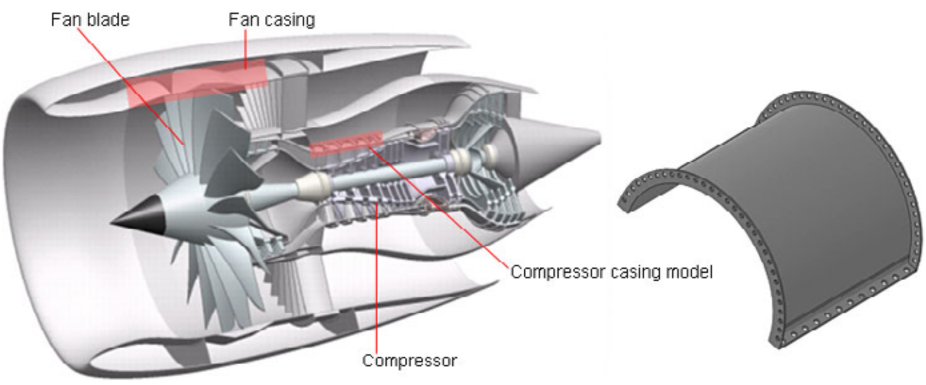



Fig.1 : Compressor casing

Fig.2 : Tensile test machine

Engine Structure Design Section
Masahiro Hojo

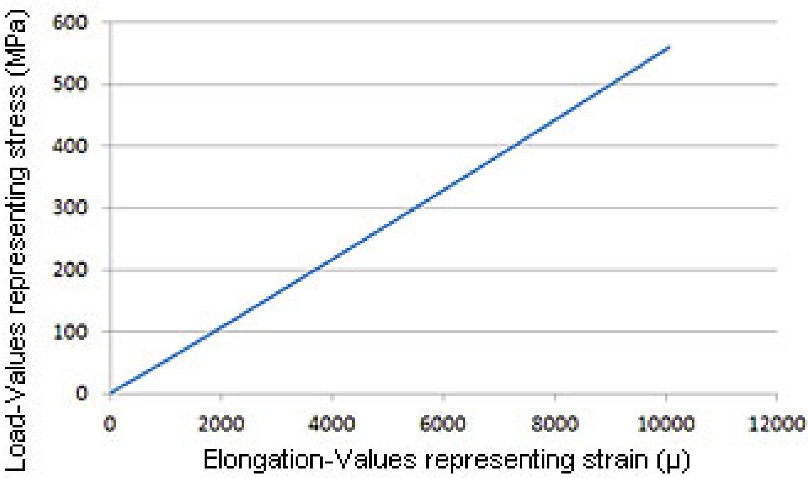



Fig.3 : Tensile test results

Fig.4 : Tensile test

lightweight composite material, we believe that the weight could be halved compared to a stainless steel compressor casing.

## Testing of composite materials

A variety of material data is necessary for the design and reliability assurance of engine parts. In general, we cannot obtain material data without conducting material tests.

Figure 2 shows the tensile test machine. The tensile test measures elongation (deformation) when a tensile load is gradually applied to a test piece of a simple shape, such as a flat plate or rod. Figure 3 shows the relationship between the tensile load and the material deformation. As the load is increased, the deformation increases until finally the test piece is fractured as shown in figure 4. Figure 5 shows the test piece fractured into various pieces by the tensile test. We obtain various materials data, such as the elastic modulus, which indicates how easily materials are deformed by the tensile test, as well as the tensile strength when it is fractured, and use it as fundamental design data for designing the engine. In addition, since materials data generally varies with temperature, materials are tested at various temperatures within the engine operating range.

We are also conducting fatigue tests, where the number of times a load is repeatedly applied to simulate engine operation cycles is counted until fracturing occurs, in addition to spin tests, which assess the durability of parts rotating at a high speed.

We expect composite materials will be widely used in jet engines in the near future. Please stay tuned to JAXA research for engine weight reduction.

(Masahiro Hojo)

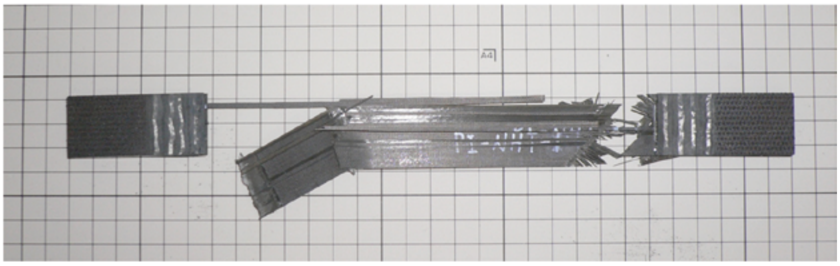


Fig.5 : Fractured test piece

Interview
**People who fly dreams**
No.21

# Clarifying the Noise Generation Mechanism

Civil Transport Team ● Hiroki Ura

In order to reduce noise, it must first be identified. That is why JAXA has been studying aircraft models in wind tunnels to improve measurement technology for identifying noise sources. 2010 provided the opportunity to leave the wind tunnels and verify this special measurement technology in the field. By measuring the noise of a small passenger aircraft in flight, valuable data could be obtained to extend our knowledge. We visited researcher Hiroki Ura, who has played an active role in this measurement test, and heard about noise measurements as well as the efforts to reduce noise.

## Demonstrating technology for identifying noise sources of aircraft moving at high speed

So, you have been conducting research and development of aircraft noise measurement technology?

Ura　What I have been tackling is measurement technology called noise source localization. Although it may be called aircraft noise, it is actually noise produced from various locations, such as the engine, high-lift devices (flaps and slats) and landing gear. Normal noise measurements use a single microphone to capture the total noise level produced from multiple locations. With this noise source localization technique, setting up multiple microphones over a wide area allows us to investigate what part of an aircraft in flight produces noise and at what level.

The standard measurement method requires an enormous amount of effort to identify the noise source. However, with this noise source localization technique, we can determine the acoustic map with one measurement, making dramatically increased efficiency one of its advantages. In addition, the result can be visually confirmed. (Refer to the acoustic maps for the noise source localization results) In 2010 and 2011, we flew a business jet at Taiki Aerospace Research Field (Hokkaido) and conducted a flight test to verify the measurement system. Now, we are planning the next flight test.

How will the actual measurement test be conducted?

Ura　An aircraft will circle so that it frequently passes over the measurement system set up on the runway to take measurements with each pass. With one pass taking an average of 4 minutes, a single flight will last 2 hours. There will be four to five flights during the testing period. This is a large test involving a total of 25 people with some measuring not only the sound but also the aircraft's position, attitude and flight speed in addition to the weather conditions and others guiding the aircraft.

What are you in charge of, Mr. Ura?

Ura　I am in charge of designing the microphone arrangement as well as developing a program for analyzing the measured noise data. How the microphones are arranged is an important factor in determining the performance of the measurement system, therefore, we are first conducting simulations and making careful considerations. Since a large amount of data will be obtained by using as many as 200 microphones, we are focusing on how to create a program that can quickly and accurately process this data. After arriving at the test site, the preparation work until testing takes 2 hours. After the flight begins, there are various tasks to perform, from the 4-minute measurements to simple analyses, and we are concentrating to avoid mistakes, so we are completely exhausted when the flight ends.

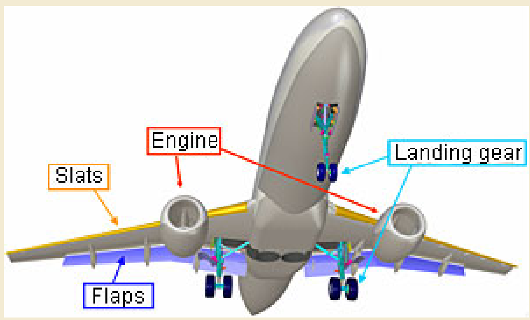
How do you identify the noise source location?

Ura　It can be back-calculated from the time it takes for sound to propagate to a microphone. This is called the propagation time. Thunder takes a short time from the flash of lightening until the rumbling sound is made. Sound propagates through air at a speed of approximately 340 meters per second. If sound produced at a location is measured by microphones at two different locations, for example, the time for it to arrive at each microphone differs. By back-calculating these and looking for the place where the waveform matches, we can identify the location where the sound was produced. If the noise source is at a location being focused on, the combination of signals from the microphones will be enhanced and appear as strong acoustic pressure. If this is done for the analysis area, the noise level distribution can be understood.

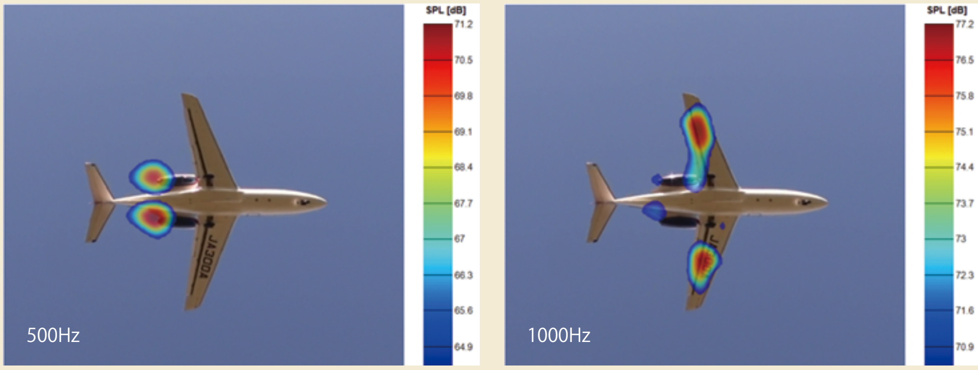
Are you able to see the distribution diagram immediately after the flight?

Ura　It can be seen after one or two minutes. The distribution diagram for

Hiroki Ura
Aerodynamics and Airframe Noise Technology Section
Born in Hyogo prefecture. Majored in mechanical engineering as an undergraduate. Employed by a manufacturer, then joined National Aerospace Laboratory of Japan (now JAXA).




Sources of takeoff/landing noise




Acoustic maps for the noise source localization results-We can identify the noise source locations and sound pressure levels at each frequency. An aircraft simulating takeoff and landing configurations flew at altitudes between 60 and 120 m at a speed of 60 m/s (approx. 220 km/hr).

many frequency ranges, though not all, is displayed in the CAD model of the aircraft. It is superimposed on the aircraft image after the test.

What are the technical issues?

Ura The noise produced by aircraft is affected by weather conditions, such as the wind, temperature and humidity, while it propagates through the atmosphere to arrive at the ground. As a result, based on the values measured on the ground, we are adjusting the sound data to account for changes in the altitude. We would like to make this a little more accurate. Another thing that we have seen in the acoustic pressure distribution is a peak at each frequency. Other than this, we have also made a program that adds the numerical data from the acoustic pressure distributions for each area to calculate what characteristics the noise being produced has, for example, if it is from only the flaps or only the engine nozzle. This must also be able to calculate more accurately.

Why is it necessary to find noise sources?

Ura Since the final objective is to reduce the total aircraft noise, if we don't know from which location noise is produced or its level, we could be trying to reduce noise from the wrong location. For effective noise reduction measures, it is very important to understand from where noise is being produced and what its characteristics are. I think many people have an image of engine noise when we talk about aircraft noise. However, in fact, the engines of newer aircraft are pretty quiet. Since engine output is maximized at takeoff, the engine noise is loud. While output is throttled when approaching the airport for landing, there are aircraft with louder noises (airframe noise) produced by the high-lift devices and landing gear. Our section is focusing on reducing this wind airframe noise.

So, you would like to make quiet aircraft even quieter?

Ura Noise regulations are getting stricter year after year. There are not only international regulations, but also airport regulations. Since penalties are imposed if standards are not met, airlines are worried about how much margin they have with international standards. For aircraft manufacturers, how much margin an aircraft has is a selling point.

## Being a cook would be the alternative

How were you as a child?

Ura I would play outside until dusk, and I was scolded often. In Gifu, where we lived at one time due to my father's job transfer, there were mountains and a river immediately behind our house, so I lived almost like a wild boy. We made a platform at the top of a large tree and collected turtles from the river. I also liked reading and read at a pace of one book a day as a competition with friends.

What were your reasons for selecting engineering?

Ura Ever since I was a child, I enjoyed making things. I used wood to make toys by myself. I also liked machines and was often doing things like disassembling an alarm clock, then re-assembling it. As an extension of that, I chose engineering, where I would be able to make things.

What do you enjoy doing in your free time?

Ura Before, I often went on drives, but lately I don't drive much and often take walks in the neighborhood or watch movies. I continue to read and am reading at a pace of two to three books a month.

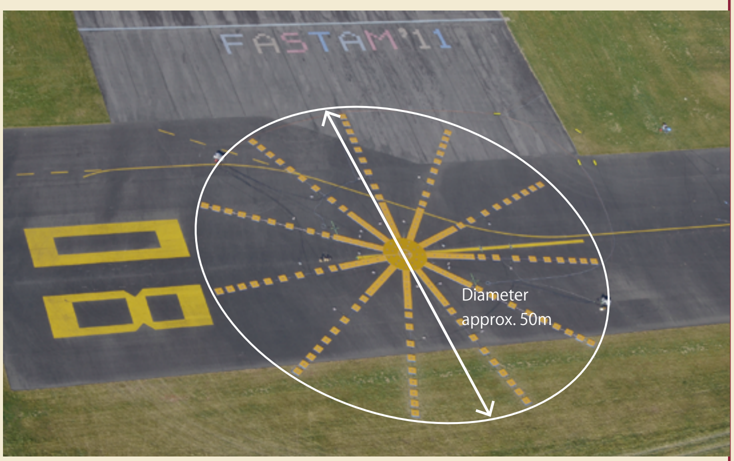
What other job can you imagine doing?

Ura I would be a cook. I enjoy cooking and often do. I can make general Japanese dishes, and omelettes and fried rice are my specialties. The most elaborate dish that I have made lately was udon. It was well received by my family.

Finally, please tell us your future goals or what research you would like to tackle.

Ura From the noise data obtained in wind tunnels using models, I would like to create a calculating tool that would be able to predict the characteristics of noise produced by aircraft. Since many mechanisms have not yet been clarified because transient fluid phenomena, including noise, are complex, I would also like to develop technology useful for mechanism clarification.

Researcher Ura (far right) during test preparations




Measurement system set up on the runway-A microphone is implanted in each yellow panel. This is a total of 198!