RESEARCH INTRODUCTION

Toward a 24h Rescue Operation

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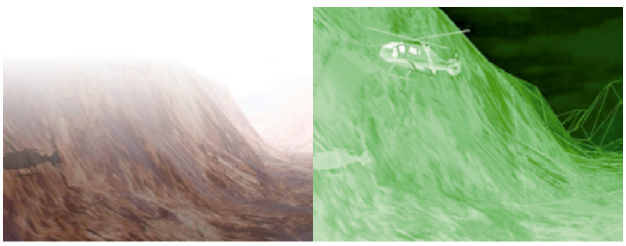
The sky resounded with the familiar "flap-flap" sound. When I looked up, I saw a helicopter passing overhead···. A helicopter doesn't require a runway.

It can hover, and fly backwards, and pass over mountainous regions which are difficult for cars to enter. These capabilities explain why helicopters are used for patrols, mountain rescues, and emergency medical services. But helicopters also have an important limitation, as they are required to fly according to the Visual Flight Rules (VFR)(*1). For this reason, they must stay on the ground when visibility is poor because of bad weather or the darkness of night.

If we can safely fly helicopters in any weather condition around the clock, we can respond to emergencies whenever required. This will enable us to save more lives. To fly helicopters safely, JAXA believes that it will require a technology for displaying the information necessary to compensate for poor visibility.

(*1) Visual Flight Rules (VFR) : A set of regulations which allow a pilot to operate an aircraft visually. When visibility is too poor, a flight under VFR becomes impossible. When an airplane flies under VFR at an altitude of less than 3,000 m over sea level, the rule stipulates that the pilot must be able to see up to 1,500 m ahead. Under the Instrument Flight Rules (IFR), the rules applied when a pilot flies under the instructions of air traffic controllers on the ground, the pilot can fly even under low-visibility conditions due to poor weather. As the flight route is limited, however, IFR is not easy to respond to an emergency.



Difficult-to-see obstacles and topographical features are projected virtually by combining FLIR, radar, topographical databases, etc. (on the right).

Fig.1 Clearing our vision by integrating sensor information (conceptual diagram)

Infrared camera that serves as the eye

The views seen by the human eye have poor visibility during nighttime or in bad weather. But we can improve visibility if we use a special eye.

Human eyes can only capture the light in the spectral range from violet to red (visible light), light of the same wavelengths that shine from a rainbow. Yet there are many other kinds of light which our eyes fail to capture in the world. One of them is infrared light, an electromagnetic wave with a wavelength greater than that of the red end of the visible light spectrum. A Forward Looking Infra-Red (FLIR) is an optical device using infrared light. With this device, we can clearly see ridge lines, clouds, and other objects even during nighttime, when they are invisible to the human eye. (refer to page 5 and Fig. 1).

Properly displaying the required information

The most reliable information for the pilot in a helicopter flying at a relatively low altitude is the visual information coming through the wide window in front of the cockpit. The pilot flies his vehicle safely flight by relying mainly on visual information, with important help from the readings on the instruments and displays (Fig. 2).

JAXA is researching technologies to display the

Fig.2 Wide window and instruments in front of the cockpit

information required by pilots in easy-to-understand ways. One approach is JAXA's high-level "cockpit display technology." Based on this technology, JAXA is conducting joint research with Shimadzu Corporation and NEC Corporation (NEC) on a pilot assistance technology called SAVERH. The final goal of SAVERH is to acquire the capability to safely land a helicopter at a heliport in a mountainous region at nighttime. (*2)

Fig. 3 shows the configuration of the system demonstrated with SAVERH. A FLIR (Fig. 4) developed by NEC is installed on board JAXA's experimental helicopter MuPAL-ε (upsilon). The pilot's helmet is fitted with a Helmet Mounted Display (HMD) (Fig. 5) developed by Shimadzu Corporation. The experimental display installed on MuPAL-ε (HDD) is also used for comparison. The monitor displays FLIR images to compensate for degraded visibility, database CG images of topographic features, and approach paths by the Tunnel-in-the-Sky Display(*3)." Basic flight information, including the speed and altitude, is also indicated.

JAXA has been researching SAVERH in a three-year plan commenced in fiscal 2008. In the first year of the plan, the participating companies combined their technologies to conduct a flight experiment for the identification of problems.

(*2) In addition to the long-awaited pilot-support technology, JAXA is also researching and developing a demonstration test on equipment developed by different manufacturers.

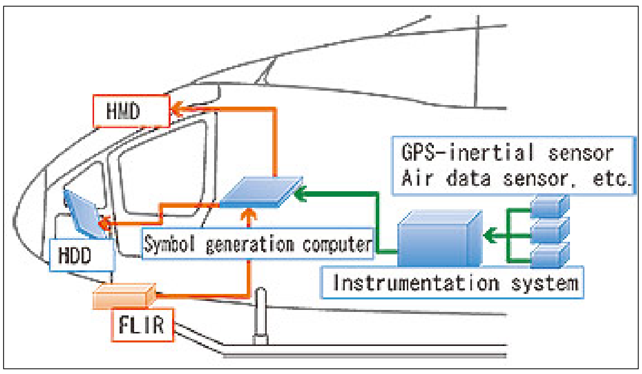


Fig.3 System configuration of SAVERH

Fig.4 FLIR installed at the bottom of the airframe

Information is projected on the visor.

Fig.5 HMD

(*3) Tunnel-in-the-Sky Display : When an obstacle appears on the display, it may be difficult to steer the airplane straight ahead on its approach to the runway. If the Global Positioning System (GPS), the system used for car navigation, is available, we can use data on the exact location of the airplane to select an available approach path within the limits of the airplane's performance. The Tunnel-in-the-Sky Display is effective in guiding airplanes in such an approach method. A tunnel tracing the approach path on the monitor display guides a flight along a curved course in a visible manner. JAXA has developed an indication system to simplify the task of piloting by adding a symbol which represents where the airplane will be positioned several seconds later.

Flight experiment conducted in fiscal 2008

Through September and October, JAXA conducted 17 flight tests, including some with approaches and landings at an airport or heliport in a mountainous region under the conditions to be expected in a search-and-rescue mission. This was Japan's first full nighttime flight by a civil aircraft with a FLIR and HMD installed on board.

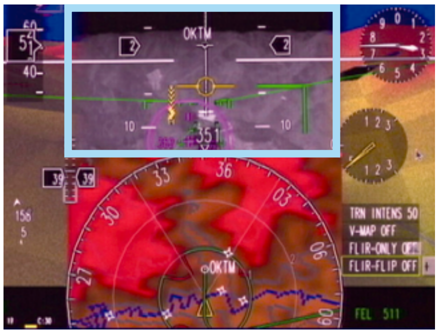
On October 14, JAXA projected the Tunnel-in-the-Sky Display on the HDD and HMD in an approach-and-landing experiment at the Okutama Fire-Fighting Heliport of the Tokyo Fire Department (Fig. 6) in Nishitamagun, Tokyo. Fig.

The Tokyo Fire Department uses this heliport to transport emergency patients.

Fig. 6: Okutama Fire-Fighting Heliport of the Tokyo Fire Department

7 shows an HDD screenshot. In the approach test on the HDD, the FLIR image was superimposed over the CG image of the topographical features. Fig. 8 is an HMD screenshot. The experiment confirmed that an approach to the heliport by Tunnel-in-the-Sky guidance was possible, and that mountain ridges and runways were visible with the FLIR at any time of day or night. And importantly, various problems with the hardware and display were identified. The lines in the CG representation of the topographic features poorly matched the actual ridge lines, for example, and the symbol used to guide the displayed approach actually covered up the heliport, hiding it from the pilot's view.

To promptly perform rescue activities, it is important to determine the exact location of the survivors. JAXA is researching and developing a technique to record the location of survivors based on a technology from Shimadzu Corporation for the support the rescue missions of the Maritime Self-Defense Forces. On October 28, JAXA demonstrated this technology in another flight test conducted in Kamikouchi, Nagano Prefecture. First, a pilot wearing the HMD finds a target (survivors), then moves the LOS(Line-Of-Sight) marker displayed on the HMD over the target. Next, the pilot takes aim at the target and presses a button, and the system calculates the intersection between the ground level and marker's line of sight at that time based on a three-dimensional topographical database.



The screen in black and white enclosed with blue lines is an FLIR image.

Fig.7 Display on the

Fig.8 Display on the HMD (Synthesized after the test)

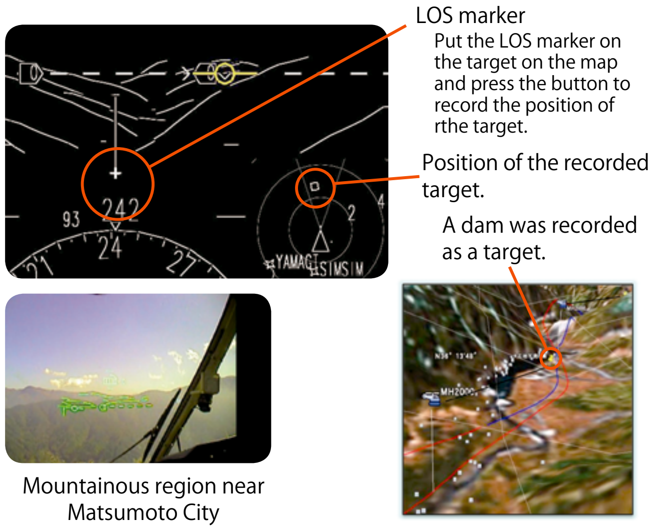
Through these steps, the position of the target can be recorded (Fig. 9).

Incorporating the results from fiscal 2008 into the test for fiscal 2009

We collect two kinds of data in the flight test. One is the record of physical data. This is objective data, such as information on when and how much the pilot moved the control stick, and how the marker was displayed when the mapping test was conducted in this state. The other is the pilot's rating and comments. We ask the pilot to find out how accurately he or she could determine the situation based on the information displayed on the screen at that time. Through this approach, we can investigate how to provide the pilot with proper information. As this is subjective data, it is important to collect it from two or more pilots.

The biggest problem encountered in the fiscal 2008 flight experiment was a visibility problem for the pilot: when the HMD displayed all of the information deemed necessary, this information masked the actual view outside the window, preventing him or her from actually seeing what was happening outside. To solve this problem this year, we will investigate what information is most essential, and the best way to display it, based on data obtained in fiscal 2008. With success, the pilot will be able to easily recognize the situation outside and control the helicopter accordingly.

There is also a problem with the time lag between the information display and the movements of the airframe and pilot. As the airframe or pilot's head moves, the display on the monitor must change accordingly in real time. The current system is not yet practical, as the time lag is still too long. JAXA is aiming to improve the performance of the system by reducing the time lag to a half or third of the current level in the flight test scheduled for October 2009.



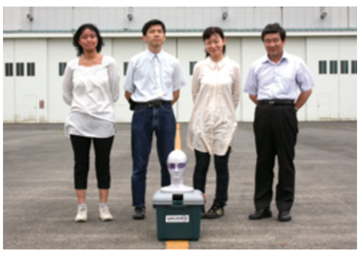
A test was conducted with a dam and building as targets. We were able to determine the exact location in spite of the complicated terrain of the mountainous region. The picture in the lower left shows a record of the HMD image the pilot actually saw.

Fig.9 Mapping test in Kamikouchi

Experiencing SAVERH

The Chofu Aerospace Center (Tokyo), one of JAXA's offices, has a flight simulator for research and development. To finish up my on-site report at the center, I tried on the HMD myself and rode the helicopter simulator to experience the technology developed by SAVERH. The pilot, seated next to me, maneuvered the flight smoothly. From start to finish, a visual stream of flight information played out clearly before my eyes on the HMD display. The results were far more seamless than what I had come to expect from hearsay: the problem identified in the fiscal 2008 flight test had apparently been corrected. My impression, however, might have been misleading I might not have felt something was wrong when the outside scenery was superimposed over the HMD information, as the scenery itself was computer graphics.

If we can use this technology to safely fly helicopters around the clock for disaster relief or emergency response in any kind of weather, more lives may be saved. Seen in this light, I hope the technology is developed as soon as possible.



[Flight Research Center]

(from left) Tomoko Iijima, Kohei Funabiki, Hiroka Tsuda, Hirofumi Shirouzu

The world we can see with infrared radiation

■ What is "light?"

The rays of the sun shower down on us and light up the world in which we live. Yet we, as humans, can only see light of a limited wavelength range, what we call visible radiation. Visible radiation is only one of several kinds of radiation traveling through the air. There are also radio waves (to carry the signals for our radios and televisions), infrared radiation (to provide heat for our heating systems), ultraviolet radiation (to suntan the skin), X-rays (to take radiographic images), and others. These forms of radiation are generically known as electromagnetic waves (Fig. 1). An electromagnetic wave propagates like a ripple caused by dropping a small stone on the surface of a lake.

Human eyes are only capable of perceiving visible light. Birds, on the other hand, can perceive ultraviolet rays, a form of light beyond the purple end of the color range. Even if we see the same scenery as birds, we see it differently.

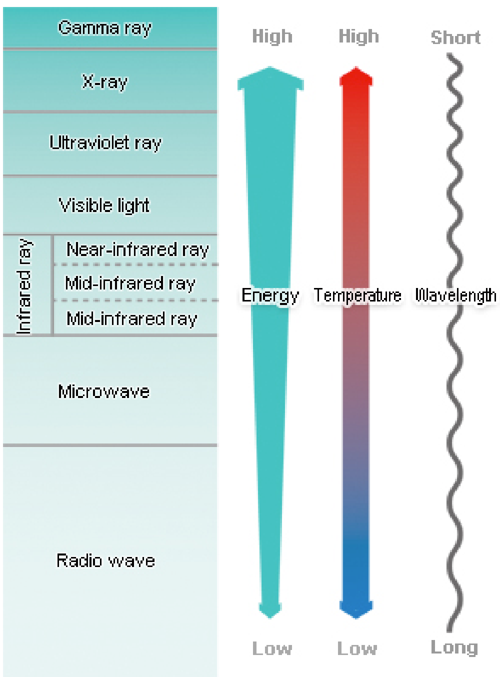


Fig.1 Different kinds of light (electromagnetic waves)

■ "Infrared rays," a light beyond the red end of the color range

When walking along the street, we often find security cameras these days. As crimes can occur at any time of day or night, security cameras should capture crime scenes clearly even in the dark. This can be achieved using "infrared rays," a light beyond the red end of the color range.

When you want to see something in the dark, you can illuminate it with a flashlight. Near-infrared rays have properties similar to visible light. You can see the thing in the dark by shining near-infrared rays toward the thing and capturing the reflection with a night vision camera (a camera capable of detecting near-infrared rays). Interestingly, people irradiated with this light never notice, as the infrared rays are unperceivable to the human eye.

Another available technique is to detect the infrared rays emitted by an object instead of reflected infrared rays. Every object around us emits infrared rays commensurate with its temperature. We can actually visualize an object by determining its temperature distribution based on the intensity of the infrared rays it emits (Fig. 2).

■ Infrared cameras in aerospace

Infrared rays were discovered in the year 1800. Their existence was deduced from a simple observable

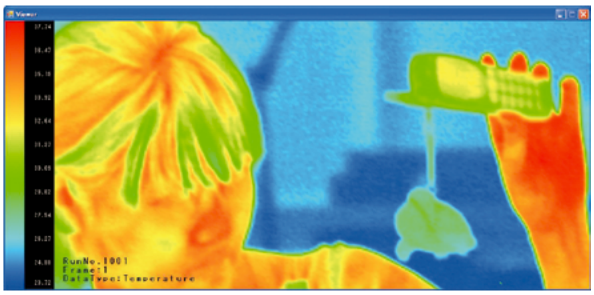


Fig.2 Image captured with an infrared camera

phenomenon: the temperature reading on a thermometer rises even in the absence of visible light.

In this issue we introduce a flight experiment with an infrared camera installed on board the aircraft. Infrared cameras have long been used for self-defense purposes. Many are installed on the aircraft operated by the Japan Coast Guard. Recently, small types have been installed on commercial aircraft to support nighttime takeoffs and landings.

Infrared cameras play an important role in the wind tunnel test, an indispensable phase in the design of aircrafts and spacecrafts. When a space shuttle reenters the earth's atmosphere, the airframe is subjected to an enormous amount of aerodynamic heating. To estimate this heating with high accuracy, infrared cameras are used for temperature measurement in wind tunnel tests (Fig. 3).

Outer space is filled with billions of low-temperature celestial bodies invisible to the naked eye. Though they can't be seen, these celestial bodies radiate infrared rays commensurate to their temperatures. For this reason, we can identify the existence of a celestial body by observing its infrared rays. Fig. 4 shows how space appears in the direction of the Great Hunter, as captured by "Akari," JAXA's Infrared Rays Astronomical Satellite. This illustrates how infrared rays allow us to see the world invisible to the naked eye.

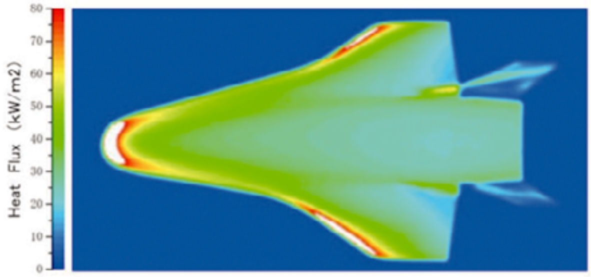


Fig.3 Temperature distribution at the atmospheric reentry of the space shuttle

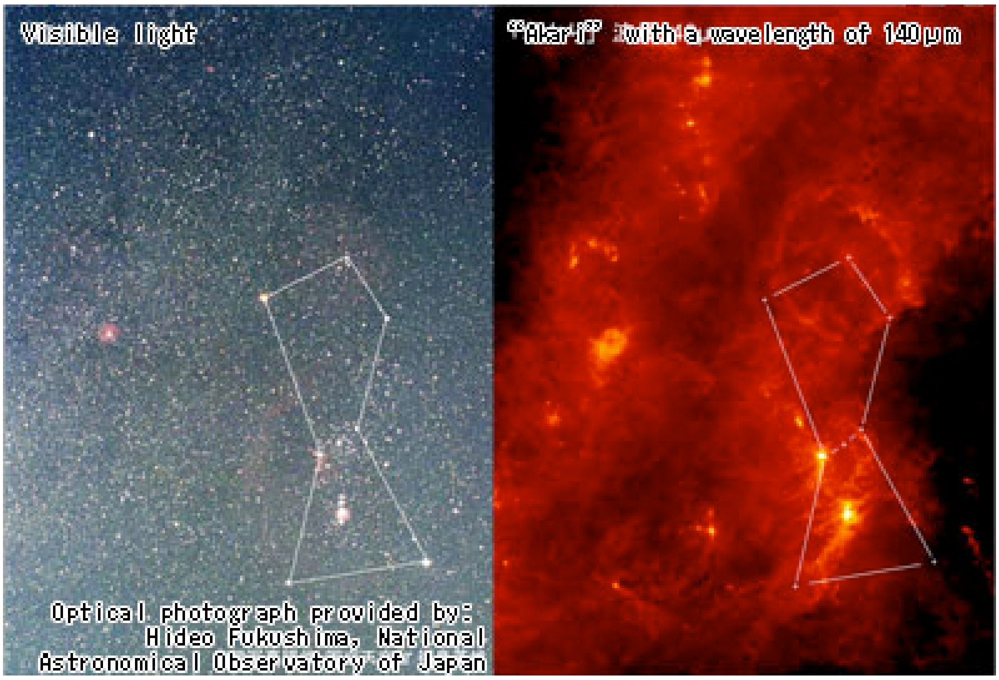


Fig.4 The Great Hunter captured with "Akari"