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Summary Report

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New High-Techs for Disaster Relief and National Defense

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Acknowledgments

The Symposium on New High-Techs for Disaster Relief and National Defense was held by Research Institute for Peace and Security (RIPS) at Grand Hill Ichigaya, Tokyo, on October 4, 2011. Experts from U.S. and Japanese industries made the presentations and participated in the panel discussions. Junichi Nishiyama, Former Deputy General Manager, Aerospace Headquarters, Mitsubishi Heavy Industries, presided over the discussion. RIPS wishes to thank all the panelists and the moderator for making the program such a success. This report was compiled by Yukari Kubota, Osaka University.

Contents

Welcoming Remarks

Masashi Nishihara

President, Research Institute for Peace and Security (RIPS)

Japan's Self-Defense Forces played an important role in disaster relief after the Great East Japan Earthquake. One of the lessons we learned from this was that some defense systems and technologies, such as unmanned vehicles and imagery-processing systems, can also be used for disaster relief, as the technologies for disaster relief and for national security largely overlap. How should we and how will we be able to maximize the use of these technologies in the future? What can Japan's Self-Defense Forces learn from the United States? Today's symposium will be a good opportunity to consider these issues.

Greetings

Masanori Nishi

Director-General, Defense Policy Bureau, Ministry of Defense

Japan's private sector has made dramatic technological progress creating industrial robots and is now fully utilizing them. The Great East Japan Earthquake, however, taught us that we should have robots that also can be used for disaster relief, where we confront problems similar to those in the battlefield. Unfortunately, Japan's R&D on robot technology for defense purposes has fallen behind that of other countries.

The disaster also presented another problem. Although Japan has been using infrared sensors for a long time, the Ministry of Defense's Technical Research and Development Institute has had great difficulty using these sensors to determine the accurate temperature of the affected nuclear reactors in Fukushima Daiichi Nuclear Power Station. Japan has thus learned an important lesson: the Ministry of Defense must establish requirements for new technologies like unmanned vehicles and imagery-processing systems. Because this disaster has presented a new challenge, I hope that the experts will consider the applicability of new high technologies to both disaster relief and national defense.

Opening Remarks

Junichi Nishiyama, *Moderator*
Former Deputy General Manager,
Aerospace Headquarters, Mitsubishi Heavy Industries

The Great East Japan Earthquake of March 11, 2011, devastated much of the Tohoku district and caused about 20,000 casualties, most of whom were killed and many of whom are still missing. Furthermore, the tsunami that followed extensively damaged Fukushima Daiichi Nuclear Power Station, leading to hydric explosions and a partial meltdown.

Satellite information, unmanned aerial vehicles, and robots all played important roles in relief operations. The United States' sophisticated UAV Global Hawk took photographs flying over the nuclear power plant. In addition, the Japanese-made remote-controlled construction machinery that had been developed to deal with the explosion at Unzen-Fugendake, Nagasaki, in 1990 and Swedish-made remote-controlled demolition machines were used to clear away much of the debris from the explosions.

According to one of the Japan's robot engineers, although the country does have the technological capability of developing and manufacturing a robot, it does not have the specifications for one that can be used for disaster relief activities. Moreover, at least ten years of R&D and an actual operations unit would be needed to develop robots and robotic technologies for a specific purpose. The U.S. military, however, has developed robots to the point that it can use them in combat missions, and feedback from their performance and utility has led to their continual improvement.

The U.S. iRobot Corporation lent to Japan both its remote-controlled military robots, PackBot and Warrior, and their operators to deal with the nuclear accident in Fukushima. According to iRobot, "Fukushima gives us real experience using robots to help in disasters." In fact, because the United States has been experimenting with military robots for use in a nuclear war, they were able to play an important role in the Fukushima nuclear accident. As a result, it is clear that military robots would be extremely useful in large-scale disasters as well as in a more confined disaster, such as in a nuclear power plant, in which using humans would be too dangerous.

Today, distinguished experts on UAVs, UGVs, and imagery systems will discuss how these new high technologies have, and have not, been able to help in disaster relief activities.

Presentations

UAV Technology in Support of Future Missions

James F. Armington, Vice President, International Business Development, Defense, Space and Security, Boeing Japan

The technology to design and build air vehicles that can fly without a human on board has been around for many decades. However, using this technology to accomplish useful missions has taken more time and effort. The United States and its allies have learned a lot over the last twenty years from actual mission experience with unmanned aerial vehicles (UAVs). Over the same period, rapid advances in information and communication technology, computer-processing power, and sensor technology have made new applications possible.

Although machines can now perform many specialty tasks faster and with greater accuracy, human judgment is still needed on board to carry out highly complex missions such as air-to-air combat and in situations in which remote on-scene decision making is needed, such as special operations and search and rescue. Multi-mission aircraft can still be operated more efficiently by human beings in cases in which the environment may call for rapid changes in tactics.

There are many reasons, however, that remotely connecting the human to the vehicle is becoming more practical than having him in the cockpit. The UAV's main advantage is removing the constraints of the human's physical limitations. First, unmanned systems have greater endurance. Second, they can operate with less risk in dangerous environments, such as those with chemical, biological, or radiological contamination; in hostile airspace; or in forest fires. Third, UAVs offer much greater degrees of stealth and surprise through their smaller size and special characteristics that larger manned systems lack. Fourth, unmanned systems are preferable to manned aircraft when recovery is less reliable because of weather, remote location, or fuel limitations. Fifth, unmanned systems are not so constrained by g-force limitations as manned aircraft are. Sixth and finally, another benefit of UAVs is their lower cost.

Although these advantages are compelling, remotely connecting the pilot or mission system operator to the aircraft also has limitations, such as the cost and bandwidth of data links, the risk of signal loss from jamming, and latency in feedback cycles that slow decision making and make accidents more likely. In our early experience with the Predator UAV, 75 percent of the major accidents were due to human factors. These challenges are leading to the development of increasingly more autonomous UAVs. The more that the vehicle can manage itself, the less dependent it will be on the operator, thereby freeing up precious bandwidth and human attention. In addition, computer-controlled machines are more effective in repetitive methodical missions, such as large-area surveillance for which the data coverage must be precise and human attention spans are short.

The next evolution of air systems will consist of a combination of manned, remotely operated, and autonomous vehicles. The U.S. Air Force is examining some future innovations to optimally integrate human and machine abilities. For instance, according to the USAF's 2009 Unmanned Aerial System (UAS) Flight Plan report, "as autonomy and automation merge, UAS will be able to swarm (one pilot directing the actions of many multi-mission aircraft) creating a focused, relentless, and scaled attack." Just as flying insects work together to increase their collective effect, a swarm of cooperating UAVs could rapidly overwhelm a target's defense or efficiently complete a wide-area surveillance task.

The UAV has come of age and proved to be valuable tool for both military and civil operations. Although remotely piloted and autonomous UAVs will increasingly work in partnership with manned aircraft, they will not completely replace them. This combination of new tools will allow global reach, indefinite persistence, hypersonic speeds, remote access, secrecy and surprise, and extreme precision. To reach this future, we will need more engineering and technology development in materials, propulsion, sensors, computers, and software, combined with advanced mission management modeling and simulation. The cost of research and development will continue to be one of our greatest challenges. At Boeing, we are continuing to push the envelope in many of these areas.

UAV technology also will be increasingly important to Japan, for several reasons. First, Japan is a large maritime nation with many islands and an expansive marine territory to defend. The high potential for natural disasters also creates a need for flexible and responsive surveillance capabilities, and UAVs are ideally suited to the surveillance of large areas. Second, listening for potentially threatening activity in Northeast Asia requires collecting long-range signals intelligence with no gaps in time or space. UAVs that can remain continuously airborne are best for this mission. Third, because Japan's shortage of manpower is increasing, using unmanned systems will free human resources for more complex decision tasks. Fourth, to defend itself against advanced threats in the future, Japan’s military capability will have to maintain a qualitative edge. With fewer manned systems, Japan can increase its leverage against more numerous adversaries by investing in smaller, cheaper, faster, and stealthier unmanned air vehicles to work in swarms. Fifth and finally, Japanese industry can make significant contributions to many of the new technology areas.

The mission capabilities of UAVs for natural disasters and for national defense are very similar. The remote sensing and persistent surveillance challenges in the aftermath of the recent earthquake and tsunami disaster and the nuclear accident in Japan call for many of these unique attributes of UAV and systems.

UAV Imagery Considerations in National Defense and Disaster Relief

Curtis L. Orchard, Vice President Japan, Northrop Grumman International

Imagery is just one important product produced by UAVs. Collecting signals data, tracking data from radar or an AIS (automatic identification system), and relaying communications are examples of equally important ISR (intelligence, surveillance, and reconnaissance) products and capabilities. Today, some operations use hundreds of different types of UAVs, as no single one can meet all ISR needs. What are their roles in layered ISR when they vary from handheld Dragon Eyes to Predator UAVs?

First, to help understand UAVs' contributions to military intelligence, we will reverse "ISR" and apply the sequence described by "RSI." Here, *reconnaissance* is the first task—to investigate, scout, or explore. *Surveillance* is the second—to maintain close watch. Many UAVs provide important capabilities in these two areas, whether they fly at an altitude of 50 feet using a small camera or at 25,000 feet using radar and multiple cameras.

Intelligence is the last term in the sequence. One definition for military intelligence is to "exploit information collection and analyses to provide guidance to commanders in support of their decisions." Of the thousands of UAVs in operation, however, relatively few fully meet this definition. The concept of an RSI value chain for UAVs is a way to include each UAV's contribution, as each has limitations in space or volume, weight, and power capacities, which translate into limits in persistence, sensing, and communicating. Continuous support for military intelligence is the goal of the value chain, and it also makes the most demands on people and aircraft. Manned aircraft cannot match the persistence of UAVs, as evident in the U.S. Navy's recent announcement that Scan Eagle has flown for more than 65,000 hours.

Second, it is important to look beyond the UAV aircraft to address process and standards to involve external users. Operational commanders require UAV imagery that contributes to intelligence, not necessarily from a single image, but as a more complex product that is exploited using other information. For example, intelligence is not just an image of a ship at sea; the imagery should be exploited to add historical and situational awareness data as well as analysis. A systems-engineering approach to UAV that addresses some of these complexities is the "TPED" process—tasking, processing, exploitation, and dissemination—to make imagery into intelligence. TPED requires direct and timely engagement with external users, commanders who do not fly the UAVs but need their intelligence. The cycle may take days, hours, or minutes.

Standardization is vital as well if a varied number of entities participate in the imagery TPED process. One such standard is the U.S. government's National Imagery Transmission Format (NITF) to exchange, store, and transmit digital imagery. Other image formats can be accommodated only in a single system, but the NITF is required for interchanges between systems. For "exploitation," the NITF format also allows for additional intelligence analyses to be added to the imagery. Japan currently uses the NITF format, and Japanese industry is well versed in integrating commercial software and hardware applications to generate its own TPED system.

Third, let me relate these points to some released images of NITF from Electro-Optic, Infrared and Synthetic Aperture Radar, each of which was taken by a Northrop Grumman Global Hawk at an altitude of about 60,000 feet. In the 2006 RIMPAC (Rim of the Pacific Exercise), before the Electro-Optic image was taken, the Global Hawk detected and tracked Japan's Maritime Self-Defense Force's ship *Samidare* using radar at long range (reconnaissance). When determined to be a military vessel, the Electro-Optic image was taken at medium to short range (surveillance). Once enlarged, it was evident how the ship was equipped, what its hull number was, and that its H-60 class helicopter was ready for flight (intelligence). Another example is that high-altitude infrared (IR) proved to be very effective in responding to the huge wildfires in California in 2007. The images provided by the Global Hawk operating at night illustrated well the dense smoke and high winds propelling the fires. These same conditions would have made nighttime manned and UAV operations at lower altitudes unsafe and of less value.

Operation Tomodachi remains fresh in our minds. The use of UAVs is emerging as an important "lesson learned" from the enormous disaster and response. The Pacific commander, Admiral Willard, testified to the U.S. Congress on the value of Global Hawk's creating an IR image "map" of Fukushima Daiichi Nuclear Power Station, through repeated monitoring over several weeks. This enabled us to look for temperature variances in order to evaluate critical risks. Among the lessons learned, we discovered that it may be possible to forecast how a small UAV can be used to image the demand infrastructure in a dangerous environment, which requires getting a camera as close as possible without risking human life.

While UAVs will not replace manned ISR in the foreseeable future, they do represent a tremendous opportunity to close gaps cost-effectively through a layered ISR concept. By the end of this decade, the U.S. Pacific Command (PACOM) will rely on UAVs for long-persistence missions to provide imagery, radar data, and signals collection. PACOM's missions include the full spectrum of both civil and military tasks, since today's UAV mission could be military intelligence, and tomorrow's could be disaster relief. PACOM considers UAV-ISR to be a "low density, high demand" asset, meaning that it will be stretched thin to meet all demands within a region. Partners and allies will need to contribute their own UAV solutions. Japan's Mid-term Defense Plans and the Joint Statement of the Security Consultative Committee (2+2 statement) over the past seven years have emphasized the necessity of improving information sharing between the United States and Japan. Collecting, exploiting, and sharing UAV imagery must be one of the key measures to strengthen the Japan-U.S. alliance.

Satellite Imagery

Andy Stephenson, Senior Regional Director Asia Pacific, GeoEye

GeoEye is known for providing highly accurate satellite imagery to support many critical missions, primarily for defense and intelligence. Today I would like to talk about "EyeQ," which is GeoEye's solution to delivering timely online geospatial data and intelligence. It allows us to catalog and manage our data and to perform product provisioning. We can also distribute geospatial information widely in hours and days rather than weeks and months. Typically, it takes much time and great expense to collect and produce data and deliver physical media to our customers. Therefore, what we had in mind when creating the online geospatial delivery platform was to change the existing paradigm by shortening the time frame and reducing the cost.

EyeQ enables us to take high-resolution satellite imagery from a broad area and then to select a particular or precise area of interest by just clipping the actionable information that we need and eliminating what we do not need. For instance, from an 8-gigabyte full image, we may get only the 20-megabyte image that we need. Using what we call "cloud" technology or "Internet" technology, we can put geospatial content into the hands of users in a very timely manner. The initial purpose of EyeQ was to change the paradigm of accessing imagery, which allows us to stream and download contents on demand. Later, EyeQ evolved into a set of platform services that include the ability to grab and discover content from existing infrastructure holdings, national assets, and resources. It also will be able to grab and process another source of information, such as data sets from UAVs, and relay it to a number of different user points, whether public or behind firewalls. Then EyeQ will deliver the data and content to users who require intelligence on the ground.

Let me briefly talk about some of the deployments of EyeQ technology. Before the Great East Japan Earthquake in March 2011, we had begun support operations for Japan Space Imaging Corporation. So as soon as a satellite became available, GeoEye delivered 30,000-square-kilometer high-resolution satellite imagery to the first responders on the ground for humanitarian relief, just hours after the crisis. By chance, because GeoEye was also working closely with the *New York Times* to create interactive slider technology, the images delivered by EyeQ enabled us to develop a site of image capture, which generated about 13 million page-views in the first 24 hours that this interactive tool became available. Satellite photos taken by EyeQ at previous points of time and an image taken within days of the disaster were made publicly available on websites around the world. When the *New York Times*, using the same slider technology, published satellite images of before and after the disaster, we were able to superimpose or overlay one on the other to detect changes and thereby to look at intelligence on the ground.

EyeQ technology also was used in Libya from February to June 2011. GeoEye started by collecting satellite images of a significant part of the key conflict areas. Taking photos of certain areas at multiple times produced a time-series stock of data, which allowed us to detect changes. In a satellite image of Ras Adjir refugee camp, located about three miles inside the Tunisian border checkpoint, which was taken a few days after the civil war began, we can see the camp already taking shape. A satellite image taken four days after this shows that a few more tents have been set up in the western clearing and also that the many buses on the northern road have brought more refugees to the camp. Three weeks after the civil war began, the camp had expanded much farther west, with more makeshift housing as more people arrived. When zooming in to a particular area, we can actually see a line of people starting to congregate at a food distribution point.

Another image shows fighter and training airplanes stationed at the Misurata Airfield Base in Libya before NATO imposed the no-fly zone. In the next image, just after NATO began enforcement, we can see that some of the fighters and one trainer have been destroyed. The reason that not all the aircraft were destroyed was that the image analysts determined, based on a full-resolution image, that those aircraft had been stripped down for spare parts or had otherwise been taken out of service. GeoEye provided these images of the base both before and after the strike, for JARIC (the Joint Air Reconnaissance Intelligence Center), the United Kingdom's National Imagery Exploitation Center.

Our customers use EyeQ in a number of innovative ways, often creating derivative products through additional analysis based on satellite imagery. For instance, HIS Jane's Defense & Security Intelligence & Analysis used EyeQ to gather information about the Libyan border at Ras Adjir refugee camp, from additional analysis based on a satellite image, and to disseminate it to commanders on the ground so that they could draw up an actionable intelligence report. UNOSAT (United Nations Institute for Training and Research's Operational Satellite Application Program) analyzed the Libyan conflict, providing a detailed commentary of activities on the ground, which also showed mobile artillery.

EyeQ technology was well received for the amount of data and contents that were made available to detect changes based on time-series analysis. Indeed, GeoEye has become a leading source of geospatial information for decision makers who need a clear understanding of our changing world.

Unmanned Ground Vehicles (UGVs)

Hirotaka Kumakura, General Manager, IHI Aerospace

IHI Group has been working on unmanned ground vehicles (UGVs) mainly in the two fields: robots used for operations in its plants and construction works, and robot technologies for space and defense. Today I would like to briefly describe how our UGV technologies are used for disaster relief and national defense.

First is the unmanned construction machinery used as a UGV for disaster relief. This is a remote-controlled ground robot capable of carrying out engineering operations in areas too dangerous for people to enter. Unmanned construction machinery has been put to use in various disaster relief operations since the eruption of Unzen-Fugendake, in Nagasaki in 1990. Japanese general contractors have led in the development and utilization of unmanned construction machinery in cooperation with Japanese machinery manufacturers. Whenever a disaster occurs, the general contractors have the appropriate equipment to deal with the reconstruction and engineering. As a result, unmanned construction machinery has played an active part in disaster relief.

Rescue robots are used for life-saving activities in confined and/or dangerous areas that humans cannot enter. Since 1995, when the Great Hanshin Awaji Earthquake happened, the national government has allocated funds to Japanese universities and robot manufacturers to conduct R&D on rescue robots. Nonetheless, rescue robots have rarely been used for disaster relief, largely because the Fire and Disaster Management Agency has not had any to use in their disaster relief activities.

Various kinds of robots that can be used to deal with accidents in nuclear power plants have been created since the JCO Co. Ltd. Tokai Plant's critical accident in Ibaraki Prefecture, in 1999. Tokyo Electric Power Company, however, did not have a ground robot to use at Fukushima Daiichi Nuclear Power Station. The so-called *safety myth*, which is a kind of groundless belief that Japanese infrastructure is absolutely safe, has prevented the Japanese government from appropriating funds for maintaining and utilizing these robots. PackBot, developed by the U.S. company iRobot, which has frequently been used in U.S. military operations, was deployed to determine radiation levels in the Fukushima power plant. Before PackBot arrived in Fukushima, Japanese-made unmanned construction machinery began removing debris from the radiation-affected area near the building housing the nuclear reactor.

UGVs are effective for disaster relief operations because they can work in dangerous environments such as nuclear power plants, volcanic eruptions, and earthquakes. Agencies involved in disaster relief operations must maintain UGVs so that they can be immediately and effectively used in the field and should subsequently be improved based on feedback from users.

The second use of UGV~~G~~s is for national defense. The characteristics and environment of battlefield operations have changed, typically to asymmetrical combat with terrorists. The U.S. military has led in the use of UGV~~G~~s, in order to avoid casualties. It uses three types of UGVs for disposing of explosive ordnance: the small-sized MK1 (iRobot's PackBot), the medium-sized MK2 (QinetiQ's TALON), and the large-sized MK3 (Northrop Grumman's ANDROS). More than 8,000 of these UGVs have been deployed in Iraq and Afghanistan, from which U.S. military has received abundant feedback about their performance. The U.S. military also uses the SUGV (downsized PackBot) for reconnaissance at close range: discovering enemies hiding among their own soldiers.

The United States has been working on the next generation of UGVs, especially the semiautonomous UGV that, under the guidance of a soldier, is capable of traveling by itself while avoiding obstacles. Lockheed Martin developed the semi-navigable UGV named SMSS, which is being deployed experimentally to support a squadron in combat operations. The versatility of this robot is expected to range from transportation support, reconnaissance, and electricity supply to communication node. The U.S. military also is experimenting with an autonomous UGV for logistics support. Convoys in Iraq and Afghanistan have constantly been plagued by IEDs (improvised explosive devices). To protect against them, the U.S. military needs to be equipped with UGVs.

The CAST (Center for Applied Special Technology) program of the U.S. Army Tank Automotive Research, Development and Engineering Center, is trying to develop a completely unmanned convoy system that uses UGV technology. When this unmanned system is put to use in the future, only the first of a convoy of tanks will be driven by a human soldier. Those in the tanks following him will not need to navigate them and so will be able to concentrate solely on surveillance.

In the case of Japan, although it has not yet deployed UGVs, the Ministry of Defense's Technical Research and Development Institute has been urging that UGVs be put to practical use. These include small-sized robots capable of going up and down stairs and moving up to 10 km/h;

spherical-shaped robots that can change their shape for traveling and then reconnaissance after going indoors; and robots capable of disposing of explosive ordnance. In addition, IHI Aerospace has been working on small-sized UGVs that specialize in traveling. We also are conducting R&D in technologies for the surrounding recognition and action control needed for autonomous UGVs.

UGVs are expected to become indispensable defense equipment that will reduce the number of combat casualties. The U.S. military and industry and also Japanese manufacturers are continuing to improve the current UGV technology.

Panel Discussions

Although Japanese companies and the Ministry of Defense have excellent UGV technology, it was not used for Fukushima Nuclear Power Station. The performance of Japanese-made unmanned vehicles will not be proven until they are actually used in the field. What should Japan do to become the global leader in this area?

◆ **Hirotaka Kumakura:**

Robots used for defense purposes are still undergoing R&D, which was still in the early stage at the time of the Fukushima plant's meltdown. The Japanese people should have learned from the Great East Japan Earthquake in March 2011 that they must have an independent, specialized organization that can deal quickly with unforeseen circumstances for at least a few days immediately after an accident. Japan also needs to understand and think about expanding its use of robot technologies.

If Japan deploys the UAVs and imagery technologies presented here by the panelists, does it need an expansive infrastructure on the ground?

◆ **Curtis Orchard:**

The United States has very large infrastructures not only for supporting both UAVs but also for rapidly providing information to various business sources. The U.S. government can simultaneously exploit the intelligence gained from UAVs for thirty different platforms worldwide, although data often need to be collected and exploited from only a few assets. Most of these technologies are part of a secure, web-based or cloud-based computer-processing environment. Whether Japan needs to build a similar infrastructure depends on its customers' requirements. As Japan already has most of these technologies, what will be needed is just to integrate them into its own system.

◆ **James Armington:**

How large this infrastructure should be depends on what type of vehicles will be deployed. A large UAV like the Global Hawk needs an enormous infrastructure, but a small, flexible, affordable, and deployable UAV needs only a runway and a hanger. Helicopter UAVs are useful in that they do not need much infrastructure. Furthermore, the equipment for ground control is becoming progressively smaller. Data exploitation is being integrated with commercial technologies such as Google-type Internet Protocol-based data, which enables the infrastructure to be much smaller than that for combat operations.

◆ **Andy Stephenson:**

When the global imagery infrastructure is in place, users will be able to obtain data in a highly compressed format and much more quickly on the web, and they will be able to download megabytes, rather than gigabytes, of data. This will reduce the cost of the infrastructure.

Are there any disadvantages to deploying UAVs and UGVs, especially in regard to data communication vulnerability and functional limitations?

◆ **James Armington:**

There are some concerns about the communications vulnerability of unmanned vehicles and remotely piloted vehicles. A link is needed to control these vehicles, and data links are vulnerable to communication jamming. If that happens, the UAVs gathering information might not be able to respond to commands. When the United States deploys Predator UAVs in Afghanistan, which are controlled from a site in Nevada, the satellite communication takes a few seconds, creating some blind spots during critical operations. To remedy this, the United States has been looking at semiautonomous vehicles, on which guidance, logic, and mission management programs could be installed, thereby limiting the dependence on communication links. Reducing frequency spectrum consumption could help resist jamming.

◆ **Hirotaka Kumakura**

The issue is not just about communication links. There are many kinds of risks in the situations in which UAVs and UGVs are used. For instance, in Fukushima Nuclear Power Station, two robots were used, but it would have been more effective to use several robots, not just two, to be prepared for every possible risk.

The panelists refer to the engineering term *autonomous* in regard to unmanned vehicle operations. How do they define *autonomous*? Also, manufacturing unmanned vehicles to cover more specifications could make them more costly. How, then, do they think this autonomous vehicle will be designed?

◆ **James Armington:**

In regard to the degree of autonomy, there are completely autonomous vehicles that are capable of completely self-contained launching missions programmed by computers. Today, however, semiautonomous vehicles are more technologically mature. They still need some program updates and some communication between the unmanned vehicle and another vehicle. The basic meaning of *autonomous* here is that the vehicle is controlled through preprogrammed intelligence run by a computer on board the UAV; that is, all the basic functions for controlling the vehicle are on the vehicle.

◆ **Hirotaka Kumakura:**

UGVs are different from UAVs. UGVs on the ground are more complicated than UAVs flying in the air because ground robots must avoid obstacles or barriers and search for an appropriate route. They should be able to move steadily over a long distance and to traverse difficult terrains. In the case of UGVs, such hurdles should not be ignored. In addition, the human operator might want a robot "to do something specific at that corner" or something similar, which does not allow us to have completely autonomous UGVs. Right now, the UGVs must be semiautonomous. But after overcoming these challenges, the next step for autonomy will be strategic actions, another level of autonomous operations, in which we hope a ground robot could become one of the troops.

The modernization of China's military power is a serious concern to the security of Asia-Pacific region. How would you evaluate the industrial competitiveness of the major developed countries, including China, in unmanned system and imagery technologies?

◆ **James Armington:**

With the technological evolution in these areas taking place around the world, the United States and Japan will want not only to stay ahead of the rest of the world, especially in defense technologies, but also to share those technologies with each other. The United States also shares technologies with its European allies. Because technological gaps necessitate additional investment, commercial technologies are often incorporated in unmanned system engineering. With these concerns in mind, it is important for our allies to invest in these technologies so as to take the lead over other countries. Many countries have major barriers to developing unmanned systems.

◆ **Andy Stephenson:**

Generally speaking in regard to the global industrial outlook, the United States and Japan excel in earth observation systems and remote-sensing technology, with some European countries close behind in resolution technology. Imagery technologies have made dramatic progress; in the past, high resolution was considered to be from 2.5 to 5 meters, but now high resolution is less than 1 meter. In the next ten to twenty years, a number of countries, including China, will launch high-resolution satellites. The technological gap in this area will narrow as countries compete with one another for advanced technology for either industrial or defense purposes.

Summary and Comments

Junichi Nishiyama, *Moderator*

I would like to thank both the distinguished speakers and the participants in this symposium. Today we discussed new high technologies for disaster relief and national defense. The importance of space-based surveillance and intelligence is an evident fact. As the speakers pointed out, Japan needs a rapid intelligence-gathering capability, from either UAVs or satellites. We also will need remotely piloted and autonomous systems as well as small-, medium-, and large-sized vehicles. The combination and deployment of these systems will be determined by their particular purpose.

As I stated earlier, Japanese general contractors are continuing their work on unmanned construction machinery in preparation for use in disaster relief operations.

In June 2011, former Defense Minister Toshimi Kitazawa declared at the tenth IISS (International Institute for Strategic Studies) Asia Security Summit (Shangri-La Dialogue) that Japan must begin using UAVs, UGVs, and robots and also participate in international cooperation. To enable Japanese industries and entities to do this, the Japanese government needs to relax the Three Principles on Arms Exports.[1] Japan is constrained in its pursuit of offensive activities, so that dual-use robots are allowed, but military robots are not, even though they use the same systems.

Although 100,000 Japanese Defense-Self Forces participated in the disaster relief activities, the Japanese people must understand that their principal mission is to secure Japan's national security. University researchers might work with the Ministry of Defense to make sure the people are aware of this. In summary, Japan needs to improve its robotic technological capability and develop unmanned systems, which will help lead to a national understanding of Japan's security issues.

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[1] The Yoshihiko Noda administration decided on December 27, 2011, to relax the Three Principles on Arms Exports, under which the export of weapons and related technologies is essentially banned. The Japanese government also set new criteria for authorizing the international development and production of defense-related equipment as well as its export for peace-building purposes and humanitarian objectives, albeit under strict conditions.

<Profiles of Moderator and Panelists>

Junichi Nishiyama just retired from the Mitsubishi Heavy Industry this September after 40 years of service for MHI, whose Nagoya department he joined in 1971. He served, among others, as General Manager of the Guided Weapon Systems Department, as Deputy General Manager of the Aerospace Hq. and finally as its Senior Advisor. He has a M.A. degree in mechanical engineering from Hokkaido University. He is now a Consultant with MHI.

James F. Armington is Vice President of Japan Business Development for Boeing Defense, Space & Security. Prior to it, he was with Raytheon, serving, among others, as Vice President of its Tokyo office, and as Director of international business development in its Washington, DC office. He was a U.S. Air Force fighter pilot, and served as a foreign exchange officer with ASDF, and country director for Japan in the Pentagon where he was instrumental in establishing cooperative defense programs with Japan.

Hirotaka Kumakura is General Manager of the Unmanned Ground Vehicle Development Office, Defense Systems Department, IHI Aerospace Co., Ltd. He joined Nissan Motor Co., Ltd. in 1984 and worked in its Aerospace Department. In 2000 he moved to IHI Aerospace Co., Ltd. He has a Ph.D. in engineering from Hokkaido University.

Curtis L. Orchard is Vice President for Japan and Regional Director in Asia for Northrop Grumman International Inc. He joined Grumman Aerospace in

1985 and worked in AEW&C and fighter aircraft programs around the world. In 1989-96 he directed the Tokyo office. He served in the U.S. Navy for 15 years and he is a Distinguished Author for the US Naval Institute. He has a MA from Georgetown University.

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