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REVIEW ARTICLE

The Japanese Antarctic Research Expedition in progress and its organization

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Abstract

A brief history, organization, current scientific activities and logistics of the Japanese Antarctic Research Expedition (JARE), Japan's national Antarctic program, are introduced in relation to international frameworks to some extent. JARE was started on the occasion of the International Geophysical Year (IGY), an international scientific research campaign, planned 1957-1958 for geophysical observation on the globe. The government of Japan decided to participate in IGY with establishment of a Japanese Antarctic station Syowa on East Ongul Island, according to a proposal by the Science Council of Japan and continues JARE until now. Headquarters was established for JARE in the Ministry of Education, Culture, Sports, Science and Technology and decides plans for JARE. Operation and logistics of JARE is managed by the National Institute of Polar Research and many research institutions and universities participate in the JARE. The Antarctic Treaty System is a fundamental framework for the Antarctic research expedition and other non-governmental bodies like the Scientific Committee on Antarctic Research and the Council of Managers of National Antarctic Program are also very important fora for international collaboration on Antarctic science and logistics, respectively.

Keywords: JARE, Syowa station, ATCM, SCAR, COMNAP

Introduction

The author appreciate very much to be invited to the Turkish Antarctic Science Programme Road Map Workshop in Istanbul, held 18-19 November 2013. He should be very pleased if experiences and expertise of the Japanese Antarctic Research Expedition (JARE) and the National Institute of Polar Research on Antarctic research expedition, introduced below could be of any help to develop the Turkish Antarctic research expedition.

This paper was presented at the Turkish Antarctic Science Programme Road Map Workshop, Istanbul,18-19 November 2013, organized by the Turkish Marine Research Foundation.

Brief History of the Japanese Antarctic Research Expedition

The Japanese Antarctic Research Expedition (JARE), Japan's national Antarctic program was established at the occasion of an international scientific campaign, the International Geophysical Year (IGY), 1957-1958, in which 67 countries participated, at the end, to carry out a series of coordinated observations of various geophysical phenomena, including those in Antarctica. Technical panels were created to pursue work in the following areas; aurora and airglow, cosmic rays, geomagnetism, glaciology, gravity, ionospheric physics, longitude and latitude determination, meteorology, oceanography, rocketry, seismology, and solar activity (http://www.nas.edu/history/igy).

The Science Council of Japan (SCJ) requested the government of Japan to place a station for the IGY observations in Antarctica in the vicinity of 35°E longitude, based to the discussion results at a meeting of the Special Committee for the IGY (CSAGI) held in Brussels in September 1955, filling the largest existing gap in the Antarctic coastal stations for IGY. The government decided to take part in the Antarctic research for the IGY and established the Headquarters for organizing the JARE in November 1955 in the Ministry of Education, Science and Culture (Monbusho, currently transformed to the Ministry of Education, Culture, Sports, Science and Technology; MEXT). The secretariat of the Headquarters was set up in MEXT.

The government also decided to task the Maritime Safety Agency (MSA, currently renamed to Japan Coast Guard; JCG) to transport expedition personnel and cargo for JARE and the Sôya, an ice-strengthened patrol vessel of MSA, built in 1938, was converted to an ice breaker (Figure 1) to leave Tokyo Port on 8 November, 1956 for the first JARE with 53 expedition personnel on board. Many Japanese, especially young generations and many companies in Japan, including the Asahi Shimbun (one of the largest newspaper companies in Japan) enthusiastically made contributions to JAREs. To this first cruise of Sôya to the Antarctic, the Umitaka-Maru, a training and research vessel of the Tokyo University of Fisheries (currently integrated to the Tokyo University of Marine Science and Technology) accompanied and obtained scientific results on oceanography and marine biology of the Southern Ocean. The Sôya succeeded to reach about 20km from Ongul Islands in Lützow-Holmbukta, East Antarctica, from where they transported cargo for construction and overwintering over the sea ice using snow vehicles.

The first Japanese Antarctic station, Syowa (69°00'S, 39°35'E) was constructed on the East Ongul Island on 29 January, 1957 and 11 expedition personnel started overwintering from 15 February in 1957 (Figure 2). The second JARE encountered difficult weather and sea ice condition for approaching Syowa and could not transport cargo to Syowa for overwintering, even though an icebreaker USS Burton Island (AGB-1), supported the operation. The Sôya had

damaged one of the two screws in ice covered water. They could only pick up overwintered expedition personnel of JARE-1 and gave up overwintering at Syowa for JARE-2 on 24 February, 1958. The Headquarters decided to take two large helicopters (S-58) from JARE-3 for transporting cargo and personnel from this tough experience. At present, there are about 60 buildings and huts at Syowa (Figure 3). Current Japanese ice breaker Shirase is operated for JARE by the Japan Maritime Self Defense Force (JMSDF), the Ministry of Defense (MOD) and has two large helicopters (CH-101).

Figure 1. The first icebreaker for the Japanese Antarctic Research Expedition (JARE), Sôya, registered to and operated for six years by the Maritime Safety Agency, Ministry of Transportation, now Japan Coast Guard, Ministry of Land, Infrastructure, Transport, and Tourism. (Photographed during JARE-3.)

Figure 2. Syowa Station in early years of JARE, consisted of four buildings with two 20 kVA electric generators.

Figure 3. Syowa Station has 61 buildings and huts with two 300 kVA and a 200 kVA electric generators in 2013.

Organization

The Headquarters of JARE comprises many governmental departments and agencies of various ministries (https://www.comnap.aq/Members/NIPR), including the Ministry of Foreign Affairs (MOFA); the Ministry of the Environment (MOE); the Ministry of Defense; the Ministry of Land, Infrastructure, Transport, and Tourism (MLIT); and the Ministry of Agriculture, Forestry, and Fisheries (MAF) (Figure 4). The scientific research and observation, as well as logistic, programs of JARE are considered and adopted as a mid-term plan at general meetings of the Headquarters.

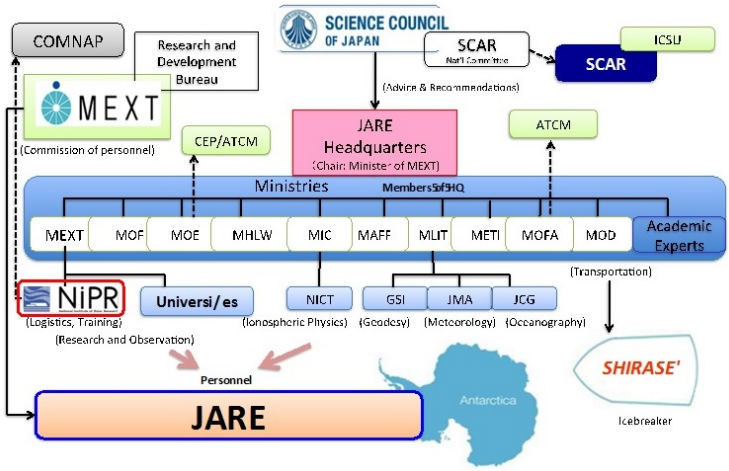

Figure 4. Organization of the Japanese Antarctic Research Expedition (JARE) and related bodies. (ATCM: Antarctic Treaty Consultative Meeting; CEP: Committee for Environmental Protection; COMNAP: Council of Managers of National Antarctic Program; SCAR: Scientific Committee for Antarctic Research)

SCJ joined the Scientific (formerly 'Special') Committee on Antarctic Research (SCAR) from the beginning in 1958 and there is a domestic sub-committee in SCJ to work with SCAR. Scientific Research Programs (SRPs) are coordinated by SCAR and those SRPs are incorporated in the JARE mid-term plan. Overseas scientists sometimes participate as members of some JARE research programs or as exchange scientists under framework of the Article 3 of the Antarctic Treaty. International collaborations is usual for Antarctic research and logistics.

The National Institute of Polar Research (NIPR) founded in 1973, is the body responsible for polar research and education, and the management of JARE, under direction of the Headquarters of JARE. NIPR has been pursuing cutting-edge polar studies, on the other hand, in collaboration with research communities relating to the earth, the environment, life, space and other fields as well. It is involved in a wide range of activities in the Antarctic research programs, both temporally and spatially, through research by using advanced method, long-term monitoring observations and field and ocean observations in many areas. Japanese four Antarctic stations, including a year-round station, Syowa, are research facilities of and managed by NIPR.

Antarctic research program applications, in accordance with the mid-term research plan decided by the Headquarters, are called for and considered from scientific and operational points of view in several committees of scientific experts including those from universities and institutions other than NIPR. Selected scientific research programs will be endorsed to the Headquarters. There are two categories of scientific programs, i.e. fundamental observation programs to be carried out every year like meteorological observation and atmospheric CO2 monitoring and research projects with limited terms, usually for a few years. Each programs are to be evaluated by the committees of scientific experts every year after the implementation and feedback will be incorporated in the plan for the next season.

Most of the expedition personnel are decided officially at a General Meeting of Headquarters for JARE in June. A summer training course for the expeditioners is held in late June in Kusatsu Highland in Nagano Prefecture, central Japan. Most of the expeditioners of logistic tasks are employed by NIPR from July and start working ordering and packing materials and being trained for JARE at NIPR, Tachikawa, with a help of supporting staff of NIPR. Research personnel, on the other hand, is endorsed by principal investigators of selected scientific programs. All candidates for JARE are screened by medical examination. The schedule for JARE-54 is shown in Table 1, as an example.

Table 1. Calendar of the 54th Japanese Antarctic Research Expedition.

Year	Date	Event
2011	November	Call for application for expeditioners
2012	January	Endorsment for expeditioners
		Medical check for expedition candidates
	early March	Winter training course for candidates
	early June	Medical screening of candidates
	mid June	General Headquarters Meeting
		Expedition personnel decided
	late June	Summer training course
	July	Employment for logistical expeditioners
	late August	General meeting (1) for expeditioners
	September	Training cruise of *Shirase* around Japan
	early October	General meeting (2) for expeditioners
	mid October	Loading cargo to *Shirase*
	10 November	General meeting (3) for expeditioners
		General Headquarters Meeting
		Implimentation plan decided
	11 November	Departure of *Shirase* from Tokyo
	25 November	Departure of JARE personnel from Tokyo for boarding *Shirase* at Fremantle (WA)
	30 November	*Shirase* leaves Fremantle for Syowa Stn
	mid December	First flight to Syowa
Summer Operations		
2013	mid February	Observations field/Syowa, logistics
		Last flight to Syowa
Oceanographic Observations		
	18 March	JARE personel arrives at Sydney
	20 March	JARE personel leaves Sydney for Tokyo
	mid March	Overwintered members arrive in Tokyo
	09 April	*Shirase* arrives in Tokyo
		Cargo unloading

The composition details of JARE-54 party is shown in Figure 5. There are two parties in JAREs; one is a summer party working only in Antarctic summer season and the other is an overwintering party working a full year starting from 1 February, responsible for maintaining Syowa, collecting routine observation data and working for research projects for a year. The number for the expedition personnel of each party was 30 for overwintering and 35 for summer in JARE-54. There is another category of personnel who join JAREs. We call it "observer", amounted 32 for JARE-54. There are several categories for observers, including media staff, government officials from MOE for collecting environmental specimens for assessing the state of the Antarctic environment, technicians for specific measurements, helicopter pilots/mechanics, graduate

students and school teachers for outreach program. From other point of view as to the area of the activity, there were four parties in JARE-54. The main party which is to work in the Syowa area and three sub-parties; one is to work in the inland Dome Fuji station area for glaciology and astronomy, the second is to work in the Nansen ice field area for meteorite search with collaboration with the Belgium Antarctic Research Expedition (BELARE) and the third is to work on board the Umitaka-maru for oceanography in the Southern Ocean.

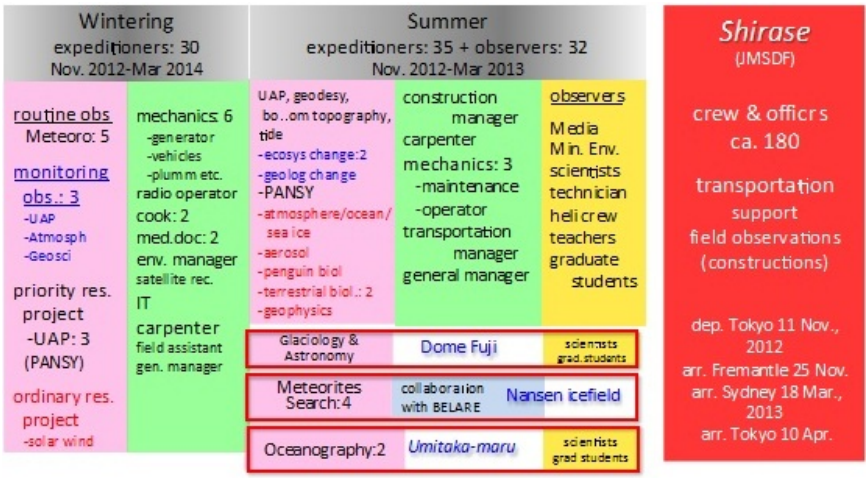

Figure 5. Composition of the JARE-54 team, for example, comprised of a main party to work at and around Syowa and three sub-parties to work in the Dome Fuji area, in the Nansen ice field with collaboration with the Belgium Antarctic Research Expedition (BELARE) and on board the Umitaka-maru in the Southern Ocean to the south of Australia. Numbers in the figure denote number of the personnel for particular task. Tasks with no number are to be done by one member.

Scientific Activities

Year-round observations have been carried out by overwintering JARE personnel at and around Syowa station. Seasonal observations are also carried out by summer expedition personnel aboard the Shirase and Umitaka-maru for oceanographic observations and in various research areas, including the Sør Rondane Mountains for meteorite search. Selected highlights of recent JAREs observations are introduced.

Meteorological observations and monitoring of atmospheric GHGs, stratospheric O_3, etc. at Syowa

Year-round meteorological observations of the surface and upper atmosphere have been carried out by the Japan Meteorological Agency at Syowa Station, and some other monitoring observations, including those pertaining to upper

atmospheric physics, atmospheric sciences, geophysics, and biology have also been carried out by governmental agencies and NIPR. Total ozone measurement has been carried out to monitor the thickness of the ozone layer with a Dobson spectrophotometer since 1960 at Syowa, which resulted in the first report of a decrease in total ozone in the Antarctic. Atmospheric greenhouse gases (GHGs) such as CO_2, methane (Figure 6), and CO have been monitored continuously since 1984, 1988, and 2000, respectively.

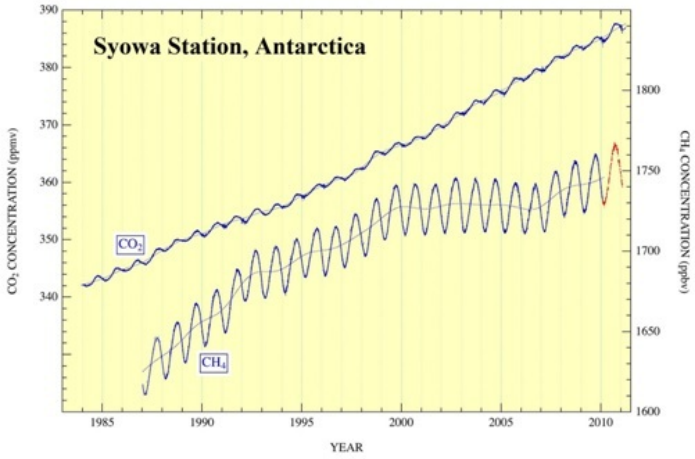

Figure 6. Annual variations of concentrations of atmospheric carbon dioxide (CO2) and methane (CH4) measured at Syowa Station.

Monitoring and routine observations cover physical, chemical, and biological oceanography carried out along the cruise track of the RV Shirase, including the 110°E and 150°E meridians, as well as sea-level observation at Syowa. Ecological monitoring includes annual observations of terrestrial flora at fixed sites around Syowa and in the Yukidori Valley, in the Antarctic Specially Protected Area No.141 and Adélie penguin census at rookeries near Syowa.

Continuous monitoring of Antarctic lower and middle atmosphere using the first Antarctic large aperture atmospheric radar PANSY started at Syowa Station
After the first light in March 2011, further installation work for the large aperture atmospheric radar PANSY (Program of the ANtarctic SYowa Mesosphere, Stratosphere, and Troposphere/Incoherent Scatter [MST/IS] Radar) was conducted during the 2011–12 austral summer, and continuous observations of the polar troposphere, stratosphere, and mesosphere began in April 2012. Although the operation still used only a quarter of the full system, it is already the largest atmospheric radar in the Antarctic, and interesting results concerning the polar atmosphere have been being obtained (Figure 7). Additional installation and adjustment work was conducted during the 2012–13 season, and

half of the system is currently complete. The program has been moving steadily toward achieving a fully operational radar in the near future with the aim of understanding how the atmospheric system works from the surface up to 500 km, with precise measurement of three-dimensional winds including vertical velocity and plasma parameters, and contributing to improve the global atmospheric model for better forecasting of the future global climate.

Figure 7. The PANSY radar system, including 1054 Yagi antenna elements, installed at Syowa Station in the 2010–2011 Antarctic season.

Meteorite search on the Nansen Ice Field by JARE-54 in collaboration with BELARE

It has been well known that a lot of meteorites are scattered on the bare ice fields of the inland area in Antarctica. These findings began when nine different kinds of meteorites were collected on the bare ice field around the Yamato Mountains by the 10th Japanese Antarctic Research Expedition (JARE-10). Since then, about 17,000 meteorites have been discovered, mainly by JARE. The Asuka meteorites were newly collected by JARE-54 in collaboration with the Belgian Antarctic Research (BELARE) from the Nansen Ice Field (72°30' – 73°S and 23–25°E, elevation ~3000 m) on the ~100 km south of the Sør Rondane Mountains. The number of meteorites collected was about 420, and the total weight was about 75 kg. A huge ordinary chondrite (18 kg), carbonaceous chondrites, and achondrites are included among the meteorites (Figure 8). The average weight is about 180 g, which is much larger than the previous two joint expeditions (JARE-51 and BELARE 2010–11). The searched area on the Nansen Ice Field has been recorded in each handy GPS of the 10 members. As a result of this detailed recording, the searched area has been clarified. This suggests that meteorite search can be carried out more efficiently.

Figure 8. A huge meteorite, found on January 28, 2013, weighs 18 kg and was the largest collected in this expedition. It is classified as an ordinary chondrite.

Responses of penguins to environmental variability

A JARE-52 biology team conducted field observations in the Lützow-Holmbukta region. One worthy of noting is a research program on the ecological responses of penguins to regional climate change. The researchers deployed various data loggers on Adélie penguins breeding near Syowa Station and examined the at-sea behavior and ecology of the penguins (Figure 9). The obtained data include novel video images of penguin feeding behavior under fast ice (http://www.nipr.ac.jp/info/penguin), detailed foraging locations in relation to sea-ice conditions, and so on. The program will be continued over the next two austral summers and will examine the effect of changing sea-ice conditions and climate on penguin ecology.

Figure 9. An image obtained from a penguin-mounted camera, showing Adélie penguins swimming under sea ice in Antarctica.

Development of infrared and terahertz astronomy at Dome Fuji

The Antarctic inland plateau is an ideal place for astronomical observatories on earth because of its very dry air and low air temperature. An astronomical research project at Dome Fuji station has been developing in the JAREs, and the first unstaffed year-round observation system for extra-solar planets was installed in the last austral summer (Figure 10, left). This system was designed in collaboration with an Australian university and contains special generators

with solar batteries that can supply electric power to the observation equipment for two years without a supply.

A telescope of 40 cm in diameter was installed (Figure 10, right) for the summer season for observation of Venus in the infrared, daytime brightness of the atmosphere, and atmospheric fluctuation. The data obtained should give important feedback for a full-scale astronomical observatory in the near future.

Figure 10. A year-round observation system for extrasolar planets (left) started operation, and seasonal observation with a 40-cm telescope (right) was carried out at Dome Fuji Station in the 2010–2011 austral summer season.

Logistics

The planning and implementation of logistics around Syowa and other Japanese stations in the Antarctic is very important for the success of JARE and has been considered and managed by NIPR. The transportation of personnel and materials of JARE between Japan and Antarctica is carried out by the icebreaker Shirase (Figure 11), registered and operated by JMSDF. All the cargo for Syowa including fuel is transported aboard the Shirase. A cruise schedule of the Shirase for JARE is almost the same every year with stops at Fremantle and Sydney. Most of JARE members will get on board the Shirase at Fremantle and get off at Sydney, flying from/to Tokyo. Figure 12 shows a schedule of main summer party of JARE-54.

Figure 11. Japanese icebreaker Shirase, 134 meter in length and 12,500 tonne in displacement (photographed 16 February, 2013).

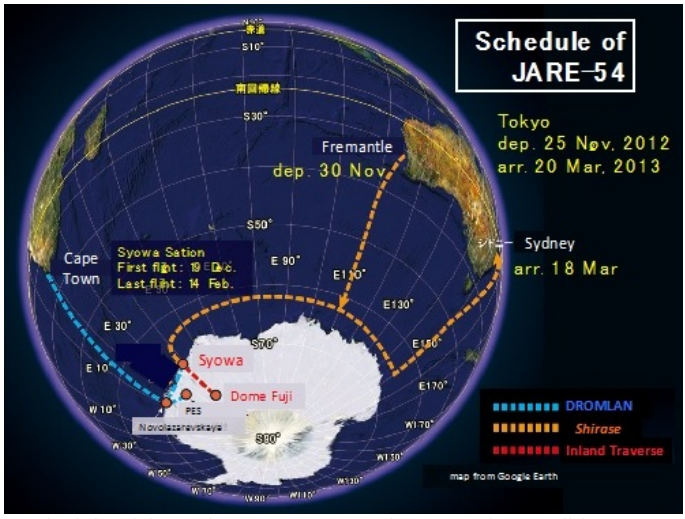

Figure 12. Schedule of the 54th Japanese Antarctic Research Expedition (JARE-54). The main party left Tokyo by air on 25 November, 2012 to get on board the Shirase at Fremantle on the next day. The summer member of JARE-54 and overwintered member of JARE-53 arrived at Sydney on 18 March, 2013 to return to Tokyo on 20 March, 2013.

Some members of JARE-54 flew to the Syowa area by DROMLAN (Dronning Maud Land Air Network). National Antarctic operators of eleven countries (Belgium, Finland, Germany, India, Japan, Netherlands, Norway, Russia, South Africa, Sweden and United Kingdom) share the cost of inter-continental flights by IL-76 large aircraft between Cape Town and Novolazalevskaya, a Russian Antarctic station. There would be about ten return flights between November and February for national Antarctic programs, operated by a Cape Town based company, the Antarctic Logistic Centre International (ALCI). Between

Novolazalevskaya runway and each research stations, ALCI charters mid-sized aircrafts (BT-67 and Twin Otter) to transport expedition personnel and cargo.

Transportation of cargo, including fuel is critically important in Antarctica. JARE needs a powerful icebreaker to access Syowa, because there exists fast ice, sometimes more than 4 m in thickness, all year-round in Lützow-Holmbukta, where Syowa situates. We had to transport all the cargo and fuel by helicopters during the JARE-54 2012-2013 season, as snow cover was too bad to have snow vehicles to pull cargo sledges to Syowa and Shirase and we could not reach close to Syowa to send fuel with pipe for difficult sea ice condition. Construction and maintenance works are carried out in Syowa Station (Figure 13). Any JARE activities in the Antarctic Treaty area, south of 60°S, are subject to the Antarctic Treaty and all the implementation plans of JARE have to be checked in accordance with the Protocol on Environmental Protection to the Antarctic Treaty (the Madrid Protocol). The Antarctic Treaty system comprised of the Treaty and its related treaties and agreements is a fundamental framework for Antarctic research expeditions, as well as other issues of Antarctic tourism. Environmental issues are getting more and more remarkable at the Antarctic Treaty Consultative Meeting (ATCM) in the last decade.

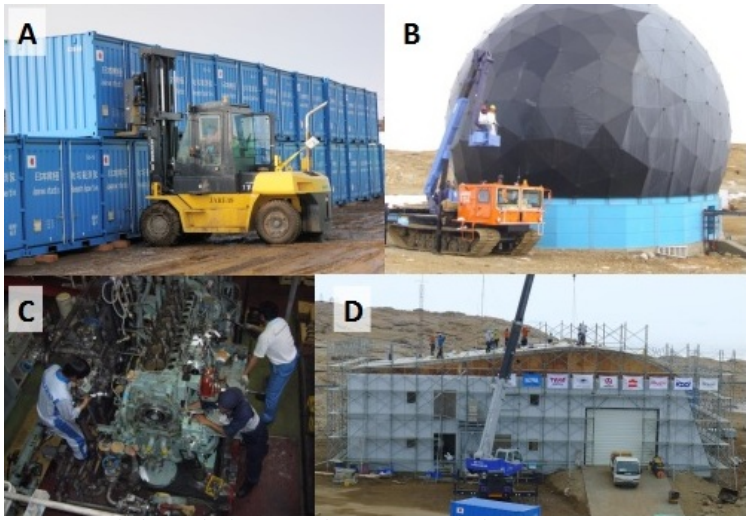

Figure 13. Logistic works in Syowa by JARE-54 during 2012-2013 austral summer season. Transportation of cargo and waste to and from Syowa (A), maintenance of a radome for scientific satellite antenna (B), regular overhaul of diesel engines for electric generator and construction work for a new workshop building for vehicles (D).

Logistical collaboration in the Antarctic among countries has been developed through a variety of channels, including ATCM and the Council of Managers of National Antarctic Programs (COMNAP) and the latter is the major forum among them (https://www.comnap.aq). Its purpose is to “develop and promote

best practice in managing the support of scientific research in Antarctica". It holds annual general meetings to discuss common logistical issues and exchange information on the national Antarctic programs. COMNAP develops many useful instruments and serves for safety and efficiency of Antarctic operations.

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