

Development of Autonomous Unmanned Aerial Vehicles for Geoscience in Antarctica and its potentiality

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An autonomous unmanned aerial vehicle (UAV) is expected to contribute to a safe and economical airborne survey in Antarctica. We developed unmanned aerial vehicles (UAV), so called Ant-Plane, to be used at the coastal regions of Antarctica in the austral summer season. Development of Ant-Plane has been started from 2001 under the Ant-Plane group consisting of National Institute of Polar Research, Kyushu University, companies, and model airplane amateurs. The Ant-Plane group has produced 6 types of airplane and one helicopter using model airplane technology, for the purpose of aeromagnetic survey, meteorological research and aerial photographs. Small onboard devices which have low weight and less power consumption have been developed in this project.

The group achieved a continuous flight up to 1108 km with a magnetometer and ascendant flight up to 5700 m with meteorological devices in Japan. The aeromagnetic survey by Ant-Plane 4 with a magneto-resistant magnetometer succeeded in the area 10x10 km (500 km of survey line) at Western Australia in 2006. Although the airborne survey around Syowa Station was performed by the winter team of JARE 46 (Jan. 2006) for aeromagnetic survey, and by the summer team of JARE48 (Jan. 2007) for meteorological research, the successful flights were not conducted due to runway problem etc.

The first successful flight of UAV in Antarctica was carried out by JARE48 using Kite-Plane for meteorological survey in Jan. 2007. Kite-Plane is a computer-controlled kite driven by engine, characterized by wingspan of 2.3 m, cruising speed of 36-55 km/h, and the flight time of about 2 hours. The temperature, humidity and size and number of aerosol were measured in the altitude of 300-1200 m (Hirasawa and Hara, 2007). The successful flight by Ant-Plane was yielded by the winter team of JARE49 (Dec. 2008) using Ant-Plane 4-3 at Ongul Strait, 2 km east from Syowa Station, for meteorological research. The plane flew along the square courses of 1.5x1.5 km keeping the altitude of 200, 400, 600, 800 and 1000 km and measured temperature and humidity on the course. The total flight time and distance were 1 hour and 110.5 km respectively. However, the autonomous flight was disturbed during the descending flight due to the tuning problem.

The first flight beyond Antarctic horizon was planned at Sough Shetland Island, near Antarctic Peninsula in 2011 by Ant-Plane 6-3 (Fig. 1). This UAV is a pusher type UAV having 2.89 m in span with 86 cc gasoline engine. The weight is 28 kg including 10 liters of gasoline and 2 kg of payload (20 kg for dry). The plane flies along waypoints, consisting of latitude, longitude, altitude and speed, controlled by an onboard computer. An onboard magnetometer system (525g in weight, 0.5 W) consisting of 3-axes fluxgate magnetometer, data logger and GPS, and a digital video camera was stored in the nose of airframe. The sensor of magnetometer was attached at the tip of aluminum pipe of 1 m in length that was extended forward from the nose to avoid the magnetic noise of the airplane.

Deception Island is located in Bransfield Strait between Antarctic Peninsula and South Shetland Island and was formed by volcanism resulting from opening structure of Bransfield Strait. The aeromagnetic survey in this study was carried out above Deception Island due to lack of the precise magnetic data in the island.

On December 17, 2011, Ant-Plane 3-5 took off from the glacier behind St.Kliment Ohridski Base (Bulgarian Antarctic Station, Livingston Island, South Shetland Island) which is 35 km north from Deception Island (Fig. 2). Characteristics of this plane is wingspan of 2.8 m, gasoline engine of 20 cc and payload of 0.5 kg. The weight is 9 kg including gasoline of 1.8 littler. Ant-Plane 3-5 covered a distance of 105 km in 1 hour 7 minutes with altitude of 370 m in South Bay, Livingston Island. During the flight, topography of glacier and outcrops and distribution of sea-ice were recorded in a video camera.

December 18, 2011, Ant-Plane 6-3 took off from the glacier behind St.Kliment Ohridski Base (Bulgarian Antarctic Station, Livingston Island, South Shetland Island) which is 35 km south from Deception Island. The survey flight was 302 km in distance with 800 m in altitude taking 3 hours 38 minutes. Twelve survey lines of 18 km in length of the parallel to latitude were set to the N-S direction within 10 km in distance, where the first 2 lines and the last 2 lines were the same courses but they were anti parallel directions each other. Namely, the interval of survey lines was 11.1 km.

As the heading of airplane was unknown, a total magnetic field was used for analyses of the magnetic anomaly. The variation of magnetic field was more than 2000 nT. The positive anomaly appearing at the east side of island is concordant with the highest peak in the island. The negative one appeared at the ocean of the N-W area of the survey area. According to the magnetic anomaly map prepared by Spanish team (unpublished), any magnetic data were not obtained from the land portion of Deception Island. The results by Ant-Plane 6-3 revealed the magnetic anomaly pattern in blank area of the northern half of island. The aerial photographs of volcanic and glacial topography

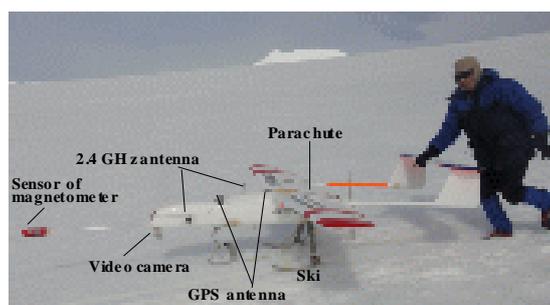


Fig. 1 Outline of Ant-Plane 6-3 with magnetometer

were taken at 800 m in altitude during the aeromagnetic survey. However, the survey in the southern half of Deception Island was not carried out due to bad weather for UAV flight. The flight fee is about 300 Yen/100 km for Ant-Plane 6. We stayed for 2 weeks in St. Kliment Ohridski Base and 1 month in King Sejong Station (Korean Antarctic station in King George Island) in 2011-12 summer seasons, but only 1 day was available for UAV flight. South Shetland Island is unsuitable for UAV operation due to the bad weather, but the UAV operation is much safe and economical compared with the manned airplane operation.

This success of aeromagnetic flight demonstrated that the small autonomous UAV benefits us for the economy and the safe airborne survey in Antarctica. We achieved small autonomous UAV production to use geoscientific research in Antarctica. The airborne survey by UAV is introduced to the various fields in the Antarctic research.

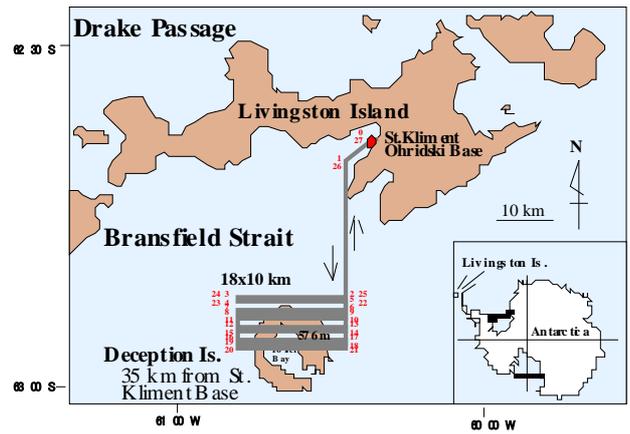


Fig. 2 Flight course for aeromagnetic survey between St. Kliment Ohridski Base and Deception Island, Livingston Island