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Development of an Unmanned Aerial Vehicle (UAV) and utility for the research work of the Institute of Cetacean Research

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The usage of drones is increasing for the observation and research of wild animals including the cetaceans. Drones are replacing helicopters and small airplanes which require airfield for departure and arrival. The key characteristics of drones are their small sizes and maneuverability. Furthermore, they can be operated from the platform of vessels. This increases their utility in difficult environments that are often encountered in cetacean research activities. Whale research using drones has already begun (e.g., Hodgson *et al.*, 2017), and they are used for various observation purposes in the polar regions (e.g., Funaki *et al.*, 2014).

The Institute of Cetacean Research (ICR) has acquired some commercially-available drones, e.g., the Phantom 4 Pro (DJI), with the aim of studying whales. Also the ICR has started the development of its own Unmanned Aerial Vehicles (UAVs). This technical note describes this development, and summarizes the application of UAVs in the context of the research work on cetaceans by the Institute.

UAV development at the ICR

Since 2019, the ICR has been working on the development of new whale research methods for cetaceans using small UAVs. It has developed a Vertical Take-off and Landing (VTOL) type UAV, specifically to operate from a cetacean research vessel. Flight tests in open seas from several oceanic regions, including the Antarctic Ocean, have been conducted to examine the performances of the UAVs. From such tests, and to ensure good performance, several important factors were identified. Among these factors were strong winds at open sea, hull swaying, magnetic disturbance and radio wave interference,

Table 1
Specification of the newly-developed VTOL-UAV in 2021.

Name	Prototype ASUKA Mk 4
Overall length	1,920 mm
Wing length	2,500 mm
Overall height	620 mm
Body weight	12.44 kg
Cruising range	Approx. 100 km (51 km in Level 3 flight mode)
Maximum speed	160 km/h
Payload	5 kg maximum
Seaworthiness	Normal operation at 20 kt wind speed, level flight maintained at 40 kt wind speed

Figure 1. Photograph of the VTOL ASUKA aircraft (Prototype ASUKA Mk 4) developed in 2021.

and geomagnetic deviation in the polar regions. The new UAV 'ASUKA,' a VTOL type, was designed to minimize all such detrimental factors. The main data of the ASUKA are shown in Table 1 and the UAV itself is shown in Figure 1.

Figure 2 is a conceptual image of the operation of VTOL-ASUKA from the platform of a cetacean research vessel in the Antarctic. No airfield is required as the UAV can depart and return using the platform of a cetacean research vessel conducting routine line transect surveys. Flight operations can be conducted in shallow waters and ice bound seas where research vessels are unable to enter.

UAV performance during a finless porpoise survey

The ASUKA was used in a survey for finless porpoise (*Neophocaena phocaenoides*) in Mikawa Bay, Aichi prefecture in March 2021. The UAV departed and arrived using the platform of the research vessel and conducted a total of six aerial visual surveys (total distance: 71.2 km). It succeeded in detecting and identifying three finless porpoise pods (four individuals). The sighting rate was 0.56 individuals/10 km. Figure 3 shows the ASUKA operating during the finless porpoise survey in Mikawa Bay on 29 March 2021.

In March 2021, ASUKA achieved an autonomous flight distance of 51 km in the North Pacific Ocean (Figure 4, left), which is considered a Japanese record for UAVs (a domestic record for flight distance under the conditions of Level 3 flight (unmanned area with no visual line of sight and no assistants) as specified in the 'Roadmap for the Industrial Revolution in the Sky' promoted by Japan.

Figure 4 (right) shows the track lines of the UAV during the finless porpoise survey in Mikawa Bay on 29 March 2021. Figure 5 shows finless porpoise detected and identified by the ASUKA's camera.

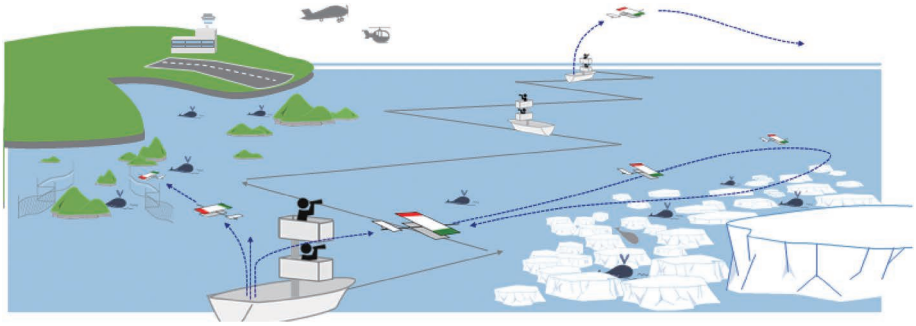

Figure 2. Conceptual image of the operation of VTOL-ASUKA from the platform of a vessel. Unlike small airplanes and helicopters, ASUKA do not require an airfield, and can operate over shallow waters as well as in polynyas in the Antarctic where the vessels cannot operate. In coastal areas, ASUKA can provide information on the presence of fishing nets.

Figure 3. VTOL-ASUKA undertaking vertical take-off from the research vessel (left) and launch landing on the vessel in strong winds (right) during a survey in Mikawa Bay on 29 March 2021.

Figure 4. Long-distance (51 km) survey trial (left) and track lines of the survey (right) by ASUKA during the finless porpoise survey in Mikawa Bay on 29 March 2021.

Figure 5. Photographs of finless porpoise taken during a flight at an altitude of 50 meters by ASUKA's camera (using zoom) during the finless porpoise survey in Mikawa Bay on 29 March 2021.

Japan 2021 Drone Exposition

The ASUKA was introduced at the Japan 2021 Drone Exposition for the Commercial Unmanned Aircrafts Systems (UAS) Market, together with its results from aerial cetacean surveys. The exposition was held between 14 and 16 June 2021 at the Makuhari Messe (Chiba City, Japan), and was organized by Japan UAS Industrial Development Association (JUIDA). During the event, ASUKA attracted the attention of many engineers as an aircraft capable of taking off and landing from vessels. During the Exposition, useful information was obtained regarding, for example, the development of technology for mounting biopsy equipment as well as surveys on marine debris and red tide. Such advances will be useful for research on cetaceans.

Further improvement

Further performance development of ASUKA continues to be focused on aspects related to shooting equipment and image processing technology. The efforts will also be focused on increasing the duration of surveys (distances) by the creation of a lightweight vehicle with a large capacity battery. The idea is to further develop and implement an UAV capable of carrying out research on marine mammals under stringent conditions, while ensuring that disturbance to the animals is minimal.

Application to the study of cetaceans at the ICR

The ICR regularly conducts vessel-based dedicated cetacean surveys. In general, UAVs operated from the platform of the vessels will increase and improve the observational capacity during the surveys. For example, the use of UAVs will allow the survey of cetaceans even in circumstances where vessel movement is inhibited, such as the polynyas in the Antarctic.

The use of UAVs will also complement the observations of researchers on board regarding species identity, number of animals in a school and behavior of the sighted cetaceans. UAVs can also obtain data for photogrammetry studies, which are important for taxonomical or stock structure studies.

Additionally, the use of UAVs will enable the collection of environmental data from above when operating over shallow waters, as well as the detection of areas where fishing gears are installed. That is, it is anticipated that the use of drones will enhance information collection from a wider range of oceanographic conditions and sea areas, thus providing more precise findings from research activities.

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