Development and experiment plan for future of the selective landing area carrier system for small sounding balloons

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The small sounding balloons have been using as transport equipment to in-situ stratospheric observation up to 30 km altitude. A small rubber balloon with a diameter of about 3 m is used with small observing sensor devices, being separated at a target altitude and usually landed with a parachute for recovery. By using a small rubber balloon, inexpensive and small-scale experiments become possible with somewhat freehand launching opportunities. Recently, even small-scale balloon project is possible to make high-performance payload by technical development such as MEMS (Micro Electro Mechanical Systems) or 3D printer.

However, as there is no vast flat land in crowded small islands of Japan, tracking and recovering of such sounding balloons in the area of urban, mountainous areas, and oceans are difficult, or it needs extra equipment and efforts for preventing a lost of the instruments. For this reason, the use of sounding balloons has not been advanced in small-scale balloon projects [1].

In order to solve the geographical constraints and realize efficient operation, our laboratory has been working on development of a selective landing area carrier system for small sounding balloons. The operation method is to perform a soft landing guidance working with a parafoil with on-board servo-motor control system while selecting the multiple reachable landing points among pre-set safety landing point candidates on the payload (Figure 1).

As a final goal, we prepare a payload system with a total mass of 3 kg with a mission equipment mass of 500 g and the total payload size of 70 mm cube. Capability of landing with an accuracy of about 300 m radius from each pre-set landing point would be required when separated from a balloon at the altitude of 30 km. Throughout these evaluating flight tests, we aim to develop the entire selective landing area carrier system along with our main target.

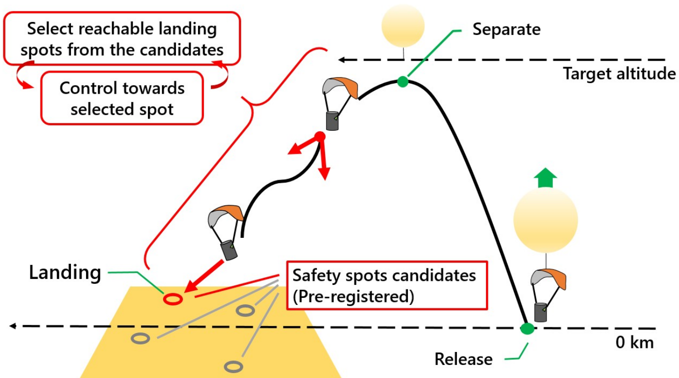

Figure 1. selective landing area carrier system overview.

In Kochi University of Technology (KUT), from October 2014 to February 2015, we studied the basic characteristics of parafoil (glide ratio and turning radius), examined appropriate control algorithm, and developed a prototype system. From low altitude of about 30 m, multiple flight tests were successfully operated at KUT in February 2016. As a result, we obtained a simple performance evaluation with a glide ratio of about 3 as well as a turning radius of about 15 m, resulting in a design validity of the developed system. On the other hand, we found such evaluation in fact was only very basic at that time due to the lack of complicated flight controller functions, and lack of rigidity of the parafoil system against landing impacts.

Therefore, based on the tasks found in the previous experiments, we started to design new payload system (Figure 2) that assumed operation from stratosphere since 2017. In order to prevent rotating motion of the body due to the landing impact which became a problem in the previous drop tests, a deploying four legs were added. Also, in order to raise the solidity of flight controller functions, gathered up almost parts in one module.

In 2018, we confirmed soundness and operability of the new element such as deploying legs or electrical module which we took in a system by low altitude flight test.

We have plan to take the next flight test to be released from a drone at an altitude of 100 m to clarify long-term flight characteristics in January 2020. Furthermore, we are aiming to conduct a landing guidance test from an altitude of several kilometers and finally conduct a flight test from the stratosphere at Antarctic in 2021.

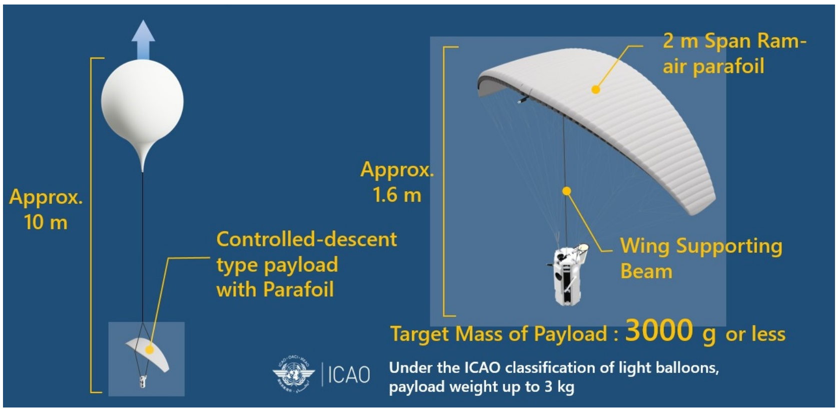

Figure 2. new payload system overview.

References

[1] Takamasa Hiratsuka, Hiroki Kono and Masa-yuki Yamamoto, Development and evaluation flight test results of a controlled-decent type payload system optimized for the recovery from a very small balloon, JAXA-RR-16-008, pp.81-100, 2017.