Development and evaluation of a quasi decent-control type payload system for small sounding balloons

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In-situ stratospheric observation up to 30 km altitude by using small sounding balloons has been increasing as a transport equipment in the recent years.
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.
However, as there is no vast flat land in crowded small island area of Japan, tracking and recovering of such sounding balloons in the area of urban, mountainous areas, and oceans are difficult, or it needs extra equipments 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.
In order to solve the geographical constraints and realize efficient operation, our laboratory has been working on development of a sounding balloon system mounted with quasi decent-control type payload.
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.
As a final goal, we prepare a payload system with a sensor mass of 500 g and the total payload size of 60 mm cube.
Throughout these evaluating flight tests, we aim to develop the entire decent-control system along with our main target.
In Kochi University of Technology (KUT), we studied the basic characteristics of parafoil (glide ratio and turning radius), examined appropriate control algorithm, and developed a prototype system.
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, flight evaluation was only very basic at that time due to flight altitude shortage and lack of some sensors and destruction of the system caused by rotational motion during its landing.
Currently, we are developing new payload system (figure1) based on the tasks found in the previous experiments. And, we will evaluate flight performance through manual flight control experiment from 100 m altitude.
The new light-weight paraglider system was made while keeping strength by using CFRP.
Further, There has a layer structure to enhance scalability and maintainability. By doing so, it will be possible to support future mission equipment installation.
In order to solve the problem about rotational motion, we attach the landing leg mechanism to the outside of the body frame. By using this mechanism, the landing stability increases, and damage to the aircraft body frame and mounted equipments can be suppressed.
In addition to conventional posture detection and acquisition of position information functions, a laser range finder for altitude measurement an ultrasonic anemometer for aircraft airspeed measurement are added to this aircraft.
The 100 m altitude flight test using this paraglider system has three objectives.
There are evaluating the flight operation against the controlled variable, checking the operation of each

function installed in the system and evaluating the flight performance in the ground layer.
With using an experimental area of about 400 m square, hanging the new paraglider system on the drone, logging various actions using the controller from the ground after separation from the drone will be carried out.
In this presentation, we will present our recent activities to make challenging small-balloon devices, results and consideration of the parafoil system to be used for manual control flight test, and future scientific applications with microphones for infrasound sensing in the middle atmosphere.

Reference
Takamasa Hiratsuka, Hiroki Kono, Masa-yuki Yamamoto, Development and evaluation flight test results of a controlled-descent type payload system optimized for the recovery from a very small balloon, JAXA-RR, 2017

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