

Systems and Operations of Reusable Sounding Rocket Vehicle

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A fully reusable rocket vehicle is proposed as a sounding rocket for observations of atmospheric phenomena, micro-gravity experiments, and so on. Vehicle systems, ground / flight operations and flight trajectories are designed and considered in order to achieve such science observations. For the development of the reusable rocket, a small test vehicle was built and flight-tested. This Reusable Vehicle Testing (RVT) lessons campaign provide repeated experiences of turnaround operations and vertical take-off and landing flights.

In the present design of the reusable sounding rocket, the total length and maximum diameter of the vehicle is about 10m and 3m, respectively. The vehicle is propelled by the propulsion system composed of four liquid hydrogen / liquid oxygen engines. The attitude of the vehicle in flight is also controlled by the hydrogen / oxygen Reaction Control System (RCS). Therefore, exhaust gas from main-engines and RCS to the atmosphere is only water vapor.

The payload carried to 150km altitude is 100kg that is equivalent to the present sounding rocket of ISAS (Institute of Space and Astronautical Science) S-310 / S-520. The payload is settled in the nose-fairing which can be opened and closed in the flight. Probes for the observations can extend and must be thrown away or pulled back into the nose-fairing in the descent flight. Some samplings of the atmosphere will be possible. The data obtained from observations are sent to the ground facilities by the telemetry and also recorded in the onboard personal computers or data recorders. These recorded data in the onboard equipments can be downloaded after the landing of the vehicle. The turnaround time for one flight is less than 24 hours (1 day). The turnaround before the flight consists of ground operations by the crews which are ground checks of engine systems and measurement facilities, charge of batteries, movement of the vehicle to launch site, upload of flight sequence program and its checks, loading of propellants to the fuel tanks, and so on. These operations were experienced in RVT flight campaign, and those are reflected to the system design of the reusable sounding rocket.

A schema of typical ballistic-flight of the reusable sounding rocket vehicle is as follow. The vehicle takes-off vertically by the main engine thrust, and cut it off in its ascent phase. Then the vehicle reaches to an altitude of 150km. After that, the vehicle enters into atmosphere and decelerated by aerobraking, and vertically lands to the launch place or other places. In the landing phase, the vehicle is decelerated by the main engine thrust for a soft-landing. In the typical ballistic-flight up to 150km, the total flight time is about 500sec. Maximum Mach number is about 4, and the altitude of the flight Mach number below 1.0 (subsonic flight) is over 135km (for 100sec). Maximum acceleration in the ascent phase is about 6G. For the micro-gravity experiments, the flight environments of acceleration less than $10^{-3}G$, $10^{-4}G$ and $10^{-5}G$ is able to be made for 250sec, 230sec and 200sec, respectively. The capability of downrange is over 30km distance. Optionally, it will be able to keep an altitude in flight by hovering due to the re-ignition of main engine. Depending on the mission objects, the apogee altitude can be adjusted by the control of engine propulsive duration time. If the vehicle has some trouble in a flight, for example, main-engine fail, control system trouble, and so on, the vehicle can return safely to the launch site, that is, the vehicle has the full-time mission-abort capability.