WADIS 2 – MSMA EXPERIMENT EJECTION MECHANISM – "A LIFT INTO SPACE"

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ABSTRACT

DLR's Mobile Rocket Base provides a "suborbital gate" into space to the scientific world. Thereby its engineering competences are not limited to the launch vehicle itself, they also comprise payload development support such as the MSMA (Measurement System Middle Atmosphere) ejection mechanism realised in close cooperation with the payload scientists. Together with the WADIS-2 (Wave Propagation and Dissipation in the Middle Atmosphere) main payload the MSMA experiment was successfully ejected at its predefined altitude of approx. 60km.

1. MSMA EXPERIMENT

MSMA is an active free falling, football sized sphere performing density, temperature and horizontal wind measurements in the middle atmosphere. It is equipped with accelerometers, gyroscopes, a magnetometer, a GPS, a bidirectional telemetry module and an aerodynamic deceleration system in form of a simple parachute; see Fig. 1. The whole concept is a development of ARGUS Electronic [1] as well as the Leibniz Institute of Atmospheric Physics [2].

Figure 1. MSMA sphere with parachute. Photo by Sebastian Finke

2. MECHANISM CONCEPT

The first MSMA experiment prototype flew "piggyback" together with the WADIS-2 main payload, therefore excess capacity in the motor adapter of the VS-30 launch vehicle was used.

Due to limited event triggers, the MSMA ejection sequence could not be directly triggered by the vehicle's internal ignition system, thus it was mechanically coupled with the WADIS-2 main payload separation event, occurring at approximately 60km altitude. Its predefined ejection vector was normal to the vehicle's longitudinal axis preventing any collision with the main payload. For structural stiffness and stability reasons the payload separation interface was used as the ejection opening instead of an additional, large cut-out in the vehicle's outer structure. Therefore the MSMA sphere was lifted from the bottom to the top of the motor adapter almost parallel to the main payload separation sequence and then was laterally pushed out at its top position; see Fig. 2.

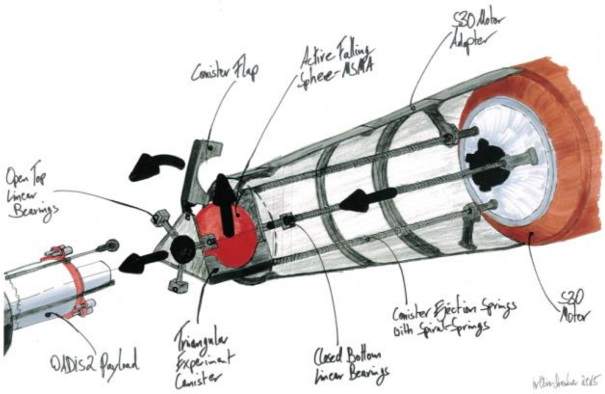

Figure 2. MSMA ejection mechanism concept sketch.

The particular packing situation of the VS-30 motor adapter, together with the experiment's ejection opening at the payload separation interface, needed a special space saving design. Therefor a triangular canister concept was developed, providing enough space for the experiment as well as the canister with its bearings, gliding along the ejection tracks through the payload separation interface without collision; see Fig. 3.

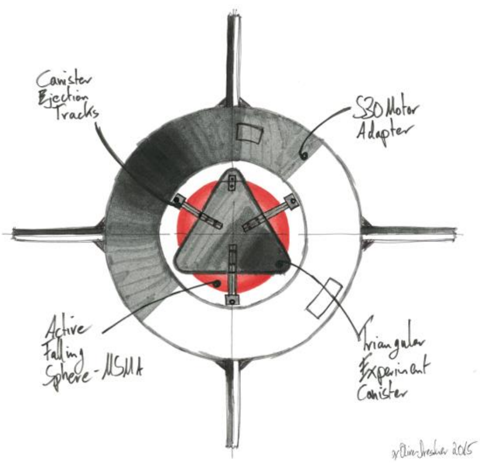

Figure 3. Packaging concept sketch.

3. DESIGN

The MSMA ejection mechanism mainly consists of two sub-assemblies: The three ejection tracks and the experiment canister.

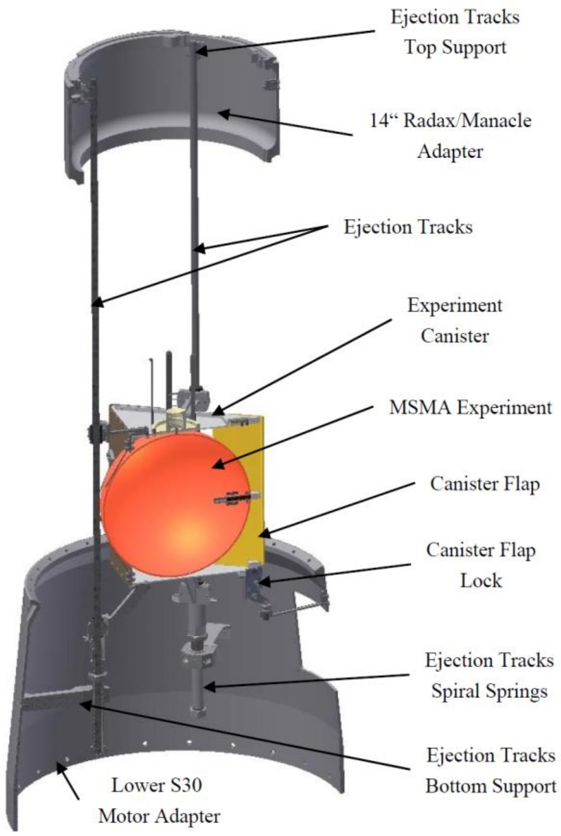

Figure 4. MSMA ejection mechanism assembly.

Each ejection track is assembled of a gliding shaft, an adjustable arrester, a spiral spring and two mounting brackets supporting each ejection track sub-assembly at its lower and upper end; see Fig. 4.

The triangular experiment canister sub-assembly houses the MSMA experiment and is guided by the three ejection track shafts; see Fig. 4.

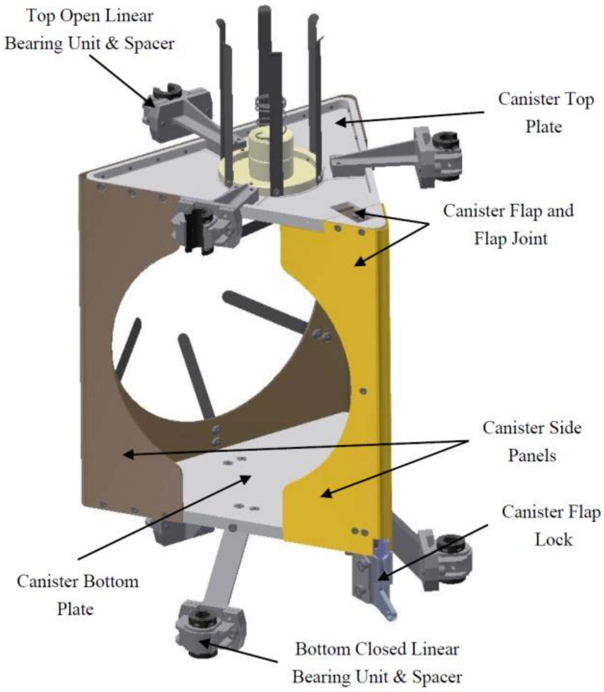

Figure 5. Experiment canister sub-assembly.

The canister is made up of triangular top and bottom plates and two side panels as shown in Fig. 5. One of the side panels (see Fig. 5, yellow structure) forms the canister flap, which is hinged by the flap joint at the top plate and closed by a mechanical lock mounted at the canister's bottom plate.

Three top and three bottom linear bearings are supporting the canister, while gliding along the ejection track shafts; see Fig. 5. The top bearings are made of an open bush design, enabling them to glide over the track's top mounting brackets, whereas the bottom bearings use closed bushes and thus working as arresters for the canister's top position.

The canister's mechanical flap lock is a simple spring loaded SOUTHCO® rotary latch with a mechanical trigger. In the canister's lower position, the lock's trigger is arrested to prevent any accidental opening induced by vibrations or accelerations during the rocket launch; see Fig. 6. As with the canister's lower arresters (part of ejection tracks), also the lock's trigger arrester is adjustable in order to overcome any deviations caused by manufacturing tolerances.

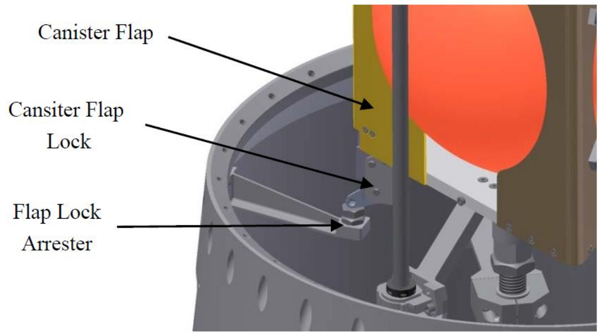

Figure 6. Canister in lower position during ascent.

The main payload separation triggers the MSMA ejection sequence. Almost parallel to this event the canister is lifted in upward direction, along the launch vehicles longitudinal axis, by the three ejection track's spiral springs. By reaching the canister's top position the lock's trigger is pushed against the trigger coulisse and thus opening the canister's flap; see Fig. 7.

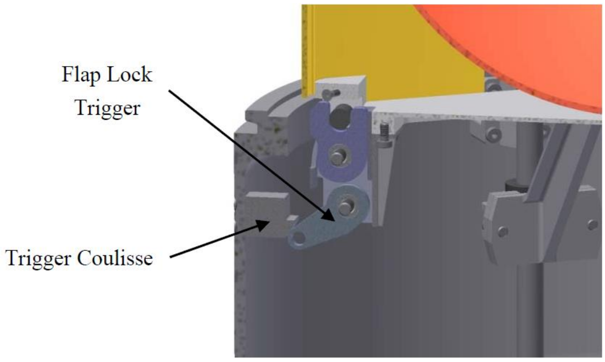

Figure 7. Canister flap at opening trigger point.

Shortly after the flap opens the canister's bottom bearings are striking against the track's top mounting brackets. At this point the lock's trigger slides over the coulisse's dead centre, flips back into the coulisse's groove, blocking the canister in its top position and thus preventing it from bouncing back into the inside of the motor adapter; see Fig. 8.

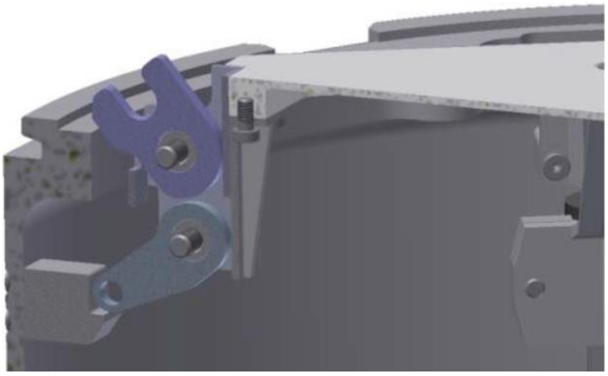

Figure 8. Canister flap lock in opened and blocked position.

As soon as the canister's flap opens, the MSMA battery trigger magnet is released and pushed out by a spring, starting the boot sequence of the active free falling sphere; see Fig. 9. Parallel to that, the sphere is laterally pushed out by six flat springs, which are mounted at the canister's rigid side panel; see Fig. 9. In order to ensure a clean push out of the experiment, the flap's hinged joint opens at a defined angle and separates the flap from the canister.

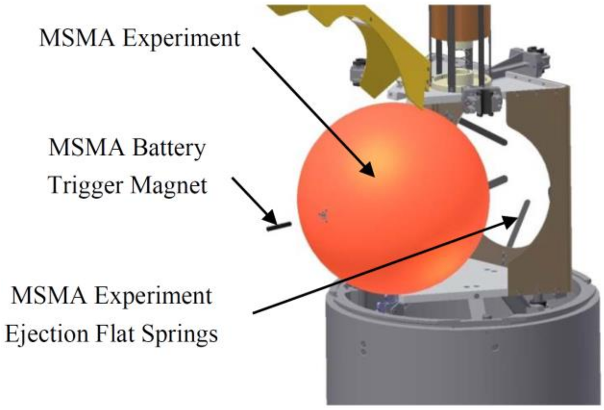

Figure 9. MSMA experiment ejection.

The WADIS-2 main payload interface forms a spring loaded polymeric cap mounted at the canister's top plate on one side and pressing against the main payload protection cylinder on the other side; see Fig. 10 brown cylinder.

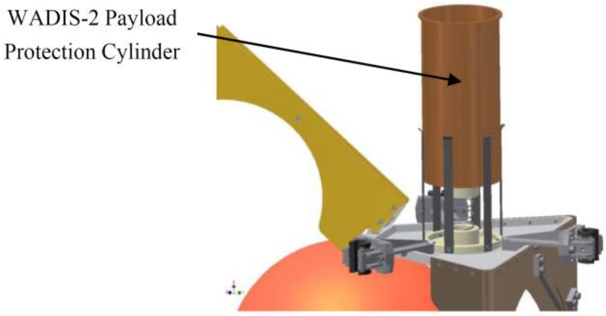

Figure 10. Canister with WADIS-2 payload interface.

The protection cylinder is evacuated and protects a sensitive ion probe during the ascent of the launch vehicle. After main payload separation the cylinder is pulled off by a string, mounted at the cylinder itself and the top plate of the canister.

4. FUNCTIONAL TESTING

A functional test on the complete motor adapter, equipped with MSMA ejection mechanism plus experiment, was performed in horizontal position. The lower part of the WADIS-2 main payload was represented by an identical dummy structure mounted by a manacle-ring interface on top of the motor adapter.

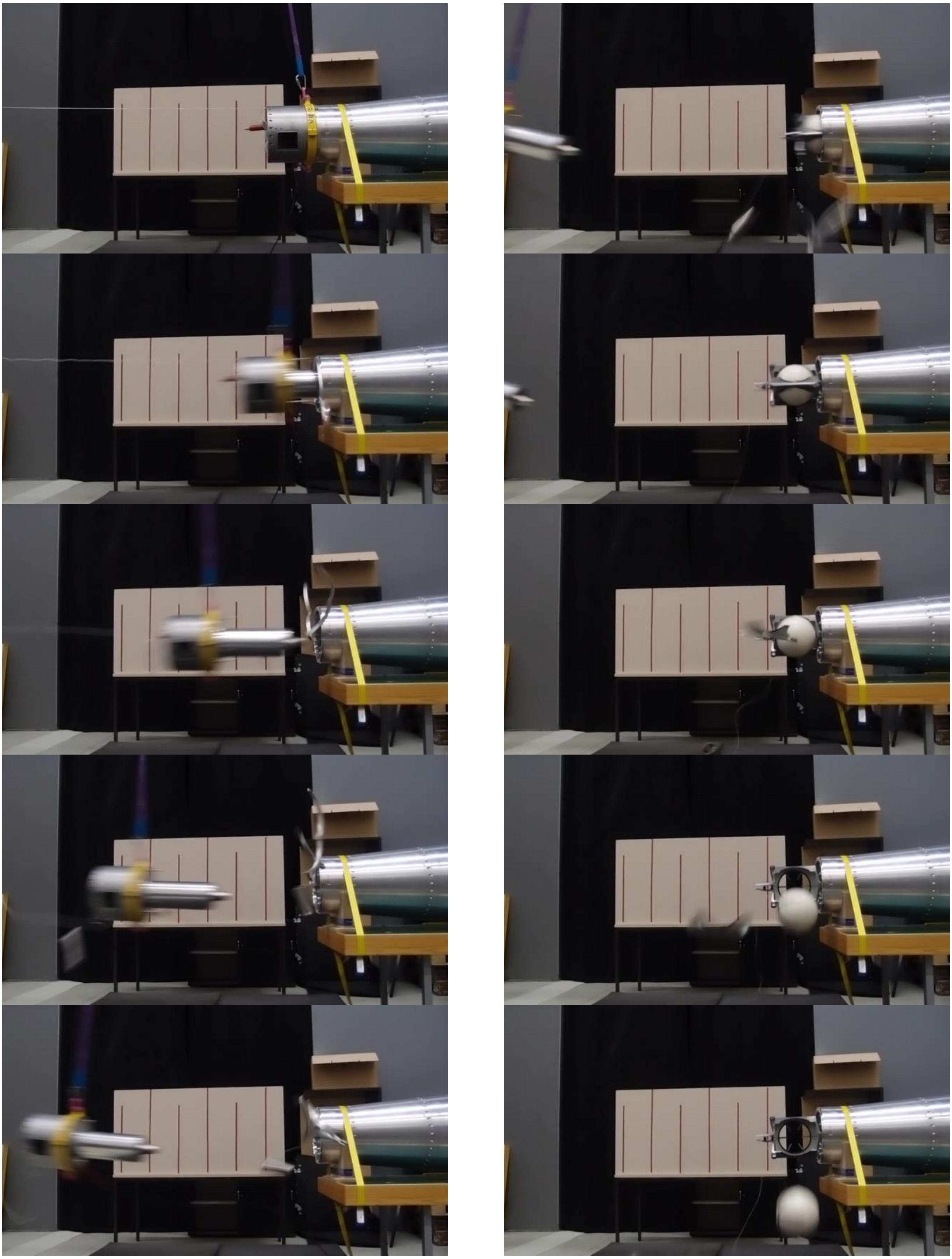

Figure 11. MSMA ejection sequence during functional testing.

In order to simulate a straight separation without collisions, the payload dummy was hanging on a crane, balanced in its centre of gravity and set under tension without lifting the test setup. The separation process was performed by an integrated gas system triggered by a pyrotechnical valve.

After the successful separation and ejection of the MSMA sphere (see Fig. 11), the functional testing was finished and the hardware was moved on to the environmental test programme, where the mechanism had to pass the dynamic loads spectrum.

5. SUCCESSFUL FLIGHT

On the 5th of March 2015 at 02:44CET (Central European Time) the WADIS-2 sounding rocket was launched from Andøya Space Center (ASC). At an altitude of around 60km and T+60.4s after lift-off the MSMA active free falling sphere was successfully ejected. Due to the required lighting conditions of the WADIS-2 main payload the ejection sequence could not be filmed. However the sphere was tracked and measured data was recovered by telemetry, thus verifying the ejection as planned.

Figure 12. WADIS-2 payload at ASC. Photo by Martin Eberhart.

REFERENCES

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