SAMPLE CANISTER CAPTURE MECHANISM FOR MSR: CONCEPT DESIGN AND TESTING RESULTS INCLUDING 0-G ENVIRONMENT

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ABSTRACT

The paper provides recent updates regarding the ESA technology development activity: Sample Canister Capture Mechanism Design and Breadboard for Mars Sample Return Mission developed under the ESA Mars Robotic Exploration Preparation (MREP) program. The technology object of the activity focuses on the Capture Mechanism and tests it in order to reach a Technology Readiness Level objective of TRL6 (ISO). An elegant breadboard of such a device has been implemented and extensively tested: functional, thermal and mechanical vibration test campaigns were conducted to assess the breadboard functionality, performances and compliance with the mission environmental requirements. In order to raise the technology TRL to 6 the breadboard was also tested on a Parabolic Flight Test Campaign (0-g environment). The Sample Canister capture operations under free-floating conditions were verified and impact forces between free flying Sample Canister and the breadboard investigated. The microgravity experiment design peculiarities, the solutions adopted to cope with the testing environment and the results obtained are critically analysed in this paper.

1. INTRODUCTION

The Mars Sample Return (MSR) is an international endeavour mission to return samples from Mars surface to Earth. Several MSR mission architectures have been studied in the past years [1]; current approach (iMARS Phase 2) proposes to implement dedicated mission spacecraft elements spread in time over a sequence of launches: e.g. a Caching rover, a Mars orbiter including the Earth Return vehicle and a Surface element, called Lander, including the ascent vehicle. In this architecture, the caching rover will be placed on Mars surface and a robotic system will collect samples of Martian rocks, soils and atmosphere. Once these samples have been collected, they will be fetched and loaded into the Mars Ascent vehicle into the Orbiting Sample (OS) canister. The Ascent Vehicle will launch the OS from Martian surface into a stable circular Mars orbit. After that, the orbiter that is waiting in Mars orbit will perform a rendezvous manoeuvre to capture the OS and secure it within the Earth re-entry capsule (ERC). Subsequently, the latter will be returned to Earth by the Earth Return Vehicle and released in Earth vicinity following a ballistic trajectory. In this context, the Sample Canister Capture Mechanism (SCCM) will be mounted on-board the Mars Orbiter and will capture, transfer and secure the OS inside the Orbiter during the rendezvous manoeuvre. Previous analyses and design activity were performed under the ESA technology activity “Sample Canister Capture Mechanism Design and Breadboard” [2] and [3]. The work presented here took place in the framework of this contract primed by *CGS S.p.A. – Compagnia Generale per lo Spazio*, where *Politecnico di Milano - Department of Aerospace Science and Technology* was in charge of performing the following tasks:

- SCCM Elegant Breadboard Model MAIT;
- Ground functional tests
- Environmental tests (thermal-vacuum and mechanical vibration tests)
- Flight test campaign on Parabolic Flight.

This paper focuses on the parabolic flight test campaign design and execution starting from the results of the functional and environmental tests reported in [3].

2. BREADBOARD MANUFACTURING ASSEMBLY AND INTEGRATION

The Elegant Breadboard Model (EBM), composed of Funnel, Arm, Actuation Chain, Support Tower and Baseplate, was assembled and integrated at PoliMi-DAST. The optical sensors were provided by CISAS, together with their own electronics specifically designed and manufactured for this project; moreover CISAS was in charge also of the DC motor procurement, purchased from Phytron. With respect to the initial EBM design [2], and after a specific test campaign conducted by Phytron to verify the motor capability of withstanding the loads requirement, the selected motor configuration and design changed. Therefore, some modifications were necessary to be implemented also on the EBM design; in particular the Support Tower and the Motor Interface Flange were extensively reshaped in order to improve the frequency response while reducing the acceleration levels of the Breadboard under qualification vibrational solicitation.
Table 1 summarizes the EBM main subsystems mass comparing the values estimated for the flight SCCM

concept design [2] with the measured masses of the manufactured breadboard. It is noticed that the higher mass of the Support Tower designed is due to the substantial reinforcement introduced to cope with vibration frequency of the whole assembly.

Figure 1: Elegant Breadboard Model, as built.

Table 1: Breadboard measured vs. design mass budget.

Item	Design Mass [Kg]	As Built Mass [Kg]
Arm assembly	1.69	1.76
Funnel assembly	5.09	5.92
Drive mechanism assembly	1.72	2.10
Tower assembly	0.95	2.58
Total	9.44	12.36

3. FUNCTIONAL TEST

The on-ground SCCM test campaign had the objective to raise the current Capture Mechanism technology to TRL 4 (breadboard validation in laboratory environment) and to validate the developed SCCM design concept by means of limited environmental testing.

The unit under test was the Elegant Breadboard Model (EBM), which is representative as much as possible of the designed Flight SCCM concept. The Functional Tests (FTs), performed at PoliMi-DAST, aimed at demonstrating functionalities and performances of the critical components of the EBM, as well as of the overall system. Such an objective was achieved by performing the foreseen SCCM operations (arm release, deployment, closure, reset, and retention) and comparing the obtained results to the defined requirements.

For the demonstration of the arm actuation functionality, the following operations were tested:

Table 2: Arm operation tests

Arm operations	**Notes**
Deployment	HDRM, no OS
Closure & reset	No OS
Retention	With OS

The EBM performance tests gave important inputs for the following parabolic flight test campaign: in particular, the following set of OS parameters, related to the incoming trajectory toward the Funnel (nominally directed along its longitudinal axis), was considered:

- OS initial angle;
- OS initial radial offset;
- OS initial speed;

For each of them, a set of different cases, reported Table 3, was investigated.

Table 3: OS initial conditions

OS initial angle [deg]	**OS initial offset [cm]**	**OS initial speed [cm/s]**
0	0	10
5	10	15

Table 4 and Table 5 summarize the FT results, while the details of the FTs set-up, execution and results are reported in [3]

Table 4: Functional tests results - functionalities

Functionality tests	**Results**
Actuation arm functionality	Compliant
HDRM functionality	Compliant
Detection functionality	Compliant

Table 5: Functional tests results - performances

Performance tests	**Results**
Arm closure/deployment duration	<20s
Motor maximum torque	11 Nm
Motorization factor	60
Failure mode	2 failure tolerant

The successful functional test campaign allowed the EBM design to be tested in environmental test campaign without design or configuration modification.

4. ENVIRONMENTAL TESTS

The Environmental Tests had the objective of demonstrating the capability of the EBM to withstand the launch and thermal-vacuum environments. Such an objective was achieved by testing the EBM under relevant environmental conditions simulating the ones expected to be faced by the Flight SCCM during its mission. The environmental test campaign occurred at Serms s.r.l., an Italian facility.

First, the Thermal Vacuum Test (TVT) was performed, followed by a full set of functional tests in order to verify that no functional degradation has occurred on the EBM. After that, the Vibration Tests (VTs) were performed followed by an additional set of functional tests to verify the EBM status.

4.1. Thermal Vacuum Test

The TVT aimed at demonstrating the EBM capability to survive and operate at the thermal conditions foreseen for the Flight SCCM during its mission. The objective was to verify that the EBM mechanisms and mechanical parts (i.e., Arm Assembly and HDRM) are able to operate also in the simulated thermal environment without performances degradation.

The minimum and maximum temperatures the Arm Assembly and the HDRM should be tested at (see Table 6) were selected taking into account the expected ones, identified by analysis during the SCCM Flight Model design activity.

The foreseen 8 cycles, shown in Figure 2, were performed continuously acquiring temperature sensor data. During the first cycle, performed at non-operative survival temperatures, the EBM was not operated. During the following 7 cycles the arm movement was tested to verify its proper functioning at minimum and maximum operative temperatures. It has to be noted, that also the HDRM was tested: in fact, during the second cycle when at minimum temperature, it was released.

Table 6: TVT temperatures

Temperatures	Values
Minimum Non-Operational/Survival Temperature	248 K
Minimum Operational Temperature	252 K
Maximum Operational Temperature	322 K
Maximum Non-Operational/Survival Temperature	335K

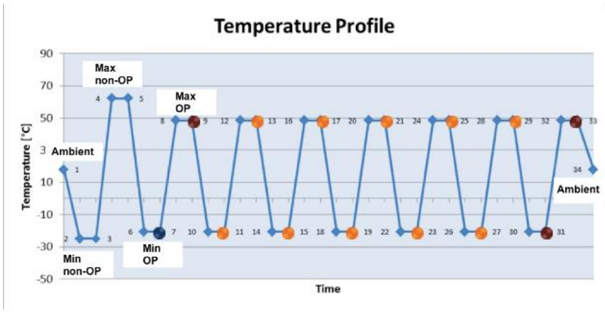

Figure 2: TVT thermal cycles.

A detailed description of the test set-up was presented in [3]. It is important to remark that the motor, due to operator's error, was not turned off after the functional test in the third hot operative case causing the temperature to increase. In this phase, however, the temperature never reached the motor design limit and did not damage the EBM or prevent the correct execution of the remaining of the test and further activities.

Despite the problem occurred, the TVT campaign successfully demonstrated the capability of the EBM to survive and operate in the foreseen thermal environment.

4.2. Vibration Tests

After the successful conclusion of the TVT the Vibration Tests (VTs) were performed. These tests aimed at verifying the capability of the EBM to withstand the expected launch loads conditions. The VTs foresaw accommodating the EBM on a vibrating slip table for the tests along the funnel entrance plane (X and Y axis), and on top of a shaker with a head expander for the tests along the longitudinal axis of the funnel (Z axis). The shaker simulated the expected launch conditions for the Flight SCCM during the launch phase, while accommodated on top of the Orbiter and inside the launcher fairing. The VTs performed on each axis foresaw the following cases:

- Low level sine vibration test for resonance search;
- Sine vibration test with levels typical of a large launch system;
- Random vibration test with levels typical of a large launch system.

The levels applied were selected to be consistent with those of a typical large launch system (e.g. Ariane5).

A detailed description of the test cases and set-up was provided in [3].

The VT campaign was overall successful, demonstrating the EBM capability of withstanding the input levels without degrading the system performances. The analyses of the results highlighted the compliance with the requirement of having the first natural frequency of the EBM higher than 100 Hz and the random vibration acceleration on the motor lower than the component limitation. The VT campaign successfully concluded the on-ground test phase raising the concept TRL to 4 and allowing the EBM to be test in a parabolic flight simulating the 0-g environment.

5. PARABOLIC FLIGHT EXPERIMENT

The Parabolic Flight Test Campaign aimed at testing the EBM in a representative 0-g environment, raising the technology up to TRL 6 ISO Standards (breadboard validation in relevant environment). The test took place during the 61st ESA Parabolic Flight Campaign at Novespace premises in Bordeaux-Merignac: it foresaw three days of tests and in each day 31 parabolas were performed by the A300 aircraft that hosted the experiment. Each sequence of parabolas was subdivided in 6 sets of 5-6 parabolas and during each parabola the experiment was exposed for about 22 seconds to a micro-gravity (<0.05 g) environment.

In order to perform such a test, a trade off led to consider a free floating OS within a fixed rack comprising the EBM: this solution had the advantage of helping both the estimation of the impact forces and reducing the safety risks having the EBM constrained to the aircraft with only the OS (~ 6kg) in free-floating condition. The cost of this compromise was the necessity to cope with the perturbation of the microgravity phases introduced by the aircraft itself.

5.1. Parabolic Flight Test Set-up

The EBM tested during the on-ground test campaign was modified in order to cope with the special conditions of a parabolic flight.
In particular, the free-floating OS was subjected up to 2g of accelerations during the hyper-gravity phases at the beginning and at the end of each parabola: an impact of the OS onto the arm, in this condition, could generate a torque that the motor was not design to withstand. To cope with this issue a brake, mounted on the arm shaft of the EBM, was added aiming at decoupling the motor from the arm during hyper-gravity phases thus blocking the arm. The selected device was the Mayr® electromagnetic safety brake ROBA-stop-M 16/891.100/28.
Furthermore, it was necessary to design a device able to provide the OS with an initial trajectory and velocity compliant with the requirements. The OS launcher is shown in Figure 3.

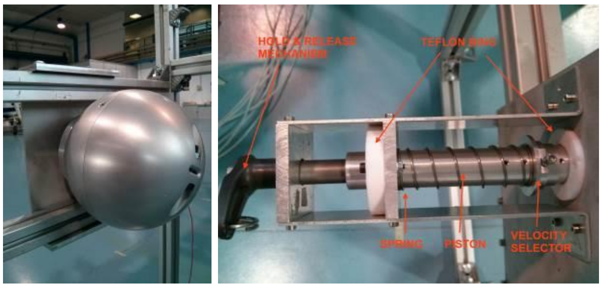

Figure 3: OS launcher.

A cylindrical container was also added at the bottom of the funnel to store the OS after the completion of the transfer tests.
The last design challenge was building a dedicated housing for the experiment compliant with both the test and the safety requirements for the parabolic flight. The Flight Experiment Rack (FER) designed and the experiment as installed in the aircraft are presented in Figure 4 and Figure 5.

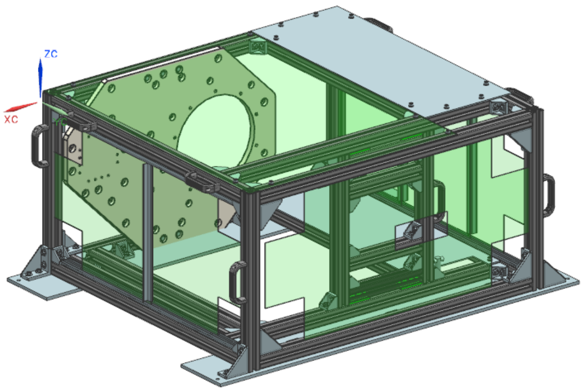

Figure 4: FER framework


Figure 5: Experiment ready for parabolic flight test campaign

5.2. Parabolic Flight Test Plan

The Test Plan for the Parabolic Flight Test Campaign was defined taking into account the specific environmental conditions simulated during the flight, which provided an improved test bench where to test the EBM. This plan was customized on parabolas set basis in order to test the higher possible number of parameters and conditions. The first day aimed at verifying the EBM functionalities in 0-g environment, calibrating the launcher and assessing the acceleration perturbation effects on the launcher performances. The results of these tests were considered to select the launching strategy for the following days in which the complete tests were performed. The tests foreseen for the first day were:

- Initialization: to verify the arm functioning (the OS was not used);
- Capture: to verify the ability of the arm to maintain the retention configuration with the OS already “captured” within the funnel;
- Transfer: to verify the “transfer” operation starting from retention configuration (OS inside the funnel). For the first test the transfer was divided into two consecutive parabolas while in the following parabolas it was attempted to perform the test within a single parabola;
- Launch: to verify the OS launcher operations and the OS “real” trajectory;
- Retention: to verify both OS launch and arm closure up to the retention configuration.

The following two test days were used to perform the complete test as presented in Figure 6. Each complete test was divided into two parabolas using the first one for launch and retention and the second for transfer and securing. This plan allowed performing two complete tests each set of parabolas. The results of the first day were used to optimize the test sequence for the complete tests. Both in test day 2 and 3 the launch was performed considering different configurations of launcher offset and angle (Table 7). The OS initial conditions pattern was the same for both test days, but at two different speeds.

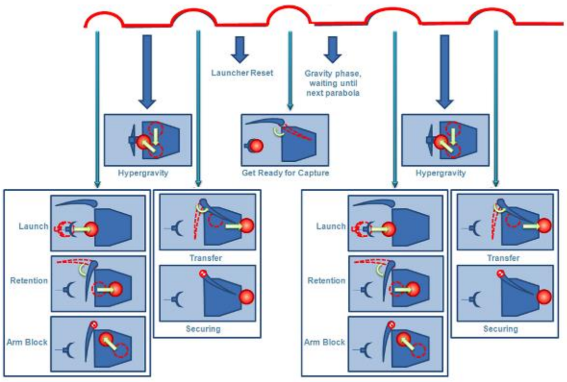

Figure 6: Complete test schematics.

Table 7: Test days 2 and 3 OS initial conditions

Set	OS initial angle [deg]	OS initial offset [cm]
1	0	0
2	*0*	0
3	*0*	10
4	*5*	0
5	*5*	10
6	*5*	10

5.3. Parabolic Flight Test Results

The parabolic flight test campaign has proven successful in every aspect allowing the validation of the design of the capture mechanism in microgravity environment. In particular, the detection sensors triggered the arm closure in every tested condition and the actuation chain demonstrated the capability of the EBM to capture the OS once it entered the funnel and to transfer it into the trap afterwards withstanding also the impacts of the OS with the arm.

In the first test day, every test was completed successfully verifying the functionality of the components and the operations of the breadboard. In particular the possibility of performing the transfer within one parabola and without pinching of the OS between arm and funnel walls was confirmed; this was not straight forward considering that the SCCM was not design to transfer and secured the OS within the microgravity period of one parabola (about 20 s). During the launch tests, even if the OS always entered the funnel and triggered the detection sensors, the effect of the perturbations on the OS trajectory was noticed to be relevant. This aspect became fundamental in some retention test cases when, because of the perturbations the OS triggered the arm closure only after being manually pushed inside the funnel by an operator. These tests were considered successful since the objective of the test was the retention operation and not the launch itself.

Analysing the test results of the first day it was decided to update the test plan for the second and third days: since the operations duration were always much lower than the microgravity phases duration it was decided to perform a complete test within one parabola instead of two, thus avoiding stopping the operations for the hyper-gravity phases. The OS speed was measured and confirmed to be the one expected of 15 cm/s; thus, it was decided to keep the OS speed for test day 2. It was also decided to increase the OS speed in the third test day, instead of lowering it at the foreseen 10 cm/s, because of the strong impact the microgravity perturbation had on the OS free-floating dynamics after its release.

The first two complete tests of the second test day were executed in two consecutive parabolas (retention in the first and transfer in the second) as foreseen in the test procedure while in the other cases it was always attempted to perform the complete test within one parabola. In some cases, the perturbations caused the OS to trigger the detection sensors with a considerable delay after the launch proving impossible to complete the test within a single parabola; in these cases the test was stopped after the end of the retention operation and the transfer was executed in the following parabola. As already noticed in the first day the perturbations strongly affected the test results: in fact, also in the failed tests, the launcher performed as expected but the OS, affected by the perturbations, did not entered the funnel thus not triggering the detection sensors. In one test, after the launch and during the retention operation, the OS was exiting the funnel (due to perturbations effects) while the arm was closing causing pinching of the OS between arm and funnel edge on the far side with respect to the hinge. In this test there was a loss of sync in the motor but the OS was still prevented from escaping and the transfer was completed: the test was therefore categorized as a success.

The tests of the third day were executed as in the second day with the difference the all the complete tests were performed within one parabola. As mentioned above, due to the effects of the perturbations on the OS trajectory, the OS launcher was set to a higher speed (20 cm/s) with respect to the previous day and not to the 10 cm/s foreseen in the procedure. This condition was outside the design boundaries of the EBM (maximum OS velocity 15 cm/s) and caused higher impact forces than the one calculated in the design phase. Despite this changed configuration, the EBM completed the foreseen operations successfully proving the design to be robust and reliable.

Even if the total number of available tests is limited due to the particular test environment, considering all the performed test cases, an evaluation of the results, summarized in

Table 9, lead to consider a percentage of success of 78% (14/18) during test day 2 and 71% (20/28) for test day 3. According to this, and considering that the failed tests were all due to perturbation effects, it can be inferred that the OS speed does not have considerable effects on the capture test outcome. This result can be extend also to lower OS speeds (not tested due to perturbation effects), provided that the test is performed in a non-perturbed environment, since the time available for the EBM to complete the retention operation would be higher with a slower OS. On the other hand, a more detailed assessment of the test outcomes, identifies the worst-case initial conditions in the 3rd set of both days: the launch with 10 cm offset and 0 deg angle show the lowest percentage of success with 50% of failed capture test.

Microgravity perturbations

In order to study the microgravity perturbation effects, Figure 7 and Figure 8 show two different aircraft acceleration profiles during microgravity phases. These profiles can be directly correlated to the result of the particular test they represent, which are a successful and failed test case respectively.

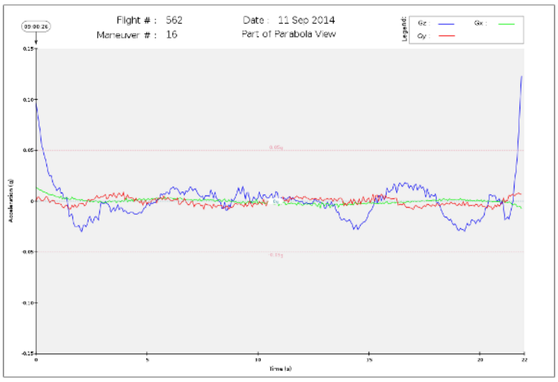

Figure 7: 3rd day, 3rd set, 1st parabola aircraft accelerations

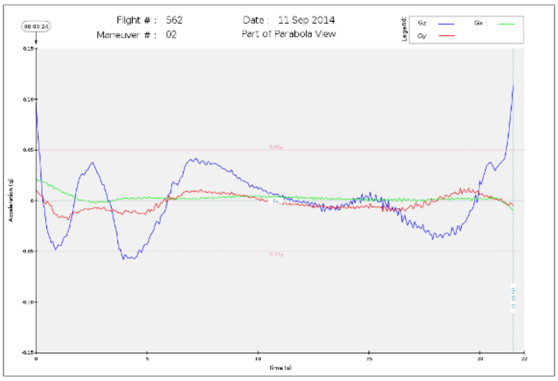

Figure 8: 3rd day, 1st set, 3rd parabola aircraft accelerations

Figure 7 reports the acceleration pattern of a smooth parabola while Figure 8 is representative of a highly disturbed one. In particular it is remarked how, besides residual Z acceleration with a peak of about 0.05g, relatively strong negative Y acceleration (the direction of the OS launch), of about 0.02g, lasts for the first 5 seconds of microgravity. Considering the acceleration delivered by the OS launcher, lower than 0.4g, this perturbation prevented the OS from reaching the funnel thus triggering the retention.

Failed Tests

In order to quantitatively assess the effects of the perturbations on the OS trajectory a detailed analysis of the aircraft acceleration after the OS launch and before the first impact with the funnel was performed; the release time with respect to the start of the microgravity was measured from the tests video data. From the launch instant the accelerations were integrated obtaining the velocity of the OS with respect to the funnel; after adding the OS speed provided from the launcher a second integration step was executed to estimate the OS trajectory disturbed from the microgravity perturbations. Figure 9 shows the centre of the OS with respect to the funnel mouth at the entrance time. The blue and red dots represent respectively successful and failed tests while the red shaded area indicates when, due to the physical dimensions of the OS, an impact between the OS itself and the funnel edge occurred, before the OS entered the funnel. It is remarked that all the failed tests occurred when the OS impacted with the edge while entering the funnel and it did not triggered the detection sensors. However, in some successful tests the OS impacted on the funnel while entering but the EBM was still able to complete the required operations. It is important to notice that the perturbations along X do not play a fundamental role in the OS entrance conditions while the vertical component is crucial in this aspect.

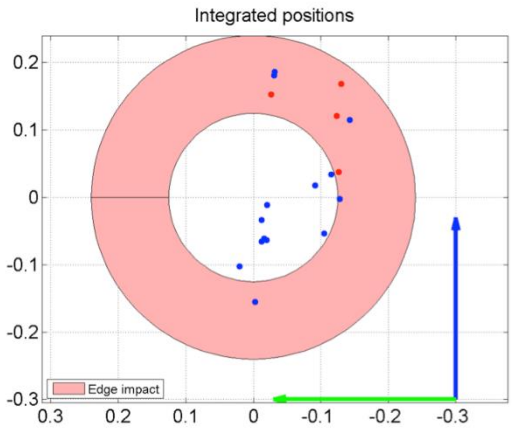

Figure 9: 2nd day: integrated position

All failed tests recorded were separately analysed to better identify the causes of the unsuccessful result in each case. It is important to remind that the OS entrance position provided in this analysis is only an estimation based on the aircraft accelerations during the microgravity phases. Figure 10 shows the result of the test performed on 2nd day, 2nd set, 3rd parabola: the OS was launched with 0 cm offset and 0 deg angle and it impacted on the upped edge of the funnel thus not triggering the arm closure. The causes of this behaviour can be identified analysing the acceleration conditions when the OS was released, the vertical green line in Figure 11. It is noticed that the launch occurred when a strong upward acceleration was present in the aircraft causing the OS to impact onto the upper edge of the funnel thus a failed test.

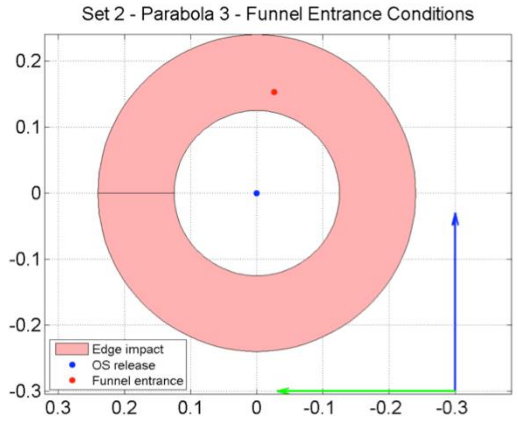

Figure 10: 2nd day, 2nd set, 3rd parabola: OS estimated position at funnel entrance

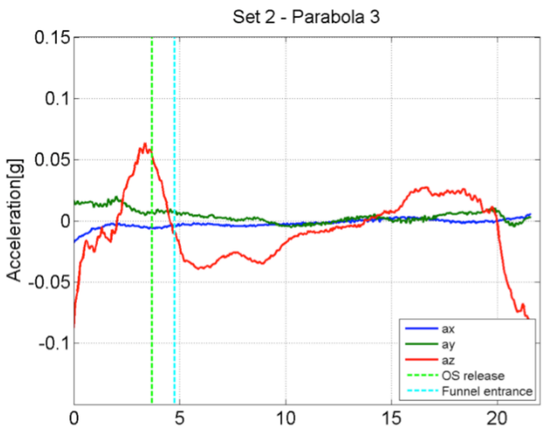

Figure 11: 2nd day, 2nd set, 3rd parabola: Microgravity phase accelerations

Impact Forces

Analysing the acceleration acting on the OS during the free-floating phases it was possible to estimate the forces and the duration of the OS impacts onto the funnel walls. It is clear from the results presented in Table 8 that both forces and durations are not reproducible since the high variation in the limited number of tests. It is important to remark, however, that this analysis does not include the trajectory impact angle. In the design phase [2] the forces were estimated to be 240 N with OS speed of 15 cm/s. The mean value calculated is similar to the estimation, but the maximum one is much higher in both days. The same consideration can be applied to the impact duration, expected to be of 12-20 ms. Despite the higher impact forces the protective layer, a crushable material aimed at damping the OS energy, inspection did not highlighted any damage proving that further analyses shall be performed to better assess its functionality.

Table 8: Impact forces and duration.

	Force [N]		Duration [ms]	
	Day 2	Day 3	Day 2	Day 3
Mean	257.0	237.0	15.6	16.1
Maximum	497.6	734.0	24.0	26.0
Minimum	154.0	139.3	10.0	6.0

6. CONCLUSIONS

The on-ground test campaign was successfully completed raising the concept TRL to 4: the EBM performances were evaluated during functional and environmental tests; the breadboard design proved effective both at system and component level in laboratory environment.

The parabolic flight test campaign was successfully performed demonstrating the EBM full functionality in relevant 0-g environment and raising the concept TRL to 6. The expected number of test cases were almost doubled since the arm actuation proved able to complete a full transfer within one single parabola; this enabled to extract a better statistics of successful/failed complete tests. No major remarks needs to be reported on the hardware itself, the major issue to cope with was the strong perturbations the OS was subjected to during the free-floating phase within the EBM rack. The failed tests were due to the OS perturbations rather than EMB malfunctioning; in particular the first seconds of microgravity are crucial for the positive outcome of the test case. Since the OS was released manually at the very beginning of the parabola, the OS launch was very sensitive of the microgravity quality, which was completely random and unpredictable.

Some of the tests performed under low perturbations conditions demonstrated the possibility of the OS to enter directly into the trap after triggering the detection sensors without the push of the arm. On the other hand, when the OS impacted onto the funnel walls, it started to rotate along the walls in a plane parallel to the funnel entrance. It is important to notice that is not possible to establish if this behaviour was caused by the acceleration perturbations. From this point of view, an improvement for the parabolic flight experiment should be to implement an automatic release mechanism triggered by an acceleration sensor: this would avoid failed launches due to perturbation.

The parabolic flight test environment poses strong limitation for the testing of low speed free-floating objects in a fixed envelope. The environment in fact is dominated by a random unpredictable gravity noise: a microgravity background level of 0.05 g prevents maintaining a foreseen free-floating trajectory with respect to a fixed target. Higher speed mitigates this effect by reducing the free-floating time span.

Table 9 summarizes the results of the tests performed during the parabolic flight campaign. In particular, for the complete tests three success percentages are reported:

- ”Success [%] over launches” is the number of successful tests for each initial condition over the total number of launches performed during the flights. This percentage is useful to identify the critical initial conditions in this particularly perturbed environment;
- ”Success with sensors triggered [%]” is the number of successful tests over the number of times the OS triggered the sensors after the launch. This percentage is still affected by the perturbation, as described in the analysis above;
- ”Success with OS inside funnel for more than 4s [%]” is the number of successful test cases over the number of tests in which the OS did not exit the funnel before 4 s, after triggering the sensors. Remembering that the retention operation duration was set at 7 s, the 100% success rate demonstrates the robustness of the EBM performances not only inside the design parameter, but also in non-nominal conditions for offset, angle, speed and retention duration.

The objective of the test campaign to raise the TRL to 6 was fully achieved

Table 9: Parabolic flight test results summary

Test Day	Test Case	Speed [cm/s]	Offset [cm]	Angle [deg]	Success over launches [%]	Success with triggered sensors [%]	Success with OS inside funnel for more than 4s [%]
1	Initialization	-	-	-	100	100	100
	Capture	-	-	-	100	100	100
	Transfer	-	-	-	100	100	100
	Launch	15	0	0	100	100	100
	Retention	15	0	0	100	100	100
2	Complete - 15	15	0	0	83 (5/6)	100 (5/5)	100 (5/5)
		15	10	0	50 (2/4)	100 (2/2)	100 (2/2)
		15	0	5	100 (4/4)	100 (4/4)	100 (4/4)
		15	10	5	75 (3/4)	100 (3/3)	100 (3/3)
	TOT	-	-	-	78 (14/18)	100 (14/14)	100 (14/14)
3	Complete - 20	20	0	0	80 (8/10)	80 (8/10)	100 (8/8)
		20	10	0	50 (2/4)	50 (2/4)	100 (2/2)
		20	0	5	60 (3/5)	75 (3/4)	100 (4/4)
		20	10	5	78 (7/9)	100 (7/7)	100 (7/7)
	TOT	-	-	-	71 (20/28)	83 (20/24)	100 (20/20)

7. AKNOWLEDGEMENTS

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8. REFERENCES

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