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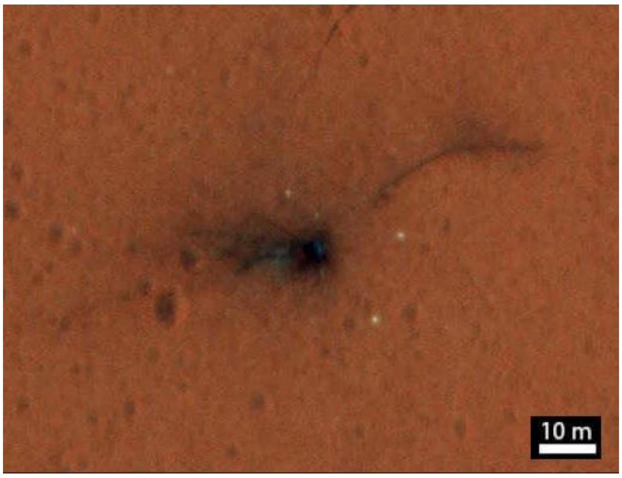
ExoMars, failure or success?

The anxiety of the first hours after the loss of telemetry signals from the Schiaparelli EDM (Entry, descent and landing Demonstrator Module), and the embarrassing silence showing up few minutes before the landing on Mars, was followed by a crushing disappointment when NASA released a picture taken by MRO (Mars Reconnaissance Orbiter) that left few doubts. The eloquent b/w picture shows the new Martian crater created by the almost 500 kg of Schiaparelli mass that, instead of landing, had crashed into the red planet, and a fuel tank may have exploded at impact.

Communication was broken during the final phase of 5 minutes and 53 seconds descent through the atmosphere: it is no wonder that those were referred as the "fateful six minutes of terror." Most of the Mars missions' failures have historically occurred at this stage.

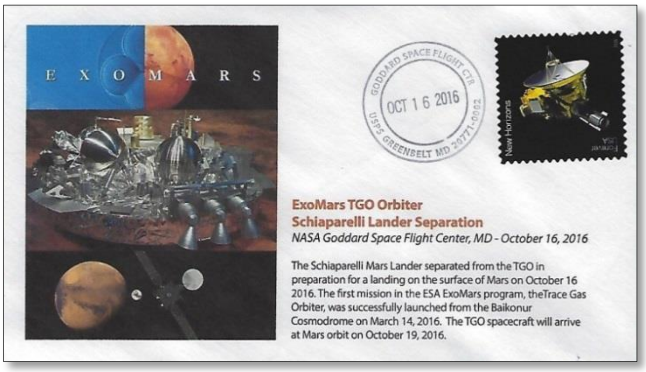


Schiaparelli crash site in the HR colour image taken by MRO on Nov. 1, 2016. © nasa.gov.

Commemorative cover of the landing of Schiaparelli, postmarked in Darmstadt where ESOC is based. The European Space Operations Centre is supporting the Exomars mission.

On October 16, three days before the landing attempt, the TGO probe had successfully undocked Schiaparelli and inserted it in a perfect trajectory, so much so that – despite all the problems it has had – EDM fell only 500 metres short of the centre of the theoretical target area which was identified as an ellipse of 50 by 100 kms.

The descent of Schiaparelli, heading for a landing in Meridiani Planum, a broad plain near the Martian equator, was monitored in real time (with a delay of 9 minutes and 47 seconds due to the distance of Mars) by the GMRT, *Giant Metrewave Radio Telescope* in India and has also been recorded by Mars Express that eventually broadcasted the data to the Cebreros ESA tracking station in Spain. Both confirm that the atmosphere entry occurred exactly as expected, and that both the heat shield and the parachute and associated braking worked properly as planned.



Exomars entered the Martian atmosphere at the altitude of 122 km and a speed of 21,000 km/h. The atmospheric friction slowed down Schiaparelli up to 1650 km/h at 11 km off the ground; At this point, the module deployed its 12 metres parachute. Four kilometres below, Schiaparelli jettisoned its heat shield, allowing the onboard Doppler radar altimeter to begin directly measuring the distance from the surface.

Here, at the beginning of the last landing phase, the problems and the mysteries started. The computer ejected the parachute (ahead of time), turned its nine thrusters for only three seconds (instead of the expected 30 seconds), then it decided to switch them off, and initiated a post-landing command sequence (including the delivery of the data collected during the entry into the Mars atmosphere) as if the craft had already touched down on Mars, but it was still about 12,000 feet (3,700 meters) above the surface and it was free-falling. It would arrive on the Red Planet 19 seconds later, and would hit the ground at nearly 200 mph (300 Km/h or 83 meters per second) and fatally crash.

It seems this is what happened exactly about sixteen years ago to the NASA Mars Polar Lander, when a sensor sent wrong signals that prematurely turned off the engines.

"*Once again* – astronaut Walter Villadei says – *the most risky and not easily predictable component is the "aeronautical" phase of the mission. The six minutes of entrance and descent in the rarefied Martian atmosphere have proven to be more complex and dangerous than the seven months of interplanetary flight. If you look at the history of spaceflight, the most serious accidents, those that cost human lives, have all taken place, except for the Apollo 1, during the phase of atmospheric flight: take-off or return.*"

Since all the attention was focused on the Schiaparelli lander, its failure was branded by some media as the failure of the entire mission. If the expectation was only the soft landing, then it is a failure. But Exomars 2016 was more than that.

Actually, while the INRRI payload, on Schiaparelli, was a passive laser retro-reflector that could be used as long as possible, even decades later, for laser range-finding of the lander, the primary goal of the "demonstrator" was to test the landing systems, including the parachute, doppler radar altimeter, hydrazine thrusters, etc. The secondary lander's goal was scientific, using the DREAMS surface science payload, designed to conduct meteorological data for a few days after landing. Some payloads (AMELIA, COMARS+, and DECA) were designed to last literally a few minutes

and collect data during the entry, descent, and landing: much of these data – actually 600 Mb of data – were luckily transmitted while it was descending.
Globally the lander Schiaparelli was a test and it seems to have operated as expected until a few seconds before contact with the ground.
But it has not to be disregarded that the GTO Orbiter, which carried the EDM to its destination and inserted it in the correct orbit, worked perfectly so far, and will continue to operate for years, supporting the second part of the European Exomars mission in 2020 and also future missions of other countries. It is now perfectly in orbit and operational, and it is expected it will provide scientific data on Martian atmospheric. This led to declare that "*ESA is keen to stress that overall, the ExoMars mission can be seen as a triumph*".
Now, let us not go over the top! The truth is that the glass is only half full…
As its name suggests, EDM was a demonstrator of new technologies. ESA was testing technologies and procedures to do something that Europe had never done before and to gain the ability to perform the three basic manoeuvers necessary to operate on the surface of another planet with atmosphere: i.e. the entry, descent and landing. When you venture into a new field, the mistakes are not only inevitable but they are part of the game. It would not be research if you go without doubts, and you know exactly what to do and how to do it.
But if Schiaparelli crashed, not everything went as it was expected, even though its scientific contribution to the mission, on the Mars surface, was almost nil. And many are rather reluctant to consider it as a "*triumph".*
At the end of November, after the release of the preliminary report of the ESA internal inquiry commission, it turned out that an unexplained fatal error fed incorrect data into the craft's navigation computer causing the probe to think it was already on the surface when it was actually still several miles above the planet. It's known that the Martial atmosphere is totally different from the Terrestrial one, and the gravity on the two planets is behaving differently.
Now it's more clear that a computer simulation could not be enough. And there are accusations against ESA for underestimating some very important aspects.
The system has become unstable and went wrong when atmospheric density increased and the higher variability factors became predominant, and where previous end-to-end tests prove to be essential, while the computer simulations haven't much to say. Because of such well-known variability, with the full support of the all ESA Member States, two critical tests to be performed in a similar environment were inserted in the industrial contract: (1) a stratospheric balloon test, in which to test all the non-hypersonic conditions during the descent phase, including parachutes, aerodynamic factors and retro-rockets, and (2) a drop test from 3000 metres to test the radar the radar. Actually it seems that of the ESA project team has underestimated the importance of these crucial tests, when they subtracted from the industrial control the execution of the stratospheric balloon and tried to cancel the descent radar test: the balloon test, which according to the industry had to be performed by a company with proven specific skill and capabilities, was first assigned by ESA according to solely geo-political criteria, and eventually simply cancelled. ESA has also tried to cancel the radar test in the Italian-Moroccan Ibn Battuta center, to reproduce the conditions of Martian soil; after trying to replace it with a test at a military Italian airport, only after high pressure from ASI, they did both the radar tests at the airport, and in the Moroccan desert. As it is known so far, the radar has worked properly.
An external, independent board of inquiry, participated by the Countries involved in the programme as well as by international experts, has been created; and a final report is expected in early 2017.
As for now a first result was obtained: ESA has recognized that it was necessary to change the management direction of the programme.

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