MARS – A HAPPY LANDING

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The successful landing of NASA's Curiosity Rover, or Mars Science Laboratory (MSL) mission to give it its full name, on August 6th 2012 was truly a great feat of space engineering. Why, you may ask, as landers and rovers have been delivered to the surface of Mars since as far back as 1975. Well, the answer, at least partly, lies in the size and weight of the MSL. It weighs in at a total of 899 kg, only about 10% less than my car! Previous rovers, for example, delivered to the surface of Mars have ranged from a mere 10.5 kg for the Mars Pathfinder up to 185 kg each for the highly successful Spirit and Opportunity rovers (although the total "landed" masses in all cases was slightly greater than the rover mass). The "traditional" technique for delivering a package to the surface of Mars involved an atmospheric braking at the top of the atmosphere followed by a parachute descent and finally, if required, a fall cushioned by airbags which are inflated around the precious payload during the last stages of descent. This works well but there is a limit to the mass (and therefore size) of payload which can be delivered in this way. With the proposed MSL, we had already reached that limit. So space engineers had to devise a new scheme – and what they came up with did almost seem like science fiction, even to the designers themselves! It involved an initial descent under a parachute followed by the firing of 8 retro rockets when the payload was about 1 km above the surface in order to slow down the payload further. At this point, the designers' imagination really took hold – they developed a system which involved lowering the precious payload from a height of some 8 m above the surface on three nylon ropes to a gentle landing. This technique has been dubbed the "skycrane" for obvious reasons. But why not use the retro rockets for a slow controlled final descent all the way down you might ask? Well, the exhaust from the rockets would have thrown up so much dust and debris from the Martian surface that the delicate instruments would have been damaged or even destroyed. Furthermore, the landing area would have been significantly chemically altered by the rockets – and one of the prime aims of the MSL is to carry out a detailed chemical analysis of the Martian surface.

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Because of the novelty of the landing system, there was real trepidation in the MSL team at NASA and the research institutes and in the worldwide Mars community. But the landing seems to have happened nearly flawlessly – a tribute to outstanding design and a meticulous test programme designed to tease out any flaws on the Earth before launch rather than during the real landing!

And what of MSL's future? It carries the most sophisticated array of instruments ever sent to the Red planet, including some never before deployed there. We want to study Mars for several reasons – it is our near neighbour, made of much the same stuff as Earth and once, in its early history, much warmer and wetter and with a thicker atmosphere than now – perhaps not too dissimilar to

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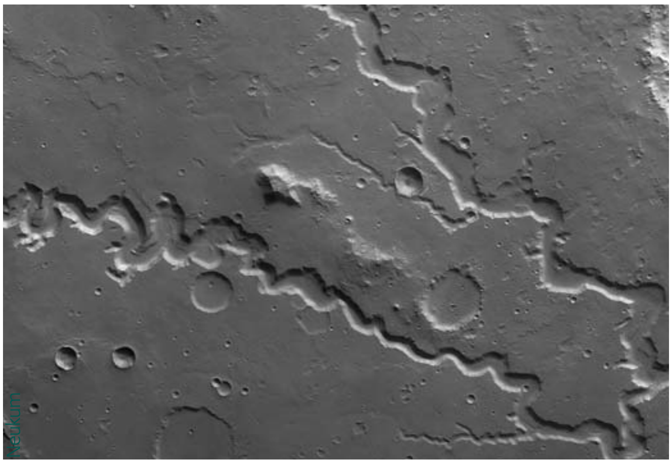
One of the earliest images taken by the Mast Camera on the Curiosity rover from the landing site. It shows interesting geology on the lower slopes of the nearby Mount Sharp. The region in the middle distance is believed to be an area of sand dunes which the rover will attempt to circumnavigate in order to reach the base of Mount Sharp where water is thought to have existed in the distant past.

early Earth. But somewhere along the line, the evolutionary paths of Earth and Mars have diverged to make them rather different worlds today. Why? That's just one of the questions that Planetologsts want to answer. Secondly, despite us having found exotic environments elsewhere in the Solar System, (such as certain of the moons of Jupiter and Saturn), Mars probably still presents the best chance of primitive life having existed there sometime in the past, during its wetter and warmer phase. It is not entirely impossible that life exists there today somewhere below the surface or in some niche protected from the harmful radiation which bathes the surface.



ESA/DLR/FU Berlin/G. Neukum

One of the many stunning images taken by Mars Express, the European Space Agency spacecraft currently in orbit around Mars. The image shows the Nanedi Valles valley system, probably formed in part by free-flowing water. There is plenty of evidence that significant quantities of water existed on Mars in the past. At the present time, water exists in the form of ice at the Poles, as permafrost below the surface and as vapour in the atmosphere.

And third is the fact that one day soon (in the next 25 years?) astronauts will undoubtedly be despatched to the surface of Mars – and before we undertake that tricky task, we need to know all we can about Mars, particularly pertaining to potentially harmful aspects of the local environment.

The landing site for the MSL is an interesting story in itself. It is within the Gale Crater, a 150 km sized impact crater formed about 3.5 billion years ago as a result of an asteroid impact with Mars. But the target area was much smaller than this – it is an ellipse of 7 x 20 km at the base of a mountain within the crater. This region was selected after painstaking work by Martian experts worldwide to select the region most likely to show tangible signs of life should it ever have existed. This region shows distinctive evidence that water flowed here in the past. A further attraction of this region is the existence of layers of exposed rock which should allow a history of this region to be determined. Apart from scientific considerations, engineering and safety issues also had to be factored in – amongst these, for example, was the need to have a relatively flat and smooth region to make a safe landing more likely and to aid subsequent mobility of the Rover.

If all goes to plan, MSL will explore a region extending to some 20 km or so from the landing site, employing its extensive range of instruments to address the above questions. The 12 scientific instruments can be divided into the following broad categories: cameras, spectrometers, radiation detectors, environmental sensors and atmospheric sensors. Taking up nearly half of the entire payload is the SAM (Science Analysis at Mars) instrument for the purpose of analysing elements and compounds that are associated with life. Another instrument is the ChemCam which will employ Laser Induced Breakdown Spectroscopy, a technique used in terrestrial applications but never so far deployed on another planet. This involves firing a laser pulse at a suitable rocky target up to 7 metres away and then analysing spectroscopically the light produced by the transient glowing plasma cloud that is momentarily generated to determine the composition of the rock. A great advantage of this technique is that it can be performed remotely thus allowing for example a rock face, much of which would otherwise be inaccessible, to be thoroughly analysed by MSL.

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At the end of the MSL's lifetime, officially in just under two years, it is unlikely that we shall get definitive answers to many of the questions that we want answered on Mars – science rarely works like that! But because of the extent and complexity of MSL's payload, delivered in this novel and daring way, we can expect perhaps our greatest "leap forward" since Viking 1 made the first controlled landing on Mars in 1975.

At the time of writing, MSL is just coming to the end of its commissioning phase – all of the instruments and on board systems, including the robot arm, are being put through their paces. So far, almost everything is working to plan – and the Rover has taken its first tentative "steps", moving for example 15m on Sol 22 (a Sol is a Martian day).

MSL is a NASA mission with two of the instruments coming also from Russia and Spain. But UK scientists, because of their particular expertise, are well represented on the various science teams, with formal involvement as participating scientists from Imperial College London and Leicester University, and informal involvement from several other institutions.

While MSL is doing its work, European space scientists and engineers will not be idle however. Through the European Space Agency's ExoMars programme, carried out in conjunction with the Russian agency Roscosmos, they will be preparing two Mars missions for launch in 2016 and 2018; the former will involve an orbiter and small landing module while the latter will deliver a sophisticated rover. Even though we no longer see canals on Mars nor worry about invasion by Martians, Mars continues to engage and fascinate both scientists and the public alike.

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