Mars CURIOSITY LAUNCHES FOR

NASA's largest and most ambitious rover is due to blast off this month

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Build a vehicle the size of a Mini Cooper, fill it with cameras and science instruments, launch it into space, gently put it down on the surface of Mars and have it check the habitability of the Red Planet. Sound like science fiction? Not for the scientists and engineers of NASA's Jet Propulsion Laboratory (JPL). Their latest rover, aptly named Curiosity, is awaiting launch in late November. It's the biggest planetary lander ever built, and it's bound to revolutionise our knowledge about Earth's most intriguing neighbour.

JPL's Peter Theisinger, who manages the Mars Science Laboratory (MSL) mission, will breathe a sigh of relief when the Atlas V 541 launcher leaves Cape Canaveral successfully on 25 November 2011 at 15.21 GMT (the launch window will extend until 18 December). "I don't do sleepless nights," he says, "but we were very worried a year and a half ago when we experienced electronics delivery challenges." Previously, Curiosity's launch had already been postponed for 26 months because of unexpected delays, while the mission's price tag soared from ►

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Curiosity is scheduled to touch down in Gale Crater on 6 August 2012

▲ Curiosity, right, is twice as big as a Mars Exploration Rover, left, and dwarfs the 65cm-long Sojourner rover

► $1bn to $2.3bn dollars in the course of a decade. "It has been very complicated to put this mission together," says Theisinger.

MSL will take over eight months to reach Mars, arriving on 6 August, at the height of the London 2012 Olympic Games. And just like the performance of an Olympic athlete, Curiosity's descent to the Martian surface will be an incredible, awe-inspiring and nail-biting experience.

Equipped with the biggest heat shield ever flown into space (4.5m across), MSL will enter the thin Martian air at the breakneck speed of 21,000km/h. Four minutes later, at an altitude of 10km, atmospheric drag will have slowed down the craft to 1,700km/h, and a 16m parachute, the largest used for an extraterrestrial mission, will be deployed for additional deceleration to 360km/h by the time MSL is less than 2km above the surface.

Then comes the trickiest part. After the heat shield has been jettisoned, the entry capsule's back shell is released. The Curiosity rover is then fully exposed, attached to a landing system dubbed the Sky Crane. This is outfitted with eight retro rockets. After putting on the brakes for less than a minute, the Sky Crane comes to a stop mid-air, hovering less than 20m above the surface. Curiosity is then slowly lowered down on three cables until its six wheels touch the ground. Finally, the cables are released, the Sky Crane flies away to crash in the distance and the rover starts to explore its surroundings, just seven minutes after it entered the atmosphere of its new home planet.

After all the tests and analyses that have been carried out, Theisinger says he is confident that the Sky Crane will work as intended. "But it is a new system," he adds cautiously. Not that there was much choice: unlike the Mars Exploration Rovers Spirit and Opportunity, Curiosity is far too massive at 900kg to use air bags to cushion its landing.

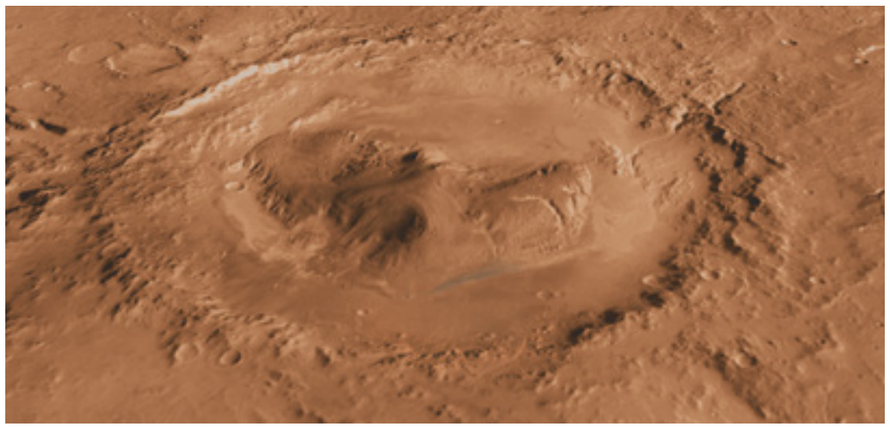
Curiosity will also perform the first ever precision landing on another planet. Flight controllers expect to put the rover down within 10km of its target location at most – much more accurate than its predecessors, which ended up in a 'landing ellipse' measuring 25km wide by 150km long.

Final destination

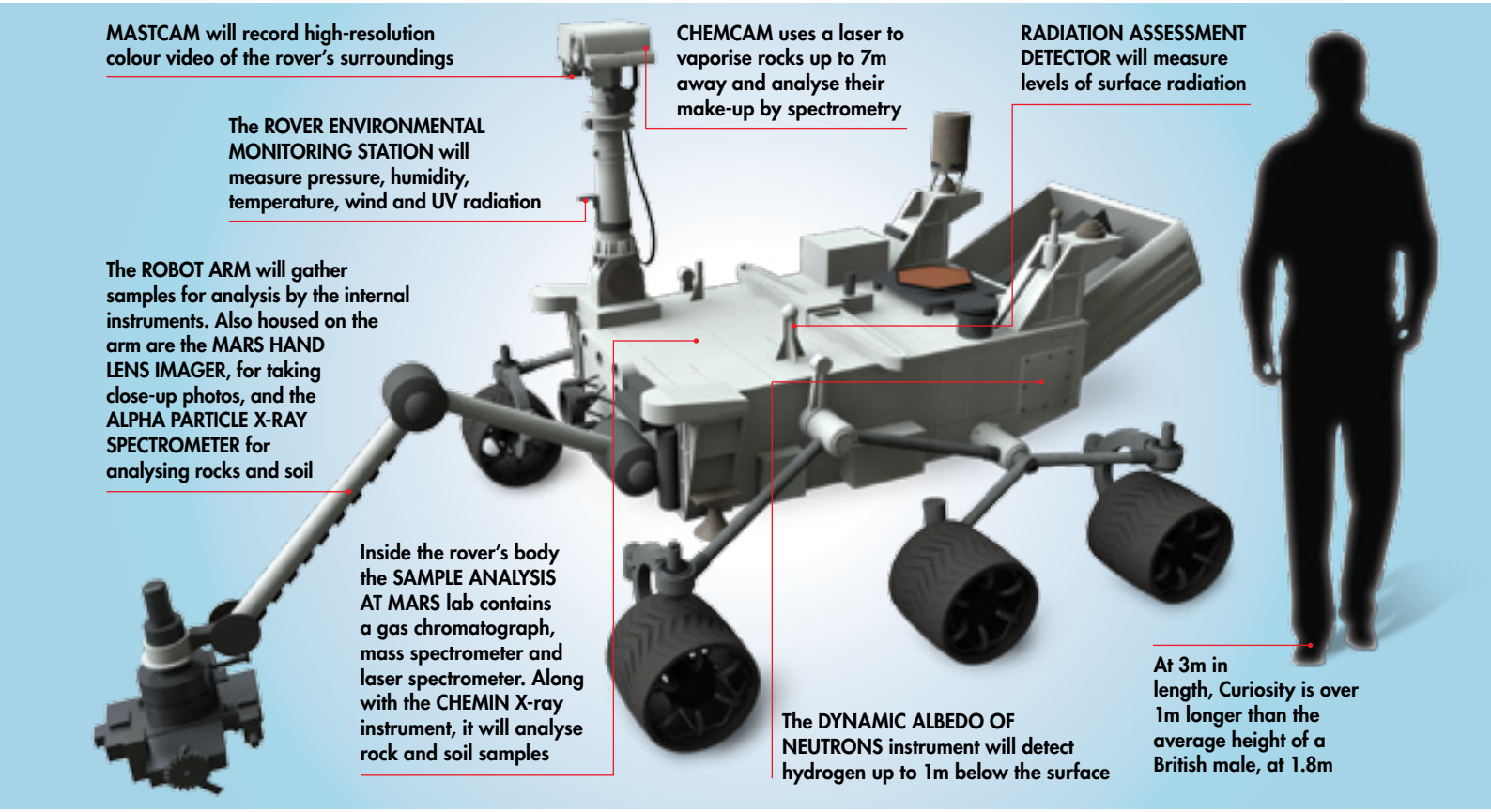
Scientists want Curiosity to touch base in a flat area on the floor of the 154km-wide impact crater Gale (named after Walter Frederick Gale, who studied Martian canals in the late 19th century). ►

▲ To land Curiosity, a huge parachute will slow the descent capsule. The jet pack-like Sky Crane then uses retro rockets to further slow the descent of the rover before lowering it onto the surface

Landing site Why Gale Crater was chosen



Before choosing Gale Crater, exciting because of its huge, mysterious debris mound – possibly eroded sediments – and the existence of both sulphate salts and clay minerals, mission scientists considered three other possible landing sites for the Mars Science Laboratory's Curiosity rover. These were clay-rich Mawrth Vallis, Eberswalde Crater with its huge dried-up river delta, and Holden Crater with its many signs of past water activity. Gale Crater (at the border of Elysium Planitia, 4.5° south of the Martian equator) is deep too: its floor is over 7km below average, meaning water probably accumulated there when Mars was younger.



▲ **Curiosity will carry a host of instruments to test aspects of the planet's surface**

► In late July, after a long and complicated selection procedure, Gale Crater was chosen as the landing site with the best total score on accessibility, scientific promise and risk avoidance. Its unique selling point is a mountainous area with canyons where orbiting spacecraft have found evidence for the existence of sulphate salts and clay minerals. Studying these deposits should shed new light on the role of water in Mars's past.

Planetary scientist Steven Squyres of Cornell University and principal investigator on the science payload of Spirit and Opportunity, is excited about landing in Gale. However, he sounded a note of caution at a conference on planetary landing sites in Noordwijk, the Netherlands, earlier this year, "Landing sites are never what you expect them to be from orbit. I can guarantee the MSL scientists that they're gonna be wrong about what their site is like."

Nevertheless, Curiosity will definitely show us what the Gale Crater is like. Armed with cameras and spectrometers, the rover will focus on four main goals: determining if Mars is (or ever has been) a habitable world, studying the geology of the planet, learning more about its climate and helping NASA prepare for future manned missions. What it will not be able to do, however, is search for living or fossil micro-organisms – that's a task for a later mission in the agency's continuing Mars Exploration Program.

Curiosity will deliver a wealth of pictures. As well as a couple of navigation and hazard avoidance cameras, a descent imager and a microscope camera on its robotic arm, the rover carries two mast cameras that will record high-resolution stereoscopic colour images and high-definition video of the surrounding landscape. Equipped with filter wheels to study specific wavelength bands in detail, the cameras will be much more capable and versatile than the eyes of any human geologist.

A heavy load of hardware

Four instruments will study the composition of the Martian surface. Using laser evaporation and spectroscopy, an instrument called ChemCam will determine the chemistry of rocks and soil. An alpha-particle X-ray spectrometer will reveal the elemental composition by measuring atoms instead of molecules. Curiosity's CheMin (chemistry and minerology) instrument will focus on the mineral structure of Martian samples, while a sample analysis instrument will use three spectrometers to search for organic molecules in the Red Planet's air and soil. Finally, Curiosity will also carry out radiation measurements to assess the Martian environment; it will search for water beneath the surface, as well as provide surface weather reports.

Powered by radioisotope thermal generators (RTGs), Curiosity is expected to travel a total distance of at least 20km during its nominal two-year operational lifetime. But scientists hope that the rover will last longer – after 10 years, the RTGs will deliver over 80 per cent of their power output.

Meanwhile, on both sides of the Atlantic, scientists are preparing for the next phase in the exploration of Mars: the multi-spacecraft ExoMars project, slated for launch in 2016 and 2018. S

ON THE CD

Watch an extended animation of the Mars Science Laboratory's key mission stages

ILLUSTRATION BY PAUL WOOTTON