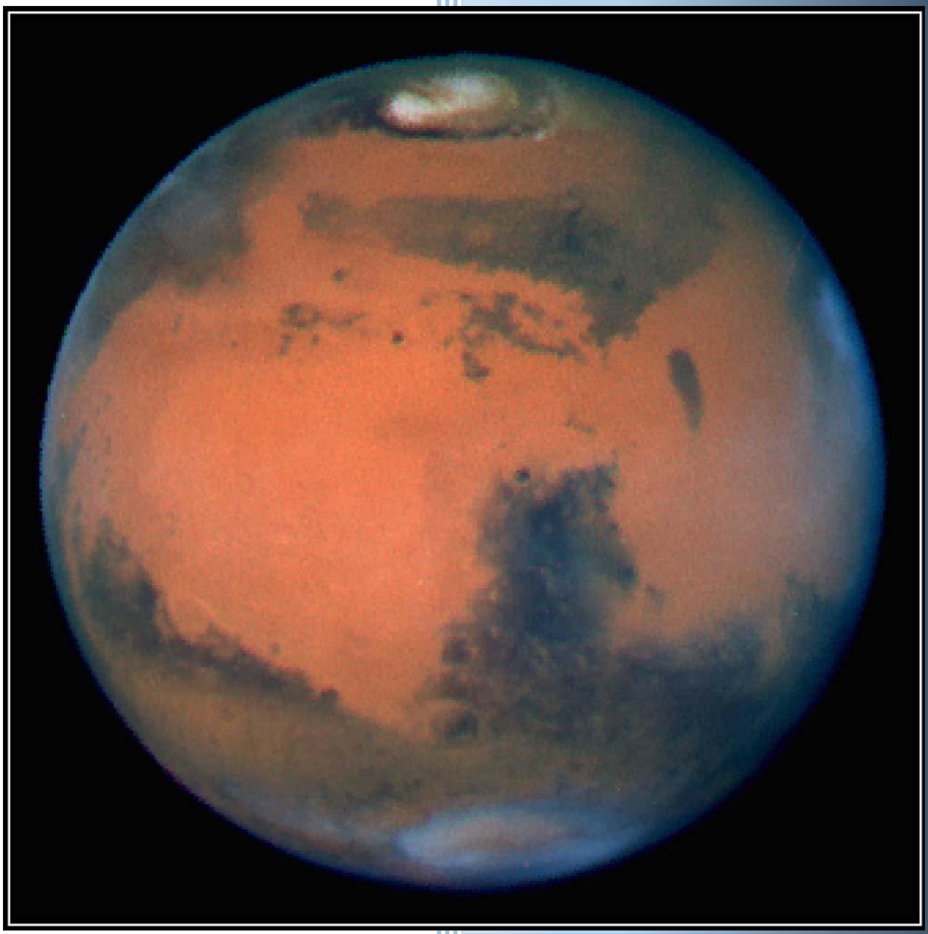
2013

Life on Mars



Marius Stuart
The Adstock Science Club
10/10/2013

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Mars

History

a) Since prehistoric times man has looked up at the stars and noted that some of them appear to move around compared to the others. These were given the name “asteres planatei” or Wandering Stars by Greek astronomers.

A few years ago there were considered to be 9 planets, Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune and Pluto. Recently however Pluto has been redefined as a “Dwarf planet”. There are two other dwarf planets which have been recently discovered, in 2003, beyond the orbit of Pluto, Ceres and Eris.

Mars Is the 2^{nd} closest of our neighbours, (Venus being the closest) and is on average 78.4 million kilometres from the Earth. It appears as a small red point or disc in the sky. The red colour was probably the reason why it became linked to the God of war. The name Mars is Roman though initially Mars was considered to have more to do with agriculture than war. Later Mars somehow got associated with the Greek god of war, Ares, and has since then stayed that way.

b) When Giovanni Schiaparelli, an Italian astronomer, first looked at Mars in the late 19th century, he saw for the first time what he termed “canali” or channels. This term got confused with “canals” and started the myth of there being intelligent life on Mars. Percival Lowell who also witnessed these canals, took this idea and ran with it, popularising this myth further.

Some astronomers even managed to convince themselves that they could actually see towns and cities with all manner of boats and ships plying the many canals between them.

Science fiction writers, of the day, also found this idea of intelligent life existing on Mars, intriguing and started to write stories based on it, the most famous of which was “War of the Worlds” by HG Wells. This is where Earth was bombarded by a large number of what seemed to be meteorites. After crashing to Earth the local population discovered that they were in fact large metal cylinders the tops of which unscrewed to release huge machines that walked about on tripod like legs. They also had heat ray weapons, similar to our modern day lasers, which were capable of vaporising just about anything they were unleashed on. Of course you will be familiar with the ending, of how the Tripods were eventually defeated.

Astronomy

a) Creation – It is estimated that our Solar System was formed about 4.6 billion years ago following the collapse of a giant cloud of dust and gas through the force of gravity. Most of the collapsing mass collected in the centre to form the Sun, while the rest flattened into a disk out of which the planets, moons, asteroids and other bodies were formed.

b) Size, orbit and distance – Mars was one of these, forming from this accretion disc. Mars is the 4th planet from the sun with an elliptical orbit taking it, at its closest point, about 206.7 million kilometres from the Sun and 56 million kilometres from the Earth. It is approximately half the size of the Earth and has a gravity about one third that of Earths. Someone weighing 100 Kg on Earth would only weigh 38 Kg there.

Actual time-lapse images of Mars' motion

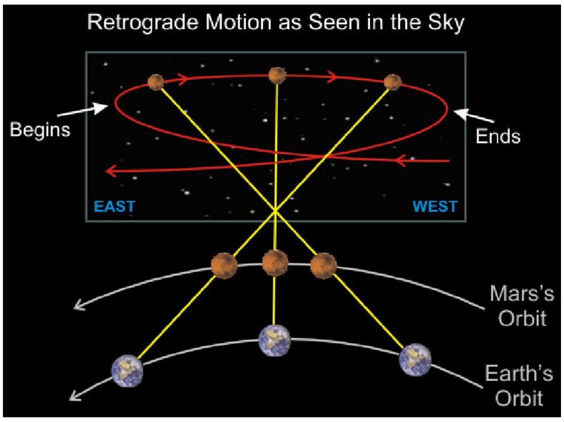
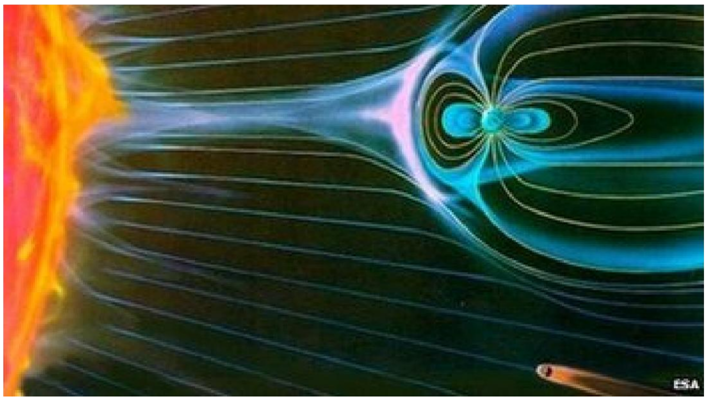


Diagram explains apparent retrograde motion

c) Magnetic fields and loss of atmosphere – Mars has no appreciable magnetosphere unlike the Earth. This is one of the factors which is thought to have contributed to the lack of an extensive atmosphere. A strong magnetosphere would protect the planet from the prevailing solar winds. It is believed that most of Mars's atmosphere was effectively "blown away" by the stream of ionized particles emanating from the surface of the Sun. Another factor would be the weakness of Mars's gravitational field, not being able to hold on to the upper layers of its atmosphere. Over time most if it would have drifted off into space.



Artist impression of effect of Solar Wind on Earth and Mars

Evidence of water – The surface of Mars seems to be mainly desert, covered by iron oxide powder, of red rust colour. Raised by wind, this powder also gives a rosy colouration to the Martian atmosphere.

A recent development in the analysis of Martian soil by the Curiosity rover, which landed on Mars in August 2012, is that there is a surprising amount of water bound up in it. The red dust covering in fact holds about 2% by weight of water. This could prove a very useful resource for future astronauts.

Curiosity researcher Dr Laurie Leshin explained that "If you think about a cubic foot of this dirt and you just heat it a little bit - a few hundred degrees - you'll actually get off about two pints of water - like two water bottles you'd take to the gym,"

d) Martian meteorites – Recent analysis of a meteorite fragment found in the Antarctic has produced evidence that it is unlikely that geological reasons could be used to explain some of the physical and chemical structures found within this fragment. Leaving Life as being a strong contender in explaining these anomalies.

The Search for Life

a) Are we Alone – One of the most intriguing un-answered questions today is “are we alone”? Most people who have given this question any thought may have come to the conclusion, because of the size of the Universe filled with trillions upon trillions of stars, surely life must exist elsewhere, even if not in our own back yard. To help try and quantify this idea and give it a face, in 1961 Dr Frank Drake while working at the National Radio Astronomy Observatory in Green Bank West Virginia came up with a formula that attempts to answer this question. It tries to estimate the number of technological civilizations that may exist in our galaxy. It is called the Drake Equation and it looks something like this

$$N=R^* \times f_p \times n_e \times f_l \times f_i \times L$$

Where,

N = The number of civilizations in The Milky Way Galaxy whose electromagnetic emissions are detectable.

R* =The rate of formation of stars suitable for the development of intelligent life.

fp = The fraction of those stars with planetary systems.

ne = The number of planets, per solar system, with an environment suitable for life.

fl = The fraction of suitable planets on which life actually appears.

fi = The fraction of life bearing planets on which intelligent life emerges.

fc = The fraction of civilizations that develop a technology that releases detectable signs of their existence into space.

L = The length of time such civilizations release detectable signals into space.

The Drake Equation does not attempt to come up with a definitive answer to the “Our we alone” question, mainly due to the number of parameters it overlooks and the fact that we have no idea what some of these parameters actually are and what numbers to allocate to them. It is nothing more than a “Best Guess” and provides scientists with a starting point for their research.

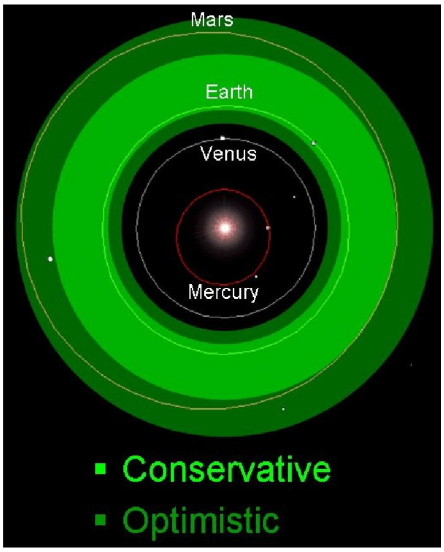
SETI or Search for Extra-Terrestrial Intelligence are an organisation who have also been trying to get a handle on “Our we Alone”?

The SETI Institute was founded in November 20th 1984 with the aim of exploring, understanding and explaining the origin, nature and prevalence of life in the universe, and has been searching the heavens all this time, so far without success, however the universe is a big place and up to now they may have not been looking at the right place.

One other bit of interesting research should be mentioned here before going on to other topics and that is the work carried out by Professor Chandra Wickramasinghe to identify molecular evidence of life precursors floating in interstellar dust and gas clouds. In 1974 he first proposed the theory that dust in interstellar space and in comets was largely organic, a theory that has now been shown to be correct. Interestingly some of the members of The Adstock Science Club went to listen to one of his lectures which was at Buckingham University and proved to be very interesting.

This of course infers that the possibility exists that life on Earth may have actually been seeded by the Earth passing through one of these organic rich clouds. Various amino acids have in fact been found within these clouds including some of those used in the formation of our very own DNA molecule.

b) The Goldilocks zone – Not too hot, not too cold but just right, well that's how Goldilocks described the porridge that was left out for the 3 bears in the children's story and this is exactly the way that we look at where our planet sits in the scheme of things within our Solar System. The Earth inhabits a zone between the orbits of Venus and Mars where temperatures are just right for water, the basis for all known life, to exist in all three states ice, liquid and gas.



Venus is at the hot end of this spectrum and would possibly be able to sustain life If it wasn't cloaked in a pretty dense blanket of poisonous "Greenhouse" gasses which have the effect of retaining a large amount of the heat that it receives from the sun, thus causing the surface temperature of Venus to be much too high to sustain liquid water let alone life.

Mars on the other hand is at the opposite end of the scale being very cold with not enough atmosphere to help retain heat from the sun even though this is composed mainly of the greenhouse gas carbon dioxide. Temperatures can get as low as – 140 ^{o}C but can also be as high as 20 ^{o}C during a summers day in equatorial regions. Water in the form of ice covers the Martian poles (see piture) during its winter periods, however most of what can be seen is actually frozen CO^2 which freezes at -78 ^{o}C and lays above the ice to the depth of several metres. Features similar to valleys, tributaries, and even seas similar to those found here on Earth also exist and indicate that once upon a time there must have been large amounts of liquid water sloshing around Martian shores.

Now if liquid water did, sometime in the past, exist on Mars then it's not a long stretch of the imagination to wonder if life also existed or even still exists there. The search for signs of the existence of life is one of the main objectives of the latest Martian rover, Curiosity.

c) Missions to Mars – The first spacecraft ever to make a successful journey from Earth to Mars was NASA's Mariner 4, which was launched on November 28th, 1964 and arrived at Mars July 14, 1965, and managed to take a series of 21 grainy photographs of the surface. Marina 4's flight time was 228 days.

The following table lists all the successes, partial successes and failures over the last 53 years for missions sent to Mars by both Russia and the United States, Oh and also a failed joint UK/European lander, Beagle 2. Out of 49 missions, some of which were flybys, 2 were on their way somewhere else and used Mars as a convenient gravity boost to get them there. 27 were abject failures, 1 a partial failure, whatever that means and the remaining 19 experienced some semblance of success. The latest of which is the Curiosity Rover which as we speak is trundling around a small part of Mars vaporising bits of rock with its on-board high powered laser beam.

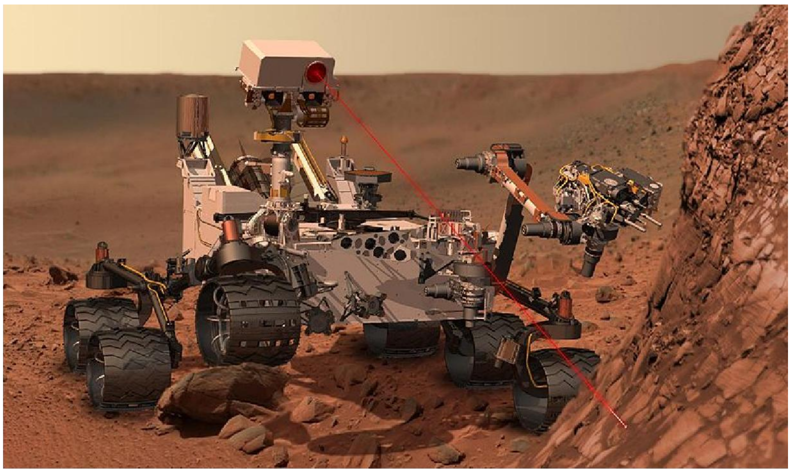
Spacecraft	Launch Date[1]	Mission[1]	Outcome[1]	Remarks	Carrier rocket[2]
1M No.1	10 October 1960	Flyby	Launch failure	Failed to orbit	Molniya
1M No.2	14 October 1960	Flyby	Launch failure	Failed to orbit	Molniya
2MV-4 No.1	24 October 1962	Flyby	Launch failure	Disintegrated in LEO	Molniya
Mars 1 (2MV-4 No.2)	1 November 1962	Flyby	Spacecraft failure	Communications lost before flyby	Molniya
2MV-3 No.1	4 November 1962	Lander	Launch failure	Never left LEO	Molniya
Mariner 3	5 November 1964	Flyby	Launch failure	Payload fairing failed to separate	Atlas LV-3 Agena-D
Mariner 4	5 November 1964	Flyby	Successful	Closest approach at 01:00:57 UTC on 15 July 1965	Atlas LV-3 Agena-D
Zond 2 (3MV-4A No.2)	30 November 1964	Flyby	Spacecraft failure	Communications lost before flyby	Molniya
Mariner 6	25 February 1969	Flyby	Successful		Atlas SLV-3C Centaur-D
2M No.521	27 March 1969	Orbiter	Launch failure	Failed to orbit	Proton-K/D
Mariner 7	27 March 1969	Flyby	Successful		Atlas SLV-3C Centaur-D
2M No.522	2 April 1969	Orbiter	Launch failure	Failed to orbit	Proton-K/D

Spacecraft	Launch Date[1]	Mission[1]	Outcome[1]	Remarks	Carrier rocket[2]
Mariner 8	9 May 1971	Orbiter	Launch failure	Failed to orbit	Atlas SLV-3C Centaur-D
Kosmos 419 (3MS No.170)	10 May 1971	Orbiter	Launch failure	Never left LEO; upper stage burn timer set incorrectly	Proton-K/D
Mariner 9	30 May 1971	Orbiter	Successful[3]	Entered orbit on 14 November 1971, deactivated 516 days after entering orbit	Atlas SLV-3C Centaur-D
Mars 2 (4M No.171)	19 May 1971	Orbiter	Mostly successful	Entered orbit 27 November 1971, operated for 362 orbits. Mapping operations unsuccessful due to dust storms on the surface[citation needed]	Proton-K/D
Mars 2 lander (SA 4M No.171)	19 May 1971	Lander	Spacecraft failure	Deployed from Mars 2, failed to land during attempt on 27 November 1971	Proton-K/D
Mars 3 (4M No.172)	28 May 1971	Orbiter	Mostly successful	Entered orbit 2 December 1971, operated for 20 orbits.[citation needed] Mapping operations unsuccessful due to dust storms on the surface[citation needed]	Proton-K/D
Mars 3 lander (SA 4M No.172)	28 May 1971	Lander	Spacecraft failure	Deployed from Mars 3; landed at 13:52 UTC on 2 December 1971 but contact lost 14.5 seconds later	Proton-K/D
Mars 4 (3MS No.52S)	21 July 1973	Orbiter	Spacecraft failure	Failed to perform orbital insertion burn	Proton-K/D
Mars 5 (3MS No.53S)	25 July 1973	Orbiter	Spacecraft failure	Failed after nine days in orbit	Proton-K/D
Mars 6 (3MP No.50P)	5 August 1973	Lander Flyby	Spacecraft failure	Contact lost upon landing, atmospheric data mostly unreadable. Flyby bus collected data.[4]	Proton-K/D
Mars 7 (3MP No.51P)	9 August 1973	Lander Flyby	Spacecraft failure	Separated from coast stage prematurely, failed to enter Martian atmosphere	Proton-K/D
Viking 1 orbiter	20 August 1975	Orbiter	Successful	Operated for 1385 orbits	Titan IIIE Centaur-D1T

Spacecraft	Launch Date[1]	Mission[1]	Outcome[1]	Remarks	Carrier rocket[2]
Viking 1 lander	20 August 1975	Lander	Successful	Deployed from Viking 1 orbiter, operated for 2245 sols	Titan IIIE Centaur-D1T
Viking 2 orbiter	9 September 1975	Orbiter	Successful	Operated for 700 orbits	Titan IIIE Centaur-D1T
Viking 2 lander	9 September 1975	Lander	Successful	Deployed from Viking 1 orbiter, operated for 1281 sols	Titan IIIE Centaur-D1T
Fobos 1 (1F No.101)	7 July 1988	Orbiter Phobos lander	Spacecraft failure	Communications lost before reaching Mars; failed to enter orbit	Proton-K/D-2
Fobos 2 (1F No.102)	7 July 1988	Orbiter Phobos lander	Partial failure	Orbital observations successful, communications lost before landing	Proton-K/D-2
Mars Observer	25 September 1992	Orbiter	Spacecraft failure	Lost communications before orbital insertion	Commercial Titan III
Mars Global Surveyor	7 November 1996	Orbiter	Successful	Operated for seven years	Delta II 7925
Mars 96 (M1 No.520)	16 November 1996	Orbiter Penetrators	Launch failure	Never left LEO	Proton-K/D-2
Mars Pathfinder	4 December 1996	Lander/Rover	Successful	Operated for 84 days	Delta II 7925
Nozomi (PLANET-B)	3 July 1998	Orbiter	Spacecraft failure	Ran out of fuel before reaching Mars	M-V
Mars Climate Orbiter	11 December 1998	Orbiter	Spacecraft failure	Burned up in the atmosphere	Delta II 7425
Mars Polar Lander	3 January 1999	Lander	Spacecraft failure	Failed to land	Delta II 7425
Deep Space 2	3 January 1999	Penetrators	Spacecraft failure	Deployed from MPL, no data returned	Delta II 7425

Spacecraft	Launch Date[1]	Mission[1]	Outcome[1]	Remarks	Carrier rocket[2]
Mars Odyssey	7 April 2001	Orbiter	Operational		Delta II 7925
Mars Express	2 June 2003	Orbiter	Operational		Soyuz-FG/Fregat
Beagle 2	2 June 2003	Lander	Spacecraft failure	Deployed from Mars Express	Soyuz-FG/Fregat
Spirit (MER-A)	10 June 2003	Rover	Successful		Delta II 7925
Opportunity (MER-B)	8 July 2003	Rover	Operational		Delta II 7925H
Rosetta	2 March 2004	Gravity assist	N/A	Flyby in February 2007 en route to 67P/Churyumov–Gerasimenko[5]	Ariane 5G+
MRO	12 August 2005	Orbiter	Operational		Atlas V 401
Phoenix	4 August 2007	Lander	Successful		Delta II 7925
Dawn	27 September 2007	Gravity assist	N/A	Flyby in February 2009 en route to 4 Vesta and Ceres	Delta II 7925H
Fobos-Grunt	8 November 2011	Orbiter Phobos sample	Spacecraft failure	Never left LEO (intended to depart under own power)	Zenit-2M
Yinghuo-1	8 November 2011	Orbiter	Lost with mothership	To have been deployed by Fobos-Grunt	Zenit-2M
Curiosity (Mars Science Laboratory)	26 November 2011	Rover	Operational		Atlas V 541

d) Curiosity Rover – They say that curiosity killed the cat, but so far the Curiosity Rover which was launched atop an Atlas V rocket in 2011 has managed to evade this fate, unlike a number of its predecessors. The only problem to date is mostly to do with US Government agencies such as NASA having to shut down due to the current shenanigans going on in Congress, though the Rover team are managing to pull together enough people to see it through.

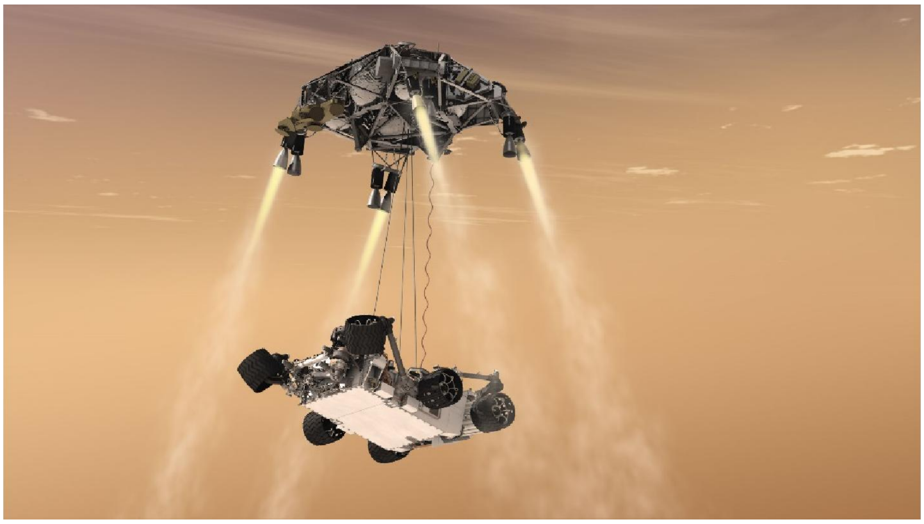


Its Mission is to search areas of Mars for past or present conditions favourable for life, and conditions capable of preserving a record of life. Its destination was Gale Crater which is 96 miles wide with a giant 3 mile high mound in the middle. To be on the safe side Curiosity landed on flat terrain next to Mount Sharp which is where it headed for, once it had landed.

The 3 mile high mountain has multiple rock layers. Each rock layer will reveal a different time in Mars' history. Curiosity will be hunting for layers that show a time when Mars could have been more friendly to life.

Here are some quick facts about the Curiosity Rover -

Mission Name:	Mars Science Laboratory
Launch:	26th November, 2011 from Cape Canaveral, Florida
Arrival:	5th August 2012 at 10:30pm PDT/6th August 2012 at 1:31 am. EDT
Rover Name:	Curiosity
Size:	About the size of a small car – 10 feet long, 9 feet wide by 7 feet tall
Weight:	900 Kg
Electrical Power:	Radioisotope Power System – a Multi-Mission Radioisotope Thermoelectric Generator (MMRTG)
Instruments:	10
Tools:	17 cameras, a laser to zap rocks, and a drill to collect samples



There were many challenges to getting Curiosity onto the surface of Mars, not least of which was landing the rover safely and intact. Because the rover was much heavier than previous Mars landers a different and more innovative approach had to be found. This was accomplished by firstly using atmospheric friction to slow down the spacecraft from 13,000 mph to 900 mph. Then a supersonic parachute slows the spacecraft down to 180 mph. While slowing down using the parachute the heat shield was jettisoned. Now the engines on the descent stage were made to fire and bring the rover down to within 25 feet of the surface. Radar was used to measure its speed and height so it could land safely. This is where the innovation came in, in the form of the “Sky Crane”, a rocket propelled platform from which the Curiosity rover was attached. Curiosity was lowered from this platform to the surface on three nylon ropes and an umbilical cord. Once the “Sky Crane” sensed that Curiosity had touched down, the cables were cut allowing the “Sky Crane” to fly off to a safe distance from the rover before crash landing.

Curiosity has a number of instruments on-board which are used to find out more about its surroundings. The general analysis strategy begins with high resolution cameras looking for features of interest. If any is found *Curiosity* can vaporize a small portion of it with an infrared laser and examine the resulting spectral signature to determine the rock's composition. If that signature is of greater interest, the rover will use its long arm to swing over a microscope and an X-ray spectrometer to take a closer look. If the specimen warrants an in-depth analysis, Curiosity can drill into the boulder and deliver a powdered sample to either the SAM (Sample Analysis of Mars) or the CheMin (Chemistry and Mineralogy) analytical laboratories.

Why Mars?

Why Mars indeed. My take on this is similar to Professor Steven Hawkins and that is if the human race wants to survive in the long term we need to expand our living space into space. Since 1969 when man first landed on the Moon we have learnt a lot more about our planet as well as the others orbiting our Sun.

We have also developed technology in leaps and bounds, it was only in 1980/1 that IBM started to sell its Personal Computer to the likes of you and me. Mobile phones appeared a short time later and in the early 90s the Internet and then the World Wide Web became accessible by everyday people. Technology has also advanced in other fields such as medicine, transport, aviation, navigation, science in all its forms. These and more have all seen some pretty amazing advances in our lifetime.

That said, we still inhabit the same planet and still seem to have some of the same sort of problems we have always had, hunger, war, epidemics, economic and financial melt downs. Not only that but we have a number of new and potentially worse problems rapidly gaining prominence, Fuel and energy shortages, food production and the relentless increase in human population, nuclear and biological weapons proliferation, potential GM disasters, rogue asteroids, serious Sun spots and other naturel disasters are all just waiting to happen. The trouble is, we don't have a clue when any of these may actually happen and God help us if they all happen at the same time.

So, why Mars? Mars is our only planetary neighbour within achievable commuting distance from the Earth that we stand a chance of using as a second home. Yes, I know, that the atmosphere is almost non existent and any way it's mainly $C0^2$. The temperature is not exactly balmy but we could survive in it. Up to recently there didn't seem to be much water about either, but now we know that all we have to do is heat up some Martian dirt and we can have all the water we want. The gravity is a bit weak, but we could manage. However this could pose serious problems to anyone who gets home sick and wants try and return to the Earth etc. etc. But with a bit of considered thought, some serious but not necessarily Sci-fi technology and some good old human drive and guts, Mars could be ours.

All we need is Vision, determination and Money, Oh, and a few brave, some would say foolish, people willing to risk all to be the first to explore this new land. The trip there can take anywhere between 150 to 300 days depending on the speed of the launch, the alignment of Earth and Mars, and the length of the journey the spacecraft takes to reach its target. It really just depends on how much fuel you're willing to burn to get there.

What are the challenges –

So far we have only sent unmanned vehicles and robotic landers to Mars. There were obviously many challenges which needed to be overcome and judging by the number of failures they were not that easy, especially in the early days.

By intending to send people to Mars a whole new set of challenges awaits us. So, I will now try and outline some of the challenges that awaits prospective explorers to Mars.

a) Time – Since the beginning of the "Space Race" men and women have been spending more and more time floating around in space. Though I'm sure this can be quite fun and we have all seen videos of astronauts twirling bananas, droplets of water, doing somersaults and generally having a good time while cooped up in something not much bigger than transit van, but returning to Earth is much less so. You see one of the main problems that a lack of gravity has on us is that we start losing bone mass as well as muscle tone almost immediately. The first astronauts that returned from space after spending a few weeks in orbit needed to be physically manhandled out of their capsule as they were too weak to move about by themselves.

Some of these problems have been tackled by making the astronauts undergo extensive physical exercise while in orbit using all manner of contraptions to hold them down while undertaking their task.

No one really knows exactly what effect a long trip to and from Mars, not to mention the stay there in one third Earth's gravity, would do to their bodies, their immune system, and their mental abilities not to mention their state of mind. Being cooped up for months on end with the same people could lead to all sorts of problems and conflicts. Plenty of research has and is being done to try and come up with answers to these issues with varying degrees of success and some not so successful.

b) Gravity – apart from not having any gravity while in-transit to Mars, once the astronauts or should I say explorers arrive they will have to contend with one third Earths standard gravity for the duration of their stay. Exactly what sort of problems they will have while on Mars because of this, I'm not sure.

c) Cosmic Rays – all the time the astronauts are on route to Mars and even when they have landed they will be bombarded by cosmic rays. These are very high energy subatomic particles which are thought to be produced by very large stars going supernova. However this is not thought to be their only source. Active galactic nuclei probably also produce cosmic rays.

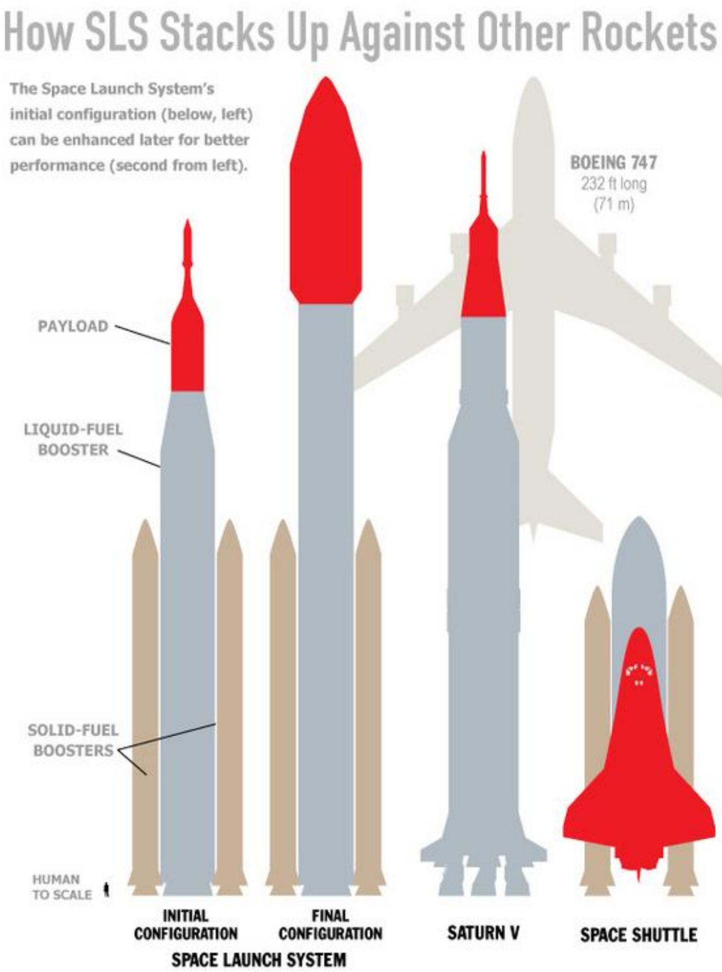
   Along with this radiation emitted by the Sun within the solar wind also poses a threat but not only to the astronauts but also to their hardware. As you may already know, so called sun spots and solar mass ejections can cause havoc here on Earth, and we're protected from most of this by the Earth's magnetic field. The astronauts will not. Other ways need to be found to provide an adequate level of protection for them.

   Some astronauts before and during the Apollo missions noticed that they could see flashes of light even when they had their eyes closed. We now know that this was caused by high energy particles impacting with the light sensitive cells in the astronaut's retina at the back of the eye. It is known that long exposure to cosmic rays damages DNA and could cause many health problems including causing cancer.

d) Psychology – I mentioned this earlier on. Just imagine being cooped up in a transit van for up to 2 years with 3 or 4 people you really get on well with. How long do you think it will take before you may not be seeing exactly eye to eye with them? Potential astronauts/explorers will need to be very closely psychologically vetted.

   When the project Biosphere 2 was conceived and established in 1991 in the Arizona desert the aim was to investigate our ability to survive in a completely enclosed artificial environment. It was thought that they had everything they need to survive with water and air being recycled, food was to be provided through the judicious management of selected plants and animals and all would be happiness and light. Problems started appearing in this closed eco-system with food being set aside for feeding chickens running out. Because of this and other problems the Biospherians started to fall out. According to a talk given later by one ot the initial participants, Jayne Poynter, "*the crew split into two factions about 6 months into the mission and from that point on, the two groups worked together, but could not get along. Their differences curtailed creativity and caused communication problems*."

e) Hardware – It goes without saying that to get to Mars the astronauts are going to need a rocket and capsules and other stuff, hardware, to get them there and once there they are going to need more stuff to keep them alive. In the case of rockets, NASA is in the process of designing the Space Launch System or SLS. At 321 feet tall, in its initial configuration, it is just 42 feet shorter than the Saturn 5 rocket, that put Neil Armstrong on the Moon.



	Initial configuration (Space Launch System)	Final configuration (Space Launch System)	Saturn V	Space Shuttle
Country	United States	United States	United States	United States
Years of operation	first launch planned for 2017	to be determined	1967-1973	1981-2011
Destinations	Earth orbit, deep space	Earth orbit, deep space, asteroids, moon, Mars	Earth orbit, moon	Earth orbit
Fuel type	solid fuel, LH2/LOX	solid fuel, LH2/LOX	kerosine, LH2/LOX	solid fuel, LH2/LOX
Height	320 ft (97.5 m)	400 ft (122 m)	363 ft (110 m)	184 ft (56.1 m)
Lift capability	70-77 metric tons	up to 130 metric tons	130 metric tons	24.4 metric tons
Thrust	8.4 million lbs (3.8 million kg)	9.2 million lbs (4.2 million kg)	7.5 million lbs (3.4 million kg)	7.8 million lbs (3.54 million kg)

LH2 = liquid hydrogen fuel
LOX = liquid oxygen oxidizer
Solid fuel = aluminum perchlorate composite mixture

SOURCES: NASA, LOCKHEED MARTIN

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Engineers wrapped up the preliminary design review for NASA's SLS rocket on 31st July 2013, giving the heavy lifter's design, production and ground support plans a stamp of approval. The review marked the final step in the rocket's initial design and development phase. The next big hurdle to clear is called Key Decision Point-C, which will see the SLS program move from concept formulation to implementation.

The first incarnation of SLS will stand 321 feet (98 meters) tall and carry up to 70 metric tons of payload. But NASA plans to develop a modified SLS that would be the most powerful rocket ever built. This "evolved" version would be capable of blasting 130 metric tons into space, officials say.

The SLS is being developed to meet NASA's ambitious goals in deep space. In 2010, President Barack Obama directed the agency to get astronauts to a near-Earth asteroid by 2025, then on to the vicinity of Mars by the mid-2030s. No human has traveled beyond low-Earth orbit since Apollo 17, the final mission in NASA's famed moon program, returned home in December 1972.

NASA are not the only ones who intend to fly astronauts to Mars a Dutch engineer, Bas Lansdorp, of the Mars One organisation, also plans to get there and by 2023 to have set up a human base on Mars. In fact more than 200,000 people have already applied for a one way ticket to Mars.

On a visit to the BBC's London office, Mars One's co-founder Bas Lansdorp explains why this would be a one-way flight. As mentioned before, during the seven-to-eight month journey, astronauts will lose bone and muscle mass. After spending time on Mars' much weaker gravitational field, it would be almost impossible to re-adjust back to Earth's much stronger gravity.

Successful applicants will be trained physically and psychologically. The team will use existing technology for all aspects of the project. Energy will be generated from solar panels, water will be recycled and extracted from soil and the astronauts will grow their own food - they will also have an emergency ration and regular top-ups as new explorers join every two years. But what happens when the hardware starts to fall to bits and spare parts become scarce, and your next relief shipment isn't due for 6 months?

f) Air, Food and Water – With the latest news coming from the Curiosity Rover that water can be extracted from the Martian soil by heating it to a couple of hundred degrees and since water can then be split using electrolysis into its basic constituents, Hydrogen and Oxygen, then producing breathable air should not be beyond our ability.

   So, that leaves food! Well, going by the experiences of those in the Biosphere 2 project this may prove more of an issue.

g) Bugs – I know we haven't found any creepy crawlies yet on Mars or for that matter anything smaller, though there are some slender hopeful signs, but once people start to live, eat and breath there, they are going to get more exposure to the Mars ecosystem. Now it maybe that there are no bugs, and here I mean bacteria, immediately obvious to the new inhabitants, but over time whilst drilling for minerals or whatever, building dwellings or just generally walking about who's to say that something nasty won't be uncovered. Alternatively some may say what right have we to infect Mars with our germs. If there is any life present then we could do to it what the Spanish did to the Aztecs, infect them with their diseases, which eventually wiped them out.

h) Survival – "The Martian surface is extremely hostile to life", says Dr Veronica Bray, from the University of Arizona's Lunar and Planetary Laboratory. "There's no liquid water, the atmospheric pressure is practically a vacuum. The radiation levels are higher and temperatures vary wildly," she says.

   "Radiation exposure is a concern, especially during the trip. This can lead to increased cancer risk, a lowered immune system and possibly infertility."

   To minimise radiation, the project team will need to cover living quarters with several metres of soil, which will have to be dug up by the colonists.

   Nasa astronaut Stan Love knows first-hand the difficulties with technology that his colleagues have experienced on the International Space Station in low-Earth orbit. The apparatus which recycles human waste and turns "yesterday's coffee into tomorrow's coffee needs frequent maintenance and would likely not survive years of continuous duty on Mars", he says.

   Love has recently returned from Antarctica which he says is a "picnic compared to Mars". "It's full of water, you can go outside and breathe the air. Its paradise compared to Mars and yet nobody has moved there permanently."

i) Making Babies – You know, I haven't heard much about this aspect so far in all my research for this article, maybe I'm not looking in the right place, but this is one facet that must be considered as extremely important.

   Apart from the physical dynamics of this, which may be more fun in the weightlessness of space, and the lack of privacy. Babies born on Mars would probably never be able to travel to their parent's home world. Firstly their bone structure would most likely be considerably less dense than Earth born infants. Other physiological factors may also be completely different from "normal" children's. In fact we just don't know what the offspring of the first colonists will be like and even if having healthy children will be possible.

j) Raw Materials – In the first instance colonists will need to take everything they need to survive with them. This of course means that every extra pound of stuff they take will require a comparative increase in the amount of fuel needed to get them to Mars. Trade-offs will have to be made, due you really need 20,000 toilet roles or would you rather have more food. I'm not sure how they are going to work this out, but someone is going to have to do it.

Once they have managed to survive the landing and had time to organise themselves their main concerns will be to set up habitable structures. These would probably be the cannibalised carcasses of their landing vehicles, or maybe they had enough fuel to bring specialised designed "tents", something like a blow up bouncy castle, but a bit more high tech. To protect these structures from impact by meteorites and also offer protection from the cold and cosmic rays they will probably have to cover them with copious amounts of Martian soil.

Setting up systems to extract water from the surrounding soil and water reclamation system would be essential for long term life. Not only would this provide colonists with drinking water but this could also be utilised to generate oxygen for the habitats and space suits.

Initially they will be using food and waste recycling systems to keep their larders stocked, but for long term survival they will need to build some kind of "green house" where plants could be grown. Maybe they would use hydroponics for this purpose instead or in conjunction.

Anyway, whatever their priorities the colonists are going to require a lot of raw materials to sustain a viable colony for any length of time, and as I mentioned earlier Earth may have to send, at least initially, regular supplies to replenish their stores. However for this project to work the colonists are going to have to learn how to extract what they need to survive from Mars itself and become mainly self-sufficient.

k) Terraforming – This leads to the possibility of over a long period of time attempting to terraform Mars into something a little bit more like Earth. No one has actually done this before so this will be a completely new experience for the colonists. There are no tried and tested handbooks on the subject, plenty of theories but as we saw earlier from the experience that the Biospherians encountered, even while trying to live and grow plants and animals on Earth, problems abounded and eventually caused failures in many of their systems. Also no one really knows just how long it would take to produce any appreciable change in the Martian environment which would be of benefit to the colonists. They have their work cut out.

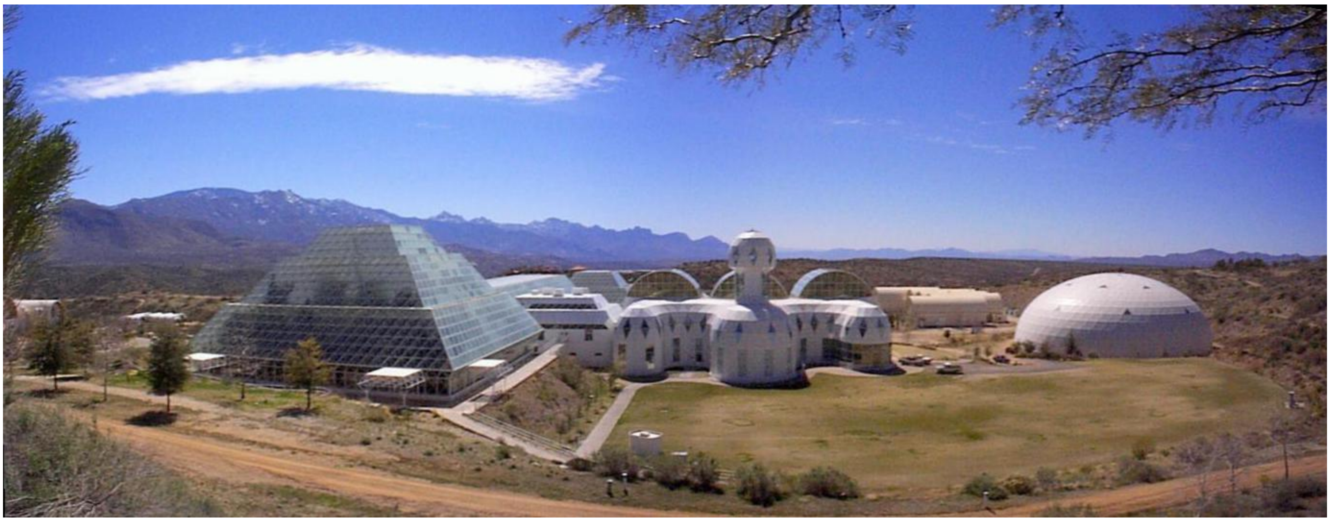
l) Returning Home – Apart from the problem of the human body acclimatising to the low gravity conditions on Mars which will make any return by the colonists back to Earth extremely dangerous, there is the little issue of what do they use as rocket fuel for the journey home.

It would be impractical to carry all the fuel they would require with them, on the outbound trip for the ascent from Mars' surface and the trip back, though not impossible. I'm not sure even the proposed Space Launch System rocket will have enough power to accomplish this but even if you manage to get all this fuel aloft and to Mars you will have to make sure that you can get it safely to the surface for it to be of any use. OK, so Mars' gravity is only one third that of the earths but we are still talking about a lot of fuel. I see the problem similar to that of normal passenger planes, taking off with a full tank of gas is one thing but trying to land with one has its own particular set of problems.

Maybe alongside regular food dumps Earth could also send the colonists stocks of rocket fuel for the time when they get homesick.

The Future –

Well, what about the future? Say in the next 10 years we get to Mars and manage to build a viable and growing colony, do we stop there. My guess is that unless some amazing new technology comes along, the fabled Warp Drive of Star Trek fame for instance, then we will probably flit around our local Solar System for a few centuries, exploring, mining, colonising etc. etc. We are reasonably secure within the Solar System for at least the next 5 billion years before our Sun starts to expand and devour us. But it would be wise not to keep all of our eggs in one basket.



Biosphere 2 as it was in 1998