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CONCEPTS FOR FUTURE ROBOTIC MARS MANNED MISSIONS

Jayakumar Venkatesan,
Technical Lead/ Space Mission and Systems
Vimana Notion Design Team
Former PG Scholar, Dept of Aerospace Engg,
Anna University, Chennai- 600 044,India
jkaeronautics@gmail.com

Dr. K.M. Parammasivam,
Director,
Centre for Aerospace Research,
Anna University, Chromepet,
Chennai - 600 044,India
mparams@annauniv.edu

Sandhya Rao,
Design Architect, Space Robotics System Integration Lead,
Vimana Notion Design Team,
1025 Sec A Vasant Kunj,
New Delhi-110070,India
sandhyrao@gmail.com

The technological improvements of new technologies for robotics and automation are required for the successful robotic exploration of Mars on the Martian surface to know the information in the disciplines of Martian geology, geochemistry, atmospheric sciences, climatology and exobiology,etc., In order to preserve crew members safety and time for those tasks that uniquely require people, many routine tasks associated with a human mission to Mars might be performed by robotic machines. Because of the greater risks for a man travel a distance on Martian surface and the associated communications difficulties, most are remote control of robotic activities on Mars may be supervised by the crew members. The development of new generations of computer and machine capabilities incorporating network in between the mars settlement camps, expert systems, and the ability to analysis the Martian surface and atmosphere of the planet and also building of Martian International Space Station . This paper is presents a overview of the role of space robots controlled by mechatronic control systems which we foresee as part of the technology development for Mars exploration.

The global space agencies are began the Martian Race to explore the Red planet and searching for the human habitability in other planets. The journey to the Red planet Mars is series of steps to be carried out for an intensified international space robotic exploration of Mars, leading to settlement of humans on Mars planet and also thinking of permanent settlement of life cycle. The advancement of technologies can be helpful for discoveries on mars explorations programs for better understanding of the planet and habitability for living beings. We are in the position is that an international program for expanding robotic and human space exploration of Mars can provide a vision of new beginnings with fresh perspectives. We need to built Robotic spacecraft generally have acquired data according to the pre-programmed expectations of their creators. This limitation will change with future automated spacecraft, but currently only a human space explorer can acquire knowledge through creative, real-time organization of information, while also learning to live and work in space. Human exploration of Mars offers a wide area of scientific exploration opportunities, but the potential cost of human Mars exploration demands more than just science return. We are confident that we can extend our capabilities to human interplanetary journeys. Such voyages of discovery can be undertaken before we fully understand the long-term response of a human being to the environment present in the crew quarters of the space habitat, but at some risk to the crew. We shall gain a significant amount of data regarding human adaptation to microgravity and isolation on long space missions such as a human mission to Mars. We shall also learn to design and build-in true long-term reliability of our mechanical and electronic systems.

Martian geology and atmosphere

The atmosphere is thin and consists mostly of carbon dioxide. The pressure at the surface is about 1/100 that at the Earth's surface, and it changes with the Martian season as part of the carbon dioxide in the atmosphere freezes out on the pole to form a polar ice cap during winter. At the equator, surface temperatures range from about -90°C at night to +20°C at noon, overlapping temperature conditions found on Earth. On the carbon dioxide polar caps, temperatures can drop to -120°C. It is of great scientific importance to explore, document, and analyze the processes that have turned Mars into a barren, inhospitable domain.

The current Martian climate is regulated by seasonal changes of the carbon dioxide ice caps, the movement of large amounts of dust by the atmosphere and the exchange of water vapor between the surface and the atmosphere. One of the most dynamic weather patterns on Mars is the generation of dust storms that generally occur in the southern spring and summer. These storms can grow to encompass the whole planet. Understanding how these storms develop and grow is one goal of future climatic studies.

A better understanding of Mars' current climate will help scientists more effectively model its past climatic behavior. To do that, we'll need detailed weather maps of the planet and information about how much dust and water vapor are in the atmosphere. Monitoring the planet for this information over one full Martian year (687 Earth days) will help us understand how Mars behaves over its seasonal cycle and guide us toward understanding how the planet changes over millions of years.

As part of the Mars Exploration Program, we want to understand how the relative roles of wind, water, volcanism, tectonics, cratering and other processes have acted to form and modify the Martian surface. The robotic probes can help us to better understanding the mars planet as well as the onsite monitoring of martian climate on the surface. The Mars atmosphere, although much thinner than the Earth's, is a natural planetary laboratory in which to test models of atmospheric processes that are applicable to Earth. Mars is of great interest because it exhibits evidence of past surface water and this hints at Mars having had different atmospheric conditions in the past than today. We have much speculation, but little hard evidence, pertaining to questions such as the relative roles of water erosion, mass wasting (landslides), wind erosion and wind deposition

Some space scientists believe that all Mars resource expenditures should be confined to robotic exploration of Mars, at least through the first half of the 21st Century, and that to implement a human expedition to Mars would be too costly. They believe that a human expedition would severely drain funds and "starve" research efforts in robotic space exploration, aeronautics, basic science research, and industrial research. Others feel that space exploration for science alone is too narrow a goal.

Robotic Technologies for mars exploration

Although we have considered general robotic spacecraft issues here which are of critical importance to the space roboticist, space robotics as a discipline is focussed on more specific issues and reflects more closely the subject-area covered by terrestrial robotics. Indeed, space robotics, like its terrestrial counterpart, is generally divided into two subject-areas (though there is significant overlap):1. robotic manipulators – such devices are proposed for deployment in space or on planetary surfaces to emulate human manipulation capabilities; they may be deployed on free-flyer spacecraft or on-orbit servicing of other spacecraft, within space vehicles for payload tending, or on planetary landers or rovers for the acquisition of samples; 2. robotic rovers – such devices are proposed for deployment on planetary surfaces to emulate human mobility capabilities; they are typically deployed on the surfaces of terrestrial planets, small bodies of the solar system, planetary atmospheres (aerobots), or for penetration of ice layers (cryobots) or liquid layers (hydrobots).

Space robots are need to operate in extreme environments. Generally this includes increased levels of ionizing radiation, requiring non-commercial electronics that have been specially designed and/or qualified for use in such environments. The thermal environment is also generally much different from terrestrial systems, requiring at a minimum systems that are cooled not by air or convection, but by conduction. Many space environments routinely get significantly hotter or colder than the design limits for normal commercial or military components. In such cases, the space robot designer faces a choice of whether to put those components into a special thermal enclosure to maintain a more moderate environment, or to attempt to qualify components outside their recommended operating conditions. Both approaches have been used with success, but at significant cost.

Robotics relies on a variety of fundamental domains and is thus to a large extent the science of integrating a broad spectrum of technologies. All technologies essential to robotics have aspects that are almost exclusively relevant in the context of robotics and aspects that are relevant not only to robotics, but also to other domains. Good examples of the first, robotics-driven group are “manipulation”, “navigation”, and “perception”. Batteries provide a good example of the second group where advances will benefit robotics, but where, for now, robotics will not be a driving force. Competitive advantages in high-technology areas are hard won. Europe must not only retain leadership where this has been achieved, but also take the lead in first-wave technologies. For Europe’s success it will be vital to capitalise on its existing strong academic base through well-managed technology transfer. However, Europe cannot afford to only concentrate on areas of strength, it will also need to foster technologies that could become critical barriers to market. In areas of relative weakness an informed decision has to be made whether a dependence on others is acceptable. To aid these choices, an estimate of the time when technologies will be found in products is given, European strengths are highlighted and the drivers of the technologies are identified. In the future robotic rovers will became as manned rovers for the transportation and also helpful for future settlement.

The activities carried out by this type of rover will be to conduct scientific investigations, collect and return samples to the habitats, and scout possible locations for human crews to investigate in more detail. Three of these rovers will be delivered as part of the first cargo mission and will be supervised from Earth during the time between landing and the arrival of the first crew. Determining sites for the crews to investigate and safe routes to the sites will be the primary activity before the first crew arrives and during those periods when no crew is at the surface base. When a crew is on the martian surface, these rovers will be available for tele-operation by the crews. Focused exploration, sample collection, and scientific measurements will be the main tasks for these rovers while under the control of the surface crew, who will be able to operate these rovers from the shirtsleeve environment of the surface habitat/laboratory. This range of mobility systems will allow exploration activities to be carried out continuously once the first cargo mission has delivered its payload to the Martian surface. The variety of range requirements and surface activities leads to a suite of mobility systems that have overlapping capabilities.

They believe that human progress overall would be stimulated and even scientific and basic research objectives would be attained faster if a mix of robotic and human space exploration is performed in parallel. Humanity reveres and supports science, but society also values exploratory journeys of the human spirit. The point of view of this Study Report is that an international program of automated Mars probes and precursors in parallel with human missions to Mars will best serve humanity. Future missions to planets such as Mars will require explorer/worker robots to perform tasks of increased complexity such as exploring, mining, conducting science experiments, constructing facilities, and preparing for human explorers. To meet the objectives of missions in the year 2014 to 2025 timeframe, planetary robots will need to work faster, travel larger distances, and perform highly complex tasks with a high degree of autonomy.

Life on Mars

The success of strategies for discovering evidence for life on Mars depends significantly on our ability to control the contamination of Mars by terrestrial biological materials, which could confuse the interpretation of sample analyses. The fate of terrestrial organic material introduced into the Mars environment must be understood early in the exploration program. Mars is the only planet beyond the Earth-Moon system where permanent settlement seems remotely feasible. Early expeditions to the planet should, therefore, include among their goals an assessment of usable resources such as water, oxygen, building materials and thermal energy.

A Martian base may require growing food on Mars. Various means of growing food on Mars must therefore be assessed. It is not possible to foresee in advance exactly what the scientific return from Mars exploration will be. It is because we know so little about Mars that its scientific exploration is so interesting and challenging projects, such as a Mars exploration mission, the development of vehicles for technology development and demonstration. Robotic missions to Mars must develop greater autonomous capability. Human missions must perform well for time durations that are significantly longer and more demanding than any previous human space flights. Among the more important challenges that will drive technological advancement and that can produce benefits on Earth are: propulsion and power; human health and adaptation; life support system development, resource utilization, and ecological technologies; increased reliability and lifetime of hardware and systems; automation and robotics; and improvements in new sensors.

Mars Automated Missions And Precursors

The detailed information has already been obtained from the Mariner, Mars, Viking and Phobos spacecraft, but we need to findout the possible way to human settlement over mars. We need to make the comparative planetology and cosmology, and to allow the formulation of a detailed scientific basis for future human flights. Robotic missions should continue to improve our scientific understanding of Mars and to demonstrate new robotic technology. Scientific robotic missions should be continued even after human landing on Mars. However, robotics can also be used for testing and verification of the human spacecraft systems and other relevant hardware, for development of the strategy and scenario of the initial human mission phase, and for preliminary logistics of cargo delivery. From this point of view, they can be considered as precursors for future human flights to Mars.

The automated missions should collect the basic information in the disciplines of Martian geology, geochemistry, atmospheric sciences, climatology, and exobiology, etc., but also data on the performance of the engineering subsystems. The precursor missions can be the backbone of a Mars scientific program, and in their development of robotic technologies, can complement future human exploration. The automated missions can help in landing site selection and site preparation for human exploration and can be an important part of the human Mars mission development program. Their dual role is not only desirable, but essential to ensure that the effort and expense of getting to Mars yields valuable scientific results and reduces the risk and cost of human exploration. Robotic precursor missions can also establish the degree to which human presence is a requirement for a more efficient and elaborate study of Mars, and what role automation might be called upon to play in assisting human exploration.

Options for Human Expeditions to Mars

Once a crew-carrying Mars ship is in Earth orbit and ready to be launched towards Mars, the sequence is straightforward: interplanetary transfer to Mars, capture in Mars orbit; direct descent to the surface using a lander; surface mission operations; ascent to Mars orbit; possible rendezvous with an orbiting ship; interplanetary transfer back to Earth; capture in Earth orbit; and finally, Earth landing. An automated mission, if it returns a sample to Earth, generally follows the same sequence. If an automated Mars surface mission does not return to Earth, then the sequence ends with the Mars surface mission, just as it did for the Viking spacecraft.

While the basic mission sequence is simple enough, the complexity arises from the choice of mission profile and the choice of interplanetary propulsion system(s). There are two basic mission profiles - a slow, minimum energy transfer; and a much more costly (in terms of propellant required) high energy "fast" transfer, each of which again has several variations. The selection of a mission profile hinges on the selection of a propulsion system or systems. There are currently three propulsion options potentially available to the designer: chemical rockets, nuclear thermal rockets, and electric engines using nuclear or solar power. Of these, only chemical rockets have been safely demonstrated for human missions.

Aerobraking and aerocapture into planetary orbit, after an interplanetary trip, can be used with any of these options, adding further choices. Selection of technical alternatives for missions to Mars must respond to a set of constraints and objectives collectively called "mission drivers." Deciding on the mission and system design is a compromise among conflicting requirements and desires. Engineers must make trade-offs between competing performance requirements. Failure to carefully define priorities between these requirements only leads to potentially harmful compromises and needlessly drives up costs.

Mission objectives affect mission design and system selection through requirements such as crew size, scientific vs. operations cargo characteristics, stay time at Mars, surface site access, and the potential desire for building towards a continuous presence at Mars (e.g., a permanent Mars base). Analysis of skill mix needs indicates a minimum crew number of five to eight for a Mars mission. Greater demands for primary science skills as well as needs for international representation could lead to a larger rather than smaller number of crew. The size and cost of a mission are directly driven by crew size.

Mars Surface Systems and Operations

The role of the Mars Surface System is ultimately to provide (with a modest start) a complete spectrum of capability for realization of the international exploration community's goals for robotic and human exploration and possible future settlement of Mars. This robotics/human exploration capability may include pre-programmed and autonomous robotic systems, tele-operated rovers, stationary geophysical stations, initial Mars human expeditionary outposts, self-supporting human bases, and Marsbased space transportation systems. To plan the Mars Surface System, it is necessary to examine fundamental top level goals, to derive the next level of requirements, and then to conceptualize a set of temporal relationships, interactions, and phase transitions that best describe a strategic approach which ensures accomplishment of those goals. The operations are automated and semi automated systems. The machatronic control system(figure 6) are given in block diagram for Martian interplanetary space station.

Goals of Mars exploration require the Mars Surface System to support the collecting of scientific data that increases our understanding of Mars on a global scale and supports the development and verification of Mars as a future abode for humans. Upon examining those two primary goals, the subsidiary goals were categorized under "Exploration", and "Human Expansion". These categories require different implementation schemes. Exploration generally emphasizes "global" Mars coverage with temporary human presence at any single site, and Human Expansion emphasizes growth and evolution outward from a single site with permanent human presence.

A characteristic of the planetary Exploration goal is that it is ultimately desirable to visit a multiplicity of sites. This implies either the capability to travel great distances across the surface of Mars using a mobile "base" concept, or that many sites can be visited from an orbital base or through several separate expeditions to Mars. Elements that provide temporary support associated with limited means and short durations are most appropriate. On the other hand, the Human Expansion goal requires a different approach in that a human settlement begins with a unique landing site from which a surface base infrastructure may grow outward. Within the framework of the Human Expansion goal, it is expected that increasing capability may be provided by utilization of local resources that will enable much longer surface stays, support other goals, and open the way to long-range surface exploration capabilities.

The implementation and operations concepts must not preclude either approach, but rather must provide for the simultaneous implementation of both through the utilization and exploitation of common assets. Indeed, the Human Expansion implementation must evolve through a growth approach that utilizes the Exploration assets.

The following basic requirements for the Mars Surface System:

Mars Scientific Goals

• Understand the composition and internal structure of the planet Mars;
• Determine the geological evolution and ages of Martian surface features;
• Determine the composition and dynamics of the Martian atmosphere;
• Determine the origin and history of water on the surface of Mars;
• Determine the existence and evolution of life on Mars, extinct and extant.

Mars Habitation Goals

• Determine the practicality of permanent human settlements on Mars;
• Determine and evaluate methods to make the human settlements self-sufficient and less dependent on Earth resupply.

Human Factors and Physiological Aspects

An interplanetary space flight or inhabiting a foreign planet for long durations can subject the crew to debilitating, injurious and possibly fatal stresses. Some of these stresses are radiation, hypogravity, isolation/confinement, toxicity, and mission specific environmental conditions. To be sure that the mission has a high probability of succeeding, it will be necessary to expand human knowledge of these stresses and their human effects over time before undertaking such a flight. Much can be learned by inhabiting and working aboard the International Space Station (ISS).

The planning for the mission should also include consideration of crew selection and performance, habitability of the environments, sociological issues, life support, environmental health, and management of crises and illnesses. The accepted level of risk needs to be decided. We must realize that, inherently, risk cannot be totally eliminated and should not be denied; missions should be designed with prudent levels of risk (possibly a 3% risk of catastrophe). The best way to manage the levels of risk for a mission is to understand the environment and the conditions of that mission, including how a human will be affected and will perform in that environment, and the mitigating benefits of possible control measures.

Human factors and physiological problems will probably not delay the human exploration of Mars, provided the quest for problem solutions begins now. The selection of the crew will be based on physiological, psychological, sociological, and task considerations, and cross training for stable relationships. A significant amount of preliminary work still needs to be performed in the areas of radiation, hypogravity, and isolation/confinement to understand the effects of these stresses. The biological effects of the radiation anticipated en route, on Mars surface, and in case of an abort flight, should be precisely determined. The timing, shielding, and countermeasures should be such that the hazard is acceptable and the effects should be mitigated as much as reasonably possible. For long duration missions, a 1-g environment for the astronauts (preferably using a long tether and low rate of rotation) would eliminate the potentially mission-defeating effects of hypogravity. Sufficient knowledge of the effects of prolonged hypogravity and zero-g should be acquired and separately addressed to ensure crew survival in case of failure of the 1-g system and to deal with the reduced gravity on Mars. The psychological effects of isolation and confinement should be reduced by the careful selection and training of crew members. The environments provided should be carefully designed for habitability, and crew activities should be carefully planned and provisioned.

Little Prince (figure 6) is a robotic greenhouse concept that is specially designed to help the future exploration and expanding population in the Mars. This intelligent robot can carry and take well care of a plant inside its glass container, which is functionally mounted on its four-legged pod

Martian Interplanetary Space Station

Martian interplanetary space station (Figure 1) would be launched to Mars together with a fleet of robotic spacecraft designed to study the planet both from its orbit and on its surface, while humans will not land on the red planet. The station would reach the Mars orbit from where its crew will research Mars by operating the space robots; for this reason the mission is called ‘hybrid mission’. Since the robots will be controlled by Martian interplanetary space station crewmembers from Martian orbit it will eliminate one of the basic problems of robotic Mars missions, the 14 minutes delay for radio signals to reach the Earth. Samples of Martian soil will then be delivered by these robots to Martian interplanetary space station and later brought back to Earth. The whole duration of the flight is set for 2.5 years with one month of work in Mars orbit. The mission would also prove that people can survive a lengthy trip through deep space and effectively perform their professional responsibilities, including operating the spacecraft and conducting research activities.

The space station modules is assemble them in orbit as an autonomous complex and launch it to Mars with a crew on board. We can name it as Martian interplanetary space station. The elements of Martian interplanetary space station (MISS) (figure 2)were designed and it can be launched into space by Space Launch Systems (SLS). The overall weight of Martian interplanetary space station is about 450 tons. The flight from earth orbit to Mars will be powered by ion thruster or advanced plasma (jet rocket) engines.

Power Management system

Solar/regenerative fuel cell power systems

A PV solar power system uses solar cells that are configured into an array and typically coupled to an energy storage device such as a fuel cell. Energy storage is required to provide power when the array does not see the sun or when power output is attenuated below load requirements. Energy storage also answers peak power demand. Current solar cells that are available and achieve 27% energy storage include, for example, the advanced triple junction GaAs/Ge (gallium arsenide/Germanium), which are the cells that are used on the MERs. Even with high-efficiency solar cells, array areas that are needed to produce the required power for a human mission become very large. For solar systems to be competitive at Mars, advances in cell efficiency, dust mitigation, array deployment, and operational maintenance strategies must be improved. Since the power system is pre-deployed prior to the arrival of the crew, a robust method of robotic or autonomous deployment, anchoring, checkout, and operation of large array systems must be developed. The Mars DRA study array option was 2.5 m high x 58 m long, the total system of which is comprised of 10 array wings.

The environment of Mars, which is very common with dust accumulation and dust storms, would profoundly affect the overall performance of solar power generation systems. Previous robotic missions to the surface of Mars have provided valuable data with respect to dust accumulation. A robust method must be identified that could operate robotically since the arrays must be operational prior to crew arrival. Technologies for dust mitigation, such as compressed gas "blow off," mechanical wiping, vibration to fluff off the dust, and electrostatic repulsion, have been considered; and further work is required to determine the best approach, particularly for large arrays. Active dust mitigation approaches must therefore be developed and incorporated in future solar system designs. Advanced energy storage devices are necessary to supply the necessary power for night time operations and during dust storms. Advances in both primary fuel cell power systems and RFC energy storage systems are being pursued.

An RFC system is a combination of a primary fuel cell and an electrolysis system, along with associated integration hardware. The fuel cell and RFC work is categorized into six major areas:

(1) flow-through primary proton exchange membrane fuel cell (PEMFC) development,
(2) non-flow-through primary PEMFC development,
(3) high-pressure electrolysis development,
(4) RFC technology development,
(5) passive thermal development, and
(6) advanced membrane-electrode-assembly (MEA) development.

Isotope power systems

Isotopic power systems offer continuous power much like the nuclear fission system. Their practical range is on the order of several kilowatts due to the availability of 238Pu, which is produced by Neptunium-237 (237Np) neutron exposure. 238Pu has many attractive features compared to other isotopes, lower radiation (minimal, low-mass shadow shield), high-power density, and an 87.7-year half-life. 238Pu has fueled all of the RTGs that are used in NASA missions. NASA's use of radioisotopes is well established since Apollo (the Apollo lunar surface experiments package (ALSEP)) and has enabled over 30 outer planet missions as well as the Viking landers. These systems work by converting the natural radioactive decay heat (largely alpha particles) into an electric current. The thermoelectric devices are limited in conversion efficiency; thus, high-power systems would require large amounts of radioisotope fuel. The Savannah River facility, which produced the 238Pu, has been shut down with plans to restart production at a combination of alternate facilities at future date. There is currently a limited supply of 238Pu and a strong competition for it to support future NASA missions.

Advances in power conversion, such as Stirling generators, are needed to improve the efficiency of converting thermal heat into electrical power. The advanced conversion technologies that are proposed could provide a four- to five-fold increase in isotope utilization, thus drastically reducing mission cost while making prudent use of our scarce resource of isotope fuel for future missions.

A Mars-Bot (figure 6) will include the drive and steering mechanisms of a conventional competition robot, plus a wireless video cam and various sensors. Science fairs that involve engineering, physics, astronomy, and chemistry have declined in recent decades, while robotics competitions have rapidly grown in popularity. After watching a number of robotics competitions, I’m confident they can be expanded to include some science. Here’s my proposal for a new kind of robot competition: Mars-Bot, a simulated space mission.

Video Camera

The most indispensable sensor on each Mars-Bot will be at least one wireless color webcam. The basic setup will have a stationary mount that looks straight ahead. More sophisticated Mars-Bots will feature a webcam that can rotate to better survey the landscape, find assigned goals, and provide visual clues when samples are collected. The camera itself can also report back data indicated by readouts or instruments in its field of view.

Simulated Dust Storm

Mars is known for its vast dust storms. A fan blowing dust across the path of a Mars-Bot could test the ability of moving parts to survive a blast of grit. The reduction in electrical power that occurs when dust falls on a Mars-Bot’s solar panel can also be measured. However, wind can remove accumulated dust from a Mars-Bot(figure 10) too, so the landscape might include a fan that blows clean air across the bot. If blowing dust is not feasible, then a fog machine could simulate a dust storm.

Wind Speed Sensor

A Mars-Bot should measure the speed of any wind it encounters. A fan or propeller, mounted on the shaft of a small DC motor, can act as an analog wind speed sensor. When wind rotates the motor’s armature, a voltage proportional to the rotation rate will appear across the motor’s terminals. Mounting a disk on the shaft of a propeller can make a digital wind speed sensor. Glue a small magnet to the outer edge of the disk, and mount the assembly so that the outer edge of the disk rotates past a Hall effect sensor. The Hall sensor will provide a voltage pulse each time the magnet rotates by it. If the weight of the magnet causes the rotating disk to stall, 2 or 3 additional magnets can be mounted around the disk to balance it. Calibrate the sensor by placing it adjacent to a commercial, handheld wind speed sensor at various distances from a fan.

Haze

Dust blown high into the Martian atmosphere can cause long-lasting haze. In an indoor competition, periodic dimming of the artificial sun can simulate haze, while passing clouds will create the same effect during an outdoor competition. A photodiode or solar cell can detect the reduced light; mount it behind a plastic diffuser to ensure it receives light no matter the artificial sun’s location.

Temperature

The temperature during a mission will slightly change with wind, haze, and cloud conditions. It can be easily measured using a thermistor or integrated temperature sensor, or with an infrared thermometer, which can also scan the temperature of various objects along the mission course.

Spectrometer

The colors of rocks, sand, and soil provide important clues about their composition. The Mars-Bot’s video camera can be used as a simple 3-color spectrometer. Photo processing software can analyze individual video frames to express the relative intensity of the blue, green, and red wavelengths of the simulated Martian landscape. A Mars-Bot mission protocol might require a 3-color analysis of various features in 3 separate video frames collected during the mission.

Sand and Pebble Sampling

An especially important part of a Mars-Bot mission is to collect geological samples and return them for analysis. The mission controllers would use their video link to steer their Mars-Bot to the sand and gravel sites along the course. The mechanical features of the current generation of competition robots can be easily modified for sand and pebble sampling.

Borer To Collect "Rock" Sample

An especially interesting task will be for a Mars-Bot to use a boring tool to collect a sample of material from a mock boulder. The mission team will steer their Mars-Bot to the boulder, bore a sample, and stash it for the return trip. The boulder might be fashioned from a thin but rigid sheet of wood or other soft material that can be easily penetrated by a standard 1/2″ to 1″ battery-powered hole saw, which resembles a short steel cup with saw teeth around its rim, encircling a standard bit mounted in a drill chuck. The business end of the drill bit extends beyond the saw teeth to provide a pilot hole so the circle saw stays on target during the cutting process. A standard battery-powered drill fitted with a 1/2″ to 1″ hole saw could be mounted on the front of the Mars-Bot and switched on and off by a radio-controlled relay connected across the drill's power switch. In my experience, a circle of wood removed by a hole saw stays inside the saw until it is manually removed, so the saw itself should hold and retain one or two thin samples. To prevent injuries to the mission team and onlookers, the exposed circle saw should always be covered by a red plastic cup with a red safety flag unless the saw is being tested or the Mars-Bot has begun a mission.

Robonaut 2

The conditions aboard the space station provide an ideal test bed for robots to work in close proximity to humans, while also working in a zero gravity environment. Once demonstrated inside the space station, software upgrades and mobility aids will be incorporated, allowing R2 (figure 11) to work outside in the vacuum of space. This will help NASA prepare for robotic capabilities for future deep space missions. As R2 technology matures, it will move on to complete tasks deeper in space. This will test technologies for more extreme thermal and radiation conditions, as well address new challenges posed by microgravity. This will also allow R2 to service communications, weather and reconnaissance satellites, which have direct benefits on earth. The next step for robotic capabilities such as R2 will be to explore near-Earth objects, including asteroids and comets, with the eventual destination being Mars and Mars' moons. The robot will serve as a scout, providing advanced maps, sampling data, answers about basic surface compositions and advanced infrastructure support in preparation for human arrival. Humans will then be able to explore the near-Earth object, much more prepared than they would be without the robotic scouting mission. This evolution of capabilities for both robotic and human exploration will make a Mars surface mission possible. This human-robotic partnership will allow Mars surface missions to be conducted safely by a smaller crew- without sacrificing mission plans and results.

Conclusions and Recommendations

we concluded that international space exploration uniquely offers humanity access to an exciting frontier of new knowledge. Discoveries on new worlds in new environments by space robotic explorers add to our knowledge of the Solar System, but they also explore the possibilities for extension of human life beyond the Earth.

The planet Mars is the most natural objective for this grand exploration. Its geologic evolution has been similar to that of Earth in many ways. In its atmosphere and on its surface, we find water, carbon, and nitrogen - all required for the existence of life. Martian landforms include volcanoes and extensive channels, apparently formed by large amounts of flowing water. Today, the atmospheric pressure on Mars is only one percent that of Earth, and temperatures are seldom higher than zero degrees Celsius. Travel to Mars is technically challenging, and operations on its surface are difficult. Therefore, a comprehensive program of Martian exploration should include both robotic and human missions. A principal issue of programmatic strategy is the proper balance between automated and crewed missions. We recommend to focus on robotic precursor effort with an ongoing effort of robotic missions to assist the emplacement of the human exploration on Mars and to continue human scientific exploration.

Space robots offer unique features, advantages, and capabilities with a wide range of potential applications in space, health care, manufacturing, materials characterization, environmental monitoring, biotechnology, search-and-rescue, and entertainment. Due to new physics and mechanisms, physics at the revisiting the traditional work carried out by human Furthermore, space robotic technology help us to overcome several challenges in mars exploration by the coordination of massive numbers of robots and rovers. Martian Interplanetary space station will be a test bed for future interplanetary automated or human missions.

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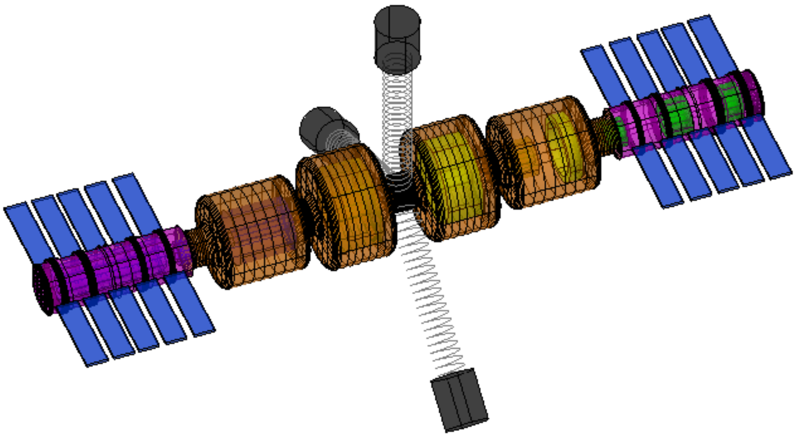
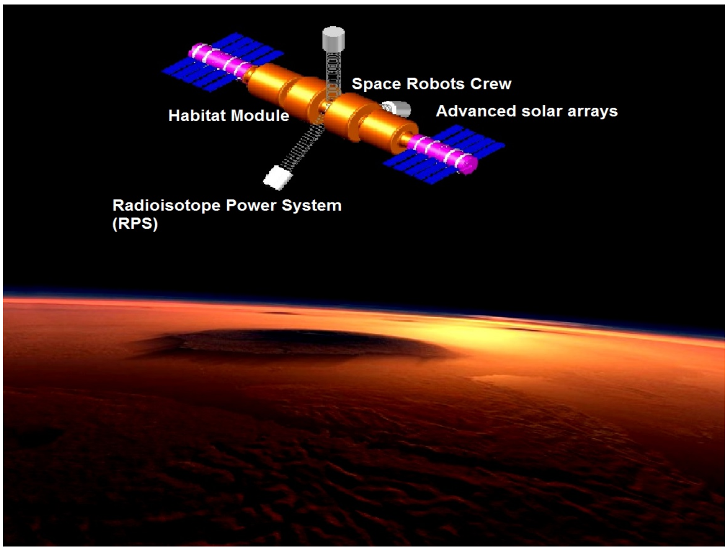
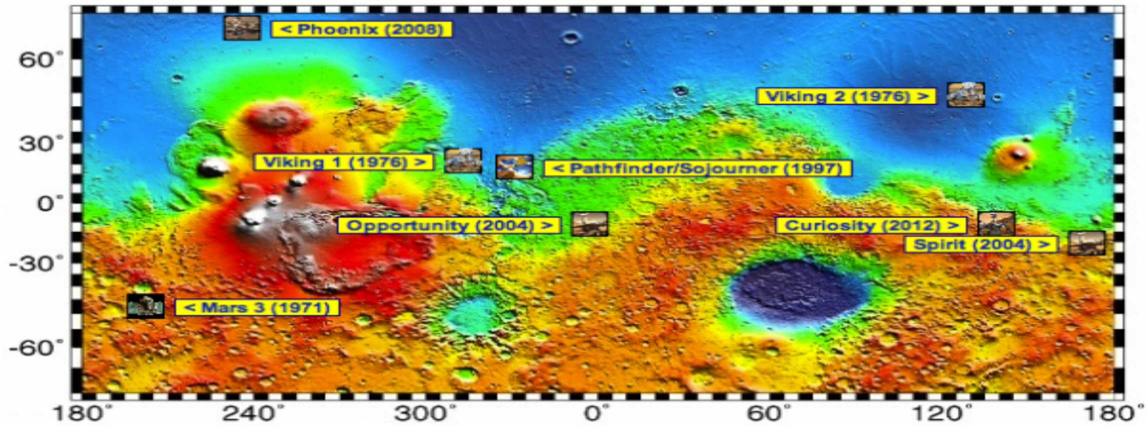


(Figure 1) Conceptual design of Martian interplanetary space station

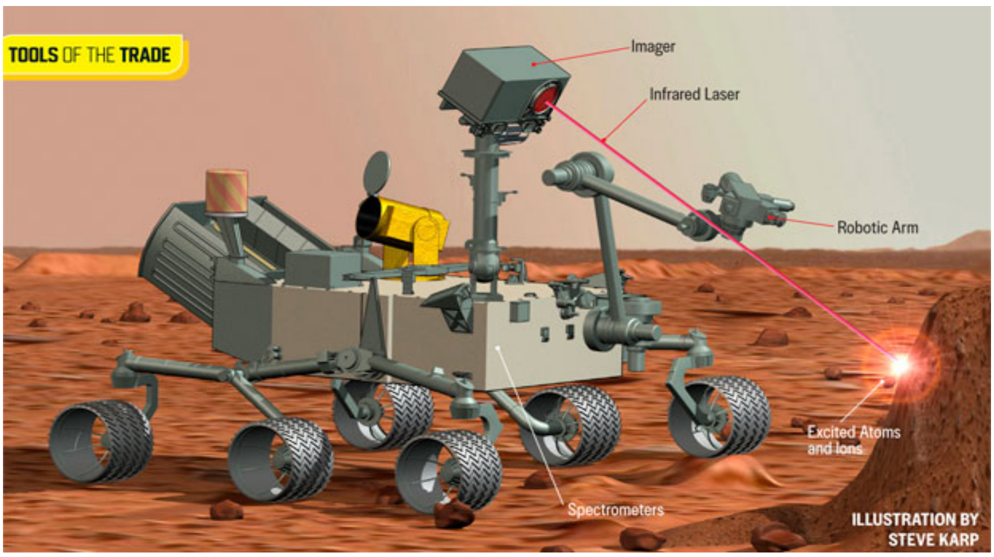


(Figure 2) Conceptual design of Martian interplanetary space station on Mars

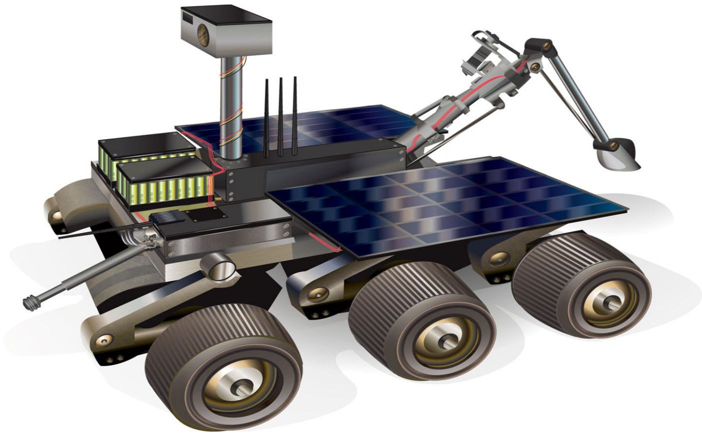


(Figure 3)Image credit: NASA/JPL-Caltech, overlay of lander/rover sites via Wikipedia.

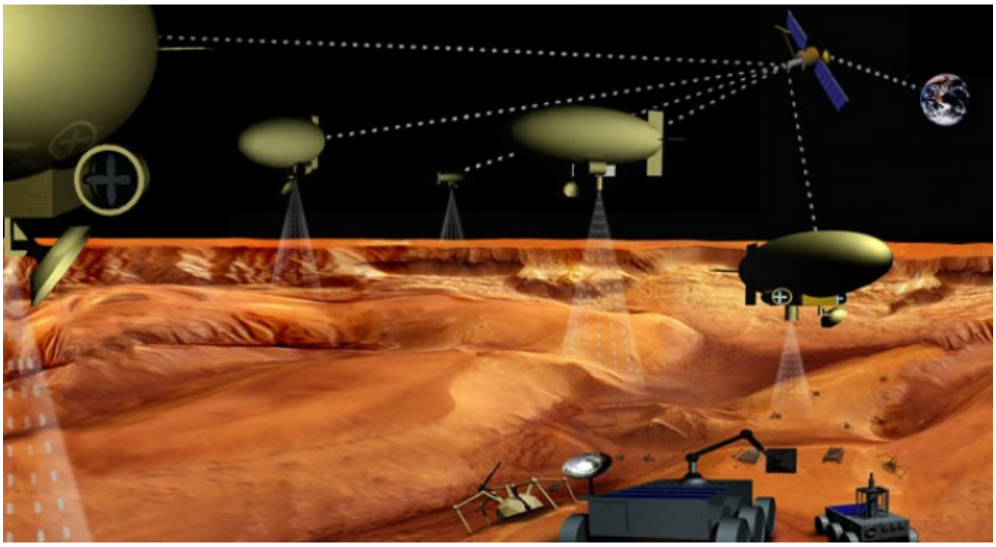
(Figure 4) Image credit NASA, Robotic manipulator on space station



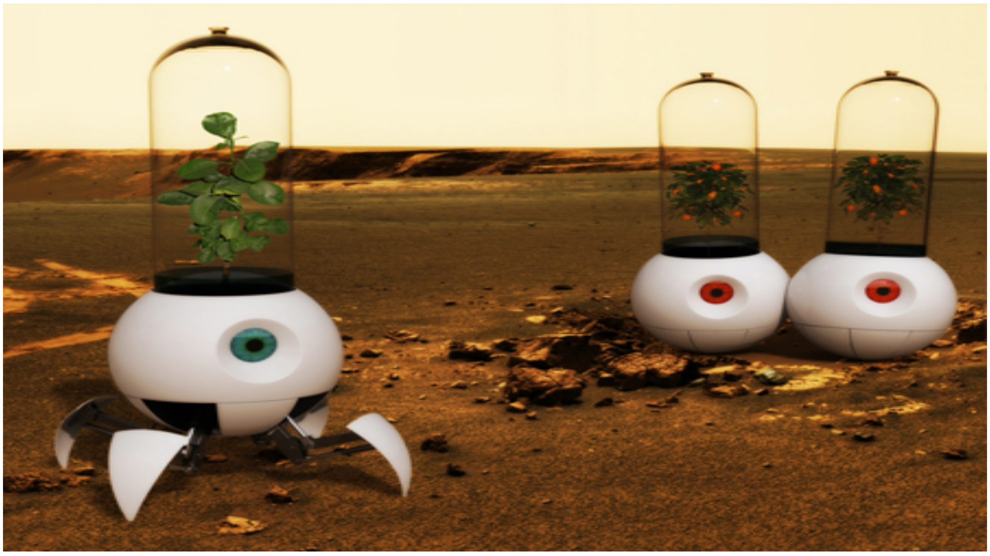
(Figure 5) Surface operations on mars



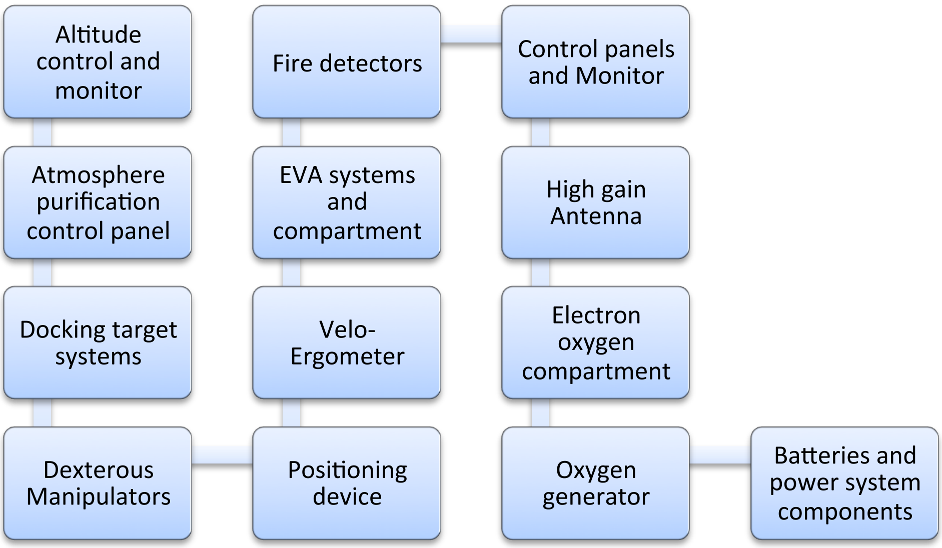
(Figure 6) Mars-bot



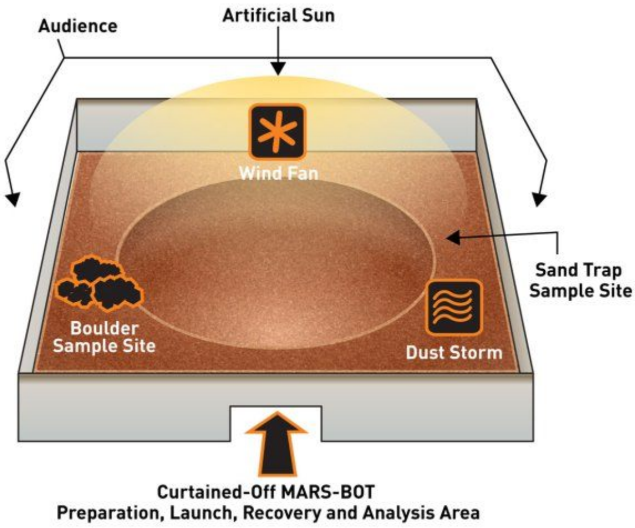
(Figure 7) Communication on mars



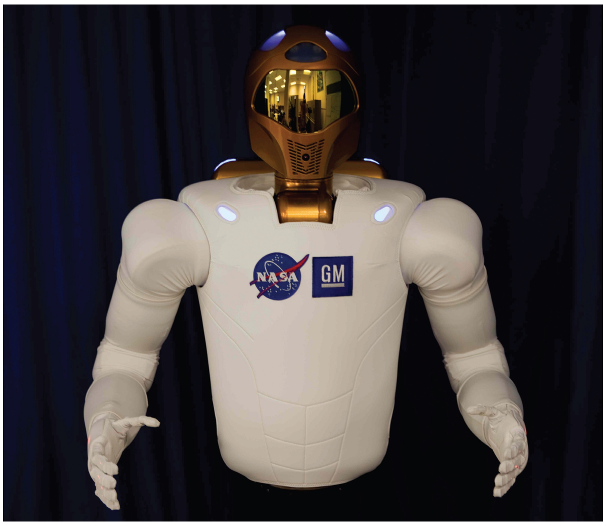
(Figure 8) robotic greenhouse concept



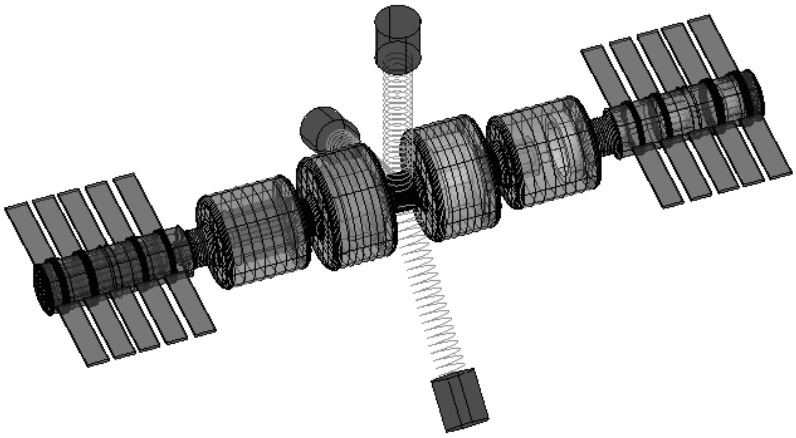
(Figure 9) Block diagram of Mechatronic control systems



(Figure 10)Mars Dust Storm Simulator



(Figure 11) R2



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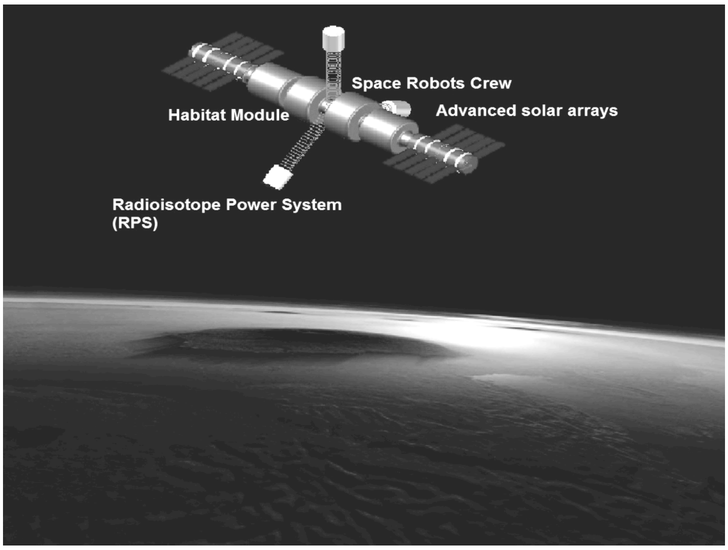
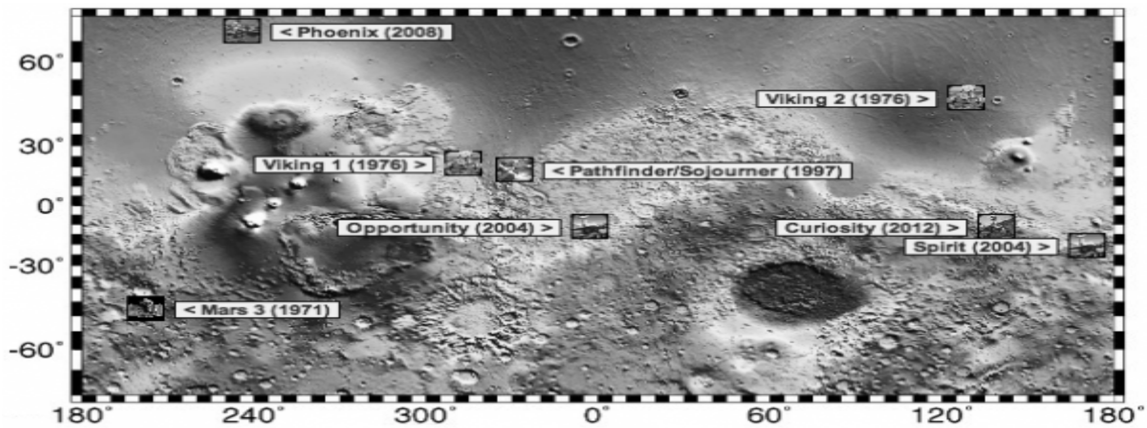


(Figure 2) Conceptual design of Martian interplanetary space station on Mars



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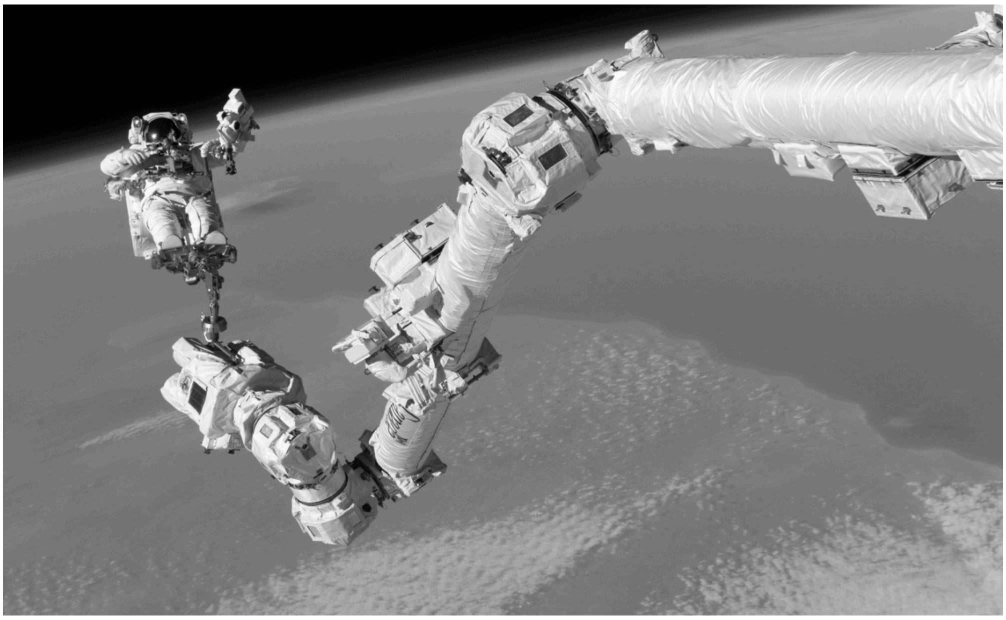

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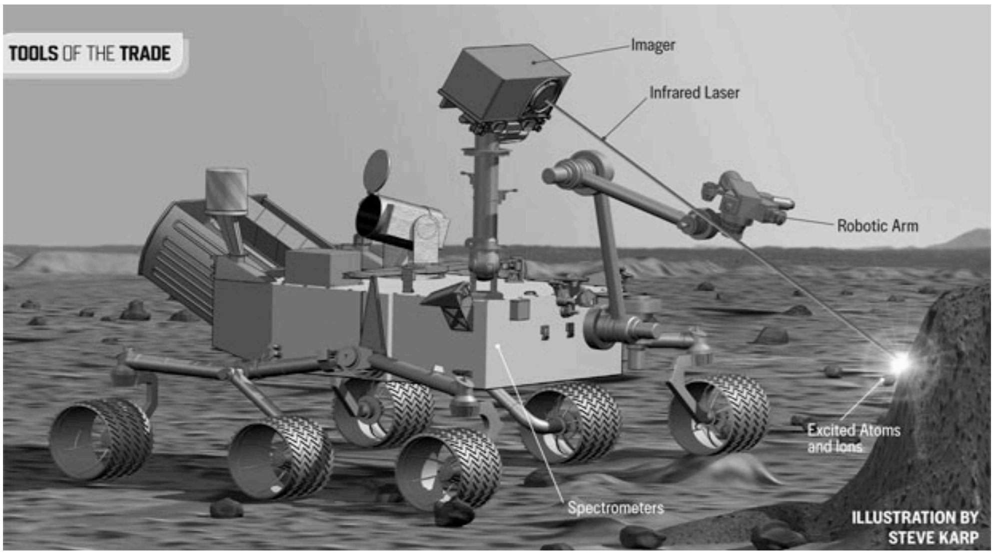

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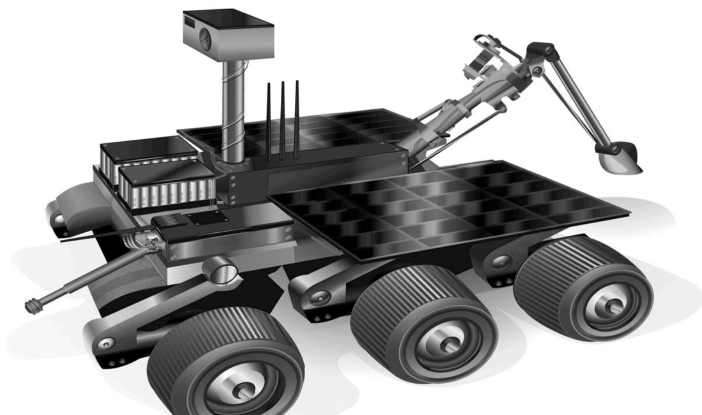

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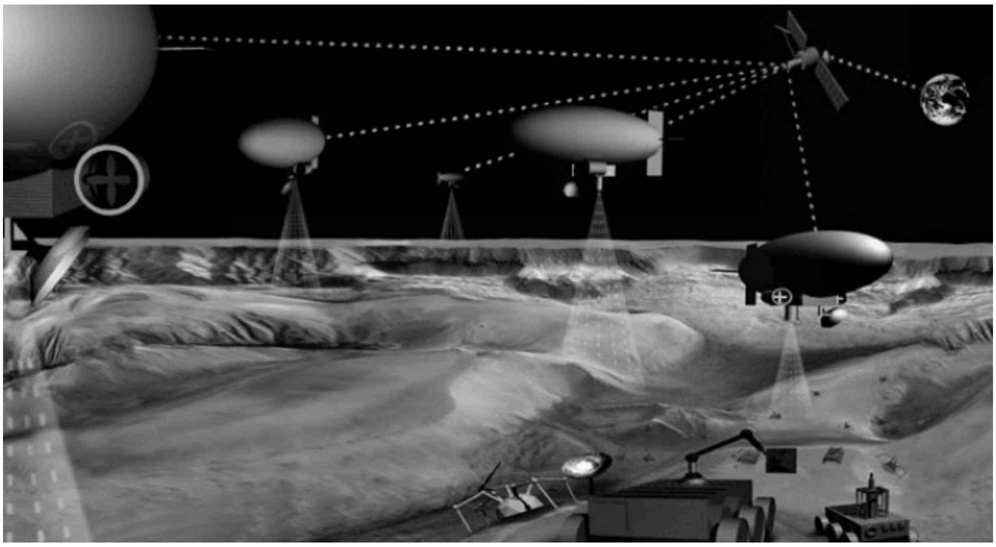

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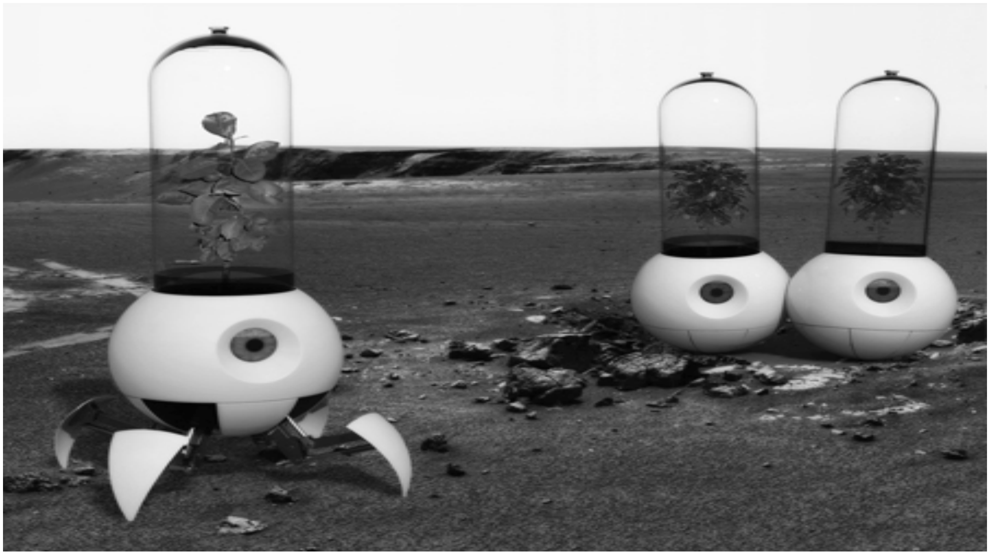

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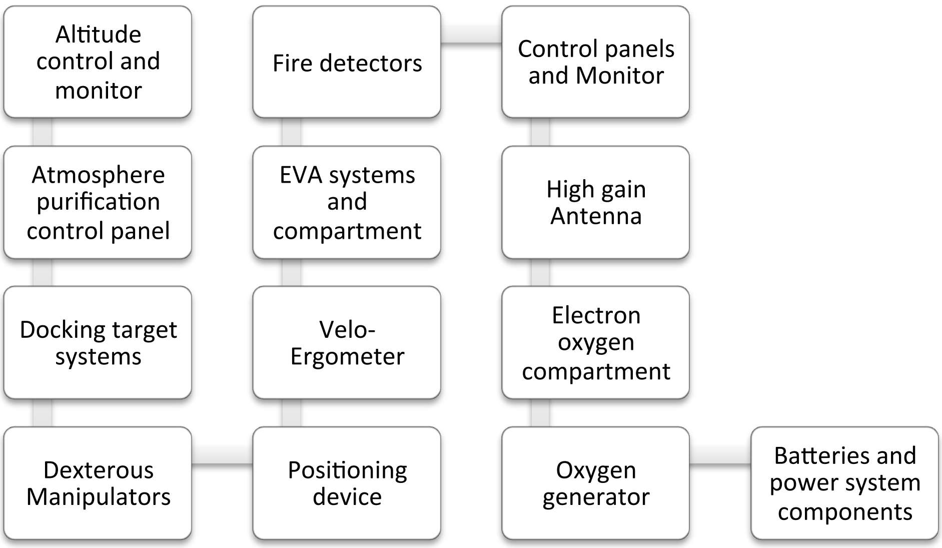

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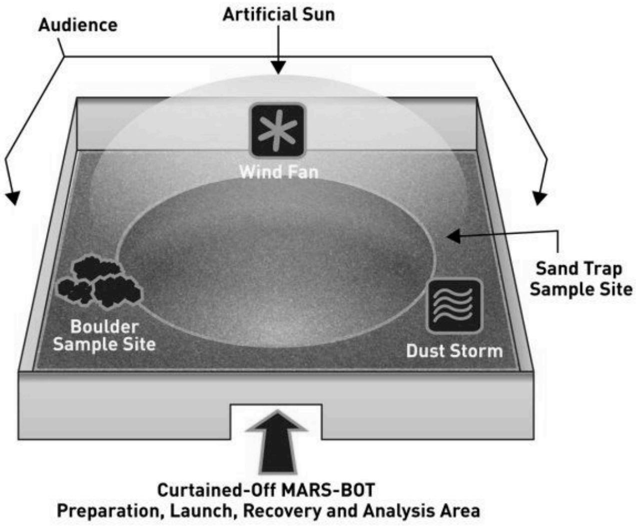

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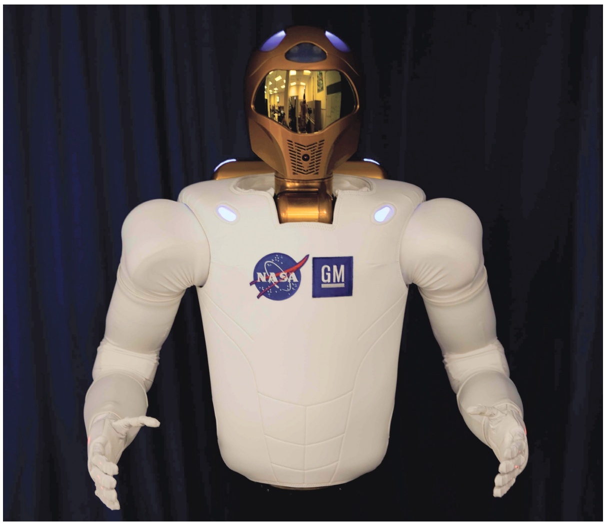

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