Editorial

Mr.M. Asoka T. De Silva

The World Science Day for Peace and Development

This edition of Vidurava has appropriately focused on Space Exploration as the theme for commemorating the World Science Day for Peace and Development, an event celebrated annually on the 10th of November under the auspices of UNESCO. An enlightening and inspirational set of articles have been lined up in this number, articulating a wide – angle view of satellite technology, space travel, communication, as well as an array of spin-offs arising for the greater benefit of mankind.

It is indeed a remarkable achievement and a commemorative event that a distinguish citizen of Sri Lanka, the Late Sir Arthur C. Clarke, whose prediction in 1945 of the possibility of creating a global communication system through what is referred to as a geostatic satellite, was to became a reality a couple of decades later. As commented by one of the contributors, Clarke's remark on 'the absurdity of mankind's present tribal divisions, and the need to conceive the idea of a global village', has been gradually taking shape over the past six decades or so. Space travel is known to involve a state of zero gravity, or a condition that may be referred to as 'microgravity'. How this phenomenon acts on the biological and physical functions of astronauts is not common knowledge. The critical impact of such an environment on astronauts, who are obviously prepared to face risks during space travel are discussed in an article in this number.

It may seem paradoxical that while climate and environmental changes back on our good Earth are demanding more and more research to help mitigate adverse consequences for the survival of living beings, it may be thought idealistic to spend huge sums of money searching for alternate human-friendly habitats elsewhere in the universe.

Space research in search of light weight materials, miniaturized devices, health effects under gravity, rapid computing systems, water and air filtering systems, energy harnessing mechanisms, as well as robotics appear to have opened up new technological pathways and innovative products that could serve the well being of human beings.

Thus NASA's efforts in developing high resolution space telescopy, had led to an innovation capable of measuring complex surfaces with high degree of accuracy. This technology has apparently been transferred to ophthalmology and eye surgery for measuring the eye lens before eye operations. Likewise a worthy contribution to agriculture had been the assembly of an automated device for monitoring of plant growth and optimizing water requirements to plants, which has helped to reduce water usage in large scale farming by about 25 %.

Many more unique applications have been described by contributors to this number, which are bound to inspire the reading public.

Future Direction of Space Exploration with Respect to Manned or Unmanned Missions

Lavanan Vengadasalam

Space Era began with the successful launch of Sputnik 1 satellite in 1957, and Vostok 3KA spacecraft was the first manned flight to take a human being to space in 1961. Along with these and the continuously progressing milestones in space exploration, the human race's astonishing event took place in 1969, with man landing on moon. Since then many manned missions were limited to only the Low Earth Orbit (LEO), and most robotic missions that took place beyond that were curiosity rover on Mars. Currently the greatest ongoing debate in space exploration is manned vs unmanned missions.

History of Space Exploration

The universe is a place filled with mysteries and myths. When humans looked up at the night sky and tried to explain the universe and its contents, their inability to observe them close enough limited their understanding. Human race always tends to seek meaningful answers for any phenomena, and in fact this is a function of left hemisphere of the human brain. This behaviour led human beings to discover, study and analyse the origins of the Universe and its contents, which in turn led to the beginning of space exploration.

In ancient times, human being believed that the Earth was the centre of the Universe which was the proposed argument of Greek scientists Aristotle and Ptolemy. The Polish astronomer Nicolai Copernicus argued that the Sun was the centre of the solar system in his book *On the Revolutions of the Heavenly Bodies* in 1543. Italian astronomer, Galileo Galilei supported this argument following his invention of the astronomical telescope in 1609. Since then telescopes have been used to observe the universe, and this led to the path of observational astronomy.

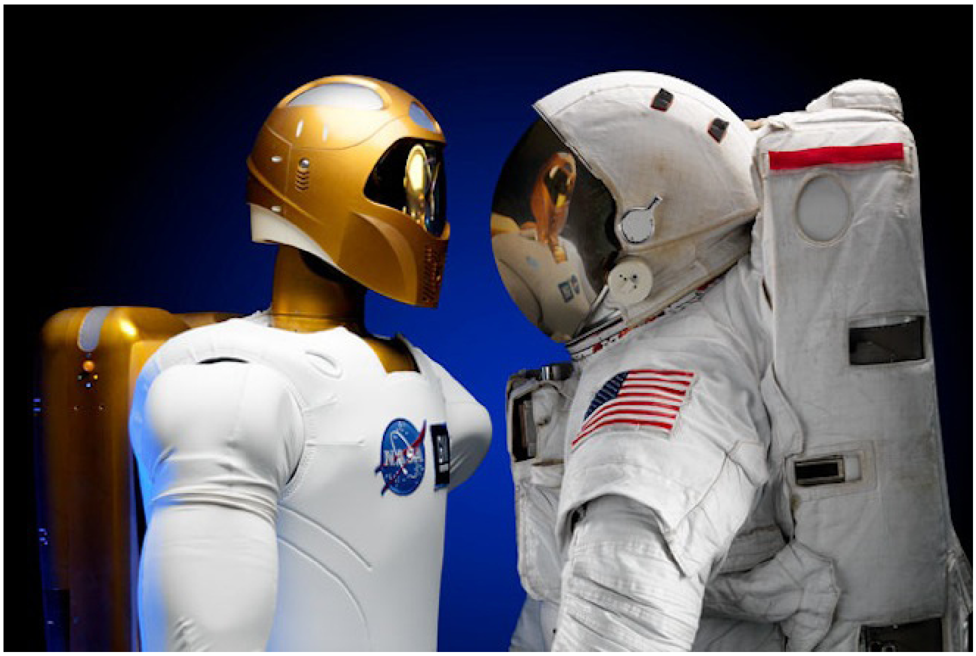
It would be best to say that Galileo Galilei's astronomical telescope was a milestone for astronomers. The use of astronomical telescopes helped the German astronomer Johannes Kepler and English scientist Sir Issac Newton to invent their laws in astronomy. Since then, these have become the most important contributions in spacecraft mission analysis and design.

The concept of a satellite was first mentioned in a story entitled The Brick Moon written by Edward Everett Hale in 1869. It mentioned that a satellite functioning in the polar orbit would provide accurate measurement of longitude for sailors. In 1909, Russian teacher Konstantin Tsiolkovsky mentioned in an academic paper the possibility of using rockets to launch spacecraft. Following these events, Russians launched the first satellite, Sputnik 1 in 1957, and this event marked the begining of the space age.

Debate on Manned or Unmanned Missions for Future Space Exploration

Stephen Hawking who holds Issac Newton's Lucasian Chair in Cambridge University, and an expert on the cosmological theories of gravity and black holes, expresses his point of view on the debate Manned vs Unmanned missions as follows:

"Robotic missions are much cheaper and may provide more scientific information, but they don't catch the public imagination in the same way, and they don't spread the human race into space, which I'm arguing should be our long-term strategy. If the human race is to continue for another million years, we will have to boldly go where no one has gone before."



According to Stephen Hawking, it is clear that if human race has to be sustained for another million years and beyond, then manned exploration has to go beyond its current constrained limits, as robotic missions would not be able to detect any life forms that are different from the earth type organic structure. This is due to the lack of programming capabilities to recognise weird things that might be below the surface of Saturn's moon Titan, or beneath the seas of Jupiter's biggest moon, Europa.

The debate extends to point out NASA's Viking program where the two Viking vehicles carrying miniature chemistry laboratories to test samples for alien life on Mars reported in their findings, that the chemical reactions with the Martian soil were strange and not comparable to any thing seen on Earth, as well as to what any living organism would produce on Earth. This event reflects the crux of the debate bringing up arguments that robotic machines in this mission did what they were programmed to do, and were not capable of detecting any weirdness or to identify any strange non-carbon life. If it was a human biologist or biochemist this would have been resolved in few hours of time.

Casey Kazan (2011) reported the statistical figures of current and future mission of NASA as fifty plus robotic missions, researching and studying Earth as well as from Mercury to Pluto and beyond in the solar system. Forty unmanned missions are in the development stage, and would be launched at the appropriate times carrying more advanced state of the art equipments to increase the depth of research and study. Currently more space agencies such as ESA, RFSA, CNSA, ISRO, JAXA etc. are also developing their own unmanned missions. The main reason being that, unmanned missions are not costly and risky as manned missions.

Even though all the space agencies are keen on developing more unmanned missions, and while governments' are cancelling their manned missions as evedent in President Obama cancelling of the NASA's Constellation program, more experts support manned missions in this debate. An astronomer and planetary scientist at Cornell University, Jim Bell supports manned missions along with Stephen Hawking, and his argument is an follows:

"Although astronaut missions are much more expensive and risky than robotic craft, they are absolutely critical to the success of our exploration program."

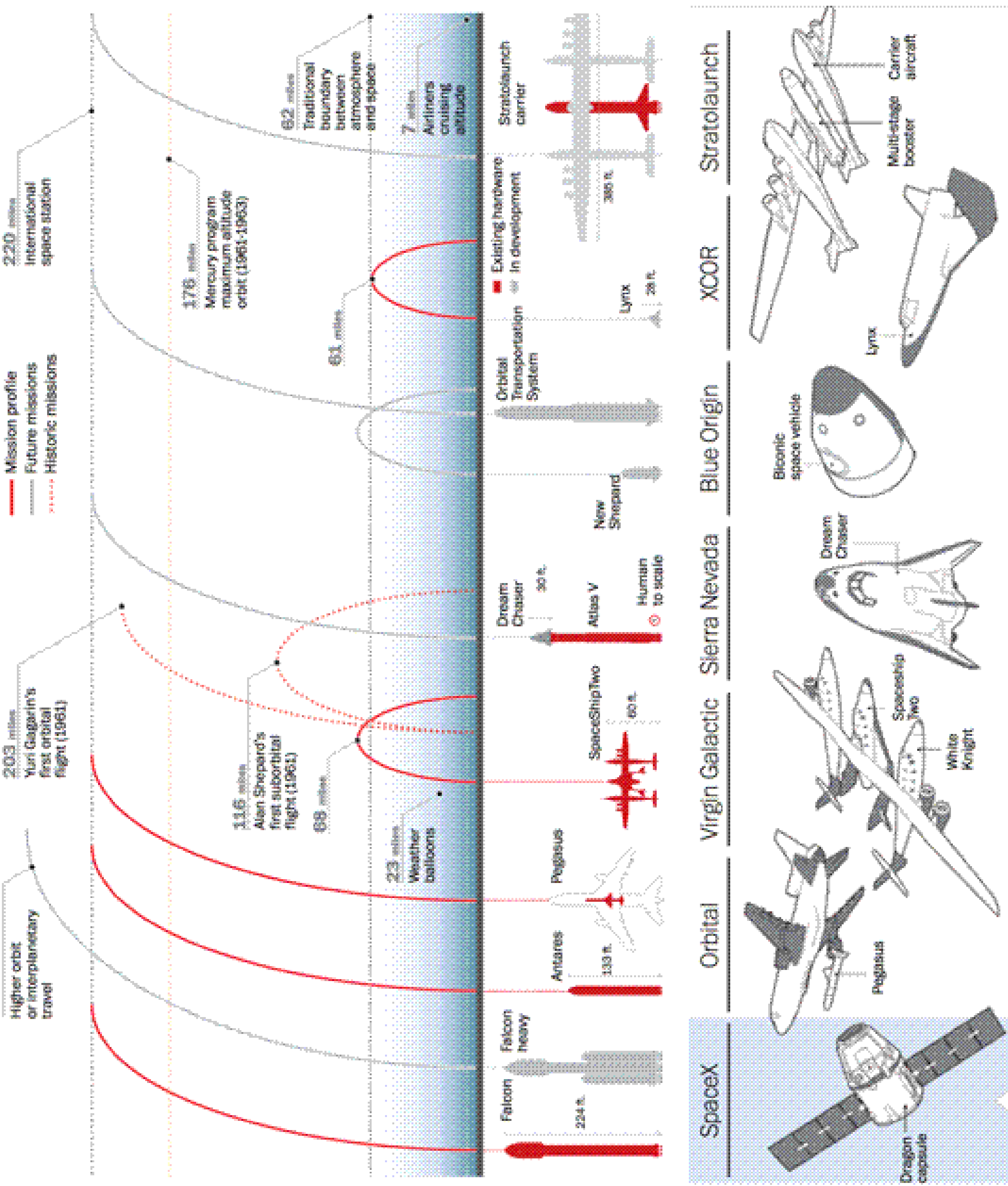
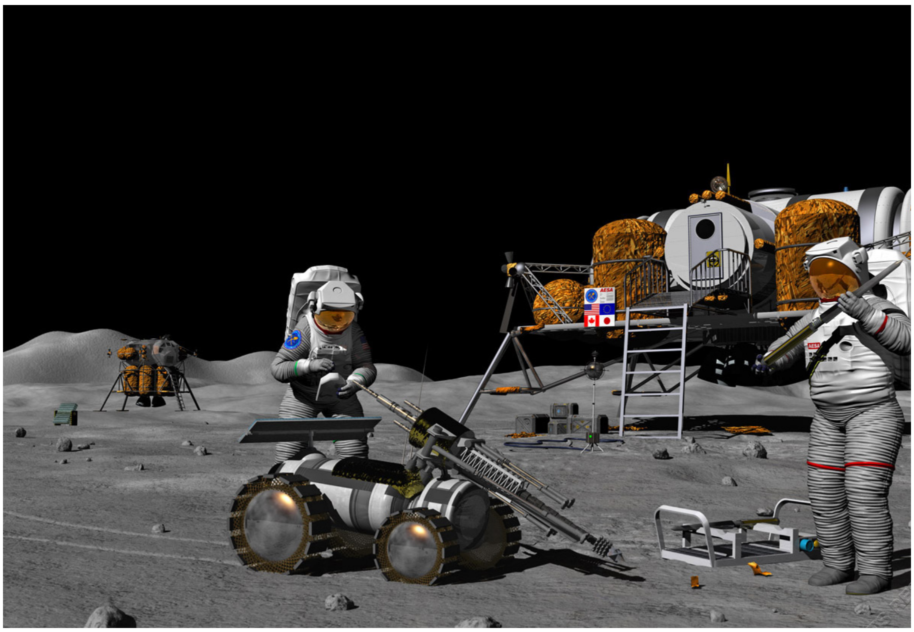


Fig.1: Launch capabilities of private space companies [Alberto Cuadra and Katie Park (2013)]

Current Focus on Space Exploration

During NASA's 50th anniversary, Hawking proposed the allocation of 0.25% of the world's collective Gross Domestic Product (GDP) for space exploration and space colonization arguing that, "isn't human race's future worth a quarter of a percent?", but the arguments of Hawking will only save the seed of human life not the entire Earth's inhabitants.



While the survival of human race is looked up far into the future, the search for extra-terrestrial intelligence continues. So far no alien civilization has been detected and the physicists have offered three possible reasons which are given below. Most scientists favour the second option as a reason.

1.Life of any kind is very rare in the universe.
2.Simple life forms are common, but intelligent life rare.
3.Intelligent life tends to quickly destroy itself.

Since the cancellation of Constellation Program of NASA, most private companies have been involved in the space sector for various transportation requirements, such as the Space X company's dragon capsule to take cargo to the International Space Station (ISS). At the same time, commercial space transportation is taking off and many of these projects are at their complication phase such as Virgin Galactic's space tourism. As has been said, previsionly most of launch vehicle capabilities were only a capability of governments but now there is wide private sector involvement in having these capabilities. Following diagram (Figure 1) describes the launch capabilities of the private space companies.

As seen in figure 1, the private space company Space X has shown successful launch capabilities in the recent years, and they have been contracted by NASA to transport astronauts to International Space Station which is yet to be proven. At the same time, the company is planning to use their falcon heavy rockets to launch payloads to Mars. Virgin Galactic is another private space company mainly focusing on space tourism, making available facilities to public to explore space. They had their successful test, and are now making arrangements to begin tourist flights in due course with the price tag of $250 000 per seat.

Future trends in space exploration has been seen to take many dimensions starting from the concept of spreading human race across the universe through the allocation of a significant fraction of the world's GDP for extensive research, and thereby inventing state of the art technologies to make it possible. An alternative proposal to provide access to public to explore space as space tourism is also been projected.

The future is however, on the balance for manned or unmanned missions due to the consideraction of their advantages and disadvantages. Nevertheless most scientists and engineers prefer to support manned mission to Moon and Mars in the future.

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Benefits of Space Exploration to Humankind

Prof. S. R. Munasinghe

The launching of the first artificial satellite, Sputnik to Earth orbit in 1957 went a long way in setting up of the global communication system using communication satellites. Same effort led to the development of global positioning system (GPS). These two technologies; telecommunication and GPS have helped to make the Earth a global village, elevating social life to a more efficient and comfortable state. The propulsion technologies developed for space travel facilitated the aircraft technology and the safety of air travel. The requirements of space travel such as reliable communication, precise control, tracking and safe navigation have helped improve air traffic control and navigation systems. Much of the electronic and computer systems developed for space travel have in later years been used in many other technical fields to ensure reliability, accuracy, robustness, and redundancy.

Space exploration has helped to accumulate an enormous amount of information (data and images) using spacecrafts and space telescopes in many space missions from sputnik (1957) to Mars Science Laboratory (2014). Space stations (Skylab and International Space Station) have carried out many experiments under low gravity, while monitoring Earth from the orbit. The knowledge gathered from these space missions have revealed the origin and evolution of the Earth, life, the solar system and the Universe. Space exploration has caused alarm among human beings because of the protential threat to their survival on the earth resulting from the adverse affects of environmental unfriendly industrial practice. Today we know that the Universe is 13.7 billion years old and is expanding with an increasing rate. There are many planetary systems other than our solar system, and there are more

Fig.1 : Artist's view of global communication

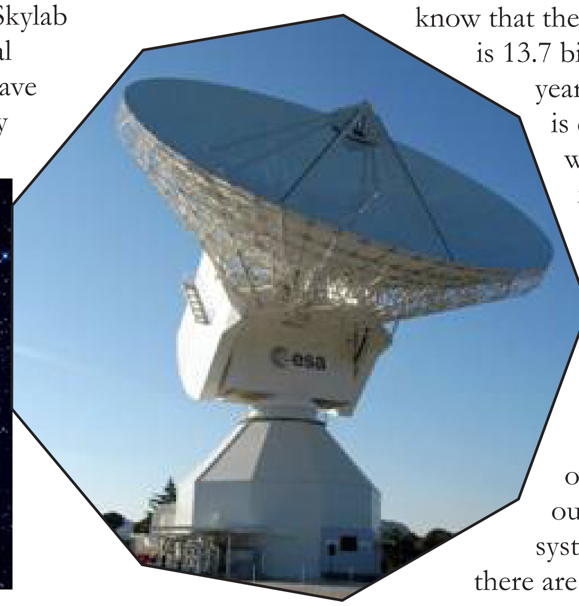


Fig.2 : Deep space tracking antenna

than 250 planets around other stars, but there is no evidance of intelligent life within our vicinity. Mars does not have any significant life on it, and the moon has only traces of water. The continuous exploration for new knowledge has

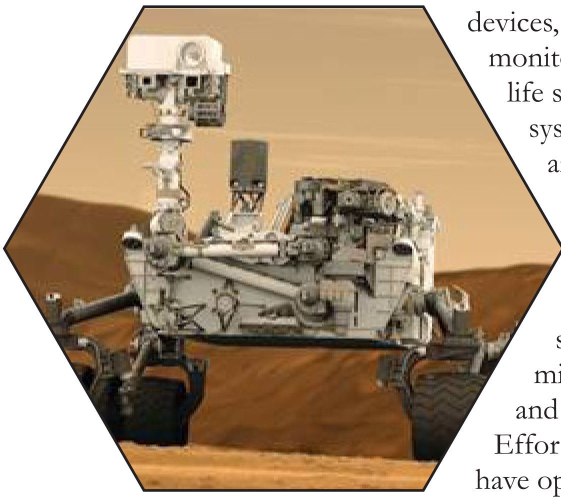


Fig.3 : Curiocity, the Mars Science Laboratory

inspired humankind and nurtured human culture. Human kind is more versatile today than ever before because of the knowledge gathered through space exploration.

Space exploration needs autonomous machines and robots for space missions. Mars Science Laboratory, named "Curiosity" is the latest such robot, which is described as a robot geologist that can carry out many geological experiments autonomously. In the future, even more advanced robots will be needed for space exploration, perhaps for colonization of Moon and Mars. This will trigger a rapid growth in the fields of robotics leading to advanced robotic equipment for medical, industrial, and social activities.

Space travel needed light weight materials, miniaturized devices, fast computing devices, remote health monitoring systems, life support systems, water and air filtering/ purification systems, energy harnessing systems (solar cells and mini atomic power plants) and other robotic devices. Efforts in building such systems have opened new inventions and products that are useful in improving social wellbeing of humankind. The new technological requirements for space travel stemmed as new fields of engineering, and these developed independently over the past half century. It has created new industries, products, and services. New jobs and new career paths were created in technical and medical fields.

NASA's next episode in space telescopes will begin with the

Fig.4 : Latest eye measurement tool, a NASA spinoff

James Webb Space Telescoope (JWST) scheduled for 2018. This telescope has 18 flat-smooth mirror segments, collectively of the size of a two storey building. These mirror segments were manufactured in an iterative cycle of grinding-polishing-measuring, which takes a very long time and required a massive effort because the mirror surfaces need to be extremely accurate in order to bring clear images of the first galaxies of the Universe. JWST will collect infra-red light coming from the objects nearly at 13 billion light years away in search of the nature of the universe at its infant stage. The most challenging part of the mirror manufacturing process was to measure the surface with the required accuracy, for which the engineers had to develop a new

Fig.5 : Life Support systems in space and on EarthCourtesy NASA

Fig.6 : Leaf thickness sensor developed for automated farming

technique they named as Infrared Scanning Shack Hartmann System (ISSHS).

Now this innovation, which is capable of measuring complex surfaces with a very high accuracy, is used by eye surgeons for taking measurements of the eye lens before performing surgeries. The original lens measurement tool ISSHS developed for space exploration has now turned into a tool in the medical field by the name Complete Ophthalmic Analysis System (COAS), which is 20 times faster compared to the other existing systems. COAS provides a detail map of the eye-lens from which the eye-surgeon can determine cataracts, keratoconus, and eye movement.

The two famous Mars Rovers- Opportunity and Spirit were equipped with 1Megapixel cameras. However, it was possible to create 96Megapixel wide angle images by stitching multiple images together. NASA had to develop a special tripod for this purpose, which allows the rotation of the camera while shooting photos. The set of photos taken are identified with respective tripod orientation, and later using a custom-built software, these photos are stitched together to make large wide-angle images. This technology has been transferred to the consumer market, and is used in many general purpose photo editing tools. Journalists and individuals are using this tool to generate very effective memorable panoramic photos of special events.

If we ever want to plan for setting up human habitats (colonies) on Mars, a number of new technologies need to be developed to solve key problems in long-haul space travel. One of these problems is continuous food supply for up to one year's journey to Mars. It is not feasible to carry a huge load of food, or to assign farming on flight for astronauts. Therefore, NASA has funded projects to develop techniques for automated growth monitoring, watering, and fertilizer supply to plants to ensure proper growth and nutrition of harvest.

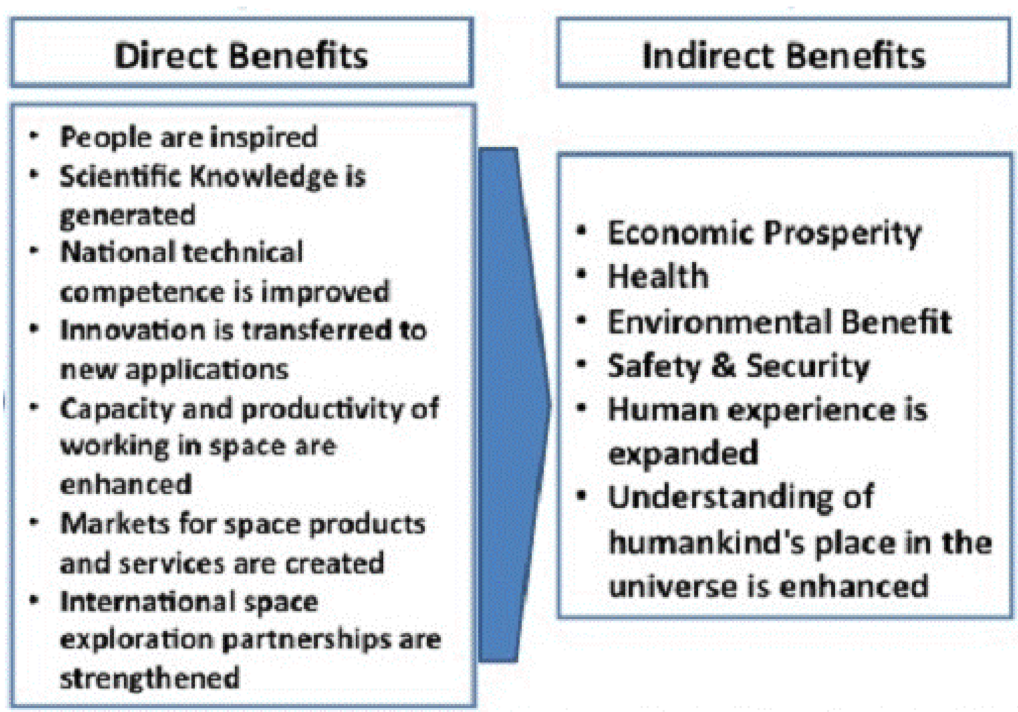


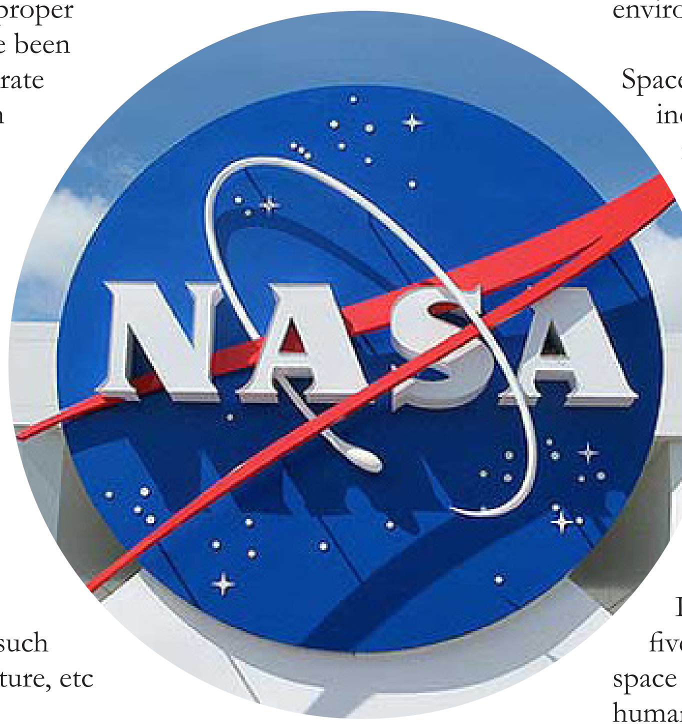
Fig.7 : Direct and indirect benefits of space exploration

One such invention uses sensors to measure leaf thickness and to control watering accordingly. These techniques are now being tested for large scale farming, and it has been found that such automated irrigation has reduced water usage by about 25%, while at the same time maintaining proper growth. These systems have been augmented recently to generate automated SMS alerts when anomalies of plant growth are detected. In the future, farming will be mostly automated, and farmers will only have to attend if there is an issue.

NASA maintains a website titled NASA Spinoffs (http://spinoff.nasa.gov/), where all technical innovations of NASA that have been transferred for useful applications in other fields such as industry, medical, agriculture, etc are listed.

Space exploration is inherently multi-disciplinary, But it is also a costly activity. Therefore, space explorations are usually carried out collectively with other nations. Many countries led by USA, Europe, Japan, Russia and China have worked together in space missions despite the disputes they have among themselves on other issues. Space exploration has united rivals for a common cause.

Colonizing Moon and perhaps Mars too are on the agenda of space exploration. Capturing asteroids, mining them for valuable minerals have also been thought of. After effects of the exposure of human body to the cosmic radiation, and effects of living in zero gravity during long-haul space travel have been studied in the international space station (ISS). These initiatives and ongoing experiments produce immense knowledge and technology for the benefit of humanity. Space



watch programs, specially the Near Earth Object (NEO) program is on alert in search for asteroids and comets that are destined to travel closer to the Earth, thus causing a potential threat of collision. It is believed that the dinosaurs, the dominant species on Earth some 65million years ago became extinct after a comet colliding with the Earth, and the records of mass extinction events show that such mass extinctions in which about half of the species is wiped out takes place at an average periodicity of 25 million years. In accordance with this view, it is unusual that such an event had not taken place during the last 65million years. However, it may alarm humankind to be on alert for the next mass extinction event, which can probably be triggered by a nuclear war or environmental pollution. Space exploration has revealed the evolution of humankind. It has also showed us what our destiny will be if we do not conserve our environment.

Space science (Astronomy included) is a fascinating hobby for kids. The curious mind at early ages wonder why the Moon changes its shape over a period of 28 days; what are shooting stars; are aliens real?; Is there life elsewhere? etc. And it inspires curious minds to explore and invent. Space exploration makes humankind more curious, exploratory, and inventive.

If we look back at the past five decades, and identify how space explorations have benefitted humanity in various ways, it would become clear that such benefits and their significance were unpredictable and unforeseen to a great extent. It would be difficult to foresee how today's space explorations will benefit humankind in the future, yet one thing is for sure, that such benefits will be of very great significance.

Prof. S. R. Munasinghe
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Satellites for Global and Mobile Communications

Prof. Dileeka Dias

Communications satellites play a vital role in linking people throughout the world, to form what is commonly referred to as the global village. A typical satellite communication system involves the transmission of a signal from an Earth station to a satellite. The satellite then amplifies the signal and retransmits it back to Earth, where it is received by terminals such as satellite phones, TV receivers, aircraft, and other fixed or mobile devices.

This article outlines the key communications services provided by satellites: telephony, data communications, and TV broadcasting. However, satellites enable a much wider variety of global and mobile communications applications such as distance learning, news gathering, navigation and tracking. Another key area of application of satellites is military communications.

Communication Satellites

The possibility of using satellites for communication was proposed by Sir Arthur C. Clarke in a paper published in 1945 entitled, *Extra-Terrestrial Relays: Can Rocket Stations Give World-wide Radio Coverage?*. He calculated that a satellite at an altitude of 35,786 km above the Earth's surface would be moving at the same speed as the Earth's rotation, and thus would remain in a fixed position relative to a point on Earth. Accordinaly an antenna fixed on the ground can be pointed to a satellite 24 hours a day. Clarke showed in his paper that three satellites in such an orbit would be able to provide radio coverage to the entire world.

It took several years for the technologies that made satellite communications practical to evolve. The first artificial satellite, Sputnik 1, was launched successfully by the Soviet Union on October 4, 1957. The Echo 1, an aluminum-coated balloon that simply reflected signals from the ground, developed by NASA and the Bell Labs was launched on August 12, 1960. The U.S. National Aeronautics and Space Administration's (NASA) ambitious satellite technology programs helped advance global satellite communications industry in leaps and bounds. The potential application of satellites for development and their ability to reach remote regions led other countries to build and operate their own national satellite systems subsequently.

Today, approximately 2,000 communications satellites orbit the Earth, relaying signals carrying voice, video, and data to and from one or many locations worldwide. Of these approximately 42% occupy the geostationary orbit proposed by Sir Clarke and 47% occupy low earth orbits (LEO). A smaller percentage of satellites operate in medium earth orbits (MEO) and elliptical earth orbits.

Frequency Bands

The frequency bands used in satellite communications are designated as L-, S-, C-, X-, Ku-, Ka-, and V-bands. The lower frequency ranges (L-, S-, and C-bands) need large antennas to communicate. The Padukka satellite station which was Sri Lanka's only link with the rest of the world at the time was commissioned in 1976, operated in the C-band with an antenna of 30m diameter. The higher frequency bands (X-, Ku-, Ka-, and V-) can use dishes of much smaller size (e.g. 45cm diameter). This makes the Ku- and Ka-bands ideal for TV broadcasting direct to homes, broadband data communications, and mobile applications.

The primary commercial frequency bands currently in use are the C-band (4-6 GHz) and the Ku-band (11-14 GHz). Over the next several years, the Ka-band is expected to increase to support evolving broadband services.

Regulation

The International Telecommunication Union (ITU), an agency of the United Nations, regulates satellite communications. The ITU, receives and approves applications for use of orbital slots for satellites, and is responsible for assigning frequencies to various applications in various regions of the world. Each country's telecommunications regulatory agency enforces these regulations and awards licenses to users of various frequencies. In Sri Lanka, this body is the Telecommunications Regulatory Authority (TRCSL).

Satellite Telephone Services

Satellite telephony provides services directly to handheld phones. These are used in telephony applications over sparsely populated territory or over oceans, where fixed or mobile terrestrial networks are not feasible or economical. The phone connects with an orbiting satellite, in the same way as a mobile phone connects with a base station. Though early satellite phones were large in size, with large retractable antennae, they are evolving to become almost indistinguishable from cellular phones. Satellite phone systems are also able to provide low-bandwidth data connectivity to user devices. The per-minute cost of satellite phone calls currently range between US$ 1.25 and 2.00.

•*Geostationary Systems*

Some satellite phone systems use geostationary satellites. The system cost is relatively low as each satellite covers a large area. However, the disadvantages are that line-of-sight between the phone and the satellite is usually required and the poor quality of services at latitudes beyond 700 . Another disadvantage is that it takes over a quarter of a minute for a signal to reach a satellite and be relayed back to earth.

Well known geostationary satellite phone systems include Inmarsat, Thuraya, ACeS and Terrestar. Inmarsat, the oldest satellite phone operator's core business is to provide fixed installation for ships. It operates 11 satellites, providing coverage to most parts of the world, except in the polar regions. The company has been in the news in recent times, for its role in the search for the lost Malaysian Airlines aircraft. AceS provides a regional service in South Asia, while Thuraya provides coverage over Europe, Africa, the Middle East, Asia and Australia. Geostationary systems are able to provide low-rate data services from 60 to 512 kbits per second in addition to voices.

•*Low Earth Orbit Systems*

LEO satellites orbit the earth at high speed, the low altitude orbits (640-1120 km). The orbital period is 70-100 minutes. Thus, LEO satellite systems need to use a constellation of satellites in several orbital planes to provide their services. The constellation architecture ensures that every location in the service area is covered by at least one satellite at all times. A usable pass of an individual LEO satellite will typically last 4–15 minutes. The service must be handed over from one satellite to the next to ensure continuity. Examples of LEO systems are *Iridium* with a constellation of 66 satellites and *Globalstar* with 44. The data rates that LEO systems are able to provide are lower than those offered by geostationary systems.

Emergency Communications

Satellite phones have helped disaster relief operations, saving thousands of lives over the years. Cellular systems and other terrestrial infrastructure can be among the first casualties of a disaster. Satellite systems operate independently of the local communications infrastructure. Hence they are ideally suited for communications during and after disasters, where other forms of communications have been disrupted. In effect, satellite systems are able to provide instant critical infrastructure in disaster situations such as

earthquakes, tsunamis and cyclones. Ambulances and fire trucks can also communicate with each other and with coordinating centers, and exchange important data by taking advantage of the data and positioning capabilities of the portable satellite phone. Disaster warning systems as well as disaster relief personnel usually have satellite systems as a back-up mechanism in their communications networks.

Satellites for Data Communications

Satellites facilitate the transfer of data through very small aperture terminal (VSAT) networks. A VSAT is a two-way satellite ground station with a dish antenna that is smaller than 3 m. An organization can set up a private network between its head office and remote branches using a VSAT service provider. The organization may configure the network in either a star topology or a mesh topology. In the star topology, the organization would operate a central uplink site called a network operations center (NOC), to transport data back and forth to each remote station via satellite. In the mesh configuration, each station may relay data via satellite to another station by acting as a hub, without the need for a NOC. VSAT service providers may provide such a service to multiple client organizations, with each organization having virtually its own private network while sharing the service provider's infrastructure with others.

With VSAT services, communications facilities similar to those available at the corporate office may be extended to their remote stations. Users in remote offices can make telephone calls, access the Internet and use common business applications to successfully run their operations even in isolated or harsh environments.

Bandwidth (or equivalently, data rates) available to the user is an important consideration in satellite data services. Today's popular social networking applications, as well as audio/video entertainment are bandwidth intensive tasks. Broadband satellite service providers adopt a wide range of technologies, and thus the available bandwidth also varies widely. Top ranking service providers offer download speeds in the range of 10-15 Mb/s. To keep this in perspective, original speeds offered just 15 years ago in the satellite Internet industry averaged 500kb/s download and 250kb/s upload. These speeds are expected to increase dramatically over the coming years. For interactive applications such as gaming and videoconferencing, upload speeds are also crucial. Current upload speeds range from about 400 kb/s to 5 Mb/s.

Broadcasting via Satellite

Satellite broadcasting services deliver radio and television directly to the consumer's fixed or mobile receivers. Direct-broadcast satellite (DBS) is a term used to refer to satellite television broadcasts intended for home reception. DBS is also known by the ITU as Broadcasting Satellite Service (BSS).
The inherent broadcast capability was what Sir Arthur C. Clarke foresaw as the potential of satellites in his article in 1945. Nearly 20 years later, the first TV broadcast via satellite happened at the 1964 Olympic games held in Tokyo. The games were telecast to the United States using Syncom 3, the first geostationary communication satellite, and from there to Europe using Relay 1.

Early satellite television was broadcast in C-band. Today's digital broadcast satellite transmits in the Ku- band. Digital technology provides better picture and sound quality, and makes more efficient use of the frequency band compared to older analog technology.
A DBS service provider obtains content from different sources, and beams a broadcast signal to a geostationary satellite. The satellite receives this and re-broadcasts it back to earth. The viewer's receiver picks up this signal, processes and displays it on a standard TV receiver. The current standard for DBS is DVB-S2 (Digital Video Broadcasting - Satellite - Second Generation). It is based on and improves upon the previous DVB-S standard. DVB-S2 supports standard TV, high-definition TV (HDTV) and interactive TV services. DVB-S2 standard was developed in parallel with HDTV and H.264 (MPEG-4 AVC) video codec standards.

In a relatively short span of time, satellite communications technology has developed from the experimental to the sophisticated and powerful. Global and mobile communications forms, the underlying threads linking the world into a single global village, and despite competition from optical fiber, satellite communication remains the most general medium to achieve this.
With increasing video, voice, and data traffic, the satellite communications industry foresees a vast range of new applications that will drive the demand for its services. A key feature that is required to meet these demands is increased bandwidth. Communications satellites are evolving to have more onboard processing capabilities, more power, and larger-aperture antennas that will enable satellites to handle more bandwidth. These types of advances are essentially required by satellite communications service providers in order to remain competitive with alternate forms of communications such as optical fiber, cable and terrestrial microwave radio. In parallel developments ground equipment is evolving to be more sensitive, more energy efficient and small in size to further encourage novel applications.

Cost still remains a prohibitive constraint for widespread adoption of satellite services. Many of the current services are relatively new, arriving in the past 15-20 years. As such, considerable costs of research, development and testing still reflect in the service costs. As the technology matures, the price of services is expected to go down significantly, as has happened in other areas of communications.

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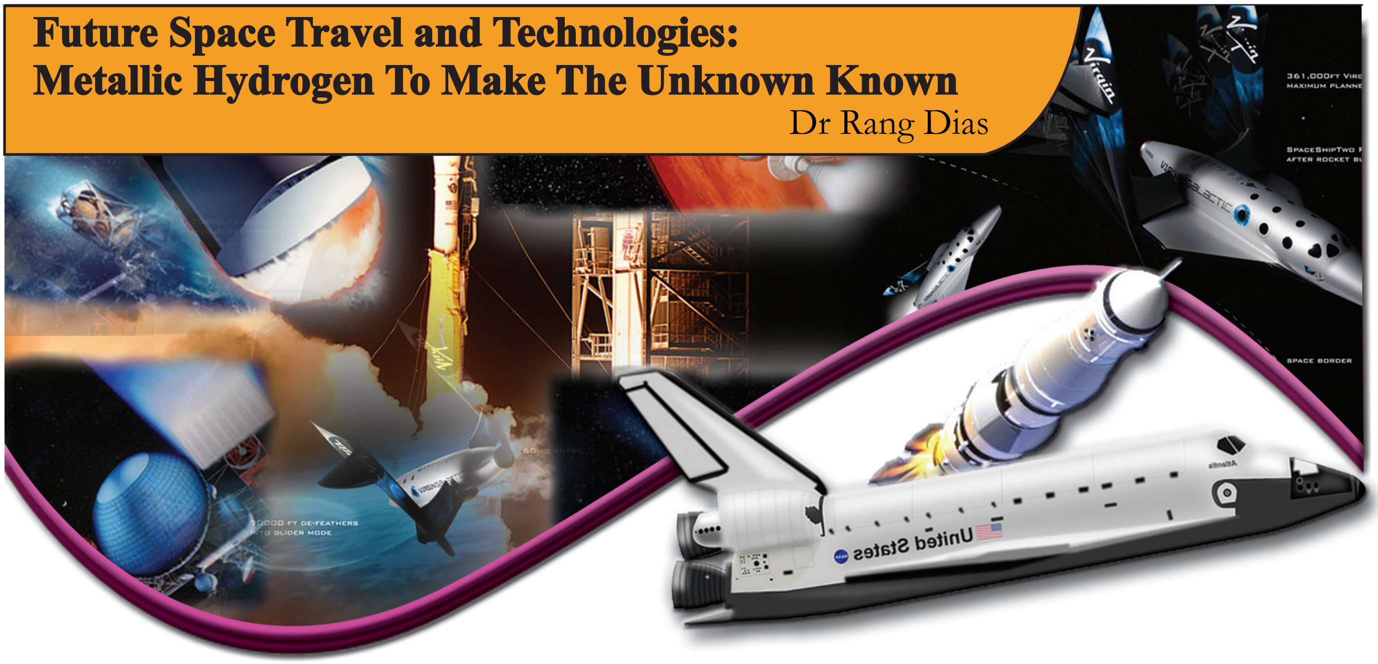
Future Space Travel and Technologies: Metallic Hydrogen To Make The Unknown Known

Dr Rang Dias



Hydrogen is the simplest and most abundant of elements. Composed of one proton and one electron, it makes up 90% of our universe. On earth, hydrogen is commonly found as a diatomic molecular gas. But on Jupiter/Saturn, where interior pressure is millions of times greater than that at our planet's surface, the hydrogen molecule is theorized to exist as a superhot liquid. Of course, it is no ordinary liquid, even if it is the most common element in the universe. Despite its simple atomic structure, hydrogen has proved to be much more complicated than scientists had imagined. Ordinarily a gas consisting of diatomic (two-atom) molecules, hydrogen can be cooled to a liquid (below 20 kelvins, or –253 degrees Celsius) and to a solid (below 14 kelvins). In all these states, hydrogen is normally an electrical insulator, but in the 1930s it was first predicted by Wigner and Huntington that subjecting hydrogen to extreme pressure found deep inside Jupiter, would cause the molecules to dissociate (break apart into atoms) thereby turning hydrogen to behave as a metal that can conduct both heat and electricity.

What is more, in 1968 Neil W. Ashcroft of Cornell University suggested that, under certain combinations of pressure and temperature, hydrogen atoms would rearrange themselves into a new kind of quantum liquid with attributes of both superconductors, which conduct electricity without resistance, and superfluid, which flow without resistance. Such exotic behaviors become particularly interesting if some of these phases of hydrogen turn out to be metastable where the phases could retain their high pressure forms for an indefinite period once external forces are removed, similar to diamonds formed by high temperatures and pressures deep inside Earth remaining diamonds even after they reach the surface, instead of immediately reverting back to carbon's more stable form, graphite. It might be used as a room-temperature superconductor, a material that physicists have been seeking for decades. It might also serve as a compact energy source and as a lightweight building material. This lightweight high energy density material can be used as rocket fuel that packs nearly four times as much propellant power per kilogram as the liquid hydrogen used in the most powerful rockets today. This would certainly revolutionize rocketry, allowing single stage rockets to enter orbit and chemically fueled rockets to explore our solar system. Production of metallic hydrogen in the laboratory is one of the great challenges of high-pressure physics.

Although efforts to metallize hydrogen have increased extensively in recent decades, prompting numerous experiments at high pressure, and uncovering increasing complexity, daunting experimental challenges have left researchers in the field on a constant quest to observe this elusive state of the element.

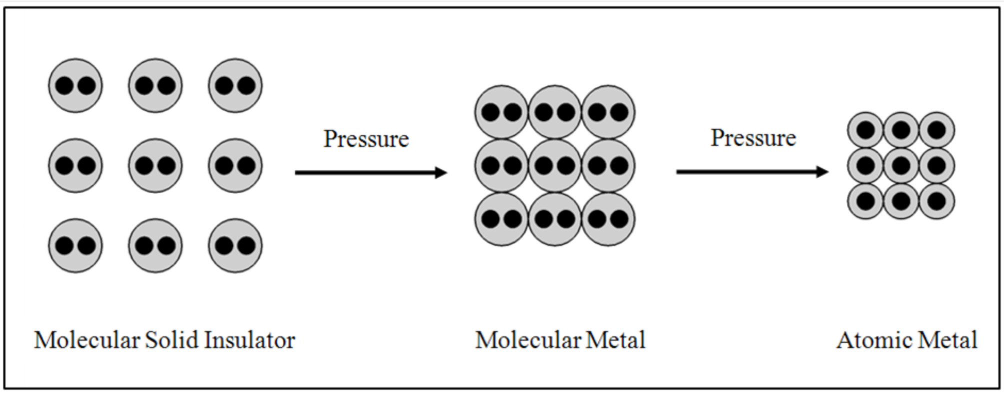


Fig. 1 : Schematic production of solid hydrogen at low pressure (left) and high pressure (right). Molecules in ordinary hydrogen (left) are well separated, and the electrons—shown as clouds of negative charge—stay close to the pairs of protons. But high pressure pushes the molecules so close to one another that the electrons can easily hop from one molecule to the next, thus creating an electric current when a voltage is applied to the liquid (right).

Since the work of Wigner and Huntington, there have been numerous calculations of the critical pressure needed for the dissociative transition from molecular to solid atomic metallic hydrogen. On the atomic scale, what happens during metallization is that some of the hydrogen's electrons are freed from their molecules. At low pressures, the tendency for two hydrogen atoms to form a molecule is extremely strong, so the liquid hydrogen contains only molecules. Each molecule contains a pair of protons surrounded by a cloud of negative charge. Because it takes a relatively large amount of energy (15 eV)— to remove an electron from a hydrogen molecule, the molecular hydrogen fluid cannot carry a current: it is electrically insulating. This situation changes however, as the hydrogen molecules are pushed together. The electronic mobility gap, that is, the energy required to remove an electron from a molecule so that it can conduct an electrical charge— decreases as the molecules move closer together [see figure 1]. However, phase transition calculations that seek the structure with the lowest lattice energy, have difficulty in handling the zero-point energy contribution to the total energy. As a result, the predicted critical transition pressures have an enormous variation, from as low as 0.25 Mbar to over 20 Mbar, while recent predictions are in the 400 to 600 GPa range [see figure 2].

The metastability of metallic hydrogen depends on temperature and pressure. Above some temperature there will be sufficient thermal energy in the atomic lattice for the atoms to rise above the potential barrier and recombine into hydrogen molecules, releasing the energy of recombination, 216 MJ/kg (note: the dissociation energy of a hydrogen molecule is 4.68 eV). This is more than twenty times the specific energy released by the combustion of hydrogen and oxygen in the Space Shuttle's main engines, 10 MJ/kg. Because of this very large potential specific energy, it is interesting to explore the possible use of metallic hydrogen as an energy source for rocket powered launch vehicles. A rocket engine is fundamentally a quite a simple device. Liquid fuel and oxidizer are injected into a reaction chamber where combustion releases the chemical energy producing a hot gas. The hot combustion products exit the chamber at fairly high pressure through a throat and then expand out of a nozzle. In rocketry one of the characteristics of a propellant is its specific impulse, related to the thrust (specific impulse represents the number of seconds that a thrust of one kilogram of force (Newtons) can be sustained by one kilogram mass of propellant). Liquid (molecular) hydrogen-oxygen used in modern rockets has a specific impulse of ~460s; while metallic hydrogen has a theoretical specific impulse of 1700s. Such a fuel would allow single-stage rockets to enter into orbit or carry economical payloads to the moon. The metallic hydrogen can be carried in a small spherical tank inside the liquid hydrogen diluents tank. Therefore metallic hydrogen propelled vehicles clearly can revolutionize rocketry. If pure metallic hydrogen is used as a propellant, the reaction chamber temperature is calculated to be greater than 6000 K, which is too high for currently known rocket engine materials. By diluting metallic hydrogen with liquid hydrogen or water, the reaction temperature can be reduced, yet there is still a significant performance improvement for the diluted mixture.

Despite the promise of this material, several challenges must be overcome before they can be used in applications. The metallic

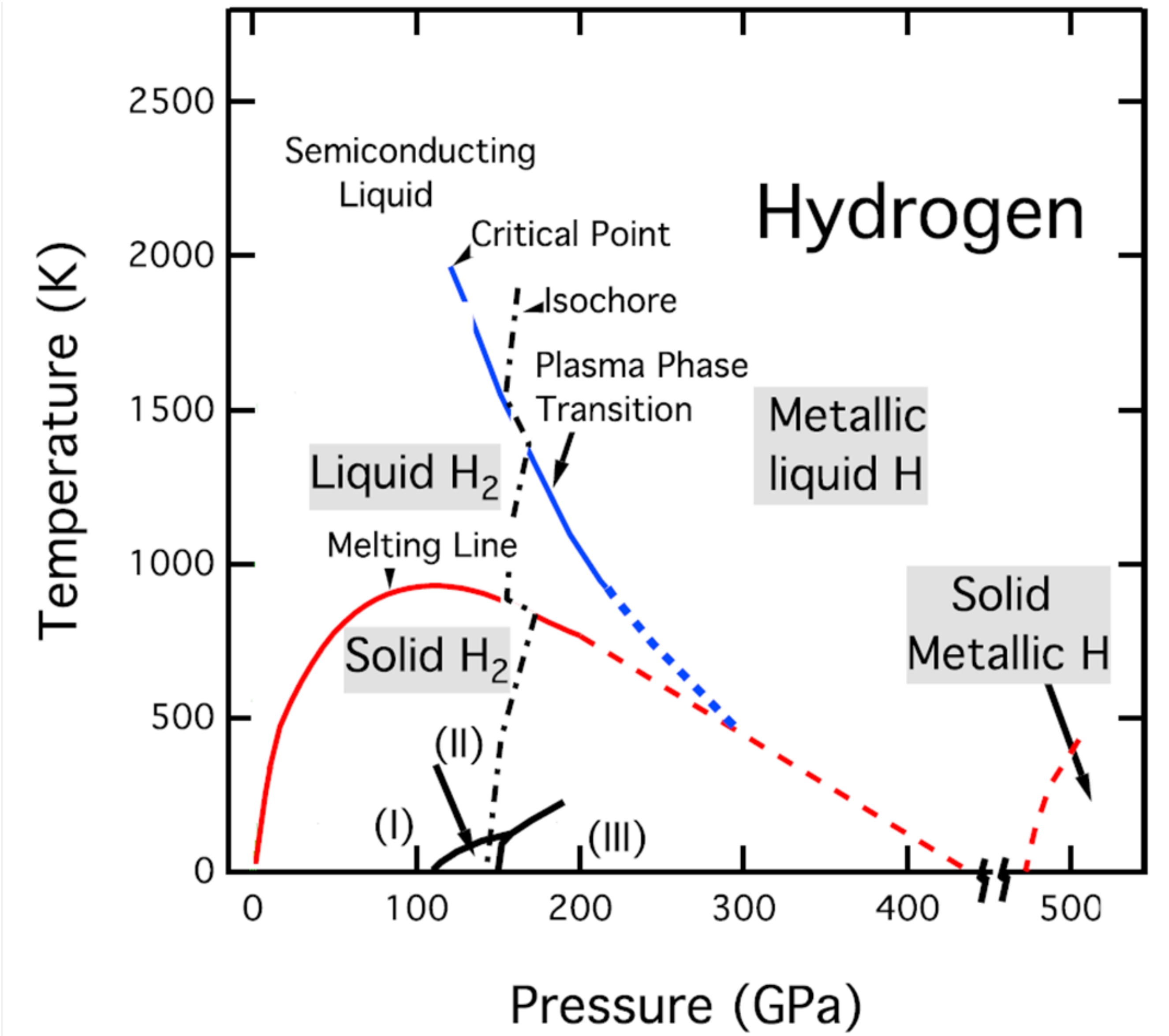


Fig. 2 : Phase diagram of hydrogen. The blue line represents the molecular-to-monatomic liquid transition (Plasma Phase Transition) and red line shows the melting line. Black lines are solid phase boundaries separating I, II and III.

hydrogen formed under extremely high pressures and temperatures entails conditions beyond the reach of current techniques for large-scale synthesis. Furthermore, despite being metastable over a large pressure and temperature range, it is often not stable at ambient conditions. Nevertheless, the quest is to generate materials with properties that exceed those of the materials that currently exist. Mixtures of molecules allow for the possibility of tuning properties and even generating novel properties. These can occur due to the incorporation of small atoms or even extra electrons within the lattice, possibly generating internal or chemical pressure and thus "pre-compressing" the material. Although metallic hydrogen has not yet been produced, it can revolutionize rocketry, in which case the world as we know would be dramatically changed and certainly unlock the secrets of the universe to make the unknown known.

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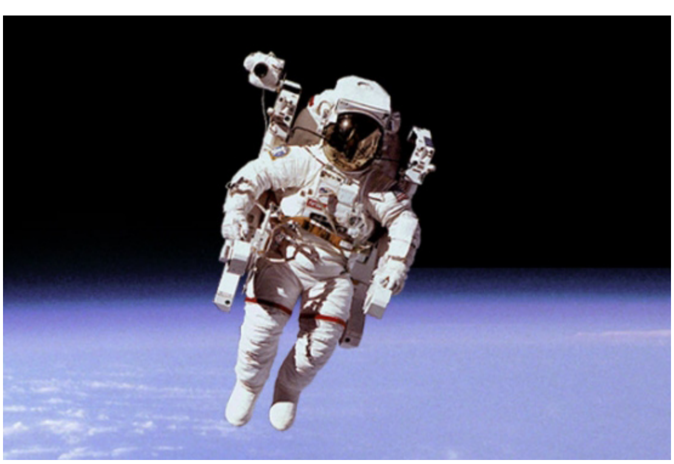
Zero Gravity Research Related to Human Body and Medicine

Assistant Prof. Kumari Andarawewa

The human body has evolved by adapting to Earth's gravitational field, and the biological structure and mechanisms of the body have developed to suit normal Earth gravity. When the Earth is in orbit, the astronaut's body is still acted on by gravity, but much more weakly because of the distance. In addition, the speed acquired by the spacecraft to send the astronaut into space partially counteracts the gravitational force that continues to act on the spacecraft. This is the law of inertia. Thus ultimately gravity disappears, and the astronaut's body becomes weightless. An astronaut is in free fall when orbiting Earth. The reason why the astronaut floats inside the spacecraft is that he or she is falling at the same speed as it is. Naturally the astronaut does not fall to the Earth, despite being in free fall, because the speed imparted to the spacecraft keeps it in orbit. Both microgravity and floating have an impact on an astronaut's body in space. The effects of gravity on our bodies and the biological mechanisms involved in adapting to weightlessness are studied under real microgravity conditions. Research on astronauts has shown that body function is disturbed in microgravity. Space agencies are therefore continuing their research in the hope of eventually reducing or eliminating some of these undesirable physical effects that appear during a stay in space.



Protecting human beings against extreme environments requires an understanding of the underlying physiologic changes resulting from exposure, and the degree of medical risk associated with such exposure.

The problem that must be overcome for long duration space missions is the harmful effects of weightlessness. These effects include loss of bone density, muscle mass and red blood cells, fluid shifting from the lower to upper parts of the body, cardiovascular and sensory-motor deconditioning, and changes in the immune system. Such reactions by the body might be appropriate for zero-gravity flight, but are inappropriate when returning to the surface of our planet or another planet. Ensuring health, safety, and effective performance of astronauts are critical for human exploration of space. NASA Glenn Research Center's Human Research Program plays a vital role in providing solutions to critical problems that place human exploration missions and their crews at risk. These efforts are directed in support of the Johnson Space Center, which leads NASA's Human Research Program. Current focus is on three main projects: Exercise Countermeasures, Digital Astronaut, and Exploration Medical Capability.

Exercise Physiology and Countermeasures Project

This project at NASA's Glenn Research Center supports the lead project office at NASA's Johnson Space Center in developing exercise countermeasure prescriptions and exercise devices for space exploration that are effective, optimized, and validated to meet medical, vehicle, and habitat requirements. A countermeasure can be defined as a therapy, procedure or device used to prevent or minimize adverse health effects that could result from spaceflight, (e.g. bone loss or weakened muscles). An exercise countermeasure prescription is a set of instructions for exercise that include the type of exercise device to be used as well as how long, how often and how strenuously it should be used. The prescription also measures the effectiveness of the exercise as a countermeasure.

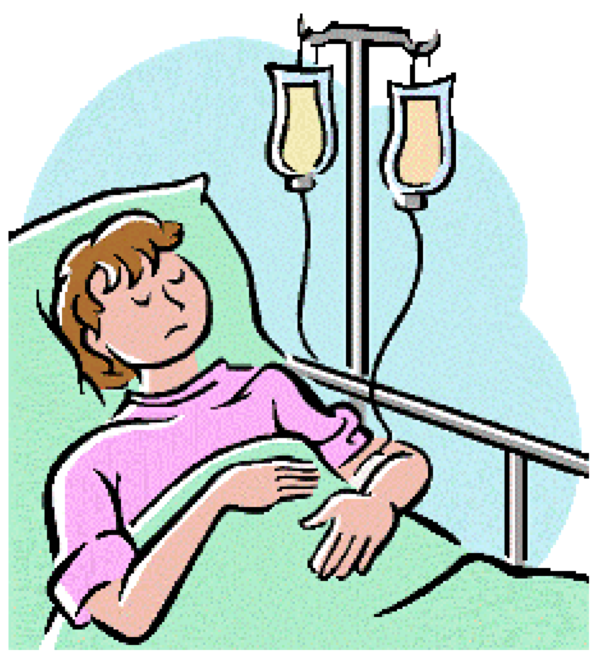
Digital Astronaut

The NASA Human Research Program Human Health Countermeasures Element chartered this project. This project is an effort to utilize deterministic simulations of human physiological functions to answer targeted questions about changes associated with the microgravity environment. The project is currently focusing on several areas, one of which is quantifying the effects of exercise. In spite of attempts to use exercise to counteract losses in bone density and muscle tone during spaceflight, the problems continue, with longer flights generally correlating with greater loss. In an attempt to quantify the response to exercise, the project personnel created a model of the advanced resistive exercise device that astronauts currently use on the International Space Station (ISS). The team is currently integrating both models, with the goal of quantifying muscle force and joint torque produced by the exercise. Data produced by these simulations will allow exercise physiologists to design better exercise prescriptions for the astronauts.

In conjunction with the exercise models, project scientists are also developing computational simulations of bone remodeling and muscle function.

In the case of bone, no current analytic formulation is able to describe the effects of muscle stress, strain, and gravitational loading on bone remodeling. Bone tissue is actually in a perpetual state of flux, with old tissue constantly being destroyed and new tissue created. In healthy individuals living in earth's gravity field, these effects balance. In microgravity, however, tissue formation in weight bearing regions of the skeleton slows dramatically, leading to bone loss. These simulations should provide key insight into how the turnover process proceeds in microgravity, as well as providing recommendations for the daily amount of loading required to counteract the effect.

Finally, many astronauts return from space with vision changes, presumably caused by an increase in cerebral-spinal fluid pressure. This pressure change is likely to be the result of the well-known head ward fluid shift that occurs as soon as human beings enter microgravity. Scientists are currently conducting a survey to determine what



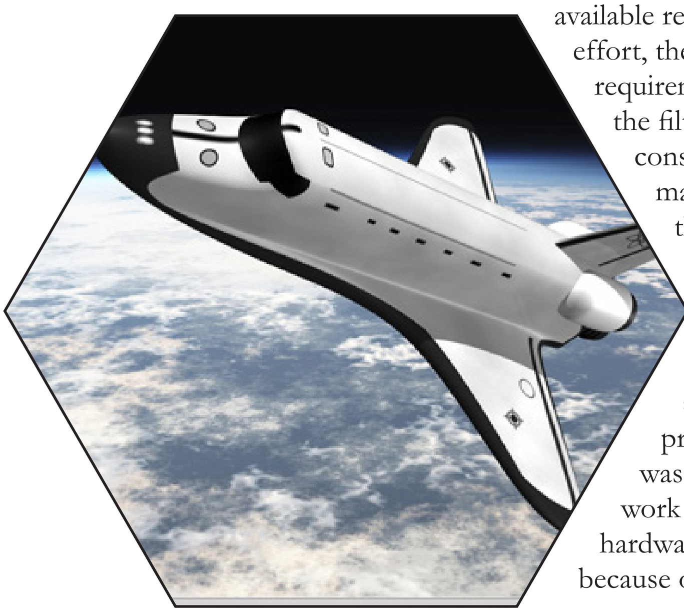
computational tools and data sets are available to simulate this problem. When that is complete, the team will use a combination of existing and custom tools to develop a simulation quantifying this effect.

Exploration Medical Capability

When traveling in space, astronauts are exposed to many changes in their physical environment that can harm their health. For example, astronauts lose up to 2% of their bone mass in weight-bearing areas of the skeleton, and fluid shifts combined with lack of resistive motion can harm cardiovascular performance. Since future exploration missions will be much longer and more physically demanding than previous missions, NASA must expand its efforts to ensure the health and safety of the astronauts. NASA's Human Research Program consists of several projects to improve astronaut health during exploration missions, of which the Exploration Medical Capability Project is one. The componants of the project at the Glenn Research Center consists of several tasks, which include development of hardware to produce IV fluid from resources onboard space vehicles, the Integrated Medical Model (IMM) to quantify the risks associated with exploration missions, and the sensors to monitor astronaut health.

Intravenous Fluids

In the event of a medical emergency, astronauts may require IV fluids to take drugs or rehydrate crewmembers that are unable to swallow. If it is to be used intravenously, water must be appropriately sterilized and mixed with the required drugs or electrolytes. The goal is to meet the requirement for IV fluid during exploration missions by constructing a filtration system that will generate fluid using available resources. In this effort, the fundamental requirement is that the filtration system consumes less mass and volume than would the equivalent amount of water that the filtration system is able to produce. Glenn was assigned the work to develop hardware such as this because of the center's expertise in microgravity fluid physics. Glenn has partnered with ZIN Technologies to identify water purification and mixing technologies that will function in microgravity environments and will be easy to operate in emergency situations.



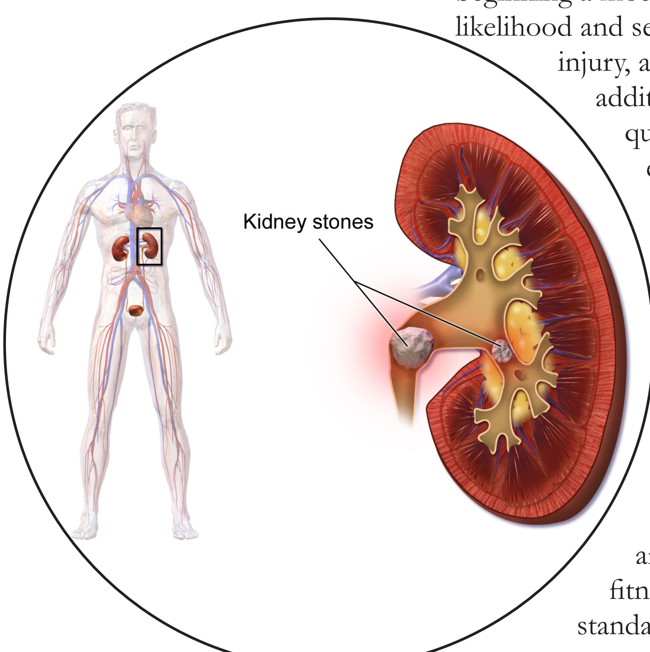
Integrated Medical Model

What will happen if an astronaut falls during a spacewalk on the moon? Is a bone fracture likely to occur? Can this injury be treated effectively? What if the same event occurs on Mars? What will be the consequences? Treating medical conditions in microgravity can be very challenging. Microgravity can make stabilizing an injured body very difficult. The limited space within the spacecraft does not allow for excess equipment to be stored for possible medical treatment if the risk of injury is low. Decisions must be made quickly using the available resources to preserve an astronaut's life. Glenn is using clinical and biomechanical analyses of bone fractures that occur on Earth to develop a bone fracture risk module. Using this computer model, the data from the analyses on Earth will then be translated to conditions on the moon and Mars. A significant effect of microgravity is the reduction of an astronaut's bone mineral density and bone strength, which can make his/her bones more susceptible to fracture. Though gravity is reduced in space, an astronaut could still fall and injure him/her self during a space walk on the moon or Mars. As mentionaed earlier, Glenn is using clinical and biomechanical analyses of bone fractures that occur on Earth to develop a bone fracture risk module. Based on current flight experience and the best Earth-based clinical evidence, this model is designed to estimate the likelihood and health impact of fractures during exploration missions. Using this computer model, the data from the analyses on Earth will then be translated to conditions on the moon and Mars.

Kidney Stones

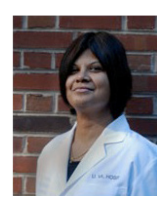
As another part of the IMM, Glenn is also developing a model to assess the risk of kidney stone formation during long duration exploration missions as well as after an astronaut has returned to Earth. This condition can occur due to an increase of calcium in the blood, which is a result of bone loss during space flight. As an additional complication, astronauts become dehydrated in microgravity, which may also increase the risk for kidney stone formation. As part of the integrated model, the bone fracture risk and renal stone models will help NASA predict the likelihood of occurrence as well as the outcome of treatment. In the future, Glenn plans to create a simulation model to help predict behavioral health changes in astronauts during and after a mission. Once completed the integrated model will establish improved safety guidelines and fitness for duty standards for astronauts.

In addition to the above simulations, Glenn is also developing a module predicting the likelihood that an astronaut will need a sleep aid due to sleep schedule disruptions. Glenn is also beginning a model quantifying the likelihood and severity of a head injury, and will conduct additional analyses quantifying the expected incidence rate of glaucoma, stroke, and seizure. The IMM is an ongoing effort to quantify risks to astronauts, guide mission planners in improving safety, and helping improve fitness for duty standards.



Kidney Stones

As a spin-off from other research efforts, Glenn has developed sensors that are capable of taking metabolic measurements inside space suits. One example is the portable unit for metabolic analysis (PUMA). It measures the amount of oxygen an astronaut consumes and the amount of carbon dioxide produced. When combined with its heart rate measurement, PUMA software quantifies how hard the astronaut is working. This information helps the astronaut manage and conserve the limited supply of consumable resources available within the space suit. Additionally, the data are used to present the most accurate picture of the astronaut's fitness level and to prevent the astronaut from working past the point of exhaustion. In addition to the above research, there are a number of other projects conducted on microgravity. All these projects will help in understanding and predicting the effects of spaceflight on the human body. Such knowledge will allow us to establish meaningful mission requirements for health and safety. (Source: NASA news, features & press releases)



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Sir Arthur C Clarke: Satellite Pioneer and Space Visionary

Nalaka Gunawardene

Sir Arthur C Clarke was the world's best known writer of science fiction at the time of his death in March 2008, aged 90.

In a remarkable career spanning over six decades, he wrote around 100 books and more than 1,000 short stories and essays. Among his best-selling novels were *Childhood's End, 2001: A Space Odyssey and Rendezvous with Rama.*

But Clarke was much more than an imaginative writer of science fiction. Trained in physics and mathematics, he also wrote many books and essays of non-fiction related to space travel, communication technologies, underwater exploration and future studies.

For decades, he was one of the world's leading promoters of space exploration. He advocated the peaceful use of space technologies and the wise use of information technologies for the benefit of all humans.

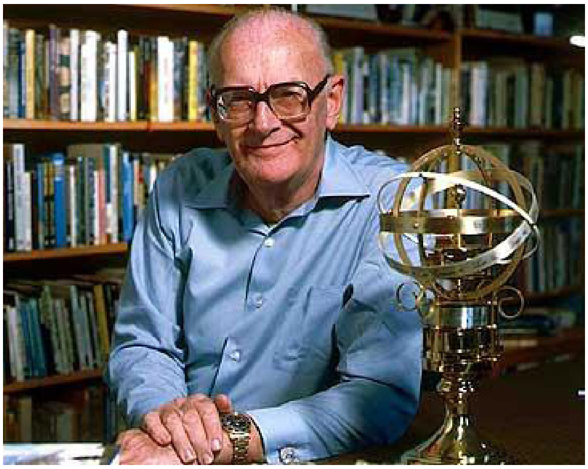
Born in Minehead, Somerset, England, in 1917, Arthur Charles Clarke was educated at Huish's Grammar School, Taunton, and later at King's College, London. In the late 1930s, Clarke worked in the British Exchequer and Audit Department, and then served as a radio instructor in the Royal Air Force during World War II. He became a full time author in 1950.

His interest in astronomy and space started early in life. As a schoolboy growing up in rural England, he was an avid observer of the night sky using his own home-made telescopes. In 1934, while still 16, he became a member of the British Interplanetary Society (BIS) – an advocacy group of starry-eyed youth who believed that one day, humans would send spacecraft to outer space.

Years later, he became one of the most active members of BIS, and served as its chairman from 1947 to 1950, and again in 1953. The BIS is credited as a pioneering citizen group that encouraged governments to support space related research and applications.

Communication Satellites

One of Clarke's most important ideas was expressed in a scientific paper in the October 1945 issue of *Wireless World,* a technical journal. In that paper -- titled *Extra-terrestrial Relays: Can Rocket Stations Give World-wide Radio Coverage?* -- he was



Sir Arthur C Clarke

the first to outline the principles of global broadcasting via communication satellites (comsats) placed in geosynchronous orbit.

He later described how war experiences had influenced his thinking.
During World War II, which lasted from 1939 to 1945, Germany used rocket technology to bomb Britain from afar. Those attacks created a bad image for rockets, but Clarke showed how the same technology can be used for peaceful purposes -- such as launching artificial satellites into orbit.

Focusing on their use for telecommunications and broadcasting, he looked for the most efficient way to provide planetary coverage with the fewest number of satellites.
Satellites in lower orbits circle the earth several times a day, but the higher a satellite is placed, the longer it takes to complete a full circle or orbit. Clarke calculated that at a certain point -- about 42,000 km or about 26,100 miles from the center of the Earth – a satellite's orbit would take exactly 24 hours.

This is the same as the Earth's rotation (which we call a 'day'). A satellite placed in such an orbit would appear to be fixed or stationary above the same point on the planet. Such a vantage position is ideal for broadcasting purposes: Clarke found that three satellites placed there over the equator could cover the entire world.

At that time, space travel was still a speculation among enthusiasts. Even Clarke did not expect Comsats to become a reality during his life time. But the dawn of the Space Age was only a dozen years ahead in the future (Soviet Union sent up Sputnik 1 in 1957). The first commercial comsat, named Early Bird, was launched in 1965 and many more followed.

Clarke never patented his idea, and earned no money from the concept that soon led to a multi-billion dollar satellite industry.
He preferred to be called the 'Godfather of Comsats', giving credit to the many engineers and technicians who actually built and launched them. In his honour, the geostationary orbit is now known as the 'Clarke Orbit'.

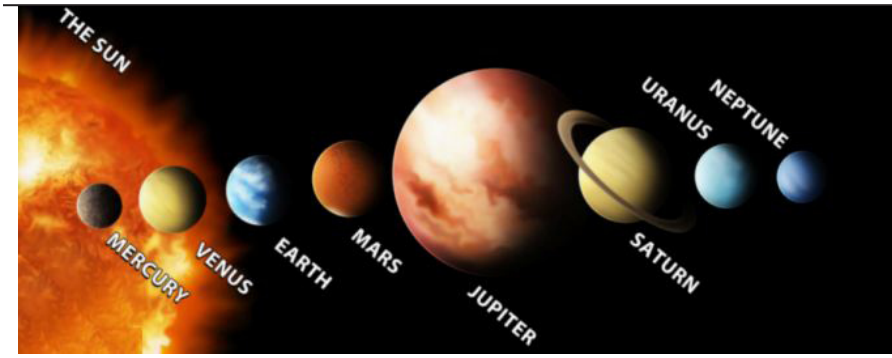
Space Travel

In the late 1960s, Clarke was closely associated with the Apollo programme that landed a dozen American astronauts on the Moon. He joined CBS network in providing live TV coverage of Apollo missions in 1969-70. He also wrote a substantial epilogue for *First on the Moon* (1970), the official memoir of the first humans to land on the Moon (Neil Armstrong, Edwin Aldrin and Michael Collins).

Early on however, Clarke realised that the true future of space travel lay in developing affordable alternatives to the extremely high cost rockets used for early launches of manned and unmanned spacecraft. For example, the Apollo programme cost a total of US Dollars 25.4 billion (at the time).

Writing in 1969, he predicted: "The closing years of this century should see the beginnings of commercial space flight, which will be directed first towards giant manned satellites or space platforms orbiting within a thousand miles above the earth's surface."

It took a little longer, but Clarke lived to see the early successes of privately funded space travel efforts, which ended decades of monopoly by governmental space agencies using taxpayer money. Agencies like NASA and (Russian space agency) Roscosmos were pathfinders, but will soon have to share space exploration with private ventures, he said in 2007.



Solar System

In October 2007, he wrote: "As the Space Age completes half a century, commercial space flight is beginning to be technologically feasible -- and will soon become economically viable. Before the current decade is out, fee-paying passengers will be experiencing sub-orbital flights aboard privately funded space-planes, built by a new generation of 'astropreneurs' with an unstoppable passion for space. And over the next 50 years, thousands will gain access to the orbital realm – and then, to the Moon and beyond."

In Clarke's view, one grand idea that could make space transport cheap and affordable was the Space Elevator. First developed by the Russian engineer Yuri Artsutanov in the early 1960s, it is a daring yet simple concept.

Comsats demonstrate how an object can remain poised over a fixed spot on the equator by matching its speed to the turning earth. If a cable can link such a satellite to the ground, payloads could be hoisted up it by purely mechanical means, reaching orbit without any use of rocket power. Like all elevators, it would run on electricity.

Clarke noted: "What makes the Space Elevator such an attractive option is its cost-effectiveness. The actual electrical energy required to go to space, if you purchase it from your friendly local utility, would cost around a hundred dollars. And a round-trip would cost only about one tenth of that, as most of the energy could be recovered on the way back!"

Clarke popularised the Space Elevator in his 1978 novel *The Fountains of Paradise*, which takes place in the 22nd century in the equatorial island of Taprobane -- a thinly disguised version of Sri Lanka.

Clarke's strength was that he wrote both plausible science fiction stories as well as accessible science fact. Through these, he appealed to different types of readers. Many astronauts, space scientists and engineers from around the world have acknowledged that they were inspired to pursue their careers by reading Arthur C Clarke books early in life.

The policy impact of Clarke's technical and fictional writing has yet to be properly assessed. For example, it was only decades later that he found out how the US space pioneer Dr Wernher von Braun had used his 1952 book, *The Exploration of Space*, to convince President Kennedy to go to the Moon. In a famous speech on 25 May 1961, Kennedy set the national goal of "landing a man on the Moon and returning him safely to the Earth" before the end of the 1960s.

Perhaps Clarke's greatest single contribution to popularisation of space was the movie 2001: A Space Odyssey, which he co-wrote with acclaimed film director Stanley Kubrick. From 1964 to 1968, the duo collaborated on this extraordinary cinematic venture which was expanded from Clarke's 1950 short story called *The Sentinel*.

The futuristic film, whose story takes place in the opening year of the new millennium (2001), was released in April 1968 — and went on to become one of the finest science fiction movies ever made. The movie played a key role in placing space exploration in the wider context of human evolution.

The movie was based on painstaking research and consultations with experts and research institutes on what the world of 2001 might look like. The special effects, all done manually (computer generated imagery was not available at the time), sought to create the feeling of being in space.

When cosmonaut Alexei Leonov, who in March 1965 became the first man to 'walk' in space, saw the movie, he exclaimed: "Now I feel like I've been in space twice."

Terrestrial Uses

Clarke did not just sit in his Colombo home dreaming up technologically-enabled futures for humanity. He also played an active role in creating that future – by mentoring various technical professionals, advising the United Nations and governments, and critiquing the progress of information and communication technologies, or ICTs.

His advice was sought and valued by space agencies in the US, Russia and India. During 1975-76, he advised the Indian Space Research Organisation (ISRO) on the world's first use of comsats for direct television broadcasting aimed at rural audiences. Known as the Satellite Instructional Television Experiment (SITE) Project, the pioneering exercise beamed TV programmes on health, agriculture and other development topics to millions of people in 2,400 villages across India.

During this time, he also spent sometime at the Physical Research Laboratory in Ahmedabad, India, as a visiting professor. Grateful for advice, the Indian government gifted Clarke with a large satellite dish antenna in 1975. Using it, he was able to capture satellite TV transmissions over the Indian Ocean. His home thus became the first household in Sri Lanka to have a working television set (before TV broadcasting started in 1979).

It seems he also inspired the World Wide Web. In his 1964 short story, *Dial F for Frankenstein*, Clarke speculated the world's inter-connected telephone system becoming a conscious entity that then takes over the world. British computer scientist Tim Berners-Lee has acknowledged how this story inspired him to invent the web in 1989.

Clarke cheered when ICT tools empowered ordinary people and activists to benefit from the free flow of information, artistic creativity and the defence of human rights. He watched how government censors were undermined first by comsats and then by the web.

Clarke was intrigued by the 'CNN Effect' – the impact that CNN and other global news channels have on how states conduct their foreign policy relations in today's globalised world. In his 1992 book *How the World Was One*, he described a dream: one day in the near future, CNN founder (and then owner) Ted Turner is offered the post of World President, but he politely turns it down – because he did not want to give up real power!

The 'CNN Effect' played a part in inspiring global aid flows to the Indian Ocean rim countries that were devastated by the tsunami of December 2004. Clarke -- whose diving facilities were also destroyed in the disaster – readily offered free advice to governments, relief agencies and the media in the days and weeks that followed.

While strongly believing in the problem solving potential of science and technology, Clarke was well aware of the socio-economic disparities that prevented many people from accessing or benefiting from ICTs.

Legacy Continues

For 23 years (1979 – 2002), Clarke was chancellor of Sri Lanka's University of Moratuwa which trains most of the country's engineers and architects. This ceremonial position entailed presiding over the annual convocation, but in his own right, Clarke was a designer of the future and a 'builder of bridges' – between hardcore science fact and credible science fiction, and between knowledge and imagination.

During his illustrious career spanning over 60 years, Sir Arthur C Clarke received a large number of honours, awards and accolades from scientific, academic and literary bodies worldwide. At one time or another, he won all the top science fiction literary awards. He received honorary doctorates from universities in the east and west. In 1998, Queen Elizabeth II knighted him for his 'services to literature'. In his adopted homeland of Sri Lanka, where he lived 52 of his 90 years (1956 to 2008), he received the highest presidential honour for science (Vidya Jyothi, 1986) and the highest civilian honour (Lankabhimanya, 2005).

The legacy of Arthur C Clarke lives on – in his many books, and through the many people whose imagination he sparked.

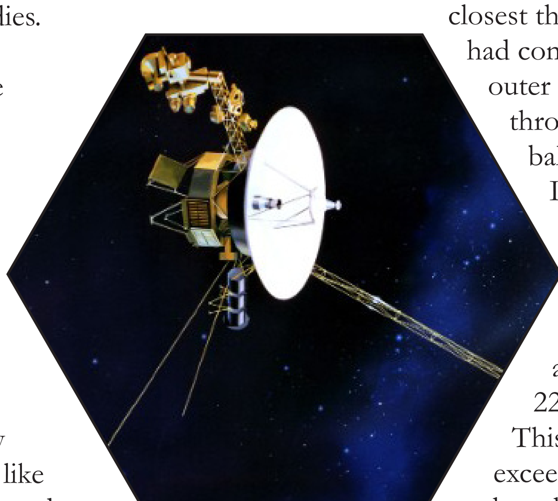
Nalaka Gunawardene
[Science writer Nalaka Gunawardene worked with Sir Arthur C Clarke from 1987 to 2008 as his research assistant and media coordinator.]

Space and Science Fiction

S.M.Banduseela

From the very early stages of human civilization, people were fascinated by the vast space above them. They observed the sky with naked eyes and formulated various theories on what they saw. As usual at that time, all natural phenomena which they could not understand were attributed to gods or spirits. However as early as 1300 BC Chinese scholars have recorded the eclipses of Sun and the Moon. Later the Babylonians and the Egyptians made great advances in the knowledge of the sky and the heavenly bodies.

People in the past thought the universe consisted of the sun, the moon, the planets and the stars. It was only in the 15th Century astronomers like Corpernicus made new discoveries. The invention of the telescope expanded our understanding of the cosmos further. According to modern cosmology universe consist of billions of planetary and star systems and is continuously expanding.



Conquering the Space

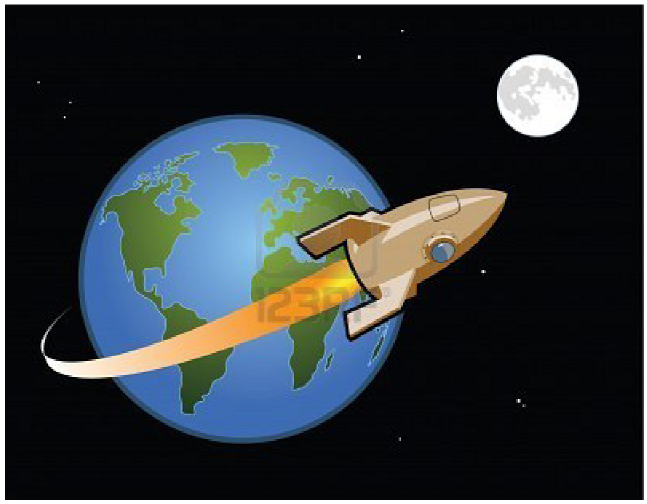
Although Man always wanted to conquer the space he did not have the means. Prior to the advent of reliable rocket technology, the closest that humans had come to reaching outer space was through the use of balloon flights. In 1935, the U.S. Explorer II manned balloon flight, reached an altitude of 22km (14 miles). This was greatly exceeded in 1942 when the German A-4 rocket climbed to an altitude of about 80km (50 miles). In 1957 Russian satellite Sputnik 1 went up to an earth orbit at an altitude of 215-939 km (134-583 Miles). The first human being to go into space was Yuri Gagarin. He was sent into an earth orbit in 1961. Three Americans escaped from the earth and went into a lunar orbit in 1968 on board the U.S. Apollo 8 which reached a maximum distance of 377,349km (234,4374 Miles) from earth. Human beings landed on the Moon in 1969 with the successful completion of Apollo 11 programme.

By now many unmanned space craft have successfully examined each of the Solar System's planets as well as their moons and many comets. Unmanned space crafts are a fundamental tool for the exploration of outer space as well as for observation of the earth. In August 2012, Voyager 1 became the first manmade object to leave the Solar system and enter interstellar space.

Early Science Fiction

Centuries before scientists started thinking of exploration of outer space, science fiction writers have discussed these issues in their stories on space and space travel. Some were written even before the advent of the scientific age. Arthur C Clarke in his address to the British Interplanetary Society in 1950 had divided these early stories into two groups. In stories that could be classified as mechanistic, some engine or technical device, more or less plausible according to the science of the time is used to bridge space. The second category consist of all those stories in which dreams, supernatural intervention or psychic forces are invoked. Most of the very early writings are in this non-mechanistic category.

Proto science fiction started appearing few centuries ago. It is no surprise that the most popular theme was space travel. The very first moon voyage story was written by Kepler, who discovered the laws governing the motion of the planets. He was a scientist as well as a mystic. The story titled Somnium was written in 1643 but was not published until after his death. Although he employed demons to carry his hero to the Moon, Kepler has foreseen two of the most important features of space travel. In this story he makes the point that as the hero leaves the Earth, air becomes rarefied and after some time it is not necessary to use any force for propulsion. At the end of the story it is revealed that the whole adventure is a dream. It is a device that has been used often in stories of this kind. Another technique used by some writers in this period was some trance like state, where the mind or even the body travels across space to other worlds.



Jules Verne's pioneering novel 'From the Earth to the Moon' was the first fiction to treat space travel as an engineering problem. This story published in 1865, dealt with issues such as loss of gravity and lack of air. Verne used a mammoth cannon to send a projectile to the moon. He took the trouble to check his astronomical facts and figures and had the ballistics of the projectile worked out by his brother in-law, who was a professor of mathematics. In spite of the impossibility of this mechanism, Verne must be given the credit for conceiving many features common to present day space vehicles, such as hydraulic shock absorbers, air conditioning and padded walls.

Another milestone publication in the science fiction literature is *First Men in the Moon* by H.G.Wells published in 1901. Wells invented an anti-gravity substance called "cavorite" which made the vehicle fly away from earth. Control was maintained by rolling up the sections of the cavorite towards the body that one wished to approach. The mechanism envisaged by Wells was much simpler than the noisy and messy rockets! However we should not dismiss the anti gravity device as an impossibility. This sounds similar to the 'space drive' used by many present day writers to reach the far corners of the universe.

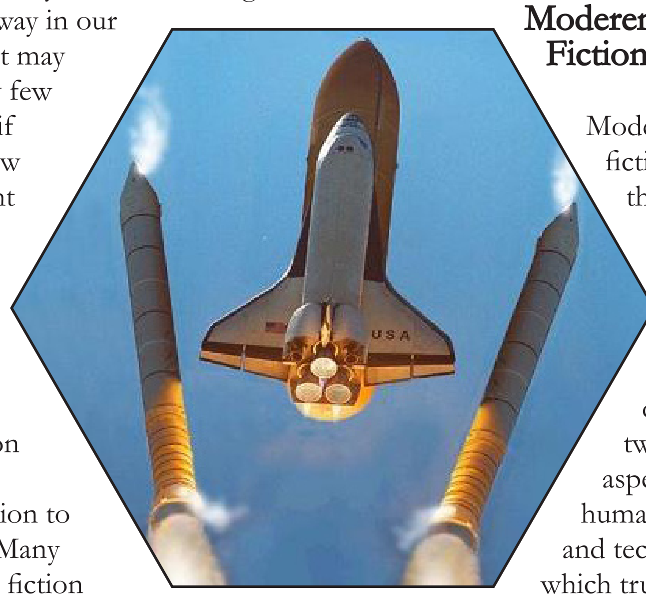
One of the first writers to use rocket for interplanetary travel is Cyrano de Bergerac in his *Voyages to the Moon and Sun* published in 1656. Since the Rocket technology came on the scene few centuries later, he was not very knowledgeble about the mechanism of rocket propulsion. The motive power was provided by vials of dew around his waist. His argument was that as the Sun sucked up the dew in the morning it would carry him up with it. However he should be given credit for introducing the idea of using rockets to conquer space.

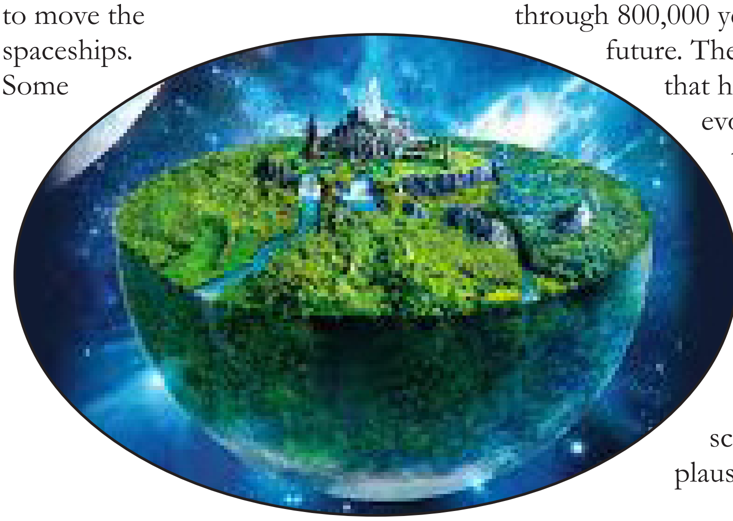
Rocket Propulsion

Although the rocket or some form of fire work was used in the space travel stories for a long time, it became prominent only in the late 19th Century. Verne used this device in his *Round the Moon* navation published in 1870 to alter the orbit of his projectile. With the scientific work on rockets becoming known among the writers, most of the stories that appeared in the Science Fiction Magazines during 20th century had very convincing technical details on rocket propulsion.

Other aspects discussed in science fiction stories with regard to space travel are the types of social systems encountered in other worlds, difficulties of communication and the reaction of extraterrestrial beings to their unexpected human visitors. Another issue taken up by the science fiction writers is the time taken to cross these immense distances and the aging of astronauts. Arthur C. Clarke in his landmark story *2001-A Space Odyssey* placed astronauts in frozen hibernation in order to complete the long journey. Some writers have taken advantage of relativistic slowing of time at high speeds while some have used the mechanism of a large ship – actually a small world- whose passengers were ready to spend millions of years and countless generations, to reach their destinations.

Some writers such as John W. Campbell have used principles of wave mechanics and uncertainty to move the spaceships. Some have made use of concepts such as non-Euclidean or multidimensional space. Although Andromeda Nebula may be million of light years away in our space, it may be only few inches if we know the right direction or the dimension to move. Many science fiction writers have found this direction to move their spacecraft and astronauts through space, and one day science may discover the same!





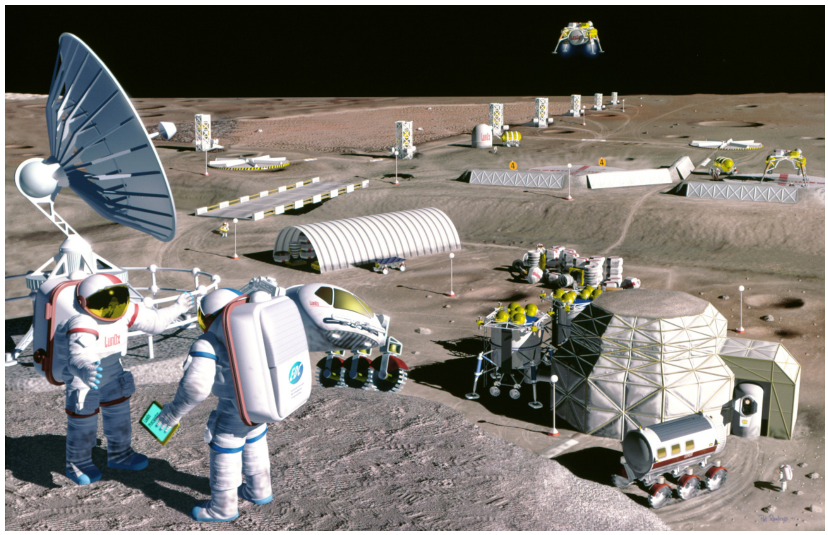
Another closely related subject is the time travel, which has been used by many writers. However the first science fictional time travel story is *The Time Machine* by H.G.Wells published in 1895. Wells made use of a mechanical device to travel through time. In this story a 19th century time traveler is taken through 800,000 years to the future. There he finds that humanity has evolved in to two races, one feeding on the other. Later writers of course used more scientifically plausible concepts, than mechanical devices, to travel though space and time.

Moderen Science Fiction

Modern science fiction is the most penetrating of all literary genres because it deals with two basic aspects of humanity –ideas and technology- which truly makes us human. Without new ideas and technology Homo sapiens would have never become human. These two concepts are still shaping the future of humanity into new and exciting directions. This phenomenon could be explored only through the medium of science fiction.

What is science fiction? Science Fiction is a form of literature for people who value knowledge and who desire to understand how things work in the world and the universe. Encyclopedia Britannica defines Science Fiction as the *form of fiction that developed in the 20th century and deals principally with the impact of actual or imagined science upon society or individuals' The term is more generally used to refer to any literary fantasy that includes a scientific factor as an essential orienting component*

According to the well-known science fiction writer Issac Asimov, Science fiction goes beyond the main stream literature in one aspect- it does not deal with society as it exists, but with societies that may exist in the future. Elaborating further this idea, he has said that “ *the successful science fiction story poses a social problem and suggests a possible outcome (though not necessarily a solution)”*



It is well known that many scientific developments and inventions were foreseen by science fiction writers. But, they did not succeed in anticipating everything connected with space travel. For instance all science fiction writers concentrated on space flight under direct human control and never realized what could be done by remote controlled probes. They foresaw computers but missed their true role in space flight. Science fiction writers also missed all sorts of activities that could be performed in space. Although they foresaw both television and landings on the Moon, no one anticipated reality by describing landing on the Moon that was watched by hundreds of millions of people on Earth as it happned.

Importance of Space

Addressing the first graduating class of the International Space University in 1988, Arthur C. Clarke emphasized the importance of space. *The resources of the universe are , by all human standards, are infinite. There are no ‘limits to growth’ among stars. Unfortunately there is tragic mismatch between our present needs and our capabilities. The conquest of space will not arrive soon enough to save millions from starved and stunted lives. Thus it is all the more urgent that we exploit to the utmost the marvelous tools that space technology has given us -comsats, weathersats, geosats and all the other sats yet to be invented. This is reason that the third world needs space technology even more urgently than the so called developed world.*

Outer space has long been the most popular venue for imaginative writing, and there is no doubt that fiction has helped to create reality. All the pioneers of astronautics were inspired by Jules Verne, and several others actually wrote fiction to popularize their ideas. Many American astronauts and Soviet cosmonauts have said that they were inspired to take up their careers by the space travel stories they read as children.

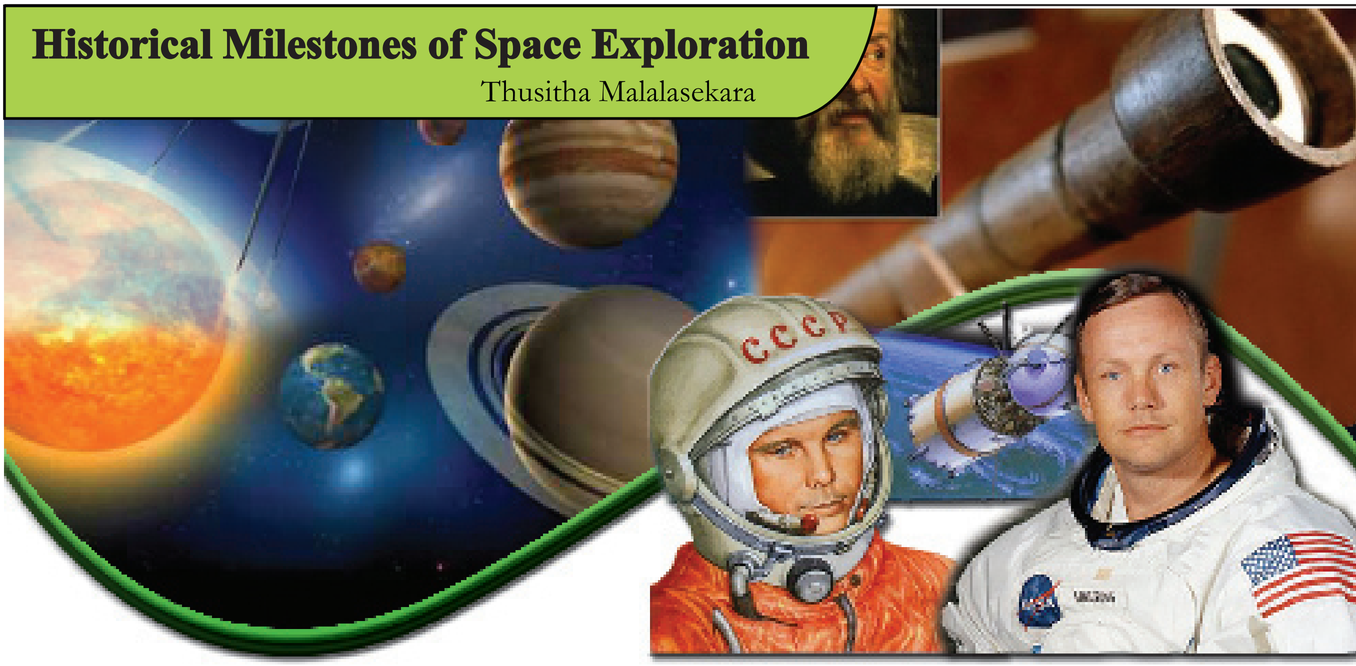
Even after space travel becomes in everyday reality, interplanetary science fiction will never lose its appeal. But certainly the approach of the future writers will be very different from past and present authors. Future writers will be no longer be writing about satellites and astronauts, but about the future effects upon ourselves of the consequence of these developments. For instance there will be new conflicts arising among mankind after the establishment of colonies on other planets. Such problems will be far more important than any number of engineering trivialities. It is those issues that will be the concern of future science fiction writers.

Commenting on the value of science fiction and understanding of the cosmos, Arthur C. Clarke has said that *Anyone who reads this form of literature must quickly realize the absurdity of mankind’s present tribal divisions. Science fiction encourages the cosmic view point. Perhaps this is why it is not popular among those literary pundits who have never quite accepted the Copernican revolution, nor grown used to the idea that man may not be the highest form of life in the universe. The sooner such people complete their education and reorient themselves to the astronomical realities the better. And science fiction is one of the most effective tools for this urgent job.*

S.M.Banduseela

Historical Milestones of Space Exploration

Thusitha Malalasekara



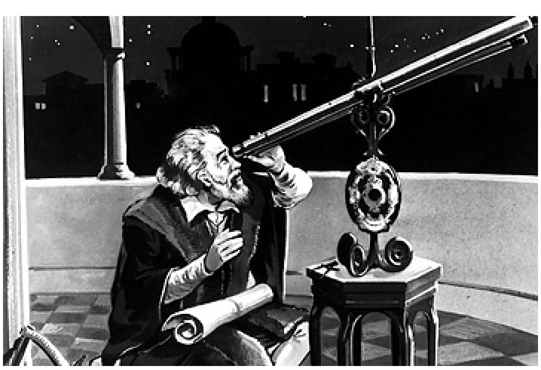
Humankind began exploring space not only for curiosity but also for the improvement of their knowledge. Listed belows are a few key milestones in space exploration since 1543 to date.

Earth is not the centre but only a planet in the solar system.

1543 – Polish astronomer Nicolaus Copernicus suggested that earth is just another planet that orbits around the sun.

First telescope to observe the solar system.

1609 – Italian astronomer Galileo Galile built a simple telescope to observe planets and proved that Corpernicus was right.



First Telescope

Birth of the rockets

1926 – The first liquid fuelled rocket was launched by Robert Goddard an American scientist. It reached a height of 12.5m in 2.5 second.

Prediction of the possible use of artificial satellites few communication.

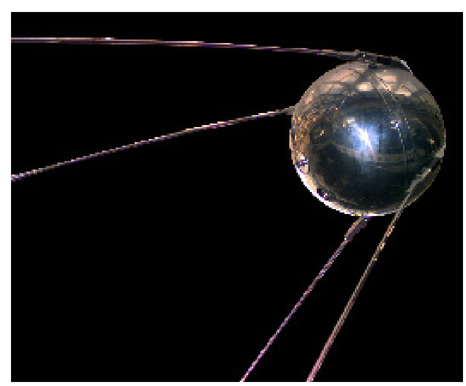
1945 – The possibility of using artificial satellites far global transmission of communication signals was first suggested by Arthur.C.Clarke.

First man made satellite

1957 – Spuntinick – 1 (USSR) the first man made satellite took 98 minutes to orbit the earth.

1957 – First living creature to be sent to space

Laika the female dog was strapped to Sputinick – 2 (USSR) and became the first living creature to be sent to space.



First Satelite

First glimpse of the rear side of the moon.

1959 – Luna – 3 (USSR) spaecraft was able to show the rear face of the moon for the first time.

First man to enter space.

1961 – Russian cosmonaut – Yuri Gagarin was the first human being in space. He was sent up in Vostok – 1 on 12th April 1961 for a 108 minute orbit.
(April 12th has been celebrated as the World Space Day due to this occurence)

Relay of first satellite television signals.

1962 – The first satellite television signals were relayed by the telestar satellite in 1962.

The first women in space

1963 – The first woman in space was the Russian cosmonout Valentina Theveshkova. Her flight in Vostok – 6 lasted 70 hours and 50 minutes. She orbited 48 times around the earth.

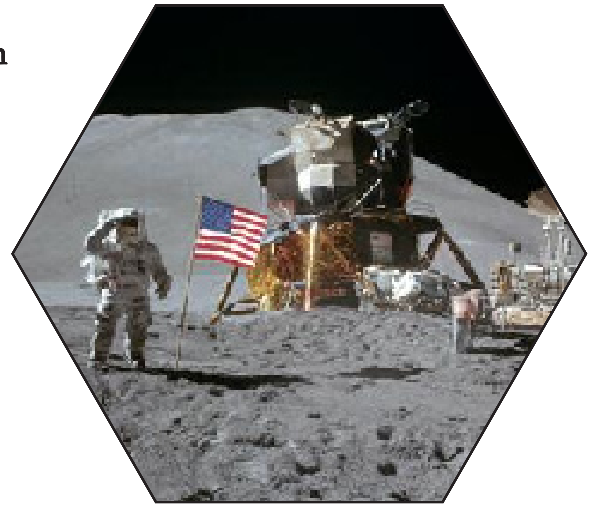
The first space walk.

1965 – The first man to walk in space (coming out from the space craft) was Alexi A.Leonor (USSR)

Space Shuttle

First human being to step on the moon

1969 – The first human being to step on the moon was Neil Armstrong from Apollo – 11 (US). This happened on 20th July 1969. He was followed by his collegue Edwin Aldrin while Michelle Collins commanded the Apollo – 11 (Mother ship) Armstrong and Aldrin landed on the moon on Eagle (The daughter ship). Apollo-11 was powered to space by Saturn –V rocket and was launched from Kennedy Space Center



First human being to step on the moon

First US space station

1973 – The first US space station named SKY LAB, went in to orbit. More than 300 experiments were conducted inside skylab before it perished in 1979 when re-entering the earths atmosphere.

Exploration of the solar system

1977 – Voyager 1 and Voyager 2 were launched to study the solar system, especially the planets Jupiter, Saturn and Urenus.

Launch of space shuttle

1981 – The first space shuttle was launched in April 1981. The partly reusable craft has taught immense amount above waring in space.

MIR –the Russian space station

1986 – The first of MIR, the Russian space station was launched. It was the first permenent resident in space.

International space station

1998 – The first part of the international space station was launched in 1998. Powered by large solar panels it orbits the earth at an altitude of 360km.

Photos from Saturn

2004 – Cassim spacecraft exploring the Saturn started sending photos of that grand planet

Mars under probe

2012 – "Curiosity" the space research exploration craft has commened sending information regarding the planet Mars.

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