International Space Station

Dr. Uma B R

Space Books Series for Children
U R Rao Satellite Centre
Bengaluru-560017

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¨International Space Station”

in English by Dr. Uma B R,

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Chairman's Message

Scientific literature for children is an essential and distinctive literary work. It is to observe all the happenings around us from a scientific point of view and explain it in simple words. This endeavour can make a high school student understand complex subjects like astronomy, satellite and rocket technology, which is highly appreciable.

In this regard, U R Rao Satellite Centre, a prestigious research Institute in Bengaluru, has launched a new program called "Space Books Series for Children" through which it plans to bring out pocket-books on "Space Technology Space

Science and Space Scientists". This book, which is now in your hands, is one such work. This work a significant step toward enriching science literature for children.

Explaining various scientific and technical topics in simple language is necessary to inculcate interest in science among children. Similarly, it is essential to explain the scientific achievements of our organization to the masses and create awareness about it. The "Space Books Series for Children" programme will fulfil these requirements.

I congratulate the Director of U R Rao Satellite Centre for conceiving and implementing this programme. I hope more topics will be covered and reach more children and commoners in the coming days.

S. Somanath

Chairman, ISRO

Director's Message

Satellite, space science, technology and related topics should be explained in simple language so everyone can easily understand them. Such a literary effort will provide essential and authentic information, especially to the young talents of rural areas. Thus, it is a significant step in providing them with better opportunities and building a great future.

This work should be done by the skilled and experienced scientists of U R Rao Satellite Centre who have been working in this field of technology for five decades. To educate children about space science and technology, U R Rao Satellite

Centre is bringing out the "Space Books Series for Children".

Our enthusiastic colleagues have written books on these topics in response to this idea. It is a pleasure to put seven pocket-books of this series in your hands today. I congratulate the authors for their efforts and wish the program success. I want the students to develop interest and curiosity in these subjects. I also hope they understand the principles, get inspiration and create a better future, thereby contributing to the country's and society's overall development. I am confident that our objective will be realized and the desired result will be achieved.

M Sankaran

Director

U R Rao Satellite Centre

Editorial Board

Space Books Series for Children

Dear Children,

U R Rao Satellite Centre (URSC) celebrated its Golden Jubilee in 2022. On this occasion, the Karnataka Rajyothsava Committee of URSC had taken up the task of publishing a series of Kannada books on Space and SpaceScientists which have been translated into English for the benefit of students across the country.

Our committee plans to publish pocket-books in simple language to make school children easily understand many topics like space science, rocket and satellite technology, etc. These books are written by the scientists of our organization. As the first set of books in this series, seven books are published. Our aim is to provide electronic version of the books to children through our website.

Our committee is grateful to Shri M Sankaran, Director, URSC who is the key person behind the successful realization of these books. Our heartfelt thanks to Shri HN Suresh Kumar, Shri KV Govinda, Dr. M Ravindra, Smt. Lalitha Abraham, Smt. Anuradha S Prakasha and Smt. Sreedevi S for having reviewed all seven books in detail and suggested suitable modifications.

We are grateful to all the authors who took time off from their work and authored the books. We are thankful to all colleagues of our Centre who helped us to bring out these books.

If you read them and give your suggestions and comments, we will be able to incorporate the same in the next set of books in this series.

Ramanagouda V Nadagouda

President

Author's Note

ISRO's U R Rao Satellite Center is publishing short books to teach the basics of space science to children. As a part of that, a brief introduction to the International Space Station is written in this book.

In this book, how the International Space Station was formed, its background, design, structure of the station, various components in the ISS is explained in brief.

The book also describes the atmosphere in the space station, life of astronauts, observation of the station from Earth, control of the space station from the ground center, cost of the station, end of station life and de-orbiting plans of the space station, future space station and space station plans of India.

This book attempts to make children interested in knowing more about

the International Space Station and satellites, so that today's children can carry out research in the field of space and make their contribution to space science and satellite technology to improve the lives of common people.

My heartfelt thanks to Shri. M Sankaran, Director, U R Rao Satellite Centre, for giving me an opportunity to write this book. Salutations to Shri Ramanagouda V Nadagouda, Chairman of the Editorial Board of this book series and to all the seniors and colleagues of the organization.

I am thankful to my Mother Bhagya B P, husband Dr. B P Shivakumar and daughters Rakshita S and Rishita S for their continuous support and encouragement to write this book.

Dr.Uma B.R.

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1. Introduction

The International Space Station (ISS) is an artificial satellite research facility jointly developed by the world's five leading International space research organizations, and is also the largest man-made and habitable artificial satellite. Its size is about 500 sq.m. and has a weight of 445 tons. You can imagine a station 50 times the size of a Maruti car and that is ISS for you. It is installed in the near-earth orbit which is about 400 km above the earth. The space station can be used as a laboratory with microgravity environment. It can conduct many scientific research and studies about biology, chemistry, physics, medicine and human body. The information gained from this study will be useful in future space projects, space

medicine and manufacturing of alloys, among others.

2. Space station concept and design

Concept: The International Space Station is the research lab of the world's five major International space research agencies - the United States of America’s NASA (National Aeronautics and Space Administration), the European Union's ESA (European Space Agency), Japan's JAXA (Japan Aerospace Exploration Agency), Canada's CSA(Canadian Space Agency) and Russia's Roscosmos. The use and inheritance of this space station is governed by international agreements and treaties. It is the largest and most habitable artificial satellite ever in Earth orbit, built to conduct research in microgravity.

Built to make discoveries, its cost is estimated to be around 100 to 160 billion dollars. A project costing such a big amount is difficult for any country to manage on its own. Hence it has been formulated as an international project and under a five-nation coordination plan. Apart from the five International space research institutes mentioned above, this space station can be used by space research institutes of eleven other countries of the European Union to conduct experiments.

Design: The space station consists of multiple components, the first of which was launched in November 1998 to an orbit of 408 km altitude from the Baikanur launch centre in Russia. After that different units were moved to USA at different times. This space station is built by using

Russian launchers, organized and coordinated in space. It orbits the earth at a speed of about 7.66 km/s and it orbits the earth 15 times in a day. It is 73 m long, 109 m wide with an area of about

Docking is the techniques used to connect two orbiting satellites or two independent spacecraftin space.This process is very important in the space station and through this, docking of two units and the astronauts "spacewalk" is also carried out. This process is used to carry astronauts, essential luggage and equipments to Space station.

500 sq.m. Since its inception in November 1998, the station has been inhabited by astronauts from various countries and six astronauts live permanently on it.

Space shuttles are used to transport astronauts from Earth to the space station and from the station to Earth, and docking techniques are used to attach the shuttles to the station. The station is planned to operate till 2024.

3. The original purpose of the space station

Continuous research and development in space technology aided various countries of the world todevelop various satellites and run various space projects. All these missions have made valuable contributions to the development

of the satellite technology. Numerous satellites have been launched to study the solar system and other celestial bodies beyond. The International space station is a crucial projectin the space arena. The International Space Station project was conceived by USA, and its idea arose during the Cold War between Russia and USA. Various countries expressed interest in implementing the space station project.

In 1980, USA conceived Freedom Module and Russia hosted the Mir-2 project. International financial embargo, the end of the Cold War, internal trouble and financial crisis in Russia, interest of many nations in the International Space Station and the insistence of many nations on the project gave rise to this space station project as a collaborative venture.

Talks between the Russian and US Presidents heralded the realization of the plan, which was announced in September 1993. All nations agreed to contribute funds, provide various components and systems for this project. The project was implemented on November 20, 1998. Figure-1 shows the orbiting of space station around the Earth

Figure 1.International space station revolving around Earth

A space station is a habitable artificial satellite and is a platform for much research. It has a platform for experiments and research, a cold environment, a microgravity environment, and all the accommodation requirements for astronauts. The space station is used to conduct research in microgravity. It is used to carry out research in all fields of science like astronomy, medicine, physics, solar atmosphere, astro-medicine, astrobiology, chemistry, biology etc. Most of this research is continuously ongoing. The study of the effects of being for a long time in space on the human body and mental health is also important research. All the information obtained from this study will be useful for future space travel plans to

send humans to the Moon, Mars and the interplanetary space.

For example, it takes about six to nine months to reach Mars from Earth, and all the information gained from this research will be useful in understanding the impact of the long-duration space travel on the human body along with determining the feasibility of the concept of human habitat on Mars - an ambitious project of mankind.

The International Space Station (ISS) is one of the various technologies built by several nations in the development of space technology. It is planned to continuously orbit the earth and will be used to conduct experiments in space about new technologies that are useful to

the mankind. About once in six months, various spacecrafts from around the world have returned to Earth after carrying out research there. The International Space Station is shown in Figure-2. Astronauts spend about ~160 hours (total man-hours including all astronauts present in the station) in a week for research. This includes various experiments conducted by astronauts, station maintenance, maintenance of various systems /components, etc. Also, collection and arrangement of depleted resources is also one of the duties of astronauts. So far, around 244 astronauts from 19 countries have visited the space station and performed many experiments.

Figure-4 shows the food and drinks required by the astronauts while on the

ISS. Their resting sleep compartment is shown in Figure-5.

4. Scientific research

Approximately 3000 experiments have been conducted so far in the International Space Station. They can be broadly categorized as follows.

• Effects on objects, materials and metals in a microgravity environment.

• Effects of space atmosphere on human body and mental health during long periods in space. The results will be used by the National Space and Biomedical Research Institute (NSBRI) in future space missions.

• Research in many fields of science like astronomy, medicine, physics, solar

atmosphere, astro-medicine, astrobiology, chemistry, astro-pharmacology, biology etc.

• Discovery of different alloys and study of their properties.

• Understanding the effects of prolonged space travel on human muscles, bones and osteoporosis.

All information obtained from this study will be useful for future missions to Moon and Mars.

The International space station is used as a platform for testing various systems and instruments of the satellite.The results of this study will be used in the design of various satellites and interplanetary satellite projects. This

information has contributed significantly to the development of satellite technology.

So far various experiments conducted by different countries in different fields are shown in figure-3.

Japan has carried out more experiments in the field of biology, also NASA has focused more on the field of biology and technology demonstration. Other space agencies have conducted research in the fields of biology, Space technology, geology, human resources etc.

The International Space Station has made many contributions / spinoffs to the scientific field, some of which are listed below.

- Water purification and recycling system
- Prevention of bone and muscle degeneration.
- Study of the functioning of the human body in microgravity.
- Growth of plants/foodstuffs in microgravity.
- Further study of black holes.
- 3D printing in microgravity
- Study of micro-organisms unknown to humans in space.

Figure2.International Space station

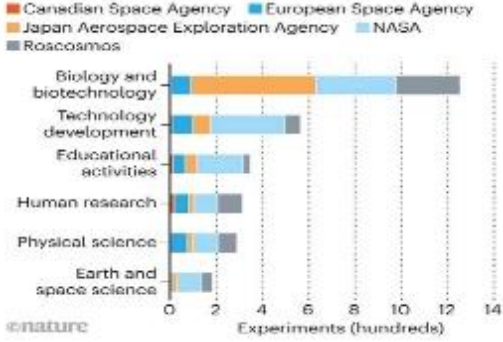

Figure 3.Details of various research carried out in ISS

Figure 4. Food and drinks for Astronauts in ISS

Figure 5. Sleep compartment of Astronaut in ISS

Viewing the planet from the sky is a unique experience. So far, hundreds of astronauts have gone to space. Indian Wing Commander Rakesh Sharma travelled to space in the Soyuz T-11 spacecraft of the Soviet Union for seven days from April 3, 1984, and became India's first astronaut. Later, Indian origin Kalpana Chawla went on a space flight in 1997 and again in 2003. While returning to Earth after completing her space flight, she died in an accident that occurred moments after re-entering the Earth's atmosphere. Sunita Williams of Indian origin also successfully carried out several studies on the ISS for 192 days in 2006 and 126 days in 2012.

5. Station structure and various units

The structure of the space station is different and more complex than any artificial satellite ever launched into space. It is the most complex and most challenging structure in satellite construction, being the largest, heaviest, most complex satellite with many systems and components. Assembling all the components and launching it to space is a very challenging task. For this reason, many modules have been launched into space by various countries / space agencies and then attached to the space station.

A description of various modules / components of the space station is given below. These units are provided by different countries to the space station to perform different tasks.

5.1. Zarya Module

This is the first unit of the station. As shown in Figure-6 this unit consists of electrical power, Sensor system, propulsion control and navigation subsystems. It is used as a storage unit at the station. It will be used as a pressurized inner unit and storage compartment of the fuel tank. This module is supplied by Russia.

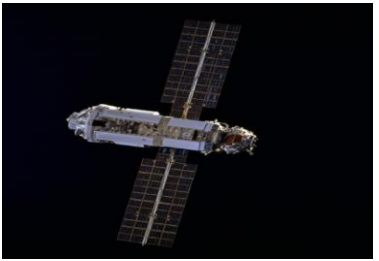

Figure 6. Zarya Module

5.2. Unity Module

As shown in Figure-7, this unit is used for connecting the US country's module / section with the Russia module. This unit is used by the station crew (a team of astronauts who will stay for a long time to maintain the station) and the astronaut team to eat together. It is cylindrical in shape and has six compartments. This is supplied by USA.

Figure 7. Unity Module

5.3. ZVEZDA Module

The Zvezda Unit (Figure-8) is the third unit of the station, which is the lifeguard and service unit for the astronauts. This has the ecosystems necessary for the crew to live. It does the orbital control of the spacecraft. It is a contribution of Russia.

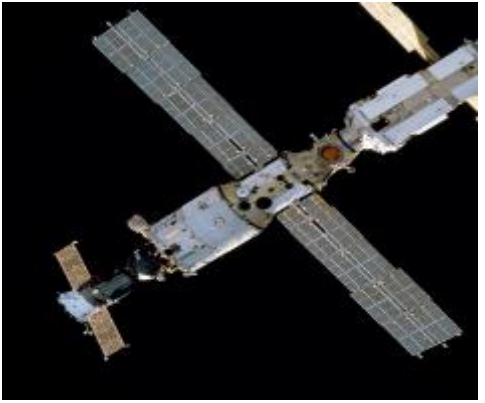

Figure 8. Zvezda Module

5.4. Destiny Module

The Destiny Unit (Figure 9) is used as a research facility for the station's American instruments. It is a permanent US laboratory used by astronauts to conduct scientific experiments in a pressurized atmosphere. This module is supplied by USA.

Figure 9. Destiny Module

5.5. Quest Module

This is the main “airlock” unit (“airlock”: a system used to separate two different atmospheric areas i.e., laboratory/clean room from other areas of the ISS), which consists of two smaller units.

Equipment Storage Unit: This is used to store the clothing and equipment used by astronauts for spacewalks.

Exit Unit: This is where astronauts exit the station on their way back to Earth.

5.6. Harmony Module

As shown in Figure-10, it is a unit that connects the laboratories of America, Europe and Japan; this supplies the power

to the station. It can be used as a bedroom for four astronauts.

Figure 10. Harmony Module

5.7. Tranquility Module

It has environmental control system and life protection system. The unit has a system that recycles waste water for use by the crew and produces oxygen for the crew to breathe. It was provided by ESA

and the Italian Space Agency and is now managed by the US.

5.8. Kibo Module

Kibo Unit (Figure-11) is a Japanese unit, the longest unit of the station and is adjacent to the Harmony Unit. This unit is used for internal transportation of equipment to different sections of the station and between units.

Figure 11. Kibo Module

6. Space station atmosphere and life of astronauts

6.1 Atmosphere

The space station's atmosphere is controlled by the station's Environmental Control and Life Support System. It performs the following functions.

• Keeping the atmospheric pressure of the station under control like Earth's atmosphere.

• Fire hazard detection and mitigation.

• Maintenance of oxygen level at the station.

• Management of waste materials and management of water supply.

• System for collection, treatment and recycling of used water.

6.2 Life of astronauts

In this section day to day life and the activities carried out by the Astronaut is explained.

Astronaut Schedule:

• An astronaut's day begins with waking up at 6 am followed by early morning routines and station inspection.

• Breakfast

• Consultation with all onboard astronauts about plans and various programs for the day at 8 am followed by consultation on various experiments and station management / functioning.

• Lunch at 2 pm, sleep at 3 pm, one hour break

• Other works and exercise

• Dinner at 8 pm, consultation and sleep at 9 pm.

Astronauts work for about 10 hours a day. Astronauts follow Universal Time (UT), which corresponds to Greenwich Mean Time (GMT).

6.3 Sleep in space

There are some permanent members on the space station and some for few days. According to this, the sleeping place has been arranged. Permanent members are given fixed residences, with sleeping arrangements for two on the Russian Orbiter segment and four on the Tranquillity. Provision will be made for temporary members to sleep in sleeping bags. Astronaut sleeper bag is shown in Fig-4.

6.4 Food and drink

Most of the food consumed by station staff is refrigerated and canned. Food is prepared as per the dietician's advice and food index (chart) is prepared and individual food packets are given to the astronauts accordingly. It maintains the level of nutrients and cleanliness. Astronauts prepare their food using food packets. There are refrigerators and food heating devices in the station. Figure-5 shows the food and drink packets of astronauts.

Astronauts also must use the toilet in ISS, like on Earth. They are trained to go to the toilet in microgravity conditions. Special commodes will be used for that.

6.5 Exercise

Prolonged space travel has various health effects, such as muscle atrophy, osteoporosis, slow circulation, depletion of red blood cells, weakening of the immune system, loss of body weight, etc. All these problems have an adverse effect on the health of the astronauts when they return to Earth. Exercise is the most effective way to prevent this. Astronauts do daily exercises for that equipment like weightlifting devices, treadmills are kept at the station.

6.7 Health

Astronauts encounter a highly radioactive environment, compared to Earth, for which they wear radiation-

blocking suits. The health of the astronauts is continuously monitored during the mission and even after their return to Earth.

7. Observation of station from Earth

Because the space station is large, the outer surface of ISS is made of many metallic materials and has got massive solar panels that reflect sunlight. Due to this reason, the space station is visible from Earth with the naked eye and through a telescope (Figure-12).

It can be clearly seen in the evening.

The time and direction of observation of the station in space is available in the following link https://spotthestation.nasa.gov.

This site also gives information on the no. of times ISS appears during a week, the time and duration for which it appears. Figure-12 shows how the space station looks from Earth.

Figure 12. ISS from Earth

8. Control of Space Station from Earth

Astronauts from the space station can communicate bi-directionally with control rooms on Earth via radio waves. Many components of the station were coordinated by sending messages from the ground control room to the astronauts via radio links. It is also used to communicate between astronauts' family members and scientists on Earth. The control centre on Earth can be contacted through the Lyra antenna of the orbital segment installed on the Zveda unit of Russia.

9. Station cost and remarks

The space station is estimated to cost around 160 billion dollars. This expenditure has been criticized by many

people. But the experiments carried out on the station and the information obtained from it has yielded invaluable benefits to mankind.

10. Termination of trip and distributions

The Russian station's contract expires in 2024. NASA's safety committee has considered decommissioning the space station in 2028. NASA, in collaboration with other International organizations, is planning to de-orbit the space station in a very safe manner. The Russian Progress Service Module will be used to de-orbit the space station, and after re-entry, it may burn up due to atmospheric collisions, with some remnants falling into the ocean. All this work is still in the deliberation stage and final planning is yet to be done.

11. Future space station and space station project of India

Many countries have shown interest in building space stations in the future. China is leading in this. India is also considering it. Some of the future plans are mentioned here. The main ones named here are NASA, ESA, JAXA and Canadian Space Agency's "Lunar Gateway", Axim Space's "Oxim Station", Russia's "Russian Orbital Service Station", Lockheed Martin's "Starlab Space Station", America's Blue Origin's "Orbital Reeve Station", ISRO's space project etc. These will take several more years to materialize.

India has been contemplating to build a space station. As per the initial proposal, the station weighs about 20 tons and is planned to be launched into an orbit

400 km above the Earth. Astronauts can live in it for 15 to 20 days, which is estimated to be operational in about 5 to 7 years after the launch of "India's Human spaceflight- popularly known as Gagan-yan".

12. Conclusion

The International Space Station has made many contributions to mankind through the experiments and discoveries facilitated by it. It is the hope of the author that many more space stations will be established in the future and numerable contributions are made to science and technology which will benefit the future generations and which in turn will encourage them to contribute their innovative ideas to this project.

Reader'sNotes:

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Dr..Uma B.R. Rao joined UR Rao Satellite Center in June 1998. She has served for about 24 years as a Scientist in Solar Panel Division, Power system Group. She is specialised in designing and testing of solar panels. She has written scientific articles for many national and international journals and presented papers in many conferences.

She has written two books for children in Kannada, "Raketgala Vismaya Loka" and "Mangalanatta", and has written and presented many scientific papers in Kannada at the Kannada Technical Conference held at U R Rao Satellite Centre.

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