INTRODUCTION TO COSMONAUTICS

(S u m m a r y)

The book “Introduction to Cosmonautics” is focused on an interesting yet complex interdisciplinary scientific and technological field – cosmonautics. Obviously, even an incomplete consideration of all questions of the book lies beyond the competence and powers of a single man; neither can they be included within the frames of a single book.

The author’s aim here is to examine and introduce the reader consecutively into issues regarding space, the stages of its studying and mastering, the various tendencies in this direction as well as the highest achievements of cosmonautics without using any intricate mathematical apparatus or rigorous specialized terminology.

For the sake of presenting the development of technology in the particular field, some technologies and equipment systems which are no longer used in practice have also been considered.

Some space has been allocated to space programs, projects and equipment systems, etc. which have been developed by Bulgarian scientists and experts over the years since the beginning of space exploration in Bulgaria.

The book also contains a part of the results the author got during more than thirty years of work at the Space Research and Technologies Institute (SRTI) at the Bulgarian Academy of Sciences, as well as some direct observations and impressions from his participation in various space projects.

At the beginning of the first chapter – 1. SPACE AND ITS EXPLORATION – the place and the significance they have in the legends of the peoples and in literature works of some of the most famous authors of the 17th-19th c. are discussed briefly.

Then, general report about cosmic space, the Solar system is provided; brief definitions of near-earth, interplanetary, intersidereal and intergalactic space are cited and the issue “where the Earth ends and where Space begins” is discussed.

The third item of this chapter (1.3) is devoted to the space sciences and in it the eight branches of modern astronomy are considered in short – astrometry, astrophysics, stellar astronomy, radio astronomy, cosmology and cosmogony.

In 1.4. there is a short historical review of the development of cosmonautics as only the most significant successes and the most important stages in studying the space are outlined – from the start of the first artificial satellite of the Earth to the sending of autonomic interplanetary stations to the outermost planets of the Solar System.

The next item focuses on general tendencies of modern cosmonautics. In fact, the current book is dedicated to those enlisted basic trends, since its sepa-
rate chapters consecutively discuss their chronology, purpose, aims, tasks and achievements along with typical examples, current state and perspectives and preconditions for a future development.

Space agencies to which cosmonautics owes its development, are the topic of item 1.6. Brief information about the national agencies of the most advanced space countries is provided, as well as about the European Space Agency. An issue which is becoming more and more immediate and topical – international space law – is considered at the end of the first chapter.

In chapter 2. **SPACE PLATFORMS** a classification based on various criteria is presented at first. From 2.2. to 2.9. short notes on chronology, construction, usage etc. of satellites, spacecrafts, spacecrafts for multiple use (space shuttles), orbital stations and complexes, geophysical rockets, carrier rockets are given consecutively; last but not least information is provided about the still exotic space vehicle – the solar sail.

The last item of this chapter is devoted to a problem which is becoming more and more serious – space waste, as some legal and technical possibilities for its settlement are discussed.

Chapter 3. **SERVICE SYSTEMS ON SPACECRAFTS** contains five items. The first one regards the electric power supply system of spacecrafts – various primary electric supplies are considered, such as chemical storage batteries and solar batteries (panels). The purpose of the thermostatic system of space vehicles and the different ways and technologies for fulfillment are the subject of 3.2.

A system important for space aircrafts and especially for satellites is the system for orientation and stabilization. In 3.3 the types of orientation and stabilization are discussed as some elementary mathematical dependencies about gravitational, aerodynamic, electromagnetic and other systems for stabilization and orientation are included. Next, the telemetric systems for connection between spacecrafts and ground connection stations are presented as well as some technical parameters of these systems.

Life support systems and means are the subject of the next item 3.4. Their significance and crucial role for life and efficiency of cosmonauts is noted; the functions of the separate systems and means, both board and individual, are considered. The issue of cosmonauts’ feeding is also discussed. At last, the purpose and types of space suits are presented.

In the following chapter 4. **ORBITS OF SPACECRAFTS**, Kepler’s laws are considered briefly; some basic mathematic expressions regarding the near-earth orbit are provided; all types of near-earth orbits and their basic elements are shown and some characteristics of the movement of a satellite on an elliptic near-earth orbit are added.

Particular attention is paid to an important kind of orbit – the geostationary one; item 4.3 focuses on it. Essential definitions, parameters, opportunities and applications of satellites in such near-earth orbits are provided.
In item 4.4 and 4.5 respectively, orbits for approximation and docking of space probes as well as the descent from an orbit are considered. The types of manoeuvres for approximation, the conditions for docking and the different kinds of sticking units are discussed. The docking and the joint flight of the manned spacecrafts Soyuz and Apollo are treated in more detail. The problems that have to be settled at descending and landing on planets with or without atmosphere, the variety of trajectories for descent from an orbit and the landing on the planets’ surfaces are also discussed.

The next chapter 5. is devoted to GROUND-BASED SPACE COMPLEXES. The basic requirements for the cosmodromes, short characteristics of the cosmodromes around the world are listed. The so called mobile cosmodromes with sea-based and air location are also discussed in short, as basic characteristics and some concrete examples for space starts from them are mentioned.

Item 5.2 treats the ground-based control complex with its structure, units and systems. Then, a brief description of the purpose and some particular examples for ground-based stations for receiving of information from space aircrafts follow. Later, (5.4.) there is a short characteristic of System for providing a unified precise time and frequencies. The next item focuses on the Centers for Training of Cosmonauts, as a short chronology and statistics about the trained cosmonauts, the way of training and rudimentary idea of the used in training thermo-hyperbaric chambers, centrifuges, anechoic chambers etc. are included.

In chapter 6. SPACE EQUIPMENT DESIGN, the peculiar features and requirements to the equipment meant for working on board of space flying machines, some terminological issues as well as the basic differences between ground-based and space equipment are considered. An overall classification of space equipment according to different criteria is referred in 6.2. In the last item of this chapter, the ground-based pre-start tests, applied to all equipment before starting flying in Space are considered. This complex of tests is discussed briefly and some particular examples are given.

SPACE PHYSICS is one of the first branches of cosmonautics by chronology, as well as by significance. In chapter 7 there is a report about some of the basic trends of space physics. First of all (7.1) the preconditions for and the basic results from studying the space rays are shown. One of the remarkable findings of space physics follows – Earth’s radiation belts. Next (7.3), the structure of radiation belts, is discussed and some general information about the first satellites of great importance for space physics and in particular – for the study of Earth’s radiation belts is given.

The study of circular current is the topic of item 7.4. Afterwards, a short description of space experiments and valuable information about revealing the processes at a magnetosphere storm are given (7.5.). An important question, directly related to the safety of space flights is that of the radiological situation in cosmic space; it is considered in brief in 7.6. In the ending (7.7.) of this chapter some evidence is provided concerning some other studies in
the field of space physics – solar space rays, galactic space rays as well as a study of atmospheric radiation: aurora and the illumination of the nighttime atmosphere.

The subject of chapter **8. SPACE METEOROLOGY** is a new branch of meteorology, occurred and developed after the dawn of the space era. First of all (8.1.), the matter and some general questions of space meteorology are revealed. In 8.2 meteorological satellites and space meteorological systems are reviewed, as some information is given on orbital features and equipment.

Chapter 9 focuses on **REMOTE SENSING OF THE EARTH**. The first item (9.1.) reviews the matter of the remote sensing of the Earth from Space, some terminological issues, basic characteristics of electromagnetic waves, the types of reflecting surfaces, the types of radiation of natural and anthropogenic objects, as well as the basic factors determining the quality and efficiency of remote space sensing– the diverse types of resolutions. Both advantages and disadvantages of the regions of the electromagnetic spectrum, most commonly used in remote studies today – the visible and near-infrared region, the thermal infrared region and the very high frequency range.

Further (9.2), the orbits of space spacecrafts for remote studies are discussed as more special attention is paid to the sun-synchronous orbits. In 9.3 a series of methods and technical means are reviewed, all used in remote studies; classifications of these methods are presented and their conventionality is stated. A consecutive presentation follows, including a photographic, television, infrared, microwave, radar, spectrophotometric, laser location, polarimetric and stereoscopic remote images, supplemented by short characteristics and concrete examples for realization.

Some place is also given (9.4) to visual studies from an orbit, as one effective way for remote sensing of the Earth. At last (9.5), there is a short chronological review of remote sensing's development on Bulgaria.

The next chapter **10. SPACE MATERIALS SCIENCE AND SPACE MATERIALS PRODUCTION** is divided in two items – Space materials science (10.1.) and Space materials production (10.2.). Among the discussed topics here are the significance of these new branches for cosmonautics, the basic trends in cosmic materials production; the conditions during weightlessness at which this production is fulfilled are analyzed and some particular examples are given for getting materials under cosmic conditions.

One of the widest and most effective applications of space technologies finds its place in **SPACE COMMUNICATION SYSTEMS** (chapter 11). First and foremost, satellite lines of communication are reviewed (11.1.). Main attention is paid to space communication systems and their three varieties – connection between ground-based stations and space aircrafts, connection between ground-based stations via space flying machines and connection between spacecrafts. Different satellites by which these connections are carried out are discussed. The following item 11.2 is dedicated to satellite television. Different ways for
receiving television signal from a satellite are mentioned and a few technical details for realization of satellite television are given.

Chapter 12. **SPACE GEODESY AND NAVIGATION** consists of two items. The first one (12.1) focuses on satellite navigation systems of first and second generation. GPS' principle and work are explained briefly and a rough analysis of its precision is made. In 12.2 scientific and applied tasks settled by space geodesy are discussed. Types and potentialities of cosmic geodesic networks are reviewed. More attention is paid to radiotechnical methods in space geodesy and in particular – to the radio interference method.

Questions of present interest before cosmonautics are considered in the following chapter 13. **SPACE BIOLOGY AND MEDICINE**. It starts with problems of terminology (13.1). In 13.2 there is a short chronological review of studies on cosmic biology including the most characteristic particular examples; biological satellites are discussed in short and information is provided concerning space radiobiology as a new branch of space biology. Some place is given to tradition and achievements of Bulgarian scientists in the study of radiation conditions in Space. Item 13.3 focuses on the main issues, settled by space medicine. The impact on human organism caused by speed, overloading and weightlessness is reviewed here. The aims and the tasks of space psychology, psychological compatibility between the members of space crews, the unique experiment “Mars 500” and some other issues are discussed in 13.4. To sleep in Space, study of sleep during a space flight and to some other of the achieved particular results is dedicated the last item (13.5) of this chapter.

Chapter 14. **STUDY OF THE MOON AND PLANETS FROM THE SOLAR SYSTEM** starts with the general principles at sending spacecrafts to the Moon and the planets, i.e. at interplanetary travels. First of all, flights and study of the Moon are considered, respectively by automated space probes (14.2.1) and the manned flights to the Moon (14.2.2). More space is given to the study of the Moon by the “Moon rovers”, and in particular to one of the epochal achievements of cosmonautics – the landing of a man on the Moon. Next, (13.3) the exploration of Venus follows – it has been one of the first targets of interplanetary cosmonautics. Chronology, supplemented by short data about flights of automated interplanetary spacecrafts to Venus are listed along with a description of concrete missions and basic results, either gained or confirmed by the direct explorations on Venus by space flying machines.

The study of the planet Mars is the topic of 14.4. Once again, the first part (14.4.1) is dedicated to the exploration of Mars by automated space stations, as another short chronology, a description of concrete missions on Mars and basic results achieved through them is provided. Later, the opportunities and the projects for a manned travel to Mars, the main problems of a manned flight of a human to Mars and the ideas for founding a Martian colony are discussed.

Items 14.5 and 14.6 are focused on the study of the planets Jupiter and Saturn respectively. The first interplanetary space probes to fly to these planets
are presented as well as the investigations made through them and some main results from these investigations. Moreover, plans about following missions to Jupiter and Saturn are mentioned, including a manned flight to Jupiter.

SPACE TECHNOLOGIES IN MILITARY SCIENCE are considered cursorily in chapter 15. Their significance is discussed and concrete examples are given regarding the relation of space technologies and military science; the types of military space forces are defined and a few characteristic reconnaissance satellites are described in brief. The increasing importance of Military space systems for securing warfare is considered and examples from the wars of the Persian Gulf and in former Yugoslavia and Iraq are given. The most large-scale and expensive programs for military use of Space are reviewed shortly.

The last chapter of the book is 16. SPACE TOURISM. The idea, the possibilities and the chronology of the Space travels with tourist or entertaining purpose are described. Two kinds of such travels are considered – suborbital flights and flights to the International Space Station. Brief information about the flights of the first space tourists is included, as well as about the agencies and companies, offering and arranging such flights. Tourist spacecrafts are discussed along with the views on future space terminals and space hotels.

The book is addressed to and can be used by a wide readership – researchers, students at secondary and higher civil and military educational institutions, experts on Earth sciences (geography, geophysics, geology, hydrology, meteorology and so on), natural sciences, aviation and cosmonautics, military experts, tutors from all levels etc.