CYBERSECURITY OF INFORMATION IN SPACE TELEMEDICINE

Evgeni Andreev[1], Veselka Radeva[2], Mariya Nikolova[3],

N. Y. Vaptsarov NAVAL ACADEMY
73 V. Drumev St., Varna 9026, BULGARIA

E-mail: e.andreev@naval-acad.bg[1]; veselka.radeva@gmail.com[2]; mpn@abv.bg[3]

Abstract

The article presents the main guidelines and requirements for space telemedicine, which should ensure the health and safety of future space tourists and spacecraft pilots. The existing ways of transmitting medical information from the International Space Station are considered. It is proposed to create special telemedicine centers for future medical centers at space airports.

The article discusses the main medical conditions and their parameters that must be monitored during space flight. This information is consistent with the small time interval of space flights for space tourists. According to the existing technical standard for the protection of space data transmission systems, a prototype of a communication protocol for data transmission has been developed. Personal and medical data are obtained from a suit specially equipped with medical sensors and transmitted to the medical center at the space-port. The advantages of the prototype protocol, which are in the field of data protection and compression, are presented. It is proposed that in order to increase the security of the data, their transmission must take place via encrypted channel.

1. INTRODUCTION

On July 11, 2021, the first space tourists successfully took off with a spacecraft of the private space agency Virgin Galaxy. Other private space agencies will also operate space tourism flights [5]. The development of a new sector in the world economy has already begun. Spacecraft with space tourists will be launched from specially created space airports or transformed airports from military and civil aviation. An interesting trend is the extended age limit of future space tourists - from 16 to 70 years. This determines the great role of space medical centers – an important area of any space airport. The selection of future space tourists and monitoring of their health during the flight will be carried out. These medical centers will monitor and control the health of the crews of the spacecraft before, during and after the flights [9].

A team of teachers and students from Naval Academy is developing a project "Space Medical Center", presented at the ESA Aerospace student challenge competition in 2019 [2]. We propose to establish telemedicine laboratories in the future space medical centers. It is extremely important to ensure secure, stable protection of personal and medical data of the crew and space tourists.

2. SPACE AIRPORTS AND MEDICAL CENTERS FOR SPACE TOURISTS

Sir Richard Branson and Virgin Galactic set the stage for space tourism. Interest in space travel is growing as many people make deposits to book their "flights"; revenues from commercial space flights are increasing and capital investment from private sources is expanding [5].

Space tourism is an area that is soon expected to be a multimillion dollar industry. Space tourism will continue to expand, and will become increasingly affordable. The implementation of this huge expansion will depend to a large extent on the security of all systems, including those in the medical sector. A process is underway to turn military and civilian airports, rocket launchers into space airports. We propose that the main areas in a space airport are: terminal, horizontal runway and vertical runway, control tower and flight control area, medical area, production area, fuel storage and fire safety area [2] Crews and tourists will be trained in special gyms under the supervision of space medicine specialists. During the flight, the health of each tourist will be monitored by sensors in the suit of each of them. If medical intervention is required, instructions will be given through direct contact with specialists from the Telemedicine Center at the Space Medical Center. After returning to Earth, the crew and tourists will undergo mandatory examinations and receive instructions for possible post-flight health problems [7]. Conceptual design of a medical center for space tourists is shown in Figure 1.

It is of utmost importance the preliminary selection of people who will have the unique opportunity to fly in space as tourists. This selection will be accomplished due to a special, unified pre-selection system

for candidates located in a medical online site of the Space Center. This way, everyone who is willing will be able to submit the necessary data and receive an answer in the shortest possible time whether it meets the basic requirements for space travelers. Pre-selection is of paramount importance, as it saves a lot of time and energy, both from the choice of medical professionals and from the space tourist.

Figure 1. Conceptual design of a Space Medical Center

It is of utmost importance the preliminary selection of people who will have the unique opportunity to fly in space as tourists. This selection will be accomplished due to a special, unified pre-selection system for candidates located in a medical online site of the Space Center. This way, everyone who is willing will be able to submit the necessary data and receive an answer in the shortest possible time whether it meets the basic requirements for space travelers. Pre-selection is of paramount importance, as it saves a lot of time and energy, both from the choice of medical professionals and from the space tourist.

The poll will be available on a specially developed web site. After completing it, in the database of Space Medical Center for future space tourists, the following information will be included: personal data, weight, height, Body Mass Index, cardio and brain diseases, cerebrovascular, respiratory accidents, problems of the digestive system, genetic anomalies, oncology illness, chronic diseases of muscles, joints and / or bones, traveling often by airplane etc.

Occasionally available medical specialists are not enough to build a multidisciplinary patient review. It is important because you may find movement in one of the indicators during the diagnostic process. For this reason, the medical center must provide the unique opportunity to build online connections with the best medical professionals from all over the world, conduct research and review of candidates Telemedicine is an important part of the overall scientific work of the center and its employees.

3. BASIC GUIDELINES AND REQUIREMENTS FOR SPACE MEDICINE

A very accurate idea of human factors and their relationships in space medicine is given by the diagram shown in Figure 2. It is based on the SHELL model [7].

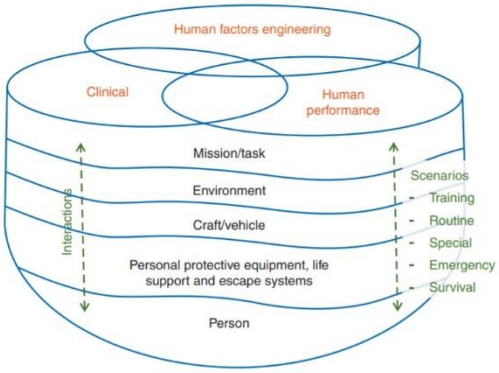

Figure 2. Model of factors and relationships in space medicine [7]

The SHELL abbreviation stands for: Software (e.g. standard operating procedures), Hardware (e.g. equipment, systems, vehicles), Environment, Liveware (individual) and Liveware (other people). The SHELL model demonstrates the importance of interfaces and interactions between different components of a spacecraft system.

Space flight refers to those trips that take place at more than 100 km above sea level. This internationally recognized altitude limit is known as the Karman line. There are three categories of human spaceflight: 1) suborbital, 2) low Earth orbit (LEO; eg, the International Space Station), and 3) exploration-class missions (eg, missions to the moon and Mars). Space tourists will participate in suborbital space flights. They are short and usually last no more than a few hours, of which only a few minutes are spent in a state of weightlessness. The flights involve exposing the human body to increased acceleration in the vertical (Gz) and horizontal (front to back; Gx) planes, which may affect the cardiorespiratory system. The degree of acceleration tested usually refers to the acceleration due to gravity near the Earth's surface. The cockpit pressures are likely to be equivalent to commercial aircraft cabins (6-8,000 feet above sea level). The low Earth orbit suggests spacecraft in orbit around the Earth at an altitude of 200-400 km.

4. MEDICAL CONTROL DURING FLIGHT

Human spaceflight takes place in a rigorous, remote, and physiologically challenging environment with medical provision severely limited by considerations of power, weight and volume and crew skills. In addition, it is an environment in which it is possible for a person with an important role in the mission to endanger the health and safety of the entire crew due to a medical problem. The most successful method of mitigating the significant physiological risks posed by spaceflight lies in adequate screening prevention. Therefore, medical standards in space flight play an important role. Their purpose is to know all existing medical conditions that could endanger the safety of the crew and the objectives of the mission. [4]

The standards are stricter for astronauts than for professional astropilots. However, all are monitored for health problems that can cause disability (eg, coronary artery disease, kidney stones, epilepsy). It should be borne in mind that poor health can be further exacerbated by interactions with the space environment or life support systems (eg, bullous lung disease or asthma). Special medical standards will be observed in the situation of a tourist space flight to a "space tourist". The Aerospace Medical Association (AsMA) publishes medical guidelines [7] for space travelers who are older and show more health problems. Preliminary studies of potential future space tourists have been conducted to understand possible tolerance to health requirements. Potential space tourists with well-controlled medical conditions will be allowed to fly. Medical standards will continue to change through future surveys of space tourists in combination with data on medical incidents from flights with an increase in the number of space tourists.

5. PROTOTYPE OF A COMMUNICATION PROTOCOL FOR THE TRANSMISSION OF MEDICAL SPACE DATA

Medical information data is transmitted after encapsulation by the prototype protocol via TCP (Transmission Control Protocol).

5.1. Concept for protection of space communication

Hacking satellite communication is not an easy task. We can talk about the possibility of potential attacks that may or may not happen at the moment. The attacks that are generally used are the so-called Spoofing or Jamming attacks. Their purpose is to deceive the systems or make them stop working altogether. Electronic warfare is a method used to stop the uplink signal to satellites sent from Earth, as well as to limit the signal received from the satellite. In this way, a false spoofing uplink signal can be sent to try to trick the satellite into executing commands by the attacking hacker. In this way, the data sent by the satellite, such as GPS coordinates with a GPS Spoofing attack, can be manipulated. This will affect GPS users. Some good practices show that we should never trust a single source, if GPS does not send accurate information we should look for alternative ways of positioning. According to the Consultative Committee for Space Data Systems, the most common space cyber attacks are: altering the transmitted data, restricting the ability to transmit data, manipulating the sender and recipient, sending incorrect data and unauthorized access to spacecraft. To prevent this type of attack, it is good practice to use an encrypted access channel from point A to point B, most often through a tunnel - VPN. The authorization should be two-factor, and the data should be encrypted and not sent in clear text. To this end, a communication protocol must be established that meets all the requirements for the protection of communication between earth stations and satellites [1, 8].

5.2. Preliminary protocol for secure communication

We propose that the secure communication protocol consists of the following fields, shown at the figure 3:

- Message type – shows the priority and seriousness of the message. For example – urgently, with normal priority, daily and informative.
- Message sender – contains information about the author of the message.
- Message Receiver – possible variants of the recorded information are: a specific doctor, a group of doctors or to all doctors.
- Message – includes a short text and / or image of the patient's symptoms
- Checksum for the integrity and authorization - ensuring that only the actual recipient will receive and be able to read the message.

The information is first converted to a binary number system and then sent. The structure of the fields that make up the protocol are presented as follows:

- The first 3 bits of the protocol allow for 8 different types of message, and in the first version only the first 2 bits are used, which allow for 4 records.
- The next 5 bits indicate who is the sender, 2 of the 5 options are provided, as the first revision of the protocol, which for the subject activity of the protocol should be sufficient.
- The next 5 bits are divided into 2 parts for the attending physician (s). The first two bits indicate whether the message should be sent to one or more doctors. As if the value is 01 - specific doctor, if it is 10 to several doctors, 11 to all and 00 initial value without recipient. After choosing the type, individual individuals or groups of doctors are specified in 3 bits.
- The message size can include up to 5000 bits. For greater protection of the information in it, it is not transmitted in its pure form, but is converted to base64 format [6]

Message Type 3 bits	Message Sender 5 bits	Message Receiver 5 bits	Message 5000 bits	Checksum

Figure 3. Conceptual version of the structure of protocol for secure communication

5.3. Advantages of the protocol

The reduced type of data transmitted in two main data types are one of the main advantages of the protocol prototype.

The data types are limited to the bit representation of the main components of the protocol. The text information is converted to base64.

The data is transmitted through a VPN tunnel for additional protection.

6. CONCLUSION

Space telemedicine is a key component of the medical care of future space tourists. Space telemedicine provides preventive, diagnostic and therapeutic assistance during the flight and allows seamless continuity of care before and after space tourist flights. Cybersecurity and a secure data transmission protocol are required for the seamless transmission of medical information from the spacecraft to Earth.

References

[1] B. Unal, Cybersecurity of NATO's Space-based Strategic Assets, The Royal Institute of International Affairs, 2019.

[2] ESA Aerospace student challenge competition in 2019, http://www.studentaerospacechallenge.eu/index.php/en

[3] G. Falco, "Cyber Security Project. Job One for Space Force: Space Asset Cybersecurity, Cyber Security Project", Belfer Center for Science and International Affairs| Harvard Kennedy School, 2018, http://osa-public.s3.amazonaws.com/papers/csp_falco_space_asset-final.pdf

[4] HL7 Fast Healthcare Interoperability Resources, Release 4, http://www.hl7.org/implement/standards/product_brief.cfm?product_id=491

[5] J. Bachman, Virgin Galactic pull off key test for Space Tourism, Bloomberg, July, 2021

[6] Lossless Data Compression, Recommended Standard CCSDS 121.0-B-3, https://public.ccsds.org/Pubs/121x0b3.pdf, 2020

[7] P. Hodkinson, R. Anderton, B. Rosselt, K. Fongq An overview of space medicine British Journal of Anaesthesia, 119,2017

[8] R. Slywczak, Low-Earth-Orbit Satellite Internet Protocol. Communications Concept and Design, Glenn Research Center, Cleveland, Ohio, 2004, https://ntrs.nasa.gov/api/citations/20040045319/downloads/20040045319.pdf

[9] S. Tkachova, Emerging Space Markets, Springer-Verlag Berlin Heidelberg, 2018