Ground-based experiments – Via ISS – to deep space

International science project

SIRIUS

Stage two:
SIRIUS-19

Moscow, 2019 г.

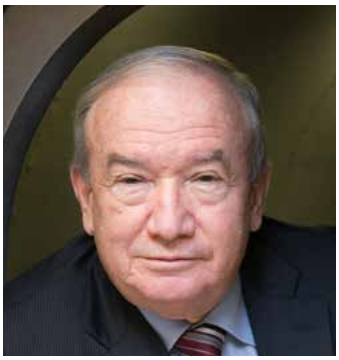
IBMP management of project SIRIUS

Orlov Oleg Igorevich

Director of the IMBP RAS, member of the Russian Academy of Sciences, Ph.D.

Co-director of the project, Chair of the Russian steering committee and the Russian program committee.

Research and applied efforts are concentrated on advanced projects and clinical and physiological investigations related to the medical monitoring and care of space exploration crews.



Belakovsky Mark Samuilovich

Head of an IBMP department, Ph.D.

Director assistant; chief manager; vice-chair of the Russian steering committee.

Experienced in organization and conduction of major international projects in space medicine and biology.

Honored worker of the public health care of Russian Federation, laureate of Russian Federation Government prize of science and technique, full member of International Academy of Astronautics, full member of Russian Academy of Cosmonautics named after K.E. Tsiolkovskiy.

Esin Valery Yurevich

Head of the Test and Research Facilities at IMBP RAS.

Has many years of experience of operating test and research facilities at NEK. Took part in the engineering support of the Mars-500 Project. Participated in research and development of instruments for radiation and biological monitoring. Awarded Order of Honor in recognition of his contribution to the development of advanced hardware.

Suvorov Aleksander Vladimirovich

Head of an IBMP department, Ph.D.

Principle investigator; vice-chair of the steering committee; vice-chair of the Russian Bioethics committee.

Expert in space, underwater and sport medicine. Corresponding member of the Russian Academy of Cosmonautics named after K.E. Tsiolkovsky, honoured space technology tester; has awards of the Russian government and Federation of cosmonautics.

Gushin Vadim Igorevich

Deputy Head of the Department of IBMP RAS, Ph.D.

Co-chairman of the project program committee, head of the psycho-physiological section of the project program.

Specialist in the psychology of labor, social psychology and psychophysiology. Winner of the Russian Federation Governmental prize in science and technology.

Ponomarev Sergey Alexeevich

Head of the Laboratory of IBMP RAS, Ph.D.

Scientific coordinator of the project.

Specialist in the field of space immunology. Member of the Russian Academy of Cosmonautics named after K.E. Tsiolkovsky.

HRP NASA management of project SIRIUS

William Paloski, Ph.D.

Director, NASA HRP.

Co-director of the project.

Leads the efforts on behalf of NASA to develop and deliver research findings, health countermeasures, and human systems technologies to support human spaceflight.

Expertise in the study of sensorimotor perforamnce of astronauts.

Leticia Vega, Ph.D.

Associate Chief Scientist, International Collaborations NASA HRP.

Leads all international activities betweeen HRP and the international scientific community

Expertise in the study of bacterial biofilms.

Lisa Spence

HRP US Project Manager, SIRIUS.
Responsible for mission planning for HRP science.

Brandon Vessey, Ph.D.

HRP US Science Implementation Manager, SIRIUS.
Responsible for complement development of HRP science.

Igor Savelev, Ph.D.

HRP International Project Manager, SIRIUS.
Responsible for planning and implementation of HRP science in NEK during SIRIUS mission.

Igor Kofman

HRP International Science Manager, SIRIUS.
Responsible for integration and implementation of HRP science in NEK during SIRIUS mission.

About «SIRIUS» project

Piloted missions beyond Earth orbits and exploration of the Solar system bodies that are closest to Earth (having in view future creation of extraterrestrial orbital complexes and planetary settlements) present a new stage in human conquest of outer space, which can become a reality provided that engineering, physiological and psychological problems that space crewmembers may face will be successfully resolved.

Study of biomedical risks associated with long-duration space missions and operation of orbital stations and planetary settlements has shown that crewmembers will be exposed not only to increased radiation levels and hypomagnetic effects but also to other challenges that need to be dealt with using current and advanced medical and psychological methods of diagnostics, prophylaxis and treatment.

They include, but not limited to:

- Refinement of methods of crewmember selection and training having in view specific environments of prolonged exploration missions and operation of orbital stations and planetary settlements.
- Refinement of food and water consumption requirements, use of clothing items and expendables, sanitation, hygienic and other needs
- Increase of the reliability and efficacy of means and methods of continuous medical monitoring and diagnostics.
- Improvement of techniques enhancing human capabilities necessary to deal with off-nominal situations.
- Maintenance of mental health, efficient performance and adequate interactions of crewmembers with each other and ground mission control centers during prolonged stay in planetary settlements (isolated, limited-size enclosures with man-made environments) where they are exposed to increased life and health risks.

Project Goals

The Institute of Medico-Biological Problems, Russian Academy of Sciences (IMBP RAS) and NASA Human Research Program (NASA HRP) have a long-lasting history of successful collaboration and cooperative investigations of humans in space missions as well as development and use of means and methods for maintaining good health of astronauts and cosmonauts. They proposed to use isolated enclosures for investigating human behavior and performance with the purpose of reducing exploration mission risks and developing efficient techniques to mitigate them during flights on the International Space Station and other space platforms.

These risks will be investigated in detail within the framework of the international project SIRIUS (Scientific International Research in Unique Terrestrial Station) implemented by IMBP RAS and NASA HRP in cooperation with their partners and researchers from Russia, Germany, France, Italy and other countries. The SIRIUS Project will include several isolation experiments of 4, 8 and 12 months in duration that will be performed within 5 (five) years.

Stages of the project:

November 2017: 17 days (completed)
2019: 4 months (completed)
2020-2021: 8 months
2021-2022: 12 months
2023-2025: possible additional annual missions

Stage Two
SIRIUS-19 (120-day isolation experiment

SIRIUS-19 was a 4-month experiment completed in the Ground Test Complex (NEK) of IMBP RAS in Moscow. The international crew included three women and three men: crew commander, flight engineer, flight surgeon and three researchers.

SIRIUS-19 Scenario

The goal of the experiment was to find a place for the lunar settlement and its scenario simulated major milestones of a Moon mission, including orbital and on-surface operations.

Milestones

Milestone 1: The crew started for the Moon, arrived to the orbit and docked to an orbital station

Milestone 2: For the period of two months the crew conducted observations of the lunar surface in order to select the landing site. Throughout Milestone 2 the crew also performed several docks with arriving transport vehicles.

Four crew members landed on the Moon, and two of them wearing spacesuits completed several egresses on the lunar surface (thus performing extravehicular activity, EVA). Meanwhile, the other crewmembers that remained on the orbital vehicle continued providing technical assistance and advice to their mates on the lunar surface.

When all the on-surface operations were completed, the four crewmembers returned to the orbiter.

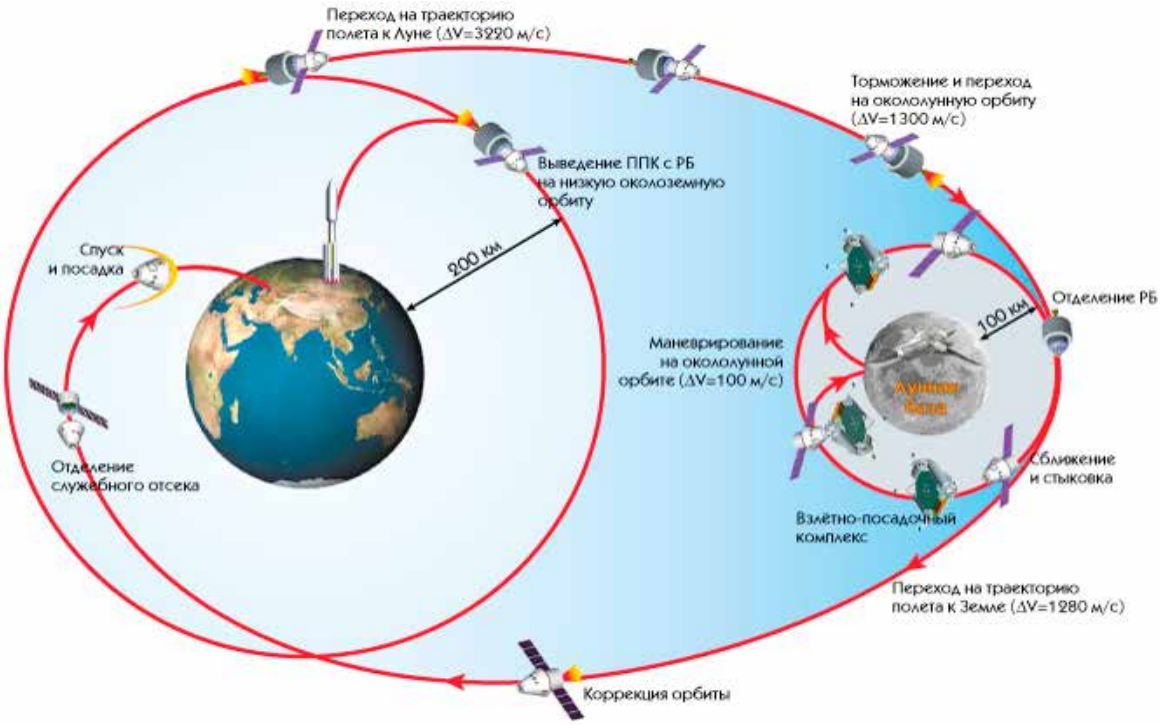
Milestone 3: Over several weeks the crew orbited the Moon in order to remotely operate Moon rovers and to receive arriving transport vehicles needed for the foundation and construction of a lunar settlement.

Upon completion of the milestones the crew returned to Earth.

Mission Objectives

In the course of the experiment the crew conducted procedures related to the real mission to the Moon, including: daily health checks and periodic detailed medical examinations; regular physical training and other activities as required by the Mission Scenario, e.g., several egresses on the virtual surface of the Moon.
In addition, the crew performed investigations to study the effects of prolonged isolation and confinement on human physiology and psychology as well as group interactions needed to support future exploration missions.

Conditional flight pattern of the SIRIUS-19 mission



Medical-technical experimental facility scheme

Medical-technical facility (NEK) of SSC RF – IBMP RAS is meant for simulation of conditions of life and activity of the crew, that are maximally close to the conditions of real spaceships, for support of conduction of the experiment simulating a space flight, including interplanetary one, with the duration of not fewer than 500 days with the crew consisting of 4-6 people.

The facility consists of several experimental units (EU) including:

1. Module EU-50.
Module EU-50 with the total volume of 50 m^3 is meant for simulation of the landing Martian module with a capacity of four crewmembers during 2-3 months, and it includes:

- living quarter, that includes four berths and working zone;
- kitchen;
- lavatory;
- two transfer tunnels with hatches for passing into the module EU-150 and into the lock chamber of the simulator of the Martian surface;
- life support systems.

2. Module EU-100.
Module EU-100 with the total volume of 100 m^3 is meant for conduction of medical and psychological experiments, and it includes:

- living quarter, including two berths and working zone;
- kitchen – dining-room;
- lavatory;
- working places with the installed medical equipment;
- transfer tunnel with hatches connected with the module EU-150;
- hermetical door at the end of the module and emergency hatch at the opposite end of the module;
- life support systems.

3. Module EU-150
Module EU-150 with the total volume of 150 m^3 is meant for accommodation and living of six crew members, and it includes:

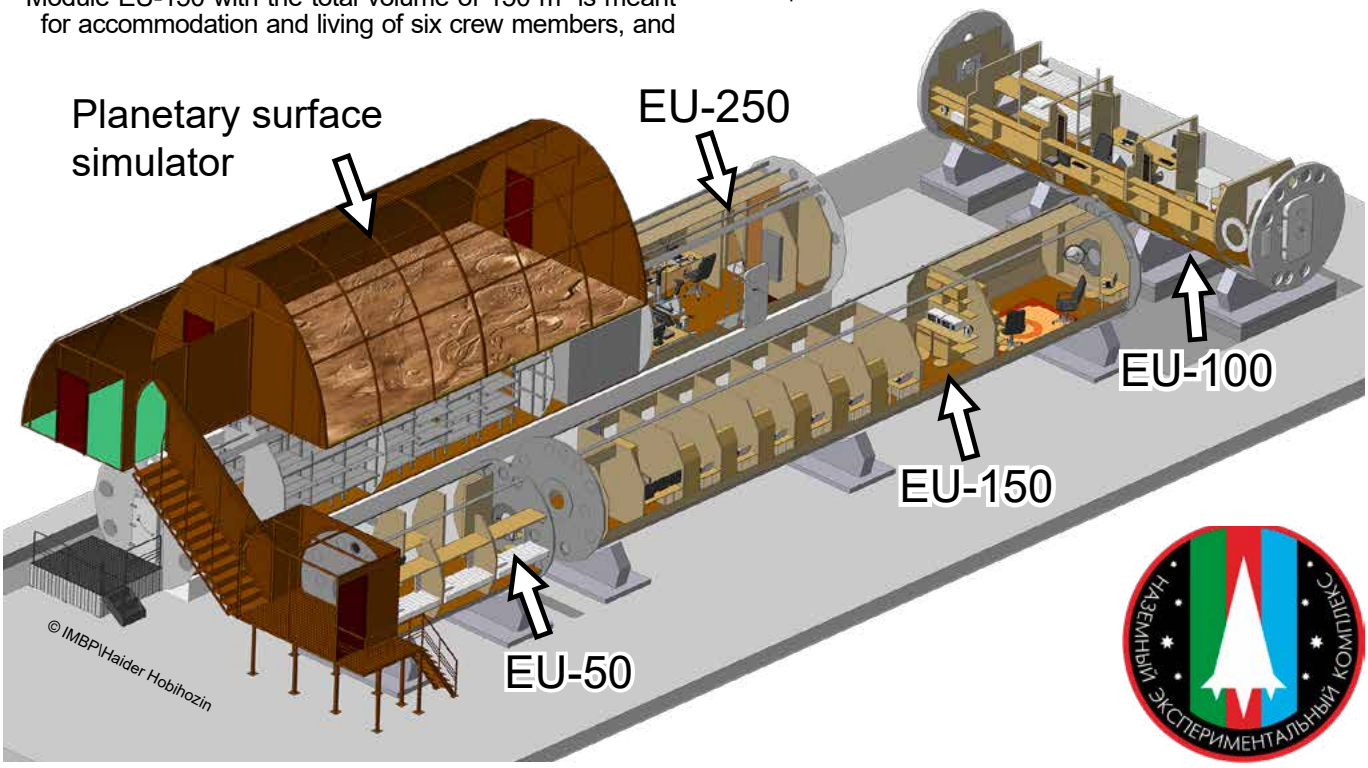
- six individual quarters;
- living-room for having rest and general gatherings;
- kitchen;
- lavatory;
- the main console;
- three transfer tunnels with hatches – end one for transfer into the module EU-50, end one for transfer into the module EU-100 and side one for transfer into the module EU-250;
- life support systems.

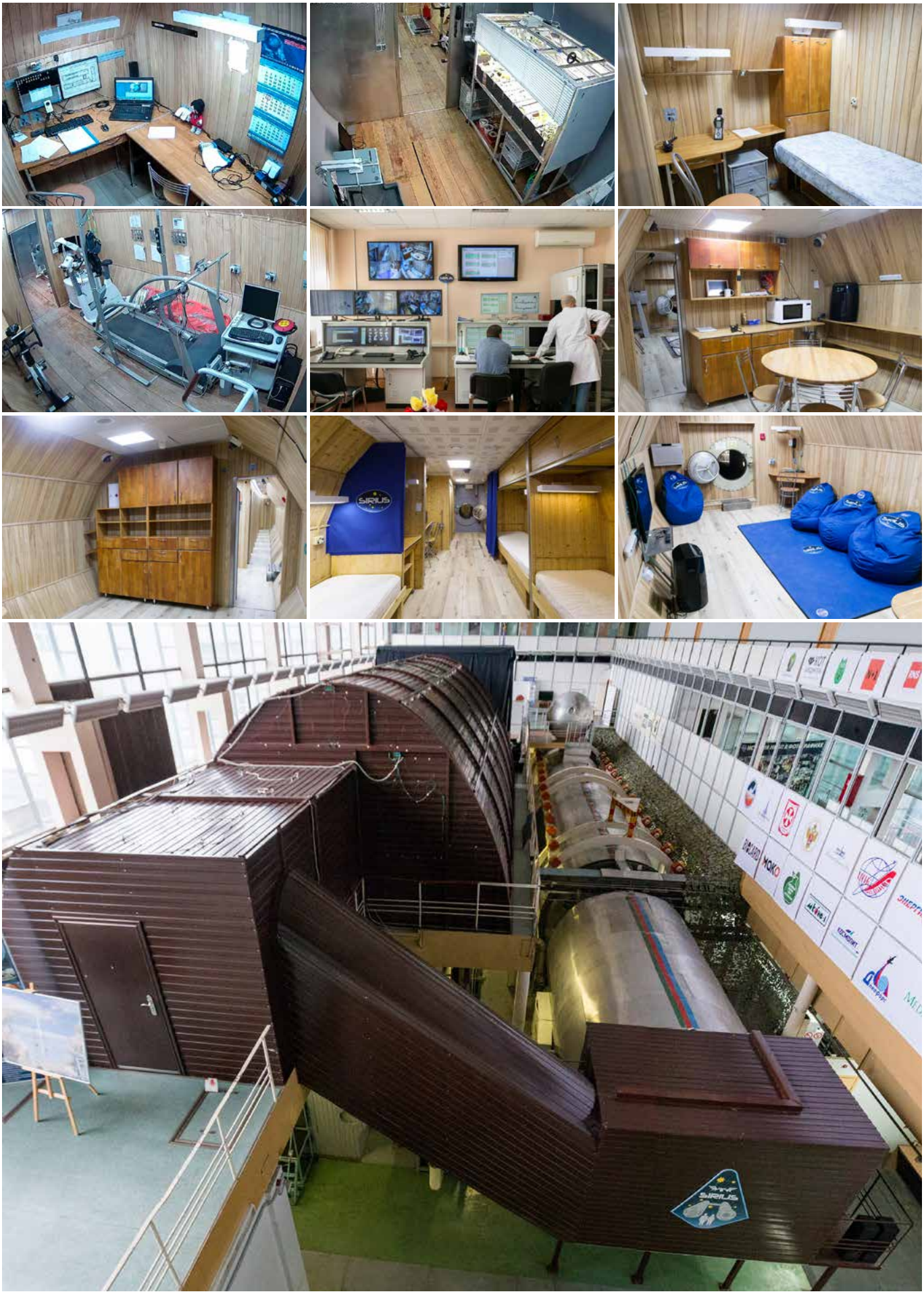
4. Module EU-250
Module EU-250 with the total volume of 250 m^3 is meant for storing of food stores, installation of the experimental greenhouse, disposable plates and dishes, clothes, etc., it includes:

- freezer for storage of food products;
- store-place with shelves for storage of food stores that do not require special conditions of storage, and disposable plates and dishes, and clothes;
- room for experimental greenhouse;
- gym;
- lock chamber for giving away waste;
- three hermetical doors – one for connection of the module with the transfer tunnel into the module EU-150, two hermetical doors with metallic stairs at the ends of the module for pre-launch loading of food stores;
- life support systems.

5. Module "Planetary surface simulator" (PSS)
Module PSS with the total volume of 1200 m^3 is meant for simulation of planet surface, and it includes:
- simulator of planet surface that is a non-hermetical chamber meant for staying of the crew in space suits, isolating from the environment;
- non-hermetical stairs and caisson separating the SMS module from the module EU-50 and having storeroom for storage of the space suits, wardrobe and a transfer tunnel.

*EU - experimental units





NEK Modernization

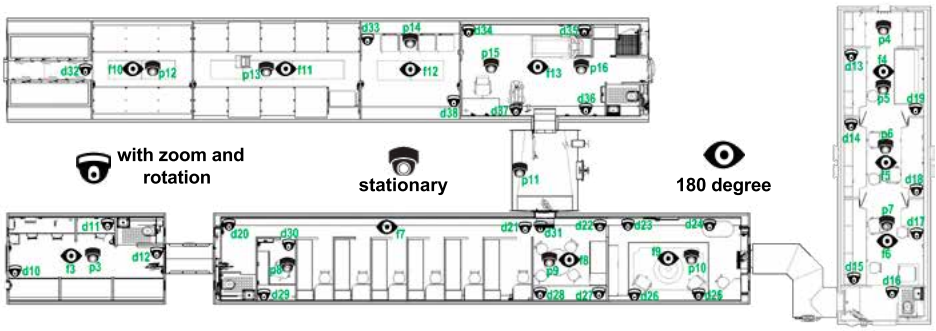
In preparation for the SIRIUS-19 4-month experiment the NEK facility underwent the following modifications:

- All the modules (experimental units, EUs) were equipped with a newly developed LED lighting system needed to support crew's optimal psychophysiological state.
- All the modules (EUs) as well as the simulated Moon surface were equipped with a newly developed digital video recording system that consisted of 84 cameras (with 66 cameras located inside and 18 outside the "Martian" complex).
- To enhance crew safety, the system maintaining adequate environmental parameters was upgraded, and the system of oxygen and nitrogen supply was equipped with gas generators.
- To meet experiment objectives, each module (EU) was equipped with a secure digital network.

The renovated NEK facilities were tested and validated December 4-6, 2018. The modules EU-50, EU-100, EU-250, EU-250 equipped with life support systems, including a LED lighting system and a video recording system, were tested.

Performance of the NEK facility and the equipment located in its modules was evaluated by a team, headed by the Russian cosmonaut Yevgeny Tarelkin, which spent two days in the enclosed environment. Based on their report, it was concluded that the NEK facilities, life support systems, ground mission control center and servicing systems performed well and were fully prepared for the SIRIUS-19 experiment..

Arrangement of CCTV cameras



Two-day testing of the renovated facility

Virtual Reality Complex Based on the «Planetary Surface Simulator»

On-surface activities of the SIRIUS-19 crewmembers were simulated using suits equipped with a virtual reality complex designed and manufactured by IMBP RAS in cooperation with Sci-VR Co. and Mechanics-Mathematics Faculty of the Lomonosov Moscow State University. The suit, shaped as a space suit, is an autonomous hardware/software complex. It includes a virtual reality helmet equipped with head and body spatial orientation sensors connected to a computation module mounted on the cosmonaut's back.

The complex allows complete immersion of a cosmonaut into his/her challenging environment as well as his/her interactions (both as an individual and as a crewmember) with on-surface interactive objects and 3D mockups of advanced space systems; also, it makes possible training and investigations within the virtual environment. The space suit is used to refine ergonomic and medical-psychological support of crew's on-surface activities, to study potential operations in extreme environments, allowing simulation of diverse situations, including off-nominal ones, as well as to examine psychophysiological aspects of crew's behavior.

It was the first time when the complex was tested in simulated on-surface activities of a spaceflight crew. The major objective was to ensure that the concepts and skills developed in simulation studies will be fully applicable to the real environments, including exploration missions.

Training on the virtual Moon prior to the start of the SIRIUS-19 experiment

Crew member for the SIRIUS-19 mission

Euvgeniy I. Tarelkin – crew commander

Russia

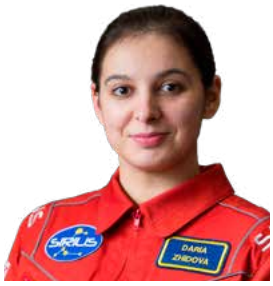
Russian Cosmonaut # 115, Hero of the Russian Federation, Air Force lieutenant-colonel (ret.). Graduated from the Gagarin Air Force Academy majoring in «Air Transport Operation and Control». Test-engineer, 3rd Class, Parachute Training Instructor, Professional Diver, PADI certified assistant-instructor.

In 2012 was selected a member of the ISS 34/35 prime crew; on October 23, 2012 launched as a flight-engineer of the Soyuz TMA-06M vehicle and as a flight-engineer of the ISS prime crew that included Russian Cosmonaut Oleg Novitsky and NASA Astronaut Kevin A. Ford. The flight duration was 143 days 16 hours.

In 2013 together with Oleg Novitsky took part in an experiment the purpose of which was to test manually-controlled descent to the Martian surface using a centrifuge CF-18 that simulated expected G-force levels.

In 2019 became commander of the SIRIUS-19 ground-based experiment crew.

Darya A. Zhidova – flight engineer



Russia

Engineer of the Flight-Testing Department of RKK Energiya.

Graduated cum laude from the Physics and Engineering Faculty of the Tomsk State University. In 2013 was conferred Master's Degree in Engineering Physics.

Took an active part in the design and verification of new-generation space systems (PTK Federation, Scientific and Power Producing Modules of the ISS Russian Orbital Segment, Lunar Take-off and Landing Module and others within the framework of the Lunar Program), supported the administration and implementation of contracts with RF SRC – IMBP RAS, Gagarin CTC and other space entities related to RKK Energiya current and advanced projects

Stephania O. Fedyai – flight physician

Russia

MD, psychiatrist and researcher, junior researcher, Department for Spaceflight Medical Support at IMBP RAS.
Graduated cum laude from the Kyrgyz-Russian Slavic University Medical School (with a diploma in general medicine). Took post-doc training in psychiatry and medical psychology at the Peoples' Friendship University of Russia in Moscow (with a specialization in psychiatry). Was awarded several diplomas and certificates, including a Good Clinical Practice certificate.
In 2018 took part as an investigator in an ergonomics experiment which simulated spaceflight crew activities in the ISS Ground Experimental Complex. One of the planners of the Algometry experiment (the purpose of which is to measure sensitivity to pain of space crewmembers) that is currently underway on the ISS.

Reinhold Povilaitis – researcher

USA

Analyst of research and operations on NASA's Lunar Reconnaissance Orbiter (LRO) mission. Graduated from the Arizona State University. Holds Master's Degree in materials science and engineering as well as nuclear power production.
Took part in the Human Exploration Research Analog (HERA) conducted at the NASA Johnson Space Center in Houston, TX. HERA is a habitat designed to study behavioral health and performance of space travelers during exploration missions.

Anastasia A. Stepanova – researcher

Russia

Journalist, engineer, junior researcher at IMBP RAS.
Graduated from the Faculty of Journalism of the Lomonosov Moscow State University (with Space Journalism as her diploma thesis). In 2015 was enrolled in the Faculty of Special Machine Building (Robotics and Mechatronics Department) of the Bauman Moscow State Technical University. In 2015-2016 completed required training and was certified as a lifeguard. In 2016 worked as a member of the SpasReserve, Public Search and Rescue Team.
In 2014 and 2016 took part in 14- and 80-day long isolation experiments performed at the Mars Desert Research Station (Utah, USA) and in 2017 in a 30-day long isolation experiment at the Flashline Mars Arctic Research Station on the Devon Island, belonging to the Canadian Arctic Archipelago, operated by the Mars Society.

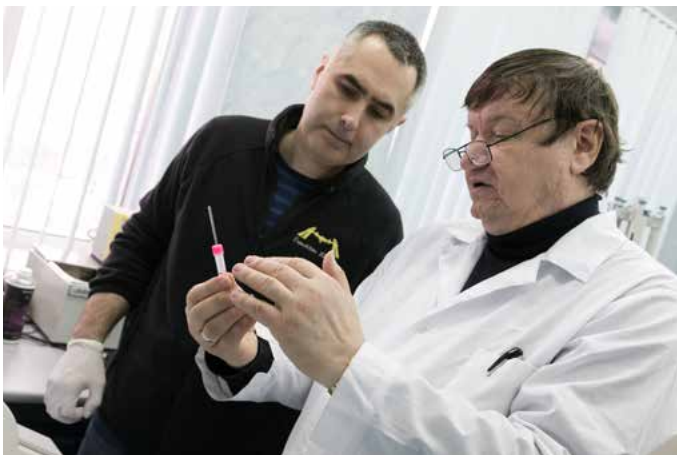
Allen Mirkadyrov – researcher

USA

Aerospace engineer, Associate Head, Telecommunication Networks and Technologies Branch, NASA Goddard Space Flight Center (GSFC). Holds Master's Degree in Aerospace Engineering from the San Diego State University (SDSU), California, USA.
Took part in the 240-day long isolation experiment HI-SEAS III on the slopes of Mauna Loa volcano on the island of Hawaii that began in October 2014 and ended in June 2015. The HI-SEAS (Hawaii Space Exploration Analog and Simulation) is an analog habitat for human spaceflight to Mars, its missions being operated by the University of Hawaii in cooperation with the Cornell University and sponsored by NASA.

Preparation, training and baseline data collection of crew candidates









Lab Quest
Lab Quest
Lab Quest
Lab Quest

Start of the 120-day mission on March 19, 2019. Press-conference and launch

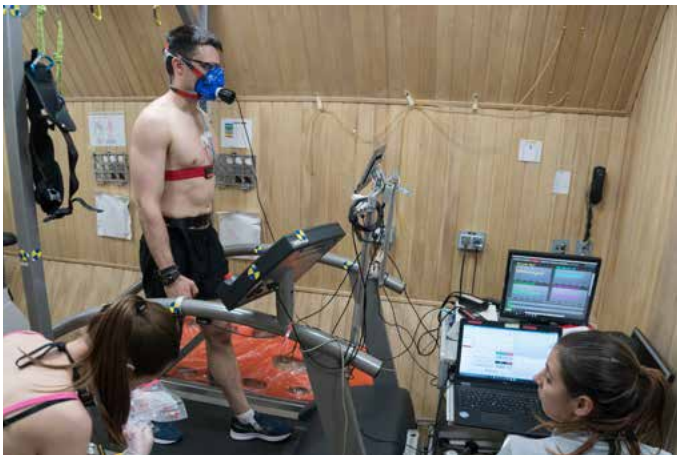





Research activities during the mission








Research activities during the mission





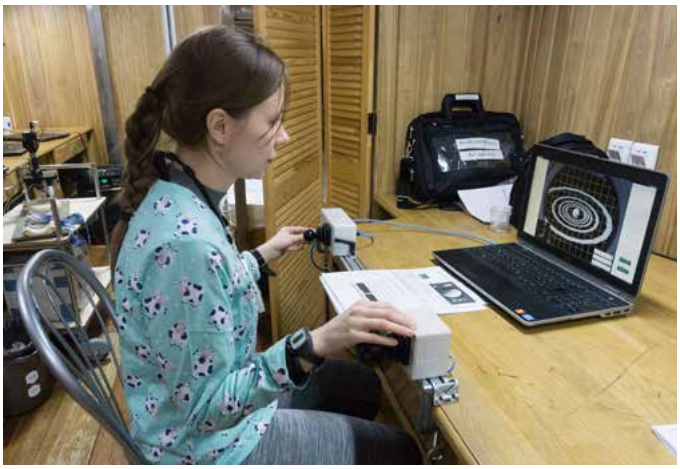



Research activities during the mission










Research activities during the mission








«Descent on the Moon» during the SIRIUS-19 experiment










Greenhouse




Taking a meal



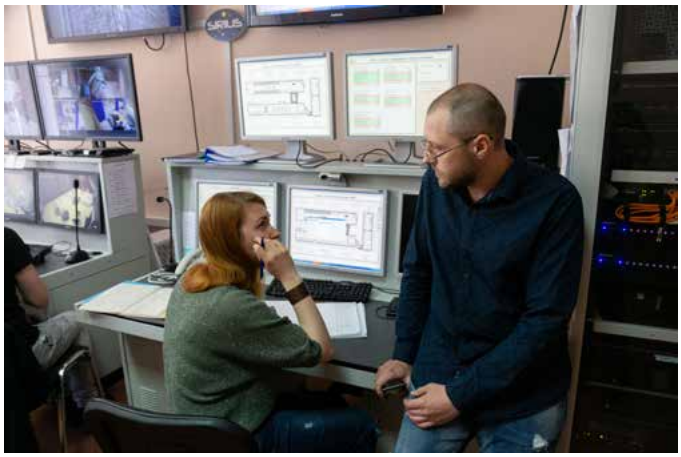
Recreation







External and internal mission control centers. Observations and interactions with crew members





Completion of the 120-day mission of Jule 17, 2019

List of studies in the SIRIUS-19 experiment

1. Psychological studies

1.1. The study of daily motor activity and sleep quality of crew members for the prediction of the psychophysiological state and operability of the operator in isolation. Code: «Vulcan 18-19». Scientific adviser: Gushin Vadim Igorevich, Ph.D. (IBMP). PI: Dr. Dmitry Shved, Ph.D. (IBMP).

1.2. Interpersonal interactions, communications and group effectiveness under simulated extreme conditions of extended spaceflight. Code «INTERACTIONS». Scientific Leader: Vadim I. Gushin, M.D., Ph.D. (IBMP). PI: Alla G. Vinokhodova, Ph.D. (IBMP).

1.3. Study of crew-MCC communication in order to assess the psychophysiological state of the crew members and the effectiveness of intergroup interaction. Code: “Content”. Scientific Leader: Dr. Vadim Gushin, MD, PhD. PI: Dr. Dmitry Shved, PhD. (IBMP). Co-I: Dr. Beata Gabriela Ehmann, PhD. (Environmental Adaptation and Space Research Group, Institute of Cognitive Neuroscience and Psychology, Research Centre for Natural Sciences of the Hungarian Academy of Sciences).

1.4. The study of psychological stability and adaptation in an isolated small group in the modeling of extreme factors of a long space flight. Code – “Stability”. Scientific Leader: Vinokhodova Alla G., Ph.D. (IBMP). PI: Kuznetsova Polina G. (IBMP).

1.5. Name and code of the study: the Relationship of chronotype and features of interhemispheric interaction with the ability to adapt to extreme conditions of life in conditions of long-term isolation, taking into account the chronophysiological and stereofunctional features of the human body. Code of the study: CHRONOTYPE. Supervisor: Olga Ivanovna Karpova (IBMP). Executive: Zakruzhnaya Maria Aleksandrovna, PhD. Co-executor: Vasilyeva G. Yu.. PhD. (IBMP).

1.6. Psychological support of crews in conditions of high autonomy. Code: «PS-SIRIUS”. Supervisor: Olga Ivanovna Karpova (IBMP). Executive: Potapova Kira Viktorovna. Co-executor: Volosyuk Yu (IBMP).

1.7. The study of neurophysiological and psychophysiological dynamics of crew members (Code: EEG + Clever balls). Scientific Leader: Kotrovskaya T.I., PhD. (IBMP). PI: Schastlivtseva D.V. (IBMP).

1.8. Neuro-semantic psychodiagnostics (Code «NSP-diagnostics»). Scientific Leader: Kotrovskaya T.I., PhD. (IBMP). PI: Schastlivtseva D.V. (IBMP).

1.9. The study of the quality and psychophysiological «price» of professional activity in driving a wheeled vehicle on the surface of the Moon. Code: «Lunokhod». Scientific Leader: Guschin V.I., PhD. (IBMP). PI: Schastlivtseva D.V. (IBMP).

1.10. The complex analysis of energy and electrical parameters of the brain with an assessment of psycho-physiological reactions. Code: «Neuro-omega-S». Scientific Leader: Potapov Mikhail G., Ph.D. (IBMP). PI: Kovaleva Anna A. (IBMP).

1.11. The study of the subjective timing (timekeeping) and prospective/retrospective view of life-time in crewmembers during long term isolation period and strictly responsible work. Code: “Psychological timing”. Scientific Leader: Natalia Sirota, MD, (Clinical psychology department of the Moscow state university of medicine and dentistry named after A.I. Evdokimov - SMSU). PI: Olga Shalina, PhD, the resident in Clinical psychology department of MSMSU, Russia.

1.12. Determination of the effect of daytime sleepiness on operator activity in the standard work schedule and against sleep deprivation. (Code: “Dream”). Scientific Leader: Kovrov Gennady Vasilievich, MD, Prof. (I. M. Sechenov Moscow state medical University, Russia).

1.13. Cis-Lunar Teleoperation: Behavioral, Subjective and Physiological Assessment (Code: TELEOP). Scientific Leader: Dr. Patrick FABIANI (PhD). PI: Dr., Dr. Eng., Stéphanie LIZY-DESTREZ (PhD). Co-I: Dr. Raphaelle ROY (PhD), Louis Maller (MSc, Master thesis).

1.14. Self-sufficient Docking learn program (Code: “6df / PILOT-U”). Scientific Leader, Bernd Johannes, Dr. rer. nat. Dipl.Psych. PI: Bernd Johannes, Dr. rer. nat. Dipl.Psych. (Institute of Aerospace Medicine, DLR, Linder Hoehe). Co-I: Institute of Movement and Neuroscience & Center for Health and Integrative Physiology in Space, German Sport University Cologne ; IBMP, Russia.

1.15. Use of a Spaceflight Simulator For Investigations on Piloting Skill Maintenance in Long-Term Confinement Under Isolation (Code: SIMSKILL RU). PI: Reinhold Ewald, Prof. (Institute of Space Systems, University of Stuttgart). Co-I: Miquel Bosch Bruguera (Institute of Space Systems, Germany).

1.16. Integrated ethological study. (Code: ETHOS). Scientific Leader: Carole TAFFORIN, Ph.D. (Jacques MAMBRÉ, Research and Study Group in Human and Space Ethology, France). Co-

I: Vadim Gushin, M.D., Ph.D. and Alla Vinokhodova (IBMP).

1.17. Emotion in Space Analog Environments: Detection and regulation of affective changes in response to a stressful task in situation of confinement (multi-stress environments). (Code: EMOTION). Scientific Leader: Prof. J. Dinet (University of Lorraine, Psychology and Neuroscience Lab.). PI: Prof. B. Bolmont, University of Lorraine, France).

1.18. Team Task Switching in Astronaut Crews: Integrating Multiteam Membership, Multiteam Systems, Multitasking, & Multidimensional Networks to Monitor & Enable Functional Work Shifts in Astronaut Crews. Scientific Leader: Brandon Vessey, Ph.D. (William Marsh Rice University). PI: Leslie DeChurch, PhD (Northwestern University, USA). Co-I: Noshir Contractor, PhD; Jessica Mesmer-Magnus, PhD; Alina Lungeanu, PhD.

1.19. Key Components of Successful Autonomous Space Missions (code: Autonomia). Scientific Leader: Brandon Vessey Ph.D., PI: Ute Fischer Ph.D. (Georgia Institute of Technology, USA). Co-I: TeamScape LLC., Kathleen Mosier Ph.D., Department of Psychology, University of New Mexico Albuquerque, Davood Tofghi Ph.D., Noshir Contractor, PhD.

1.20. Facilitating the Synergistic Side of Cultural Diversity in LDSE: Identification of Challenges and Development of Cultural Training. Scientific Leader: Shawn Burke, Ph.D. (University of Central Florida, USA). PI: Lorrie Primeaux, Analog Science Lead.. Co-I: Eduardo Salas, Ph.D (William Marsh Rice University).

1.21. Understanding and Preventing Crew Member Task Entrainment. Scientific Leader: Brandon Vessey (HFBP). PI: Jeff LePine, PhD. Daniel Newton. Co-I: Ned Wellman, PhD.

1.22. Behavioral Health and Performance (BHP) Standard Measures in NEK. Scientific Leader: Brandon Vessey, Ph.D. PI: Peter Roma, Ph.D. (BHP laboratory NASA JSC,). Co-I: Jason Schneiderman Ph.D., Lauren Landon Ph.D. and Sandra Whitmire Ph.D.

2. Physiological studies

2.1. Study of the state of the food status and digestive system (Code: Splankh). Scientific supervisor of studies B.V. Afonin M.D., Ph.D., PI: E.A. Sedova M.D., Ph.D. (IBMP).

2.2. Study of the state of bone system in volunteers exposed to isolation conditions in hermetically closed environment (4 months) (Code: Osteology). Scientific Leader: G.Yu.Vasilyeva PhD, PI: V.E.Novikov. Co-I: Boris V. Afonin PhD, MD; Irina M. Larina, Professor, PhD, MD; Liudmila Kh. Pastushkova, PhD, MD ; Marina P. Rykova, PhD, MD (IBMP) and Joern Rittweger, Professor (DLR, Germany).

2.3. Effect of 4-month isolation with controlled environmental conditions on the change of vegetative index Kerdo during sleep-Wake cycle in healthy people (Code: Kerdo INDEX). Scientific Leader: A.Suvorov MD, PhD. PI: A.Demin (IBMP). Co-I: Ingo Fietze, Prof. MD. (Charité, Berlin, Germany).

2.4. Lung volumes and capacities in conditions of long-term isolation. (Code: “Spiro S”). Scientific Leader: A.V.Suvorov MD, PhD. PI: Zaripov Rustam (IBMP).

2.5. Acoustical study of pulmonary ventilation during long-term isolation (Code: «FE Acoustics». Scientific Leader: A.I. Dyachenko PhD. PI: A.N. Mikhaylovskaya (IBMP).

2.6. Investigation of pain sensitivity in humans in conditions of prolonged isolation (Code: Algometry-Is). Scientific Leader: Aleksey Polyakov, MD, PhD. PI: Arslan Niiazov, MD. (IBMP).

2.7. The study of microcirculation via laser Doppler flowmetry and computer capillaroscopy

(Code: “Capillary”). Scientific Leader: A.V.Suvorov MD, PhD. PI: Pamova Anastasia (IBMP).

2.8. Title and Code of the Study: Study of the influence of isolation conditions and various types of training loads on the cardiopulmonary system at rest and in the performance of physical work and the level of physical work capacity (Code «Cycle CPET»). Scientific Leader: A.V.Suvorov MD, PhD. PI: Ruzhichko Irina (IBMP).

2.9. The effect of the conditions of enclosed space on adaptation to physical loads. Research supervisor: Ph.D. Galina Stepanova, PI: Olga Pasekova (IBMP).

2.10. The effect of the conditions of enclosed space on adaptation to ortho-and antiorthostatic loads. Research supervisor: Galina Stepanova, Ph.D., PI: Natalia Degterenkova (IBMP).

2.11. Blood Gases and Acid-base Balance in Healthy Humans under Chronic Exposure to Moderately Elevated CO2 in the Rest and at the Physical Load / Blood Gases – Workload (Code: ABB – PhE). Scientific Leader: A.V.Suvorov MD, PhD. PI: Julia A. Popova, PhD (IBMP).

2.12. Investiagtion of electromyographic and cinematic characteristics of locomotions at different

levels of unloading (Code: SUSPENSION). Scientific Leader: Tomilovskaya Elena, PhD, PI: Brykov Vitalii. Co-I: Saveko A. (IBMP).

2.13. Analysis of the dynamics of human performance in conditions of a reduced physical activity as a result of the impact of various training regimes with the purpose of constructing a mathematical model of the training process (Code: Physical performance). Scientific Leader: Fomina Elena, Prof. PhD. PI: Uskov Konstantin, Rezvanova Svetlana (IBMP). Co-I: Dr. Uwe Hoffmann (German Sport University Cologne Institute of Physiology and Anatomy), Dr. Vera Abeln (Institute of Movement and Neurosciences Center for Health and Integrative Physiology in Space German Sport University Cologne), Germany.

2.14. Monitoring of the electromagnetic noise effect of the environment on a person in conditions of isolation and shielding structures of the room. Research supervisor: Vladimir Tsetlin PhD. Executive researcher: Galina Stepanova, Ph.D. (IBMP).

2.15a. Study of the chemosensitivity of pulmonary ventilation (Code «Chemosens»). Scientific Leader: Shulagin Yu.A., PhD. PI: Ermolaev Eugine (IBMP).

2.15b. Determination of the respiratory center chemosensitivity and variability of the heart rhythm of volunteers to hypercapnia stimulus (Code «Chemosens 2»).Scientific Leader: Vladimir Kulchitsky, MD, PhD, Prof., PI: Svetlana Pashkevich, PhD, Head of Lab. (NAS,Belarus). Co-I: Leader: Shulagin Yu.A., PhD (IBMP).

2.16. Modulation of Cardiac Autonomous Nervous System Activity by a Simulated 4-Month Outer Space Transit-Phase Mission (MANSA-TPM). Scientific Leader: Ingo Fietze, prof, MD, PhD. PI: Tomas Pensel, prof, PhD (Charite, Berlin, Germany). Co-I: A.Suvorov, MD, PhD, M.Belakovskiy MD (IBMP).

2.17. The influence of different training stimuli on cardiorespiratory regulation and cognitive skills during 4 months of isolation. Scientific Leader and PI: Dr. Uwe Hoffmann (Germany). Co-I: E.Fomina PhD (IBMP).

2.18. Impact of physical activity on brain performance and health “Bodyfitness = Brainfitness“

Scientific Leader and PI: Dr. Vera Abeln. Co-PI: Prof. Dr. Dr. Stefan Schneider (Institute of Movement and Neurosciences, German Sport University Cologne). Соисполнитель: Штефан Шнайдер. Кооперация: У. Хоффман и С.Хоффман (Немецкий спортивный университет г. Кёльн, Германия).

2.19. Biomarkers as Predictors of Resiliency and Susceptibility to Stress in Space Flight. Scientific Leader and PI: Namni Goel Ph.D. (University of Pennsylvania Perelman School of Medicine) PI Representative: Tiffany M. Swarmer M.S. (NASA).

2.20. Investigation of the influence of changing the adjustable parameters of the light environment on the threshold characteristics of the operator’s perception of visual information during the 4-month study with isolation according to the SIRIUS project. Scientific Leader: A.Agureev. PI: I.Kutina (IBMP).

2.21. Evaluation of the effect of LED lighting in long-term isolation conditions on the operator’s visual functions (Code: OFT-2). Scientific supervisor D.Sci, prof., Rozhkova G.I. (IITP RAS)

D.Sci, Man’ko O.M. (IBMP RAS), PI: D.Sci, Vasilyeva N.N., PhD, Dmitrieva S.V.

2.22. The study of the effect of LED lighting modes in a limited volume and other factors of prolonged isolation on the functional activity of the visual pathway and hemodynamic parameters of retinal vessels of the human operator (Code: OFT-1). Scientific adviser: V. Neroev (Federal State Budgetary Institution «Moscow Helmholtz Research Institute of Eye Diseases «of the Ministry of Health of Russia. PI: M.Zueva and O.Manko (IBMP).

2.23. HRP Standard Measures in NEK. Scientific Leader: Giles Clement (HRP NASA). PI: Sara R. Zwart, Ph.D. Co-I: Pete Roma, PhD (KBRwyle, USA).

3. Immunological studies

3.1. The effect of four-month isolation in a sealed chamber on phenotypic characteristics of dendritic cells derived from human peripheral blood monocytes (Code “DC”). Scientific Leader: Ponomarev Sergey, PhD, MD. PI: Kutko Olga (IBMP).

3.2. The effect of sleep deprivation and increased psychoemotional load on the state of human innate and adaptive immune system in conditions of 4-month isolation in the sealed chamber (Code: «Deprivation»). Scientific Leader: Ponomarev Sergey, PhD, MD. PI: Rykova Marina, PhD (IBMP).

3.3. The effect of regular physical exercise on the immune status of volunteers under conditions of 4-month isolation in the hermetic object, taking into account individual-typological features (code: «IS»). Scientific Leader: Ponomarev Sergey PhD, MD. PI: Kalinin Sergey PhD (IBMP).

3.4. Study of the influence of isolation factor complex on the latent intracellular human infections

reactivation (Code: «Reactivation»). Scientific Leader: Ponomarev Sergey PhD, MD. PI: Kayunova Sofiya (IBMP).

3.5. Predictive diagnostics of health problems in the body based on changes in the characteristics of extracellular DNA; search for genetic markers that determine high or low resistance to stressors. Scientific Leader: Kostyuk Svetlana PhD. PI: Elizaveta Sergeevna PhD (Medical genetic research center RF).

4. Studies of metabolism

4.1. Neurohormonal, metabolic and psychological aspects of adaptation of the human body to the conditions of 120-day isolation in a hermetic object. Scientific Leader: Nichiporuk Igor M.D., Ph.D. PI: Zhuravleva Tatiana (IBMP).

4.2. Investigation of morpho-biochemical parameters of erythrocytes and hemoporphyrins of hemoglobin in volunteers during a 4-month isolation. Scientific Leader: Ivanova Svetlana Ph.D. PI: Anisimov Nikolai (IBMP).

4.3. Investigation of 4-month isolation in a hermochamber factors complex impact on human plasma hemostasis system. Scientific Leader: Markin, Andrey M.D., Ph.D., PI: Kuzichkin Dmitry Ph. D. (IBMP).

4.4. Acute Phase Reagents in a Study with Long-Term Isolation Code: Cascade. Scientific Leader: Larina Olga, PI: Bekker Anna (IBMP).

4.5. Investigation of metabolic reactions in volunteers in the dynamics of 4-month isolation in the hermochamber, including stress exposure. Scientific Leader: Markin Andrey M.D., Ph.D. PI: Zhuravleva Olga M.D., PhD (IBMP).

4.6. Study of the influence of typological features of initial psychoneuroendocrine status, neurohormonal regulation of water-electrolyte homeostasis and metabolism, their dynamics and interrelation on a choice of a strategy of adaptation of a human body to conditions of long-term isolation in hermetic chambers and its realization. Supervisor of studies Nichiporuk Igor M.D., Ph.D. PI: Chistokhodova Svetlana (IBMP).

4.7. Investigation of the dynamics of some biochemical markers and nucleic acids as predictors of pathological processes in humans in conditions of prolonged isolation with additional evaluation of ultrasonic indicators of liver metabolism changes (Code: SLM-Is). Scientific Leader: Aleksey Polyakov, MD, PhD. PI: Arslan Niiazov, MD (IBMP).

4.8. Antioxidative homeostasis of the human body in model conditions of a space flight. Scientific Leader: Popov, Igor MD, prof. (Medical lab Oxidaq UG), PI: Vostrikova, Larisa (IBMP).

4.9. Study of lipid peroxidation biomarkers in breath gas of healthy human during physiological adaptation to conditions of isolation, with biological-technical testing of analytical instruments for monitoring of biomarkers and environmental air at the conditions of space flight. Scientific Leader: L.N.Muhamedieva MD, PhD. PI: Dmitry Tsarkov (IBMP).

5. Telemedicine studies

5.1. Express control of humans adaptation possibilities in the conditions of long isolation with use of telemedicine system for individual prenosological monitoring (Code: Stress-control II). Scientific Leader: Chernikova Anna, Ph.D. PI: Isaeva Olga (IBMP).

5.2. Study of possibilities of wireless registration of physiological parameters during simulation of extravehicular activity. Scientific Leader: Oleg Perevedencev, Ph.D. PI: Roman Chernogorov (IBMP).

6. Microbiological and sanitary-hygienic studies

6.1. Investigation of the physiology of the dentoalveolar system of operators and agents prevention (Code: «Parodont-2»). Scientific Leader: Ilyin V. MD, PhD. PI: Solovyova Z. Ph.D. (IBMP).

6.2. Personalized approach to the evaluation and correction of microorganisms of the ENT organs of operators in conditions of prolonged isolation (Code: Microflora). Scientific supervisor: Ilyin V. MD, PhD. and Matznev E. MD, PhD (IBMP). PI: Kiryukhina Natalia and Kashenkova Lyudmila (Russian Federation State Scientific Center of Science and Technology).

6.3. Countermeasures. Scientific Leader: Agureev Alexander PhD and Polyakov A.V. Ph.D. PI: Kutina Irina, Co-I: Kovachevich Irina (IBMP).

6.4. Research of stomatopharynx inflammation prophylaxis efficiency by means of SALIPAR® biomembranula. Scientific Leader: Ilyin V. MD, PhD. PI: Prokopovich L. (IBMP).

6.5. Kvass enriched. Scientific Leader: Ilyin V. MD, PhD. PI: Usanova Nonna (IBMP). Co-I: Serge Ameye (Puratos group, Belgium).

6.6. Research of bio-medical, microbiological, psychological and technological aspects of using fermentation products in the conditions simulating

expedition to the Moon (Code “Kvass”). Scientific Leader: R.R. Kaspranskiy PhD (Yu.Gagarin’s Center). PI: Sergey Savin (IBMP).

6.7. Aerosol Accumulation in the Atmosphere of Hermetic Inhabited Objects During Prolonged Isolation. Scientific Leader: Petr Aleksandrov, D.Sc. (Information technologies Institute of NRC Kurchatov Institue). PI: Vadim Kalechits, Ph D. and Alina Aleksandrova, D.Sc. (Moscow State University).

6.8. Investigation of surfaces inhibiting growth of microorganisms (Code: AGXX in space). Scientific Leader and PI: Prof. Dr. Elisabeth Grohmann (Berlin, Germany). Co-I: N.Novikova (IBMP).

6.9. Dynamic assessment of the state of the oral cavity organs and neuromuscular occlusion in the testers during the ground experiment «SIRJUS18/19» (Code «OCCLUSION»). Supervisor: Sigaleva Elena MD , Prof. (IBMP). PI: Malamuzh Svetlana. Co-I: Juravleva Olga.

7. Operation and Technologist studies

7.1. Long-term ground-based experimental study of functional characteristics of greenhouses developed for life support systems and psychological support of space crews of the lunar orbital station and lunar bases. Code: “Greenhouse”. Scientific Leader: Dr. Vladimir Sychev (IBMP). PI: Dr. Margarita Levinskikh, (IBMP). Co-I: Dr. Igor Podolsky, PhD and Dr. Vadim Gushin, MD, PhD (IBMP).

7.2. Research of crew activity algorithms in modeling of typical flight operations in “close to real” conditions «Algorithm». Scientific Leader: M. Serov. PI: D. Zhidova (S.P. Korolev Rocket and Space Corporation Energia).

7.3. Remineralizing effect on hard tooth tissues of the two-component complex Remarsgel

Scientific Leader: S.A.Kholodov. PI: V.Kapitonov MD, PhD («Dental Space Clinic», Russia).

7.4. Biodegradation of used personal hygiene means of operators, accumulating in conditions of prolonged isolation (Code: biodegradation). Scientific Leader: Ilyin MD, PhD. (IBMP). PI: D.Korshunov.

7.5. Monitoring of underwear and garment application and their change and sanitary-hygienic activities on processing for conditions of the piloted space flight. Scientific Leader and PI: Shumilina Irina (IBMP).

7.6. Development of a psychological support system using virtual reality technology. Discipline: A virtual reality. Scientific Leader: Simone Giusti (Sigma ingegneria S.R.L.). PI: Tommaso Pardini (Sigma ingegneria S.R.L., Italy).

7.7. Development of simulation system for extravehicular activity using virtual reality technology. Scientific Leader: Gianluca Parrini (Scienzia machinale SRL). PI :Niccolo` Albertini (Scuola Normale Superiore, Pisa). Co-I: Sant`Anna (Scuola Universitaria Superiore, Pisa), Italy.

7.8. Approbation of the interior components for the purpose of their ergonomic evaluation in conditions of prolonged isolation in hermetic chambers. Scientific Leader: Bardi Lorenzo, BARDI S.P.A. PI: Bardi Lorenzo (BARDI S.P.A.), Italy.

629.788:001.891.57
ББК:39.68
И-73

The authors:
Belakovsky M.S. (IBMP RAS), Voloshin O.V. (IBMP RAS),
Suvorov A.V. (IBMP RAS)

Contacts

State Scientific Center of the Russian Federation
Institute of Biomedical Problems
of the Russian Academy of Sciences
(SSC RF – IBMP RAS)

Russia, 123007, Moscow,
Khoroshevskoye shosse, 76a

Tel.: +7 (499) 195-1500
Fax: +7 (499) 195-2253
E-mail: info@imbp.ru, pressimbp@gmail.com

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ISBN 978-5-902119-60-9

Edition: 200 copies
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Layout and design: Oleg Voloshin

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