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Main Results of the ISS-53/54 of Expedition Training and Activity When Carrying out the Mission Plan. A.A. Misurkin, A.A. Kuritsyn, A.I. Kondrat, V.A. Kopnin, D.E. Rybkin, E.I. Korzun

The paper considers results of the ISS-53/54 crew activity aboard the "Soyuz-MC-06" spacecraft and the ISS. The tasks solved when performing extravehicular activity are reviewed.
Keywords: tasks of crew training, spaceflight, International Space Station, scientific applied research and experiments.

REFERENCES

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Medical Aspects of Securing the Flight of the ISS Crew for Expedition 53/54 (Express Analysis).
V.V. Bogomolov, V.I. Pochuev, I.V. Alferova, E.G. Khorosheva, V.V. Krivolapov

Abstract. The paper shows the results of medical maintenance of the ISS-53/54 expedition and gives a brief description of operation of the medical support system and maintaining the stability of human environment aboard the ISS RS. Besides, the paper sums up results of implementing medical recommendations, program of medical monitoring and the use of onboard means designed to prevent the alteration of cosmonauts' health status in spaceflight.
Keywords: medical support, medical monitoring, preventive system, human environment, work/rest schedule.

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Results of Implementing the "Ekon-M" Space Experiment Program by A.A. Misurkin, a Member of the ISS Crew for Expedition 53/54.

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Abstract. The paper consideres the problems of training cosmonauts for emergency situations, argues the necessity of training crews in flight, gives the on-board simulator structure and describes the process of on-board training.

Keywords: space station, crew safety, training, skills, level of preparedness, on-board simulator, training tasks, methods of on-board training.

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"Plasma Crystal – 3 Plus" Laboratory at the Russian Segment of the International Space Station is a Successful Project on the Complex Plasma Physics.

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Abstract. The paper contains information on the results of the successful realization of the joint Russian–German project of studies in the field of physics of the strongly-coupled complex (dusty) plasma under microgravity conditions. Complex (dusty) plasma is low temperature plasma containing solid particles of micron size. These particles acquire a high charge and become the dominating component in the plasma. Owing to a possibility of observing a behavior of separate dust particles and studying a system of many particles at the kinetic level, the dusty plasma is now actively used to investigate the phenomena of nonideality in the classical condensed matter. To perform experiments with large (more than a million of microparticles) isotropic three-dimensional dusty systems it is necessary to eliminate a strong influence of gravity on the charged dust particles what is possible during studies aboard the International Space Station. With the help of the unique PK-3 Plus laboratory which operated at the ISS Russian Segment from 2006 through 2013 the great volume of scientific

information on processes in the complex (dusty) plasma has been obtained. Experimental studies of the "plasma crystal - plasma liquid" phase transition at varying a number of parameters, recrystallization of the dusty-plasma system, peculiarities of processes in the binary dusty systems, electrorheological plasma, fluctuations of the position of microparticles in the plasma crystal lattice points were carried out. Experimental studies of collective motion of dust particles, interaction of the complex plasma with a large highly charged macroparticle, and the features of dusty plasma instabilities were conducted. More than 60 papers on the results of experiments on the PK-3 Plus have already been published in the leading refereed scientific journals, nevertheless analysis and processing of the obtained data array are still in progress.
Keywords: strongly nonideal complex (dusty) plasma, microgravity, phase transition, plasma crystal, plasma liquid, scanning.

REFERENCES

[1] Complex and dusty plasmas. From the library to space / edited by V.E. Florov. E. Fortov, G. Morfill. – Moscow: Fizmatlit, 2012. – 443 p.
[2] Introduction to the physics of complex/dusty plasmas / A.V. Ivlev, S.A. Khrapak, V.I. Molotkov, A.G. Khrapak. – Dolgoprudny: "Intelekt" Publishing House, 2017. – 124 p.
[3] Complex plasma laboratory PK-3 plus on the international space station / H.M. Thomas, G.E. Morfill, V.E. Fortov et al. // New Journal of Physics. – 2008. – Vol. 10, – P. 033036.
[4] Dusty Plasma Crystals And Liquids In Experiments On The International Space Station / V.E. Fortov, O.F. Petrov, V.I. Molotkov and others. // Manned Space Flights. – 2011. – № 1(1). – pp. 65-77.
[5] Freezing and Melting of 3D Complex Plasma Structures under Microgravity Conditions Driven by Neutral Gas Pressure Manipulation / S.A. Khrapak, B.A. Klumov, P. Huber et al. // PHYSICAL REVIEW LETTERS. – 2011. – Vol. 106. – № 20. – P. 205001.
[6] Experiments on phase transitions in three-dimensional dusty plasma under microgravity conditions / V.I. Molotkov, V.N. Naumkin, A.M. Lipaev et al. // INTERNATIONAL CONFERENCE - THE PHYSICS OF LOW TEMPERATURE PLASMA (PLTP-2017) : Journal of Physics Conference Series. – 2017. – Vol. 927. – P. UNSP 012037.
[7] Khrapak S.A. Multiple phase transitions associated with charge cannibalism effect in complex (dusty) plasmas / S.A. Khrapak, H.M. Thomas, G.E. Morfill // EPL. – 2010. – Vol. 91. – № 2. – P. 25001.
[8] Observation of metallic sphere-complex plasma interactions in microgravity / M. Schwabe, S. Zhdanov, T. Hagl et al. // NEW JOURNAL OF PHYSICS. – 2017. – Vol. 19. – P. 103019.
[9] Dust coupling parameter of radio-frequency-discharge complex plasma under microgravity conditions / D.I. Zhukhovitskii, V.N. Naumkin, A.I. Khusnulgatin et al. // PHYSICAL REVIEW E. – 2017. – Vol. 96. – № 4. – P. 043204.
[10] Latest results on complex plasmas with the PK-3 Plus laboratory on board the International Space Station / M. Schwabe, C.R. Du, P. Huber et al. // Micrograv. Sci. Technol. – 2018. – published online.
[11] Density waves at the interface of a binary complex plasma / L. Yang, M. Schwabe, S. Zhdanov et al. // EPL. – 2017. – Vol. 117, – P. 25001.
[12] First observation of electrorheological plasmas / A.V. Ivlev, G.E. Morfill, H.M. Thomas et al. // PHYSICAL REVIEW LETTERS. – 2008. – Vol. 100. – № 9. – P. 095003.
[13] Dynamics of Lane Formation in Driven Binary Complex Plasmas / K.R. Suetterlin, A. Wysocki, A.V. Ivlev et al. // PHYSICAL REVIEW LETTERS. – 2009. – Vol. 102. – № 8. – P. 085003.
[14] Interpenetration of two clouds of microparticles in complex plasma under microgravity conditions / V.I. Molotkov, A.M. Lipaev, V.N. Naumkin et al. // DUSTY/COMPLEX PLASMAS: BASIC AND INTERDISCIPLINARY RESEARCH: SIXTH INTERNATIONAL CONFERENCE ON THE PHYSICS OF DUSTY PLASMAS : AIP Conference Proceedings. – 2011. – Vol. 1397.
[15] Comprehensive experimental study of heartbeat oscillations observed under microgravity conditions in the PK-3 Plus laboratory on board the International Space Station / R.J. Heidemann, L. Couedel, S.K. Zhdanov et al. // PHYSICS OF PLASMAS. – 2011. – Vol. 18. – № 5. – P. 053701.
[16] Nonviscous motion of a slow particle in a dust crystal under microgravity conditions / D.I. Zhukhovitskii, V.E. Fortov, V.I. Molotkov et al. // PHYSICAL REVIEW E. – 2012. – Vol. 86. – № 1, 2. – P. 016401.
[17] Density distribution of a dust cloud in three-dimensional complex plasmas / V.N. Naumkin, D.I. Zhukhovitskii, V.I. Molotkov et al. // PHYSICAL REVIEW E. – 2016. – Vol. 94. – № 3. – P. 033204.

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Basics of the Analysis and Designing of IT-Infrastructure for the Integrated Simulator Complex of Cosmonaut Training. V.E. Shukshunov, V.V. Yanushkin, M.M. Kharlamov, V.P. Khripunov, B.A. Naumov, S.N. Kovrigin

Abstract. The paper considers approaches to the creation of an integrated simulator complex at the Gagarin CTC on the basis of modern hardware and software. An approach to the development of a single information space on the basis of the TRIO distributed modeling environment is discussed. Key technical and conceptual solutions as well as proposals on designing the software/hardware infrastructure on the basis of modern technologies including with the use of centralized calculations at the data processing center are given. The results of the performed testing the existing IT-infrastructure at the GCTC in the interests of implementing an integrated simulator complex and main requirements for

hardware are briefly described.
Keywords: simulator complex, simulator facility, resources virtualization technology, technical facilities for cosmonaut training, integration.

REFERENCES

[1] Naumov B.A. Space Simulators. – FSBO Gagarin Research&Test CTC, Star City, Moscow region, 2013. – 214 p.
[2] Naumov B.A., Khripunov V.P. Basic Approaches to the Creation and Operation of the Technical Facilities for Cosmonaut Training // Manned Space Flights. – 2014. – No 2 (11) – pp. 30–34.
[3] Naumov B.A., Khripunov V.P. Putilin D.V. Simulator Complexes. Virtues and Shortcomings of the Development and Operation // Manned Space Flights. – No 2(23). – 2017. – pp. 29–36.
[4] Bezrukov G.V., FomenkoV.V. TRIO Software in ISS Simulators // Proceedings of the Scientific and Technical Seminar «Technical Facilities and Technologies for Construction of Simulators». – Star City, 1998. – Issue. 3. – pp. 73–77.
[5] Lunkin K.S., Vinogradov Yu.A., Saev V.N. Experience in Designing and Operating the Computer Systems of Space Simulators // Manned Space Flights. – No 2(15). – 2015. – pp. 102–111.
[6] Lonchakov Yu.V., Naumov B.A., Khripunov V.P. General Provisions for the Creation of an Integrated Technical Facilities Complex for Cosmonaut Training at Gagarin CTC // Manned Space Flights. – No 4(13). – 2014. – pp. 25–39.
[7] Shukshunov V.E., Yanyushkin V.V. Advanced Simulator Complexes for Cosmonaut Training. – Moscow: Mashinostroenie Publ., 2015. – 112 p.
[8] Shukshunov V.E., Tsibliev V.V. Pototskiy S.I. Simulators and Simulator Complexes. Technology Development and Operational Experience. – Moscow: Mashinostroenie Publ., 2005. – 384 p.
[9] Kovrigin S.N., Yanyushkin V.V. The analysis of an IT infrastructure of the Astronaut Training Open Automation System to Create an Integrated Simulation Complex // Programmnye Produkty I Sistemy (Software&Systems). – No 4. – 2015. – pp. 16–21.
[10] Shukshunov V.E., Yanyushkin V.V. Conceptual Framework for Development of the Next-generation Educational Training and Simulation complex (etsc) // Programmnye Produkty I Sistemy (Software&Systems). – No 4. – 2015. – pp. 5–15.
[11] High-Level Architecture, The official website of JSC "Rusbitech": http://rusbitech.ru/press/news/news-company/high-level-architecture.

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Robot of Space Application as a Component of Scientific Hardware.

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Abstract. The reasonability of usage of anthropomorphic structure in designing of a robot of space application is proved. The classification of robots of space application depending on external conditions of functioning is proposed. The main features of construction of each type of a robot are indicated. The purposes and tasks of "Ispytatel" manageable project within the framework of which an orbital flight with "FEDOR" anthropomorphic robot will be accomplished are presented. Special preparation of "FEDOR" robot will make it possible to perform research of its functioning under the impact of orbital flight factors, such as vibration, suddenly-applied load, zero-gravity.

Keywords: anthropomorphic robot, "FEDOR", "Ispytatel", types of robots of space application, robot hand, basic components, space station, space experiment, orbital flight, flight tests**.**

REFERENCES

[1] Main Results of EVA performed by the ISS Crews / Krychkov B.I., Altunin A.A., Dolgov P.P., Yaropolov V.I., Usov V.M., Irodov E.Yu., Verba D.I., Korennoy V.S. // Manned Space Flights. – 2017. – No 1 (22). – pp. 56–67.

[2] Sorokin V.G. An Option of the Configuration and Structural Scheme of the Base Unit of the Stand-Alone Humanoid Space Robot // Manned Space Flights. – 2017. – No 1 (22). – pp. 68–64.

[3] Julia Badger, Dustin Gooding, Kody Ensley, Kimberly Hambuchen, Allison Thackston. A Case Study on Robonaut 2 // ROS in Space. The Complete Reference (Volume 1). P. 343-373. Doi: https://doi.org/10.1007/978-3-319-26054-9.

[4] A Schiele, T Kruger, S Kimmer, M Aiple, J Rebelo, J Smisek, E den Exter, E Mattheson, A Henandez, and F van der Hulst. Haptics-2 – A System for Bilateral Control Experiments from Space to Ground Via Geosynchronous Satellites. In IEEE International Conference on Systems, Man, and Cybernetics (SMC), pages 892–897. IEEE,2016.

[5] Bamfaste S. Development of a Software Layer for the Integration of Robotic Elements into the METERON Infrastructure using Robotic Services, Master Thesis, Luleå University of Technology, 2016.

[6] Mishkin A., Lee Y., Korth D., Blanc T. Le. Human - Robotic Missions to the Moon and Mars: Operations Design Implications. IEEE Aerospace Conference, 2007.

[7] Bualat M., Carey W., Fong T., et al. Preparing for Crew-Control of Surface Robots from Orbit . IAA Space Exploration Conference, 2014. Lastly accessed 09.07.2015. URL: http://www.ri.cmu.edu/pub_files/iaa14-bualat-et-al. pdf.

[8] Birkenkampf P., Leidner D., Lii N.Y. Ubiquitous User Interface Design for Space Robotic Operation / 14th Symposium on Advanced Space Technologies in Robotics and Automation (ASTRA).

[9] Basis of Structural Scheme Selection of Space Application Robots / Zhidenko I.G., Kutlubaev I.M., Bogdanov A.A., Sychkov V.B. // Reshetnev Readings – Vol. 1. – No 17. – pp. 278–280.

[10] A General-purpose System for Teleoperation of the DRC-HUBO Humanoid Robot / M. Zucker, S. Joo, M. X. Grey, C. Rasmussen, E. Huang, M. Stilman, A. Bobick Journal of Field Robotics, vol. 32, No. 3, 2015, pp. 336–351.

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Virtual 3D-Simulation of Real Manned Space Complexes in the Interests of Historical and Technical Studies and Saving Scientific and Technical Information About Objects. Yu.M. Baturin, B.I. Kryuchkov, A.V. Leonov

Abstract. The paper evaluates the feasibility of creating 3D-models of unique manned space complexes in real conditions of a space flight for carrying out historical-technical and historical-scientific studies and also for popularizing manned space exploration. The experience in applying three-dimensional graphics in manned space exploration as well as the content of hardware used and methodical techniques are analyzed. Available and potentially feasible content of instruments required for implementing 3D-simulation of large-scale manned objects in space on the basis of the experience in creating three-dimensional graphic models of large-scale scientific and technical objects on the earth are considered. Main proposals for scanning the International Space Station within the space experiment framework for creating its virtual 3D-model are put forward.

Keywords: 3D-simulation, manned space complex, cosmonaut, astronaut, crew, 3D-graphics, filming in space, history of science and technology, laser scanning, virtual simulation, photogrammetric methods, 3D-models of a lunar base.

REFERENCES

[1] Leonov A.V. Virtual 3D Modeling in the History of Science and Technology. Doctoral Dissertation, IHSTS RAS Publ. – 2018. – 319 p.
[2] Serdechnov A. How the 3D Film about the ISS Was Created. Populyarnaya Mekhanika, April 2014.
[3] Sabbatini M., Visentin G, Collon M., Ranebo H., Sunderland D., Fortezza R. Stereo Cameras on the International Space Station. SPIE 64901P, San Jose, California, USA, ISSN 0277-786X, 2007. – 2018. – 1–6 p.
[4] http://spacegid.com/pryamaya-onlayn-translyatsiya-s-mks.html#i
[5] https://sketchfab.com/models/bd6ac084ae5645848a67597b17665579?ref=related
[6] https://sketchfab.com/models/6dfff011b8df4b0891366aab8b6b0349?ref=related
[7] Borodkin L.I., Zherebyatyev D.I. 3D Modeling in Historical Research: from Visualization to Analytics // Istoricheskaya Informatika. – 2012. – No 2. – pp. 49–63.
[8] Leonov A.V. Application of 3D Technologies in the History of Science and Technology. 3D-model as a Historical and Technical Source. Coll.: Interdisciplinary Methods in the History of Science and Technology: Proceedings of Scientific Conference, Moscow, May 27, 2015. / Executive Editor Yu.M. Baturin. - Moscow: IHSTS RAS Publ., 2015. – pp. 42–45.
[9] Mikhailyuk M.V., Torgashev M.A. Modeling and Distributed Real-Time Stereo Visualization of the ISS // The XVIII Annual Scientific Conference Dedicated to the 80th Anniversary of the IHSTS RAS: Moscow, S.I. Vavilov Institute for the History of Science and Technology of the Russian Academy of Science, April 17–19, 2012: Proceedings of the Conference, Vol. II. – Moscow: Yanus-K, 2012. – pp. 859–860.
[10] Rys I.V., Leonov A.V. Methods of Virtual Reconstruction of Technical Monuments: World Experience. Coll.: S.I. Vavilov Institute for the History of Science and Technology. Annual Scientific Conference (2016) / Executive Editor R.V. Artyomenko. – Moscow: IHSTS RAS Publ., 2016. – pp. 720-721.
[11] Rys I.V., Kartashev M.O., Leonov A.V. Virtual Reconstruction of Electric Vehicle Columbia (1901): 3D-modeling Technique and First Results. Coll.: S.I. Vavilov Institute for the History of Science and Technology. Annual Scientific Conference, 2015, Vol.1 / Executive Editor Yu.M. Baturin. – Moscow: IHSTS RAS Publ., 2015. – pp. 434–439.
[12] Kryuchkov, B.I., Usov, V.M., Chertopolokhov, V.A., Ronzhin, A.L., and Karpov, A.A. Simulation of the «Cosmonaut-Robot» System Interaction on the Lunar Surface Based on Methods of Machine Vision and Computer Graphics // International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XLII-2/W4 (2nd International ISPRS Workshop on PSBB, 15–17 May 2017). – 2017. – pp. 129-133. – DOI: 10.5194/isprs-archives-XLII-2-W4-129-2017.
[13] Technical Recommendations for Creation of Virtual Museums. Moscow: The Ministry of Culture of the Russian Federation, 2014. https://www.mkrf.ru/documents/po-sozdaniyu-virtualnykh-muzeev-250714/
[14] Altunin A.A., Verba D.I., Dolgov P.P., Irodov E.Yu., Korenna V.S., Onufrienko Yu.I. / Some Issues of Improving Extravehicular Activity of Cosmonauts // Manned Space Flight, No 2(27), 2018. – pp. 64–80.
[15] Afanasyev V.O., Baigozin D.A., Baturin Yu.M., and others / Visualization and Virtual Environment Systems in Space Exploration: the Present and the Future. Book. “Cosmonautics of the XXI century”. – Moscow: “RTSoft” Publ. 2010. – pp. 185–256.
[16] Kryuchkov B.I. Maintenance and Repair in Space. GCTC Publ., 2010. – 257 p.

[17.https://www.ferra.ru/ru/digiphoto/review/how-to-shoot-in-the-space/
[18] https://www.geocam.ru/online/iss/
[19] Shukshunov V.E., Shukshunov I.V. Fomenko V.V., Kryuchkov B.I. and others. Educational Simulator Complex for Training Cosmonauts to Carry out Scientific Studies aboard the ISS / Patents of Invention/.RU 2617 433 C2/ МПК G09B 9/52. Issue Date of the Application: 15.03.2017 Bulletin №8.
[20]http://www.geometer-center.ru/kontakty;
http://leica.geometer-center.ru/catalog/HDS_Systems/p20#tabs-1
[21] Luhmann Thomas, Robson Stuart, Kyle Stephen, Boehm, Jan. Close-Range Photogrammetry and 3D-Imaging. Translation from Engl. URSS. 2018. – 704 p.
[22] ISS RS. User's Reference. 191 p. http: // knts.tsniimash.ru
[23] http://eea.spaceflight.esa.int/portal/exp/?id=9150

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ГИРД – КАК ИСТОРИЧЕСКОЕ НАУЧНО-ПРАКТИЧЕСКОЕ НАЧАЛО ОТЕЧЕСТВЕННОГО РАКЕТОСТРОЕНИЯ.

А.П. Александров

Group on Propulsion Research (GPR) – as a Historical Scientific and Practical Initial Point of National Rocketry.

A.P. Aleksandrov

Abstract. The paper on the background of world cosmonautics evolution gives a historical retrospective of first works related to development of rocketry in the USSR. It evaluates briefly the contribution to science made by national specialists who started working on rocket technology in GPR, Moscow. It describes issues of organization of pioneer works in GPR, and draws attention to the necessity for preserving its scientific heritage.
Keywords: rockets, rocketry, propulsion, cosmonautics, cultural heritage.

REFERENCES

[1] Korolyova N.S. My Father. – Book 1. – Moscow: Nauka Publ., 2001.
[2] Glushko V.P. Development of Rocketry and Cosmonautics in the USSR. – Moscow: Mashinostroenie Publ., 1987.
[3] Stratospheric Storm: Collection of Articles // Tekhnika Publ. – September 9, 1932.
[4] History of Astronautics and Rocket Technology. Proceedings of the XVIII International Congress. Belgrade, September 25–29, 1967. – Moscow: Nauka Publ., 1970.
[5] TsGAOR the USSR. F. 8355, inventory4 (Quot. Po(23)).
[6] Golovanov Ya.K. Korolyov: Facts and Myths. – Vol. 1. – Russkiye Vityazi Publ., 2007.

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