Russia's ISS Utilization Program

GEORGE KARABADZHAK,

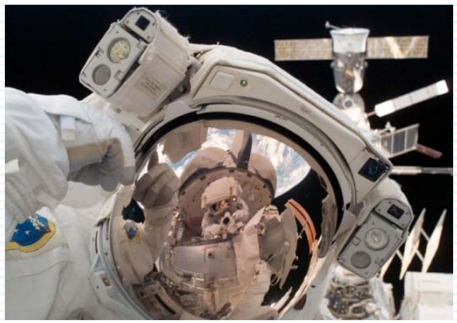
TSNIIMASH/ROSCOSMOS

ISS Symposium 2012

May 4, 2012, Berlin, Germany

ISS – One of the Most Successful international Projects Ever Undertaken by Humanity

ISS is an important milestone of the human space exploration

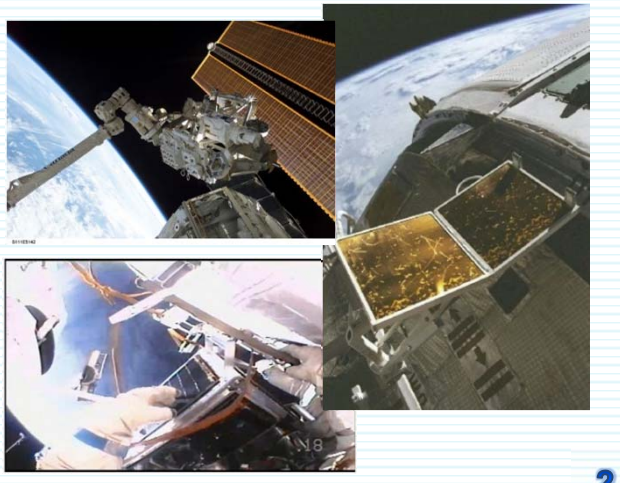


More than 10 years of ISS utilization and 25 years of PERMANENT human presence in space

Demonstration of international cooperation capabilities

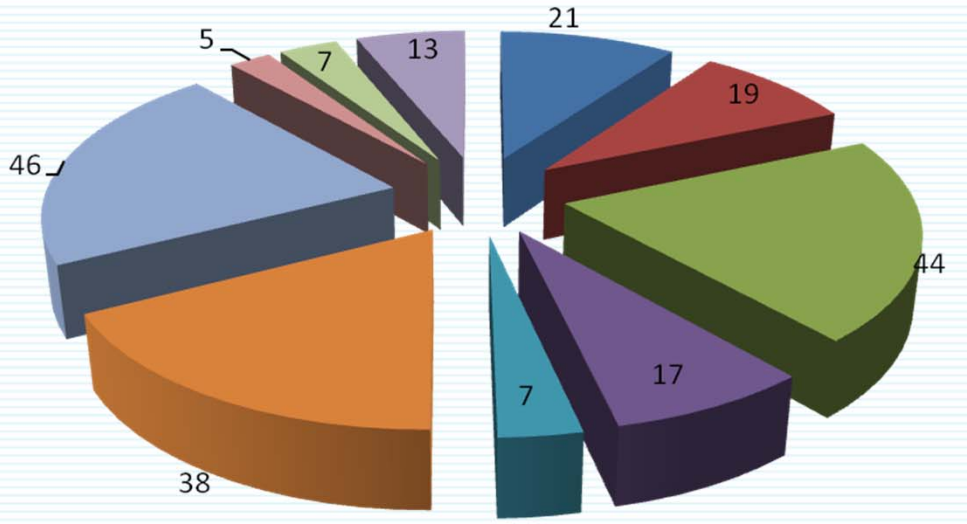
Unique scientific laboratory

Advanced technology maturation



Russian Long Term ISS Utilization Program

- 10 research directions specified by Roscosmos/RAS
- More than 200 research programs



- Processes and materials under microgravity conditions
- Geophysics and near-earth space research
- Human life science and biology
- Earth remote sensing
- Solar system investigation
- Space biotechnology
- Technical investigation and experiments
- Astrophysics and fundamental physical problems
- Investigation of physical conditions on the ISS orbit
- Education and popularization of space research activity

Human Health

Research objectives:

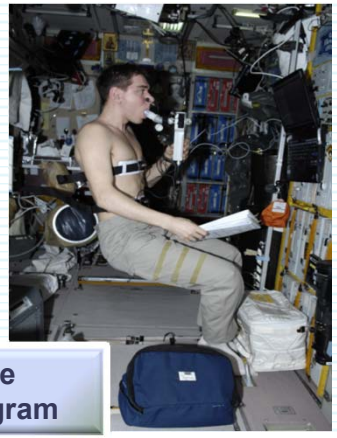
- Health support during long-term ISS missions, experiments for future missions to other planets;
- Adaptation to mission conditions (weightlessness, radiation, artificial environment).

Results:

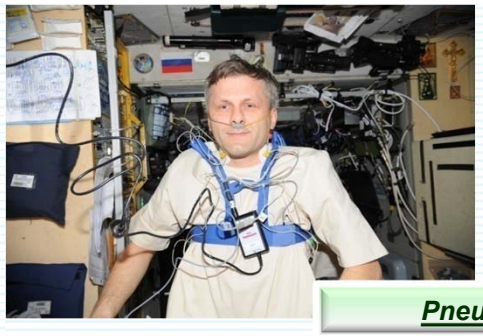
- Basic knowledge on physiology in space environment;
- Individuality of space adaptation => risk evaluation and mitigation should be individual too;
- Methods and apparatus for screening, prophylactics and treatment;
- A number of patents on health diagnostics, monitoring and countermeasures (experiments: ***Dykhanie***, ***Pneumokard***, ***Sonokard***, ***Virtual***, ***Slezhenie)***

Suit "Regent" to treat locomotor system

Compact multifunctional diagnostic facility "Rezerv" for cardio-vascular system



Dykhanie space experimental program



Pneumokard exp., Inc28

Suit "Kentavr" to treat circulatory system

Biology & Biotechnology

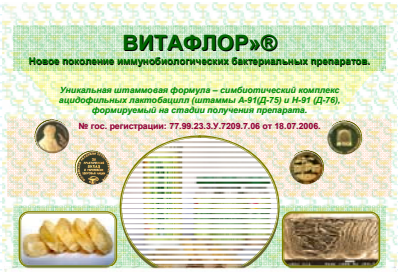
Research objectives:

- Development of basic technologies for manufacturing of bio-products under microgravity conditions.

Results:

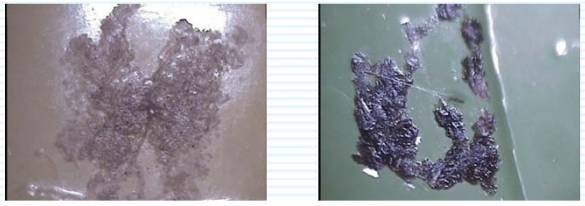
- Basic knowledge on bio-processes in space environment;
- Investment projects for application of new space bacterial and fungi strains to produce Hepatitis-B vaccine (***Antigen***), remedies, plant growth stimulators and oil biodegradation (***Bioekologia***);
- Results of ***Biorisk*** exp. confirm the feasibility of long-term storage of high plant seeds in space for further use them in Martian or other long-term missions;
- Space pro-biotics production (***Bioemulsia***) (2 patents).

Biorisk **experimental program: 23 month exposure on board the ISS doesn't worsen crop seeds**

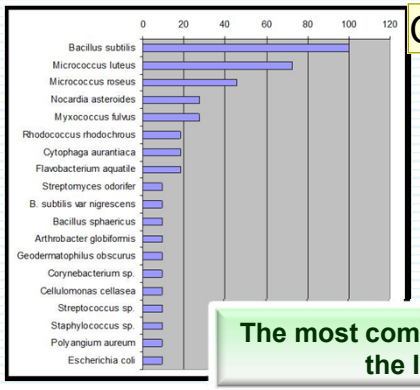


Probiotic Vitaflor®,

Recultivation of oil polluted lands (*Bioekologia*)



Bar **program: fungi strains in SM**



G1

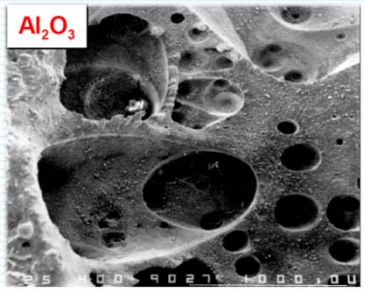
The most common bacteria on the ISS RS

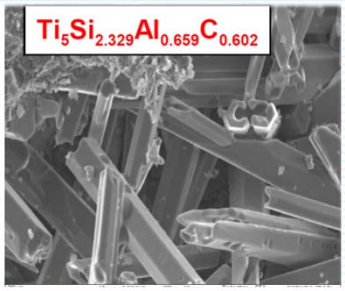
G1 К чему эта картинка

GFK, 24/04/2012

Materials and Processes in Space Conditions

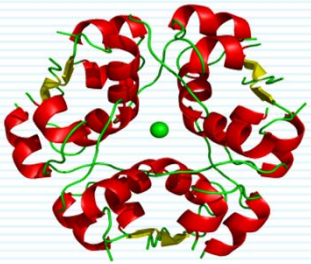
- Crystal growth, new materials and structures, physics of burning and synthesis, liquids, phase transitions, low temperatures under microgravity conditions.





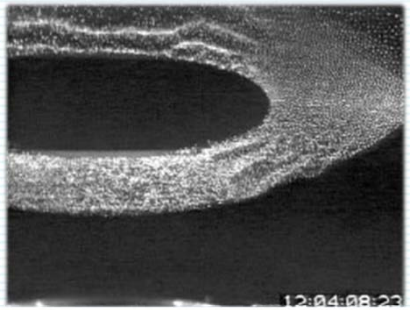
Self propagating high-temperature synthesis of different high-melting inorganic materials. Results can be used for repair works in space and building on other planets

Beta-glycosidase crystal grown in space for Gaucher's disease treatment

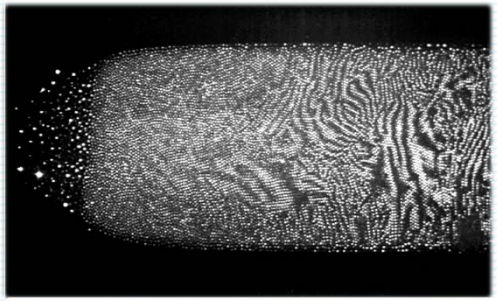


The record data of X-ray diffraction analysis of space grown crystals of genetically engineered human insulin were deposited to the Protein Data Bank (PDB).

***Plazmennyi Kristall*: investigation of plasma-dust crystals and liquids in microgravity**



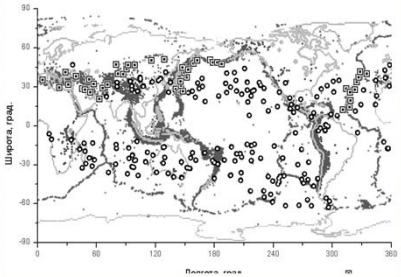
Nonlinear waves in dusty plasma



Liquid-crystal phase transition in plasma-dust formations under microgravity

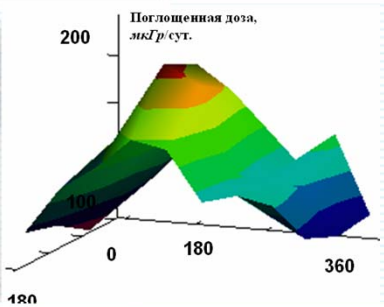
Astro- and Geophysics, Solar System & Space Environment Investigation

- Study of the universe, solar system, planets and asteroids;
- Interplanetary environment investigation on ISS by contact methods (mass-spectrometry, physical and chemical LEO dust analysis techniques);
- Radiation, electromagnetic and other space environmental conditions.

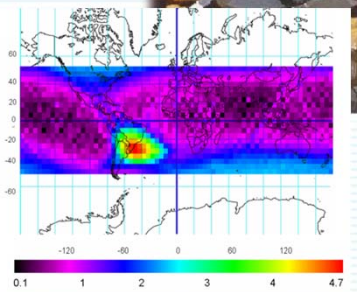


***Vsplesk*: bursts of high energy charged particles and tectonic faults**

Radiation doze on the phantom surface

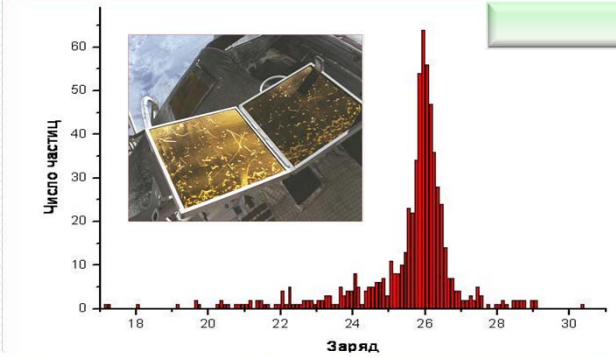


***Matryoshka*: Investigation of radiation environment inside and outside the ISS (using different phantoms)**

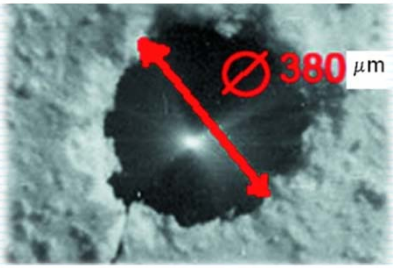


***BTN-neutron:* Charged and neutral particles investigation within solar flares. Neutron doze map**

***PLATAN* experimental program**



Charge distribution of nuclei (galactic space rays)



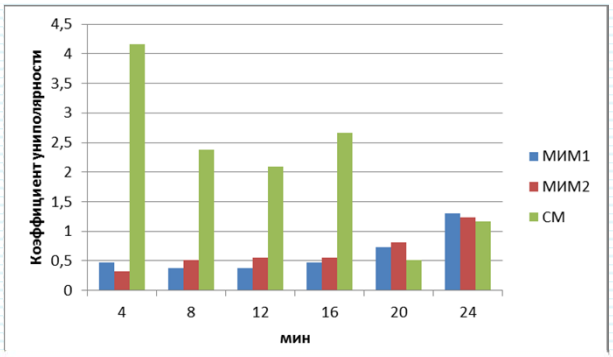
Microparticle collision hole.
The particle number is twice more than it was predicted.

Space Engineering & Technology

Leak detection

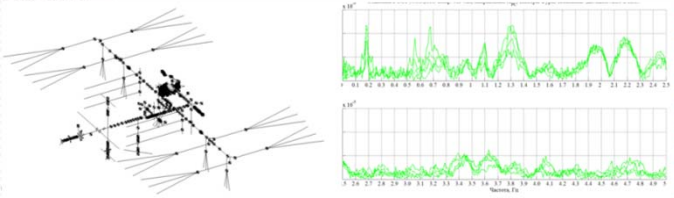
Aluminium alloy corrosion under joint ultrasonic and water condensate impact (x200)

Veterok: **ISS RS air parameters control**



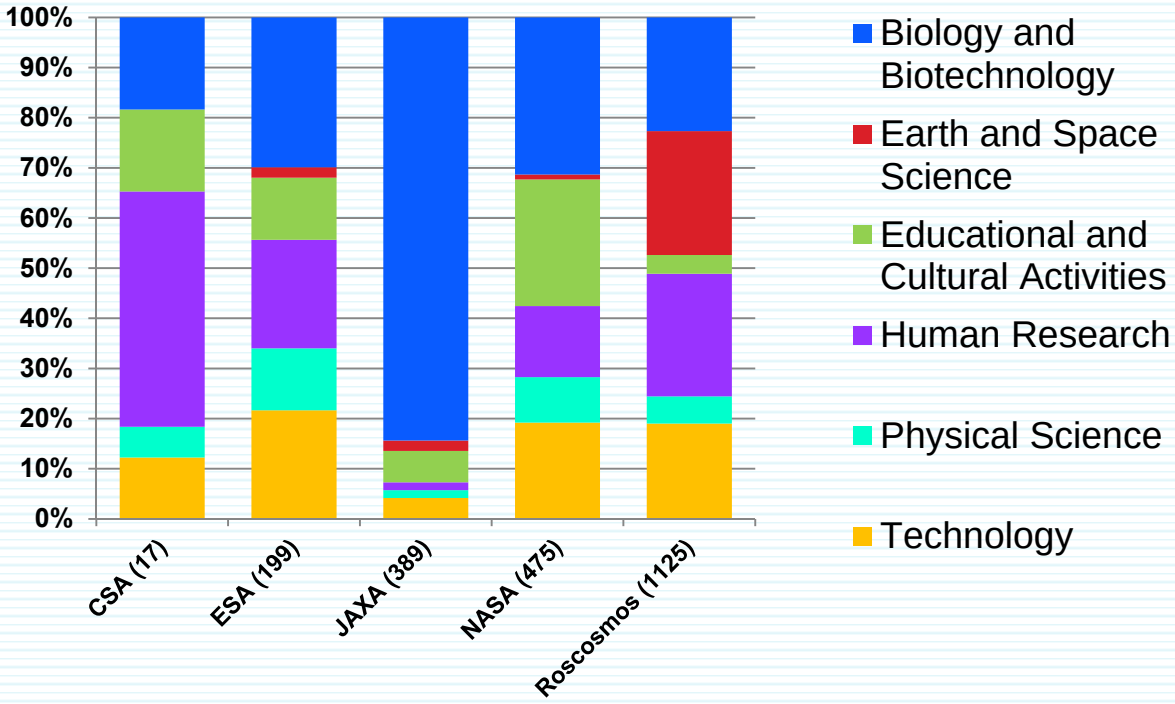
Veterok **experiment: Dynamics of positive/negative ions in ISS RS modules (should be in the range of 0.4- 1.0)**

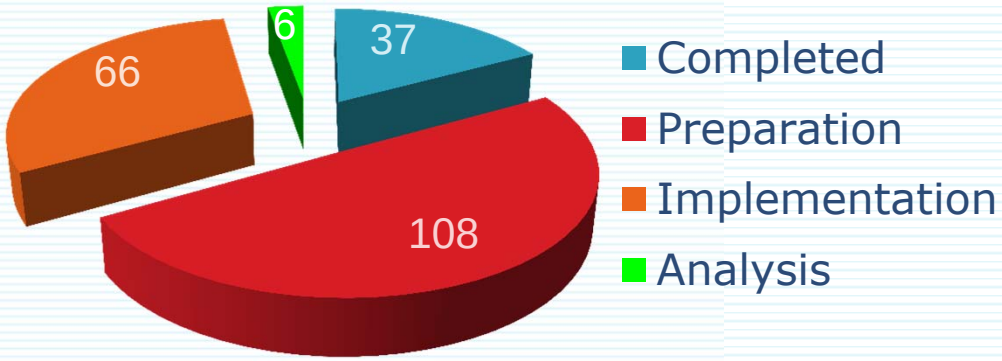
- Space exploration efficiency and safety improvement, ISS utilization extension;
- Innovation methods for leak, break-points, corrosion detection;
- Methods of orbital structures construction, automation and robotic support;
- Radiation protection;
- Development of future space technologies.



Identifikatcija **experimental program: Spectral and amplitude analysis of the accelerations during spacecrafts docking for calculation of the ISS residual resource**

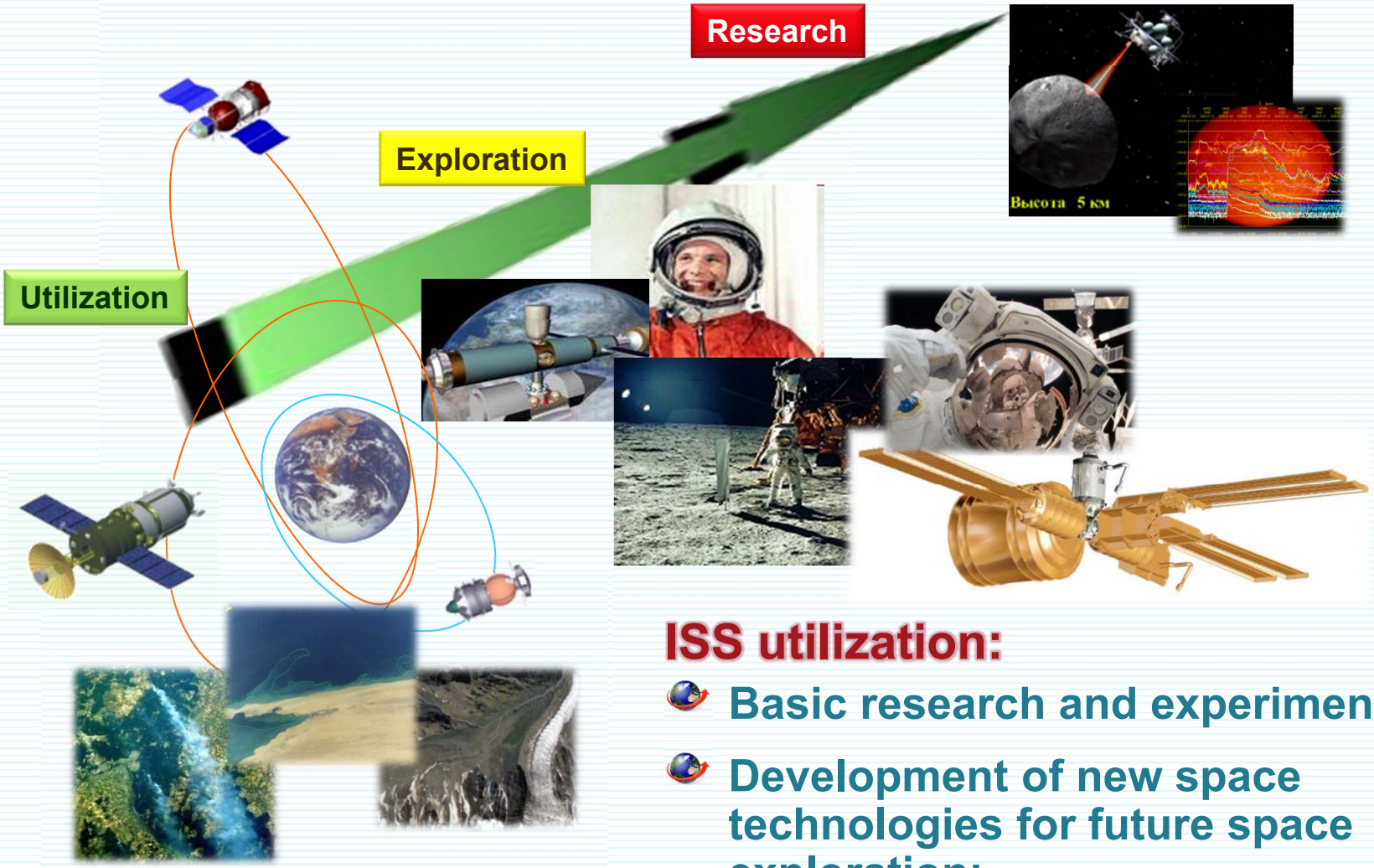
ISS RS Utilization Program Accomplishements





- 109 space experimental programs have been conducted (43 of them have been completed)
- More than 1100 experiments/investigations (Increments 1-28)
- 108 exp. programs in preflight preparation.
- >1000 scientific papers, reports and research articles.
- More than one third of them are in peer-reviewed publications

Space Expansion and Utilization by Humans

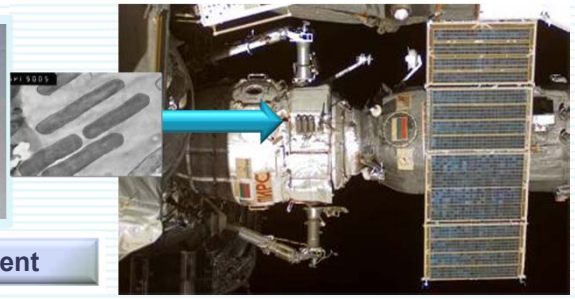


ISS utilization:

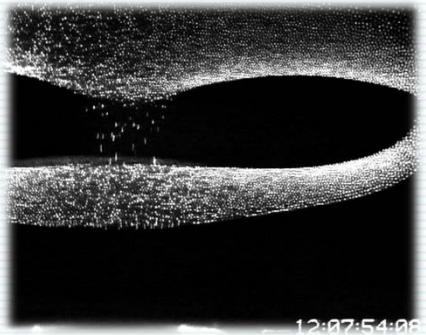
- Basic research and experiments;
- Development of new space technologies for future space exploration;
- Utilization of the ISS for practical tasks.

ISS for Basic Research

(taking advantages of the ISS environment and capabilities)

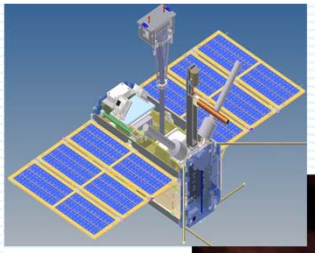


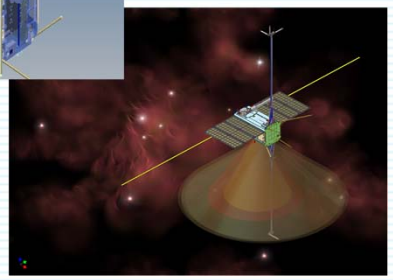
Biorisk **experiment**



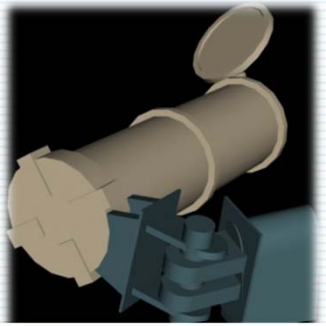
Ekran-M **space experiment: Synthesis of heterostructures in ultra high space vacuum by Molecular Beam Epitaxy technology**

- Biology (including long-term exposures);
- Physics of vacuum and gravity-sensitive phenomena (including ones on free-flying spacecrafts periodically docked with the ISS);
- Solar system, astro- and geophysics investigations requiring large power resources and maintenance.





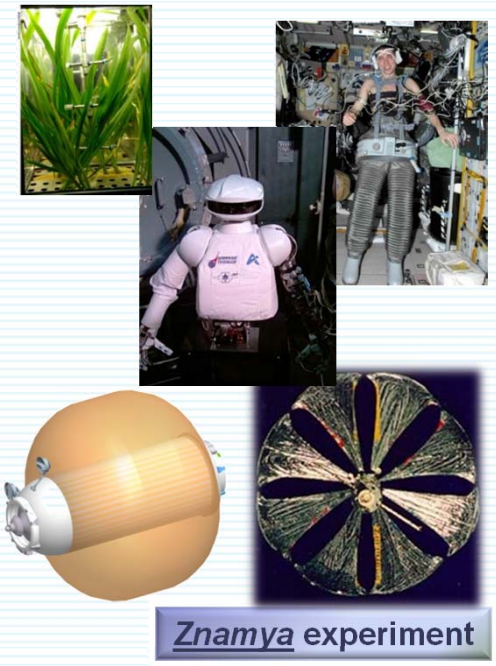
Microsatellite *Chibis-M*: study of lightning discharges across the whole spectrum of electromagnetic radiation



600 mm diameter telescope for planet monitoring

ISS for Space Exploration (1) (testing key technologies)

- New generation Life Support Systems with high degree of regeneration;
- Technologies and systems for key parameter autonomous real time diagnostics and correction of astronaut`s health.
- Robotic systems to support astronaut`s operations;
- Inflatable transformable space modules and large structures;
- Deep space rendezvous and docking, spacecraft maintenance, communication and navigation;



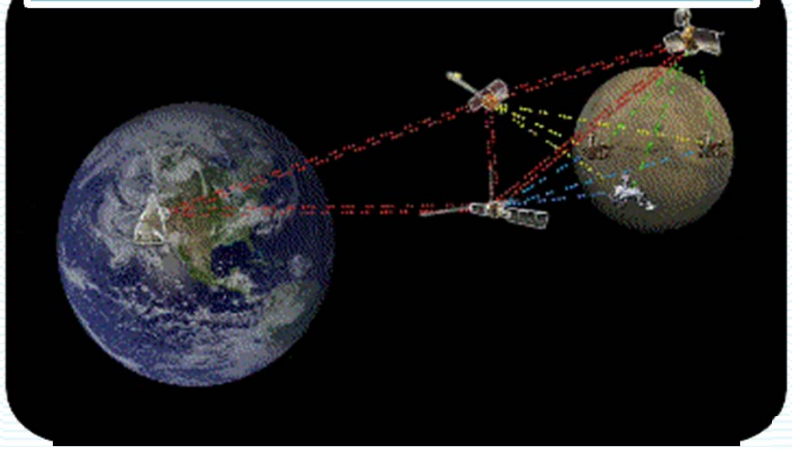
Znamya experiment

Results of about half of Russian experiments could be used for exploration, mainly in the areas of:

- Biomedical research;
- Space engineering and technologies.

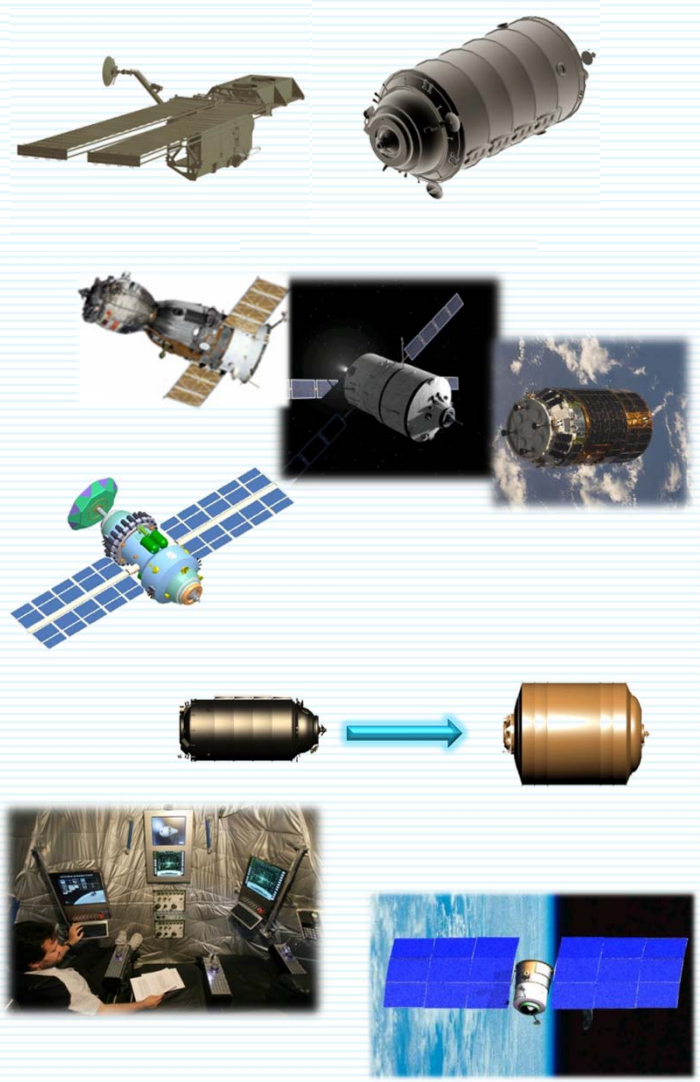
CURRENT ISS CAPABILITIES FOR EXPLORATION MAY BE IMPROVED

Delay/Disruption Tolerant Networking (DTN)

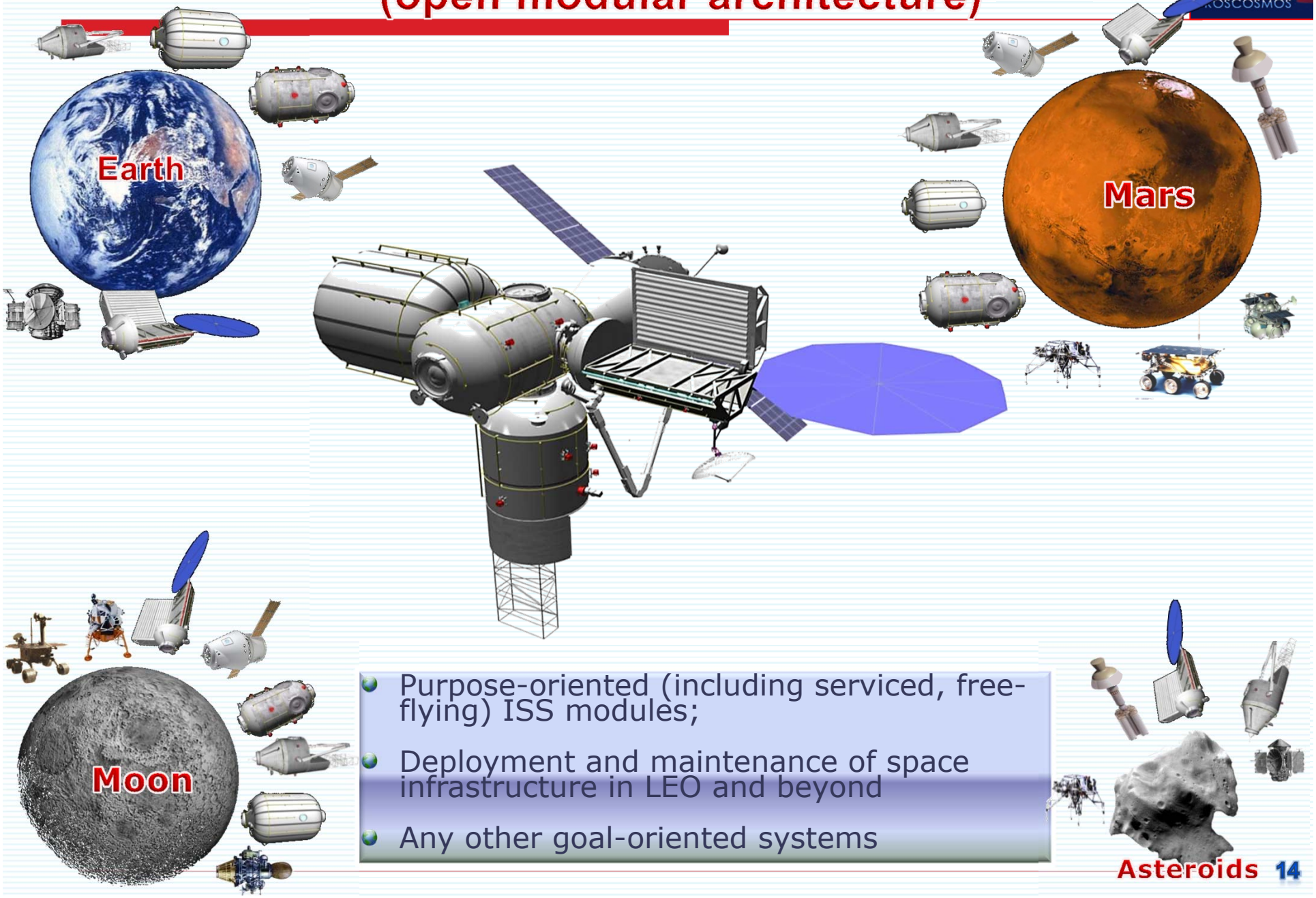


ISS for Space Exploration (2)
(ISS further development)

1. New modules (transformable (inflatable) modules, jig module etc.);
2. New (free-flying) spacecrafts to get conditions for research not achievable on board the ISS;
3. Testing of new assembly and operation technologies (rendezvous, docking, robotic systems, transformed structures etc.);
4. Other technology for future manned flights beyond LEO.



ISS for Space Exploration (3)
(open modular architecture)

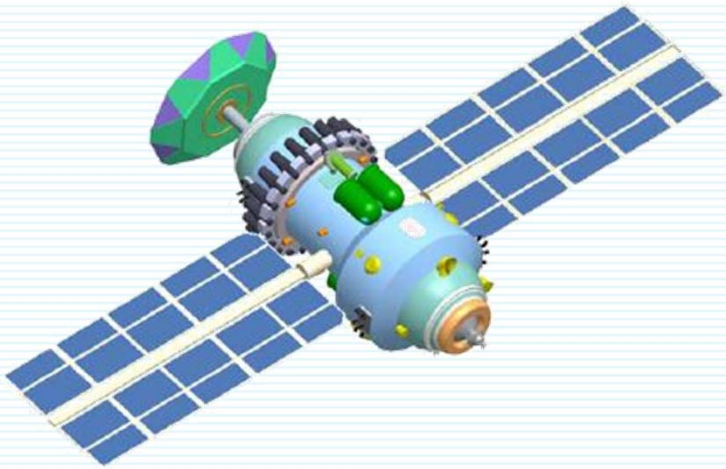


- Purpose-oriented (including serviced, free-flying) ISS modules;
- Deployment and maintenance of space infrastructure in LEO and beyond
- Any other goal-oriented systems

ISS for Space Exploration/Utilization

Serviced Technological Spacecraft (STS)

(OKA-T)



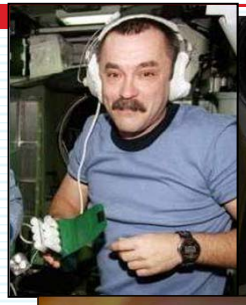
STS Performance

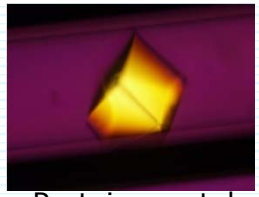
Micro-acceleration	not more than 10^{-7}g
Vacuum pressure in the zone where experiments and technological processes are conducted	10^{-14} mmHg
One cycle of autonomous operation	up to 180 days
Total solar array power at the end of life	5 600 W
Launch mass	7 800 kg
Lifetime	>5 years
Maintenance cycle length at Russian Segment	3-5 days

- STS is a free-flying spacecraft which docks to the ISS periodically for maintenance, refueling, changing samples, materials and research equipment.
- The main objective of the STS is testing of exploration technologies (dangerous for humans), obtaining materials with specific properties non achievable on Earth and similar.
- It is possible to conduct space experiments on STS at microgravity, deep vacuum, as well as absence of vibrations and strong magnetic fields, in the conditions not achievable on board of the ISS.

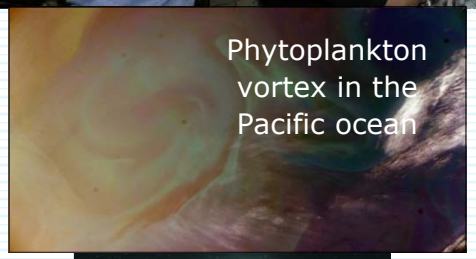
Utilization of the ISS for Practical Needs

- **Human health**
  - Methods and tools for disease prevention, diagnostics and medical treatment applicable in clinical practice on Earth;
  - Technologies for space production of ultrapure substances, bioproducts and medicine (vaccines, drugs and strains).
- **Earth observation**
  - New methods and tools for the Earth remote sensing;
  - Monitoring of the atmosphere, ground and ocean for study of natural recourses and ecology;
  - Space weather effects;
  - Study of disaster (earthquakes, climate change etc.) forecasting methods and precursors.
- **Education and popularization**
  - Educational and outreach projects
  - Lessons from space
  - Inspiring youth to study science.





Protein crystal

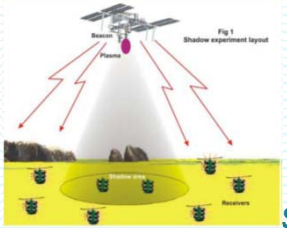


Phytoplankton vortex in the Pacific ocean

Glacier monitoring

UV-band high-altitude electrical storm

Forest fire



Shadow-Mayak experiment

Fizika-obrazovanie
TV-lessons from ISS RS

ISS Utilisation purpose-oriented programmes to the benefit of interested customers

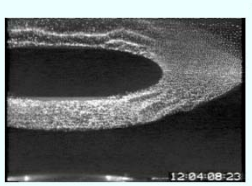
More detailed information about ISS RS utilization programs may be found on http://knts.tsniimash.ru

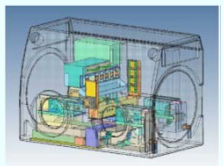
International Cooperation

ESA

Upon the Frame Agreement signed

Joint Experimental Program is being enforced





In the first line

Plasma crystal

Matroshka

Immuno

Relaxatsiya (ATV-reentry)

Dal'nost' (GTS-2)

DSMIX

Peritektika (Parsec)

In the second line

Disk (SISSI)

Display (Pasta)

VIPIL

Kinetika(Multiphase)

… about 10 experiments

Dozens of experiments in future

JAXA

Matroshka-P - Padles

Crystallizer - PCG experiment

Investigation of fishs behavior in ***Aquarium-AQH***

NSAU

The Program of Scientific & Applied Experiments has been updated in framework agreement between Roscosmos and State Space Agency of Ukraine.

NASA and CSA

Suggestions on possible areas of future scientific collaboration with NASA have been elaborated

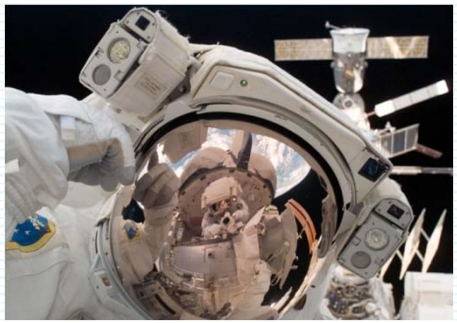
Joint Russian-Canadian experiment TriDar is planed.

Summary

- International space station – unique space laboratory for basic and applied research – has become a symbol of intellectual potential of humanity
- Roscosmos has already obtained promising outcomes from the ISS utilization program and expects more benefits in future both for Earth needs and further space exploration
- There are promising opportunities to improve efficiency of research programs and ISS utilization on the basis of mutual interests for cooperation of scientists over the world

ISS – Crucial Stage of Human Space Exploration

ISS is an important milestone of the human space exploration

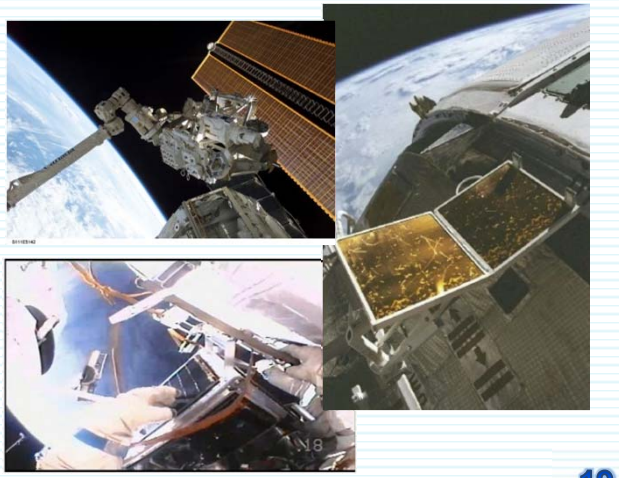


More than 10 years of ISS utilization and 25 years of PERMANENT human presence in space

Demonstration of international cooperation capabilities

Unique scientific laboratory

Advanced technology maturation



ЦНИИМАШ
TSNIIMASH

ROSCOSMOS

Thank you for your attention!