



Ukraine's R&D Capacity in Space Industry



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Consortium



**EU Project: Joint Support Office for Enhancing Ukraine's Integration
into the European Research Area (JSO-ERA)**



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With its high R&D and production capacity, young and independent Ukraine has become one of the world leaders in the space industry.

Founded in 1992, the National Space Agency of Ukraine (NSAU) brought together almost 30 design offices, R&D institutions, and industrial manufacturers which gained extremely valuable scientific and practical experience during the Space Era.

The leading companies of the space industry have great experience in the development and production of up-to-date launch vehicles, spacecrafts, engines, control facilities and telemetry systems. New materials and technologies, mostly with unrivalled features, have been launched into production.

The space industry, which annual export turnover (including products and services) exceeds EUR 100 Million, employs 30,000 highly qualified specialists.

Ukraine pursues associated membership in the EU 7th Framework Programme for Research and Technological Development (2007 – 2013) with the budget of approximately EUR 52 billion.

This booklet is intended primarily for the European partners interested in space R&D technologies and establishing international research consortiums jointly with Ukrainian entities.

Looking forward to fruitful cooperation between European and Ukrainian researchers,

Yuriy Alekseyev, National Space Agency of Ukraine, Director General
Oleg Fedorov, Institute of Space Research NASU-NSAU, Director

1. UKRAINE IS A CENTRAL EUROPEAN LEADER IN THE SPACE INDUSTRY

With its unique geopolitical position in the middle of Europe, Ukraine played a prominent role in the space programs of the former Soviet Union.

The world's largest aerospace research and production centre was based on enterprises located in Dnipropetrovsk, Kharkiv, and Kyiv.

Ukrainian researchers, design engineers and experts invented and developed four generations of strategic missile complexes including SS-18 (Satan) and SS-24 (Scalpel) and launched large-scale manufacture of more than 10 thousands ballistic launch vehicles, about 300 space vehicles, and more than 400 artificial military and civil satellites.

The first soviet spaceships, orbital stations and lunar vehicles, spacecrafts and interplanetary stations, in near and distant space, were operationally controlled from the Crimea (Ukraine).

The powerful strategic rocket force comprising 130 intercontinental ballistic missiles SS-19 and 46 SS-24 missiles was deployed in the territory of Ukraine.

Upon independence, Ukraine has taken several unprecedented steps to strengthen its R&D and production capacity to ensure its peaceful use for the benefit of mankind.



The most important steps are summarized below:

- Renunciation of possession of nuclear weapons and abandonment of manufacturing and of nuclear weapons delivery systems
- Destruction of ballistic missile launching shafts
- Disposal of SS-19 and SS-24 missile complexes and implementation of the program for SS-18 intercontinental ballistic missile conversion into the Dnipro launch vehicle
- Reorganization of the Special Centre for Nuclear Test Monitoring into the Seismic Monitoring Centre
- Use of missile attack early warning stations for space surveys and control
- Development of the National Peaceful Space Exploration Program

Main achievements of the space industry during the years of independence of Ukraine:

- Development of the integrated industry based on the powerful world known manufacturers such as Production Association Yuzhny Machine Building Plant n.a. A. Makarov, Yuzhnoye Design Office n.a. M. Jangel,

State Research & Production Corporation Kommunar, Hartron JSC, Central Design Office and Plant Arsenal, production associations Kyivprilad and Kyiv Radio Plant, Yevpatoria Space Centre and others.

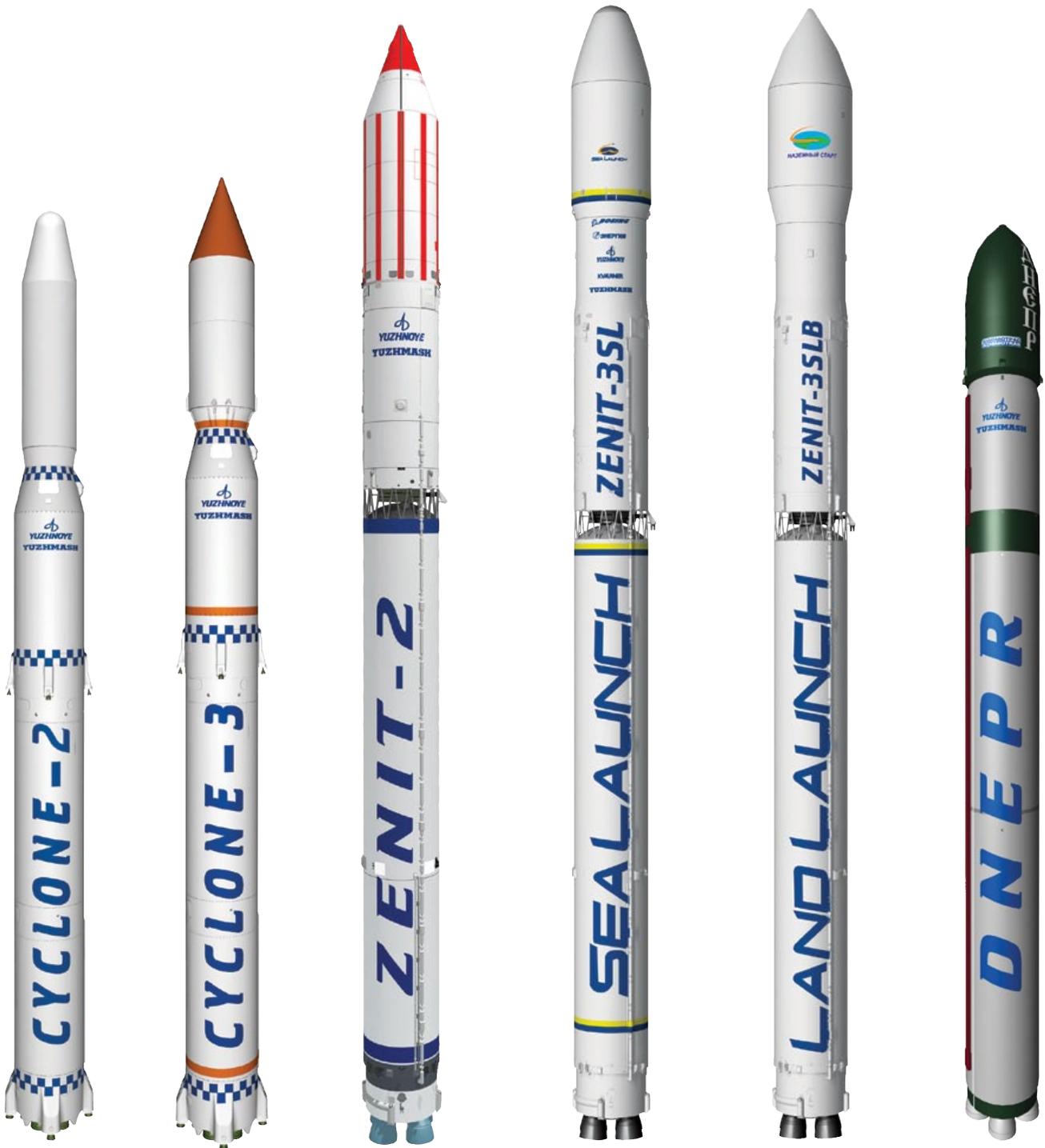
- Bilateral cooperation agreements signed with Russia, USA, China, India, Brazil, Egypt, EU member states and the European Space Agency (ESA)
- Involvement of industry leaders in international commercial projects such as Sea Launch, Land Launch, Dnipro, Cyclone 4, Vega, Taurus II and other joint projects being implemented under bilateral agreements with foreign partners
- 118 launches made-in-Ukraine launch vehicles Cyclone, Zenit, and Dnipro have been successfully performed from four launch sites located in other countries and more than 200 spacecrafts were placed into orbit under contracts with 10 countries.

Today, Ukraine has all the necessary resources to implement large scale space projects and is open to international cooperation in the peaceful use of outer space.



NUMBER OF LAUNCHES IN 1991- 2010

Over the years of Ukraine's independence, 118 launches of launch vehicles have been completed and more than 200 spacecrafts have been put into orbit under contracts with 10 countries.



Cyclone-2	Cyclone-3	Zenit-2	Zenit-3SL	Zenit-3SLB	Dnipro
14	33	22	30	4	15
Baikonur	Plesetsk	Baikonur	Marine platform in the Pacific Ocean	Baikonur	Baikonur, Yasnyy



INTERNATIONAL SPACE PROJECTS

Dnipro Project

The Russian & Ukrainian Dnipro Conversion Project was launched to reequip SS-18 (Satan) inter-continental ballistic rockets developed and manufactured in Ukraine into three-stage Dnipro space launch vehicles.

The Russian & Ukrainian International Company Kosmotras was founded in 1997 as a launch vehicle manufacturer and commercial operator. Domestic operators – Yuzhnoye Design Office, Yuzhmash and Hartron – upgrade and provide operational and technical support for launch vehicles.

In 1999 – 2010, 14 Dnipro launch vehicles have been successfully launched from Yasny Launching Platform (Russia) and Baikonur Spaceport.

The residual service life and the number of combat missiles that are being removed off duty in Russia and subject to conversion will ensure commercial launches until 2020.



Sea Launch Project

Yuzhnoye Design Office and Yuzhny Machine Building Plant (Yuzhmash), two Ukrainian manufacturers, in cooperation with Boeing (USA), Kvaerner (Norway) and Rocket Space Corporation ENERGIA (Russia) founded an international stock company Sea Launch in 1995 to implement their unique project known as Sea Launch.

The floating launching system was developed for operation of Zenit carrier developed by Yuzhnoye Design Office and manufactured by Yuzhmash (both are Ukraine-based companies).

30 launches of Zenit-3SL launch vehicles have been carried out from the sea platform in 1999 – 2010.



Land Launch Project

By combining technologies developed as a part of the Sea Launch Project and Baikonur Spaceport ground infrastructure, the use of Zenit launch vehicle was expanded within the framework of the new initiative – Land Launch Project.

This project has been implemented since 2004 by an international stock company Sea Launch and Ukrainian & Russian joint venture International Space Services acting as equal project partners.

In 2008 – 2010, Zenit-3SLB launch vehicles have been launched from the Baikonur Spaceport 4 times.

Cyclone 4 Project

The Ukrainian & Brazilian Cyclone 4 Project is to develop the new light class Cyclone 4 launch vehicle in Ukraine and to construct launching site at the Alcantara Spaceport (Federal Republic of Brazil).

The Alcantara Cyclone Space Binational Company (Ukraine – Brazil) was founded as a project implementer.

The Project is supposed to provide space vehicles and launching facilities to meet the needs of Ukraine and the Federal Republic of Brazil and to serve third parties on a commercial basis.

The beginning of Cyclone 4 operation and the first launch of spacecraft from the Alcantara Spaceport are planned for 2012.



GROUND-BASED SPACE INFRASTRUCTURE

Ukrainian ground-based space infrastructure include the **National Space Facilities Control and Test Centre**, the **Ukrainian National Time Navigation System** and **Ground Satellite Television Broadcasting Network**.

The National Space Facilities Control and Test Centre comprises several operational systems.

The Near Space Spacecraft Application System provides operational control for the Ukrainian satellites, receives and process Earth remote sensing data and is involved in operational control of foreign spacecrafts.



Built near Yevpatoria 50 years ago, *the Flight Control Centre* started its operation by receiving signals from the first artificial Earth satellite. The Centre provided radio communication with Yuri Gagarin, the first man in space, and flight control for the first soviet space missions, orbital and interplanetary stations.

The System for Control & Analysis of Space Conditions efficiently detects sources of danger in space, classifies space objects and controls the fulfilment of international treaties on the use of outer space.

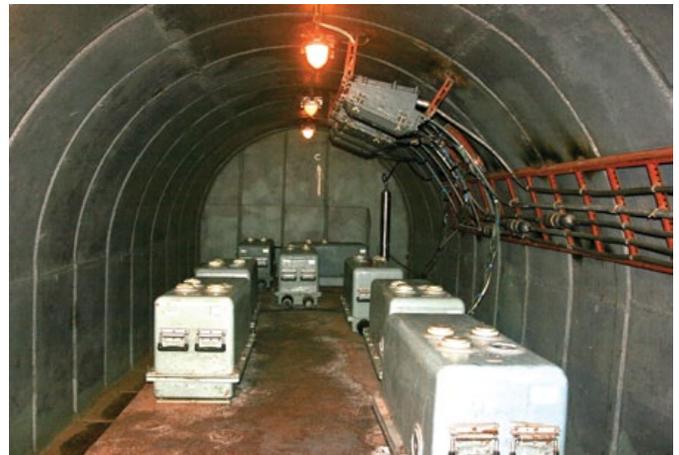
The System for Far Space Scientific Exploration controls interplanetary space stations and spacecrafts and conducts radio astronomical and physical explorations of the Universe with the ground-based RT-70 telescope.





The Geophysical Monitoring System keeps records on earthquakes and other processes in the earth crust in and outside Ukraine. A system unit, PS-45 Seismic Station, is a part of the International Monitoring System to control fulfilment of the Comprehensive Nuclear Test Ban Treaty.

The Ukrainian National Time Navigation System was developed to increase positional accuracy within Ukraine, national airspace and adjacent seas by means of the global navigational satellite systems GPS and GLONASS, and the upcoming GALILEO satellite system.



The Ground Satellite Television Broadcasting Network was developed to broadcast Ukrainian TV programs via geostationary communication satellites to the regional centres of Ukraine, Ukrainian embassies and consular offices in foreign countries.



TOWARDS THE NATIONAL EARTH REMOTE SENSING SYSTEM

The launch of the first spacecraft SICH-1 into orbit by Cyclone 3 launch vehicle in August 1995 was a first milestone on Ukraine's way to the development of SICH Multipurpose Earth Remote Sensing System.



In April 2007, the Dnipro launch vehicle placed into orbit the first Egyptian satellite for remote Earth surface sensing developed by the Yuzhnoye Design Office and manufactured by the Yuzhmash. Developed and manu-



In July 1999, Zenit 2 launch vehicle put into orbit a Ukrainian-Russian satellite Okean-O to study natural resources. It was designed for remote ocean and continental surface sensing.



factured in Ukraine, the satellite flight control, data receiving and processing ground systems were located in Egypt. The Egyptian spacecraft EgyptSat-1 has been successfully performing in the orbit for 3 years.



A new vehicle SICH-1M and the first Ukrainian microsatellite MS-1-TK were launched from the Plesetsk Launching Site in December 2004.

Remote sensing data generated by Ukrainian satellites facilitate solving urgent problems in oil and gas layers, nature management and forest fire risk assessments, classifying soils and crops, monitoring snow melting and ice condition in sea areas and water reservoirs, assessment of floods, and searching for pollutions in dry lands and natural water areas.

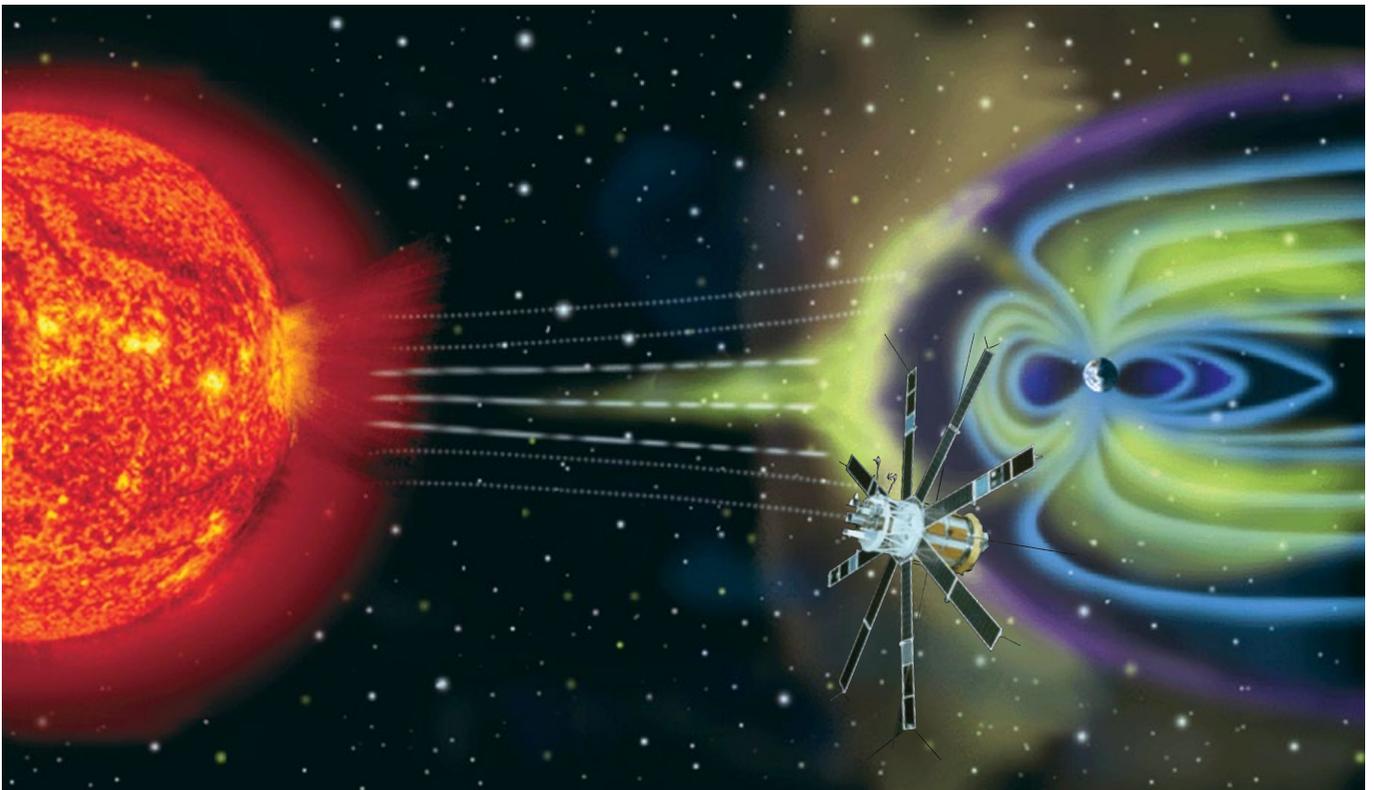
The new Ukrainian optoelectronic Earth sensing satellite SICH-2 based on microsatellite technology is being prepared for the launch.

The development of the up-to-date SICH family satellites and ground infrastructure along with the use of advanced information technologies provide good background for efficient functioning of the National Earth Space Surveillance System.

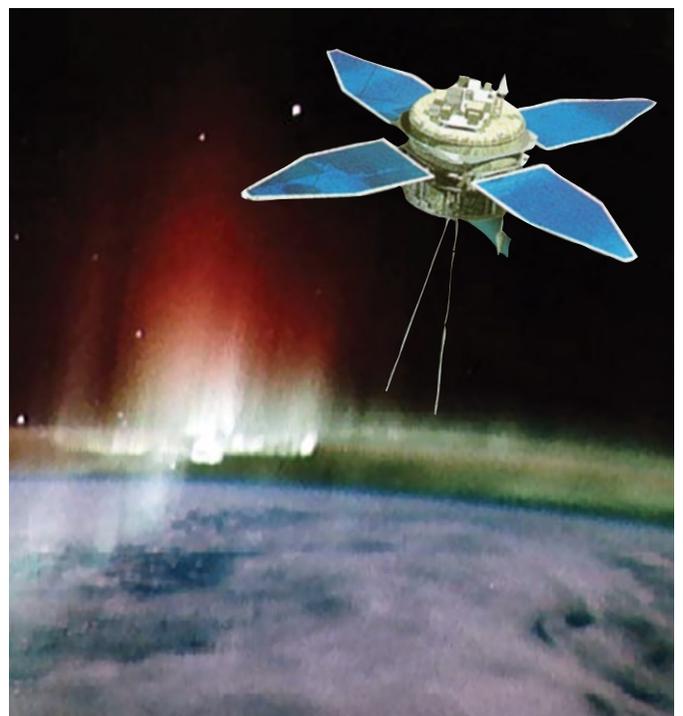


2. MAJOR AREAS OF SPACE RESEARCH AND TECHNOLOGY IN UKRAINE

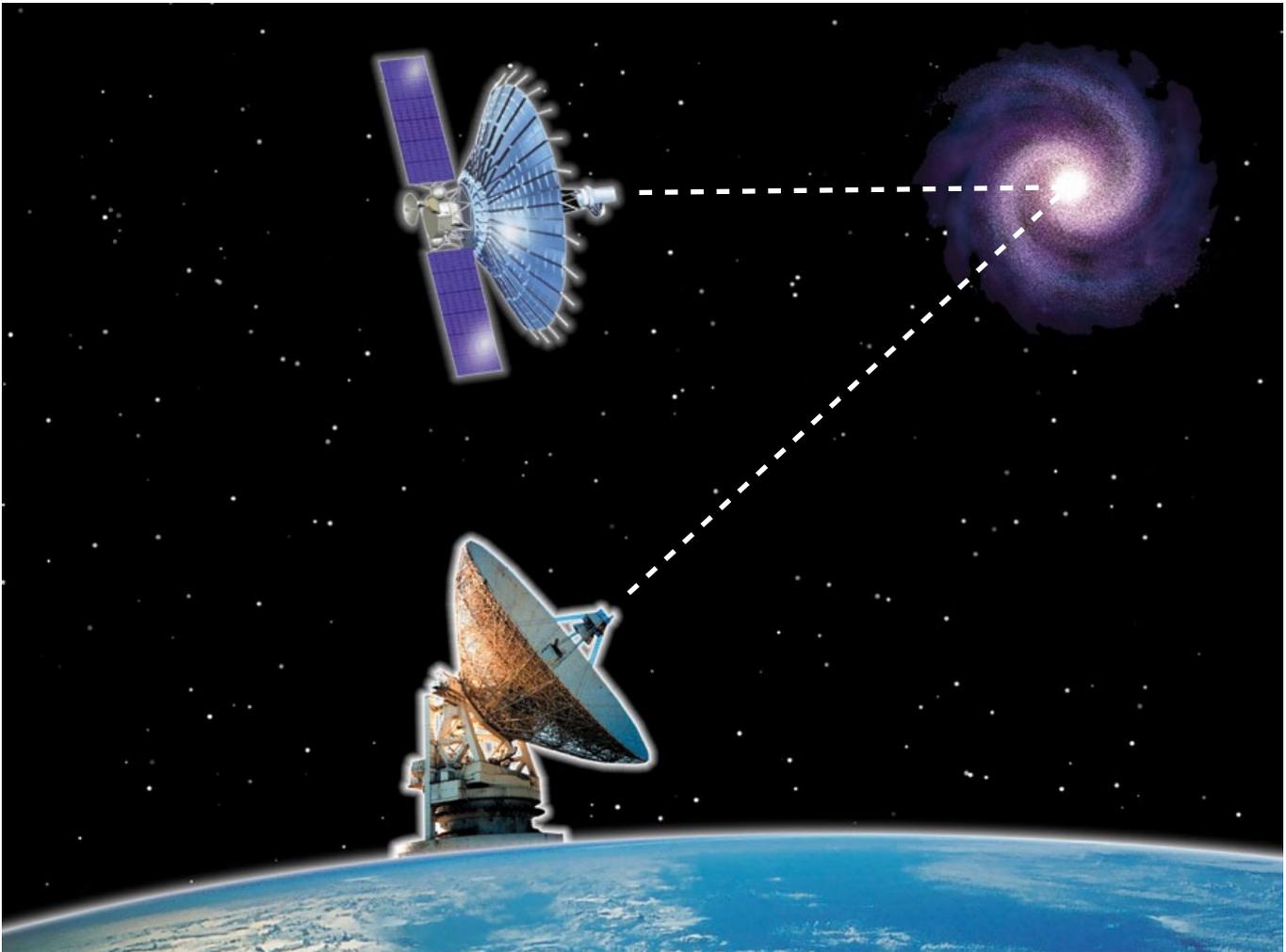
2.1. EXPLORATION OF SUN - EARTH CONNECTION



Exploration of processes in the magnetosphere and ionosphere of the Earth caused by solar activity is a priority for the global space science. Space weather impacts people's health and condition of technical systems in the near Earth space to a large extent. Many Ukrainian research centres explore solar activity through observation from the surface of Earth and from board of spacecrafts, processes in the active areas of solar atmosphere, and elaborate the solar wind model. They explore mechanisms of ionosphere storms' origin during solar flares, observe solar masses emission into interplanetary space, study non-linear wave processes in the near-Earth space and influence of solar disturbances on the geosphere and biosphere of the Earth. The applied aspects of their research include earthquake forecasts and weather control methods. An appropriate IT system is under development to provide space weather data.



2.2. ASTRONOMY AND ASTROPHYSICS



Among Ukraine's priorities is radio interferometry since Ukraine possesses RT-70 telescope, one of the largest radio telescopes in the world which was upgraded with advanced radio receivers and registration facilities. The basis of navigational support of flights for SCs in the near- and deep space was combined with highly precise positioning and timing functions to track basic parameters and planet location, explore asteroids and space debris in addition to exploration of the Universe' objects with high resolution capacity. The preliminary phase of the Radioastron Project which will use unique on ground domestic facilities is close to completion.

The unique satellite telescope for measuring electrons and protons STEP-F developed by Ukrainian researchers is an element of onboard research instruments. With such telescope, flows of electrons, protons and alpha particles trapped in the internal and external radiation belt of the Earth and solar space streams can be measured and investigated on a continuous basis. In 2009, STEP-F was successfully operated on the orbit as a part of research equipment of the Russian spacecraft KORONAS-FOTON.



Technological sample of STEP-F instrument



2.3. SPACE BIOLOGY AND MEDICINE

Space medical and biological projects study gravity and sensitivity of living beings at various levels of their organization, adaptation to microgravity, development of space instruments and biotechnology. Ukraine has become one of the world leaders in this field.

The project results represent revolutionary research information about casual relationship between changes in cells and a body as a whole. It was the first time when the bone absorption mechanism was studied at the level of nano subsystems of bone tissue which helped elaborate counter measures to halt deossification caused by microgravity and osteoporosis on the ground. The response of virus/plant system on microgravity was also investigated, and new models for exploration of its effect on biological rhythm in a human body, immune and nervous system, blood micro circulation have been proposed.

Cultivation technologies have been elaborated for a number of biological objects for the human life support system during the long-term space journeys. The results allow to better understand the biological role of gravity in existence and functioning of the biosphere of the Earth and its input to the development of gravity- and general biology.



Wheat plants, nursed at "Cycle-2" clinostat



The "Malakhit"(green copper) set with orchids creates a wonderful design for cosmonauts



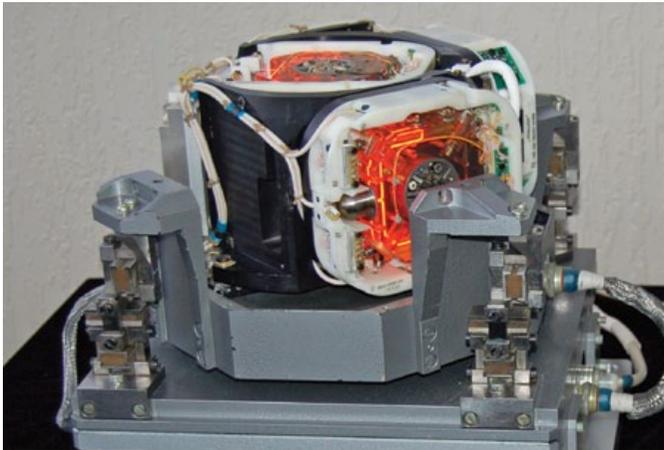
Flowers, grown with help of micro-organisms on the analogue of lunar ground, by the scientists of the NASU Institute of Molecular Biology and Genetics



2.4. SPACE MATERIAL SCIENCE AND INSTRUMENT ENGINEERING

Development of advanced units and prototypes of rocket and space equipment is a primary objective of scientific, technical and technological research.

In 2009, the development of domestic gimballess inertial navigation system BINS was completed. This system is intended for perspective control systems for launch vehicles, including Cyclone 4. BINS test models were successfully designed and tested on board of a motor vehicle and aircraft mobile labs. BINS completed verification tests in situ in June 2010 on board of Dnipro launch vehicle.



The platformless inertial navigation system BINS developed by the NVO Khartron-Akros and the TsKB Arsenal

The researchers have developed a test model of small-sized astromasuring system MAVS-B. This system provides highly precise spacecraft navigation and is equipped with a combined satellite sun navigation sensor.



Small-sized astromasuring system «MAVS-B»

Aluminium foil processing technologies for production of honeycomb filler and carbon/carbon composite materials for solar voltaic array frames of spacecrafts have been developed so far.



Samples of carbon-carbon composite materials

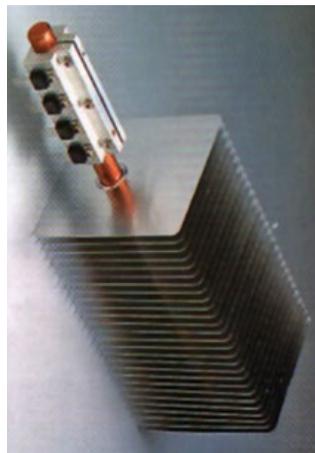
Space experiments are going through the preparation phase and will be conducted on board of the Russian segment of the International Space Station (ISS) to study the effect of microgravity on physical and chemical processes and properties.



Friction knot of tribometer



Module of on-board tribometer



Heat transfer tube



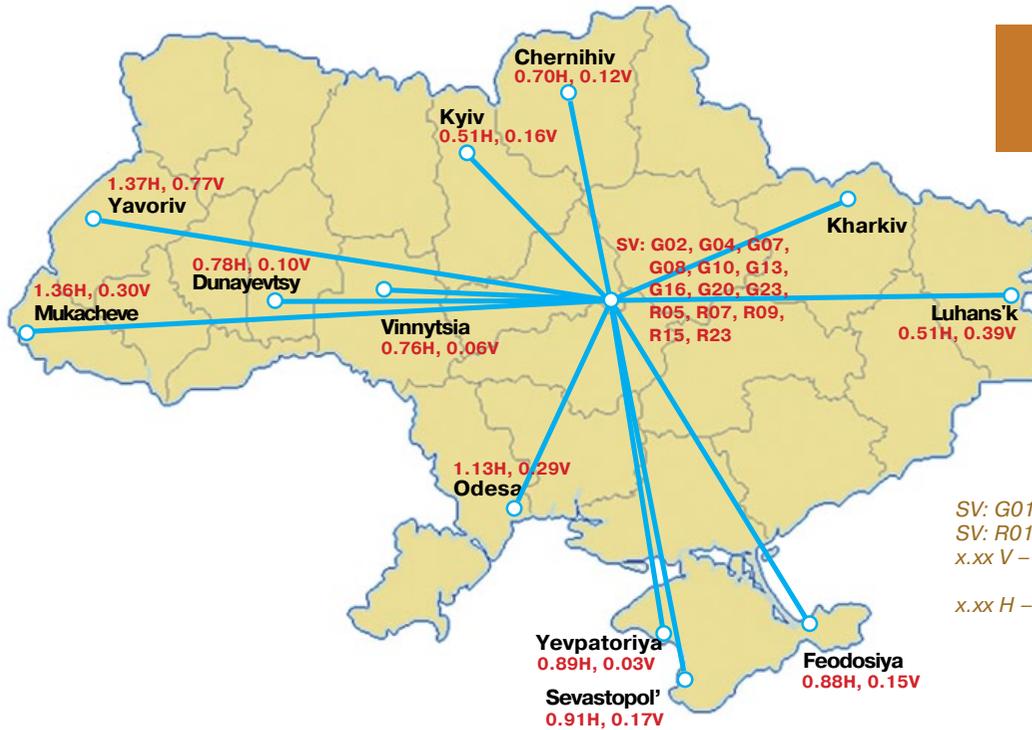
Repeated load unit



2.5. SATELLITE NAVIGATION

NSAU supervises the development of Coordinate/Time and Navigation Support System of Ukraine (SCNOU) to enhance positioning quality over the territory of Ukraine based on global navigation satellite systems (GNSS). With a network of 13 reference stations deployed in Ukraine and operating on a continuous basis, SCNOU offers 1 m position accuracy based on GNSS GPS and GLONASS real-time technology.

The Cooperation Agreement on a Civil Global Navigation Satellite System between Ukraine and the European Community is a legal framework for their joint activity under the European GALILEO Program. Extension of coverage for EGNOS (European Regional Satellite Navigation System) to include the entire territory of Ukraine shall become the first step of such cooperation.



Structure of the coordinate-time and navigational support system of Ukraine

SV: G01, ..., G32 – numbers of GPS satellites
 SV: R01, ..., R24 – numbers of GLONASS satellites
 x.xx V – average value of deviation in height after introduction of corrections, m
 x.xx H – average value of deviation in plane after introduction of corrections, m

2.6. SPACE VISUAL SURVEY

Space IT methods for Earth and near Earth visual surveys have become a platform for further development of a brand new system – geoinformation support system. Such system could hardly be developed without active participation in the global initiative GEO and European GMES. As a result, Ukraine has delivered a range of solutions and developed GEO-UA Information System which may be considered as a Ukrainian segment of the global “system of systems” GEOSS. The primary purpose of GEO-UA is online satellite-based visual survey data capture and processing for any system user. GEO-UA provides special tools for emergency situations, environment monitoring and many solutions for the agricultural sector.

UN-SPIDER Program Regional Office was opened in April 2010 at ISR to serve as a data processing centre for information from spacecrafts of different countries to enhance emergency monitoring in Ukraine.



The First Ukrainian Conference on «Earth Observation for Sustainable Development and Security GEO-UA», Kiev, 2008



Town of Mykolayiv
with surrounding areas



Crimea.
The Sevastopol Bay
and the Cape of Khersones

3. UKRAINIAN - EUROPEAN COOPERATION IN SPACE

Contractual and legal framework

International legal instruments governing cooperation between Ukraine and Europe:

- Cooperation Agreement on a Civil Global Navigation Satellite System (GNSS) between the European Community and its Member States and Ukraine dd. Dec. 01, 2005;
- Framework Agreement between the Government of Ukraine and ESA on Cooperation in the Use of Outer Space for Peaceful Purposes dd. Jan. 25, 2008;



- Framework Agreement between NSAU and the National Space Research Centre of France (CNES) on Cooperation in the Field of Space Activity dd. June 21, 2007;



- Framework Agreement between NSAU and German Aerospace Centre (DLR) on Cooperation in the Field of Space Activity dd. May 29, 2008.

The Space Section describing the main areas of cooperation between Ukraine and the European Community in the exploration and peaceful use of outer space was incorporated to the Association Agreement between Ukraine and EU and prepared for approval.

Cooperation with the European Space Agency

NSAU has taken consistent efforts to join the European Space Agency. The Framework Agreement between the Government of Ukraine and ESA on Cooperation in the Use of Outer Space for Peaceful Purposes signed on Jan. 25, 2008, ratified by the Parliament of Ukraine on Oct. 30, 2008, and effective since Jan. 25, 2009 was a very important milestone on this way.



Today, NSAU and ESA leaders have defined the main areas of cooperation and established a joint working group NSAU-ESA to have its first session held in late September 2010 in Prague.



Launch of European Spacecrafts by Ukrainian Launch Vehicles



June 15, 2007. Ukrainian launch vehicle Dnipro injected successfully German ERS spacecraft TERRA SAR-X into the sun synchronous orbit from Baikonur.



April 8, 2010. Dnipro successfully launched Cryo-Sat-2 SC (ESA) from Baikonur for ice cover monitoring.

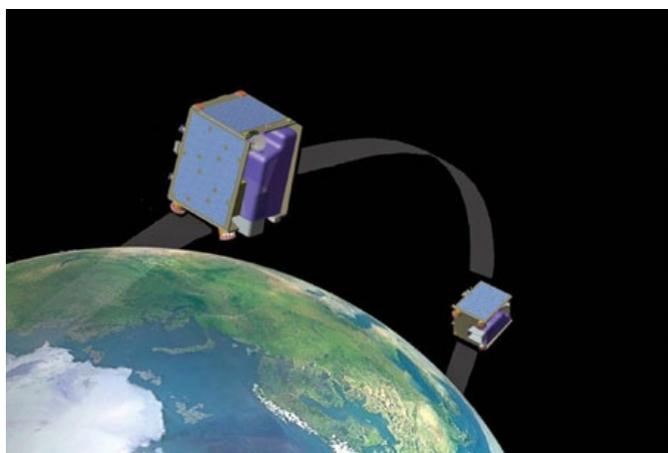
June 15, 2010. Dnipro was launched from Yasniy Spaceport with Swedish and French spacecrafts PRISMA and PICARD onboard. PRISMA SC was developed to demonstrate targeting, navigation and control technologies, while PICARD SC was intended for monitoring of solar conditions.



August 29, 2008. Ukraine's Dnipro successfully launched 5 RapidEye spacecrafts into the near Earth orbit for remote sensing and monitoring from Baikonur under the contract with a spacecraft manufacturer, Rapid Eye AG (Germany).



June 21, 2010. Dnipro launched German ERS TanDEM-X SC into the near Earth orbit from Baikonur.



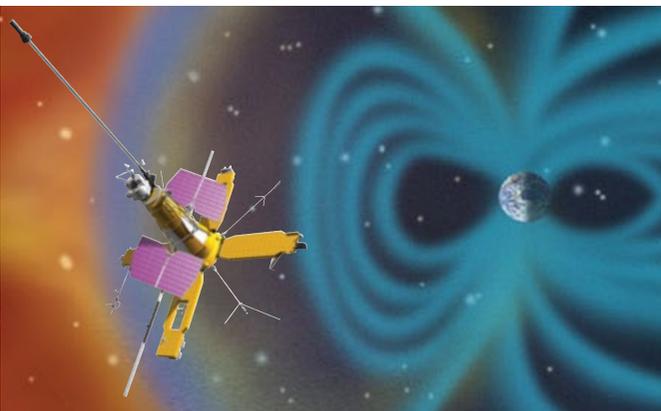
Vega Rocket & Space Project

Under the contract between SDO Yuzhnoye / Yuzhmash Plant and Italian AVIO SPA dd. February 2004, Ukrainian contractors manufactured and delivered the cruise engine of the upper stage for the upcoming European light class launch vehicle VEGA.



Variant Satellite Project

In 2004-2005, an international team of experts from United Kingdom, Poland, France, Russia and Ukraine completed measurements of electric currents and electromagnetic fields of ionosphere plasma on board of Ukrainian SICH-1M SC to forecast abnormal phenomena in the atmosphere and lithosphere of the Earth. Extremely valuable scientific information gathered during the satellite flight was subsequently processed and interpreted.



INTAS Program

In 2007 – 2008, seven joint new technology development projects were implemented under INTAS Program according to the Convention between NSAU, CNES and International Association for Promotion of Cooperation with Scientists from the Newly Independent States of the Former Soviet Union.

Scientific and technical guidelines for development of modern constructions of heat transfer tubes have been elaborated and the structure of spacecraft fuel compartments has been optimized. New atomic clocks, alloys with multifunctional characteristics have been designed for the new sensor class, and new technologies have been developed for ERS data integration and processing.

ERS Projects

In 2009-2010, upon request of the Joint Research Centre EC, the Institute of Space Research NASU-NSAU implemented the Project “Evaluation of Crop Acres in Ukraine based on Satellite Survey Techniques” in line with methods which have been widely used in the European Community.



In 2009, Dniprococosmos SE successfully implemented the pilot project AGRO-UA to monitor agricultural resources of Ukraine using RapidEye data. In 2010, another pilot project was implemented: cartographic classification of the Earth surfaces.

Dniprococosmos signed the Partnership Agreement on June 9, 2010 at International Air Show ILA 2010 (Berlin) to operate as a dealer of RapidEye AG in Ukraine. This company is focused on data capture and processing techniques in agriculture, forestry, cartography, terrain management, emergency monitoring and consequences evaluation.



Twinning Space Project



The Twinning Space Project “Boosting European-Ukrainian Space Cooperation” was implemented in Ukraine in 2008-2010. The project promoted long-term international contacts with Member States and ESA, implemented joint R&D projects, and shared experience and best practice in space law, standardization of high-tech developments and restructuring of space industry.

The project team has arranged and held 15 visits and 12 working group meetings between European experts and NSAU/industry specialists, 17 workshops and trainings, and 3 international conferences. More than 500 specialists of the Industry were engaged in the Twinning Space; 30 representatives of NSAU

and its enterprises visited Germany, France and The Netherlands as a part of their study tours. As a result, Ukrainian and European researchers can now contact directly and initiate new projects as a part of Twinning Space.

Prospects for Cooperation

- Enhancement of cooperation in ERS (GMES Program)
- Enhancement of cooperation in satellite navigation programs (EGNOS, GALILEO)
- Development of cooperation in commercial use of space technology
- Preparation for implementation of joint projects under the Seventh Framework Programme.





4. PARTICIPATION IN THE EU SEVENTH FRAMEWORK PROGRAMME FOR RESEARCH AND TECHNOLOGICAL DEVELOPMENT

In **2009**, R&D institutions within NSAU and the National Academy of Sciences of Ukraine (NASU) in cooperation with European partners submitted for consideration 8 proposals for participation in the 7th Framework Programme for Research and Technological Development, Section Space, and 4 proposals have won financing:

- **ROV-E** (Lightweight Technologies for Exploration Rovers) with the participation of SDO Yuzhnoye;
- **SIDER** (Radiation Shielding of Composite Space Enclosures) with the participation of SDO Yuzhnoye;
- **AFFECTS** (Advanced Forecast for Ensuring Communications through Space) with the participation of the Institute for Space Research NASU-NSAU;
- **POPDATE** (Problem-oriented Processing and Database Creation for Ionosphere Exploration) with the participation of Lviv Office of the Institute for Space Research NASU-NSAU.

Ukraine welcomes and looks forward to cooperation with European partners in space research and technological development.



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