Ukrainian Aeronautics Research and Technology Report - 2010

An initiative of the FP7 Aero-Ukraine project

SEVENTH FRAMEWORK PROGRAMME

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Preface

We would like to welcome you to the *Ukrainian Aeronautics Research and Technology Report – 2010*.

Ukraine is one of the few countries in the world to have research, engineering and production capabilities across the complete range of aeronautics technologies. However, knowledge of its strength in aeronautics research and technology (R&T) remains comparatively low in Europe. Consequently, there exists a rich and timely opportunity for Ukrainian aeronautics organizations and their R&T activities to be presented collectively.

This report has been prepared under the FP7 AERO-UKRAINE project. The project is a European Commission funded initiative entitled "*Stimulating Ukraine - EU Aeronautics Research Cooperation*" (Contract No 233640). It aims to support the participation of Ukrainian aeronautics organizations in EU aeronautics research. The project runs from April 2009 until March 2011.

The specific objectives of the project include:

- Facilitate EU-Ukraine aeronautics research cooperation
- Map and report on Ukrainian aeronautics capabilities
- Organise FP7 aeronautics events in Ukraine
- Support Ukrainian participation in FP7-AAT programme
- Support preparations for a FP7 Aeronautics National Contact Point in Ukraine

The project is being implemented by a consortium of European and Ukrainian partners:

- SLOT Consulting, www.slotconsulting.hu, Project Coordinator
- Intelligentsia Consultants, www.intelligentsia-consultants.com
- University of Patras - Laboratory of Technology and Strength of Materials, www.mead.upatras.gr
- National Aerospace University of Ukraine (KhAI), www.khai.edu
- Frantsevich Institute for Problems of Material Science (IPMS-NASU), www.materials.kiev.ua
- SE Ivchenko-Progress, www.ivchenko-progress.com
- Antonov ASTC, www.antonov.com

If you would like further information about the FP7 AERO-UKRAINE project and its events, please visit our project website: www.aero-ukraine.eu

We hope you enjoy reading this report and it helps to strengthen future EU-Ukraine aeronautics research and technology collaboration.

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Introduction

This report aims to provide a thorough description of the Ukrainian aeronautics research and technology sector.

Besides examining the main Ukrainian aeronautics research organisations and Ukraine's current and future research perspectives, the report describes the role played by the Government and Ukraine's track record of international cooperation.

Finally, an assessment of Ukraine's current strengths and weaknesses and emerging opportunities and potential threats leads to a set of practical recommendations on ways for Ukraine and Europe to develop their aeronautics research cooperation into the future.

The report is structured into the following chapters:

- **Chapter 1** summarises the *State's role in the national aeronautics sector*.
- **Chapter 2** describes the *main aeronautics organisations* and *research and technology areas* in Ukraine.
- **Chapter 3** examines *current and future perspectives* for aeronautics research and technology in Ukraine.
- **Chapter 4** describes Ukraine's past and current *international aeronautics research and technology activities*.
- **Chapter 5** describes *existing EU networks and initiatives that facilitate research cooperation*, provides a *high-level SWOT analysis of the aeronautics research and technology sector in Ukraine*, and defines a specific set of *recommendations to strengthen aeronautics research and technology cooperation between Ukraine and the EU*.

1. The Role of the State in the National Aeronautics Sector

The State plays an important role in the organisation and development of the aeronautics sector in Ukraine. In order to have an understanding of the State's role, it is vital to have a thorough description of the national governance system as well as the direct and indirect policy measures that influence Ukrainian aeronautics research and technology activities.

1.1 National Governance System

The **President of Ukraine** has the power to issue decrees in different areas. These decrees have a lower status than laws passed through Parliament but they have to be considered by the Cabinet of Ministries. The President is the Head of the Council for Defence and Security, which, among other issues, considers the state in S&T and innovation spheres. The President has also the right to create different commissions and advisory councils, which work on recommendations for the executive authorities in the area of S&T and innovations. The most well known council is the S&T Policy Council.

The **Cabinet of Ministers** is composed of the Head of the Cabinet of Ministers (Prime Minister) and the ministers. It has executive powers and is a main forum for preparing policies which directly or indirectly influence research and technology (R&T) and innovation. It therefore plays a very important role in aeronautics R&T. Specifically, the Cabinet of Ministers determines the system of executive power responsible for performing administration in the science and technology area in Ukraine. It ensures control over the establishment and operation of the public administration system in science, technology and innovation areas; determines priorities in science and innovation areas (they have to be passed through the Parliament); and develops strategies of science, technology and innovation development.

The Cabinet of Ministers of Ukraine, as a higher executive authority, makes science and technology policy. It gives to the Parliament of Ukraine proposals on priorities of science and innovation development and its logistical support; implements national science and technology programmes; and approves the state (interdepartmental) science and technology programmes according to the priorities of S&T and innovation development adopted by the Parliament of Ukraine.

The **Ministry of Industrial Policy** exercises control over organizations in the aviation sector, machine-building sector, metallurgical sector; chemical sector, woodworking sector; light industry sector; new activity enterprises and research organizations. Altogether, it supervises more than 300 research institutes and design bureau. The Ministry is the main government body with respect to the aviation industry with control over the industrial enterprises Antonov ASTC, SE Aviant, SE FED, SE Ivchenko-Progress, JSC UkrRIAT and JSC UkrNIITM.

The Ministry only has a modest budget for financing R&T. The total allocation from the State Budget to the Ministry of Industrial Policy in 2007 was 570 million hryvna (approx 52.5 million euro). Out of these funds, 31 million hryvna (approx 2.8 million euro) was allocated to R&T and 81 million hryvna (approx 7.5 million euro) to innovation projects. As a result, the bulk of research funds come from Ukrainian industrial enterprises and foreign customers (almost 70% of all funds). The rest of the financing comes almost entirely from the funds of the institutes, which receive income by selling their research results, providing technical assistance, and leasing their buildings to commercial companies. At the same time, the Ministry has the right to nominate the heads of the institutes, and, formally, the vast majority of institutes belong to the state sector. However, this control is rather informal, as the institutes conduct their commercial activities without substantial organizational or financial support from the Ministry. Having the status of "state-owned scientific organization" allows certain tax privileges.

The **Ministry of Education and Science** is responsible for both "education" and "science", with education being the main focus. The Ministry has a Scientific Council with several sections, one of which is responsible for aviation technology and transport. The Council meets several times a year to assess projects and applied research conducted by higher educational institutions under its responsibility. This section should provide an overview of the role and influence of government on the national aeronautics research and technology development activities.

The Ministry administers public funds based on a list of innovation priorities and S&T programmes approved by the Parliament. It oversees the bulk of R&T expenditure in the university sector and some branch research institutes. However, this is on the periphery of the Ministry's attention as it provides

only 3% of its total budget to R&T and innovation activities. The Ministry has a special Department for Science and Innovation, which is the one the most closely linked to aeronautics R&T matters.

In 2003, the Ministry established the National Information Center for Ukraine-EU S&T Cooperation, which provides information for Ukrainian organizations wishing to participate in the EU's FP7 programme including FP7 Transport (and Aeronautics). Currently, the Ministry is in the process of establishing national contact points (NCP) for various FP7 themes – including Aeronautics – within the scope of the EU funded Technical Assistance project "Joint Support Office for Enhancing Ukraine's Integration in the European Research Area" (EuropeAid/127891/C/SER/UA).

The **National Academy of Sciences of Ukraine** comprises of about 200 research institutes and centres with most of them involved in natural and technical sciences. At least 10 institutes are involved in R&T related to aeronautics. The research activities of the Academy are mainly financed by the State. The Academy is required to co-ordinate its activities with the Ministry of Education and Science. Likewise, the Ministry involves representatives of the Academy, when it launches a basic scientific research programme. The Academy has also a strong voice in the State Foundation for Fundamental Sciences. Academician Platon Kostiuk, one of the most cited Ukrainian scientists, is the President of the Foundation. Institutes from the Academy have often formed the base for Ukraine's most successful technoparks, such as the Technopark Paton Electric Welding Institute.

Under the **Ministry of Transport and Communications**, civil aviation matters are dealt with by the State Aviation Administration, which was established by Regulation of the Cabinet of Ministers of Ukraine in November 2006. Its key responsibilities include:

- Implementation of the state policy in the area of Civil Aviation regulation: aircraft operations, ATM, aerial works & services, airports, financial, technical, investment and social policy
- Safety oversight and aviation security
- Registration and certification of Civil Aviation activities
- Elaboration of National Civil Aviation regulations

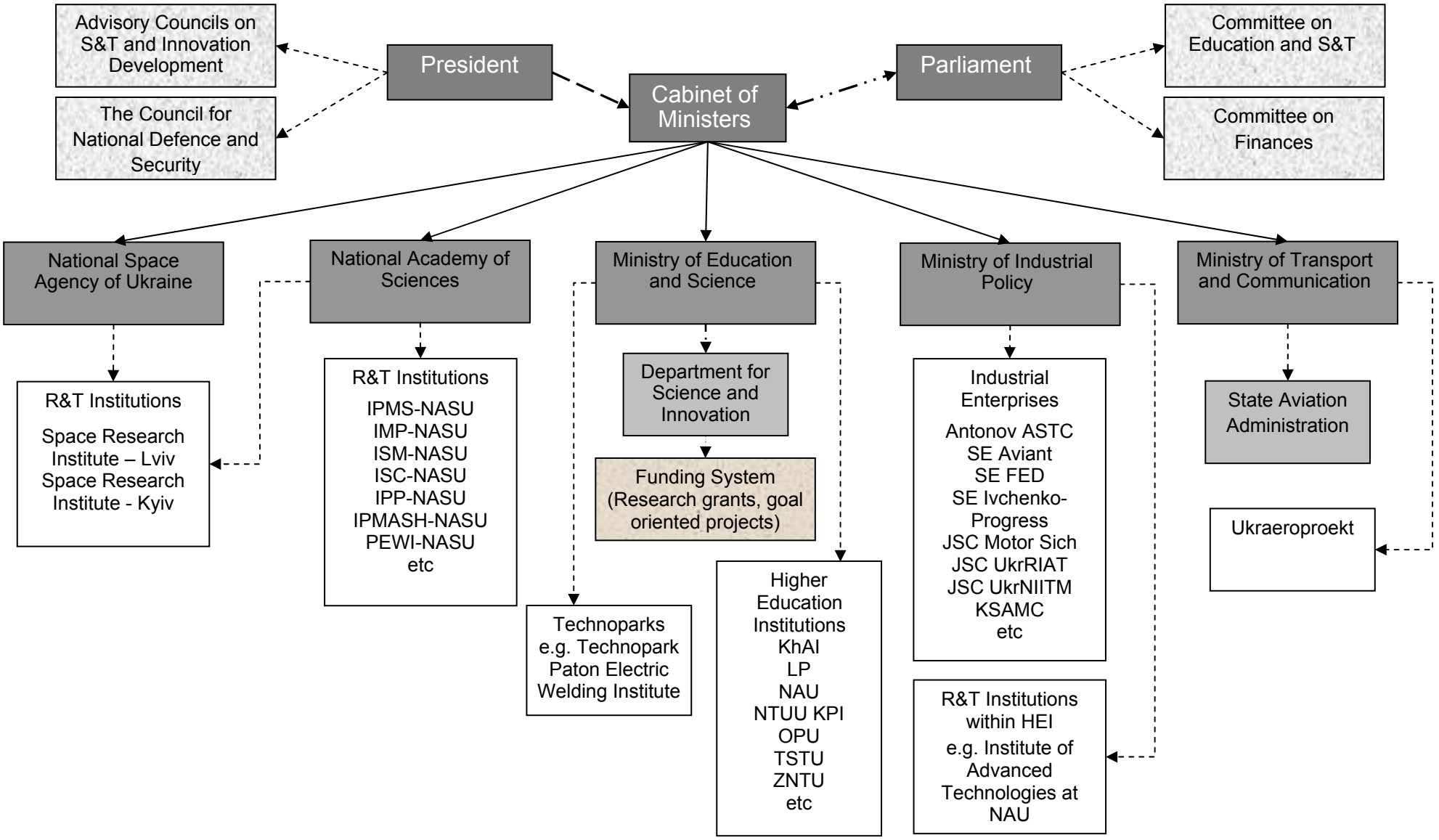
Recently, the State Aviation Administration was involved in the EU funded twinning project "Harmonisation with EU Norms of the Legislation and Standards of Ukraine in the Field of Civil Aviation" (UA/06/PCA/TP/01) that ran from 2007 – 2009.

In 2007, by order of the Ministry of Transport and Communications, the Ukrainian State Designing Technological and Scientific Research Institute of Civil Aviation "Ukraeroproekt" (also known as UGPT NII GA "Ukraeroproekt") was given the status of head industrial research organization in the area of development of civil aviation ground infrastructure in Ukraine. Currently, Ukraeroproekt employs about 80 highly qualified specialists. Ukraeroproekt's main activities include development of design estimates for construction, reconstruction and development of airports, aerodromes and other facilities of civil aviation ground infrastructure. Ukraeroproekt has developed the majority of civil aviation projects in Ukraine and a number of facilities in Belarus, Moldova, and Krasnodar Region of Russian Federation. Recently, Ukraeroproekt has worked with the State Aviation Administration to prepare Ukrainian airports for the Euro 2012 soccer championship.

The number of **Higher Education Institutes** has varied between 340 and 360 in Ukraine during the past decade. However, only about half of the institutes have research facilities and conduct research (172 during 2005/6). The total R&D expense for all Ukrainian universities was below 300 million hryvnas (approx 27.5 million euro) in 2007. Only the two biggest universities in Kyiv - National Taras Shevchenko University of Kyiv and National Technical University "Kyiv Polytechnic Institute" - have research budgets in excess of 35 million hryvna (approx 3.2 million euro). Nevertheless, there are at least 10 universities spread across the country – Donetsk, Dnipropetrovsk, Lviv, Kharkiv, Kyiv, Odessa and Zaporozhye – conducting research related to aviation and aerospace.

The **National Space Agency of Ukraine** (NSAU) is the civil body in charge of co-ordinating the space efforts of government installations, research, and industrial companies (mostly state-owned). Several space-related enterprises and related institutes – such as the Space Research Institutes in Lviv and Kyiv - are directly subordinated to NSAU. The agency oversees launch vehicle and satellite programmes, co-operative programmes with the Russian Aviation and Space Agency, ESA, NASA and commercial ventures such as Sea Launch.

The Role of the State in Ukrainian Aeronautics Research and Technology



1.2 Direct and Indirect Policy Measures influencing Ukrainian Aeronautics R&T

Ukraine has a national strategy for the aviation industry up to 2020 ("*National strategy of the aviation industry development for the period to 2020"*) and is in the process of approving a state funded aeronautics research programme covering the period 2011-2020 ("*State Funded Aeronautics Research Programmes*"). The main government organisation responsible for these policy measures is the Ministry of Industrial Policy.

Furthermore, aeronautics related R&T is also supported by the Ministry of Education and Science, National Space Agency of Ukraine and Cabinet of Ministers, through a variety of policy measures that directly or indirectly refer to aviation and aerospace activities.

The policy measures affecting aeronautics R&T are summarised in the following table and described afterwards in more detail.

Summary of direct and indirect policy measures influencing Ukrainian Aeronautics R&T

N°	Title	Government organisation responsible
1	National strategy of the aviation industry development for the period to 2020	Ministry of Industrial Policy
2	Law on the Development of Aircraft Industry	Ministry of Industrial Policy
3	State Funded Aeronautics Research Programmes	Ministry of Industrial Policy
4	State Funded Space Research Programmes	National Space Agency of Ukraine
5	Law on Tax Privileges for the Space Industry	Cabinet of Ministers
6	Law on Science Park 'Kyiv Polytechnic Institute'	Ministry of Education and Science
7	Law on Science and Technology Priorities	Ministry of Education and Science
8	Law on Innovation Priorities	Ministry of Industrial Policy
9	State Complex Programme of Development of Science-Intensive Technologies	Ministry of Industrial Policy

National strategy of the aviation industry development for the period to 2020
Ukraine has a national strategy entitled "*National strategy of the aviation industry development for the period to 2020*", which was approved by the Cabinet of Ministers of Ukraine on 27 December 2008[1]. JSC UkrRIAT is a key organisation in the development and implementation of the strategy.

The strategy is quite broad and declarative with few quantitative targets. The strategy's overall goal is to create the necessary conditions for a competitive and sustainable Ukrainian aeronautics industry. The strategy's sub-goals include:

- definition of priority directions for aeronautic industry development taking into account Ukraine's accession to the World Trade Organization;
- aeronautic industry restructuring;
- support of strategic directions of aeronautic sector production, design, R&T and staff potential modernization and development;
- ensuring of specialists advanced training as a result of educational and laboratory facilities of aeronautic higher educational institutions improvement and faculty strengthen;
- taking measures for accelerated innovation development of aeronautic sector and science intensive technologies, conclusion agreement about strategic partnership and diverse applied R&T with international partners;
- improvement of aeronautic industry scientific support, including establishment of several specific research centres;

[1] http://zakon.rada.gov.ua/cgi-bin/laws/main.cgi?nreg=1656-2008-%F0&check=4/UMfPEGznhhSat.Zi9VKegOHI4jUs80msh8Ie6

- ensuring of governmental order forming on training of aircraft engineering, aeronautic propulsion engineering and radio-electronic aircraft equipment engineering (including aero-navigation) specialists in institution of higher education;
- legislative system improvement;
- gradual decrease of budget expenditures on aeronautic industry development up to the conversion to the self-financing;
- application of offset schemes for aeronautic products export and import;
- development of efficient system for aeronautic products leasing and ensuring its operation with assistance of the state;
- ensuring of governmental and defence order forming on national aeronautic enterprises products in 2009-2012.

The strategy is to be implemented in three stages. The first stage (2008-2010) is mainly focussed on the development, production and/or modification of the AN-148, AN-140 and AN-74 aircraft; D-27, D-436-148, TB3-117VMA-SBM1 aircraft engines; and KT-112 helicopter. Also, the first stage is to address systemic reform of the aeronautic industry by:

- developing and approving regulations, approving and implementing national aeronautic standards for stable industry functioning;
- restructuring state aeronautic enterprises with the view of their further combination in corporation;
- turning state enterprises into joint-stock companies and save 100% of shear in state ownership;
- developing association of aircraft construction, helicopter, propulsion, radioelectronic aircraft equipment, satellite communication systems engineering industrial enterprises based on corporation principles;
- setting up regular regional service centres and technical-maintenance centres for aeronautic products;
- improving currency crediting system of commercial banks to support aeronautic products export activity;
- developing a facilitation system for purchasing and use of national aeronautic products at internal market;
- organizing efficient system for aircraft leasing at internal and foreign markets.

The first stage is to be funded by industrial enterprises, credits, and state budgetary funds. However, the forecasted amount required is not indicated in the strategy document.

The second stage (2011-2015) will focus on improving aeronautic product development and serial production rates; further improvement of business entities; optimization, reconstruction and re-equipment of aeronautic industrial enterprises production facilities; development of new products; and attracting the resources of strategic investors/ co-owners. This stage will provide:

- development and implementation of state insurance for investment and innovative risks at the stage of new aeronautic products development;
- adoption of legislative acts to create export incentives for aeronautic products;
- application of offset schemes for the export and import of aeronautic products;
- introduction of new knowledge management techniques for aeronautic products across all stages of their life cycle;
- privatization of aeronautic enterprises and industrial mergers taking into account their specific features and retaining governmental influence on strategic decision-making;
- priority development and/or modification of the following aeronautic products: AN-38, AN-70, AN-124 aircraft; D-27, D-18T (fourth generation), AI-450, AI-222-25 and BK-2500 aircraft engines; and KT-112 helicopter and their modifications.

The third stage (2016-2020) will focus on continued development and implementation of new aircraft and ensuring dynamic production growth via national and international projects.

The government expects the strategy to support the aeronautic industry to exit the recession and overcome the lag with advanced foreign countries. It has declared that the strategy will:

- improve the aeronautic industry management system;
- increase the volume of competitive production by up to 3-5 times;

- create favourable conditions for national aeronautic industry integration to the foreigner countries industrial fields;
- increase the level of aeronautic industry research, engineering and technical staff training up to modern requirements;
- stimulate aeronautic R&T;
- enable a large-scale restructuring and technical re-equipment of aeronautic industrial enterprises and raise employees social maintenance.

Law on Development of the Aircraft Industry
This new law was recently approved and signed by the President in January 2010. Among other provisions, the law provides privileges to the aircraft industry including specific conditions on import customs, exemption from land tax, favourable VAT rates, and preferential taxation on profits and foreign currency payments.

State Funded Aeronautics Research Programmes
The State has been funding dedicated aeronautics research programmes since 1992. The current researches list has several priorities including the following:

- aircraft building;
- aircraft engine building;
- helicopter building;
- new materials and technologies;
- airborne avionics.

The Cabinet of Ministers announced in December 2009 that it planned to approve a State funded, goal-driven, scientific and technical programme on *Development of the Aircraft Building Industry of Ukraine until 2020*. An estimated total R&D budget of $4-5 billion is required for the programme for the period 2011-2020 but it has yet to be approved.

State Funded Space Research Programmes
The State has been funding dedicated space research programmes since 1992. The current programme is the fourth and runs from 2008-2012.

The main aim of the third space programme (2003-2007) was to support enterprises and research institutes in the space sector and to utilize R&T results more effectively. It had eight sub-programmes including the development of new satellites for communication and research of the Earth from space; further development of infrastructure; experimental projects on new space technologies; and joint projects with other countries such as Russia, USA, EU countries and Brazil. During the third space programme, the State provided a minimum level of annual funding of approximately 361.5 million hryvna (33.2 million euro). Also, a substantial amount of co-funding was expected to come from the private sector and foreign customers.

For the fourth space programme, the Cabinet of Ministers announced in November 2008 that it planned to allocate 1,460 million hryvna (134 million euro) from the State budget, 1,035 million hryvna (95 million euro) from other sources, and a further 3,000 million hryvna (275 million euro) is expected to be attracted from foreign companies[2]. The fourth programme also has eight sub-programmes comprising the following:

- Scientific space research
- Remote sensing of the Earth
- Satellite telecommunication systems
- Development of the ground-based infrastructure for navigation and special information system
- Space activities in the interests of national security and defence
- Space complexes
- Development of base elements and advanced space technologies
- Development of research, test and production base of the space sector

[2] http://zakon.rada.gov.ua/cgi-bin/laws/anot.cgi?nreg=608-17

Law on Tax Privileges for the Space Industry
The Government approved a draft law on 23 April 2009 that provides tax privileges to the space industry[3]. In particular, the law provides preferential taxation of VAT and exemption from land tax.

Law on Science Park 'Kyiv Polytechnic Institute'
The Government approved a law in December 2006 to establish a science park at Ukraine's largest technical university, "Kyiv Polytechnic Institute". The aim is to facilitate technology transfer from the university to industry.

Law on Science and Technology Priorities
The law defined the legal, financial and organizational foundations for the formulation and realization of S&T priorities in Ukraine during 2001-2007. The law established that not less than 30% of state budget financing had to be spent on priority–related projects and programmes. Initially, seven specific priorities for S&T were established:

- fundamental research of the key problems in different areas;
- demography and human potential development;
- environmental studies;
- new biotechnologies;
- new computer technologies and ICT;
- energy-consuming technologies, especially in energy sector and industry;
- new materials.

Law on Innovation Priorities
The law determines the legal, organizational and economic foundations for the formulation of innovation priorities in Ukraine during 2003-2015. The law describes two types of priorities – medium term and strategic. Strategic priorities are for not less than 10 years. The list of strategic priorities includes the following:

1. Modernization of power-stations; new and renewable sources of energy; new resource-saving technologies;
2. Engineering industry as a base for high-tech development of all branches; development of modern, quality–oriented metallurgy;
3. Nanotechnologies, microelectronics and ICT;
4. Development of chemical technologies, new materials and biotechnologies;
5. High-tech development of agriculture and manufacturing industry;
6. Transportation systems: Construction and reconstruction;
7. Protection and improvement of health care and environment;
8. Development of innovation culture of society.

State Complex Programme of Development of Science-Intensive Technologies
The goal of the measure is accelerate the modernization of the national economy through the creation and adoption of new technologies. The programme involves two stages:

1. The undertaking of R&D projects aimed at the creation of new technologies (2005-2008)
2. The implementation of new technologies developed during the first stage (2009-2013)

The programme is to be financed from the state budget and private enterprises. The exact amount of money and the form of support for each company or innovation project is determined by the Ministry for Industrial Policy on the basis of an expert committee, but usually the state share in financing the projects does not exceed 30% of total expenses. Specific technology sectors are not defined but the programme assumes that projects are based on manufacturing. Some projects can be co-financed by enterprise, but no exact rules for such co-financing exist.

Initially twenty two projects were selected for financing. However, the actual level of financing of the programme in 2005 was less than 5% of the original declared budget. No data about financing of the programme in later years have been reviewed. Finances were distributed in the form of grants from the state budget to different state-controlled companies.

[3] http://rescommunis.wordpress.com/2009/04/23/draft-ukrainian-law-on-tax-privileges-to-space-industry

2. The National Aeronautics Research and Technology Sector

Obtaining accurate and up-to-date quantitative information specifically about the aeronautics research and technology (R&T) in Ukraine is quite difficult. For the overall aerospace industry (i.e. aeronautics and space), it is estimated over 68000 scientific and technical employees work across 39 plants and companies[4]. In 2007, the Ukrainian aerospace industry's turnover was estimated to be $830m[5].

In broad terms, organisations conducting aeronautics research fall into one of three categories: institutes of the National Academy of Sciences of Ukraine, higher education institutes or companies (state or privately owned).

The **National Academy of Sciences of Ukraine** comprises of about 200 research institutes and centres with most of them involved in natural and technical sciences. At least 10 institutes are involved in R&T related to aeronautics. The research activities of the Academy are mainly financed by the State and it co-ordinates its activities with the Ministry of Education and Science.

The number of **higher education institutes** has varied between 340 and 360 in Ukraine during the past decade. However, only about half of the institutes have research facilities and conduct research (172 during 2005/6). The total R&T expense for all Ukrainian universities was below 300 million hryvnas (approx 27.5 million euro) in 2007. Nevertheless, there are at least 10 universities spread across the country – Donetsk, Dnipropetrovsk, Lviv, Kharkiv, Kyiv, Odessa and Zaporozhye – conducting research related to aviation and aerospace. Altogether, there are about 30000 aerospace students.

The major aeronautics **industrial organisations** are state owned e.g. Antonov ASTC (Aeronautical Scientific/Technical Complex), SE Ivchenko-Progress (State Enterprise) and Yuzhnoye SDO (State Design Office). With regard to R&T, state owned companies rely heavily on the input and support of institutes of the National Academy of Sciences and several universities. Also, there are estimated to be a few hundred small-to-medium-enterprises (SMEs) involved in the aerospace sector with a significant number privately owned.

2.1 Main Organisations conducting Aeronautics Research and Technology in Ukraine

2.1.1 Institutes of the National Academy of Sciences of Ukraine

A list of website addresses for the following institutes can be found in Annex 2.

Frantsevich Institute for Problems of Materials Science of the National Academy of Sciences of Ukraine (IPMS-NASU) is Ukraine's leading research centre in the field of materials science and advanced technology of metal, ceramic and composite materials. It provides advanced scientific and engineering consultancy as well as contract research and technology services.

IPMS-NASU was set up in 1955 on the base of the laboratory for special alloys of the Ukrainian Academy of Sciences. Since then it has progressively widened its fields of research and customer base. IPMS-NASU's activities in new material development and commercial application are supported by a large pool of researchers in solid-state physics and chemistry, inorganic physical chemistry, and mechanics of deformable media.

Altogether, IPMS-NASU employs about 1700 people, including 70 doctors and more than 345 PhD. It is a large scientific and research complex, including Special Design Bureau with Pilot Plants, Computer Centre and Laboratory for Basalt Materials Production.

G.V. Kurdyumov Institute for Metals Physics of the National Academy of Sciences of Ukraine (IMP-NASU) is the leading research centre in Ukraine for nanoscale systems, nanomaterials and nanotechnologies. It has 620 employees spread across 27 departments and 10 laboratories. Its main fields of research include:

[4] **Ukrainian Aviation Industry and Capabilities for Cooperation with the European Union**, Presentation, Oleg Bogdanov, Deputy General Designer, Antonov ASTC, 28 October 2009
[5] Source: Ministry of Industrial Policy

Organisations conducting Aeronautics Research and Technology in Ukraine

- Physics of strength and plasticity of metals and alloys
- Electronic structure and properties of metals and compounds
- Nanoscale systems
- Atomic structure of metals and heterophase systems

V. Bakul Institute for Superhard Materials of the National Academy of Sciences of Ukraine (ISM-NASU) conducts research on novel mono- and polycrystalline superhard materials (synthetic diamonds, cubic boron nitride, composites and ceramics), which are widely used in the tool industry for machining metal and non-metal materials, as well as structural elements for instrument-making, electrical industry, space equipment, optics, and electronics. The institute cooperates with a number of Ukrainian enterprises including Antonov ASTC. The institute's staff of 420 employees includes 38 doctors, 81 candidates of sciences, and more than 100 young researchers and post-graduate students.

Physical-Technological Institute Metals and Alloys of the National Academy of Sciences of Ukraine (PTIMA-NASU) was established in 1958, initially under the name the Institute of Foundry Problems. It conducts research in the fields of foundry, metallurgy and materials science. This includes:

- Liquid state of multi-component steels and alloys;
- Interaction of melts with soluble and insoluble, liquid and gaseous reagents;
- Physical, chemical, heat and mass exchanging processes and their influence on properties and on characteristics of metallic melts during their laser, plasma and electron-beam treatment;
- Elaboration of scientific principles of creation of new ferrous and non-ferrous alloys; researches of influence of power and electromagnetic fields, centrifugal forces, controllable heat treatment on hydrodynamic, heat-exchanging and solidification processes of molten metals.

Chuiko Institute of Surface Chemistry of the National Academy of Sciences of Ukraine (ISC-NASU) was founded in 1986. The Institute carries out fundamental and applied research in the following areas:

- chemistry, physics and technology of surface;
- theory of chemical structure and reactivity of surface of solids, research into nature of active sites of surface, mechanisms of adsorption, chemical reactions, and transformations in surface layers;
- biomedical problems of surface;
- researches into surface states, diffusion phenomena, charge and mass transfer, phase formations in nanostructures, collective interaction in assemblies of particles, size-quantized effects of systems, interaction with radiation;
- technology of production of nanomaterials, highly disperse oxides, their modified forms, and composites on their basis.

ISC-NASU also runs the Kalush Experimental Plant (Ivano-Frankivsk region) to develop and produce nanoparticulate metal oxide fillers and their modified forms.

A.N. Podgorny Institute for Mechanical Engineering Problems of the National Academy of Sciences of Ukraine (IPMASH-NASU) is a well known research centre in power and mechanical engineering. It has 14 scientific departments and plays an active role in the following activities: forming the energy strategy of Ukraine to 2030, and the concept of the State programme for ensuring technological safety in key branches of the economy; the regional programme "Resource"; the initiator of the Academic Scientific-and-Educational Complex (ASEC) for open-end training of researchers starting from school (academic lyceums) and through to post-graduate courses and Doctorate studies.

G. S. Pisarenko Institute for Problems of Strength of the National Academy of Sciences of Ukraine (IPP-NASU) was founded in 1966 on the basis of the Department of Strength of the Institute for Problems of Material Science of the Academy of Sciences of Ukraine. In the past, research efforts were concentrated on scientific and technical investigations of novel structures for rocket, aerospace, and propulsion engineering. Today, the institute's main concern is with the evaluation of the remaining life expectancy and safe operation of equipment used in nuclear and thermal power engineering, oil-, gas-, and product pipelines; aeronautic apparatus; oil-refining and chemical industries; and railway transport.

Institute of Engineering Thermophysics of the National Academy of Sciences (ITTF-NASU) has a department dedicated to high-temperature thermogasdynamics, which is a leader in the field of gas turbine blade cooling. The department's 25 staff conducts research into swirling and vortex flows fundamentals, air-cooled gas turbine blades, heat transfer augmentation, internal blade cyclone cooling, novel oscillating film cooling, and high temperature heat exchangers.

E.O. Paton Electric Welding Institute of the National Academy of Sciences (PEWI-NASU) is a multidisciplinary research institute which realizes fundamental and applied research works, develops technologies, materials, equipment and control systems, rational welded structures and weldments, methods and equipment for diagnostics and non-destructive quality control according to the following directions:

- Advanced technologies of welding and joining of materials;
- Strength, reliability and life of welded structures;
- Technology of surfacing, coating and treatment of surface;
- Processes of special electrometallurgy;
- New structural and functional materials;
- Technical diagnostics and non-destructive testing;
- Automation of processes of welding and related technologies.

The E.O. Paton Electric Welding Institute is a head organization of the Scientific-Technical Complex "The E.O. Paton Electric Welding Institute" of the National Academy of Sciences of Ukraine (STC PWI), which includes Design-Technological Bureau, Engineering Centres of high technologies, pilot workshops on explosion welding and treatment, and also a powerful production facility in the form of three pilot plants manufacturing welding equipment, consumables and using new technologies, which are capable to design, manufacture and deliver the pilot samples and batches of specialized equipment, welding and filler materials, welded structures and weldments.

A. Usikov Institute of Radio-Physics and Electronics of the National Academy of Sciences of Ukraine (IRE-NASU) was established in 1955 on the basis of the former Departments of Electromagnetic Oscillations and Radio Wave Propagation of the Kharkov Institute of Physics and Technology of NASU. The main objective of the newly founded Institute was research and technology in the wide frequency range of electromagnetic wave spectrum, with a special emphasis on millimetre and submillimetre waves.

Since its establishment, the Institute has gained the status of a widely-known scientific centre, whose achievements determine the level of the national science in radio physics, vacuum electronics, quasioptics, microwave studies in solid-state physics and biophysics, radio wave propagation, remote sensing of the earth from airborne and space-borne platforms.

2.1.2 Higher Education Institutes

A list of website addresses for the following institutes can be found in Annex 2.

National Aerospace University "Kharkiv Aviation Institute" (KhAI) is the only engineering University in Ukraine providing the full cycle of higher education in aviation and aerospace science. Founded in 1930, KhAI has over 12,000 students, 800 teachers, 1200 researchers, and 2000 employees. 75% of teachers have academic titles of Professors and Associate Professors, scientific PhD and Dr.Sc. degrees. Today, KhAI provides training of students on 45 major subjects at its 44 chairs. KhAI participates in numerous international collaborative research projects in aeronautic and space areas with academic and industrial partners from Germany, France, UK, Italy, Sweden, Finland, Greece, Israel, USA, Japan, Mexico, S. Korea and China. It receives between 8-10 million hryvna/year (700–900k euro/year) in research funding from government

and private sources. Amongst the University's diversified research activities, the following advanced areas are in top priority: aerodynamic and wind tunnel tests; aircraft/helicopters/spacecraft/UAV; CAD/CAM/CAE design; aircraft engines design and performances improvement; space propulsion systems (plasma thrusters/electric propulsion/etc.); aircraft/spacecraft dependable control systems (based on FPGA approach) and equipment; aerospace thermal engineering; material science and high-performance coatings deposition; advanced aeronautic structures manufacturing processes; composite structures design and manufacturing; structural strength analysis and improvement; digital signals and images processing.

National Aviation University (NAU) was established in 1933 for the education and training of specialists in civil aviation. Since its establishment, over 150,000 specialists and master students have been trained at NAU. Today, there are more than 25,000 students studying in the University including all the necessary specialties for airports, airlines, design offices and other aviation organisations.

NAU has seven research institutes: Institute of Advanced Technologies; Research Institute of Technological Systems within Ministry of Education and Science of Ukraine and Ministry of Industrial Policy; Research Institute of Integrated Telecommunication Technologies; Aerodynamic Research Center of National Aviation University of Ukraine; Research Institute of Aviation within Ministry of Education and Science in Ukraine and Ministry of Transport; Research Institute of fast-going processes; and Educational-Scientific Centre for Air Traffic Controllers Training. Research is carried out on: improvements on aircraft operational processes, on air traffic control, on flight and maintenance provision and on safety, including problems of environment protection.

National Technical University of Ukraine "Kyiv Polytechnic Institute" (NTUU KPI) was founded in 1898. It is one of the oldest and largest technical universities in Europe and is ranked first in Ukraine. It has 40,000+ students attending 29 university colleges. NTUU KPI is involved in the following areas of science and research and technology:

- information technologies, system analysis and management;
- airspace systems;
- electronics, radio engineering and communications;
- electrical engineering and energy saving;
- material science and mechanical engineering;
- power engineering and power generating technologies;
- instrument manufacture and measurement technologies.

Zaporozhye National Technical University (ZNTU) consists of 7 institutes, 5 colleges, 14 faculties and over 16,000 students. The university has scientific schools involved in foundry technology, material science, thermal treatment, welding processes, radio technics, microelectronics, mechanics of dynamical systems, and technical cybernetics. ZNTU publishes 4 science-technical magazines. Since 2000, specialist training has been provided about technology for aviation engine production. ZNTU has close working and educational relations with the aero-engine factories in Zaporozhye.

Ternopil State Ivan Pul'uj Technical University (TSTU) was founded in 1961 and has over 9800 students. The university is a full member of the European Association of Universities (since 1999) and Bologna Charter of Universities (since 1995). The university has eight departments including Mechanical Engineering Department; Electrical Engineering Department; Testing Instruments and Radio Computer Systems Department; Computer Technologies Department; and Electronic Apparatuses and Computer Systems Department.

Dnepropetrovsk National University (DNU) was founded in 1918. It has 20 faculties including physics and mathematics, medicine, history, linguistics and law. The university has 1300 professors and 15000 students. It has strong ties with one of the largest world's rocket space centres Yuzhnoye Design Bureau.

2.1.3 Industrial Organisations

A list of website addresses for the following companies can be found in Annex 2.

Antonov ASTC was founded in 1946 by the famous aircraft designer Oleg Antonov. More than one hundred types and modifications of various aircraft classes and purposes have been designed since the company's foundation. The characteristic advantages of ANTONOV aircraft include structural reliability and economic efficiency, flexibility of transport operations, ability to use unpaved airfields and easy maintenance. Due to these qualities, over 1500 Antonov aircraft have been exported to more than 70 countries all over the world. All in all more than 22,000 aircraft have been built.

Antonov AN-148
(Image courtesy of Antonov ASTC)

Nowadays, Antonov is engaged in designing and building new aircraft prototypes as well as modifications of earlier designs, the provision of operational and product support and engineering work on extending the service life of existing aircraft. Antonov also participates in international cooperation in the field of aircraft and equipment design and manufacture as well transit vehicle development.

Antonov has invested heavily in computer-aided-design equipment and skills thereby creating a powerful engineering and research potential. In-house wind tunnel facilities enable the testing of aircraft models. All aircraft types, including such giants as the Ruslan and Mriya, can be subjected to structural tests to determine their service lives in one of the world's largest fatigue test laboratories. Finally, Antonov completes the aircraft development cycle with flight test programmes to demonstrate compliance of the aircraft with airworthiness requirements and customer specifications.

An overview of the planes developed by Antonov over the past 60 years can be found in Annex 3

Zaporozhye Machine-Building Design Bureau Progress State Enterprise Named After Academician A.G. Ivchenko (SE Ivchenko-Progress) has been designing a wide range of aero-engines to power aircraft and helicopters since 1945. During the past 65 years, more than 80,000 of Ivchenko-Progress' aviation piston and gas turbine engines, turbine starters, auxiliary power units and industrial application drivers have been manufactured. Aero engines designed by Ivchenko-Progress power 57 types of aircraft in 109 countries from Europe, Asia, Africa and America. The total operating time of its gas turbine engines exceeds 300 million hours.

Ivchenko-Progress was responsible for first introducing many new engineering designs in the USSR including:

- AI-20 turboprop engine with long service life;
- AI-25 bypass turbofan engine;
- D-36 three-shaft bypass turbofan engine with high bypass ratio;
- D-18T turbofan engine with a thrust over 20 tons (which powers the AN-225 and AN-124-100).

Similarly, Ivchenko-Progress has been responsible for numerous "world firsts" including:

- D-136 helicopter engine – the most powerful in the world helicopter engine;

- D-27 cruise turboprop-fan (open rotor) engine (which powers the AN-70);
- Unified gas generators for turboprops and turbofans of high reliability and low cost.

D-18T Engine from SE Ivchenko-Progress
(Image courtesy of SE Ivchenko-Progress)

Since the 1990s, the company's design team has been developing gas turbine drivers for industrial applications and special equipment. This line of activity covers 21 types of engines with a power range from 0.5 to 25 MW. Gas turbine drivers from the D-336 family (4 to 10MW) and the AI-2500 (2.5MW) are currently operating in more than 31 compressor and 3 power stations in Ukraine, Russia, Belarus, Azerbaijan, Turkmenistan, Uzbekistan, Bulgaria, Turkey and Iran. The operating time for some driver gearboxes has reached 30000 hours without the need for repair.

Today, the sphere of Ivchenko-Progress activities covers design, manufacture, test, development, certification, putting into series production and overhaul of gas turbine engines for aviation and industrial applications. The company has more than 60 design, quality and reliability certificates from international bodies including Bureau Veritas, EASA, Central Civil Aviation Administration of China, IAC AR and GosAviaSluzhba of Ukraine.

Notably, the research and test facilities of the company are amongst the most advanced in the world. They include 17 test benches and 78 rigs used for solving various problems related to engine testing, component development, certification, reliability and fuel-consumption.

An overview of the aero-engines developed by SE Ivchenko-Progress can be found in Annex 4

Buran Research Institute and the **Radar Plant** developed jointly the metro-navigation systems for the Antonov AN-140 and AN-70. Both organisations are based in Kyiv.

JSC Element is one of Ukraine's leading certified suppliers of electronic measurement systems, parameter monitoring systems and aviation engine control systems. It has 36 employees. Specifically, JSC Element develops measuring transducers, aviation control and monitoring systems, programme and technical complexes of aviation engine testing, embedded real-time software, SCADA, monitoring and simulation systems, gas-turbine engine models, trend and correlation analysis. The firm works in cooperation with Ukrainian, Russian, European and US companies and universities and has taken part in ambitious development projects such as Antonov AN-70, Antonov AN-148, Kamov Ka-226 "Sergei" and Tupolev Tu-334.

JSC Hartron is the leading designer of space and industrial control systems in Ukraine. The company was founded in 1959 and has centres in Kharkiv and Zaporozhye. Between 1959 and 1991, it was the largest producer in the USSR of control systems for strategic missiles, launch vehicles and heavy class space vehicles (including the Mir station modules). Recently, the company has been involved in new aircraft engine development.

JSC Motor Sich is Ukraine's largest aircraft engine manufacturer. The company was established in 1907 and is based in Zaporozhye. It was amalgamated a few years ago with "Progress" Zaporozhye

Machine-Building Design Bureau (Progress ZMDB) to form the single design/production enterprise SE Ivchenko-Progress.

Kharkiv State Aircraft Manufacturing Company (KSAMC) is the largest manufacturer of aircraft in Ukraine. The company has produced aircraft since 1926. Currently, the company produces the Antonov AN-140-100 turboprop aircraft and AN-74 multifunctional transport convertible aircraft. Besides full scale production of AN-140-100 and AN-74 at its facilities, KSAMC delivers AM-140 aircraft kits to HESA Company Iran and Aviacor in Russia for final assembly.

Kotris Ltd designs, produces, supplies and commissions process control systems for the aviation, oil and gas, chemical and municipal economy sectors. Kotris' main research directions are technical diagnostics, industrial safety, resource and energy savings. For example:

- vibration monitoring and diagnostics devices and systems;
- complex systems for processes control of different branch of industry and municipal economy;
- industrial monitoring and supervisory control systems.

State Enterprise Kyiv Aviation Plant "Aviant" was established in 1920 and is based in Kyiv. It currently specializes in the production of Antonov AN-32, AN-70 and AN-148 aircraft.

State Enterprise Radioizmeritel based in Kyiv produces electronics applications for the aerospace sector in particular navigation-landing systems.

Scientific and Technical Enterprise "TDM" was founded in 1992 and is engaged in the study of semiconductor materials and the development of measuring sensors. The company has carried out several research contracts with the D.V.Efremova Scientific Research Institute of Electrophysical (Russia) to develop semiconductor sensors for temperature, mechanical tensions and magnetic fields measurements for a wide range of temperature and hard environmental conditions. These sensors have been used for navigation, guidance and target designation systems at the superconducting facility "Phoenix" in Kyiv.

Today, TDM conducts R&T on semiconductor properties and sensors and analyses their characteristics. We are able to measure sensors characteristics at room and liquid nitrogen temperature. Some aspects of sensor and semiconductor material production as well as complex sensor tests are conducted in collaboration with Ukrainian and Russian partners.

Since 1940, **Southern National Design & Research Institute of Aerospace Industries ("YUZHGIPRONIIAVIAPROM")** has been the leading specialised enterprise for construction and modernisation of aerospace industries facilities in Ukraine. It has 115 staff including 90 engineers. The Institute has departments for Process, Masterplan, Architectural, Civil, Sanitary and Electrical Engineering; as well as laboratories for civil structural surveys, field surveys; dwelling architectural studio.

Ukrainian Research Institute of Aviation Technology (JSC UkrRIAT) is a key organization in the field of material science and technology of aircraft production. UkrRIAT comprises of different specialists from production organization, aircraft construction and machine-building. It also deals with resolving European and Ukrainian standards issues in the sphere of aviation technologies, systems and equipment. UkrRIAT also provides consultancy services concerning the application of Ukrainian aviation technology and products.

Ukrainian Research Institute of Manufacturing Engineer (JSC UkrNITM) is responsible for developing manufacturing engineering technologies and methods for space rockets. The institute has a considerable experience of composite material production, galvanic coverings, non-destructive testing, welding and machining.

2.2 Main Aeronautics Research and Technology Areas in Ukraine

The following review of aeronautics R&T activities in Ukraine is largely based on information collected during: i) an extensive survey of Ukrainian aeronautics organisations conducted by the FP7 AERO-UKRAINE consortium between May 2009 and March 2010 and ii) presentations made during the FP7 AERO-UKRAINE workshop "*Bridging the Ukrainian Aeronautics Industry with the European Union*" held in Kyiv in October 2009.

2.2.1 Materials

Titanium
Titanium is a special metal gaining an increasing profile in the aeronautics sector. Titanium alloys have high strength-to-weight ratios and excellent corrosion resistance. In Ukraine, there are a number of institutes of the National Academy of Sciences involved in titanium research for aeronautics applications. For example, the research activities of Frantsevich Institute for Problems of Materials Science of the National Academy of Sciences of Ukraine (IPMS-NASU) include:

- Elaboration of silicon-strengthened titanium "steels" possessing increased high-temperature strength, oxidation resistance and ductility;
- Elaboration of advanced in situ reinforced Ti-matrix composites;
- Thermomechanical processing and powder metallurgy technology with high solidification rate in manufacturing Ti-based alloys to exert effect on formation, geometry and morphology of boride phase;
- Creating a scientific basis for elaborating silicon boride-strengthened Ti-based materials possessing increased values of Young modulus and high temperature strength;
- Studying effects of alloying, solidification rate, thermomechanical processing and boron addition technique on structure and mechanical properties of Ti-Si-X, Ti-B-X, Ti-B-Si-X (X = Al, Zr, Sn).

Transmission components made from novel titanium composites (tribotic)
(Image courtesy of IPMS-NASU)

Indeed, IPMS-NASU has been supporting Ivchenko-Progress with the development of advanced steels as well as scientific and technical documentation to manufacture blanks for high speed heatproof bearings for new generation aircraft engines.

Meanwhile, G.V. Kurdyumov Institute for Metals Physics of the National Academy of Sciences of Ukraine (IMP-NASU) is involved in the development of high strength titanium alloy production technology as well as the cost effective production of powder metallurgy titanium components. It has developed an integrated production technology that can produce beta-titanium alloy parts characterized by extremely high strength (UTS ≥ 1600 MPa) whilst keeping reasonable level of ductility (RE ≥ 8%). The production technology is based on a blended elemental powder metallurgy method in its simplest press-and-sinter approach, without application of pressure or deformation during or after sintering. A distinctive feature of technology is the employment of hydrogenated titanium powder instead of traditional titanium powder. Hydrogen has a major effect on synthesis

improvement, providing production of alloys having 98.5-99.5% density, desired microstructure and chemical homogeneity, low impurity content and high mechanical properties. The production technology has been successfully used to produce high strength titanium springs for the Antonov 148 aircraft.

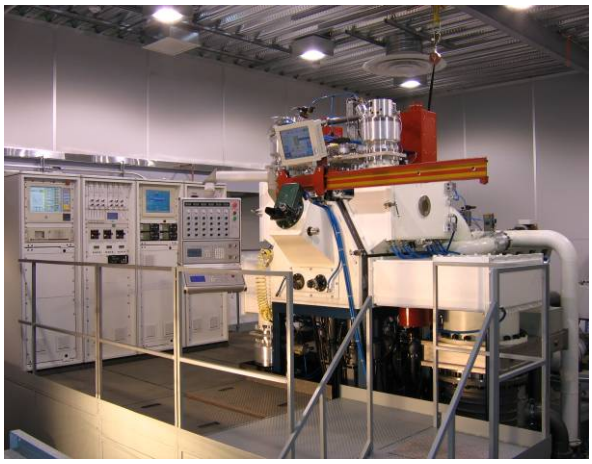
In recent years, Antonov's titanium development work has focused on its application in landing gear (e.g. now 80% relative volume of titanium alloys in AN-148 landing gear), high lift devices (using VT-22) and pipelines (using PT-7M).

Surface Engineering

Surface engineering is a major branch of materials science that deals with the way solid surfaces degrade through wear, corrosion and fatigue. Normally, the main aim of surface engineering is to increase the wear properties of a solid's surface to reduce its degradation over time. This can be accomplished by coating or altering its surface properties. Surface engineering is considered an enabling technology for the aerospace industry. It has been estimated that over 2 millions components in a typical Airbus passenger jet require some form of surface engineering to enhance their properties.

Surface engineering related R&T in Ukraine is performed by several Ukrainian organisations. For example, International Center for Electron Beam Technologies (ICEBT) has worked on thermal barrier coating (TBC) projects for companies in the USA (General Electric, Pratt & Whitney, Chromalloy, Phygen), Canada (Cametoid) and China (BAMTRI, BIAM, Xian Aero-Engine). It has developed an electron beam physical vapour deposition (EB-PVD) system that enables the deposition of a multilayered graded nanostructured coating to be conducted in a single unit. It enables a major reduction in process time and cost as well as an improvement in the principal service properties of the coatings (thermal barrier, damping and erosion resistant). For graded thermal-barrier coatings, the EB-PVD system can:

- reduce ceramic layer thermal conductivity to 0.6 W/mK;
- improve adhesion strength with bond coat (more than 150 MPa);
- increase thermal-cyclic life-time 2-2.5 times compared with traditional TBC.



ICEBT's pilot-production EB-PVD unit
(Image courtesy of ICEBT)

For multilayered graded erosion-resistant and damping coatings of 25-45 microns thickness deposited at high deposition rate (up to 1 micron/min), the EB-PVD system can:

- increase 10-15 times the erosion resistance (compared to Ti-6-4 alloy) due to application of B4C-based layer, stable up to temperature up to 600 C;
- increase damping characteristics and absence of coating influence on fatigue limit of the substrate being protected;
- reduce the cost by half.

ICEBT offers clients EB-PVD equipment, patent licensing and know-how concerning:

- Graded thermal-barrier coatings NiAl/YSZ for hot section components of gas turbines
- Graded nanostructured erosion-resistant and damping coatings on steel & Ti alloy items.
- Manufacturing of EB-PVD units in accordance with customer requirements.

In recent years, Antonov has been working with Paton Electric Welding Institute (PEWI-NASU) to develop a new metal deposition process for local surface repair of components made of Ti alloys. The process offers several benefits: minimum thermal cycle effects on the structure of the base material, lower residual stresses in the base material and no wear effects up to a considerable depth.

Also, Ivchenko-Progress has been working extensively with PEWI-NASU to develop new types of high-temperature and heat-resistant coatings; ceramics materials; technologies to apply new coatings and materials to gas turbine engine components; technologies to recover parts made of titanium and high-temperature nickel alloys by welding and brazing methods; friction welding; wear-resistant coatings and associated deposition methods.

Meanwhile, Chuiko Institute of Surface Chemistry of the National Academy of Sciences of Ukraine (ISC-NASU) has been involved in several international projects with European partners dealing with:

- Environment-friendly hexavalent chromium free anticorrosion nanocoatings for corrosion protection of aluminium, magnesium and light alloys;
- Easy-to-clean and self-cleaning nanocoatings on the surface of metals and glass.

Also, G.V. Kurdyumov Institute for Metals Physics of the National Academy of Sciences of Ukraine (IMP-NASU) is involved in the development of cobalt-based eutectic alloys (XTN-1 and XTN-2) with excellent heat and wear-resistance at high temperatures, high corrosion stability and good casting characteristics. The alloys can be used for nickel based aviation alloy applications such as gas turbine blades.

Similarly, Frantsevich Institute for Problems of Materials Science of the National Academy of Sciences of Ukraine (IPMS-NASU) is involved in investigating dispersion- and eutectic-strengthened structural materials (metallic, ceramics, ceramic metals). It recently completed an STCU project on new light eutectic alloys for coating based on cubic L12 aluminium intermetallics. IPMS-NASU is also deeply involved in the creation of detonation coatings based on titanium aluminide alloys and aluminium titanate ceramic sprayed from mechanically alloyed powders Ti—Al. It has developed the detonation coating gun “Dnepr-5MA” and established service centres to support its detonation coating technology in Japan, China, former Yugoslavia and Iran.

Lastly, G. S. Pisarenko Institute for Problems of Strength of the National Academy of Sciences of Ukraine (IPP-NASU) is involved in lifetime estimation of materials under fretting fatigue taking into consideration interference of electrical phenomena and complex stress states in the zone of contact and friction. Their development work has included studying the effect of various surface modifications and coatings on fretting fatigue of titanium alloys for dovetail joints for Ivchenko-Progress.

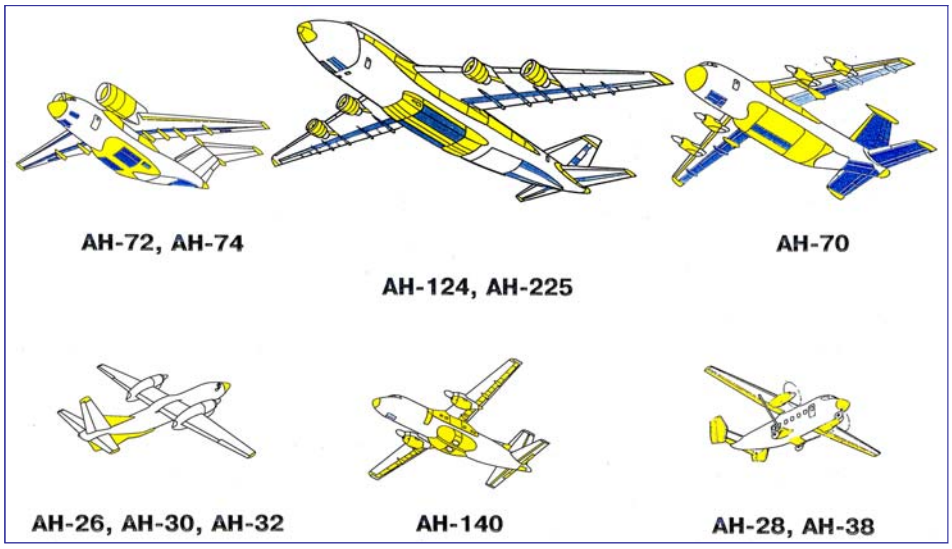
Composites

The aerospace industry’s demand for composites is advancing rapidly as a result of the drive for lighter, energy saving and environmentally friendly materials. The most widely produced composites are polymer composites with carbon fibre reinforced plastic (CFRP) being particularly popular.

Antonov has a centre dedicated to composite structures where it develops nonmetal structures based on carbon, glass, organic and hybrid fibres. The company works closely with Frantsevich Institute for Problems of Materials Science (IPMS-NASU), Podgorny Institute for Mechanical Engineering Problems (IPMASH-NASU) and Pisarenko Institute for Problems of Strength (IPP-NASU). Development work is focussed on:

- Investigations of high- and medium-stressed structures made of composite materials
- Investigations of resistance to fuel, flame and corrosion
- Investigations of atmospheric effects on strength and service life
- Development and introduction of processes for series production of integral structures

Composite material has been applied extensively to Antonov aircraft e.g. stabilizer of AN-70, engine nacelle of AN-148 and cargo door panels of AN-124.



Areas and type of composite material used in Antonov Aircraft (Image courtesy of Antonov ASTC)

The National Aerospace University "Kharkov Aviation Institute" (KhAI) has a specialized composite material laboratory fully equipped to develop, manufacture and test composite/CFRP components and structures. It has an oven, vacuum system, autoclave (up to 5 atmospheres) and tensile-testing machine. KhAI researchers are experienced in:

1. Development of analytical models for design and calculation of composite aeronautic structures;
2. Development of innovate composite-to-composite and composite-to-metal joints with increased characteristics in comparison with traditional ones;
3. FEM simulation and checking calculation of composite materials structures;
4. Verification of finite element and analytical models by holographic interferometry;
5. Composite structures curing process optimization and control;
6. Design and production of efficient heating tool;
7. Experimental determination of strength, electric and thermal (thermal expansion coefficient and shrinkage) characteristics of polymeric and reinforced materials.

KhAI offers the following technologies/services for international cooperation and joint projects:

1. Set of mathematical models and analytical design algorithm for thin anisotropic structures stress-strain state determination that take into account initial technological stresses;
2. Method for cure process time-temperature conditions determination for predefined cure degree obtaining with minimal time and energy consumptions;
3. Method for manufacturing tool and additional layers rational parameters determination for reduction of thermal field non-uniformity in cured part;
4. Design and technological solution of innovative metal to composite joints and methodology for joint analytical and experimental analysis.

Finally, Ivchenko-Progress has been working closely with IPMS-NASU to develop composites and manufacturing techniques in order to produce composite parts for aircraft gas turbine engines.

Nanomaterials

Nanomaterials have a high potential for application in several areas of aeronautics including lightweight structures designed for harsh environments and high temperatures as well as thermal and mechanical protection layers with excellent tribological characteristics for engine or landing gear parts.

Frantsevich Institute for Problems of Materials Science of the National Academy of Sciences of Ukraine (IPMS-NASU) has been successfully conducting international research projects concerning nanostructured materials with partners from Europe, India, Russia and USA since the 1990s. Its expertise and achievements include the following:

- Production of tens of particulate substances and compounds had been obtained on laboratory, pilot and industry scales;
- Development of a new concept of nanoparticle synthesis in nanoreactor considering wide number of possible reactors;
- Development of rate-controlled synthesis method appropriate for flexible control of nanoparticle size distribution;
- Development of new combined method for synthesis of nano-cubic boron nitride under shock–wave conditions in diffusion-controlled area of transformation from graphite-like BN;
- Development of pilot-scale manufacturing of single walled carbon nanotubes (SWNT) and multi walled carbon nanotubes (MWNT) by carbon oxide conversion reaction;
- Development of laboratory synthesis of nanorods, nanowires and other elongated nanostructures based on SiC, Si3N4, TiB2, BN.

Meanwhile, Podgorny Institute for Mechanical Engineering Problems of the National Academy of Sciences of Ukraine (IPMASH-NASU) can produce new nonoxide powder materials using new milling equipment operating in liquid nitrogen (77K / -196 0C). Using cryogenic milling, SiC, HfC, etc, powder materials can be produced with the following physical and chemical properties: chemical homogeneity of size composition, high dispersivity (up to 1 mkm), high purity, low sintering temperatures, high adhesion and without an oxide layer on the surface. New structural carbon-ceramic material based on SiC demonstrate significantly improved strength and thermal physics characteristics compared to traditional materials. For example, gas turbine engine combustion chambers produced from these materials have ultimate bending strength, ultimate tensile strength and ultimate compressive strength that are two times higher. Also, their high-temperature strength and heat-resistance are significantly increased.

2.2.2 Manufacturing

Joining and Welding

Joining and welding are vitally important to the construction of reliable aircraft structures. Consequently, the development of improved joining and welding techniques, as well as new methods to assess the integrity of joints and welds, are of keen interest to aircraft manufacturers.

The E.O. Paton Electric Welding Institute of the National Academy of Sciences (PEWI-NASU) is world renowned for its welding development work. This institute's department of pressure welding conducts investigations into flash-butt welding, flash and resistance welding, friction and magnetically-impelled arc welding (for similar and dissimilar materials). Also, investigations concerning the physical-metallurgical processes involved in welding steels (including carbon and stainless) and alloys based on aluminium, titanium and nickel.

The institute's department of optimization of welded constructions for new equipment's is involved in the optimization of welded thin-sheet stringer panels and cases from aluminium and titanium alloys for the construction of new generation, wide-body aircraft. The main aim is to increase operation life by regulating deformation and minimising welding heat by means of ray and arc techniques and also by friction welding with mixing. The department has developed technologies and equipment for non-deformation welding of stringer panels from BT-1 and AMg6 alloys up to 2.5m in length and cases from AMg5 and AMg6 alloys with 0.5 – 4.0m diameters.

Frantsevich Institute for Problems of Materials Science of the National Academy of Sciences of Ukraine (IPMS-NASU) is deeply involved in the welding and soldering of inorganic materials: ceramics, oxides, nitrides, quartz glasses, glass ceramics, carbon reinforced materials and special functional materials (segneto- and piezoelectric materials, infra-transparent materials, etc). For such purposes, IPMS-NASU has developed special metallic soldering melts (adhesion–active solders), which can wet non-metallic materials.

Single-impact riveting tool developed at KhAI (Image courtesy of KhAI)

National Aerospace University "Kharkov Aviation Institute" (KhAI) has extensive joining R&T experience from close cooperation with Antonov, Kyiv State Aircraft Plant and Kharkiv Aircraft Manufacturing Company. Also, KhAI has worked with numerous international aviation organisations. Within the STCU funded collaborative project "Composite Laminates Titanium Riveting Technology Development with Process Parameters Optimization", KhAI worked with Boeing to develop technical knowledge and tools for pulse riveting of carbon-filled plastic aircraft structures. In a project with Evektor, KhAI was involved in the detailed study of composite parts machining and riveting, holes burnishing in aluminium structures, tightness bolts installation and torque box tanks press riveting.

Metal Forming and Machining

National Aerospace University "Kharkov Aviation Institute" (KhAI) has laboratories dedicated to metal forming, sheet and electrohydrodynamic stamping, and high-speed impulse technologies. Utilising these facilities, KhAI conducts the following research:

1. Development of methods for increased application of adaptable rigging (machining in modern machining centres).
2. Modern control of manufacturing processes and quality in sheet-stamping production.
3. Upgrading of press equipment for forming and sheet stamping in aircraft production.
4. Sheet stamping by means of high-speed cumulative influence of transmission medium.
5. Technology and equipment for high-speed (impulse) metal forming.
6. Development of enhanced high-lifetime plasma generators

Meanwhile, Zaporozhye National Technical University (ZNTU) is involved in innovative machining technology and services to optimise modes of high-speed milling of shovels for compressors. By using its technology, Ivchenko-Progress has been able to improve production rates for aviation blades, shafts and disks by 50-55%. Specifically, ZNTU has developed manufacturing techniques for compressor blings for the high pressure turbojet engine D-27 and researched the influence of technology twist extrusion on constructional durability of titanic alloys for compressor blades.

The Institute of Engineering Thermophysics (ITTF-NASU) has been working with Ivchenko-Progress to investigate and develop advanced convective film cooling schemes for high-temperature turbine blades.

2.2.3 Numerical Simulation and Analysis

Fluid Dynamics

Podgorny Institute for Mechanical Engineering Problems of the National Academy of Sciences of Ukraine (IPMASH-NASU) has major experience in numerical simulation of viscous flows in aerodynamic passages, taking into account three-dimensionality, compressibility, flow separation, unsteadiness, influence of turbulence and other physical effects. It has developed its own computer simulation system – OPTIMUM – used for solving multilevel conditional-unconditional scalar and

vector optimisation. OPTIMUM was used successfully to help design the aviation engines AI-25TLSh and D-436T1 for Ivchenko-Progress.

The department of information technology at the National Aerospace University "Kharkov Aviation Institute" (KhAI) is also heavily involved in fluid dynamics related work:

- numerical modelling of gas flows in complex form channels (including chemical reactions);
- design and test maintenance of aerodynamics objects: axial-flow and centrifugal blowers, axial-flow and centrifugal compressors, ejectors, heat-exchange devices, catalytic converters;
- numerical modelling of gas mixing at atmosphere and industrial plants (determination of pollutant gases hot spots, combustion and explosion of inflammable gases, risks assessment of man-caused emergency conditions);
- computational fluid dynamics, finite-difference and finite volume methods;
- computational multi-objective optimization methods;
- 3D CFD codes, CAE-systems, CAD-systems, computational decision support systems on the basis of inverse problem quasi-solutions searching for turbomachines;
- technologies of flow separation control;
- computational methods of gas turbine engine diagnostic analysis.

2.2.4 Structure

Antonov has one of Europe's largest structural testing facilities for conducting static, fatigue and simulated bird strike tests. It conducts research into the development of surface hardening processes; corrosion damage and its after effects; structural reliability and durability; and methods and tools for non-destructive testing of structures.

The National Aviation University (NAU) carries out fundamental and applied research within its aircraft strength and fatigue life laboratory. This includes fatigue testing according to ASTM standards (tension testing of metallic materials, measurement of fatigue crack growth rates and measurement of fracture toughness) and fatigue testing according to variable amplitude test programmes (TWIST/MiniTWIST, HELIX/FELIX and FALSTAFF).

The National Aerospace University "KhAI" has a stress test lab certified according to Ukrainian aviation regulations part 23, sections C and D; as well as airworthiness specifications JAR-VLA, sections C and D. The lab is used for examining the static and fatigue characteristics of materials, aircraft parts, and small aircrafts. Also, finite element analyses are conducted to define and predict airframe durability.

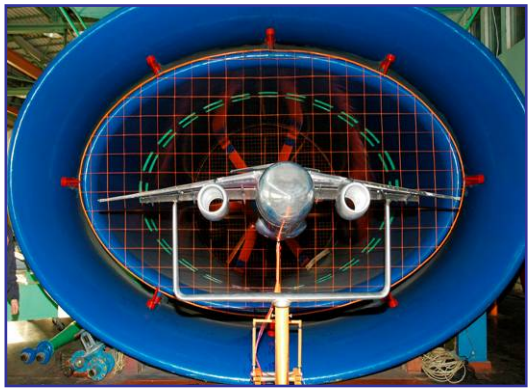
Over many years, G. S. Pisarenko Institute for Problems of Strength of the National Academy of Sciences of Ukraine (IPP-NASU) has been developing a general concept of Mode I fracture in plates and tubes subjected to monotonic loading– called the Unified Methodology - with much of the work focussed on express tensile fracture testing of thin-sheet metal for Antonov.

Meanwhile, E.O. Paton Electric Welding Institute of the National Academy of Sciences (PEWI-NASU) has developed a method of reducing fatiguing effects by means of electrodynamic treatment of cracks using electric current impulses. The method increases the operating life of aircraft where the cracks are below a critical length when first discovered. The equipment involved is compact and easy to use so aircraft can be simply treated at an airport.

Finally, Ternopil Ivan Pul'uj State Technical University (TSTU) has conducted several national projects to model and evaluate the influence of temperature and waveform loading on fatigue crack growth rates in transport plane wings.

2.2.5 Aerodynamics

Antonov develops new aerodynamic configurations for complete aircraft, wings, wing flaps, slats and other high-lift devices. Recent work has focused on improving the aerodynamic characteristics of its aircraft in cruise configuration and methods of increasing wing lift using engine power (by blowing on the upper and lower wing surface with the stream of a bypass turbo-jet engine or propfan).



Wind tunnel testing
(Image courtesy of Antonov ASTC)

The department of aerodynamics and acoustics at the National Aerospace University "Kharkov Aviation Institute" (KhAI) conducts fundamental and experimental research. KhAI's fundamental research includes wing in ground effect aerodynamics, adaptive airfoils, coanda effect, boundary layer, jet-controlled high-lift devices, wing and fuselage integration, and semi-empirical methods. KhAI's experimental research spans: aircraft of various configurations (TsAGI, Tupolev Design Bureau, Ilyushin Design Bureau and Antonov); wing-in-ground effect craft and amphibious aircraft (Beriev Design Bureau); UAV of various configurations for a wide range of Mach number (Yuzhnoye); and helicopters of various configurations.
The department has the following facilities:

- Subsonic aerodynamics laboratory
  - Subsonic wind tunnel T-3 (velocity up 45 m/s; diameter of flow core 1.2 m; length of working section 2.3 m; initial degree of turbulence 0.06%)
  - Subsonic wind tunnel T-4 (velocity up 60 m/s; diameter of flow core 1.2 m; length of working section 2.3 m; initial degree of turbulence 0.08%)
- Supersonic aerodynamic laboratory equipped with supersonic wind tunnel T-6 (Mach number – 0.5÷4; cross section – 0.6x0.6 m; length of working section 1.3 m)
- Study wind tunnels T-5 (velocity up 35 m/s; diameter of flow core 0.6 m; length of working section 1.5 m)

2.2.6 Propulsion

An overview of the aero-engines developed by SE Ivchenko-Progress can be found in Annex 4

Ivchenko-Progress is continuously developing new aero engines for civil and military applications. The company investigates new materials, control systems, elements and components to help improve their gas turbine engines. The developed and evaluated ideas, technologies and materials are not only introduced in their new advanced engines, but also used to modify and improve the quality and performance of existing serially produced engines.

The company has several departments involved in research and technology of aero-engines. The compressor department carries out research, design, test and certification of compressors. In recent years, its development work has included:

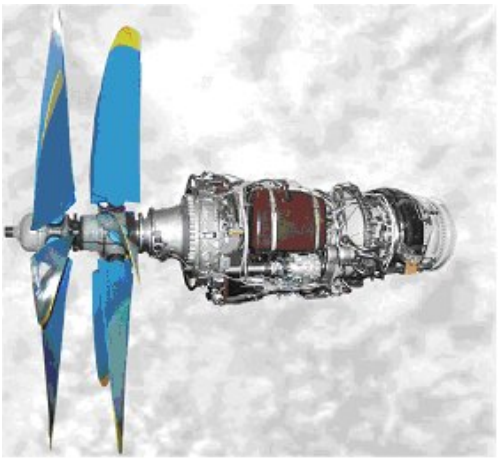
- One stage axial fans, multistage axial compressors of high and intermediate pressure and axial centrifugal compressors;
- High efficiency and high pressure compressors of D-18T, D-436T1/TP, D-436-148, D-27, D-36, AI-222-25 and other aviation engines;
- Small-size centrifugal compressor with high pressure ratio AI-450M (400-470hp) aviation engine.

On the other hand, the combustion chamber research department has been working on:

- Development of new low-NOx-level fuel-burning technologies;
- Ensuring burning stability;
- Increasing altitude characteristics of engine starts;
- Implementation of new temperature-resistant ceramic materials and thermal barrier coatings;
- Minimization the combustor exit temperature profile.

Meanwhile, during the 1990s, the reduction gearbox department developed reduction gearboxes for the turboprop engines TV3-117VMA-SBM1 and AI-450, with gear meshings with a transverse contact ratio above two, which significantly increased their life time and reduced gear vibrations and noise. In the 2000s, the department has developed the main and tail reduction gearboxes for the light helicopters KT-112 and AK-1-3. In order to increase the contact durability of gear teeth, the department developed an antifriction coating. Research results have indicated the coating increases durability by up to 40%. It has now been implemented on reduction gearboxes for the aircraft engines AI-450, D-27 and TV3-117VMA-SBM1.

Moving on now to consider specific gas turbine engine developments, Ivchenko-Progress developed the world's first turbopropfan engine – the 14000 hp D-27. The engine is currently undergoing official flight testing on the medium-range military airlifter AN-70. Modified versions have also been developed: AI-127 (14500hp); a family of ultra bypass turbojet engines (about 13); and AI-727 (9000-11000 kgf thrust) driven by a reduction gearbox for the AN-148T transport aircraft.



D-27 counter rotating open rotor propeller
(Image courtesy of SE Ivchenko-Progress)

Understandably, Antonov has expertise as well in counter rotating open rotors through its long term use of such propellers on the AN-22 aircraft and development of two-row counter-rotated propfans on the AN-70 aircraft.

For the new regional AN-140 aircraft, Ivchenko-Progress has developed the TV3-117VMA-SBM1 turboprop engines and AI9-3B auxiliary power unit. Work to further extend the service life and improve the reliability of these engines is currently being performed.

For the new passenger TU-334 and AN-148 aircraft, as well as the BE-200 amphibian, Ivchenko-Progress has developed the new-generation D-436 engine family (6400 to 8200 kgf thrust). Engine series production is executed in cooperation with JSC Motor Sich (Ukraine), FGUP Salut MMPP (Russia) and JSC UMPO (Russia). In November 2008, the D-436TP turbofan engine received EASA (European Aviation Safety Agency) airworthiness approval - the first from an ex-Soviet country - and ensuring that the BE-200ChS amphibian could enter the European market.

In recent years, the company has been developing a family of AI-222 turbofan engines with a thrust ranging from 2200 to 4500 kgf (afterburning version) for powering modern combat training airplanes. In 2009, the programme was completed and the acceptance report signed for the joint state flight tests of a Russian Yak-130 combat trainer powered by AI-222-25 engines (2500 kgf thrust). Currently, the development of the AI-222-25F engine (4200 kgf thrust with afterburning power) is in its final phase.

Also, work is now being carried out on the development of the AI-222-40 turbofan engine (3500-4150 kgf thurst based on the baseline engine core) for powering commercial aircraft.

For new aircraft and helicopters, turboprop and turboshaft versions of the AI-8000 are currently being investigated with a power of 7000-8000 hp.

A small-sized turboshaft engine, AI-450, rated at 465 hp has been recently designed for powering KA-226 helicopter. An experimental batch of engines was manufactured at JSC Motor Sich. Based on the AI-450 engine core, the AI-450MS auxiliary gas turbine engine is used to power the AN-148 regional aircraft. Also, a modified version, AI-450M, with a rear shaft output (400 - 465 hp) for upgrading MI-2M helicopter, is under development. It is currently undergoing bench testing and preparations for series production are in progress. Furthermore, an upgraded version, AI-450-2 (630-730 hp), to power helicopters of Ansat type, AI-450C (400-465hp) and AI-450C-2 (630-730 hp) turboprop engines are also being developed for light airplanes of Yak-18, Yak-152, SM-92T “Finist Turbo”, EV-55 type, as well as, modified versions of turbofan engines AI-450BP (409 kgf) and AI-450-2BP (560 kgf) for light multipurpose airplanes and UAVs.

By using the considerable experience gained in the development of the AI-222-25, AI-222-25F and D-27 engines, Ivchenko-Progress is currently developing the AI-9500F engine with a thrust of 9.5 tons for use in the power plants of light combat airplanes. Also, proposals to develop an advanced engine - AI-40 (3500-4500hp) - for powering commercial airplanes are being developed.

In order to increase the weight-lifting capability and efficiency of the AN-124-100 transport aircraft, a modified version of D-18T series 4 engines, with a maximum take-off thrust of 25830 kgf, is being developed. The new AN-124-100M-150 aircraft will be able to carry cargo of up to 150 tons.

Based on the AI-25TL engine, a modified version - AI-25TLSh – was recently developed as part of the upgrade of the Czech AeroVodohody L-39 trainer. The modified engine provides a combat mode of increased maximum thrust of up to 1850 kgf and will extend the service life of the L-39 aircraft by 10-15 years. In December 2008, the upgraded L-39 airplane with the modified engine successfully undertook the state flight tests. Today, the upgraded L-39 airplanes have entered the Ukrainian Air Force.

We now move on to consider other Ukrainian organisations involved in propulsion R&T.

The department of aviation engine design at the National Aerospace University “Kharkov Aviation Institute” (KhAI) has over 30 years of experience in turbine engine monitoring, diagnostics, numerical modelling and simulation. Its comprehensive research activities include:

- gas turbine engine parametric diagnostics;
- development of fast calculated multi-mode dynamic models of turbine engine;
- sensor fault detection procedures using information redundancy and engine subsystem mathematical modelling;
- development of combustor, including innovative design for further NOX reduction;
- development of analytical and experimental techniques for modelling the kinetics of combustion and related computational fluid dynamics;
- development of technologies for advanced combustor and injector systems with regard to NOx, soot and unburned hydrocarbon;
- lifetime depletion of critical gas turbine engine parts monitoring methods based on dynamics temperature and stress states identification;
- development of the fast calculating monitoring models of temperature and stress state critical turbine engine parts on steady-state and transient modes based on upper level computer models.

Finally, Podgorny Institute for Mechanical Engineering Problems of the National Academy of Sciences of Ukraine (IPMASH-NASU) has major experience in numerical simulation of viscous flows in aerodynamic passages, taking into account three-dimensionality, compressibility, flow separation, unsteadiness, influence of turbulence and other physical effects. It has developed its own computer simulation system – OPTIMUM – used for solving multilevel conditional-unconditional scalar and vector optimisation. OPTIMUM was used successfully to help design the aviation engines AI-25TLSh and D-436T1 for Ivchenko-Progress.

2.2.7 Safety

The increased use of carbon plastics in aircraft is invoking increased interest in lightning strike protection of composite parts. Unlike metals, when struck by lightning, carbon plastics are subjected to damages which are accompanied with splitting and delamination in the form of trough breakdowns and consequently a separation of damaged layers by free-stream flows. The nature of carbon plastic damage is of thermal origin being a process of rapid binder destruction of material.

Frantsevich Institute for Problems of Materials Science of the National Academy of Sciences of Ukraine (IPMS-NASU) is working with Antonov to develop knitted lightning protection meshes for composite parts. The meshes comprise of current-conductive layered reinforced coatings based on microwire composite cells that include nanostructure electric-conductive fillers. The meshes allow for repair and renewal of lightning damaged composite materials in structural elements of aircrafts.

The work involves optimizing the structure and weight characteristics of knitted lightning protection meshes; offering efficient electric conductive nanostructure fillers for polymer composites; and studying the energy dissipation in carbon plastics composites with a lightning protection system when struck by lightning.

Meanwhile, National Aviation University (NAU) has a wind tunnel and equipment to research how sudden impacts during flights can affect the aerodynamic qualities of planes. NAU produces scale-down models of plane wings that contain the optimum number of sensors to register moment, degree and location of typical impacts. Based on past positive crew actions in similar situations, NAU has created a contingency plan rule base.

2.2.8 Systems

The department of aircraft control systems at the National Aerospace University “Kharkov Aviation Institute” (KhAI) has performed for many years various systems related projects for aerospace organizations. Its research and technology development activities include:

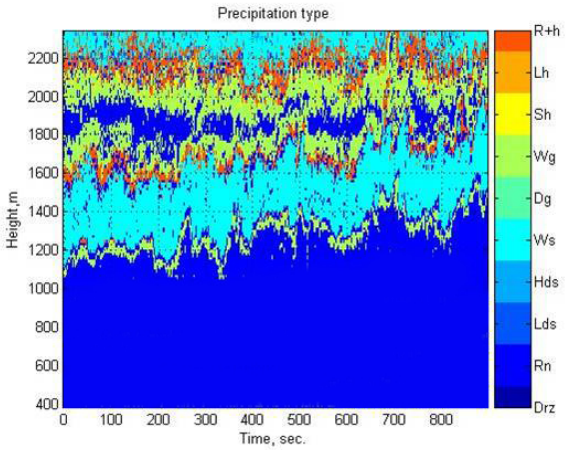
- development of aircraft control systems with the capability of active fault-tolerance;
- development of methods, models, algorithms of aircraft control system state deep diagnosing;
- development of methods, models of determining aircraft control systems diagnosability;
- development of methods, models, algorithms of aircraft control systems functions recovery after faults and airframe damages;
- experimental research of aircraft control systems using test benches and computer programmes.

Meanwhile, the electronic control and monitoring systems department at Ivchenko-Progress carries out development work on the following systems:

- Automatic control systems: electronic control systems; fuel systems; pneumatic systems; hydro-mechanical systems; test and control equipment; and bench control systems;
- Monitoring and diagnostic systems: on-board; on-ground; monitoring systems of vibrations; systems of representation of parameters; and signals of the engine.

2.2.9 Communications and Navigation

The radio-electronics department of the National Aviation University’s (NAU) main research directions include: 1) Remote detection and estimation of dangerous weather phenomena for aviation safety; 2) Doppler-polarimetric radar; 3) Surveillance systems including multilateration, secondary radar, automatic dependent surveillance-broadcast (ADS-B), and traffic and collision avoidance system (TCAS); 4) Noise immune coding and cryptographic protection of information; and 5) Compression of signals and images. The department has conducted numerous research projects with IRCTR-TU Delft, Holland, and the Technical University of Hamburg-Harburg, Germany.



Radar hydrometeor type recognition (Image courtesy of NAU)

The R&T achievements of the A. Usikov Institute of Radio Physics and Electronics of the National Academy of Sciences of Ukraine (IRE NASU) include:

- development of a series of new radiation sources operating in millimetre and sub-millimetre wavebands with wide potential for radar, communication systems, and defence applications;
- design of pulse-mode magnetrons whose operation mode is called the "Kharkov 11", as well as continuous-mode magnetrons, klynotrons and reflection klystrons covering the wavelength range from 0.5 mm to 2 cm;
- design of new sources of coherent radiation of in mm and sub-mm ranges: orotrons (diffraction radiation sources) of pulsed and continuous modes having champion parameters in terms of high stability, narrow spectrum, low noise and high power;
- development of high-efficiency sources of far-infrared and optical band: dye lasers with a tunable frequency of induced emission;
- development of full sets of the waveguide measuring devices (within the range from 1 mm to 10 mm), a set of quasi-optical wide-range measuring devices and components for measurements within the wavelength range from 0.1 mm to 1 mm.

For aircraft flight information systems, Lviv Polytechnic National University (LP) develops radio-electronic equipment using digital signal processors (DSPs), field programmable gate arrays (FPGAs), and high-speed analogue-to-digital conversion devices (ADCs). Also, it develops specialized software for information and signal processing including application programmes, device drivers, DSP firmware, and FPGA configuration.

The department of instruments and systems of orientation and navigation at the National Technical University of Ukraine "Kyiv Polytechnic Institute" (NTUU KPI) is heavily involved in the development of signal processing methods and control algorithms for inertial navigation systems (including strapdown systems); researching the static and dynamic characteristics of vibratory gyroscopes; and development of intelligence system for flight information processing and decision making for aircraft engine rotary details.

2.2.10 Testing

Scientific and Technical Enterprise "TDM" develops semiconductor sensors for temperature (thermo-resistors), mechanical tension (tenzoresistors, strain sensors) and magnetic field (Hall sensors) measurements across a wide temperature range 4,2 – 400 K. The firm's sensors are small: Hall sensors – 1x1x0,5 mm, strain sensors – 1x8x0,4 mm, and thermo-resistors – 1x1x1 mm. Their sensors have high measurement sensitivity: temperatures – 100%/K, magnetic fields – 500 mV/Tl and mechanical tensions – 100 mkV/mln^{-1}.

Kotris Ltd has developed a hardware and software system called KAI-25F for aviation gas turbine engine testing with automated modelling and diagnosis features. KAI-25F is used for real-time synthesis and analysis of control laws and algorithms of automatic control systems during engine and laboratory tests. KAI-25F's features include:

- automatic and hand remote engine control in process of engine tests and laboratory tests of hydromechanics;
- monitoring of the engine control system and hydromechanics measuring channels in process of motor tests;
- real-time simulation of gas turbine engine, hydromechanics and electronic digital control system algorithms and measuring channels.

JSC Element is one of Ukraine's leading certified suppliers of electronic measurement systems, parameter monitoring systems and aviation engine control systems. It develops measuring transducers, aviation control and monitoring systems, programme and technical complexes of aviation engine testing, embedded real-time software, SCADA, monitoring and simulation systems, gas-turbine engine models, trend and correlation analysis. The firm has taken part in the development projects for Antonov AN-70, Antonov AN-148, Kamov Ka-226 "Sergei" and Tupolev Tu-334.

Meanwhile, the electronic control and monitoring systems department at Ivchenko-Progress carries out development work on the following systems:

- Automatic control systems: electronic control systems; fuel systems; pneumatic systems; hydro-mechanical systems; test and control equipment; and bench control systems;
- Monitoring and diagnostic systems: on-board; on-ground; monitoring systems of vibrations; systems of representation of parameters; and signals of the engine.

2.2.11 Airports

The centre of environmental problems of airports at the National Aviation University (NAU) conducts research into airport noise and air pollution reduction including:

- Semi-empirical methods for assessment of aircraft noise levels and noise exposure around airports;
- Methods for assessment of air pollution concentrations around airports;
- Methods for assessment of third party risk around airports;
- Numerical methods for optimization of aircraft trajectories and flight scenario for minimum noise and air pollution impact around airports;
- Development of software tools for acoustic signal analysis and synthesis in aircraft cabins and its implementation in production.

Southern National Design & Research Institute of Aerospace Industries ("YUZHGIPRONIIAVIAPROM") is the leading enterprise for developing, constructing and modernising airports and aviation facilities in Ukraine. Their expertise covers:

- Deep & comprehensive turnkey engineering for the aircraft building & repair enterprises;
- Comprehensive design projects for airfields, airports, heliports, and infrastructure facilities;
- Comprehensive design projects for aviation hangars.

3. Current and Future Perspectives for Aeronautics R&T in Ukraine

In order to understand current and future perspectives for aeronautics R&T in Ukraine, the FP7 Aero-Ukraine project conducted:

i) interviews with key Ukrainian aeronautics R&T decision makers at Antonov ASTC, SE Ivchenko-Progress, Ukrainian Research Institute of Aviation Technology (JSC UkrRIAT), National Aerospace University (KhAI), Frantsevich Institute for Problems of Materials Science (IPMS-NASU) and Physical-Technological Institute Metals and Alloys (PTIMA-NASU).

ii) a survey of research groups at Ukrainian aeronautics organisations to map their research activities and identify which research priorities in the FP7 Aeronautics work programme they would like to become involved with.

3.1 Interviews with key Ukrainian aeronautics R&T decision makers

3.1.1 Antonov ASTC[6]

Antonov's current aeronautics research and technology (R&T) priorities are:

1. Design of the AN-148, AN-70, AN-124 cargo and passenger aircrafts,
2. Research in aerodynamics, strength, new materials, design, systems and equipment,
3. Production technology,
4. Flight tests of new aircrafts and their certification.

Meanwhile, the company's aeronautics R&T priorities over the next 5 – 10 years are expected to be:

1. Design of the AN-158, AN-178 aircraft, and new transport aircraft,
2. Increasing of aircraft lift-drag ratio,
3. Increasing of aircraft service life and reliability,
4. Reduction of environmental impact,
5. Reduction of aircraft weight,
6. Reduction of operational costs,
7. Increasing of aircraft operation efficiency,
8. High comfort for the passengers.

The main sources of influence on Antonov's R&T priorities are:

- Customer requirements,
- Aviation development trends,
- Antonov's own vision of aeronautic development and its own strategic goals,
- Government policy.

Antonov considers its main R&T strengths compared to European and other international organisations as being:

- Broad experience in creating number of cargo aircrafts different size that provide effective operation under conditions of unprepared runways. Antonov took off the AN-70 in 1994 yr. The aircraft AN-124-100 is successfully used for transportation large-size cargo.
- Experience in development methods of increasing lift by blowing on wing surfaces and mechanization by jet exhaust and propeller streams.
- Antonov research laboratories and prospective complexes that provide conducting researches in every area of aeronautic development.

[6] Based on information received from Oleg Bogdanov, Deputy General Designer, Antonov ASTC, 11 February 2010

3.1.2 SE Ivchenko-Progress[7]

Ivchenko-Progress's current aeronautics research and technology (R&T) priorities are:

1. Creation of aircraft engines of any type and dimensions;
2. Creation of aircraft reduction gears, having no world analogues;
3. Creation of ground-based commercial plants on the basis of aircraft engines;
4. Development of innovation designs, techniques, materials, design styles, manufacturing and test methods that increase the safety and decrease the environmental hazard and the costs.

Meanwhile, the company's aeronautics R&T priorities over the next 5 – 10 years are expected to be:

1. Creation of high-performance aircraft engines of 5th generation (increase and optimization of thermo-gas-dynamic cycle parameters, increase of effectiveness of all engine components, decrease of fuel consumption);
2. Increase of service life and reliability;
3. Decrease of weight and maintenance costs;
4. Decrease of harmful emissions and noise;
5. Increase of competitiveness.

The main sources of influence on Ivchenko-Progress's R&T priorities are:

- Customers requirements;
- Modern world trends in aviation propulsion engineering;
- Government policy;
- Our own strategic goals and tasks.

Ivchenko-Progress considers its main R&T strengths compared to European and other international organisations as being:

- Wide experience in creation of aircraft engines of all types and dimensions;
- First in USSR AI-20 turboprop engine with long service life;
- First in USSR AI-25 bypass turbofan engine for powering regional aircraft;
- First in USSR three-shaft bypass turbofan engine, D-36, with high bypass ratio;
- Most powerful in the world helicopter engine, D-136;
- D-18T engine powering the world's largest load-carrying aircraft: AN-225 and AN-124-100;
- First in the world cruise turbopropfan (open rotor) engine, D-27, powering the AN-70 aircraft (which excels on performance attributes the A400M aircraft being developed by EADS);
- Differential coaxial (epicyclic) reduction gear of high reliability for engine rated to 14000 hp;
- Unified gas generators for turboprops and turbofans of high reliability and low cost;
- The experimental-design bureau carries out all production string of aircraft engine creation from designing up to certification and service support.

The main areas where Ivchenko-Progress is interested to collaborate are as follows:

- Small-size centrifugal compressors of high compression ratio (perspective design, fabrication technique, new materials);
- Highly effective low-noise fans;
- Low-emission combustion chambers;
- Strength investigations;
- Highly effective small-size cooled contra-rotating turbines;
- Advanced distributed systems of automatic control;
- Advanced onboard and on-ground monitoring & diagnostic systems, up-to-date algorithms and methods of troubleshooting and maintenance on condition, logistics;
- Advanced materials (new coatings, alloys, other types of materials).

[7] Based on information received from Igor Kravchenko, General Designer – Head of Enterprise, SE Ivchenko-Progress, 22 March 2010

3.1.3 Ukrainian Research Institute of Aviation Technology (JSC UkrRIAT)[8]

UkrRIAT's current aeronautics research and technology (R&T) priorities are:

1. Different types of high-loaded joints for airframes including those based on composites;
2. Development and production of hand-held pneumatic and hydraulic tools for aircraft manufacturing;
3. Increasing the effectiveness of aircraft production.

They are also expected to be the company's priorities over the next 5+ years.

UkrRIAT considers its main strengths to be:

- Deep knowledge of the Ukrainian aircraft industry,
- Ability to identify the appropriate Ukrainian partner for international organisations looking to establish joint projects in the area of aircraft, space and defence.

3.1.4 National Aerospace University "Kharkiv Aviation Institute" (KhAI)[9]

KhAI currently receives 8-10 million hryvna/year (700 – 900k euro/year) from government and private sources to conduct the following research and technology:

1. Research in theoretical and experimental aircraft aerodynamics;
2. Research in aeronautic composite structures design and manufacturing;
3. Research in efficient unmanned aerial systems development;
4. Research in aeronautic structures strength and life time;
5. Development of efficient processes for aeronautic structures manufacturing.

Meanwhile, the university's aeronautics R&T priorities over the next 5 – 10 years are expected to be:

1. Research in theoretical and experimental aircraft aerodynamics;
2. Research in aeronautic composite structures design and manufacturing;
3. Improvement of methods for aircraft aerodynamic design and experimental facilities;
4. Development of new composite materials with nano-reinforcement for aircraft structures load-carrying ability and special characteristics enhancement, and manufacturing processes efficiency increasing;
5. UAV weight/payload efficient increasing due to development of new navigation and control systems, propulsion system, structures and used materials or existent ones improvement;
6. Development and verification of new methods for aircraft structures fatigue life capability and life time prediction;
7. Development and implementation of impact (impulse) technique in mechanical treatment of hard-to-machine metal and composite materials;
8. Advanced joints for aircraft structure development.

The main factors that determine the abovementioned priorities come from a systematic analysis of possible aviation development scenarios and aircraft engineering trends that can lead to important results. Government policy, legislation and other human factors can only accelerate or slow down the goal achievement.

KhAI considers its main R&T strengths compared to European and other international organisations as being:

- Deep and old scientific tradition, long-term experience;
- Capability and tendency to produce own scientific results based on initial data formulated by its own models and methods and their experimental validation;

[8] Based on information received from Victor Shulepov, Director – International Projects and Programmes, JSC UkrRIAT, 22 February 2010

[9] Based on information received from Olexandr Gaydachuk, Vice-Rector of Science, National Aerospace University "Kharkiv Aviation Institute", 14 October 2009

- Opportunity for advanced training of scientific personnel in specific research area;
- Tendency towards original and non-traditional approaches to solving new problems.

3.1.5 Frantsevich Institute for Problems of Materials Science (IPMS-NASU)[10]

IPMS-NASU's current aeronautics research and technology (R&T) priorities are:

1. Development of materials with high values of specific strength;
2. Creation of materials with high values of high-temperature strength and heat-resistance;
3. Elaboration of materials with high fatigue values;
4. Development of materials for tribotechnical systems and friction units.

Between 1999 - 2009, IPMS-NASU won approximately $1 million worth of R&T contracts from the USA.

Meanwhile, the institute's aeronautics R&T priorities over the next 5 – 10 years are expected to be:

1. New generation of materials on the basis of Ti-Al-Mg alloys;
2. Development of coatings with special physical properties;
3. Production of composite materials with high values for mechanical properties.

IPMS-NASU considers its main R&T strengths compared to European and other international organisations as being:

- Lengthy experience of developing composite materials;
- Extensive experience of applying materials science research to the development of pilot and production technologies;
- Achievement of world-class results in materials science.

3.1.6 Physical-Technological Institute Metals and Alloys (PTIMA-NASU)[11]

PTIMA-NASU's current aeronautics research and technology (R&T) priorities are:

1. Modification of existing and development of new Al-alloys for aircraft constructions;
2. Development of equipment and technologies for alloy casting, treatment and batching;
3. Development of technologies and devices for express-analysis of alloy composition and prediction of their properties during operation.

Meanwhile, the institute's aeronautics R&T priorities over the next 5 – 10 years are expected to be focussed on the development of new alloys, technologies and equipment for the production of high quality products for aircraft constructions.

The institute's R&T priorities are determined by their customers and government policy. Meanwhile, their research work is characterized by originality, comparatively low cost and high reliability.

3.2 Interests of Ukrainian aeronautics organisations in FP7 Aeronautics

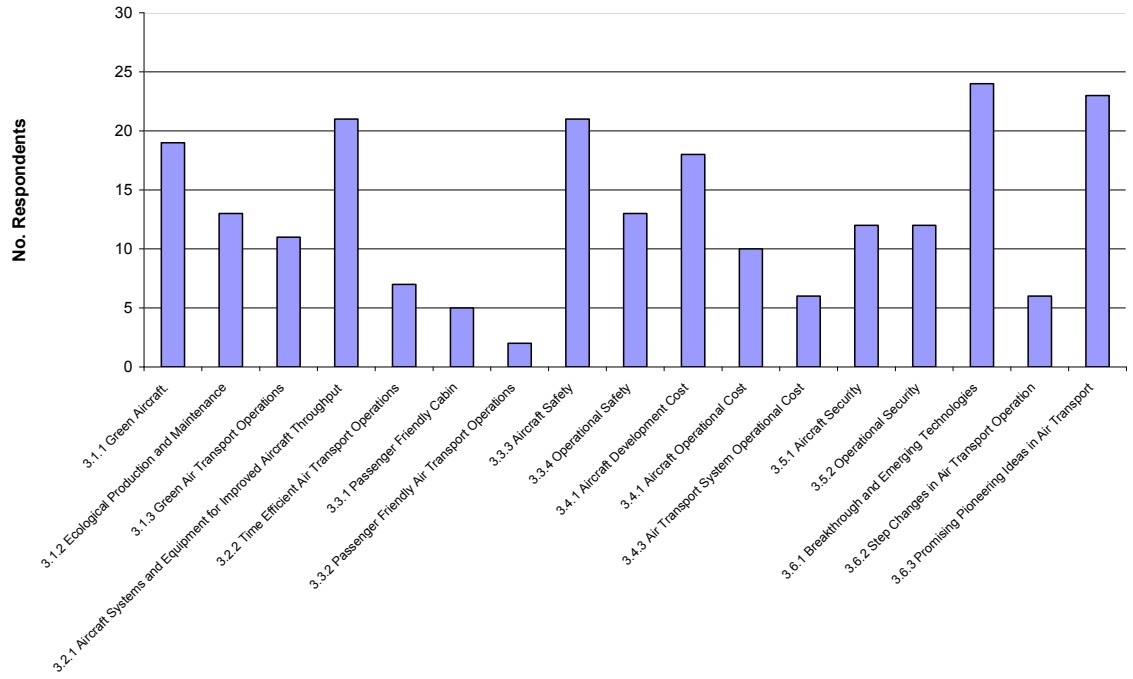
During 2009, the FP7 Aero-Ukraine project partners conducted a survey of research groups and departments at Ukrainian aeronautics organisations (i.e. institutes of the National Academy of Sciences, universities and companies). The survey work involved mapping their research activities and identifying their interest in the research priorities of the FP7 Aeronautics work programme. Altogether, there were 49 research groups and departments that replied.

[10] Based on information received from Sergey Firstov, First Deputy Director, Frantsevich Institute for Problems of Materials Science, 30 April 2010

[11] Based on information received from Vladimir Gavrilyuk, Deputy Director, Physical-Technological Institute Metals and Alloys, 30 April 2010

The figure below shows the research priorities of FP7 Aeronautics work programme (X-axis) versus the level of interest from respondents (Y-axis).

The respondents showed a distinct interest in the priorities: green aircraft; aircraft systems and equipment for improved aircraft throughput; aircraft safety; aircraft development cost; breakthrough and emerging technologies; and promising pioneering ideas in air transport. This can provide direction for current and future EU-Ukraine research cooperation.



4. Ukraine's involvement in International Aeronautics R&T Activities

4.1 Russia

Antonov
Antonov has been collaborating for several decades with the Russian production company Polyot on the AN-3T, AN-70 and AN-74.

The AN-3T is a light multipurpose aircraft developed by Antonov and Polyot. It is a result of further development and modernization of the well-known AN-2 aircraft, which has been operating since 1974 in many countries around the world. By using the AN-2 airframe and some of its component parts, Polyot has been able to reduce the material and production costs of the AN-3T. So far, Polyot has produced about thirty AN-3T aircraft.

Polyot carries out final assembly of the Antonov designed AN-70-100 middle class, transport aircraft.

Since 1993, Polyot has been producing and carrying out final assembly of the AN-74 multipurpose aircraft. The aircraft can make short take-offs and landings on difficult terrain and in harsh weather conditions. In recent years, Antonov has worked with Polyot to carry out modernisation and modifications of the aircraft.

In 1995 Antonov and NAPO (Novosibirsk Aircraft Production Association) established a joint venture company, Siberian Antonov Aircraft, to produce and provide after-sale support for the AN-38, a 27-passenger twin turboprop. Series production of the AN-38-100 aircraft has been carried out by NAPO. Two prototypes (one at Antonov and one at NAPO) and a static test airframe were built. Vostok Airlines became the launch customer for the production aircraft and the first three were received by mid-1995. In recent years, Antonov has worked with NAPO to carry out modernisation and modifications of the aircraft.

Antonov's close collaboration with VASO (Voronezh Aircraft Plant) dates back to the 1950s when VASO began producing the AN-10 and AN-12. During the 2000s, the collaboration has been particularly intense with work to design and produce the AN-148 regional jet. In 2006, the plane was certified and made its maiden flight in October 2009. In its basic configuration, the AN-148 is designed to carry 70-90 passengers up to 5000 kilometres. It costs an estimated $20 million to produce, which is cheaper than Sukhoi's SuperJet-100 (around $28 million). In late 2008, the volume of orders for the aircraft up to 2012 was estimated at over 50 machines from customers such as SCC 'Russia', AirUnion (Krasnoyarsk), 'Volga-Dnepr', 'Polet' (Voronezh) and 'Muscovya' (Russia).

The AN-148 has certain unique design features. The twin jet turbine engines, located under the wing, drive the high wing monoplane into flight, and this unusual configuration provides protection for both the wing and the engines. The design of the wing along with the auxiliary power unit, also assists the aircraft to land at airports that are not as technologically advanced as those found in bigger cities.

AN-148 – Sections made of composite material are grey coloured (Image courtesy of Antonov ASTC)

The AN-148 has an extensive amount of composite material. The total weight of the composite parts is above 2500kg, or about 12% of the aircraft's empty weight. The wing's leading and trailing edges and spoilers/interceptors are made of carbon plastics. Nose cone, fairings of the wing-to-fuselage attachment points and undercarriage fairings, and engine nacelle surfaces are made of glass plastics.

SE Ivchenko-Progress

Ivchenko-Progress' D-27 engine was the world's first three-shaft propfan engine (14000hp) and derived from the D-236 turbofan. Ivchenko-Progress developed the D-27 engine and SV-27 propfan together with SPE Aerosila of Russia in the 1980s for commercial and military transport aircraft. The D-27's two-shaft gas generator is made up of an axial low-pressure compressor, a centrifugal high-pressure compressor, an annular combustion chamber, a single-stage high-pressure turbine, and a single-stage low-pressure turbine. The SV-27 contra-rotating propfan, provided by SPE Aerosila, is driven by a 4 stage turbine via a shaft connected to a planetary reduction gear housing a thrust meter and mechanism to prevent rotor acceleration. The D-27 has been applied to the Antonov AN-70.

D-27 Propfan on the Antonov AN-70
(Image courtesy of Antonov ASTC)

A new engine proposed by Ivchenko-Progress is a 14,000hp turboshaft for the MIL (Mil Moscow Helicopter Plant) Mi-26 heavy helicopter using the core of the D-27 propfan. It would replace the 11,000hp D-136 also developed by the Ukrainian designer and produced at Motor-Sich.

Ivchenko-Progress' AI-450 small sized engine has 465 to 600 hp takeoff power and is designed to be used as auxiliary power plant for various light helicopters weighing between 1.5 to 4 tonnes. Ivchenko-Progress has collaborated closely with Kamov and MIL on the design, because the new engine is intended to replace those in many thousands of obsolete helicopters, notably the Kamov Ka-26 and MIL Mi-2. Bench testing of the AI-450 engine for the Ka-226, modified Mi-2 and Ansat helicopters has been completed. Qualified for 2,000h operational life, it is already flying as an auxiliary power unit on the Antonov AN-148 regional jet.

Ivchenko-Progress' major fixed-wing engine is the D-436 series – a three shaft turbofan - that powers the Antonov AN-148, AN-72/74, Tupolev Tu-334, Beriev Be-200, and Yakovlev Yak-42. Ivchenko-Progress collaborated with SALUT MMPP - one of the largest Russian companies dedicated to production, modernization and maintenance of the aircraft engines – to modify the engine for the Tu-334 and Be-200. A maritime version of D-436 – the D-436 TP - was bench tested in 1995 and had its maiden flight on a Be-200 in 1998. It received EASA European type certification in 2008.

In recent years, the company has been developing a family of AI-222 turbofan engines with a thrust ranging from 2200 to 4500 kgf (afterburning version) for powering modern combat training airplanes. In 2009, the programme was completed and the acceptance report signed for the joint state flight tests of a Russian Yak-130 combat trainer powered by AI-222-25 engines (2500 kgf thrust). The AI-222-25 series production is being executed together with JSC Motor Sich and FSUE SALUT MMPP (Russia). Ivchenko-Progress and FSUE SALUT MMPP are also collaborating together on the development of the SPM-21 high-bypass engines for short-medium haul aircraft such as United Aircraft Corporation's

MS-21, a 180 to 210 seat aircraft based on the Yakovlev Yak-242. The SPM-21 engine is based on technologies developed for the D-27 propfan.

Lastly, the 26,500lb-thrust AI-436T12 modification is offered as an option for the Ilyushin/Yakovlev MS-21 passenger jet and Iluyshin Il-214/MTA transport, and uses the core of the commercial D-436T3/4 mated to an all-new low-pressure turbine and a large geared fan.

National Aerospace University "Kharkiv Aviation Institute" (KhAI)
KhAI has extensive R&T experience in advanced manufacturing for aircraft assembly with Russian organizations such as Sukhoi, Ulianovsk Aviation Production Complex, and Lukhovitsky Engineering Plant. Most recently, KhAI has applied its know-how to the development of the Sukhoi Superjet SSJ-100. In the Sukhoi project, KhAI supported development of the SSJ-100 airframe assembly in order to increase quality and reduce labour and assembly costs.

4.2 China

Antonov's cooperation with China began over 50 years ago when it provided a license to produce its AN-2 single-engine biplanes, which are called Y-5 in China. It has also been working extensively with Chinese aviation companies during the past decade.

Based on the Antonov AN-12, the Shaanxi Y-8 (aka Yunshuji-8) is a medium size medium range transport aircraft produced by Shaanxi Aircraft Company. It has become one of China's most popular military and civilian transport/cargo aircraft, with many variants produced and exported. Although the AN-12 is no longer made in Ukraine, the Chinese Y-8 continues to be upgraded and produced. An estimated 100 Y-8 aircraft had been built by 2007.

In 2001 and 2002, new consulting arrangements between Antonov and Shaanxi resulted in modernized redesigns to the Y-8's wing and fuselage. As a consequence, the redesign allowed the Y-8's fuel capacity to be increased by 50 percent. Later, in 2007, Shaanxi and Antonov signed a memorandum of understanding to establish a joint aviation-engineer centre in Beijing. The centre will carry out scientific research and design work to develop new airplanes and modernise existing ones. Among the centre's top priorities is further development of the Y8-F600 – the latest version of the Y8 transport place. The new plane will have redesigned fuselage, western avionics, PW150B turboprop engines with R-408 propeller systems, and a two-seater glass cockpit.

Antonov also supported the design of the Comac ARJ21, a twin-engined regional airliner, which had its maiden flight in November 2008. It is the first passenger jet to be developed and indigenously produced in China. Antonov was responsible for designing an all-new supercritical wing with a sweepback of 25 degrees and fitted with winglets to improve aerodynamic performance. Also, Antonov assisted with geometrical determination and integral analysis of the construction strength of the aircraft. The ARJ21 programme has also been supported by 19 major European and US aerospace components suppliers, including General Electric (engine production),http://en.wikipedia.org/wiki/Comac_ARJ21_-_cite_note-GE-2 Honeywell (fly-by-wire system) and Rockwell Collins (avionics production).

Meanwhile, Ivchenko-Progress is in the final phase of development of the AI-222-25F (4200 kgf thrust with afterburning power). The first engines have been delivered to Hongdu Aviation Industry Corporation for the L-15 Falcon supersonic training aircraft.

The National Aerospace University (KhAI) has bilateral cooperation agreements with Peking Aerospace University and Nanking Aerospace University covering research and education. KhAI has also been working with the Chinese aviation industry. In 2005, it provided training on modern aircraft control systems development to 25 avionics specialists from China Aviation Industry Corporation (AVIC). In 2008, it carried out work with the Zhuzhou Aviation Power Plant Research Institute.

Based on its work on detonation coatings and its detonation coating gun "Dnepr-5MA", Frantsevich Institute for Problems of Materials Science of the National Academy of Sciences of Ukraine (IPMS-NASU) has established several service centres around the world including China. Finally, Paton Electric Welding Institute has undertaken development with Beijing Aeronautical Manufacturing

Technology Research Institute (BAMTRI), Beijing International Aeronautical Materials Corporation (BIAM) and Xian Aero-Engine Company.

4.3 India

Antonov has been cooperating with India for over 40 years. For example, since the early 1960s, India has purchased over 45 AN-12 transport planes. Originally, the aircraft was expected to have a service life of 25,000 flying hours, 8000 landings and 15 years due to the adverse climatic conditions in the country. However, thanks to close development cooperation between Antonov and the Indian Air Force, the service life of the AN-12 was extended up to 30 years.

More recently, in June 2009, Antonov was awarded an estimated $400 million contract to upgrade the entire fleet of AN-32 transport aircraft of the Indian Air Force. Under the contract, approximately 100 AN-32s will get an upgrade and life extension overhaul over a period of five years, with an initial lot being sent to Ukraine and the rest undergoing work at Kanpur depot of Hindustan Aeronautics Limited. The project will be executed during 2009 - 2013 and will include life extension of the engines and airframe, improved avionics suite, communication equipment and landing aids.

4.4 USA

CRDF

The CRDF (Civilian Research and Development Foundation) is a nonprofit organization authorized by the U.S. Congress and established in 1995 by the National Science Foundation. The organization promotes international scientific and technical collaboration with countries of the former Soviet Union through grants, technical resources, and training. Since 2000, CRDF has funded a number of aeronautics related projects involving Ukrainian organizations:

- Design and Testing of Advanced Plasma Fuel Nozzles for Gas Turbine Engines (2002) - Plasma Tekhnika Consult
- Production advanced materials for aerospace industry by hip of rapidly quenched Ti-Al-Si powders (2000) - Frantsevich Institute for Problems of Materials Science
- Optimization of Photorefractive Cadmium Telluride for Laser Ultrasonic Receivers (2001) - Institute of Physics of NASU
- Aerospace and Civil Technologies (2003) - Yuzhnoye

Of course, Ukrainian aeronautics organizations also work on research projects directly for private US companies. However, they are normally protected by confidentiality agreements so information tends to be scarce. Certainly, Paton Electric Welding Institute of the National Academy of Sciences (PEWI-NASU) has worked very successful over the years with North American companies such as General Electric, Pratt & Whitney, Chromalloy and Phygen in the US and Cametoid in Canada.

Boeing

In 1995, the Sea Launch consortium was established. Led by Boeing (40% shareholding), the consortium includes Yuzhnoye SDO (15%), Energia of Russia (25%) and Aker Solutions of Norway (20%). Sea Launch is a spacecraft launch service that uses a mobile sea platform for equatorial launches of commercial payloads on specialized Zenit 3SL rockets produced by Yuzhnoye. The sea-based launch system means the rockets can be fired from the optimum position on Earth's surface, considerably increasing payload capacity and reducing launch costs compared to land-based systems.

EchoStar IX/Telstar 13 Launch from Sea Launch Platform
(Image courtesy of Sea Launch)

The first launch was made in March 1999 and, by April 2009, Sea Launch had assembled and launched thirty rockets, with two failures and one partial failure. In June 2009, Sea Launch filed for Chapter 11 bankruptcy protection. However, by early 2010, the firm had announced it was finalizing its reorganization plan and was working towards emerging from Chapter 11 bankruptcy status in the second quarter of 2010.

4.5 Europe

European Commission

Formal cooperation between Ukraine and the European Commission in aeronautics can be traced back to at least 1998 when the Partnership and Cooperation Agreement (PCA) came into force[12]. The Agreement provided a framework for political relations. Cooperation in the field of aeronautics was addressed either directly or indirectly in several articles. Under Article 64 "Transport" and Article 65 "Space", several areas of cooperation were identified including modernisation and development of airport and air navigation infrastructure and promotion of joint research and technology programmes.

In July 2002, an "Agreement on Cooperation in Science and Technology" between the European Community and Ukraine was signed. It established a base for further enlargement and enhancement of collaboration between scientists. This agreement stipulated that cooperation can be implemented in research areas including fundamental studies, technology development and demonstration activities. Furthermore, the European Research and FP6 Conference (Brussels, November 2002) opened a new possibility for Ukrainian scientists within European research. FP6, and now FP7, are open to the participation of Ukrainian organisations and offer Ukrainian researchers the opportunity to integrate into the European Research Area (ERA).

In August 2003, the National Information Centre for Ukraine – EU S&T Cooperation (NIP Ukraine) was established to promote the FP6 programme to the Ukrainian S&T sector and facilitate the participation of Ukrainian researchers in EU scientific activities, including aeronautics. It is a state agency that reports to the Ministry of Education and Science of Ukraine.

Since 2005, EU-Ukraine cooperation activities have been largely defined by the bilateral EU-Ukraine European Neighbourhood Policy (ENP) Action Plan[13], which is based on the PCA. The Action Plan sets out an agenda of political and economic reforms with short and medium-term priorities. It has three articles – 14, 49 and 65 – that touch upon aviation, namely:

Article 14: Strengthen cooperation on regional and international issues, conflict prevention and crisis management

- *…*
- *Continue consultations on the possible EU use of Ukraine's long haul air transport capacities*

Article 49: Implement selected measures and reforms in the aviation sector

- *Determine an effective model of negotiations on bilateral aviation agreements concluded with EU Member States in order to include the Community designation clause, taking into account the horizontal mandate given to the Commission*
- *Obtain full member status in the European Joint Aviation Authorities (JAA), explore possibilities for arrangements in the field of aviation safety with a view to the stated Ukrainian objective to become a member of EASA*
- *Cooperate on safety and security issues*

Article 65: Promote Ukraine's integration in high-level scientific exchanges

- *…*

[12] Partnership and Cooperation Agreement between the European Communities and their Member States, and Ukraine, http://trade.ec.europa.eu/doclib/docs/2003/october/tradoc_111612.pdf
[13] EU/Ukraine European Neighbourhood Action Plan, DG External Relations, http://ec.europa.eu/world/enp/pdf/action_plans/ukraine_enp_ap_final_en.pdf

- *Make further progress in cooperation in the space sector and continue support for the joint space working group under the PCA*

Under the ENP Action Plan, the EU funds technical assistance activities to support legislative approximation, regulatory convergence and institution-building via several mechanisms: i) technical assistance and information exchange (TAIEX); ii) long-term twinning arrangements with EU Member States' administrations (national, regional or local); and iii) participation in relevant Community programmes and agencies. Recently, Ukraine's State Aviation Administration was involved in the EU funded twinning project "Harmonisation with EU Norms of the Legislation and Standards of Ukraine in the Field of Civil Aviation" (UA/06/PCA/TP/01) that ran from 2007 – 2009.

The Tempus programme is another EU scheme that has provided a potential route towards aeronautics cooperation since 1990[14]. Tempus projects support the modernisation of higher education and create an area of cooperation in countries surrounding the EU, including Ukraine. A recent good current example is "*MSc and PhD Studies in Aerospace Critical Computing (2006-2009)*" involving the National Aerospace University (KhAI), Khmelnitskiy National University, "Polysvit" Design Bureau, Ministry of Education and Science and several European academic partners. Meanwhile, the EU's FP7 Marie Curie Actions help to fund all kinds of training and mobility opportunities for researchers – including computer science and technology - throughout their careers.

Under the EU's FP6 AEROSPACE programme, Ukrainian organisations participated in the following aeronautics related research projects:

FP6 AEROSPACE Project	Ukrainian Organisation
Advanced Low Cost Aircraft Structures (ALCAS)	National Aerospace University (KhAI)
Advanced sensors and novel concepts for intelligent and reliable processing in bonded repairs (SENARIO)	National Aerospace University (KhAI)
Cost Effective Small Aircraft (CESAR)	SE Ivchenko-Progress
Unsteady effects in shock wave induced separation (UFAST)	Podgorny Institute of Mechanical Engineering Problems of NASU
Multifunctional Structures (MULFUN)	Yuzhnoye
Aircraft external noise research Network and co-ordination (X3-NOISE)	National Aviation University

Currently, the Ministry of Education and Science is in the process of establishing national contact points (NCP) for various FP7 themes – including Aeronautics – within the scope of the EU funded Technical Assistance project "Joint Support Office for Enhancing Ukraine's Integration in the European Research Area" (EuropeAid/127891/C/SER/UA).

INTAS

Although now discontinued, the International Association for the promotion of cooperation with scientists from the New Independent States of the former Soviet Union (INTAS) was also a very valuable body for funding aeronautics related research projects involving Ukrainian and European partners[15]. It was established in 1993 by the European Community and like-minded countries, in order to promote scientific research activities in the New Independent States (aka former Soviet states) and scientific cooperation between scientists in these countries and the international scientific community.

Between 1993 and 2006, INTAS funded numerous aeronautics related research projects involving Ukrainian partners. In fact, in 2004, INTAS and AIRBUS launched a joint call which funded nine projects with four of them involving Ukrainian partners:

- Simulation of welded aircraft structures (Paton Electric Welding Institute)
- Real-Time Multiscale Composite System for Structural Health Monitoring of Fatigue Damage (G.V. Kurdyumov Institute for Metal Physics)
- Holistic Strategies for Chromate-Free Surface Treatment of Aluminium (Karpenko Physico-Mechanical Institute)
- Vortex Dynamics (Taras Shevchenko National University of Kiev)

[14] Tempus Scheme, http://ec.europa.eu/education/external-relation-programmes/doc70_en.htm
[15] INTAS, http://www.intas.be

STCU

Also worth mentioning is the STCU (Science and Technology Center in Ukraine)[16], an intergovernmental organization dedicated to the prevention of the proliferation of expertise related to weapons of mass destruction. Since 1993, private companies and government agencies from the European Union, United States, and Canada have used the STCU to manage over 1350 R&T projects worth over $188 million. This includes numerous aeronautics research projects such as "Heterogeneous composite-to-composite and composite-to-metal heavy loaded joints (P296)" involving the National Aerospace University (KhAI) and EOARD and "Modern methods of welding and production of the constructions from aluminium and lithium alloys" involving Paton Electric Welding Institute and Boeing. Through the STCU Partner Program, private companies, academic and non-government organizations, and government agencies may contract research and technology work to Ukrainian as well as Azeri, Georgian, Moldovan and Uzbek scientists and institutes. In Sept 2009, the STCU, Canadian Embassy in Kyiv and National Space Agency of Ukraine held a joint business summit dedicated to aerospace and aviation.

EADS

In May 2003, Antonov (AN-70) submitted a proposal – as did Airbus, Boeing (C-17) and Lockheed (C-130 J) – to develop and produce the A400M aircraft in the framework of OCCAR (Joint Armament Cooperation Organisation). However, Airbus Military was selected by the six countries responsible for the contract (Belgium, France, Germany, Spain, Turkey and the United Kingdom).

During the June 2005 Le Bourget Air Show, a strategic cooperation agreement was signed between the Ukrainian Government and EADS on five possible areas of cooperation: the aeronautical sector, space, defence, border surveillance and secure communications[17]. The agreement was signed by the Ukrainian Prime Minister and EADS co-Chairman at the time. However, the dismissal of the Ukrainian Prime Minister in September 2005 and subsequent political instability in Ukraine were not conducive to developing cooperation and it is only in the areas of border surveillance and secure communications that significant progress has been made.

[16] STCU, http://www.stcu.int

[17] Assembly of Western European Union – The Interparliamentary European Security and Defence Assembly, 30 December 2006, http://www.assembly-weu.org/en/documents/sessions_ordinaires/rpt/2006/1947.pdf?PHPSESSID=f3137d60

5. Opportunities & Recommendations to Support EU-Ukraine Cooperation

5.1 EU-Ukraine Cooperation on an Industrial Level

A large potential exists for collaboration between the Ukrainian aeronautics industry and its European counterpart, however it is currently underexploited. For both partners, increased research cooperation would be useful for two reasons:

- Participation in European research projects, or in bilateral developments with leading European companies, would help to gain first hand information on advanced developments;
- Could act as a first step to business-to-business industrial co-operation.

In order to increase interaction between Ukrainian and EU industry, there are a number of European organisations which Ukrainian companies should consider contacting.

ASD-IMG4 Industrial Association

The Aerospace and Defence Industries Association of Europe's (ASD) Industrial Management Groups (IMGs) represent the interests of larger aerospace companies in Europe. The IMGs are divided into four distinct domains of the aeronautical industry (with some overlaps). The four groups (often referred to as IMG4 or IMG[4]) are *Euromart IMG* (airframe), *Engine IMG*, *Equipment IMG*, and *ATM IMG*. The main role of the IMGs is to coordinate industry's position with regard to the EU's civil aeronautics framework programmes (e.g. FP7) and ACARE (Advisory Council for Aeronautical Research in Europe – European Technology Platform)[18]. The IMGs maintain tight links with aeronautics research establishments, support workshops with universities and those to promote international cooperation.

The following table shows the structure and members of the IMGs[19]:

ATM - IMG	**Engine IMG**	**Equipment IMG**	**Euromart IMG** *(Airframe)*
Airbus	AVIO	Auxitrol	Aernnova Aerospace
Alenia Aeronautica	ITP	BAE systems avionics	Aero Vodochody
BAE Systems	MTU Aero Engines	Barco	AgustaWestland
Dassault Aviation	PBS Velka Biteš	Cesa	Airbus SAS
EADS	Rolls-Royce	Diehl Aerospacve	Alenia Aeronautica
Eurocopter	RRD	Drager AG	Alenia Aermacchi
GE Aviation Systems	SNECMA	Fokker-Elmo	Bombardier Aerospace
Hellenic Aerospace Ind.	Techspace Aero	GE Aviation Systems	Dassault-Aviation
Indra	Turbomeca	GIFAS	EADS IW.
Raytheon Ltd	Volvo Aero	Goodrich	EADS MAS
Selex Comms	WSK Rzeszow	Hellenic Aerospace Ind.	Eurocopter
Selex Galileo		INASCO	GE Aviation Systems
Selex Sistemi Integratil		ISQ	GKN Aerospace Services
Thales Aerospace		Jihostroj	HAI
Thales Air Systems		Liebherr-Aerospace	Latecoere
Thales Alenia Space		Lindenberg GmbH	LET Aircraft Industry
		Megitt	Patria Oyj
		Messier-Bugatti	Piaggio Aero Industry
		Messier-Dowty Ltd	PZL Mielec
		Nord-micro	PZL-Swidnik
		Qinetiq	RUAG
		Saab AB	S.A.B.C.A
		Sagem	Saab AB
		Selex Comms	SONACA
		Selex Galileo	Stork Fokker
		Skysoft	AeroPortal, IAI (observers)
		Thales Aerospace	
		Thales avionics electronic systems	
		ZF Luftfahrttechnik GmbH	

[18] ACARE is a joint initiative of DG Transport, DG Energy and European aeronautics industry. It has about 40 members. Its main focus is the establishment of a strategic research agenda (SRA) to influence European stakeholders in the planning of research programmes, particularly national and EU programmes (www.acare4europe.com)

[19] IMG4 list of members as of November 2009

The IMGs are open to all European aeronautics industrial players on a voluntary basis. The different groups hold several meetings each year, usually in Brussels. The key activities of the groups include exchange of information on a voluntary basis, building an individual IMG's position towards the EC and IMG4, and organising workshops or giving presentations during workshops.

For Ukrainian industrial organisations active in the four domains, it is highly recommended to get in touch with the IMGs through the AeroSpace and Defence Industries Association of Europe (ASD)[20]. For example, thanks to contact with IMG4, the Ukrainian company JSC Element was able to join a consortium for an FP7 proposal led by Snecma in 2010.

ACARE INCO Group

ACARE[21] is a European technology platform initiative to improve the competitive situation of the EU in the field of aeronautics. The platform is a joint initiative (Public-Private Partnership) between the Directorate-General for Transport and Energy of the European Commission and private industry. ACARE has produced twice a Strategic Research Agenda (SRA), which determines the priorities for European aeronautical R&T.

Since the FP7 AAT work programme is closely tied to the priorities listed in the current SRA, it is important for EU member states and other countries - including Ukraine - to be aware and to try to harmonise their research activities with those defined in the SRA.

The ACARE INCO Group will be responsible for mapping aeronautics activities outside of the EU and providing advice on the strategic research directions of the main international aeronautics states. The ACARE INCO Group is also managed by ASD.

AeroPortal

AeroPortal[22] is a consortium of experts in European aeronautics technology funding who offer their services free of charge to small and medium sized enterprises (SMEs).

AeroPortal is funded by the European Commission, co-ordinated by the AeroSpace and Defence Industries Association of Europe (ASD) and co-managed by EURO INTER, the former SCRATCH co-ordinator. Among other services, AeroPortal offers support to join proposals under preparation, support in turning an idea into a project proposal and support in proposal writing and partner search. The main communication tools used by AEROPORTAL are awareness campaigns, regular mailing and business events.

The AeroPortal Servicing Team is funded to help SMEs in setting up collaborative R&T aeronautical proposals and this activity is commonly named "Servicing Activity". Support is given to the SME coordinator from the very first definition of the research idea up to the final submission of a proposal answering a call launched by the European Commission. This servicing support is free of charge for the SME whatever the evaluation results of the proposal serviced are.

Participation in European research programmes

Ukrainian organisations have several possibilities to get funding from the European Commission (EC) to conduct collaborative aeronautics research with European partners. The Aeronautics Unit in DG Research of the EC is the main focal point for information on European research programmes. The EC's Seventh Framework Programme (FP7) runs from 2007-2013 and offers a wide range of opportunities for industrial organisations to combine their research efforts with SMEs (small and medium-sized enterprises) and academic or research establishments. The calls are regularly published on the EC's Cordis website[23] and presented during EC organised info-days, which are typically held in Brussels. For example, thanks to participation at the FP7 AAT Call 3 info-day in September 2009, the Frantsevich Institute for Problems of Materials Science (IPMS-NASU) identified potential consortium partners for FP7 proposals.

[20] AeroSpace and Defence Industries Association of Europe (ASD), www.asd-europe.org
[21] ACARE, www.acare4europe.com
[22] AeroPortal, www.aeroportal.eu
[23] Cordis website, http://cordis.europa.eu

Also, two other EU initiatives present opportunities for Ukrainian organisations to learn about European collaborative research and European aeronautics research priorities. The Clean Sky JTI[24] is a private-public initiative involving the EC and European industry which aims to develop breakthrough technologies to reduce environmental impact. Research is funded in six domains: green regional aircraft, SMART fixed wing aircraft, green rotorcraft, sustainable and green engines, systems for green operation, and eco-design. Meanwhile, the SESAR JU[25] aims to develop a modernised air traffic management system for Europe to ensure the safety and fluidity of air transport over the next thirty years, make flying more environmentally friendly and reduce the costs of air traffic management.

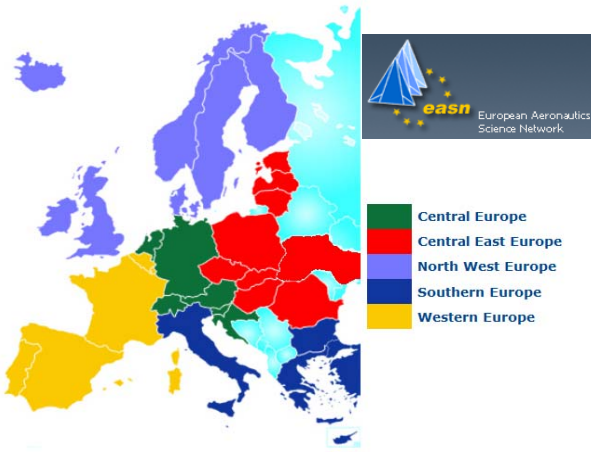
5.2 EU-Ukraine Cooperation on Academic and Public Research Levels

Ukrainian researchers have a strong reputation for their creativity, upstream ideas and conceptual design abilities. Thus, Ukrainian universities and research establishments would not only benefit from, but would be of significant value to research projects in technological readiness levels (TRL) 1-3 i.e. from basic technology research through to technology development. Participation of Ukrainian entities, either in EU funded research projects or bilateral co-operations, would lead to win-win situations, as both sides have significant knowledge, expertise and human resources to share.

In order to increase interactions between Ukrainian and EU universities and research establishments, there are a number of networks which Ukrainian research organisations and researchers should consider contacting.

European Aeronautics Science Network (EASN)

EASN[26] is the academia representative in the Advisory Council for Aeronautics Research in Europe *(*ACARE*)* and the European Commission. Its members include academics, university labs and universities from several European countries. EASN currently connect to several thousand academia and research staff throughout Europe. EASN has mapped the European universities according to their geographical distribution and the areas of expertise. Importantly, EASN organizes informative workshops and campaigns to prepare and submit projects to FP7 calls. For example, thanks to its membership of EASN, the National Aerospace University (KhAI) was able to identify consortium partners for an FP7 Space proposal in 2009.



EASN Regional structure
(Source: www.easn.net)

[24] Clean Sky JTI, www.cleansky.eu
[25] SESAR JU, www.sesarju.eu
[26] European Aeronautics Science Network (EASN), www.easn.net

PEGASUS Network

PEGASUS[27] (Partnership of a European group of aeronautics and space universities) provides a European portal for higher education services for aerospace. The twenty founding institutions of PEGASUS had previously collaborated for some years in an ad-hoc manner - largely supported by EU funding - and decided to work more closely together in a manner that better satisfied the needs of their students and aerospace companies across Europe.

One of the first actions taken by the PEGASUS partners was to define diplôme/postgraduate level requirements enabling the granting of a European certificate in the education and training of aerospace engineers, and an award in recognition of an individual student's multi-national experience. All PEGASUS partners have agreed on a specific curriculum description format, enabling an immediate understanding of the level of education provided by the partners. Admission to PEGASUS is based on a set of criteria, focusing on two fundamental keywords: quality and international co-operation, all related to the higher education offered in aeronautical / aerospace engineering at European level.

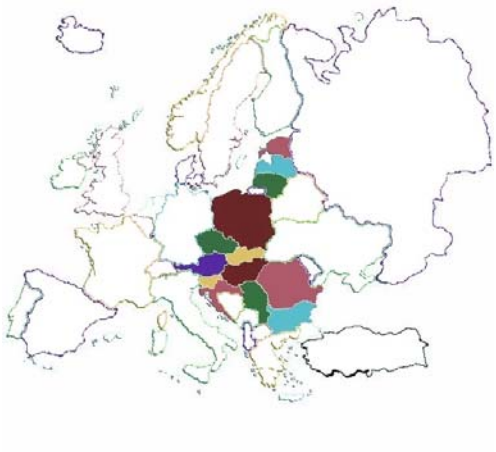
Today, more than 2000 aeronautical engineers graduate from the member institutions of PEGASUS each year. Furthermore, PEGASUS' close relations with industry have enabled the establishment a set of Airbus international industrial placements dedicated to students of PEGASUS institutions.

Distribution of current PEGASUS network members
(Source: www.pegasus-europe.org)

CEARES Network

CEARES[28] is a closely coordinated network involving aeronautics research organisations from central European states. Its aim is to facilitate the sharing of know-how and latest research results as well as easier contact with the European aeronautical industry. The network was established during the FP7 CEARES project. Network members are informed about the capabilities, research activities and research needs of other members through workshops and through the CEARES website. Thanks to contact with Czech aerospace organisations during a CEARES workshop in 2009, Ivchenko-Progress and the National Aerospace University (KhAI) were subsequently involved in a couple of aeronautics related FP7 proposals.

[27] PEGASUS Network, www.pegasus-europe.org
[28] CEARES, www.ceares.eu



CEARES network countries
(Source: www.ceares.eu)

EREA Network

EREA[29] is the Association of the European Research Establishments in Aeronautics. It was established in May 1999 with the main aims:

- to promote and represent the joint interests of its members;
- to intensify the co-operation between its members, aimed at further integration of their activities in the field of civil, military and space-related aeronautics;
- to improve and intensify the co-operation of EREA and its members with third parties in the field of aeronautics;
- to facilitate the ultimate goal of the Members of an integrated management of joint activities, thereby contributing to Europe's role as a global player in aeronautics.

The association's full members are CIRA, DLR, ILOT, FOI, INTA, NLR, ONERA and VZLU and associate members are ARC, INCAS, VKI and VTT. The association provides a forum for liaising with the European Commission, European industry (e.g. ASD, IMG4 and AeroPortal) and other interested research organisations on aeronautical and security research issues.

ACARE Human Recourses Group (AHRG)

AHRG[30] acts as an interconnection between the aeronautics human resources supply (universities) and the demand side (industry, research establishments and SMEs). It aims to ensure that supply meets demand for aeronautics human resources. AHRG's activities include the organisation of workshops on education and training of aeronautics engineers and researchers for Europe in collaboration with the European Commission, EASN, PEGASUS and European Aeronautics ERA-Net (AirTN).

[29] EREA, www.erea.org
[30] ACARE, www.acare4europe.com

5.3 SWOT Analysis of the Ukrainian Aeronautics R&T Sector

The following table summaries the main strengths (S) and weaknesses (W) of the Ukrainian aeronautics R&T sector and the expected opportunities (O) and threats (T) from the external environment over the next 5+ years.

SWOT Analysis of Ukrainian Aeronautics Research and Technology Sector

Strengths (S) and Weaknesses (W) of Ukrainian Aeronautics Sector	Opportunities (O) and Threats (T) from the External Environment
Strengths S1. Large number of well qualified and skilled aerospace scientists and engineers S2. Full cycle of aerospace R&T, production and maintenance S3. Long and successful experience in aerospace R&T and production S4. Specialised know-how linked to unique Ukrainian aerospace products (e.g. super-cargo planes, counter rotating open rotors, rocket launchers and small satellites) S5. Advanced facilities for gas turbine engine development (Ivchenko-Progress) S6. Historical global presence on different markets S7. Close and long term relationships with aerospace organisations in EECA countries	**Opportunities** O1. Inclusion of Ukraine in EU and international aerospace processes O2. Participation in European aerospace networks aimed at higher education institutions, public research organisations and industry (e.g. EASN and IMG4) O3. Growth of the global aviation transportation market O4. Withdrawal and/or upgrade of large number of obsolete Soviet mid-range airplanes O5. State-funded aviation industry support programme development O6. Increasing number of leasing schemes for aircraft purchase O7. Potential offset obligations if Ukraine purchases aerospace equipment from European suppliers
Weaknesses W1. Outdated aerospace R&T infrastructure at higher education institutes and institutes of the National Academy of Sciences W2. Ageing aerospace research staff at higher education institutes and institutes of the National Academy of Sciences W3. Lack of government funds for aeronautics R&T W4. Insufficient experience of international R&T cooperation W5. Lack of knowledge and experience of EC's R&T framework programmes (e.g. low participation in FP6 AEROSPACE) W6. Insufficient marketing know-how	**Threats** T1. Continued "brain-drain" of talented young aerospace scientists and engineers T2. Obsolescence of aerospace research infrastructure at higher education institutes and institutes of the National Academy of Sciences T3. Further exclusion from traditional markets due to increasing international competition T4. Continued political instability in Ukraine T5. Delays in implementing EU-Ukraine cooperation policy measures T6. Global economic crisis

5.4 Recommendations to strengthen EU-Ukraine Aeronautics R&T Cooperation

The following recommendations have been formulated by considering current barriers and opportunities for EU-Ukraine aeronautics R&T cooperation.

Description of Barrier or Opportunity	Recommendations
1. Lack of awareness in Europe of Ukrainian aeronautics R&T potential	**a) Disseminate broadly the FP7 Aero-Ukraine project's *Ukrainian Aeronautics Research and Technology Groups Brochure*** Prepare short news release announcing brochure publication and link to an electronic copy of the brochure on the FP7 Aero-Ukraine website. Submit news release to: - FP7 Aero-Ukraine email contacts list - European Aeronautics Science Network (EASN) - FP7 Aeronautics NCP in EU Member States (and invite them to distribute amongst their members) - ACARE - DG Research Air Transport website and Cordis Wire - Alpha Galileo (Internet press centre for European science and technology) Responsible Organisation(s): FP7 Aero-Ukraine Consortium Timing: By June 2010 **b) Support to Ukrainian aeronautics research experts to meet private and public research organisations in Europe** - FP7 Aero-Ukraine project to facilitate visits of Ukrainian experts to Europe (e.g. FP7 AAT info-day events and Antonov to visit Airbus) Responsible Organisation(s): FP7 Aero-Ukraine Consortium Timing: Up to March 2011 - Investigate possible support from the EC funded project "*Joint Support Office for Enhancing Ukraine's Integration in the European Research Area*" (EuropeAid/127891/C/SER/UA). This project is responsible for developing EU-Ukraine networks in support of R&T and innovation and will organise delegation tours. Responsible Organisation(s): FP7 Aero-Ukraine Consortium and Ecorys (Contractor for "Joint Support Office …" project) Timing: Up to March 2011 **c) Increase the number of Ukrainian organisations that are members of European aeronautics networks** - Write directly to Ukrainian universities and public research organisations inviting them to join the European Aeronautics Science Network (EASN) - Write directly to Ukrainian companies inviting them to join relevant Industrial Management Groups (IMGs) - Write directly to Ukrainian aeronautics organisations (SMEs, universities and public research organisations) inviting them to register with AeroPortal Responsible Organisation(s): University of Patras (EASN), Ivchenko-Progress and Antonov (IMGs), KhAI and IPMS-NASU (AeroPortal) Timing: Up to March 2011
2. Lack of awareness in Ukraine about FP7 Aeronautics and lack of skills to participate	**a) Support to the establishment of a FP7 Aeronautics NCP (National Contact Point) in Ukraine** - FP7 Aero-Ukraine project to provide budget and training support to future NCP Responsible Organisation(s): FP7 Aero-Ukraine Consortium

	Timing: Up to March 2011 **b) Organise FP7 Aeronautics awareness and training events** - FP7 Aero-Ukraine project to hold events in Zaporozhye (Oct 2010) and a final dissemination event in Kyiv (Mar 2011) - Organise events in conjunction with EC funded project "*Joint Support Office for Enhancing Ukraine's Integration in the European Research Area*" (EuropeAid/127891/C/SER/UA) Responsible Organisation(s): FP7 Aero-Ukraine Consortium and Ecorys (Contractor for "Joint Support Office …" project) Timing: Up to March 2011 **c) Promote the FP7 People Programme (Marie Curie Actions)** - Promote the FP7 People Programme - e.g. Marie Curie Action – International Incoming Fellowships – during FP7 Aero-Ukraine events - Future FP7 Aeronautics NCP for Ukraine to promote FP7 People Programme NB: These are EU programmes that fund researchers to come to European host research organisations to begin research projects and return to their home organisations to complete them. Responsible Organisation(s): Future FP7 Aeronautics NCP for Ukraine and FP7 Aero-Ukraine Consortium Timing: Up to March 2011 **d) Support up to the end of FP7 programme (2013)** - Evaluate the need for a further support action beyond FP7 Aero-Ukraine project Responsible Organisation(s): DG Research, European Commission Timing: By 2011
3. Opportunity for closer EU-Ukraine Aeronautics R&T Cooperation	**a) Identify areas of common interest between the National Aeronautics R&T Strategy of Ukraine and the ACARE Strategic Research Agenda (SRA)** - Compare the National Aeronautics R&T Strategy of Ukraine with ACARE SRA - Identify areas of common interest - Hold discussions with ACARE INCO Group on possible cooperation Responsible Organisation(s): JSC UkrRIAT, Ministry of Industrial Policy of Ukraine, Ministry of Education and Science of Ukraine and ACARE INCO Group Timing: By 2011 **b) Investigate the potential for a Joint EU-Ukraine Aeronautics R&T Call** - Speak to FP7 INCONET EECA (www.inco-eeca.net) and FP7 BILAT-UKR (www.bilat-ukr.eu) projects, which are involved in developing formal EU-Ukraine Science and Technology Agreements, including joint calls such as special international cooperation actions (SICA). Responsible Organisation(s): Ministry of Education and Science and Ministry of Industrial Policy of Ukraine. FP7 Aero-Ukraine, FP7 INCONET EECA and FP7 BILAT-UKR consortia Timing: Up to March 2011 **c) Increase the number of Ukrainian organisations that are members of European aeronautics networks** - Write directly to Ukrainian universities and public research

	organisations inviting them to join the European Aeronautics Science Network (EASN) - Write directly to Ukrainian companies inviting them to join relevant Industrial Management Groups (IMGs) - Write directly to Ukrainian aeronautics organisations (SMEs, universities and public research organisations) inviting them to register with AeroPortal Responsible Organisation(s): University of Patras (EASN), Ivchenko-Progress and Antonov (IMGs), KhAI and IPMS-NASU (AeroPortal) Timing: Up to March 2011 **d) Strengthen EU-Ukraine aeronautics technology transfer** - Investigate possible support from the EC funded project "*Support to knowledge-based and innovative enterprises and technology transfer to business in Ukraine*" (EuropeAid/127644/C/SER/UA). This project is responsible for developing technoparks and innovative clusters to support innovation and technology transfer (NB: The project does not support the mobility of researchers). Responsible Organisation(s): Ministry of Education and Science and Ministry of Industrial Policy of Ukraine, FP7 Aero-Ukraine Consortium and European Profiles SA (Contractor for "Support to knowledge-based …" project) Timing: Up to March 2011

Annexes

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AeroSpace and Defence Industries Association of Europe (ASD), www.asd-europe.org

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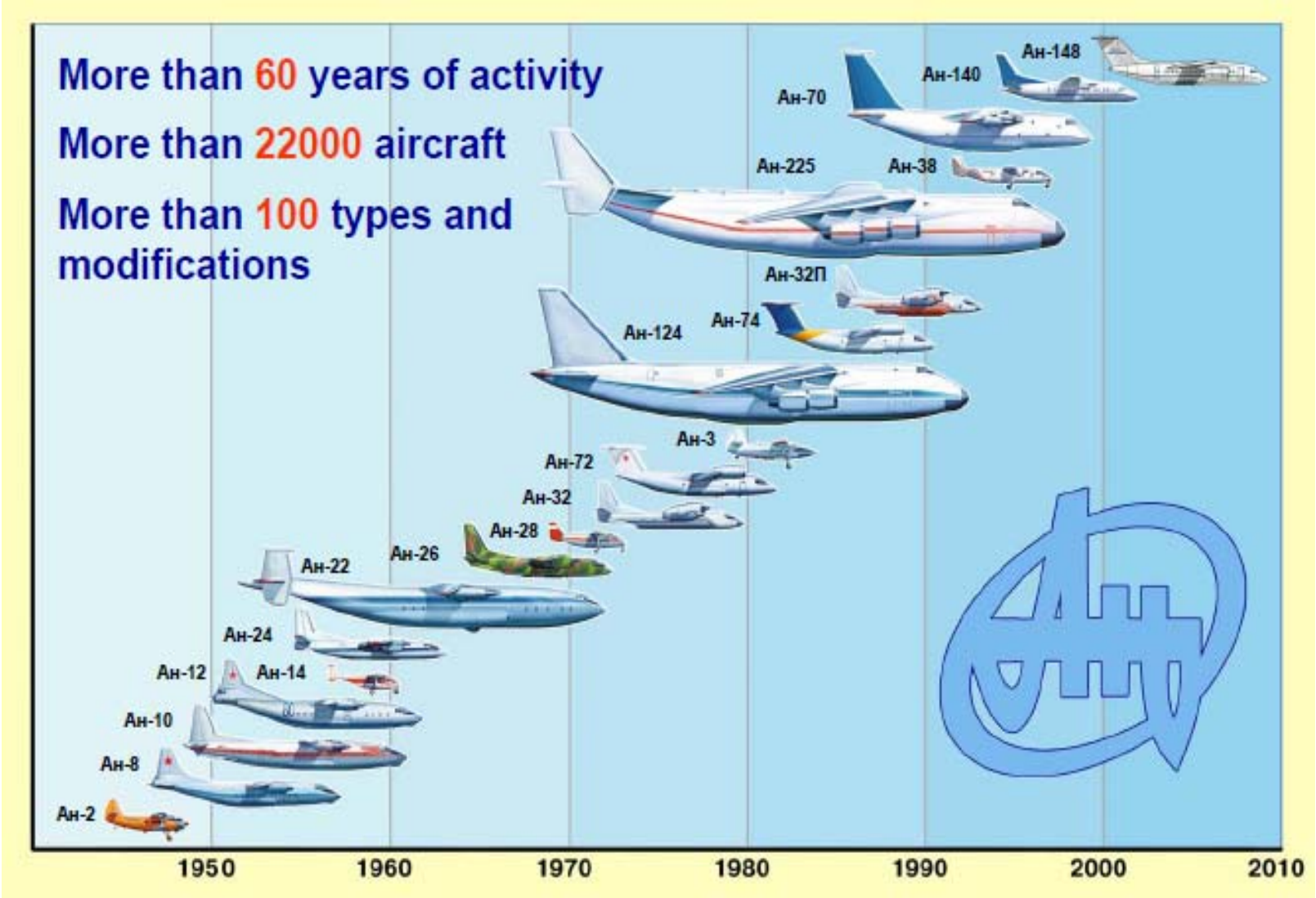
Annex 2. Ukrainian Organisations involved with Aeronautics

Type of organisation	Name of organisation (in English)	Website
Government and legislative bodies		
Legislative bodies		
	Supreme Council (Verkhovna Rada of Ukraine)	www.rada.gov.ua
	Committee (of Verkhovna Rada of Ukraine) on Science and Education	http://kno.rada.gov.ua
Government bodies		
	Cabinet of Ministries of Ukraine	www.kmu.gov.ua
	Ministry of Transport and Communications	www.mintrans.gov.ua
	National Space Agency of Ukraine (NSAU)	www.nkau.gov.ua
	State Aviation Administration of the Ministry of Transport and Communication	http://www.ukraviatrans.gov.ua/eng/index.htm
	Ukrainian State Designing Technological and Scientific Research Institute of Civil Aviation "Ukraeroproekt" reporting to the Ministry of Transport and Communication	http://www.ukraviatrans.gov.ua/ukraviaproekt_e.htm
	Ministry of Education and Science	www.mon.gov.ua
	Ministry of Industrial Policy	http://www.industry.gov.ua/
Industrial organisations (State and private)		
	Antonov ASTC	www.antonov.com
	JSC Element	http://element.od.ua
	JSC Hartron	www.hartron.com.ua
	JSC Motor Sich	www.motorsich.com
	Kharkiv State Aircraft Manufacturing Company (KSAMC)	www.ksamc.com
	Kotris Ltd	www.kotris.kiev.ua
	Scientific and Technical Enterprise “TDM”	http://geocities.com/tdm.sensor
	SE Ivchenko-Progress	www.ivchenko-progress.com
	SE Kyiv Aviation Plant “Aviant”	www.aviant.ua
	SE Radioizmeritel	-
	Southern National Design & Research Institute of Aerospace Industries (“YUZHGIPRONIIAVIAPROM”)	-
	Ukrainian Research Institute of Aviation Technology (JSC UkrRIAT)	www.ukrniat.com

	Ukrainian Research Institute of Manufacturing Engineer (JSC UkrNITM)	-
	Yuzhnoye SDO	www.yuzhnoye.com
Knowledge institutes (R&T and education bodies)		
National Academy of Sciences		
	Frantsevich Institute for Problems of Materials Science (IPMS-NASU)	www.ipms.kiev.ua
	G.V. Kurdyumov Institute for Metals Physics (IMP-NASU)	www.imp.kiev.ua
	V. Bakul Institute for Superhard Materials (ISM-NASU)	www.ism.kiev.ua
	Physical-Technological Institute Metals and Alloys (PTIMA-NASU)	www.ptima.kiev.ua
	Chuiko Institute of Surface Chemistry (ISC-NASU)	www.isc.gov.ua
	A.N. Podgorny Institute for Mechanical Engineering Problems (IPMASH-NASU)	www.ipmach.kharkov.ua
	G. S. Pisarenko Institute for Problems of Strength (IPP-NASU)	www.ipp.kiev.ua
	Institute of Engineering Thermophysics (ITTF-NASU)	www.ittf.kiev.ua
	E.O. Paton Electric Welding Institute (PEWI-NASU)	www.paton.kiev.ua
	International Center for Electron Beam Technologies (ICEBT)	www.paton-icebt.kiev.ua
	A. Usikov Institute of Radio-Physics and Electronics (IRE-NASU)	www.ire.kharkov.ua
Universities		
	Dnepropetrovsk National University (DNU)	www.dsu.dp.ua
	Lviv Polytechnic National University (LP)	http://lp.edu.ua
	National Aerospace University “Kharkov Aviation Institute” (KhAI)	www.khai.edu
	National Aviation University (NAU)	www.nau.edu.ua
	National Technical University of Ukraine "Kyiv Polytechnic Institute" (NTUU KPI)	http://inter.kpi.ua
	Odessa National Polytechnic University (OPU)	www.opu.ua
	Ternopil Ivan Pul’uj State Technical University (TSTU)	www.tu.edu.te.ua
	Zaporozhye National Technical	www.zntu.edu.ua

	University (ZNTU)	
Research Support Intermediaries		
	FP7 National Information Point (NIP) of Ukraine	www.fp7-ncp.Kyiv.ua
	Ukrainian Research Institute of Aviation Technology (JSC UkrRIAT)	www.ukrniat.com

Annex 3. Aircraft produced by Antonov ASTC
(Image courtesy of Antonov ASTC)



Annex 4. Aero-engines produced by SE Ivchenko-Progress
(Image courtesy of SE Ivchenko-Progress)