EU-Ukraine : New Possibilities for Aeronautic FP7 Collaboration

National Aerospace University "KhAI"

Kharkiv, UKRAINE

Igor Rybalchenko

Deputy Vice-Rector

Ukraine is European country

Ukraine is aerospace country

AN-225 is the largest cargo plane in the world

SEA-LAUNCH equipped with Ukrainian rocket

Collaboration in aeronautics can be a WIN-WIN partnership

Current FP7 Project:

AERO-UKRAINE (CSA)

www.aero-ukraine.eu

Stimulating Ukraine – EU Aeronautics Research Co-operation

AERO-UKRAINE

Consortium Partners:

- Slot Consulting Ltd (HU), Coordinator
- Intelligentsia (UK)
- UPatras-LTSM (GR)

- ANTONOV (UA)
- PROGRESS (UA)
- IPMS-NASU (UA)
- KhAI (UA)

- Project duration: 2 years

Project Objectives

- Assessing and publicising the aeronautics collaboration potential between the EU and Ukraine
- Raising awareness and understanding of EU aeronautics collaborative research
- Supporting Ukraine participation in FP7 aeronautics research

We plan to attract from Ukraine:

- More than 50 key players
- Leading engineering Universities
- Research institutes Academy of Science
- Aircraft designers and manufacturers
- Manufacturing process researchers
- Private research groups

Expected Impact (levels):

- Policy - helping to address several EU policy objectives relating to Ukraine
- Socio-economic - facilitating research co-operation between aeronautics actors from the EU and Ukraine
- Technology – technological diversity
- National - bridge to EU research area
- European - influence future EU-Ukraine S&T policy cooperation

AERO-UKRAINE
Ukrainian Consortium
Members Presentation

ANTONOV SE

More than 60 years of activity
More than 22000 aircraft
More than 100 types and modifications
6043 aircraft into 76 countries

ANTONOV ASTC

- Design bureau

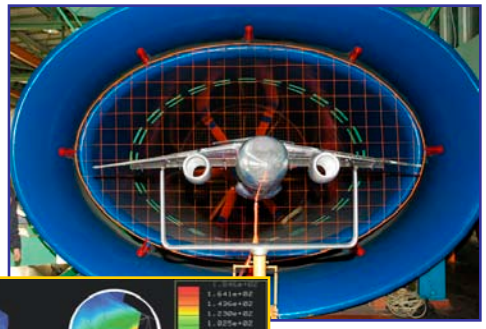
- Flight-test facility

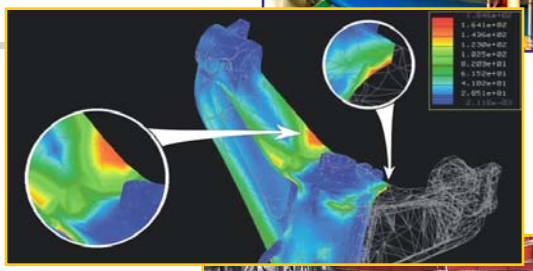
- Production plant

- Antonov Airlines

RESEARCH AREAS:

- **AERODYNAMICS**
- **STRENGTH**
- **MATERIALS SCIENCE**
- **DESIGN**
- **POWERPLANT**
- **AIRCRAFT SYSTEMS**
  (flight control, energy systems etc.)
- **AVIONICS**
- **PRODUCTION processes**
- **IT**





ANTONOV aircrafts


AN 74


AN 140


AN 70


AN 148


AN 158

mignews.com.ua->novostey.com

SE Ivchenko-Progress

Zaporozhye Machine-Building Design Bureau

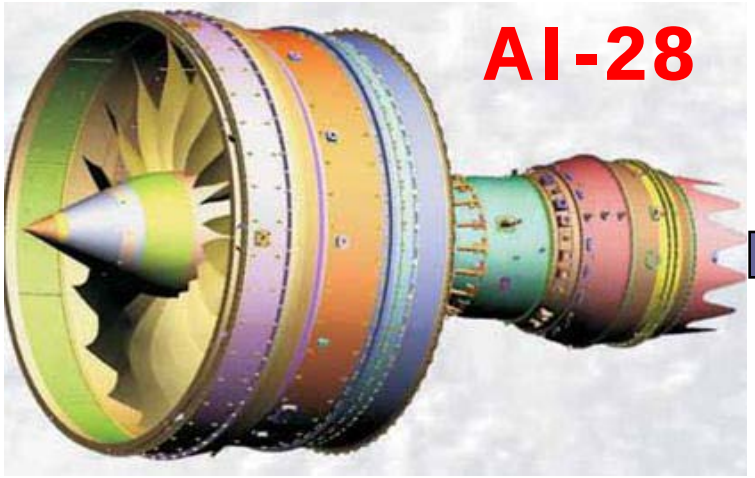
- 65 years history
- 57 types of engines designed
- 80 thousand engines manufactured
- Total operating time > 300 million hours

Engines of the third Millennium

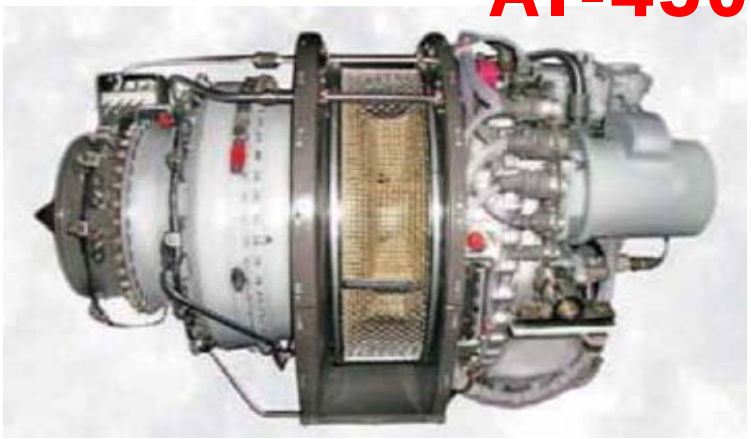
Advanced aeronautic engines

An, Tu, Be aircrafts

AI-28

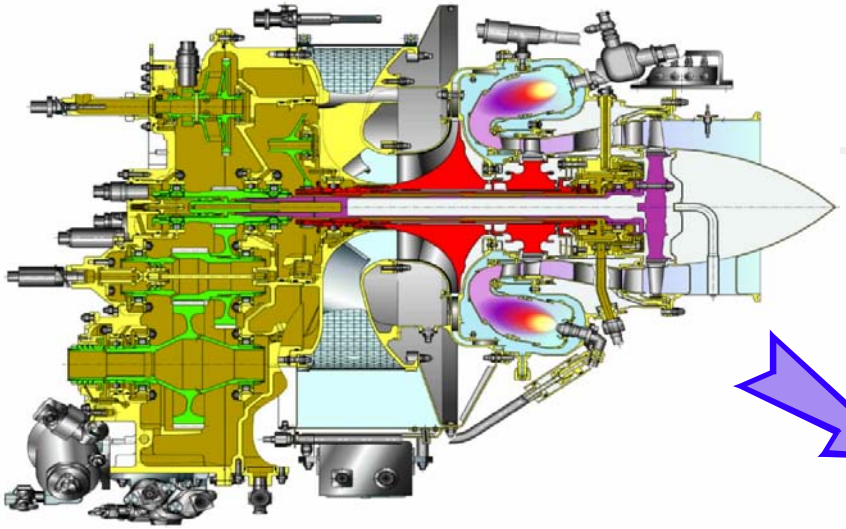


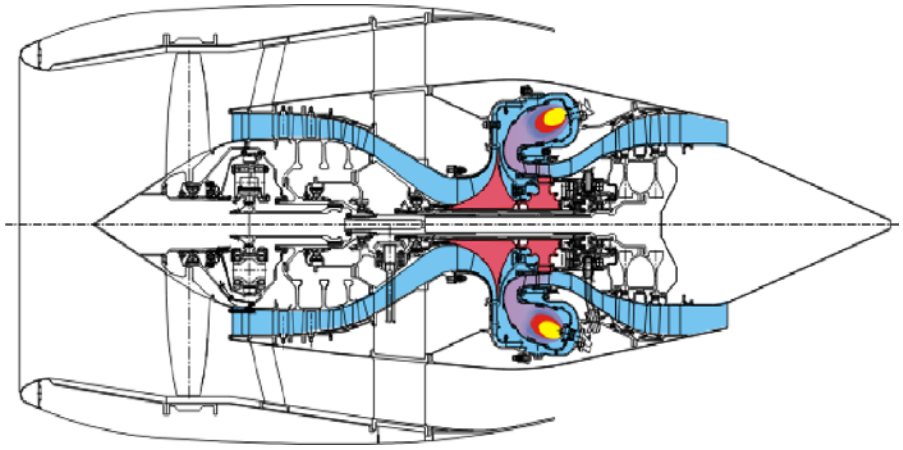
AI-450

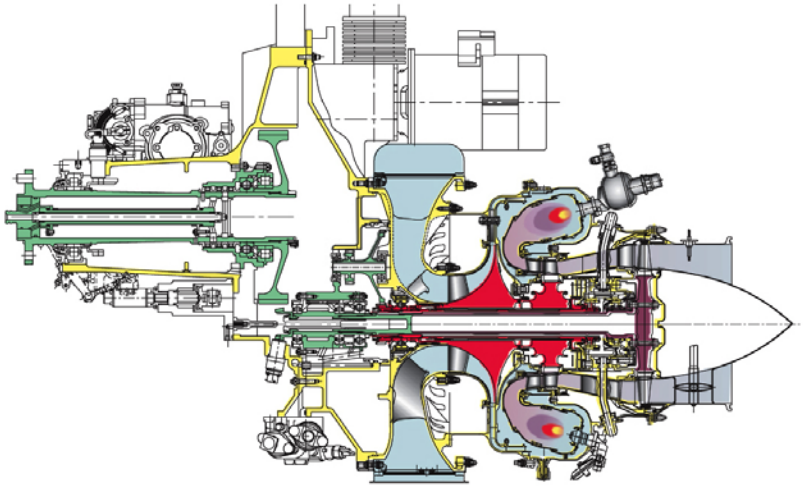


Ka-226

ADVANCED CORE





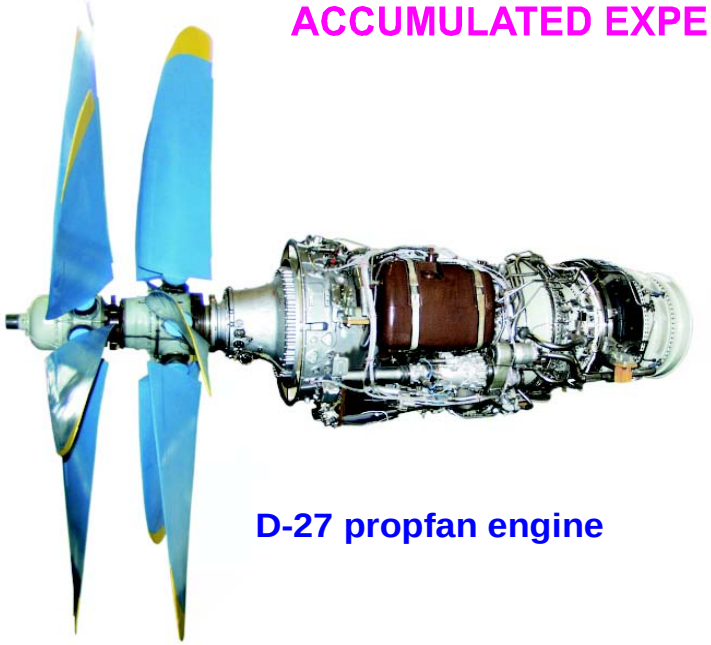


TURBOPROP ENGINE

TURBOFAN ENGINE

400 – 1000 h.p
ADVANCED ENGINE

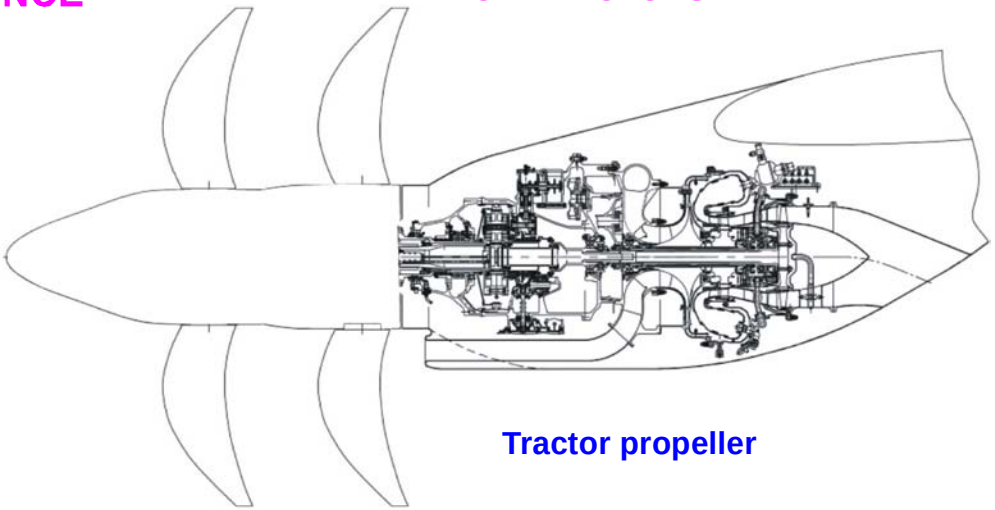
ACCUMULATED EXPERIENCE



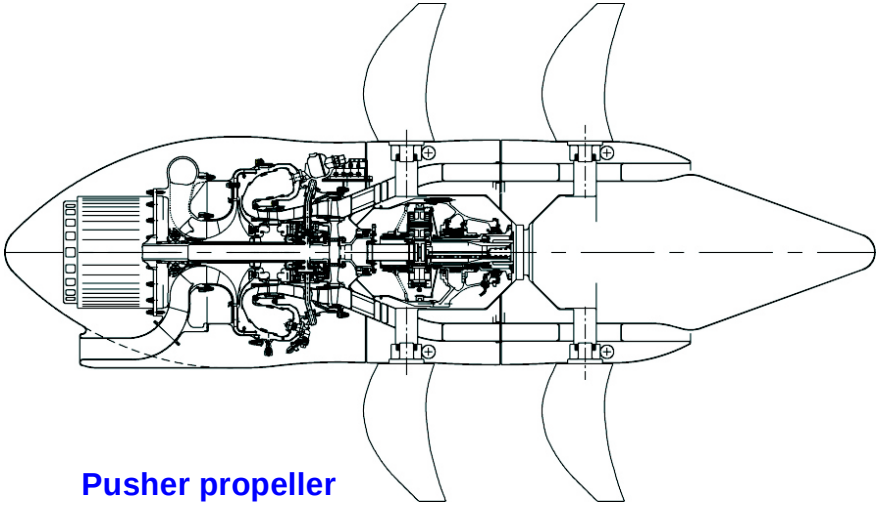
D-27 propfan engine

AI-450 turboshaft engine

OPEN ROTORS

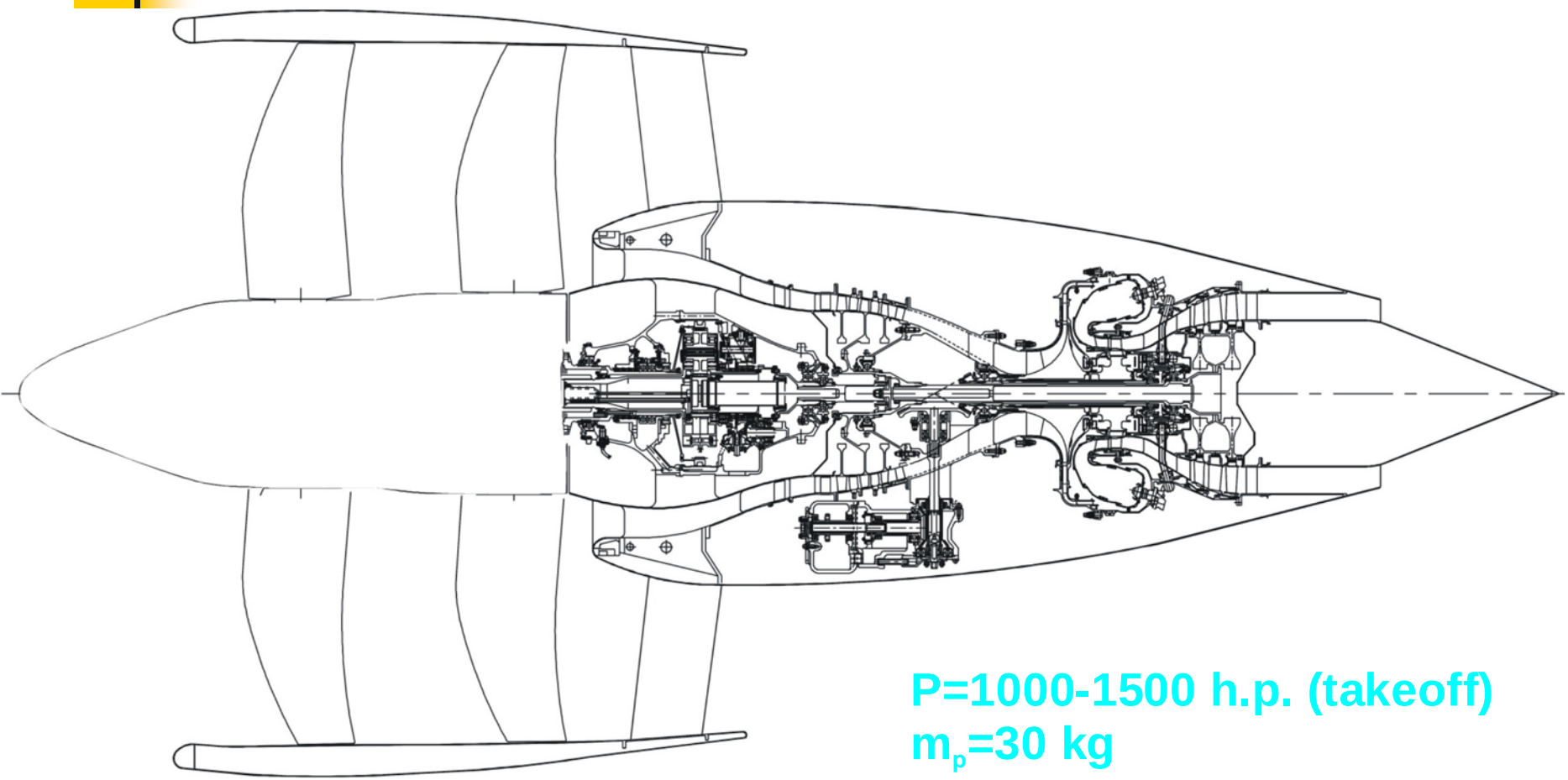


Tractor propeller



Pusher propeller

THE GEARED ENGINE WITH BPR>10 FOR LIGHT EXECUTIVE AIRCRAFT



P=1000-1500 h.p. (takeoff)
m_p=30 kg
D=300 mm
L=300 mm
I=5...6

IPMS - Institute for Problems of Material Science (National Academy of Sciences of Ukraine)

- 50 years of experience
- Leading international research center
- More 800 researchers (285 Ph.D., 88 D.Sc.)

Competencies:

- Advanced Material Science
- Prospective energy-efficient and clean technologies
- Design of structures for aerospace, nuclear power engineering, transport, etc.

IPMS Research areas:

Thermally expanded graphite samples

- High-temperature ceramic for aircraft engines
- Unique friction and antifriction wear-resistant materials
- Thermally extended graphite with steel or cooper nets reinforcement
- Sputtering techniques of wear-corrosion-resistance and heat-resisting coatings

IPMS Research areas:

- Titanium alloys for aerostructures

- Aluminum alloys with unique mechanical properties (YS +160% and UTS +90% in comparison with 2024)

- Climatic tests of composite materials at different conditions

Titanium rotor turbo charger

IPMS Research areas:

« Noise and vibration »

The sound-proof materials on the basis of mesh materials

« Aerostructures »

Materials for composite aircraft lightning strike protection (knitted copper mesh with CNT)

National Aerospace University “KhAI”

Who we are:

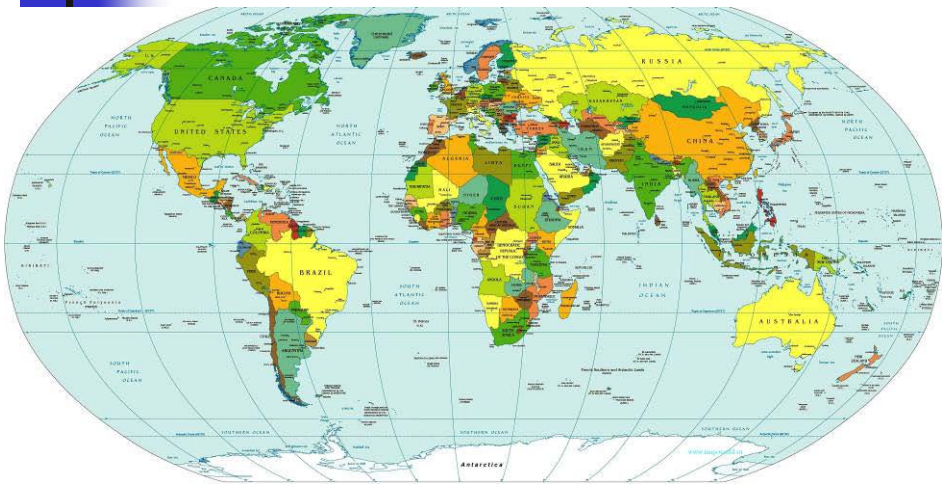
National Aerospace University «KhAI»

- 1930 - Founded as Kharkiv Aviation Institute
- 1998 - Aerospace University
- 2000 - National Aerospace University

National Aerospace University «KhAI»:

- 12000 students
- 160 postgraduates
- 700 teachers (400 Ph.D., 95 D.Sc.)
- 2000 employees
- 10 Faculties
- 27 Specialities
- 45 departments
- terr. 25 hectars

International Activity:



More than 1000 students from 60 countries

EASN associate member

PEGASUS associate partner

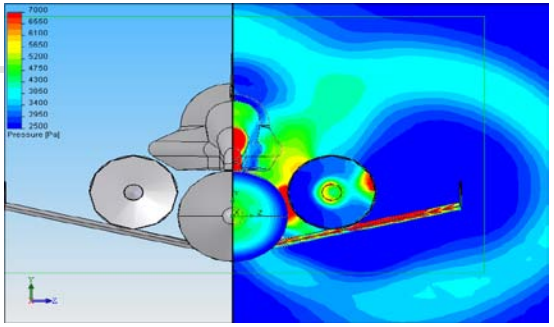
Research Collaboration:

- United States
- United Kingdom
- Germany
- France
- Finland
- Mexico
- South Korea
- China
- Austria
- Sweden
- Australia

OUR PARTNERS

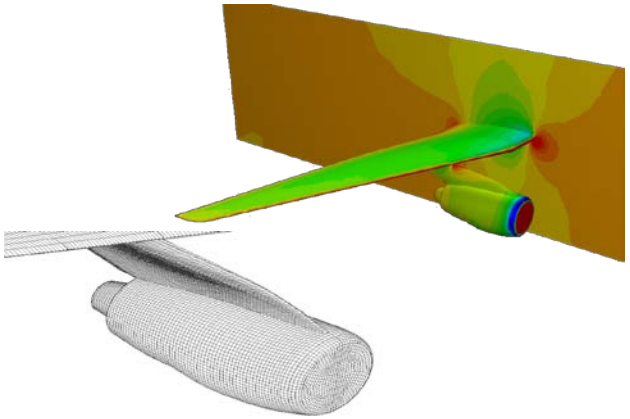
What we do?

Subsonic and supersonic aerodynamics



Unique aerodynamic complex

+ Simulation capabilities

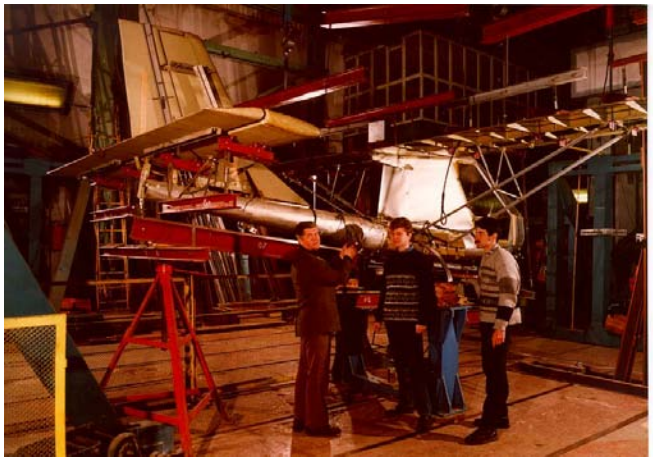


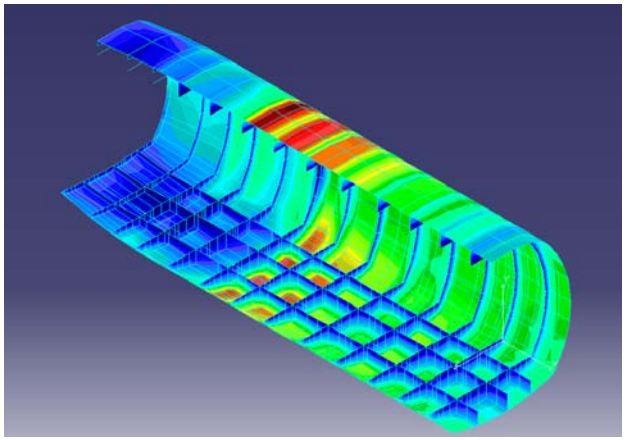
- ✓ 6 wind tunnels
- ✓ 1 to 4 Mach number range

Structure strength:

Static and fatigue test facilities

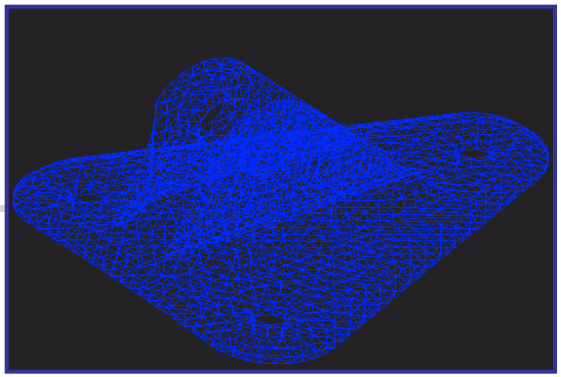
- Aircraft structures full-scale testing
- Static and fatigue materials characterisation
- Structures fatigue life-time prediction



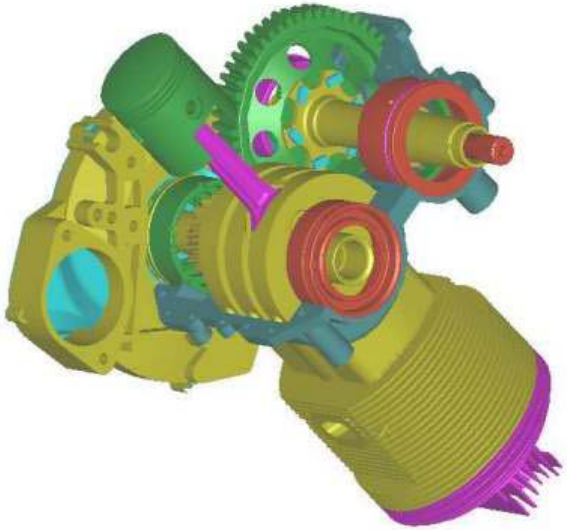


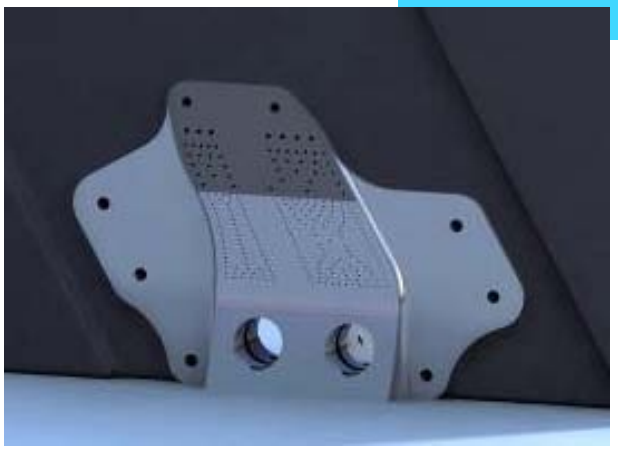
Certified:
- Aviation Regulations of Ukraine, part 23, sections C and D.
- Airworthiness Specifications JAR-VLA, sections C and D.

Design Centre:
CAD / CAM / CAE



UNIGRAFIX, EUCLID, ANSYS, NASTRAN, COSMOS, SOLID WORKS, LS DYNA etc.
Design, 3D models, FEM





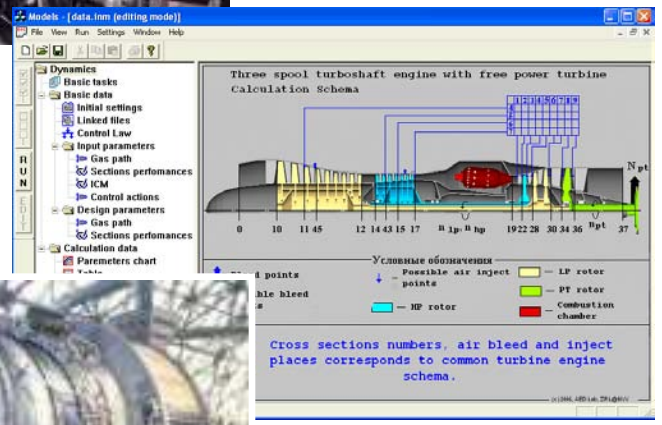
Aircraft engine research

Simulation and testing of gas-dynamic processes in gas-turbine engines.

Real-time diagnostics of gas-turbine engines.

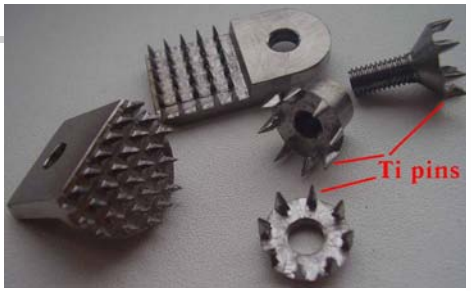
Engine control simulation software

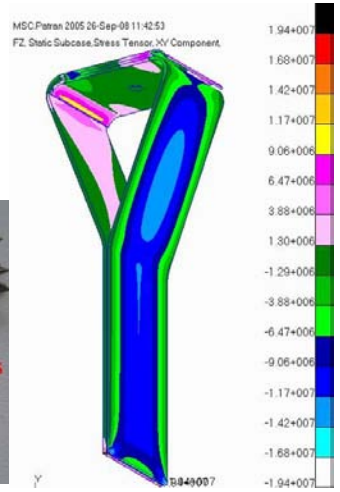
“Green turbine” research

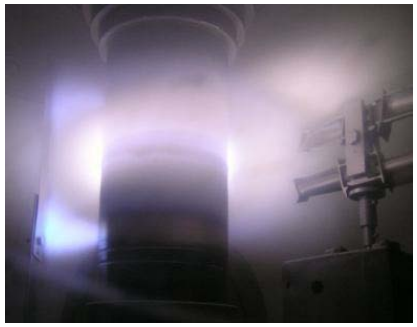


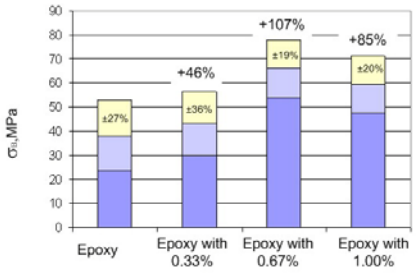
Material Science

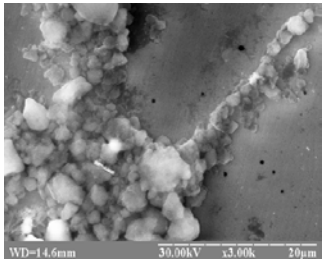
- Advanced composites
  - Design methodology
  - Micro-level simulation
  - Innovative joints design
- Multi-layer coatings
  - Erosion-resistant
  - TBC
  - Hardening
- Nano-science
  - Nano-particles production
  - CFRP properties enhancement



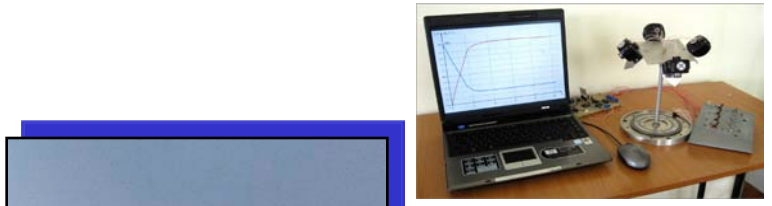


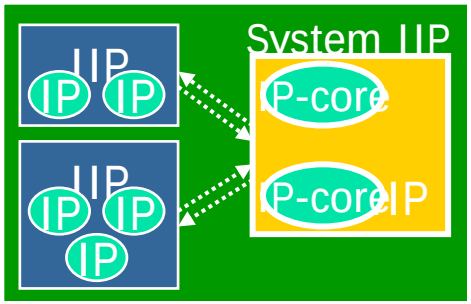




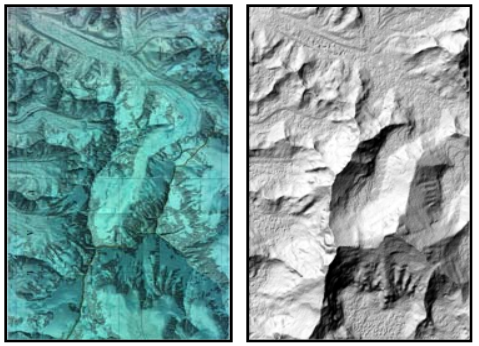


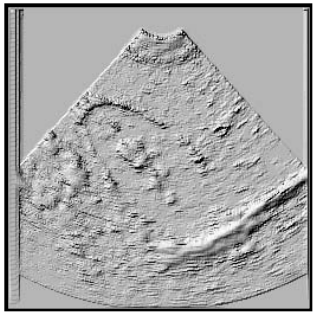
Various ICT applications:





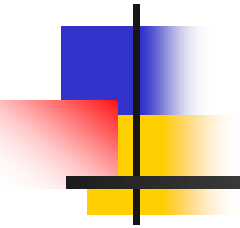
- UAV Auto-pilot system
- Fault-tolerant embedded control systems
- Remote sensing & advanced signal processing





EU Research Projects:

- **FP6 – SENARIO** (Advanced Sensors and Novel Concepts for Intelligent and Reliable Processing in Bonded Repairs)
- **FP6 – ALCAS** (Advanced Low Cost Aircraft Structures)
- **FP7 - HPH.com** (Helicon Plasma Hydrazine Combined Micro Engine)
- **FP7 – AERO-UKRAINE** (Support actions for further cooperation EU/Ukraine aeronautic communities)
- **FP7 – WASIS** (Composite Fuselage Section Wafer-design Approach for Safety Increasing in Worst-case Situations and Minimizing of Joints)



Next AAT Call Ideas

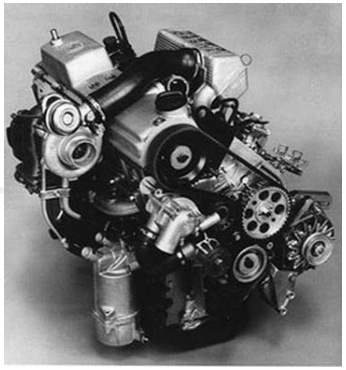
Project Idea:

NONOX
NOx elimination in gas-turbine engines exhaust

NOx emission sources

Aircraft engines

Gas turbine power plants



Diesel & piston engines

NOx negative effect:

- Environment pollution
- Power plant efficiency reduction
- Structure elements acidic destruction
- Life threat

Current approach to NOx emission mitigation:

Separated combustion zone

High hydrodynamic losses
Low effective temperature
Complicated design

Catalytic combustion chamber

Small flow rate
Low effective temperature
Expensive catalysts

Vapor injection

Addition consumables
Inappropriate for aircraft
Water recycling devices

Depleted mixtures

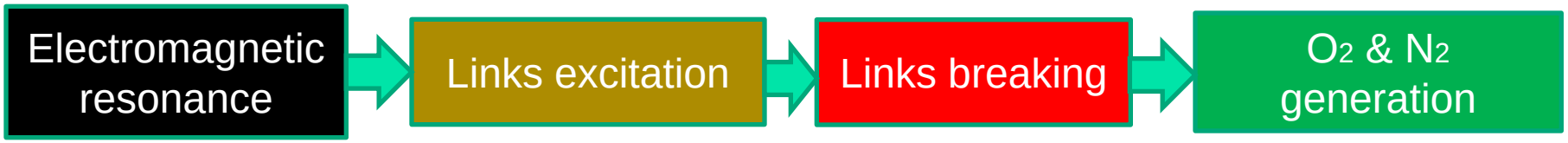
Low effective temperature
Low efficiency
Chamber size increasing

- General approach – NOx generation restriction
- Existing NOx amount reduction – impossible!
- Limited application

Our approach: NOx molecules decomposition with electro-magnetic resonance

- Application of high frequency transient electromagnetic fields in working parts of exhaust nozzles
- Electron links resonance excitation into NO_x molecules up to dissociation
- NOx decomposition and recombination reactions
- Nitrogen and oxygen replace NO_x in exhausting gas mixtures

How it works



$$\nu_{ext} = \nu_e$$

$$A_{ext} + A_e \geq \Delta E_n$$

$$N = O \rightarrow N \overset{*}{=} O$$

$$NO \xrightarrow{\vec{E}_1(t)} N + O$$

$$NO_2 \xrightarrow{\vec{E}_2(t)} NO + O$$

$$NO_2 \xrightarrow{\vec{E}_3(t)} N + O + O$$

$$O + O \rightarrow O_2$$

Expected benefits:

- 99,95% initial NOx eliminated
- Any type of power plant
- Unlimited flow rate, flow speed 3M
- Working temperature: 173 – 1400 K
- High pressure: up to 200 atm
- Initial NOx concentration: 10 – 10 000 ppm;
- Regardless of initial gas consistence
- No consumables

Project Idea:

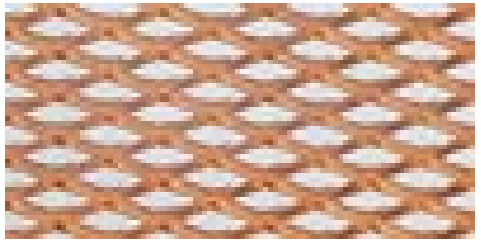
COALIS

Composite Aircraft Lightning-Strike Protection with Advanced Materials

Motivation:

- Composite aircraft needs specific lightning strike protection measures
- Conductive coatings, foils,

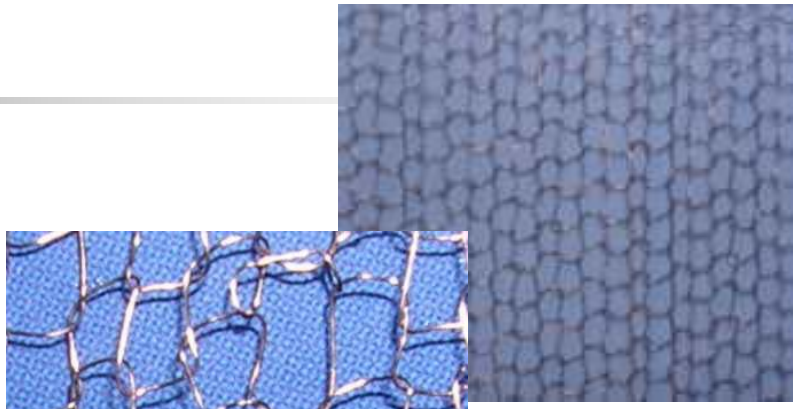
extended foils are used now

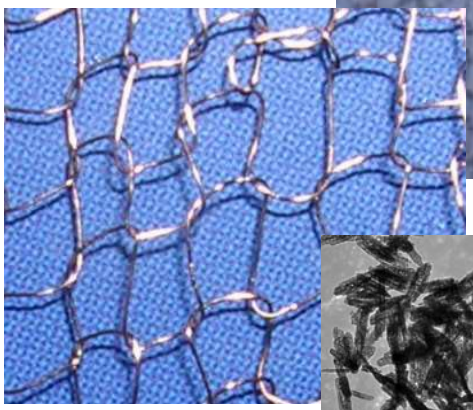


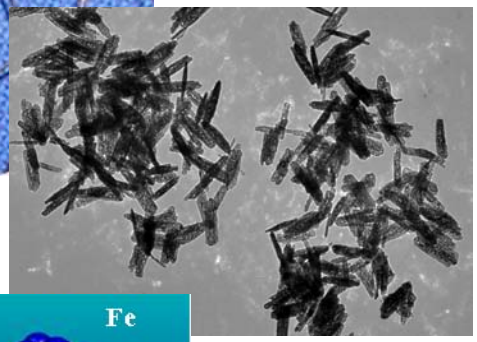
- Weight/Costs/Conductivity trade-off
- Advanced conductive materials is the scope

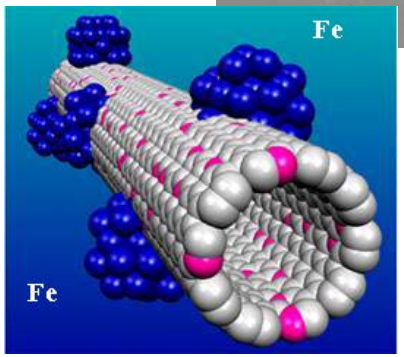
Technical approach:

- Knitted mesh made of 0.8 mm copper wires with controlled cell dimensions. (soldered or welded).
- Epoxy resin modified with carbon nano-tubes (CNT) with embedded molecules of iron (Fe). (CNT chains)
- Synergy effect gives increased conductivity









Expected Impact:

- Twice more effective in lightning energy dissipation comparatively to the best examples of widely used extended foils
- ~50% less in weight (comp. Astrostrike)
- Can be also used for after-strike repair of composite airframe structures for upper layer conductivity restoration

Following Work Packages assumed:

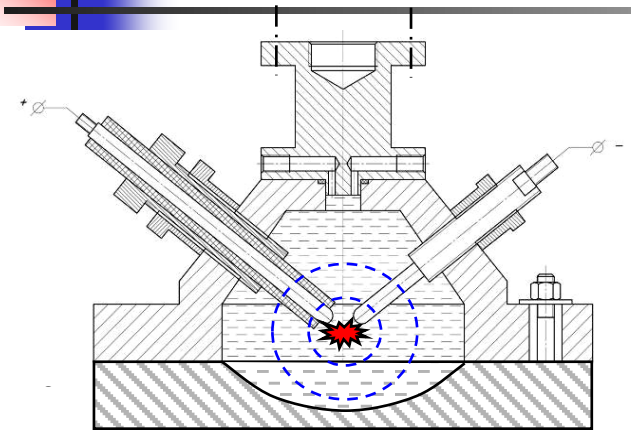
1. Copper knitted mesh conductivity research and optimization, manufacturing process development
2. CNT-Fe epoxy resin curing process research and optimization for highest conductivity, manufacturing process development
3. Composite panels test samples manufacturing using several conventional and developed materials
4. On-ground comparative lightning strike testing of manufactured panels

Project Idea:

EHF-3D

Cost-effective Electro-Hydraulic Forming (EHF) technology for complex 3D aircraft/engine parts manufacturing

What is Electro-Hydraulic Forming (EHF)?



High-voltage discharge in a liquid .

Forming factors :

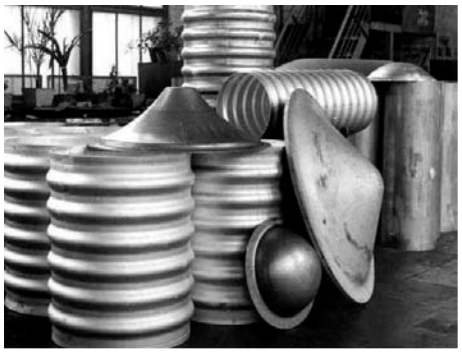
- high-intensity electric field
- high temperature
- high pulse pressure

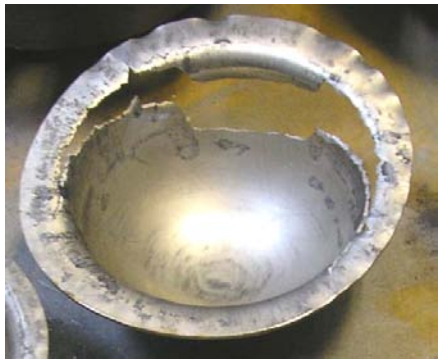
JUST ELECTRICITY AND WATER !

Motivation:

- Aircraft/engine parts has complex 3D geometry
- Conventional pressing technology is pretty expensive, post-production finishing is needed
- Electro Hydraulic Forming can sufficiently decrease pre-production and manufacturing costs
- Parts accuracy can also be increased (no post-production)
- Heavy-deformed materials (Ti) can be easily formed (with heating)

Aircraft parts manufactured with EHF:





EHF advantages and benefits:

- Sufficient tooling cost decreasing (only one hard tool – die or punch)
- Pre-production time is very short (0.5-1 month)
- Tooling from cheap materials: carbon steel, aluminium, aluminium-zinc alloys, plywood, etc.
- Complex 3D geometry parts (better plasticity of metals)
- Highest accuracy of the formed parts
- **Extremely cost effective** (pilot, small-batch and middle-scale production)

Work Packages:

1. Software development for EHF process and tooling simulation
2. Non-metal dies manufacturing
3. Coating technology for forming tools development
4. Automated EHF control system development
5. Manufacturing process testing for different materials
6. Combined application of EHF and EMF

We are seeking partnership for:

- FP7 Aeronautics Call participation (but not limited to!)
- Two-way exchange of ideas and demand
- Strategic partnership
- Joint R&D projects
- Patenting and licensing
- Commercialization
- Spin-off and joint ventures

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