CENTRAL AERODYNAMIC INSTITUTE n.a. prof. N.E. Zhukovsky

27th CONGRESS OF THE INTERNATIONAL COUNCIL OF THE AERONAUTICAL SCIENCES
19 – 24 September 2010, Nice, France

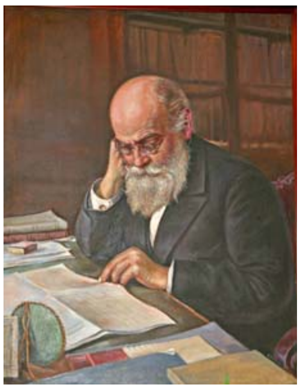
THE RUSSIAN AVIATION: Challenges & New Opportunities for International Cooperation

Dr. Sergey CHERNYSHEV
Executive Director
TsAGI

TsAGI: CENTRAL AERODYNAMIC INSTITUTE

ЦАГИ – The Russian Abbreviation ***Since 1918***

- Russia's Leading Aerospace R&D Center
- Over 90 Years of Technology Excellence
- World Largest Testing Facility
- Mother Organization for Many Russian R&D Institutes and Design Bureaus
- Training facility for top Russian Technical Universities
- Russia's ICAS Member since 1960



Prof. Nikolay Zhukovsky
(1847 – 1921)
The Founder

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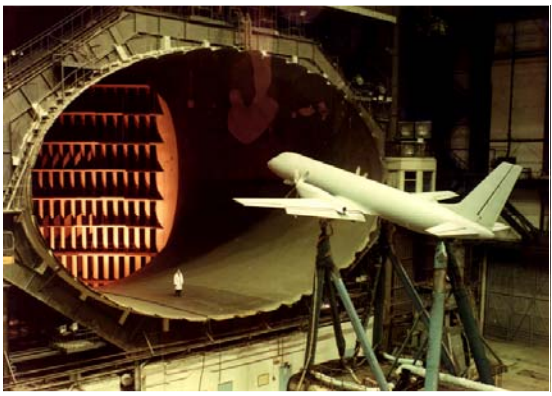
ZHUKOVSKY: HOME TOWN FOR THE RUSSIAN AERONAUTICS

T-101 SUBSONIC WIND TUNNEL

Technical specs:

Flow velocity	5–52 m/s
Re number per 1 m	up to $3{,}3 \cdot 10^6$
Test section dimensions:	
Nozzle section	**24×14 m**
Test section length	**24 m**
Angles of attack range	–20°…+20°
Sideslip angle range	–180°…+180°

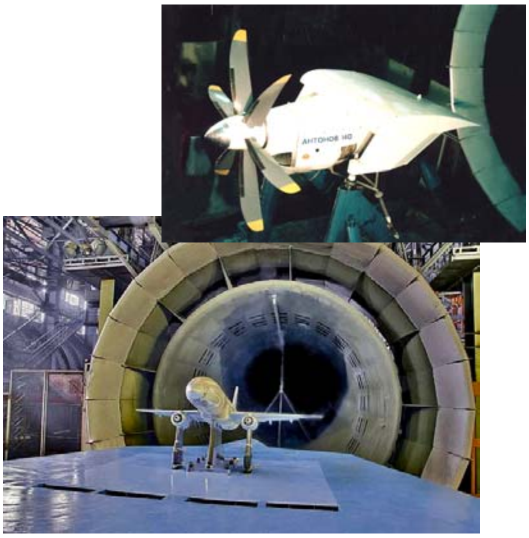


T-104 SUBSONIC WIND TUNNEL

- Aircraft – Engine integration
- Propeller Aerodynamics
- Various engine failures simulation

Technical specs:

Flow velocity	10–120 m/s
Re number per 1 m	up to $8{\cdot}10^6$
Test section dimensions:	
Nozzle diameter	**7 m**
Test section length	**13 m**

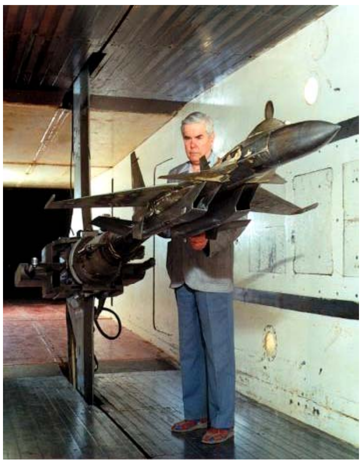


T-105 VERTICAL WIND TUNNEL

T-128 TRANSONIC WIND TUNNEL

- Test section size: 2.75 × 2.75 m
- Adaptive wall perforation
- Advanced technique of wall correction
- Real flight Re numbers

T-109 SUPERSONIC WIND TUNNEL



T-109 test section:

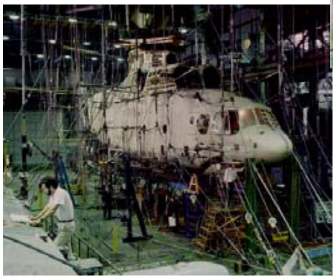
2.25 × 2.25 m
M = 0.4 ÷ 4.0
Variable nozzle

Type of Testing:

- Simultaneous measurement of 3-D forces, moments, & pressure distribution (up to 400 points)
- Simulation of cold & hot engine jets
- Measurement of aircraft pressure pulsation
- Aeroelasticity testing: flatter, buffeting, reverse
- Aircraft - body separation study

FULL SCALE STATIC TEST LABORATORY

- Area: 3600 m^2
- Multi-channel automatic loading systems (up to 120 channels)
- Automatic measurement system (up to 18000 sensors for measuring strain, deformation etc.)



THE TPVK-1 THERMOSTRENGTH VACUUM CHAMBER

Diameter:	13.5 m
Length:	30 m
Min pressure:	5×10^{-8} bar
Temperature range:	120÷1700 K
Max effort when strength testing:	up to 500 t
Acquisition:	4250 channels

WATER TANK WITH TOWING TROLLEY

Length	– 220 m
Trolley Velocity	– up to 15 m/s

TECHNOLOGY CHALLENGES:

- ❑ SAFETY
- ❑ GREENING TECHNOLOGIES
- ❑ ECONOMIC EFFICIENCY
- ❑ ROTORCRAFT AND AIRFIELD-FREE TRANSPORT

ICAS

SAFETY

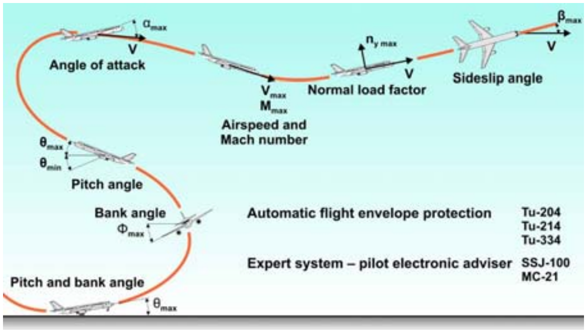
ICAS

SMART INTEGRATED CONTROL SYSTEM FOR SAFETY IMPROVEMENT

FLY SAFE

TsAGI' contribution:

Approach Router: to assess flight situation, to generate and analyze set of possible approach trajectories

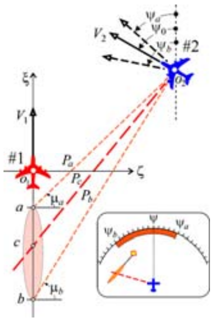


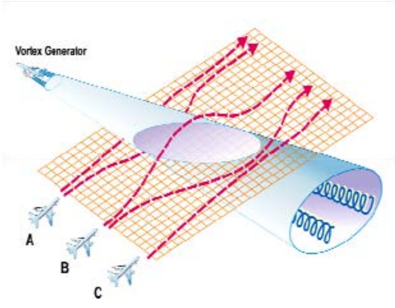
VORTEX SAFETY

FLY SAFE

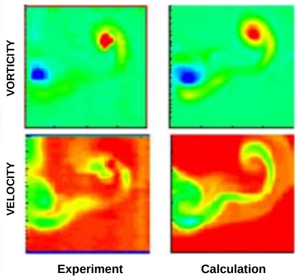
TsAGI' contribution:

- On-board Wake Vortex Predictor and Indicator to provide warnings and recommendations to pilots.





Experimental Verification



UPSET AND STALL RECOVERY

SimSAC SUPRA

TsAGI' contribution:

- Software for estimation stability and control characteristics at early design stage
- WT tests of unsteady aerodynamic characteristics for Transonic Cruiser
- Software for flight control system synthesis
- The extended mathematical model of jet airliner at high angles of attack and other critical flight regimes
- The simulator specifications for the modeling of aircraft upset recovery

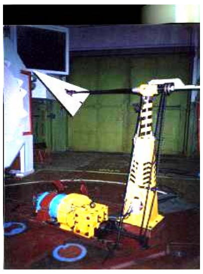
SPECIAL RIG WIND TUNNELS FOR UNSTEADY AERODYNAMICS RESEARCH

TESTING TYPES:

OVP-102B

Aerodynamic damping derivatives, forces and moments at small and large amplitudes

UV-103



Oscillatory conning rig (steady rotation about axis inclined with respect to free stream velocity)

SCAD

Estimation of the flow separation characteristic time lag

SKM

Compressibility effects investigation in transonic and supersonic range (up to M = 1.5)

ENGINEERING FLIGHT SIMULATORS

FS-102

Engineering simulator applications

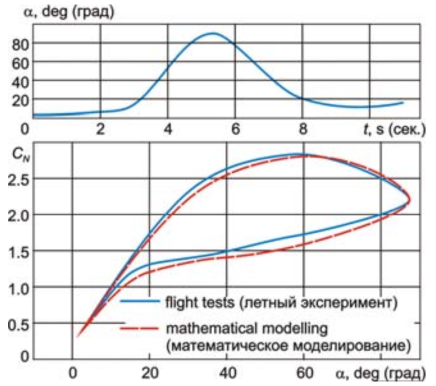
6-DOF

- **Engineering assistance for aircraft design:**
  - investigation of flight dynamics and control systems
  - optimization of the control system algorithms, feel system and aircraft visual system
  - recommendations for aircraft piloting
- **The tool for flight testing:**
  - flight task and flight regimes analysis
  - test pilots training
  - certification testing

MATHEMATICAL MODELLING OF AERODYNAMIC CHARACTERISTICS AT HIGH ANGLES OF ATTACK

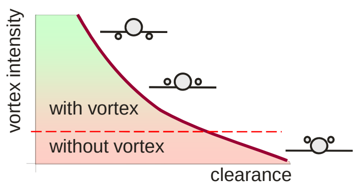
Pugachov`s cobra

$$C_N(t)=C_N(\alpha,x)+\left(C_{N_q}+C_{N_{\dot{\alpha}}}\right)\bar{\dot{\alpha}}, \qquad \tau\frac{dx}{dt}+x=x_0(\alpha)$$

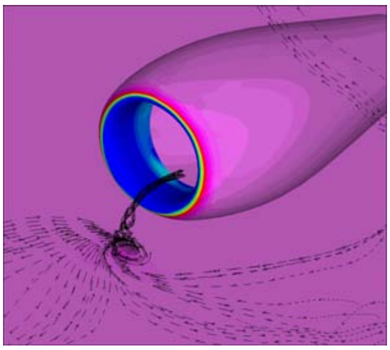


GROUND VORTEX AERODYNAMICS OF TURBOFAN INTAKE

- Safety
- Long service life



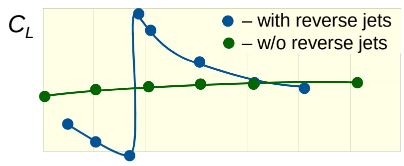
CFD visualization



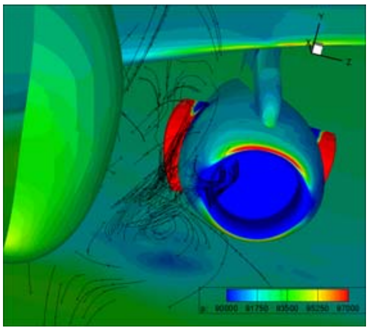
WT tests

THRUST REVERSER (TR) AERODYNAMICS

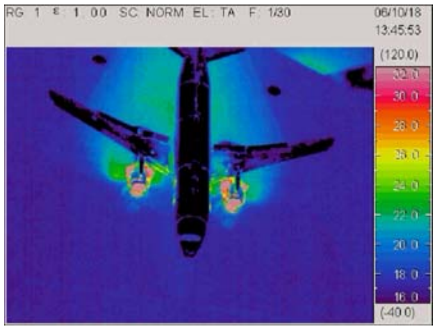
- TR efficiency
- TR jet reinjection
- Stable operation of engine
- Effect on aircraft aerodynamics



CFD visualization



WT tests



GREENING TECHNOLOGIES

OPEN-ROTOR TESTING FOR THE EU PROJECT DREAM

DREAM – valiDation of Radical Engine Architecture systeMs

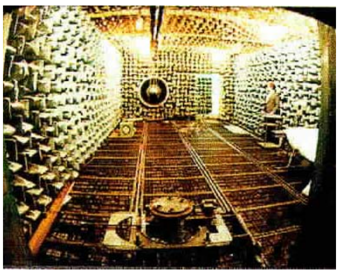
Aero-acoustic test in TsAGI's WT

DREAM objectives:

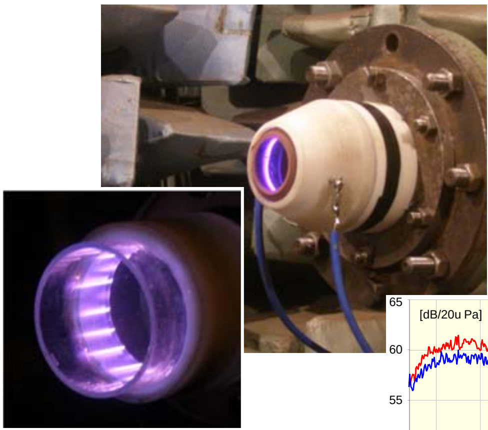
- CO_2 – 7% better than ACARE goals or 27% better than Year 2000 engine
- Noise – 9 dB cumulated on 3 cert points versus the Year 2000 engine
- NO_x – will be reduced accordingly with engine specific fuel burn reduction

LOW-NOISE NOZZLE CONFIGURATIONS

The set of various nozzle configurations has been tested at TSAGI quiet acoustical chambers in order to define the optimum.

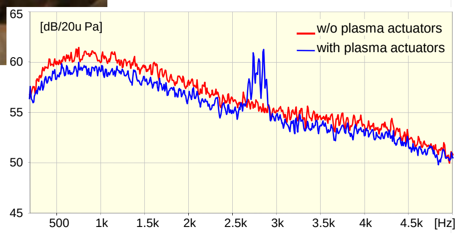


NOISE CONTROL BY PLASMA ACTUATORS

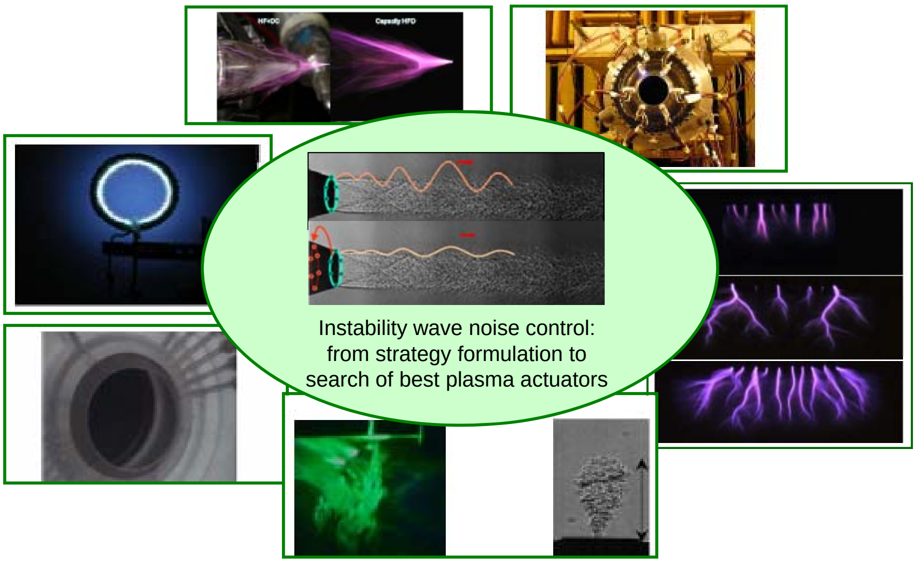


New concept based on direct control of noise radiation mechanisms by plasma actuators (DBD)

Noise level improvement – 1.3 dB

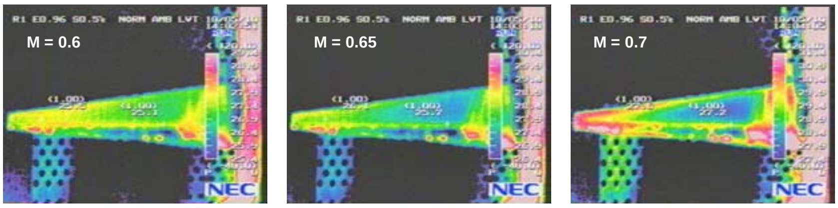


INSTABILITY WAVE CONTROL BY PLASMA ACTUATORS

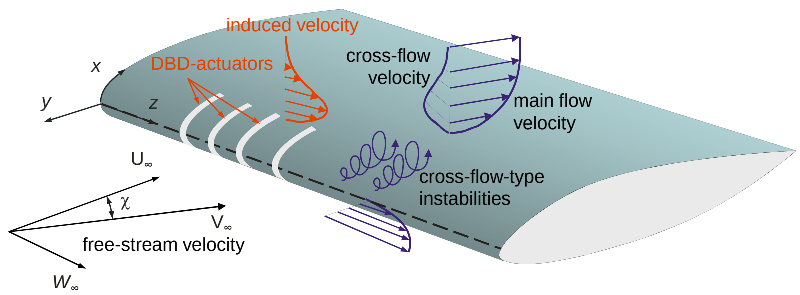


GREEN REGIONAL LOW-NOISE AIRCRAFT WITH NLF

Infrared Images of wing upper surface



LAMINAR FLOW CONTROL BY PLASMA ACTUATORS



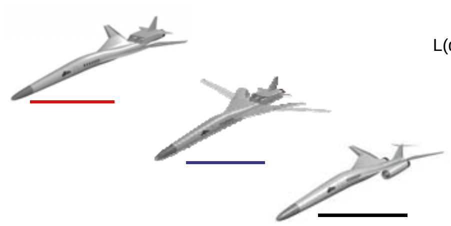
Basic Principle:
Volumetric force impact of DBD-actuators directed along a wing leading edge for attenuation of cross-flow-type instabilities

Result:
Reduction of spatial growth of cross-flow-type instabilities increments by 25÷30%

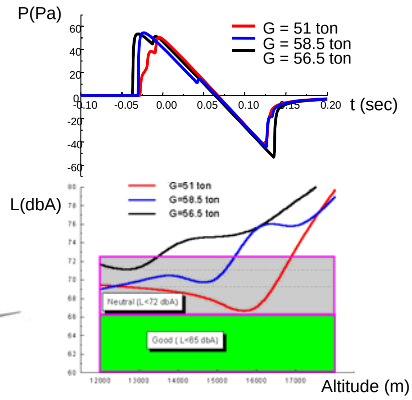
LOW SONIC BOOM SUPERSONIC BUSINESS JET

TsAGI' contribution:

- sonic boom criteria
- sonic boom and aerodynamic modeling
- design of low-boom a/c configuration; aerodynamic, noise and sonic boom assessments
- analyses of sensitiveness for MDO processes



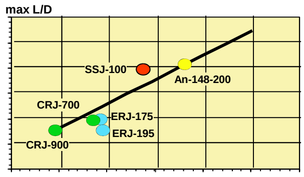
Pressure Signatures and Sonic Boom Loudness



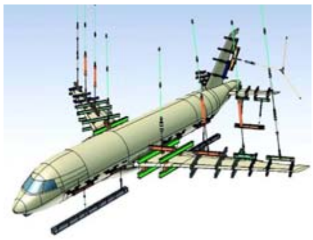
EFFICIENCY

RESEARCH ON NEW RUSSIAN REGIONAL AIRCRAFT SSJ-100

Research of cruise, take off and landing characteristics



T-128 transonic wind tunnel testing

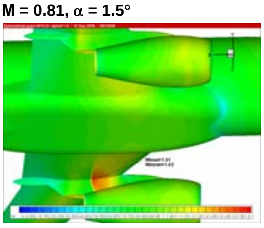


Computational and experimental research of static strength, aeroelasticity and fatigue

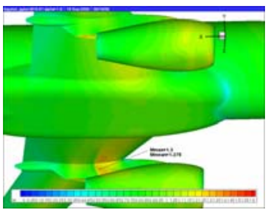
SSJ-100: LOCAL AERODYNAMICS OPTIMIZATION

Curvilinear pylon design

M = 0.81, α = 1.5°



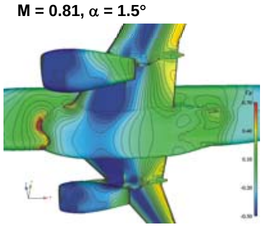
Original pylon configuration



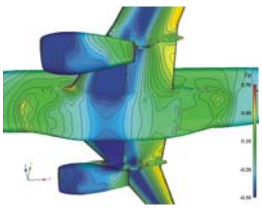
Curvilinear pylon configuration

Wing + fuselage modification

M = 0.81, α = 1.5°

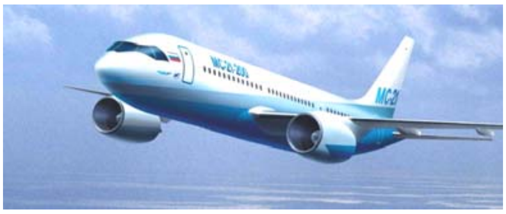


Original wheel fairing

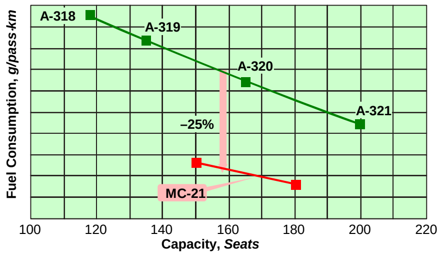


New enlarged wheel fairing

MC-21: THE NEW GENERATION OF SHORT-MEDIUM RANGE AIRCRAFT



FUEL EFFICIENCY

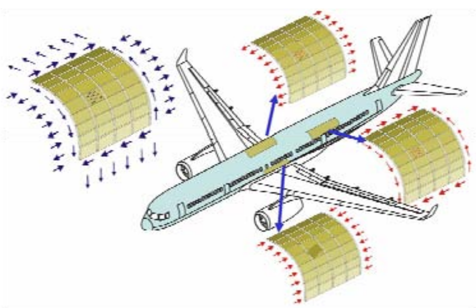


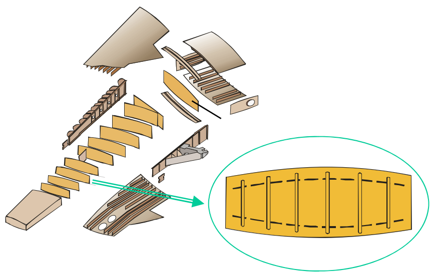
TECHNOLOGY INNOVATIONS FOR THE MC-21

- Composite wing with a very high aspect ratio
- Load reducing active system
- New generation engines
- New generation airborne equipment
- Satisfaction of perspective ecological requirements
- Innovative technological production processes
- Advanced system of the MC-21 post-sail operational maintenance

RESEARCH OF COMPOSITE STRUCTURES IN FPs PROJECTS

- Development of algorithm for calculation of strength and weight parameters of the composite fuselage taking into consideration nonlinear skin behaviour





- Studies of the post buckling behaviour of stiffened composite structures

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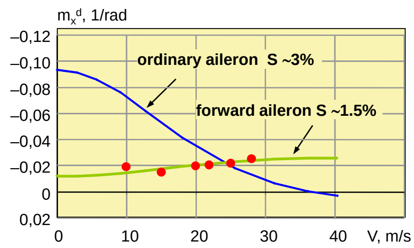
ACTIVE AEROELASTICITY CONCEPT DEVELOPMENT

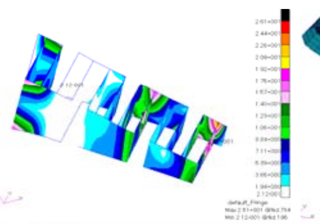


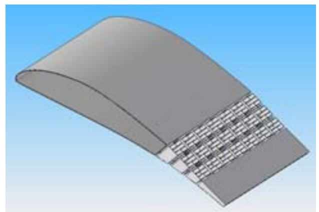
Research directions:

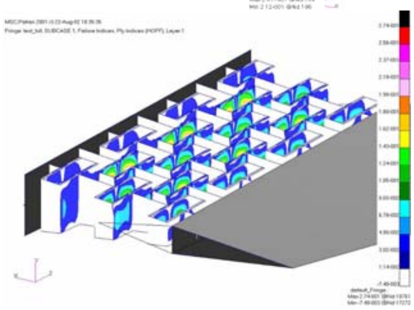
- **Structural deformation optimization and control**
- **Adaptive control surfaces for composite / metal wing**
- **Integrated active control system for loads alleviation**
- **Aeroelastic safety under minimum weight penalty**

ICAS

SMART TRAILING EDGE OF ADAPTIVE WING BASED ON SELECTIVELY DEFORMABLE SDS-STRUCTURE





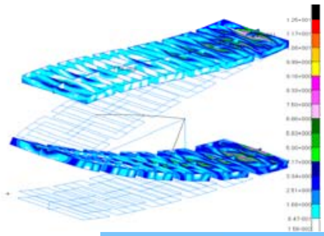


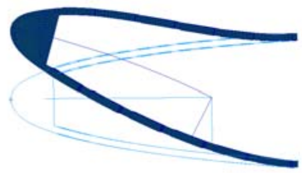
Smart Trailing Edge – (SDS-structure with elastomeric filler).

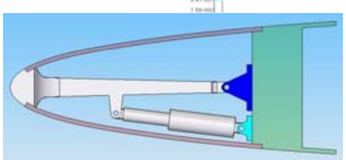
Typical stress-distribution of STE one chordwise row of SDS-structure.

SMART ACTIVE LEADING EDGE BASED ON SDS WITH ELASTOMERIC FILLER

SADE

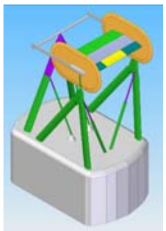






SADE Project Large-scale Demonstrator;

TsAGI T-101 Wind Tunnel



Use of aeroelasticity concept. Adaptive differentially deflected smart leading edge (forward aileron – foraileron) – SDS-structure with elastomeric filler.

Typical stress-distribution of SLE one chordwise row of SDS-structure for deflection up.

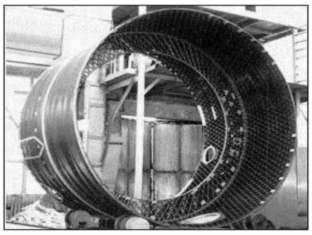
19–24 September ICAS 2010 • Nice, France 37

LATTICE TECHNOLOGY FOR CIVIL FUSELAGE STRUCTURE

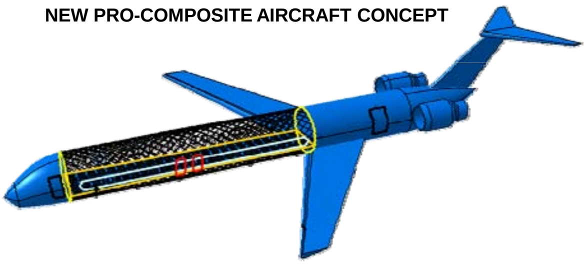
ADVANTAGES OF LATTICE TECHNOLOGY:

- Real weight saving for rocket airframe – 25–40%
- Expected weight saving for fuselage structure – 15–20%
- Expected cost reduction of fuselage structure – 30–35%

STRUCTURE OF THE PROTOTYPE



NEW PRO-COMPOSITE AIRCRAFT CONCEPT



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UNCONVENTIONAL CONFIGURATIONS

TsAGI' contribution to:

- numerical investigation of control surfaces, handling qualities, concepts of design of a family of Flying Wing aircraft, structural concepts of Flying Wing and its pressurized section
- numerical and experimental investigation of engine burst protection

Manufacturing of external contour parts of an 1:5 scale full-span powered wind tunnel model. Final assembly by NLR

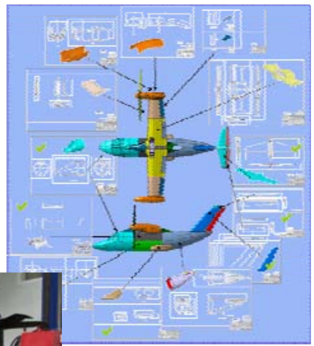


Photo by NLR

ROTORCRAFT AND AIRFIELD-FREE TRANSPORT

ЦАГИ ICAS

MAIN DIRECTIONS OF ROTORCRAFT DEVELOPMENT

- speed increase
  (up to ~ 400 – 500 km/h);
- range increase
  (up to ~ 1000 – 1400 km);
- reduction of community noise;
- comfort improvement
  (reduction of noise and vibration
  in cabin);
- service life increase;
- reduction of operating costs;
- increase in stability, controllability and
  maneuverability.

High-speed helicopter Mi-X1

High-speed helicopter Ka-92

Tilt rotor aircraft

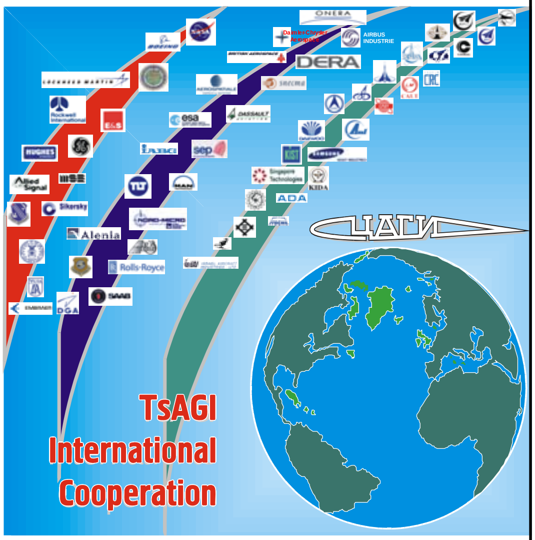
ЦАГИ ICAS

AIRFIELD-FREE TRANSPORT AIRCRAFT

AMPHIBIAN AIRCRAFT

WING-IN-GROUND VEHICLES

INTERNATIONAL COOPERATION



POLITICAL & TECHNICAL EXCHANGES

Beginning in the 90s

NASA - TSAGI COOPERATION IN AERONAUTICS

Dr. Wesley Harris (left)
NASA Associate Administrator
TsAGI, 1993

Mr. Richard Christiansen
NASA Associate Administrator
TsAGI, 1999

RUSSIA – US STUDENT EXCHANGE

MERGING THE EFFORTS: RUSSIA IN EUROPEAN AERONAUTICS RESEARCH PROGRAMMES

The Conference was supported by EC as a specific support action for ILA-2004 exhibit

The event was supported by ISTC as well

ANNUAL TsAGI–ONERA SCIENTIFIC SEMINAR

2001, Zhukovsky (Russia)
2002, Chatillon (France)
2003, Zhukovsky (Russia)
2004, Madan (France)
2005, Moscow (Russia)
2006, Paris (France)
2008, Zhukovsky (Russia)
2009, Lille (France)
2010, Gelendzik (Russia)

TSAGI-DLR YOUNG SCIENTISTS WORKSHOP

Moscow-2009, Berlin-2010





"EU-RUSSIA CO-OPERATION IN AERONAUTICS RESEARCH"

2006 Workshop-Brussels

Seminar programme


I. Analysis of the current participation of the Russian partners in FP6, applying for calls and further development of cooperation under FP6 and FP7.

II. Determination of the main lines of the EC-Russian Aerospace Industry cooperation.

III. Discussion of the prospective joint projects


- Air traffic management
- Flight simulators and pilot training
- Harmonization of standards and regulations
- Scientific exchange, including scientific workshops, conferences, exchange of scientists / students

ЦАГИ ICAS

"EU–RUSSIA COOPERATION IN AERONAUTICS RESEARCH"

2007 Workshop-Moscow

- The main topic is participation of Rosprom enterprises in cooperative research projects of the 7th Framework programme
- Rosprom acts as the main organizer while support is granted by TsAGI, GosNIIAS, VIAM, CIAM and Sukhoi Civil Aircraft

March 28 – 30, 2007
Moscow

ЦАГИ ICAS

"EU–RUSSIA COOPERATION IN AERONAUTICS RESEARCH"

2010 Workshop-Moscow

October 15–16, 2010, Moscow, Russia supported by Minpromtorg and EC:

The Main Tasks:

- Improvement EU–Russia cooperation in aeronautics research
- Support of the Russian participants involvement in FP7
- Support of the Coordinated Call EU–Russia in frame of the 3rd Call of FP7

ЦАГИ ICAS

IX International Scientific-Technical Symposium “AVIATION TECHNOLOGIES OF THE XXI CENTURY”

During MAKS’2009 Air & Space Salon
Number of participants: 497 including 107 foreign participants

MAKS

Symposium topics

- Aircraft aerodynamics
- Flight dynamics
- Modern materials and technologies
- Aircraft structures and strength
- Flight tests and safety
- Challenges of power plant engineering
- Avionics
- Rotorcrafts
- Future aircraft projects

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Thank you!