# WARSAW UNIVERSITY OF TECHNOLOGY

Mechanical Faculty of Power Engineering and Aeronautics Institute of Aeronautics and Applied Mechanics



# **Centers of Excellence**

# in Aeronautics R&TD in Poland

**Janusz Narkiewicz** 

Contributions from Andrzej Bogusławski Piotr Doerffer Witold Elsner Zdobysław Goraj Jan Holnicki-Szulc Wojciech Kania Marek Morzyński Wiesław Ostachowicz Zbigniew Pągowski Romana Śliwa



"Centers of Excellence"

- Universities
- Research institutes
- Centers of Excellence (EU, PL)

Successes in FPs programs

Opportunities for collaboration

Presentation has two parts

#1. Presented

#2. Appendix - material provided by Authors



# Universities

Częstochowa University of Technology (CUT) Poznań University of Technology (PUT) Warsaw University of Technology (WUT)

# Institutes

- Institute of Aviation, Warsaw (IoA)
- Institute of Fluid Flow Machinery, Polish Academy of Sciences, Gdansk (IMP)
- Institute of Fundamental Technological Research, Polish Academy of Sciences, Warsaw (IPPT)



combustion modelling of aero-engine combustor aircraft wake/engine jet interactions (prof. A. Bogusławski)

wall transitional flow modelling in gas turbine blades simulations of turbulent boundary layer (prof. W. Elsner)



### Areas of interest - Modeling of aeroengine combustion chamber

**MOLECULES** (5<sup>th</sup> FP) - Elaboration of modern software tools (CFD) for calculations and simulations of flows and combustion processes proceeding inside combustion chambers of aeroengines

**INTELLECT** - 6<sup>th</sup> Framework Programme of UE. Elaboration of numerical models of modern aeroengines

**TIMECOP-AE** (6<sup>th</sup> FP) – Toward Innovative Methods for Combustion Prediction in Aero-Engines

#### **Bilateral project**

Vrije Universiteit of Brussels - Czestochowa University of Technology

"Modeling of turbulent flows with combustion by Large Eddy Simulation in connection with Conditional Moment Closure model"



# **Częstochowa University of Technology**

### Areas of interest - Investigation of aeroengine aerodynamics



**TRANSPRETURB Thematic Network** (5<sup>th</sup> FP) – upgrading of current industrial CFD capabilities, defining requirements for further RTD model and transition model development



**UTAT** (5<sup>th</sup> FP) - Understanding of mechanisms of blade-row interactions as well as unsteady laminar-turbulent transition process in axial-flow turbines

**Bilateral project** Ghent University - Czestochowa University of Technology "Turbulence and transition modelling methods in turbomachinery applications"

Areas of interest - Aircraft aerodynamics

**FarWake** (6<sup>th</sup> FP) – interaction of vortices with airplane for Airbus

**WallTurb** (6<sup>th</sup> FP) – basic research on turbulent boundary layer affected by adverse pressure gradient for **Airbus** 



Fundamental research of fluid flow stability and control, unstructured CFD computations and aeroelasticity

>development of parallel computing environment (prof. M. Morzyński)

TAURUS - Technology Develompment for Aeroelstic Simulations on Unstructured Grids - 5 FP



# aerodynamics and computational fluid dynamics (prof. J. Rokicki)

aircraft structures and design (prof. Z. Goraj)

airplane and rotorcraft systems (prof. J. Narkiewicz)



### **CAPECON - 5 FP (completed)**

### **Civil UAV APplications & Economic Effectivity of Potential CONfiguration Solutions**

Configurations developed by WUT in CAPECON project (prof. Z. Goraj, Local WUT Coordinator)









# Affordable Digital Fly-By-Wire Flight Control Systems for Small Commercial Aircraft (Second Phase)

### **Objectives**

ADFCS-II addressed 4 key cost drivers

- the design process by the increased use of highfidelity simulations and analysis tools;
- Fault Tolerant Control technologies to improve Flight Control System effectiveness;
- actuation architectures to provide the required integrity and ensure the continuity of control;
- the specification of a set of Flying Qualities Requirements to focus the design process.

### WUT (with RzUT) results

- Autopilot and autothrottle functions embedded into fly-bywire system
- Tested by simulations
- Some functions validated in NLR simulator by flight test pilots



Local WUT Coordinator prof. J. Narkiewicz



### **New Aircraft Concepts Research, IP**

Number of partners: **35** Start date: **1st April 2005** Duration: **48 months** Total budget: **30.3 M€** EC funding: **16.9 M€** 



#### **WP 1 Novel Aircraft Concepts**

Assessment of recovery from hazardous flight conditionss Model design and manufacture Flight test analysis (prof. Z. Goraj) **WP 2 Novel Lifting Surfaces** Forward swept aerodynamics & aeroelastics (prof. J. Rokicki)

Optimization of fuel tank systems (prof., Z. Goraj) Simulation of Flight Control Laws (prof., J. Narkiewicz)



### Novel Innovative Competitive Effective Tilt Rotor Integrated Project

Modelling of flight control system

Definition of operational service and environment



Local WUT Coordinator prof. J. Narkiewicz



- SimSac Simulating Aircraft S&C Characteristics for Use in Conceptual Design (prof. Z. Goraj)
- VULCAN (dr. A. Dacko)
- ADIGMA Adaptive high order methods for aerodynamic applications in industry (prof. J. Rokicki)



computational and experimental aerodynamics (dr W. Kania, dr J. Żółtak, dr D. Szeląg)

smart undercarriage structures (dr Z. Wołejsza)

dynamics of structure (dr A. Niepokólczycki)

specific actions like Aeronet, Xnoise, UAVnet, ViewLS



HELIX - Innovative aerodynamic high lifts concepts
X Noise - Air external noise network
Scratch IV - Promoting SME Participation - Contact Point in IoA, PL
ViewLS -Diamond VIP- Biofuels in transport
FLITE - Flight test easy (Eureka)
HiReTT - High Reynolds Number Tools and Techniques for Civil Transport Aircraft Design

UAVnet - Civilian UAV Thematic Network: Technologies, Application, Certification NAS-TAURUS - Technology development for aeroelastic simulations on unstructured grids



Aeronet III - Aircraft Emissions and Reduction Technologies Scratch - Promoting SME Participation - Contact Point in IoA, PL Adland - Adaptive Landing Gears for Improved Imapact Absorption HISAC- High Speed Environmentally Friendly Aircraft Air TN- Air Transport Net UFAST - Unsteady effects of shock wave induced separation Flite 2- Flight Test Easy Extension (Eureka) CESAR - Cost effective small aircraft SOFIA - Safe Automatic Flight Back and Landing of Aircraft X Noise Phase 2/3 - Air external noise network EPATS - European Personal Aircraft Transportation System





### EC Research Projects



in the 5th FF



High Reynolds Number Tools and Techniques for Civil Transport Aircraft Design NAS HiReTT

Innovative Aerodynamic High Lift Concepts - HELIX



Cicilian Unmanned Air Vehicles NAS – UAV NET Thematic Network



COORDINATOR : Airbus UK 11 Partners: Airbus UK, Airbus D., Airbus F., ETW, DLR, ONERA, NLR, IoA, QinetiQ, RWT, WUT IoA participation – Principal Contractor AERODYNAMIC DEPARTMENT

COORDINATOR : Airbus UK 13 Partners: Airbus UK, Alenia Aerospace, IAI, IoA, FOI, VZLU, QinetiQ, NLR, INTA, Cranfield Univ., KTH, IST, WUT IoA participation - Principal Contractor AERODYNAMIC DEPARTMENT AIRCRAFT DESIGN GROUP

# COORDINATOR : IAI 19 Partners:

IAI, Airbotics, Alenia Aerospace, BAE Syst., EADF, SNECMA, SONACA, SSC, THALES, CIRA, NLR, ONERA, IoA, DLR, WUT, BUT, DUH, POLITO, VGU IoA participation - Principal Contractor AERODYNAMIC DEPARTMENT



# EC Research Projects

in the 6th FP



#### Environmentally Friendly High Speed Aircraft



INTEGRATED PROJECT Contract No. 516132 (AIPA-CT-2005-516132) Duration: 48 months (2005 - 2009) COORDINATOR : Dassault Aviation 37 Partners: Airbus UK, Airbus D., Airbus F., ETW IoA participation - Contractor AERODYNAMIC DEPARTMENT Unsteady Effects in Shock Wave Induced Separation



SPECIFIC TARGET RESEARCH PROJECT Contract No. 01226 (AST4-CT-2005-01226) Duration: 36 months (2006-2008) COORDINATOR : IFFM 18 Partners: IMP, IUSTI, ONERA, UCAM, QUB, ITAM, TUD, INCAS, SOTON, URMLS, LIV, NUMECA, IMFT, FORTH, LMFA, EADS-M, IOA IOA participation - Contractor AERODYNAMIC DEPARTMENT **Cost-Effective Small AiRcraft** 



INTEGRATED PROJECT Proposal No. 030888 Duration: 36 months (2006 - 2008) COORDINATOR : VZLU 40 Partners:

VZLU, CENAERO, CIRA, DLR, EADS, Eurocopter, IoA, Liebherr, NLR, ONERA, PIAGGIO AERO, TURBOMECA, UoM, ULg IoA participation - Contractor AERODYNAMIC DEPARTMENT Third Call: Recommended for funding, expected start – May 2006

### **EPATS**









ADLAND - Adaptive Landing Gears for Improved Impact Absorption (6 FP)



### **Project objective**

- to develop a concept of adaptive shock-absorbers
- to develop technology for actively controlled shockabsorbers applicable in landing gears (MR fluidbased or piezo-valvebased
- to design, produce and test in flight the chosen full-scale model of the adaptive landing gear



experimental and numerical simulations of internal and external flows (prof. P. Doerffer)

combustion (prof. J. Badur)

materials (prof. W. Ostachowicz)





Department of Transonic Flows and Numerical Methods:

Presentation of:

- Transonic Flows Dept. research tools
- General research directions
- Participation in European research projects













Flight Reynolds Number Testing

Coordinated by Airbus D

**CFD analysis:** FI OWer code from DI R

Chimera mesh techniques

**IMP PAN contribution:** 

penisch

BLADE STING Rear end measurements MODELI



19-21 June, 2006







# **TLC** - Towards Lean Combustion



The subject of TLC focuses on low-emission combustion of liquid fuel in aircraft engine combustors.

Many specific difficulties have to be solved from the physical point of view (auto-ignition, flashback, instabilities, lean extinction limit).

**Contribution of IMP PAN:** 

#### **Trapped Vortex Combustor**



**Process of** premixing and prevaporisation







Unsteady effects in shock wave induced separation UFAST

Coordination by



**Industry Observer Group:** 

RRD, Ansys Group Alenia Dassault aviation SNECMA

No	Full name	Short name	Country
1	The Szewalski Institute of Fluid Flow Machinery Polish Academy of Sciences	IMP PAN	Poland
2	CNRS Lab. IUSTI, UMR 6595, Marseille	IUSTI	France
3	ONERA: (DAFE, DAAP)	ONERA	France
4	University of Cambridge, Dept. of Engineering	UCAM-DENG	Great Britain
5	Queens University Belfast, School of Aero. Eng.	QUB	Great Britain
6	Russian Academy of Science, Siberian Branch, Novosibirsk, Inst. of Theor. App. Mech.	ITAM	Russia
7	Delft University of Technology, Aerodyn. Lab.	TUD	Holland
8	Romanian Institute for Aeronautics	INCAS	Romania
9	University of Southampton, (SES)	SOTON	Great Britain
10	University of Rome "La Sapienza"	URMLS	Italy
11	University of Glasgow, Dept. of Aero. Engin.	UG	Great Britain
12	NUMECA, Belgium, SME	NUMECA	Belgium
13	de Toulouse	IMFT	France
14	FORTH/IACM, Found. for Res. and TechnHellas	FORTH	Greece
15	Ecole Centrale de Lyon	LMFA	France
16	EADS-M, Deutschland GmbH Military Aircraft	EADS-M	Germany
17	Institute of Aviation, Warsaw	IoA	Poland





### **Objectives of UFAST:**

<u>The first objective</u> of the UFAST project is to provide a comprehensive experimental data base

**Experiments of "basic" interaction (WP-2)** 

<u>and with flow "control devices" (WP–3)</u> e.g. perforated walls, sublayer vortex generators, streamwise vortex generators, synthetic jets, electrohydrodynamic actuators EHD/MHD

<u>The second objective</u> - application of recent developments in numerical simulations:

RANS/URANS (WP-4),

hybrid RANS-LES and LES (WP-5).

"best-practice guidelines"

<u>The third objective</u>, improvement in physical understanding of unsteady effects in shock induced separation

19-21 June, 2006

**Aeronautics Days, Wien** 

Interaction types considered in UFAST:



**Transonic interaction** 



Nozzle flow



**Oblique shock reflection** 





Polish Academy of Sciences Institute of Fluid Flow Machinery Prof. W.M. Ostachowicz - Gdansk, Poland

ARTIMA

### Aircraft Reliability Through Intelligent Materials Applications

SIXTH FRAMEWORK PROGRAMME PRIORITY 4 AERONAUTICS AND SPACE



Grant No. FP6-2002-Aero-1, AERO-2002- 1.3.2.1.A2, AERO-1.

Period: 2005–2008.

Gamesa Desarrollos Aeronáuticos S.A. – Spain AdaptaMat – Finland DLR Institute of Structural Mechanics – Germany EADS Deutschland GmbH, Corporate Research Center – Germany Eurocopter–D – Germany Swedish Defence Research Agency – Sweden Institute of Fluid Flow Machinery, Polish Academy of Sciences – Poland Instituto Superior Técnico – Portugal Tecnatom – Spain Universidad Politécnica de Madrid, Laboratory of Composites and Smart Structures. ETS. Ingenieros Aeronáuticos. – Spain University of Sheffield, Department of Mechanical Engineering, Dynamics Research Group – UK



# Aerodynamics CFD and experimental external flows – CUT, IMP, IoA , PUT, WUT internal flows and combustion – CUT, IMP, WUT engines and turbine blades – CUT, IMP, WUT, Adaptive structures – IMP, IoA, IPPT Novel concepts – WUT Airplane and rotorcraft systems - WUT



### **Collaboration of groups of researchers**

- Join knowledge, experience and resources
- Synergy effect
- Critical mass
- No effort duplication

## **Sample national initiatives**

Centre of Advanced Technologies AERONET - Aviation Valley Scientific Network "Aeronautica Integra" Centres of Excellence

- CONAV Control and Navigation Centre of Excellence
- CoE for Computational Fluid Dynamics

Follow up projects inspired by FP



### Centre of Advanced Technologies AERONET "Aviation Valley"



### Scientific Network "Aeronautica Integra"



Rzeszów University of Technology – coordinator Lublin University of Technology Lodz University of Technology Silesian University of Technology Warsaw University of Technology University of Rzeszów Institute of Aviation Institute of Fundamental Technological Research Polish Academy of Science Aviation Valley Association (industry)

19 - 21 June 2006



Centre of Advanced Technologies AERONET "Aviation Valley" Sieć Naukowa

Scientific Network "Aeronautica Integra"

### **Centre of Advanced Technologies AERONET - Aviation Valley**

Objective of AERONET is to initiate interdisciplinary, collective and long-term research and training programmes.

Main fields of CoAT AERONET expertise are

- design and investigation of aeronautical structures
- aircraft engines
- data communications and avionics systems
- material engineering and processing
- production techniques in the aerospace industry



### **National participants / interests**

Warsaw University of Technology (WUT) **Department of Automation and Aeronautical Systems (DAAS)** Airplanes and helicopters, satellite navigation, FBW control **Department of Theory of Robotics and Machines (DTRM)** Robotics, biomechanics Industrial Institute of Automation and Measuremets (PIAP) Robotic security systems Poznan University of Technology (PUT) **Department of Control and System Engineering** Modern control methods in robotic applications Szczecin Maritime Academy (SzMA) Visual and satellite navigation for surface transport Rzeszów University of Technology (RzUT) **Department of Avionics and Control Systems** Aircraft control and avionics, FBW systems Space Research Center, Polish Academy of Science (CBK PAN) Spacecraft control, satellite navigation **Chełm College of Engineering (ChCE)** Air traffic control



### SAMONIT MINI UAV studied in WUT (inspired by Israeli K70)





[Aerodays] This European aeronautics event has the following main objectives

To present the technological achievements and on-going activities of specific aeronautics R&TD with the European Research Area; done

➢ To contribute to future perspectives and to the implementation of the Vision 2020 along with the Strategic Research Agenda of European aeronautics;

see presentation of Zbigniew Turek from NCP

To establish links and international research collaboration with countries and partners outside the European Union in the view of the global role of aeronautics

outside the scope of this presentation