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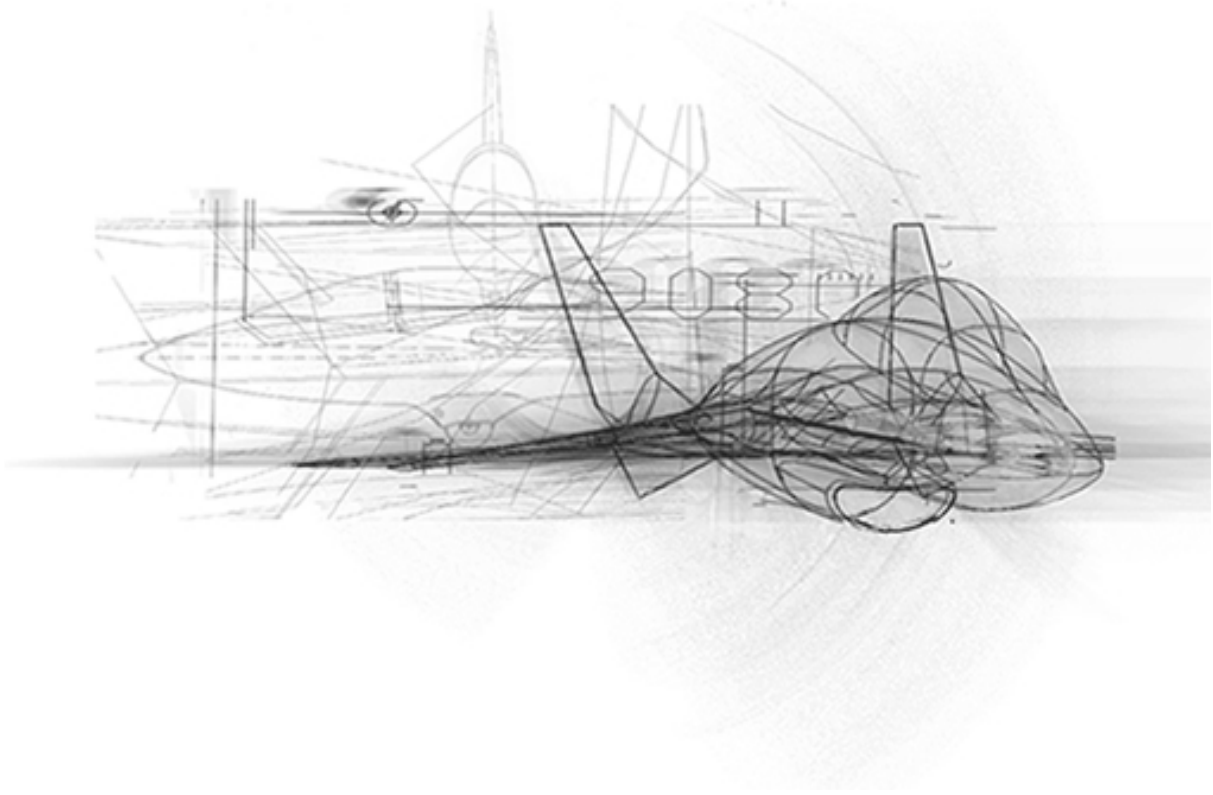
Presentation of EM-10 „BIELIK" project

- new concept in military pilot training



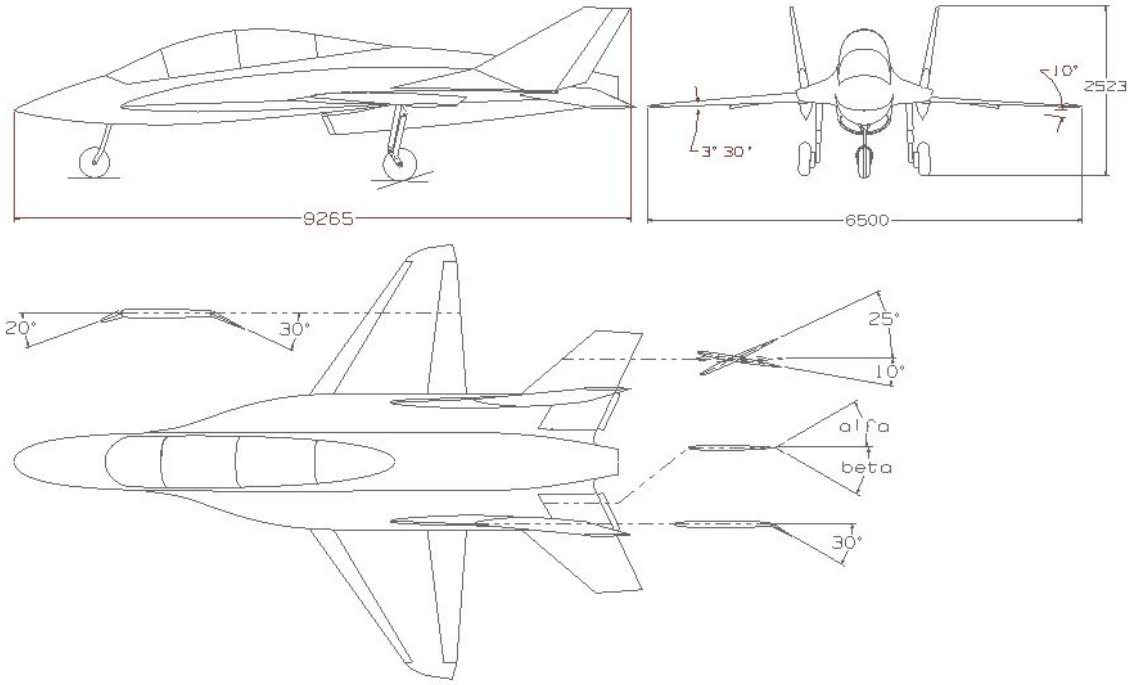
March 2004

subject of this project

2-seat, all-composite, light jet training aircraft, planned in 2 following version:

A. **primary-, and advanced military trainer, „flying simulator", carrier of the combat applications electronic simulation system**

B. **general aviation aircraft for primary-, and advanced training, aerobatics included;**
air-taxi for medium range, high-speed, "point-to point" cruise



EM-10 „BIELIK"

premises to the new concept elaboration

- *market studies: demand for several thousand of jet training aircraft worldwide*
- *replacement of the trainers operated now, and covering gap between former generation trainers and the latest generation combat aircraft*
- *from the point of view of country with limited military budget: all hitherto, as well as the proposed new training aircrafts much to expensive, reducing effective pilot flying time*
- *recent generation on-ground simulation system contribute to enhance the economy of training process still, the application of these in the military pilot training is limited*
- *onboard weapon systems on advanced trainer, however installed and carried permanently, are utilized rather rarely when compared to the total flying time – which is occupied with maybe unnecessarily high level of aircraft complication, and higher than necessary TOW resulting directly in high operation cost*
- *regardless from the established segments of trainer market, there might be a place for the new category of training machines - suitable for high percentage of pilot training process*

- *above observations resulted in the proposition of a light, low-budget jet training aircraft (both purchase price and operation costs) ensuring large pilot flying-time thanks to the unattainable until now in jet trainer low level of maintenance and low direct operation cost*
- *in place of intentionally resigned onboard armament systems, this ship is to be equipped with the electronic in-flight simulation system of the aircraft combat operation (battle-field effects e.g. own- and enemy armament operation included); thus the concept resolves itself into "flying simulator"*
- *when supplemented with a fly-by-wire control system, offers a simulation of various mission profiles including wide range of simulated flight condition and aircraft characteristics*

project targets

- *technology demonstrator of the all-composite, light, turbo-jet trainer*
- *construction of 1 airworthy flying prototype*
- *compliance with the above item confirmed by completion of the aircraft first flight*

brief fore-design

- *aerodynamic lay-out for the high subsonic airspeed range (max 0.90 Ma),*
- *high maneuverability over wide Angle of Attack (AoA) range (beyond 40 deg),*
- *Aerobatic Category flight envelope (limit loads: +9/-4.5 g)*
- *no board armament systems ➡ TOW reduced to 3.0 ton (pay-load 250 kg of electronic system),*
- *turbo-jet power plant unit of 2000 kG thrust category,*
- *pressurized cockpit, equipped with 2 ejected seats in tandem arrangement,*
- *wherever possible - adoption of equipment and systems from existing aircraft,*
- *composite structure (carbon/epoxy), ensuring low production costs also at small-lot production, offering at the same time chances for easy production improvement*
- *purchase price of standard version with basic version of ejected seats & turbo-jet engine (by-pass turbojet unit from Ukraine or Slovakia) – slightly above 2 000 000 US$,*
- *low weight plus robust & simple design ➡ low level of maintenance and low operation costs,*
- *cockpit standardized with final aircraft in training program,*
- *in a future, with „fly-by-wire" control added, possible simulation of desired aircraft flying/ pilotage characteristics*
- *unique ground handling feature – transport on a trailer towed by a jeep; on destination airfield - complete assembly and flight preparation within 1 hour, with 4 person crew*

electronic system of an aircraft combat application simulation, providing:

- *simulation of on-board armament system operation*
- *observation and sight systems (radar-, and thermovision technique based) covering both real as well as virtual (computer generated) objects*
- *running, real time evaluation of sight, and armament operation technique*
- *simulation of battle-field effects (enemy's air defense facilities etc.)*

project run

- *aerodynamic design and wind tunnel tests by Dr Sc Krzysztof Kubryński, Warsaw University of Technology (WUT)*
- *aerodynamic analysis and test program repeated by a team from Military University of Technology (MUT), Warsaw, with different wind tunnel installation and analytical tool,*
- *analysis on aircraft dynamics completed independently at WUT and MUT. Also structural load analysis - held in parallel at two sites (ZRiPSL and at another aviation company in Poland).*
- *aircraft structure design completed at ZRiPSL.*
- *whole design work – entirely with aid of UNIGRAPHICS 3D-CAD system*
- *production tools/forms and complete, full-scale glass-composite mock-up,*
- *construction of assemblies for structural tests; constructed were complete wing, fuselage with vertical fins and elevator (structure equipped with control systems, as necessary for structural test program),*
- *structural test program (over 35 static tests agreed with, and supervised by responsible airworthiness Authority, cockpit pressurization test included) - passed successfully,*
- *construction of flying prototype structure,*
- *hydraulic and pneumatic systems adopted from TS-11 "ISKRA", the prototype installation of board system held on the glass full-scale mockup, and repeated on flying prototype,*
- *on flying prototype , a preliminary program of Ground Vibration Test (GVT) completed, followed by flutter analysis for the limited flight envelope – next both GVT and analyses amended adequately for the needs of planned maiden flight*
- *program of on-board systems operational test completed on the prototype*
- *installation of the selected for prototype engine (GE CJ 610-6) completed thanks to cooperation with FRA Airmotive, UK (extensive program for collection of source data on engine installation, identification and collection of necessary accessories, verification of isolated engine on test bench as well as on the aircraft, concluded with engine performance test on the aircraft),*
- *in spring 2003, pre-flight acceptance test and runway high-speed taxiing completed, after arrangements with Polish airworthiness Authority, on 4 June 2003 the prototype successfully made its first flight*
- *after analysis of recorded flight data, on 9 July, the second flight has been completed*

- *specification and technical-economical guidelines for development of simulation system for the military pilot training process - under work now*

project distinctive features

- *design oriented on military trainer application thus, contrary to other light jet projects under work now, the characteristic features incorporated already at the early stage:*
  - *aerodynamic lay-out for high subsonic speed range and high AoA operation*
  - *airframe designed for aerobatic flight envelope*
  - *landing gear for training process hard landing conditions*
  - *pressurized cockpit*
  - *ejected seats*

project summary

- *time: 4 year project run*
- *budget: 1 000 000 US$*
- *crew: 5 engineers + 25 prototype dept. workers*
- *results:*
  - *design documentation in UNIGRAPHICS*
  - *wind tunnel tests made twice on 1:12 and once on 1:5 models with different installation*
  - *full-scale mock-up*
  - *structural prototype*
  - *structural test program*
  - *flying prototype*
  - *ground test program for flight allowance*
  - *first flight completed*

project actual status and future

- *preliminary flight tests program, aimed at verification of aerodynamic lay-out and aircraft piloting characteristics – within limited flight envelope and AoA range (up to 25°) planned for this year*
- *for this a.m. test program - new main landing gear plus some further modifications sought, depending on the test program budget and schedule*

next stages of the project depend on finding the partner ready and willing to finance the project, but also competent enough to support project in technical and organizational aspects of the development, certification and production of the subsonic, highly-maneuverable turbo-jet aircraft

- *basing on test results – development of production / market models, in military (A) and general aviation (B) version*
- *test program, as necessary for aircraft certification*
- *certification of market oriented models for selected territory*
- *advertisement and marketing to selected territory*
- *organisation, and start of aircraft production*
- *basing on hitherto experience and test results, the serial version could be developed within 2 years, to the stage of first prototype test flight*
- *Type Certificate to civil aviation standards should be gained within next 1 - 1.5 year, starting from this a.m. maiden flight date, also deliveries of first information series planes should take place at the same time. Delivery of these planes to Polish Air Force is considered advantageous, since aircraft validation should be done at military pilot training centre – and accomplishing this in producer country seems most attractive choice*
- *standard version selling price of approx. 2 000 000 US$ should be possible already at production rate of 24 planes annually – gained over next 1 year*

(for the sake of operation/ maintenance reason, specially for general aviation version, it is considered advantageous to standardise on-board systems & equipment with, or adopt these from operated now, popular on American market business jet, with established already, existing service facilities network)

prospects

- *this new category trainer, when introduced into the existing environment of Polish Air Force training system, might be element of contribute to form a local training centre, oriented on primary & advanced training level – for the group of Eastern Europe countries*
- *however originally planned for the jet trainer, and General Aviation market, the scaled-up version might be offered as a light intercepting fighter – in certain European and non-European countries concept still considered interesting*
- *on a market of the General Aviation executive aircraft, new category of air-taxi services, high speed "point-to-point" cruise, above the existing airways*

proposed range of cooperation

- *contribution to financing of project next stages*
- *common realisation of flight test on existing prototype*
- *elaboration of aircraft specification for general aviation version, including selection, and arrangements for standardisation of the on-board systems & equipment with existing popular business jet*
- *specification of production/ serial version for military pilot primary-, and advanced training*
- *co-operation on development and testing of production/ market versions,*
- *co-operation on aircraft certification for U.S. market*

Program financing for the serial version R&D and test program up to the stage of aircraft Type Certification, approx. 3 years time period, containing:

Task	***Budget***
development & construction of serial version prototypes + test program as necessary for flight allowance (production of 1 structural and 2 flying prototypes incl.), concluded with prototypes first flight	*15 000000 US$*
test program for certification process, concluded with Type Certificate to civil aviation standards (production of 3 pcs information series included)	*24 000000 US$*
serial production organisation	*program dependent*

possible production program

with assumed 24 planes/ year production rate, every 4-th plane to be equipped with electronic simulation system, the following production capabilities should be ensured:

Task	***Production area***	***Crew***
production of airframe composite structure + control systems + subassemblies	*3000 sqm*	*150 person*
aircraft assembly	*1500 sqm*	*100 person*

Within cooperation, planned purchase of the following accessories and systems:

- *Fuel system*
- *Hydraulic system*
- *Electrical system*
- *Avionics*
- *Electronic simulation system (development and production of simulation system at Aerospace Industries Ltd., Poland, assumed at a price of 1 500 000 – 2 000 000 US$ per unit)*

research programs

BIELIK project has been a start point for several research programs, both at Margański company and outside. Most remarkable among these are:

- **Aircraft Control System – ZRiPSL**
- **SHARV - Scaled High Angle Research Vehicle - Warsaw University of Technology**

Aircraft Control Method

The subject of this study is the method of aircraft control employing the additional control surface, one located in front of the aircraft C.G. and articulated by application of a fixed, controllable torque with reference to the hinge axis of such a surface.

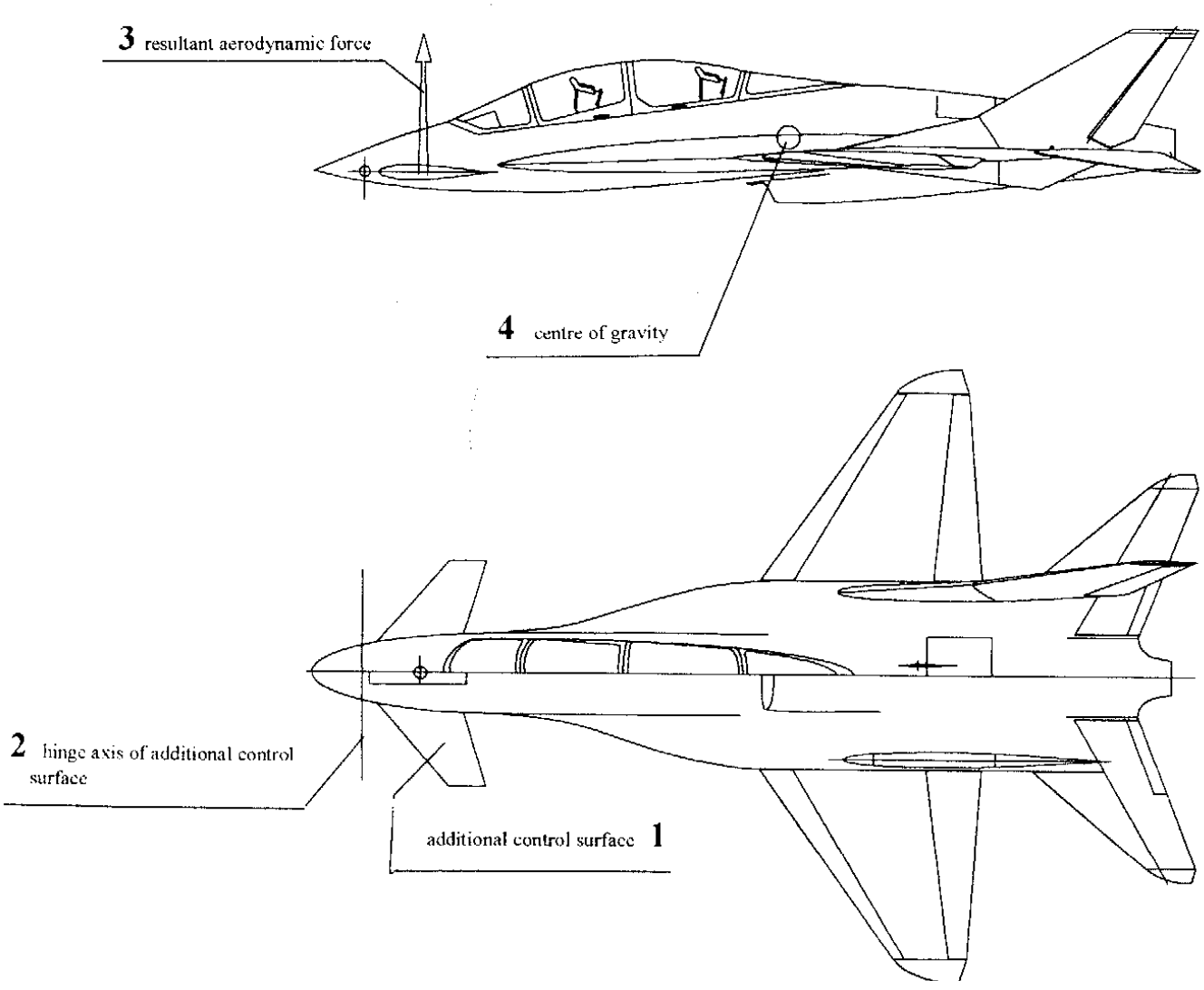


Fig. 1

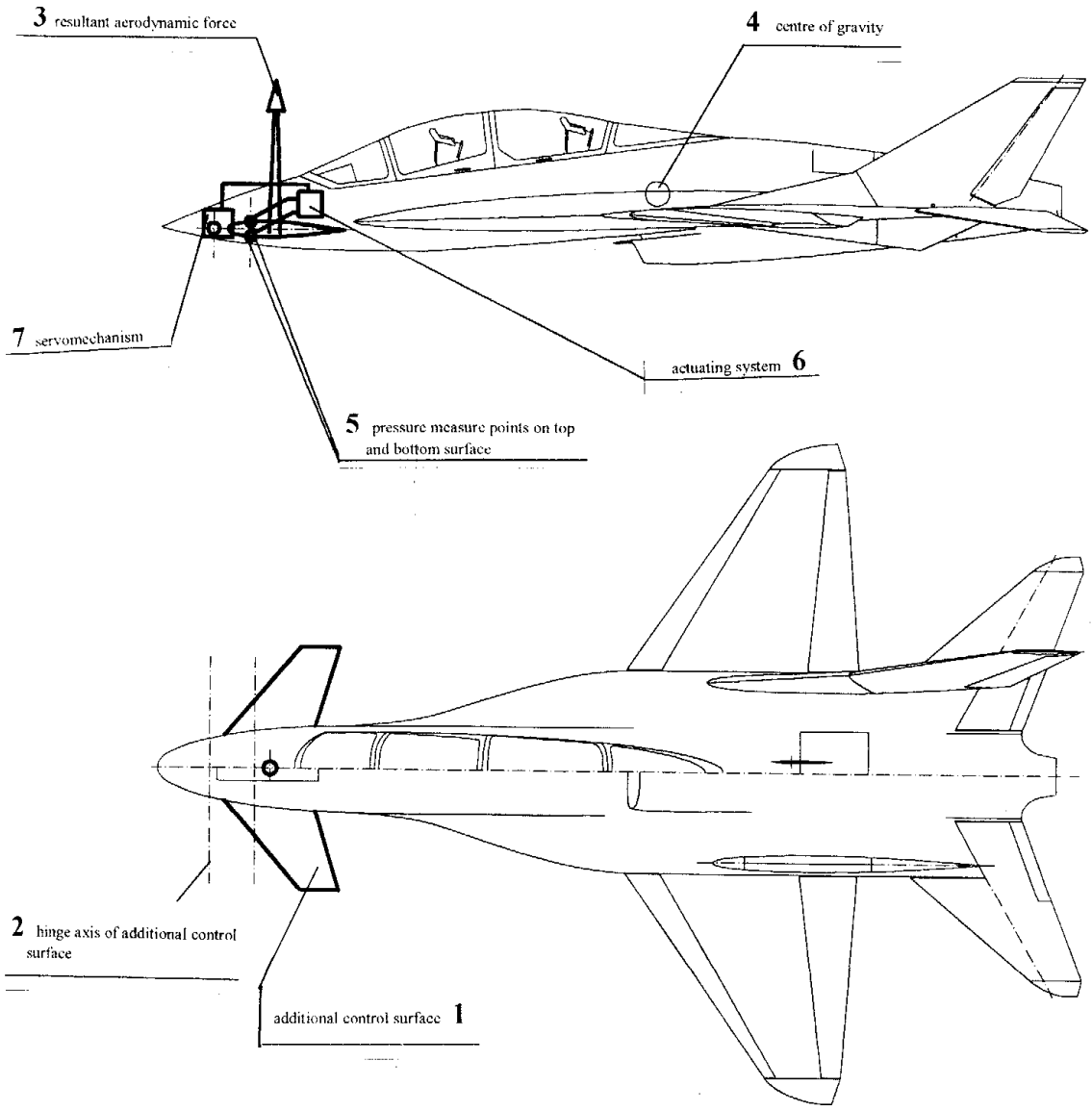


Fig. 2

Characteristic is that on the added extra control surface the controlled by a pilot, constant value aerodynamic force might be achieved independent from the airframe angle of attack, the control surface setting angle and other elements of the airframe attitude.

As a result, positive forces on all aircraft surfaces can be achieved under all flight conditions. Moreover, improved spin recovery capabilities are expected.

The idea has reached a stage of experimental verification, on scaled models, initiated summer last year. In parallel, wind tunnel tests have been initiated already.

SHARV - Scaled High Angle Research Vehicle

Marcin Szender M.Sc.
Warsaw University of Technology, Faculty of Power and Aeronautical Engineering

SHARV is scientific research program commenced at the Faculty of Power and Aeronautical Engineering, Warsaw University of Technology, Poland. Program is aimed at the development of an aircraft flight characteristics research method employing dynamically scaled, remotely piloted vehicle. The main point of interest is investigation of aircraft stability and controllability within high angle of attack range. A remotely piloted vehicle, equipped with the same (scaled) flight control laws as the full scale aircraft, has been used initially to bring added safety to the flight test program, improving the test conditions for the test pilots and limiting some of the financial risks.

Research aircraft description

SHARV is dynamically similar, scaled down model of "Bielik" aircraft(www.marganski.com.pl). The turbine powered, remotely controlled research aircraft is equipped with all control surface similar to full scale aircraft. SHARV's airframe designed for loads +16/-8g is glass/epoxy and agamid/epoxy composite structure. The rear fuselage part with gas exhaust duct is made of high temperature resistant composite. Research aircraft takeoffs and lands on specially designed pneumatically retractable landing gear system. Spin recovery chute which may be used also as a rescue system is installed onboard. Two methods of remote control are employed. During low altitude research flights SHARV is controlled by ground based pilot heaving visual contact with the aircraft. High altitude tests flights employs video transmitted in real time to the ground control station.

Dimensions and weights:

Length	2m
Wing span	1.3m
Max takeoff weight	18kg
Area loading	38kg/m^2
Engine thrust	120N

Flight data acquisition system

Flight data acquisition system consists of high accuracy, wind tunnel calibrated sensors connected to two onboard flight data recorders and telemetry link. Down link transmits major flight parameters and GPS position to ground control station. A unique method of angle of attack (AoA) measurements was developed. The method based on pressure difference measured on nose part of SHARV fuselage, correlated with air speed, indicates AoA with high accuracy at all flight modes, including high rate pitch maneuvers

Flight Tests

The initial series of test flight covered following flight modes:

- Stall analysis. Pre and post stall dynamics, controllability and stability within high angle of attack and stall recovery method.
- Analysis of aircraft maneuverability. Measurements of maximum pitch and roll rates at different flight conditions.
- Analysis of spin resistance and recovery method.
- Recovery from hazardous flight conditions, e.g.: flight with unsymmetrical flap deflection, aerobatics beyond predicted flight envelope

Planned flight tests include:

- Analysis of developed spin
- Analysis of aircraft maneuverability with neutral and negative static longitudinal stability

Accuracy of flight data acquisition system and aircraft dynamical similarity makes possible to transform SHARV flight tests results into characteristics of full scale aircraft.

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