EWADE'02

European Workshop
on
Aircraft Design Education

June 2 – 4, 2002

INSTITUTE OF TECHNOLOGY

LINKÖPINGS UNIVERSITET

Linköping, Sweden

Preface

The first European Workshop on Aircraft Design Education was held in Madrid in 1994 and was hosted by the University of Madrid (ETSIA). Since then workshops followed in 1996, 1998 and 2000, hosted by the Universities of Berlin, Bristol and Turin respectively. The objectives with these workshops are as follows:

- To allow European lecturers concerned with Aircraft Design to continue their active collaboration.
- To discuss Aircraft Design problems as regards research and education.
- To enhance close cooperation with the aerospace industry for the two aspects mentioned above.

This the Fifth European Workshop on Aircraft Design Education is held at Linköping University in Sweden and is organised by the Department of Mechanical Engineering. Aircraft Design Education at Linköping University began relatively recently, in 1994, motivated by the fact that Linköping is the home of Sweden's major aircraft manufacturer, Saab Aerospace. Saab Aerospace is also the main sponsor of this workshop. The chairman of these events is, as always, Professor Egbert Torenbeek from the Netherlands.

I welcome you to Linköping and wish you an enjoyable and useful workshop.

Petter Krus
Chairman of the Organising Committee

The 5th European Workshop on Aircraft Design Education is supported by Saab AB.

FINAL PROGRAMME

Sunday, June 2

9.00	**Social Tour** Trip to Motala, Vadstena and the Motala Motor Museum
16.30	Return to Linköping

Monday, June 3

9.00	**Welcoming Adress** Egbert Torenbeek and Petter Krus
9.15	**Industrial Perspective** *Research and Technology at SAAB Aerospace* Gunnar Holmberg, Saab AB
10.00	*Coffee break*
10.30	**Aircraft Design Methods I** *QCARD* Askin Isikveren and Tomas Melin *Configuration Global Change at the Conceptual Level; A Particular Way for the Evolution and the Optimization of the Design* Sergio Chiesa, Sabrina Corpino, Nicole Viola *Increasing the Accuracy of Estimation of Aircraft Basic Characteristics at Earlier Design Stages* Valeri Komarov
12.00	*Lunch*

13.00 **Aircraft Configurations**
"Polyplane" - an aircraft with nontraditional configuration for very large commercial transport
N. K. Liseytsev
New generation of aircraft for pilot training, tourism and sport flying
Antonin Pistek
From Specification & Design Layout to Control Law Development for Unmanned Aerial Vehicles – Lessons Learned from Past Experience
Zdobyslaw Goraj, Philip Ransom, Paul Wagstaff

14.30 *Coffee break*

14.50 **Education**
Using Tornado, Didactics in the Aeronautical Education at KTH
Tomas Melin
Use of "Scenario Methods" in the Education for Aircraft Design
Dieter Schmitt
Free as a Bird
Patrick Berry

17.30 **Bus pickup at hotel for dinner**

Tuesday, June 4

09.00 **Aeronautical Laboratories**
The Aerospace GNC Laboratory at the University of Naples "Federico II"
D. Accardo, G. Rufino, M. Russo, A. Moccia
Aerospace Research Centre in Bmo University of Technology - goals, organisation and project activities
Antonin Pistek
Building a Fixed-Base Flight Simulator around $100 Software
Trevor Young

10.15 *Coffee break*

10.45	**Aircraft Systems**
	Modeling of Unsteady Aerodynamics of Delta Wings
	Christopher Jouanet
	Aircraft Systems - Reliability, Mass, Power and Costs
	Dieter Scholz
	Simulation Based Optimisation
	Petter Krus
12.00	*Lunch*
13.00	**European Network Discussion Forum**
	EASN – The European Aeronautical Science Network
	Dieter Schmitt
	Aircraftdesign.org
	Dieter Scholz
14.00	**Conclusion**
14.30	**Saab Tour**
17.00	**Finish**

Extended Abstracts

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Configuration Global Change at the Conceptual Design Level, A Particular Way for the Evolution and Optimization of the Design

Sergio Chiesa, Sabrina Corpino, Nicole Viola – Politecnico di Torino

Aim of this paper is to investigate about opportunities, in aircraft conceptual design, of performing global changes of layout by modifying the previous version or by starting a completely new design.

Even if numerical characteristics of an aircraft concept (i.e. main dimensions, weights and more relevant performances) seem to be adequate, and so to be maintained, changes in architectural layout may be of interest; usually a global change of layout means a new design run because of interactions between architectural (qualitative) characteristics and numerical (quantitative) ones.

By the way, in a context of design activity greatly based on CAD-3D sw tool, the definition of the new configuration by utilizing a previous one could be a good strategy; this thesis will be illustrated in the paper by referring about a "Design Case" driven up by Aerospace Systems Engineering Group of Politecnico di Torino

Some years ago the Aerospace Systems Engineering Group of Politecnico di Torino started a series of studies about advanced trainer aircraft, in order to improve Flight Safety levels by increasing Pilot's skill, in addition to caring intrinsic Safety levels of the aircraft.

The result was a "Delta-Canard" a.c. concept called SCALT [1], [2].
The study was driven up till to sub-systems level with extensive utilisation of CAD-3D in all SCALT design process, as far as possible, to obtain a "digital mock-up", already in the early phases of design (Digital Mock-Up at Conceptual Level - DMUCL).

We can observe that the SCALT "Delta-Canard" layout is related to the clearly said idea [1] that SCALT could be a European solution for training of new Pilots for Eurofighter 2000, Dassault Rafale and Saab Grippen.

In a more global context, and also considering the time passed from the SCALT conception, configurations unlike Delta-Canard could be preferred today; the motivation could be the prevision of a future large diffusion of operational a.c. like the Lockheed F 22 "Raptor" and, in particular, the new JSF Lockheed F 35.

On the basis of these consideration, i.e. the prevision of great prevalence of configurations with horizontal tail surfaces in the future operational fighters, the Aerospace Systems Design Group of Politecnico di Torino, in the ambit of continuous study of new a.c. concepts (to maintain an adequate skill in the field), took the decision of defining a new advanced trainer (CT / LIFT) concept, similar to the SCALT by the points of view of numerical characteristics and subsystems configuration, but with a new global architectural layout similar to the Lockheed X 35 one; the new concept was called SCALT35 and it is now under development.

The basic mission considered is the same of the previous SCALT. It is an Air To Ground mission, in particular[1] a LOW-LOW-LOW penetration with combat time (launch of anti-radars or air to ground missiles) of 3 min; the radius of action is 350 km and payload is 1224 kg; these values drive us to a TOGW of 7500kg, value that, on statistical way, suggests an estimation of empty weight We = 4280 kg.

With the hypothesis of 100kg for a pilot weight and 120kg for operational devices weight it is possible to define:

- Fuel weight: Wf = 1775kg → 2.100 [mc]
- Landing weight: Wl = 5625kg
- Manouvring weight: Wm=We+200 +120+Wf/2= 5487Kg

Please note that the last assumption is related to a training mission;
the Wm value, with the idea of having a very realistic training, suggests a value of T/W ratio about 1, with the adoption of the ITEC TFE 1042-70, advanced version of existing engine; the engine has been already chosen for the original SCALT.
Considerations about wing loading value, in particular influence on Landing distance and on Take off distance (in this case accounting also the T/W value) suggest a wing area value: S = 21.6 mq

Please note that all these steps are completely equivalent to the previous SCALT ones; so we also adopt the same Aspect and Taper ratios values for the wing and the same a.c. length (l = 11.6 m) of the previous SCALT.

On the contrary the layout definition, at this moment still under development, will be quite different. In particular we will have:
-a) Dissimilar wing geometry (sweep back angle) and position relatively to the body
-b) Completely new empennages configuration
-c) Completely new landing gear main elements, because of "a)"
-d) The internal provision of a lifter engine, in order to achieve VTOL capabilities in conjunction with vectorizing main engine thrust. As alternative, in CTOL variant, an internal weapons bay will be obtained.

To synthesize the main feature of new a.c. concept SCALT35, in comparison with the previous SCALT, please refer to fig. 1 and fig. 2.

The new SCALT35 concept, at this stage of development, has been checked, following the Group conceptual design methodology, by the points of view of aerodynamic characteristics and of weight congruency. As expected, these steps gave results closely similar to the previous SCALT ones.

We think that the following activities, in particular more detailed verifications and analysis, will confirm that SCALT 35 performances will be similar to the SCALT ones; on the contrary we think we will have to consider and manage differences in the sphere of costs, operational evaluations, analysis based on DMUCL, like accessibility studies and Safety zonal analysis and Risk Analysis, especially for VTOL version.
way a very important aspect, in our opinion , is the easy way in which a so interesting a. c. concept so different in comparison with previous SCALT has been defined on the basis of the same SCALT, specially the CAD-3D modellisation.

[1] "By the *vehicles", Aircraft Design 3 (2000), Elsevier Science Ltd.*

Please note that the experience linked to the described activity contributes to improve skill of students that at various levels of their training are involved in the project.

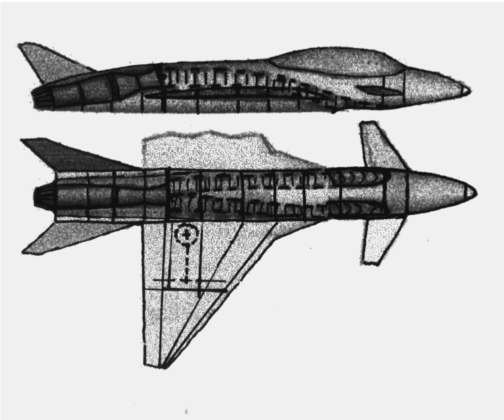

Fig. 1 SCALT layout [1]

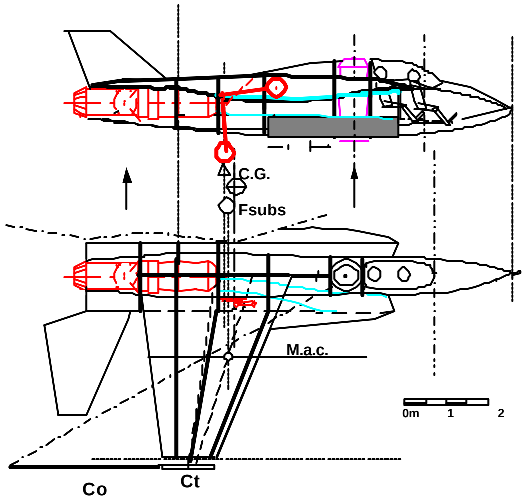

Fig. 2 SCALT35 layout

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S. Chiesa, D. Camatti, S. Corpino, M. Pasquino, N. Viola – "Hypothesis about cost-effective unmanned offensive airplane

Increasing the Accuracy of Estimation of Aircraft Basic Characteristics at Earlier Design Stages

Prof. Valeri Komarov - Samara State Aerospace University, Russia

In the first part of the report the results of testing of three different methods for estimation of aircraft basic characteristics [1-3], further referenced as Eger method, Torenbeek method and Raymer method, are discussed.

The research was conducted according to the following plan:

1. All three methods were transformed to algorithmical form [1].
2. Tu-154, Tu-204 and Il-96 aircraft were selected as design objects.
3. External shape and characteristics of aircrafts – payload, range, take off run, landing speed and etc. were considered as initial data for estimation of specific wing loading, thrust-to-weight ratio and takeoff gross weight for each of the aircraft according to three methods (i.e. 9 projects in total).
4. The results of the redesign of the aircraft were compared with their real characteristics.
5. A new combined method was proposed, which allows to increase the accuracy of estimation for transport aircraft.

The main attention in the present research was paid to the estimation of the aircraft takeoff gross weight. High accuracy of the estimation of wing mass fraction according to weight equations [3] was noticed, while the significant disagreement in the estimation of some components of the takeoff gross weight, especially equipment, should be mentioned.

It is asserted that the high-accuracy mathematical modeling should be utilized at the earlier stages of design process, especially when unconventional external shapes are used. Statistical weight equations can't provide high accuracy in such cases in principal.

In the second part of the report a new approach to the estimation of absolute masses and mass fractions of aircraft structures is discussed. It was developed in SSAU during a long period of time and was widely used both in academical and commercial research.

The idea of this approach is the following:

1. A new criterion is introduced – load factor G, which takes in account both for internal forces in the structure and for length of their action. For frames

$$G = \sum_i |N_i| l_i \ , \qquad (1)$$

where i – rod number, N_i and l_i – rod force and rod length.

For thin-wall structure

$$G = \sum_i R_i S_i \ , \qquad (2)$$

where R_i – equivalent forces flow in 2-D element, S_i – element area.

2. Mass of the structure m_s is estimated as

$$m_s = \varphi G / \bar{\sigma} \ , \qquad (3)$$

where $\bar{\sigma}$ - structural material strength-to-weight ratio, φ - full mass coefficient, which is calculated using (3) from retrospective analysis of already available aircraft and accounts for mass of additional elements (fittings and etc.), requirements of constant element thickness and etc.

In (3) φ expresses the perfection of detailed design of the structure, G is defined by external loads, external shapes of the aircraft and location of its structural elements, $\bar{\sigma}$ expresses of strength and density of structural material.

Load factor G can be easily found using finite element method (FEM) for the aircraft of arbitrary external shape.

In the report the application of the above-stated approach to the development of the theoretical basis for weight analysis of aircraft structures is demonstrated. This approach allows to obtain a rigorous mathematical proof for the “square-and-cube law”, relationship between wing mass and specific wing load and for some other fundamental relationships.

The practical application of the proposed approach is illustrated by estimation of wing mass for the “ECOLIFTER” project, mass estimation for the aircraft with integral fuselage, wing-in-ground-effect craft and some others.

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2. Torenbeek, E., Synthesis of Subsonic Airplane Design. Delft Univ. Press, Delft, The Netherlands, 1982.

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Modeling of Unsteady Aerodynamic Characteristics of Delta Wings

Christopher Jouannet – Linköping University, Sweden

The high angles of attack region has become more accessible to modern aircraft. Therefore, mathematical modeling of the unsteady aerodynamic forces and moments play an important role in aircraft dynamic investigation and stability analysis at high angles of attack. Consideration of separated flow around an airfoil and flow with vortex breakdown around a slender delta wing gives the bases for mathematical modeling using internal variables describing the flow state. This work seeks to create a model for unsteady aerodynamic coefficients, which could be used in simulations in the early design process, and to enable the investigation of static and dynamic forces measurements in water tunnel tests.

The simulation models are based on a representation of C_L using internal state variables. In this approach all the variables have been determined on a geometrical bases, no implementation or parameter determinations have to be done from tests cases. This is to provide full simulation of different delta wing configurations for a low cost without wind or water tunnel tests. All the modeled coefficients are functions of state $x(t)$ and inputs $\alpha(t)$ and $q(t)$. The state variable depends on the flow separation or the vortex breakdown.

The model was applied to oscillatory data in pitch for 70-degree sweep leading edges. The god results obtained show that, this method is applicable to generic delta wing configurations, it is not dependent on specific empirical information, and is economical to use. The method has been validated with comparison with static and dynamic wind tests.

This study has shown that a simple model describing the unsteady characteristics of delta wings undergoing pitching motions can be obtain with good relation to water and wind tunnel tests. The present method can then by used for different purpose, such system simulations or stability and control in an early design stage and will be included in the flight dynamic model used for complete aircraft system modeling at Linköping University.

"Polyplane" – an aircraft with nontraditional configuration for very large commercial transport

Nikolai K. Liseytsev, Moscow Aviation Institute

The paper is devoted to the comparison of the "polyplane" and reference aircraft of traditional configuration.

The work has been fulfilled in the Moscow Aviation Institute with the participation of TSAGI researchers and leading specialists of Russian Aviation Industry in the frame of ISTC Project. Partners of the project were from Airbus Industries and Rolls-Royce. The objectives of the project were investigations on design, definition and comparative analysis of high range heavy commercial aircraft characteristics with conventional and nontraditional "polyplane" scheme with special lifting system. The scheme was suggested by the authors of the project and protected with a patent.
The design of compared aircraft was carried out for the same requirements. The main versions of the aircraft have to provide the transportation of 616 passengers in three class version on the estimated range 13700 km with cruised velocity corresponded to M_{cr}=0.85. The planes have to meet all basic requirements (FAR25, ICAO, 80m box). General views of the compared aircraft are given on figures 1 and 2. The comparison was carried out with the use of the following criteria: lift to drag ratio, take-off mass, relative mass of empty aircraft with operational item, total fuel for the flight.
The comparison of "Polyplane" and basic aircraft polars at estimated altitude and velocity demonstrates that in spite of relatively high minimum drag coefficient $Ñ_{D\ min}$, negative influence of increased washed surface was manage to suppress by decrease of induced drag. At the same time the function (C_L/C_D) = f(M) for "Polyplane" in the area M > 0.8 has more monotonous character in comparison with basic aircraft. At M = 0.87 the advantage in (C_L/C_D) of basic aircraft disappears. Nevertheless at estimated altitude and velocity for C_L = 0.5 the lift-to-drag ratio of "Polyplane" up to 0.8 (4%) less then for basic aircraft.

According to parameter relative mass of "empty aircraft with operational items $\overline{m_{oi}}$" the "Polyplane" aircraft has considerable advantage. Values $\overline{m_{oi}}$ are 0.4574 for "Polyplane" aircraft and 0.4824 for basic aircraft. It is 5.18% higher. It reaches by "Polyplane" advantage on parameter airframe structure mass first of all by decrease (in 1.5 times) of wing structure mass. It is a consequence of change of console wing by lifting system (frame structure). The fuselage mass decreases somewhat too.
This advantage compensates completely insignificant increase of flight control system mass of "Polyplane". In spite of negative influence of lift-to-drag ratio on fuel use, the "Polyplane" estimated take-off mass is 488,21 ton. It is 52,75 ton (9,75 %,) less then weight of aircraft with traditional configuration (m_0 = 540,96). That is considerable advantage of "Polyplane" aircraft. It can influence positively on its economic parameters.

In spite somewhat less lift-to-drag ratio in cruise flight "Polyplane" aircraft has noticeable advantage in comparison with basic aircraft in parameters of fuel effectiveness.

For example the flock fuel for "Polyplane" is 206,2 ton and 221,3 ton for basic aircraft what is 15,12 ton higher. The estimated $q_{ò}$ for "Polyplane" and basic aircraft is 23,06 and 24,927 g/p*km correspondingly.

According to the initial requirement the compared aircraft have the same main flight performances: payload, range, cruise flight velocity, take-off and landing characteristics. Nevertheless in the frame of given limitations there are insignificant differences in characteristics of flight profile. For example because of higher start thrust-to-weight ratio “Polyplane” has better characteristics of climb and in spite of less C_{Lmax} at take-off and landing practically the same with basic aircraft take-off and landing characteristics. At the same time the "Polyplane" parameters of manufacturing and operation service will be worse in comparison with aircraft with traditional configuration. It is associated with lower nomenclature of airframe sections and component of on board systems at the basic aircraft.

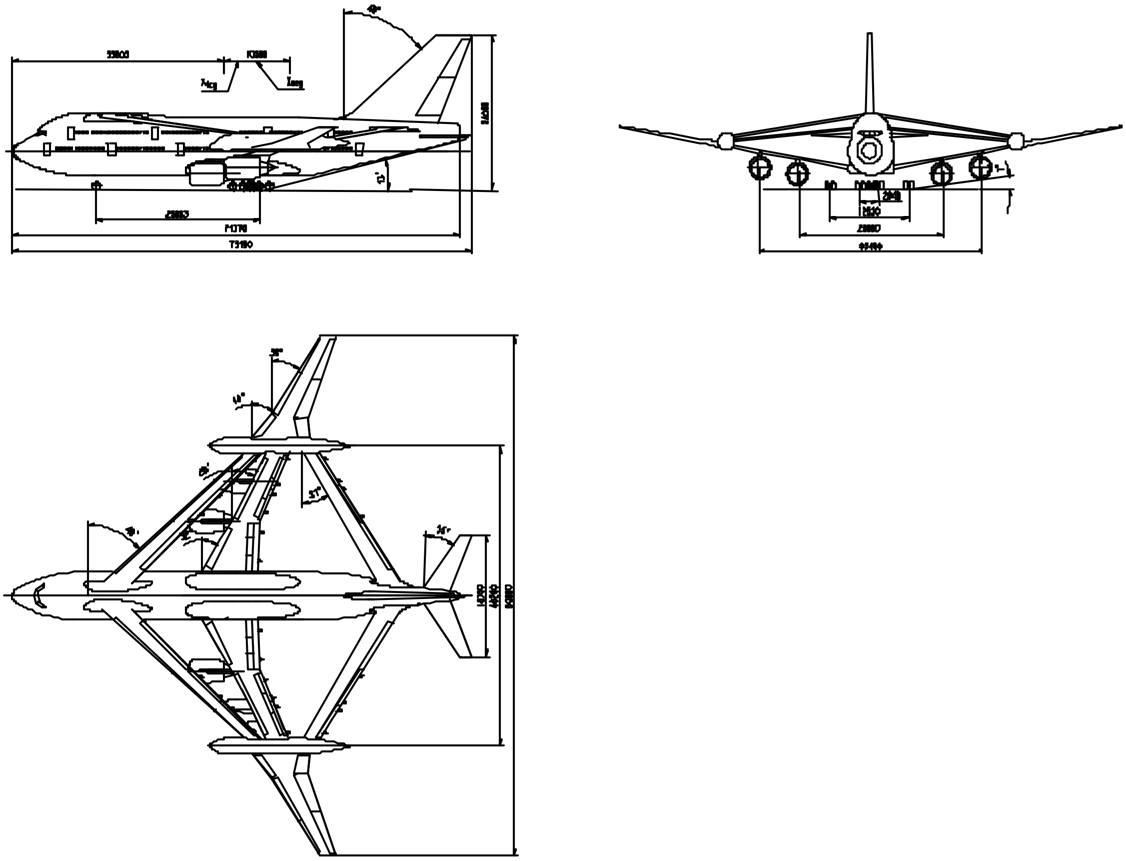


Figure 1 General view of “Polyplane”

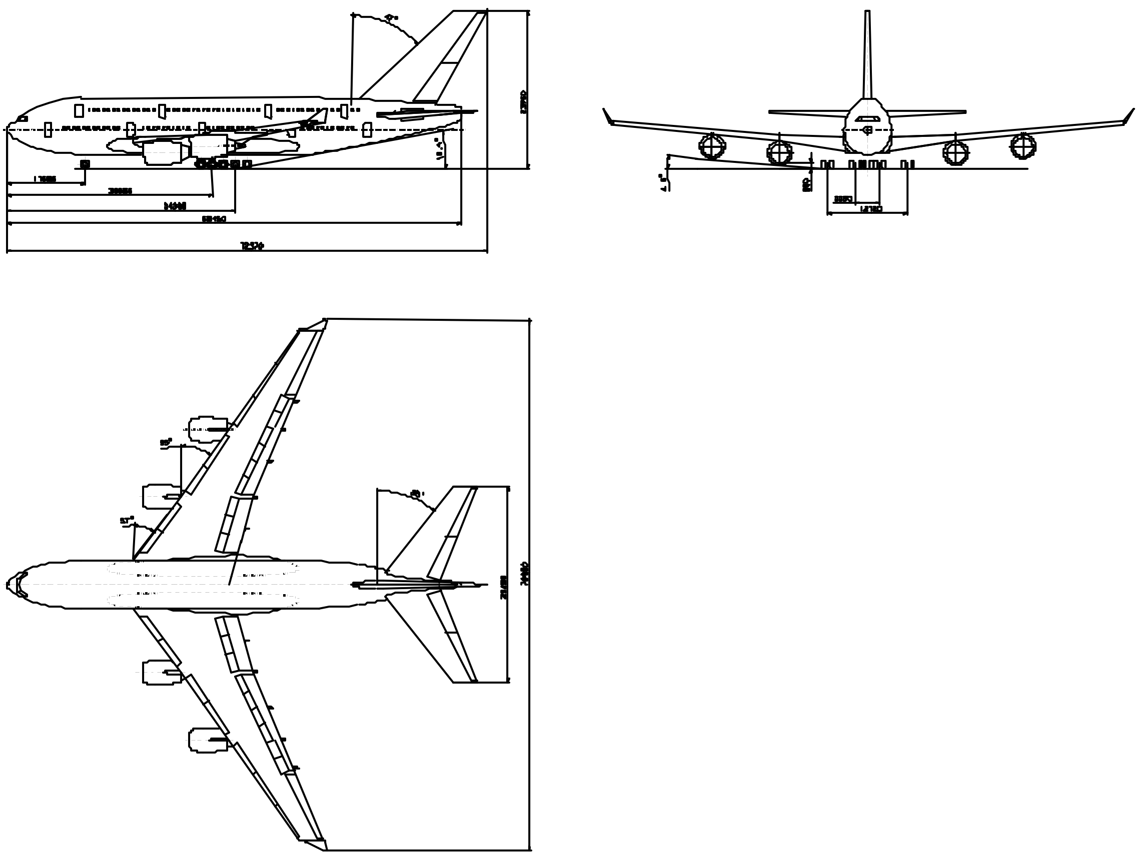


Figure 2 General view of basic aircraft

New generation of aircraft for pilot training, tourism and sport flying

Prof. Antonin Pistek - Brno University Of Technology, Czech Republic

Abstract

The Institute of Aircraft Engineering (IAE) has participated in several projects. The largest and most successful so far has been the design of KP 2U ultra-light plane, that has gone as far as the serial production and over 70 planes have been manufactured so far. The latest project of the IAE is the design of a family of General Aviation category planes that now is in the stage of construction and technology preparations. The project is supported by a grant of the Czech Ministry of Industry and its management is fully in the competence of the IAE. Chief designer of the project is the Head of the IAE, Prof. Ing. A. Pistek. The project team includes the IAE staff members, graduate and Ph.D. students, and external partners from the Brno University of Technology (BUT) and collaborating companies. In order to secure the realisation of the project, a consortium of Czech aircraft industry companies, headed by the IAE, was established.

The IAE contributes to the project mainly in the area of:

- Aerodynamics analysis,
- Flight characteristic s, performance and aero elasticity computations
- Selected parts of the strength analysis (landing gear, seats)
- Strength tests of the airframe
- Strength tests of the seats
- Fatigue tests of the airframe.

The project supporting activities are carried out in semestral, diploma and doctoral theses, research work and primarily through experiments for the certification of the static, fatigue and flight tests of the plane. The IAE has developed the experiment basis, licensed by the CAA CR and the results of the experiments can be used in the process of certification. Technical documentation, technology and manufacturing are ensured mainly through collaborating companies, members of the consortium.

The project is supported also by the activities of the Aerospace Research Centre (ARC) established at the IAE in 2000. The Centre covers the whole range of aeronautical research and design. Mainly doctoral students carry out the activities.

Conception of the VUT 100 new generation aeroplane family

The core of the family is the VUT 100 plane, intended for basic and advanced training of private and military pilots, night and instrument flying, general commercial use, tourism and sport flying, aero-towing and various other specific purposes that cover a significant part of the General Aviation category.

Technical description and data of VUT 100

VUT 100 is a new generation of four- to five-seater designed in accordance with JAR-23/FAR-23 regulations. Light, multi-purpose, single engine, all metal, low wing aircraft with 2+3 seating arrangement and retractable three-wheel landing gear. The VFR and IFR operation is assumed.

GENERAL DIMENSION

Length	8,03 m	Height	2,9 m
Wing span	10,2 m	Wing area	13,1 sqm

Weights

Max. TO Weight	2780 lb	Empty weight	1250 lb
Fuel capacity	340 l	Useful Load	1260 lb

Performance

Max. level speed	168 kts	Max. cruise speed	150 kts
Stall speed	50 kts	Range	1080 NM

Power plant

Engine	LOM M 337 A	Power (MTO)	210 HP
Propeller	LOM V 546 3-blades	constant speed D=1,85 m	

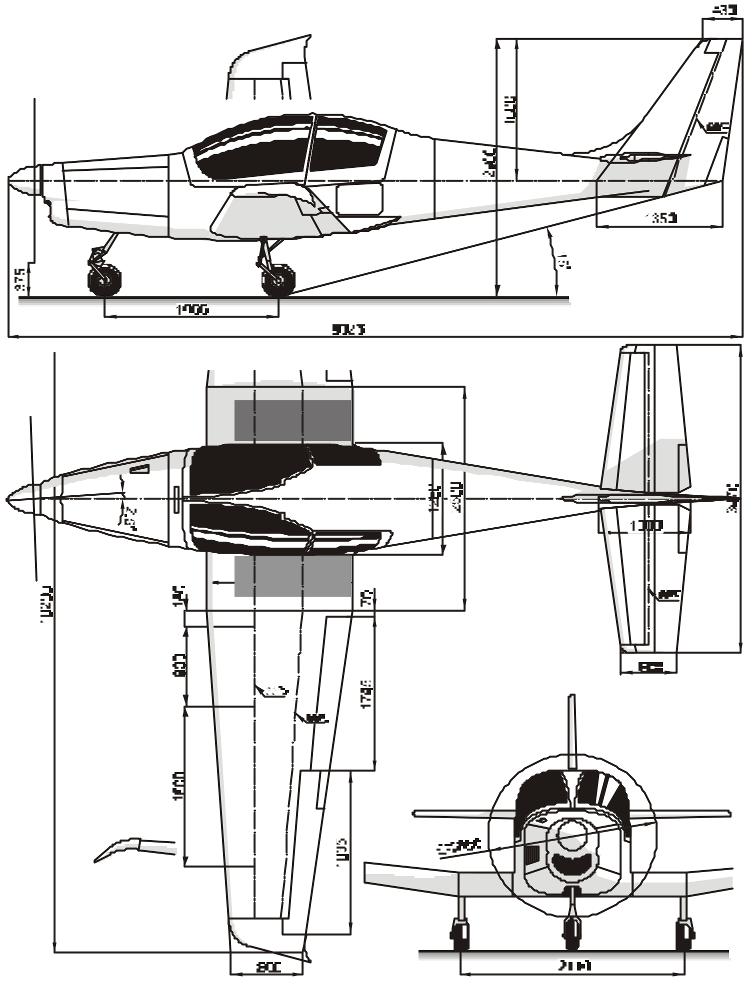


Figure 1 Three view of the aeroplane VUT 100

From Specification & Design Layout to Control Law Development for Unmanned Aerial Vehicles – Lessons Learned from Past Experience

Zdobyslaw Goraj – WUT, Poland
Philip Ransom, Paul Wagstaff – Kingston University, UK

The first Unmanned Aerial Vehicles (UAVs) entered service in the sixties, but it has been only recently that their potential, particularly for military applications has become apparent. As in many other aviation sectors, development has been driven by military requirements, for which the operational success of the intended mission is the most important design criterion. For civilian use, the most important criteria are safety of operation, respect for the environment, economic in operation as well as successfully fulfilling its planned role. A successful design will have a clearly defined mission and flying characteristics, carefully considered design layout, redundancy of sensors and computers – triplex or sometimes quadruplex systems - modern guidance and control that is either a pre-programmed/remote controlled system or a pre-programmed/autonomous system.

The causes of system malfunctions leading to the loss of an aircraft are often not detected because data transmission to the controller ceases at a critical moment. Typical examples are quoted below:

- "The Global Hawk was in its landing sequence when there was a control surface malfunction immediately followed by a data link break. The communication link was quickly re-established, but then the aircraft was already in a flat spin, as part of its selfdestruct program, and unrecoverable." – Aviation Week & Space Technology, Jan.7, 2002;
- "On 22 April, 1996, DarkStar AV#1 crashed on its second flight. A thorough investigation by an independent review team identified the accident's cause as interactions between the landing gear and the vehicle's inertia which caused an undamped oscillation, the so-called "porpoise". The low moment of inertia exacerbates the pitch motions and the only damping was the tires, and any disturbances would cause the porpoise." – Unmanned Vehicles, May 1998;
- "At least two of the three Predators downed in Afghanistan in September & November 2001 were lost due to icing of pitot tube, a problem that plagued the aircraft during operations in Balkans." - Aviation Week & Space Technology, Nov.12, 2001.

In order to simulate or analyse these malfunctions a knowledge of the UAV's performance characteristics and configuration is required. However such information is classified and not generally available. Limited performance data, overall dimensions, weights etc may be gleaned from published material, for example from technical journals, manufacturers' publications and appropriate web sites.

Future designs must take into account experience derived from previous UAVs. Using the data sources given above, a data base has been set up for Global Hawk, Predator, Hunter and other UAVs. From this information it has been possible to compute and analyse a range of performance characteristics including flight envelopes, fundamental performance, natural modes of vibration, gust sensitivity and some dynamic responses. This has enabled some comparisons to be made. Additionally pro-spin tendencies have been analysed, but these are very sensitive to post-stall aerodynamic wing characteristics. Thus the so called tail-damping power factor (TDPF) and dimensionless difference of moments of inertia cannot be a reliable indicator of spin resistance.

Based on the above analyses, a series of recommendations has been formulated, including control law development, for the preliminary design and layout of a UAV optimised for a long endurance observation mission at either medium or high altitude.

Educationally there a number useful benefits that may be derived from this analysis and design activity. These include:

- How to search for data essential for a preliminary performance assessment from secondary sources. Students at Warsaw University of Technology given basic geometrical data are required to calculate performance and dynamic characteristics. Those at Kingston University working in design teams produce performance data for their preliminary designs which may be validated on a flight simulator.
- How to allow for uncertainty in data which may be unreliable.
- How to reconcile the design philosophy for manned and unmanned aircraft.

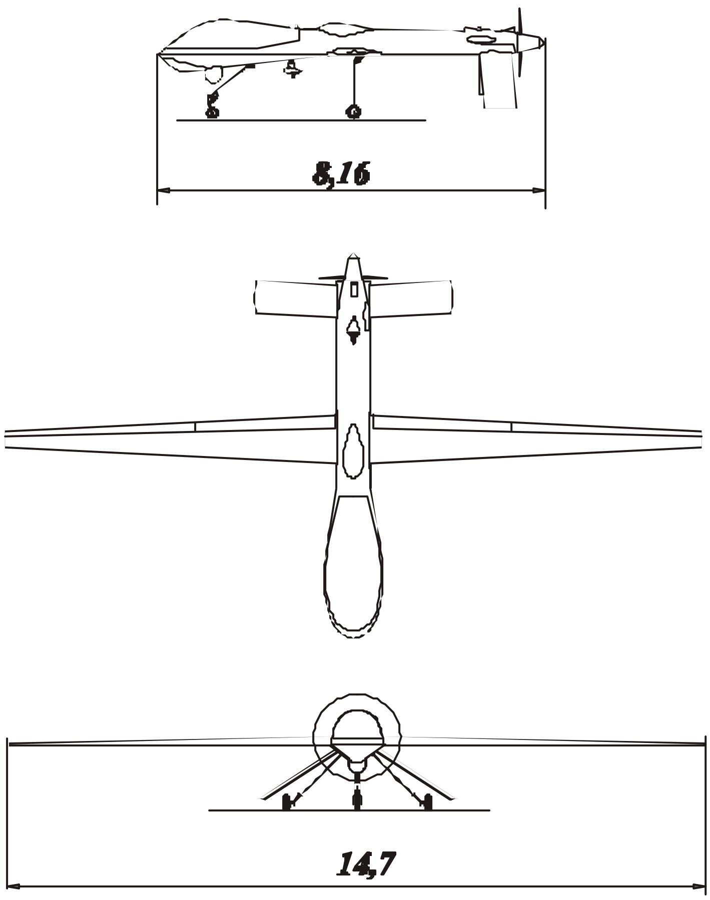


Figure 1 Predator RQ-1B – general arrangement

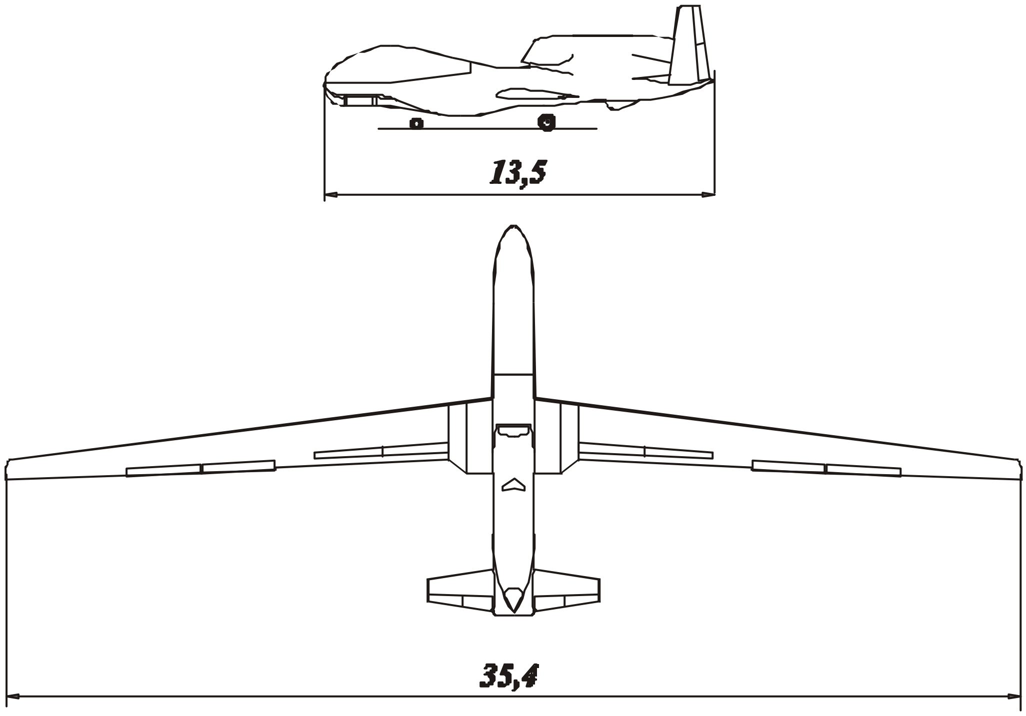


Figure 2 GLOBAL HAWK – general arrangement (configuration based on Website sources)

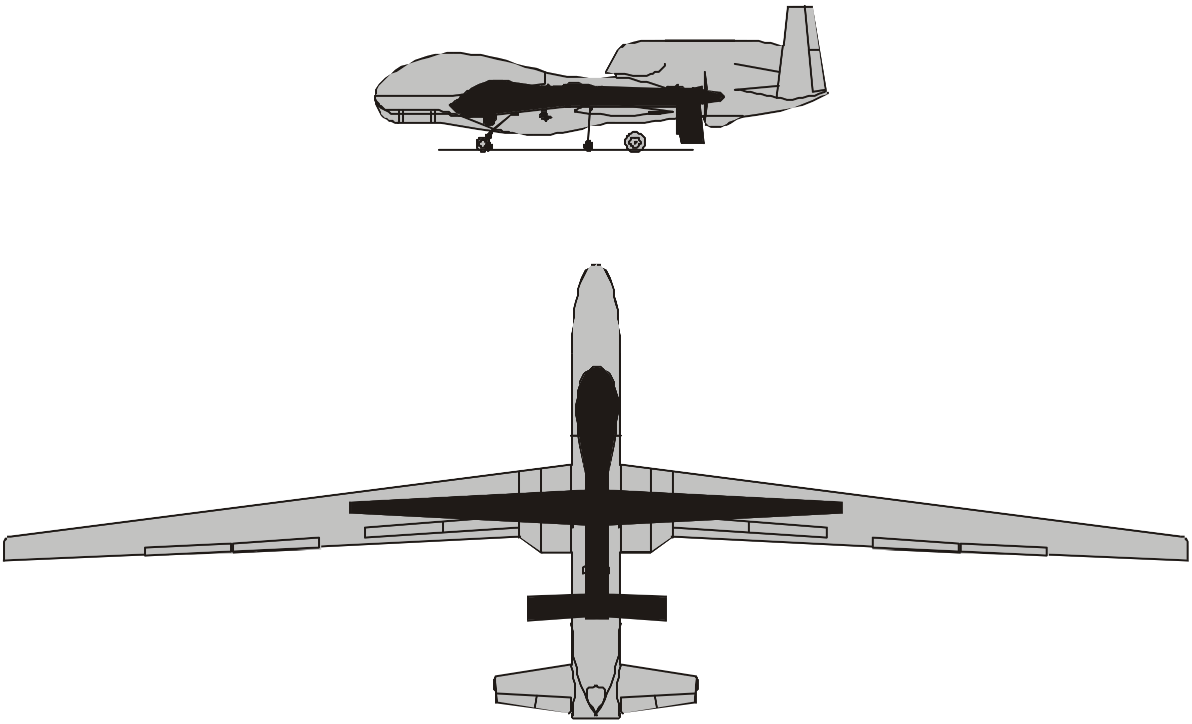


Figure 3 GLOBAL HAWK & Predator RQ-1B – comparison of view plans

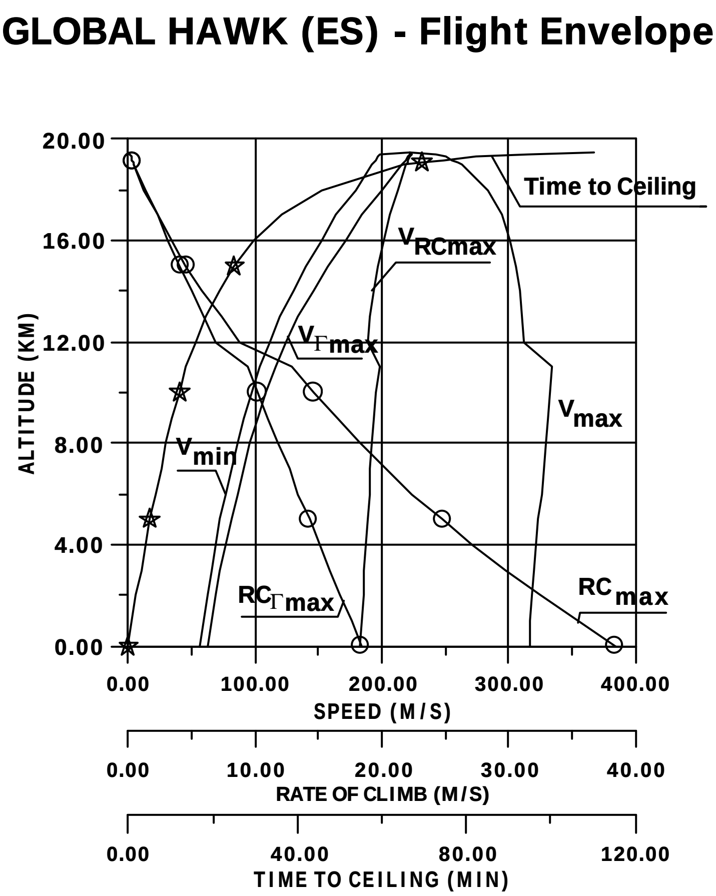


Figure 4 GLOBAL HAWK – flight envelope, time to ceiling, steepest & fastest rates of climb

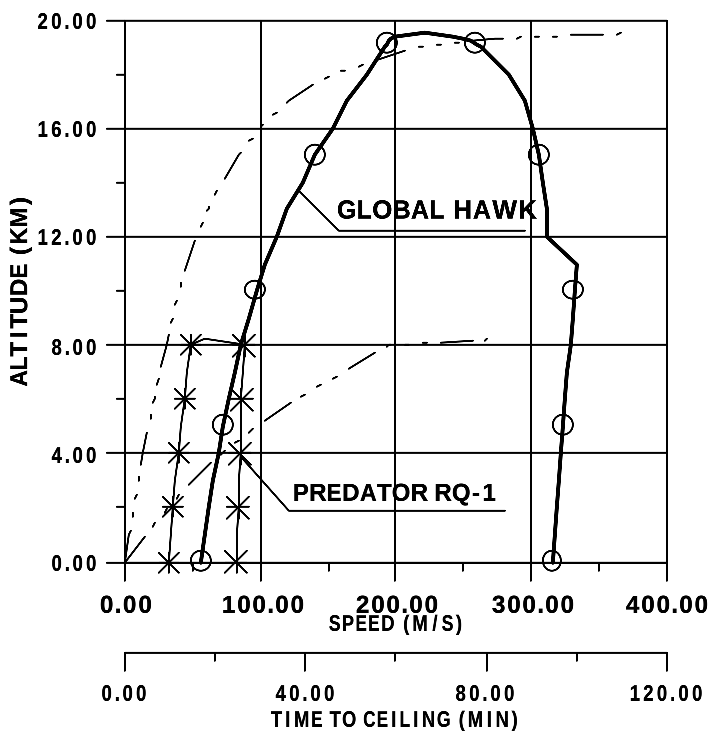


Figure 5 Global Hawk & Predator – flight envelopes

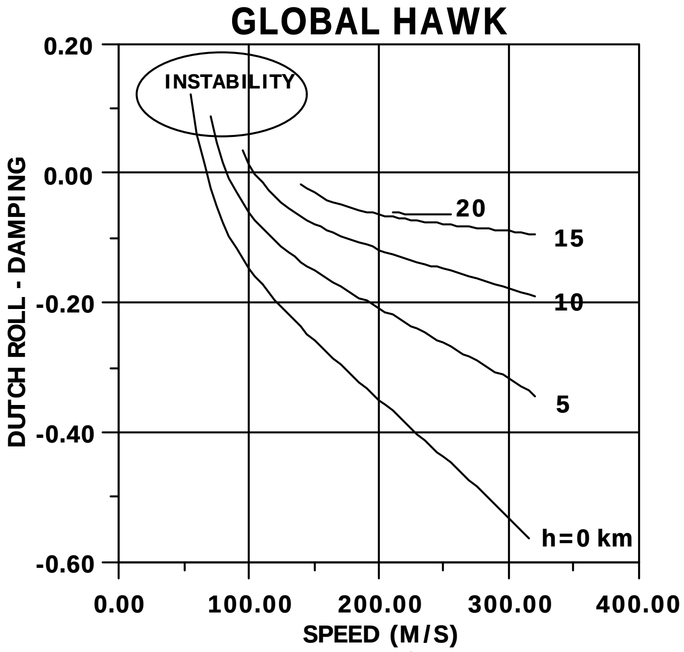


Figure 6 Local instability of Dutch Roll mode

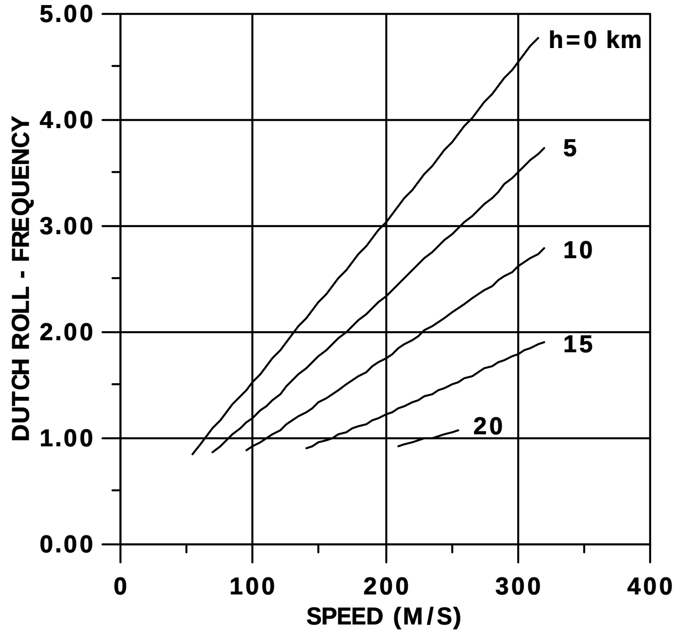


Figure 7 Frequency of Dutch Roll mode of GLOBAL HAWK

Some of these problems are addressed, investigated and financially supported by European Union in the Thematic Network Project UAV-NET, entitled "Civilian UAV Thematic Network: Technologies, Applications and Certification", related to the Key Action 4: New Perspectives in Aeronautics. The Project No is GTC2-2000-33017.

Using Tornado, Didactics in the Aeronautical Education at KTH

Tomas Melin – Royal Institute of Technology (KTH), Sweden

Introduction.

In the undergraduate aeronautics education, the fundamental phenomena that are being addressed requires both mathematical rigor and, equally important, an artistic panache in their description in order to provide the students with a good mental model.

From this viewpoint, the academic and industrial objective differ in the sense that in education the final product is a mental model while the industrial product often is a more packaged model in the form of compiled software, technical reports or a physical product.

To accommodate the scholastic demands a set of goals as presented below serves as a guideline in finding the appropriate methods in the learning problem.

Goals.

- Communicate the physical principles behind the aerodynamic phenomenon.
- Create an understanding of the available methods of analyzing aerodynamics.
- Give working knowledge with the numerical implementations of the methods.
- Provide a large number of handles towards adjoining disciplines.

In essence, the student should leave a class with more unanswered questions than the student had before class. Provided of course, that these are new questions.

Methods.

In order to work towards these goals the aerodynamics division at KTH utilizes programming exercises with the students as course work. Because of the complex problem formulations the students are provided with a number of aerodynamics tool structures. The selected platform is MATLAB due to its: platform independence, intuitive user interface, and standard syntax.

One of the applications provided in the tool structure is the vortex lattice method

Tornado

Tornado is a 3D-vortex lattice program that supports a wide variety of planforms with a infinite number of lifting surfaces. The wake is allowed to skew to accommodate the free stream. In the current version the outputs are: force vector acting on each panel, pressure distribution plots, aerodynamic coefficients in both body and wind axis. Stability derivatives with respect to angle of attack, angle of sideslip, angular rates and rudder deflections.

As the source code is open and available under the GNU General Public License, the students are encouraged to make their own modificatios, and/or add functions to the basic program in order to accommodate their sought results. This approach relives the student of some the drudgery work usually accompany programming. Especially with the aircraft geometry definition functions, that correspond to half to two thirds of the total code volume.

As Matlab is very generous in providing easy plotting functions in a vide variety of forms, the students can follow the numerical model graphically in a step by step fashion. This means that the time required to master the input interface of Tornado is minimized. Figure 1 shows two different geometries used in Tornado, a Boeing 747 and a Cessna 172. Figure 2 shows sample results of an alpha sweep on a oblique wing with 20 degrees of sweep.

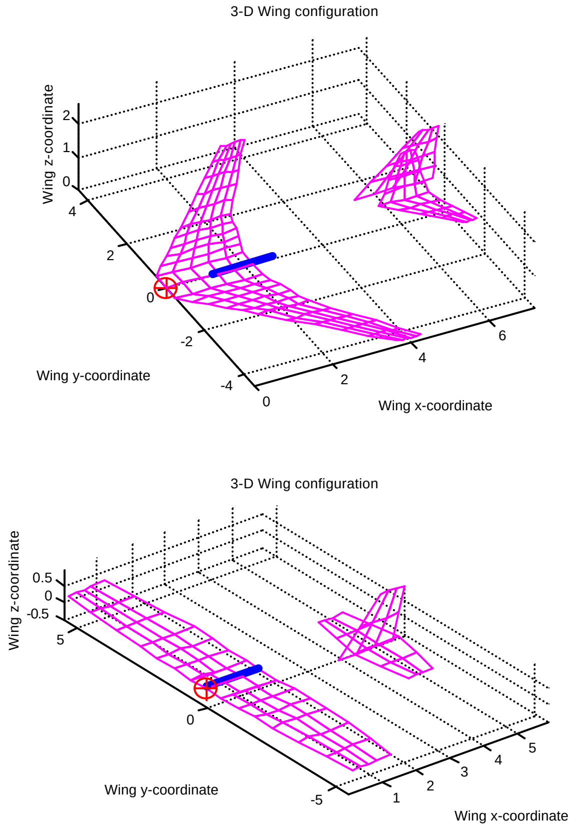


Figure 1 Different example aircraft geometries in Tornado

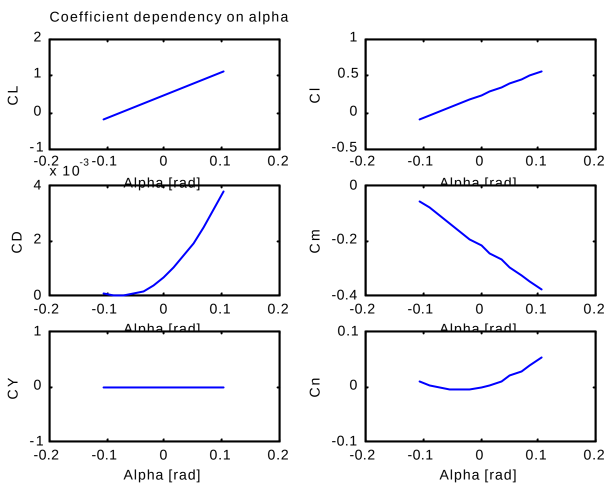


Figure 2 Sample alpha sweep output

Worldwide response.

Tornado has also become popular at other research establishments, such as Virginia Tech in the USA. Tornado is used in the undergraduate education there, where the students are currently working with developing supersonic module. Tornado can be downloaded from the Internet at:

http://www.flyg.kth.se/Tornado/htm/tornado.htm

Use of "Scenario Methods" in the Education for Aircraft Design

Dieter Schmitt - Technische Hochschule München, Germany

Compared to other industries, the aviation sector is characterized by long product cycles and a complex marketing environment. Both aspects have to be considered by the airplane manufacturer in order to define their product strategy in a sustainable and profitable way. The development of robust requirements for future products combined with a set of different market possibilities are essential element for a balanced long term strategy in the aeronautical business. Business managers, acting in the strategic departments, will need a set of instruments like Scenario methods, market forecast techniques and future trend analysis, to develop their robust strategy.

At the Technische Hochschule München, a student course has been developed, which explains the scenario methodology and involves all student to actively participate in this scenario process.

To be as realistic as possible, a new subject is chosen each year for the scenario process. The course is held as workshop (three times two days with some tasks in between), where students learn and are directly involved with the development of all steps, which lead to different future scenarios. As the scenario process requires the participation of several different specialists in order to have a global view, some specialists from industry are invited, to give their input to the process.

The paper will explain on one example, how the scenario process is structured, will explain the essential steps in the process and will give results, obtained out of such a process. In the winter 2000/2001, the subject of the scenario process was dealing with "Unconventional civil aircraft configurations in 2030+". This scenario process will be used as used as example.

Free as a Bird

Patrick Berry - Linköping University, Sweden

Flight of birds has always been a great source of inspiration. Flapping flight looks so easy when executed by birds, but is as we all know very difficult to implement into an aircraft; being a challenge we decided to take a closer look at flapping flight in this year's aircraft project at Linköping University.

Why then flapping flight? There is a never ending, steady growing, interest for more information on what the other guy is doing behind the fence or around the corner; to do that it would be handy to use something of a small flying object, which is able to fly quite slowly as well as rather fast and by its size and appearance being rather difficult to detect. This would favour birdlike flight and since it's now becoming increasingly possible to really make very small UAV:s fly due to the present revolution in microelectronics (low power consumption, low weight), we thought why not giving it a try.

The goal was set up high initially: the aircraft should be battery powered and be able to fly a circuit being defined as a figure of eight at least two laps; the payload is a video camera, which should be used on the way around the circuit to transmit live pictures down to ground.

The oral presentation will give more details on the project and the result of the contest.

The Aerospace GNC Laboratory at the University of Naples “Federico II”

D. Accardo, G. Rufino, M. Russo, A. Moccia - University of Naples “Federico II”, Italy

In the latest years, a laboratory of Guidance, Navigation, and Control (GNC) of aerospace vehicles has been set up at the Department of Space Science and Engineering “Luigi G. Napolitano” (DISIS) of the University of Naples “Federico II”. It is intended to carry out both scientific research and educational activities. This has been achieved thanks to the financial support of the Italian Ministry of Education, University, and Research (MIUR), the Italian Space Agency (ASI), and Italian aerospace industries.

Given national and international interest in automatic control of unmanned aerospace platforms and smart integrated sensors, the guidance and navigation laboratory at DISIS is developing to fit advanced research trends. Besides the benefits for research activity, a relevant spin-off results for students who can gain direct experience of state-of-the-art aerospace applications. In particular, the most important currently running projects deal with the development of a star tracker for space platform attitude determination, and the fusion of GPS receiver and inertial sensor data in strapdown configuration for Unmanned Aerial Vehicles (UAVs) autonomous flight control.

The activities of the star tracker project have been addressed to two main fields: the sensor and the laboratory facilities for its validation. Both of them have concerned theoretical studies, design, performance analysis, numerical simulations, algorithm development, software implementation, design and assembly of hardware prototypes based on COTS components.

The prototype hardware model is composed by the image acquisition and processing sub-units. The first is based on commercial components: a CCD area sensor with its proximity electronics, and F/1.4 lens (fig. 1). The second one consists of an embedded pc-104 stack formed by a 233-MHz Pentium™ CPU, a frame grabber, a 32-MB solid state disk, and a power conditioning board (fig. 2).

Electronics was chosen accounting for temperature, vibration, vacuum, and harsh environment requirements for space applications. Algorithms and software routines for typical star tracker operating modes (autonomous initial acquisition, rotational velocity measurements in high-rate rotations, tracking) have been developed for the VxWorks real-time operating system in target-host architecture. This aims at producing an autonomous, mobile prototype for indoor and outdoor tests.

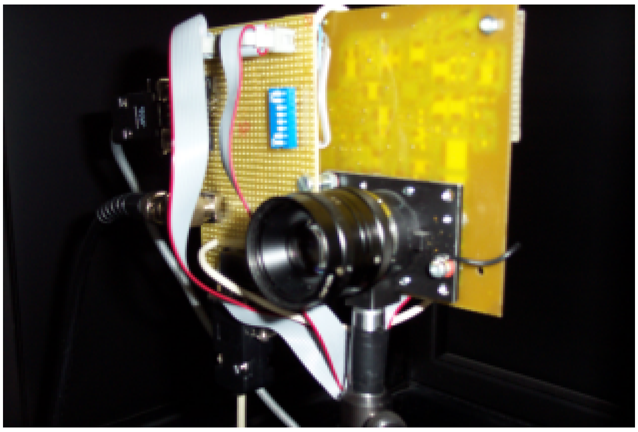


Fig. 1 - Star tracker Image Acquisition Unit

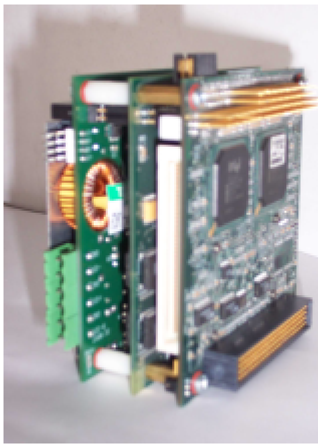
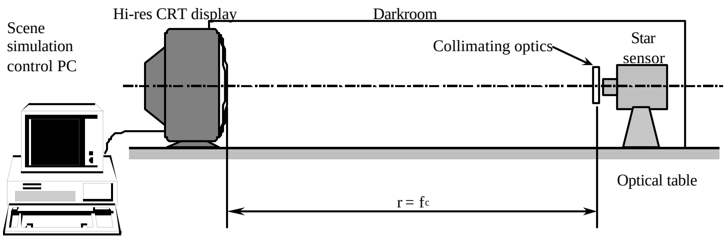


Fig. 2 - Star tracker Processing Unit

A laboratory facility for functional validation of the star tracker has been designed and set up. It is a CRT-based optical stimulator for end-to-end, full-field-of-view tests (fig. 3). The system is capable of realistic static and dynamic star field simulation, accounting for orbit and attitude of a space platform supplied as input. A considerable amount of test has been carried out, achieving validation of the instrument. In addition, it has been exploited as a case study for attitude determination educational purposes.



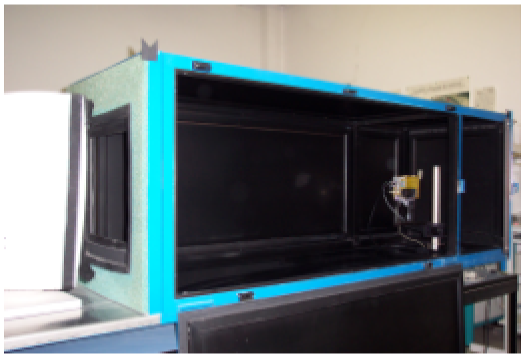


Fig. 3 – Star tracker functional validation laboratory facility

An effective tool to experiment GPS/INS strapdown integration for autonomous navigation has been realised. It is composed by an 8-channel GPS receiver and an Inertial Measurement Unit (IMU) manufactured with silicon based miniaturised sensors. They have been arranged with a mobile power unit and a notebook PC (fig. 4) for real-time testing of strapdown navigation algorithms in vehicle application (fig. 5).

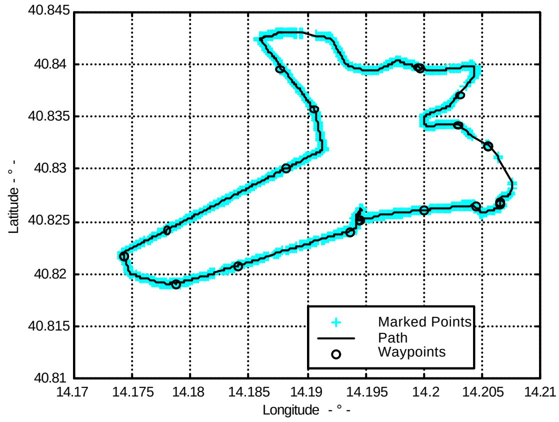


Fig. 4 – GPS/INS integrated navigation tool

Fig. 5 – Route of an outdoor GPS navigation test

This resulted to be a valid support tool not only for research purposes, but also for demonstration to navigation course students and graduation thesis work. Presently, an aircraft model is being equipped with the system to operate flight experiments. Other devices, such as digital aerodynamic sensors, an embedded computer, a radio-modem, and a digital camera as payload, will be added to the system. The final goal is the development of a fully autonomous flight control system onboard a UAV vehicle with real-time telemetry link to ground station and remote payload operation functionality. By carrying out flight test, several educational applications will come out:

- test mission schedule planning;
- set-up and tuning of the equipment for flight test operation;
- automatic flight control logic development and implementation;
- post-flight analysis and processing of the gathered data for different applications (navigation, control, payload operation, on-board resources management).

Further developments will involve the adoption of a star tracker for INS navigation aiding. Indeed, the analysis of the best configuration of the sensor for this application is under investigation to identify modifications to the developed model for its use onboard aircraft models to support the specific INS drift compensation requirements.

The laboratory of the research team is equipped with several network-connected PCs, equipped with engineering software packages (MATLAB, AUTOCAD, LABVIEW, ORCAD circuit design and simulation tools, several programming languages compilers) and hardware devices for signal acquisition, conditioning, and analysis. In addition, the laboratory is equipped with an electromechanical bench for small components integration and testing

Several software packages have been developed by the research team for:

- simulation of satellite dynamics and control;
- simulation of airborne and spaceborne sensors functioning, in particular SAR acquisition simulation and high-accuracy radar raw data processing;
- mission simulation for Earth observation satellites (flying both microwave and electro-optical sensors);
- star tracker procedures for autonomous initial acquisition (triplet-based star catalog browsing and neural approach), tracking, angular velocity vector determination during high-rate rotations; star field scene simulation, both

static and dynamic, accounting for mission orbital and platform dynamics, to be used to test star tracker procedures.

Building a Fixed Base Flight Simulator around $100 Software

T.M. Young - University of Limerick, Ireland

Building a flight simulator around $100 software written for the PC games market may on the surface be a rather strange thing for a university to undertake. FS 2002, the latest offering from Microsoft in a long line of progressively improved software, has received excellent reviews from armchair pilots around the world, since its release this year. Due to the phenomenal popularity and open architecture of this product, a vast number of third party developments are available for the program; features that make it possible to use the software in a way that is far removed from the traditional mode of play, involving a gaming joy-stick and keyboard.

The author's objective was to develop a low cost, fixed base (i.e. no motion) simulator that could be used for a number of activities, including an introduction to flying, CRM studies, and as an aid for teaching undergraduate subjects like flight mechanics, stability & control and avionics. The possibility of using it to assess the flight dynamics of student project designs was also considered, although current limitations of the software are likely to restrict this aspect.

A Boeing 707 cockpit was acquired; the airframe was sliced off behind the cockpit door. This large 4-seat cockpit was ideally suited to the development of a Boeing 737 simulator as the physical dimensions are almost the same and the additional space between the pilots' seats and the cabin wall could be utilised for an instructor station and for housing the computers. The lower portion of the cockpit - below the floor beams - was cut off and a metal frame built to support the structure. It was then stripped down to the basic metal shell; wiring, hydraulic pipes, accumulators, and electrical components were removed, but all flight control components (cables, pulleys and control rods, etc.) were left intact. The instrument panel was removed and a new panel manufactured to house six flat panel displays. These displays were selected to replicate the modern EFIS displays in a B737-800. To enhance realism, original hardware was used whenever possible. For example the undercarriage lever was removed, cleaned and reinstalled in the correct position on the new panel. The engine controls required modification by removing two of the four levers. The flap selector was reinstalled and some of the original overhead cockpit lights and switches were refurbished.

Below the cockpit floor the control cable runs were modified. The cables for the pitch and roll control were shortened, additional pulleys were installed and the cables joined to form a closed loop from the port to starboard side. A simple artificial feel system for pitch, roll and yaw commands, was developed based on the use of pneumatic actuators and pressure regulators; all mounted below the floor. Positional information of the flight controls comes from rotary potentiometers and switches; the signals are taken to a customised IO (input-output) card installed on the server PC. This card is programmed to send appropriate signals to the PC in response to the external inputs. For example if the software responds to the keystroke Ctrl U by raising the undercarriage, then the IO card can be programmed to emulate this keystroke when a signal from a hard wired switch installed on the undercarriage lever, is closed. The process works both ways. Flight data on speed, height, heading, etc., used within the program may be made available externally via the IO card. It is possible to develop a fully functional autopilot panel using this feature. (The main difficulty encountered in doing this was obtaining representative switches and lights.) The ultimate objective is to "fly" the software, designed for a standard PC, using the actual flight controls, without touching a keyboard or mouse.

The familiar display format of the PC game, where the instrument panel and the external view are shown on a single monitor, may be substantially manipulated and enhanced using freeware software, which has the ability to separate out individual parts of the display. External views (forward and 45º left and right, for example) may be placed on appropriately installed monitors whilst the instrument panel display may be split up and placed on individual screens. Three high specification PCs (with 1.6 GHz processors) simultaneously run the software, linked through a local hub. The program execution is performed on the server unit, with signals sent to the two "slaves", whose sole function is to provide the visual displays. This ensures a high frame rate and a very smooth graphics display. Each PC is fitted with a duel head graphics card permitting two different views to be simultaneously generated. When identical views are required on two screens, a "splitter" cable is used. In this way it is possible to generate four high quality displays from a single PC. A fourth PC (500 MHz processor) with a monitor, keyboard and mouse is installed at the instructor station. This provides a limited capability to chart the flight profile and monitor progress.

The current status of this project, which has been undertaken by undergraduate students, is that the primary flight controls are complete, the instrument panel and autopilot panel installed and full functionality of the software has been demonstrated. An interim solution for displaying the external views is achieved using Fresnel lenses placed in front of four externally mounted PC monitors. Some secondary controls and the backup displays are outstanding; these will be installed within the next year, as will a projected external display. An evaluation of the capabilities and limitations of the software will commence shortly. In its favour it can be said that the software has undergone a phenomenal improvement in recent years, with each new release providing more realistic scenery and better flight characteristics. With FS 2002 the distinction between home entertainment and pilot training software is starting to blur. What is assured is that future releases of the software will be even more realistic with enhanced inactive features. An adaptable simulation tool, like this one being developed in the B707 cockpit shell at the University of Limerick will find new uses, particularly as the software is Windows based, permitting students to extend the capabilities of the simulator and to evaluate new ideas at very low cost.

Aircraft Systems – Reliability, Mass, Power and Costs

Dieter Scholz - Hochschule für Angewandte Wissenschaften Hamburg, Germany

1 Introduction

Although *aircraft system design* is part of aircraft design, it seems not to be given much emphasis in *preliminary aircraft design*. Aircraft systems are considered briefly when it comes to aircraft mass prediction. The landing gear is taken account of in preliminary design, as is the problem of fuel storage. The type of flight control system (fully powered or manually actuated) may be considered. Anything else is often left to the level of more detailed design activities. **The aim of this paper is: To extend the view on aircraft system design beyond the preliminary aircraft design level** by stressing the focal points of aircraft system design: Reliability, mass, power and costs**.**

Significance of Aircraft Systems

The mass of aircraft systems accounts for about 1/3 of the aircraft's empty mass. Similarly, aircraft systems have a high economical impact: More than one third of the development and production costs of a medium range civil transport can be allocated to aircraft systems – and this ratio can even be higher in case of military aircraft. In the same proportion, the price of the aircraft is driven by aircraft systems. Aircraft systems account roughly for one third of the Direct Operating Costs (DOC) and Direct Maintenance Costs (DMC).

Historical Trends

Since the 1960th stability in aircraft silhouettes and general design concepts can be observed. Nevertheless, remarkable progress has been achieved since that time: In the same way as aerodynamics, structures, and power plants have been optimized, also aircraft systems have been gradually improved in economics, reliability, and safety. This has been made possible by a constant evolution and optimization through in service experience, research & development and also by employing new technologies. Probably the most important impact to the changes has been made by digital data processing.

2 Definition

Aircraft System:	A combination of inter-related items arranged to perform a specific function on an aircraft.

3 Breakdown

Aircraft systems are distinguished by their function. It is common practice in civil aviation to group aircraft systems according to **ATA iSpec 2200** successor of the well known Specification 100 of the Air Transport Association of America (ATA).

Table 1 Aircraft systems (**ATA iSpec 2200**)

identifier	**name of system**
21	air conditioning
22	auto flight
23	communications
24	electrical power
25	equipment / furnishings
26	fire protection
27	flight controls
28	fuel
29	hydraulic power
30	ice & rain protection
31	indicating / recording systems
32	landing gear
33	lights
34	navigation
35	oxygen
36	pneumatic
37	vacuum
38	water / waste
41	water ballast
44	cabin systems
45	central maintenance system (CMS)
46	information systems
49	airborne auxiliary power
50	cargo and accessory compartments

4 Certification

Certification requirements for aircraft systems of large aircraft can be found in various paragraphs of JAR-25 and FAR Part 25. The certification requirements are grouped into Subparts. Subpart F "Equipment" contains requirements for aircraft systems:

§ 1301 General
§ 1302 ... Instruments and Navigation
§ 1351 ... Electrical System
§ 1381 ... Lights
§ 1411 ... Safety Equipment
§ 1431 ... Miscellaneous Equipment (incl. Cockpit Voice Recorder, Flight Recorder)

Subpart E "Power Plant" also contains requirements for power plant related systems:
§ 951 ... Fuel System
§ 1195 ... Fire Protection (detection and extinguishing related to the power plant)

Subpart D "Design and Construction" contains requirements for aircraft systems:
§ 651 ... Flight Control
§ 721 ... Landing Gear
§ 771 ... Equipment / Furnishings (personnel and cargo accommodations)
§ 831 ... Air Conditioning (ventilation, heating, pressurization)
§ 851 ... Fire Protection (detection and extinguishing related to the cabin)

5 Safety and Reliability

The *safety requirements* for aircraft systems are stated in § 1309 of the certification requirements JAR-25 and FAR Part 25. The reliability $R(t)$ and the probability of failure $F(t)$ can be calculated from the failure rate λ

$$R(t) = e^{-\lambda t} \quad , \quad F(t) = 1 - e^{-\lambda t} \quad .$$

For low failure rates, as they are common in aviation, the probability of failure calculated for a period of one hour ($F(t)$/FH) equals almost exactly the failure rate λ. *Redundancy* is the existence of more means for accomplishing a given function than would simply be necessary. The *steady state availability* is defined as the probability that a system will be available when required, or as the proportion of total time that the system is available for use.

6 Mass

Mass estimation of aircraft systems is part of the mass (or weight) estimation of the whole aircraft. The mass of all aircraft systems m_{SYS} amounts to 23% ... 40% of the aircraft's operating empty mass. The figure "23%" is true in case of a modern long-range airliner, whereas 40% is about right for a smaller aircraft like a business jet. We follow a *top down approach* and get (**Scholz 2002**):

$$m_{SYS} = 0.92 \, m_{MTO}{}^{0.85}$$ for system mass m_{SYS} and maximum take-off mass m_{MTO} in kg .

Some aircraft systems, like the landing gear system (ATA 32) and the equipment and furnishings (ATA 25) account for a large percentage of total aircraft system mass. A number of systems are of minor importance for aircraft system mass predictions.

7 Power

Propulsive power for any conventional flying depends on fuel. This fuel is used in the aircraft main engines. *Secondary power* systems (hydraulic power, electrical power, pneumatic power) in turn draw on engine power to supply their client systems with *non-propulsive power* in all those cases where functions are not directly actuated by the pilot's muscles. Secondary power is also needed, due to safety requirements and the need for autonomous operation of the aircraft on the ground with engines shut down. Various *secondary power sources* are available in the air and on the ground: ground power, auxiliary power unit (APU), ram air turbine (RAT) and aircraft batteries. *Secondary power loads* may be grouped into two major categories: technical loads and commercial loads. *Power conversion* transforms secondary power from one form into another.

8 Costs and Trade-Off Studies

Trade-off studies play an important roll in the aircraft system design. *Trade-off studies* try to find the best among several system design proposals. *Safety* aspects allow no compromise because certification regulations have to be closely followed. Also *performance* aspects do not leave much room, for the reason that usually only as much performance as necessary to do the job will be allowed for. More powerful aircraft systems will unnecessarily produce *costs* – costs that add to the overall costs of the aircraft. Clearly, costs need to be reduced as much as possible to come up with a viable product. Therefore, it is the costs aspect that mostly decides in trade-off studies which system design will get on board the aircraft.

At the aircraft system level, evaluations are done in the early design stage by looking separately at various aspects:

- mass
- maintainability
- reliability
- system price
- other specific criteria depending on the aircraft system in question.

Based on these separate evaluations, the simplest way to come up with one single figure of merit for a proposal is to subjectively define a *weighted sum* of the results *based on* the *individual criteria*.

In contrast to the above approach, at the aircraft level an evaluation is traditionally based primarily on one single figure: the Direct Operating Costs, DOC. Also DOC take account of criteria like mass, maintainability, and aircraft price, but DOC combine these separate parameters unambiguously by calculating their economical implications. Subjective manipulations of the results are largely avoided in this way.

Unfortunately, aircraft DOC-methods cannot be taken "as is" to apply this advantage to an aircraft system evaluation. In contrast to aircraft DOC methods, a DOC method on the systems level must incorporate many system-specific parameters. Therefore, a *DOC method for aircraft systems* called DOC_{SYS} has been developed (**Scholz 1998**) which follows the principles of aircraft DOC methods as closely as possible, while taking aircraft system peculiarities into account as much as necessary.

In contrast to the method outlined above, a method by **Shustrov 1999** combines system mass effects and effects related to the system's energy consumption to a quantity called *starting mass*.

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Simulation Based Optimisation

Petter Krus – Linköping University, Sweden

Modelling and simulation is of crucial importance for system design and optimisation. In aircraft, simulation has been strong in the area of flight dynamics and control. Modelling and simulation of the hydraulic systems also has a long tradition. The rapid increase in computational power has now come to a point where complete modelling and simulation of the sub systems in an aircraft is possible and also to use such a model as a basis for system optimisation.

There are several levels of design from requirement analysis and system architecture down to detail design. There is a clear danger that systems engineering activities are performed only at the top level of a design. In order to have an impact on the product development process it must, however, permeate all levels of the design in such a way that a holistic view is maintained through all stages of the design. This can be achieved if all design teams can work towards a common system model where the subsystem designs can be tested in an environment where the interaction with other sub-system and the whole aircraft can be studied.

Using the HOPSAN package (developed at Linköping University, Department of mechanical engineering) an actuation system control surfaces can be simulated using a flight dynamics model of the aircraft coupled to a model of the actuation system. In this way the system can be optimised for certain flight condition by "test flying" the system. The distributed modelling approach used, makes it possible to simulate this system much faster than real time on a 650 MHz PC. This means that even system optimisation can be performed in reasonable time.

An aircraft can to some extent be regarded as a heterogeneous system in that different parts eg wing, tail, propulsion etc are regarded as separate components with interaction. It also contains heterogeneous subsystems in different disciplines such as the hydraulic, electrical and fuel system. The engines can also be treated as such. This means that the aircraft model can be built in a more or less modular fashion.

A considerable effort has been made to develop methods suitable for simulation of systems. This means for example that it is possible to model basic aircraft systems, such as hydraulic system, air system and fuel system, much more efficiently than before, and that a lot of systems can even be simulated in real time. These models can also be coupled to models of flight dynamics, propulsion and flight control, to produce a more complete aircraft system model. Such a model can be used already in preliminary design, thus allowing the preliminary subsystem designs to be designed concurrently with the aircraft layout.

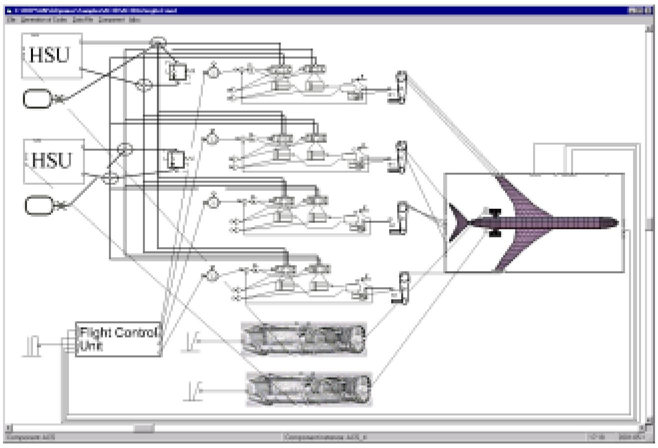


Figure 1. Simulation model with flight dynamics mode, actuator system, propulsion and flight control unit for the HOPSAN

Optimisation

If a simulation model is defined it is possible to use optimisation based on simulation. Using this method the system is simulated using a set of input signal sequences. The objective function could be to minimize the error in a certain node or nodes compared to a reference trajectory. Although this method may sound very time consuming it has some attractive features. Perhaps the most important is that it is possible also to include dynamic properties that can be optimised

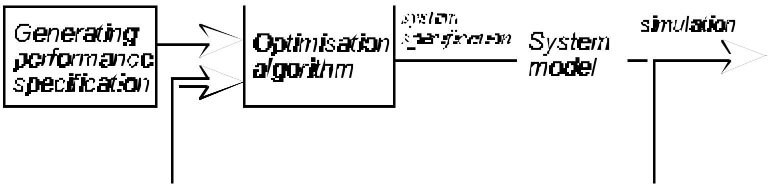


Figure 2. Optimisation based on simulation.

Tools-requirements

In order to handle modelling and simulation of large systems here are a range of requirements that need to be fulfilled:

- Object-oriented, to handle complexity in modelling
- Tool independent, modelling language to ensure longevity of the models.
- Database-technology to handle complexity in simulation data (and modelling).
- Distributed modelling for robustness and linear scaling properties
- Co-simulation capability, for flexibility

If simulation based optimisation is to be used there are also other considerations:

- Very strong emphasis on simulation speed.
- Deterministic simulation times are highly desirable.

Some simulation runs done in optimisation can result in very strange sets of parameters as the parameter space is searched for the optimum solution. This can result in system that are highly dynamic which can result in very long simulation runs if automatic variable time steps are used in the simulation. Therefore methods using fixed time step are desirable. The time step may, however, be different in different subsystems instead.

These requirements has resulted in the following strategy that is adopted for the development of the HOPSAN package:

- Modelling on a detailed equation level using a symbolic math package to generate implementation
- The distributed modeling approach for partitioning of systems
- Different time step for different parts of the model

XML

There is also ongoing development with the prime objective to introduce a model centric architecture as opposed to the traditional tool-centric architecture. The extensible markup language XML is a prime candidate for defining tools independent model-structures. The XML technology is characterized by the fact that is made to be transformable. There are transformation tools XSLT that can convert a XML-document based on one schema (format) into another a document based on another schema, or into any other arbitrary textual form. XML allows for a highly modular approach of system development, since the different tools can interact with the same model. XML also has a great potential beyond simulation. Defining an XML-schema for aircraft (eg AircraftML) could be a very useful thing since it would allow easy transfer of aircraft definitions between different tools.

EASN – The European Aeronautical Science Network

Dieter Schmitt - Technische Universität München, Germany

The EASN initiative has started in 2000, when several European universities with strong aeronautical research activities were complaining in Brussels, that they have little or no chances to submit own research proposals within the 5th framework programme. The European Commission reacted and started an initiative, called EASN (European Aeronautical Science Network).

Main goal of this project is to intensify the cooperation between European Universities as well as between Universities and Industry and Research Establishments in Europe in the context of the future European framework programmes.

3 main tasks should be developed within the next three years:

- Establish a database of the European aeronautics universities, classified with respect to their interests and skills, research activities and geographical regions.
- Establish thematically oriented ”Interest Groups” with strong expertise on related scientific and technological subjects
- Establish “Center of Excellences” specializing in key aeronautical areas, particularly in countries and regions with less developed aeronautical industry.

The EASN project is structured in 5 regional groups and will be coordinated by the Universities of Cranfield (UK), Chalmers (S), ENSMA (F), Munich (D) and Patras (GR). The paper will outline the structure and activities in more detail.

Aerospace Research Centre in Brno University of Technology -goals, organisation and project activities

Prof. Antonin Pistek - Brno University Of Technology, Czech Republic

Introduction

At the beginning of year 2000 Ministry of Education, Youth and Sports (MSMT) set a program named “”Research Centres“ (RC). Aviation was represented by the project “Aerospace Research Centre” (ARC). Founding organisations are: Institute of Aerospace Engineering FME BUT in Brno as the project leading institution, Aeronautical Research and Test Institute, plc (VZLU) in Prague and Aerospace Division of Institute of Automotive & Aerospace Engineering FME CTU Prague as the co-leading institutions. Structure of the organisation is shown in Figure 1.

Goals of ARC project

Basic goals and principles of the ARC project is to establish research centres as new element to support the science, research and development in the Czech Republic mainly in academic institutions.

The main goal in the **technical area** is the progress of chosen aviation disciplines and specialisation, from which many of them have deep impact to the line set in all economy of the Czech Republic.

In the **personal area** is concerned permanent process of professional preparation of young engineers, specialists and also scientists. This is possible in necessary quality only by interconnection of theoretical and pedagogical base of universities with application and experimental fields, which are represented by research institutes and particular companies.

Economical goals and effects of Centre formation are connected with the significance of aerospace engineering for economic contributions to whole industry.

Project contribution and impact on research and development areas

Project contributions are related to goals and can be divided into several groups.

Technical contributions can be summarised by expressive improvement of technical and expertise levels of all scientific branches, which are included in the Centre, and their highlighting to the international level.

Expressive improvement and better quality of educational process, interest enhancement of youth for technical branches and their insertion to the scientific-research activities and realisation groups give education contributions.

Fundamental change in comparison with current distributed educational system, but also with scientific-technical activities will be introduction of effective connection for educational and scientific-research process as permanent element in the education system. Significant contribution will be also realisation of this process at particular objectives and projects in cooperation with industry and also at international level. Flight photo (see Figure 2) of KP-2 U aircraft, which was developed in close cooperation with industry and aerodynamic and structural measurements are currently performed.

Project implementation manners and its schedule

In the scope of the Centre close interconnection between technical universities, scientific-research institutions and manufacturers was established based on particular projects. This interconnection will practically result in formation of scientific-research teams employing knowledge and experience of the most eminent specialists in the field on one side and invention of young engineers on the other side. In Figures 3 is shown example of output from the project of new generation aircraft family, which is being prepared for realisation and will provide the basis on which the results of particular projects of the Centre will be verified.

Research program of the Centre

The research program is structured to particular projects that cover group of as highly specialised so "universal" disciplines. Particular projects solve specialised problems of aviation and space disciplines with impact on several other disciplines.

Participation on the realisation of study programs

Standard education programs of young engineers will be significantly enriched by the scientific work on the implementation of particular projects and in specialised teams with increased responsibilities of students solving the problems. Postgraduate students represent key capacity in all institutions forming the Centre. The age structure of ARC is shown in Figure 4.

Conclusion

The aerospace research concentrates basically all science disciplines, which play important role in the technology development. If we consider other related disciplines such as meteorology, aviation medicine, psychology, navigation, flight control and others it becomes clear why the aviation has crucial importance for technological level of entire economy of the country. The concept and particular projects of ARC cover entire field of aviation and in its seeming independence present complex of disciplines that lead to practical application on aircraft up to the stage of certification.

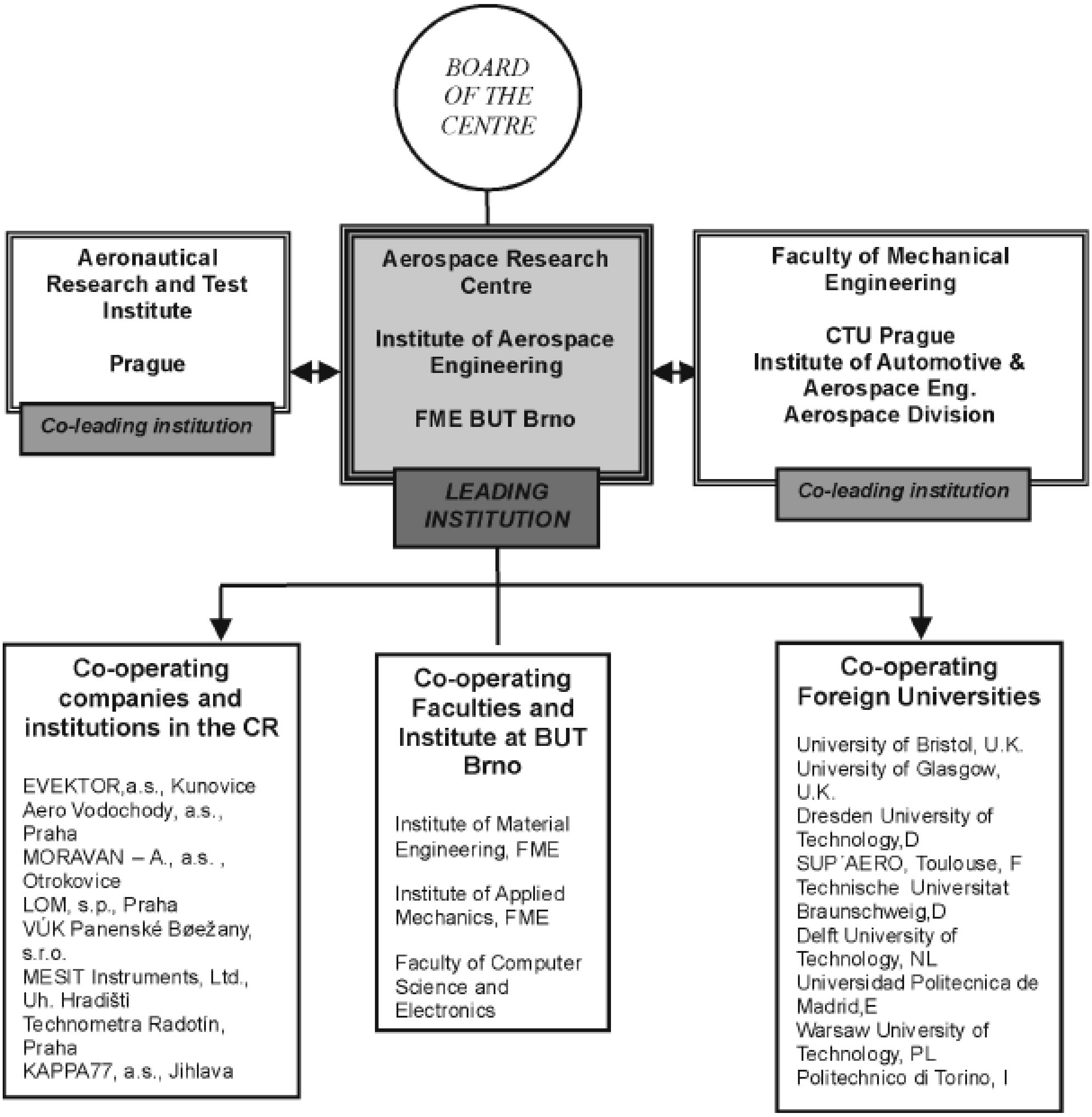


Figure 1 Structure of the organisation ARC

Figure 2 The aircraft KP-2 U, which was developed in close co-operation of IAE with KAPPA77, a.s. Company and aerodynamic and structural measurements are currently performed in ARC framework

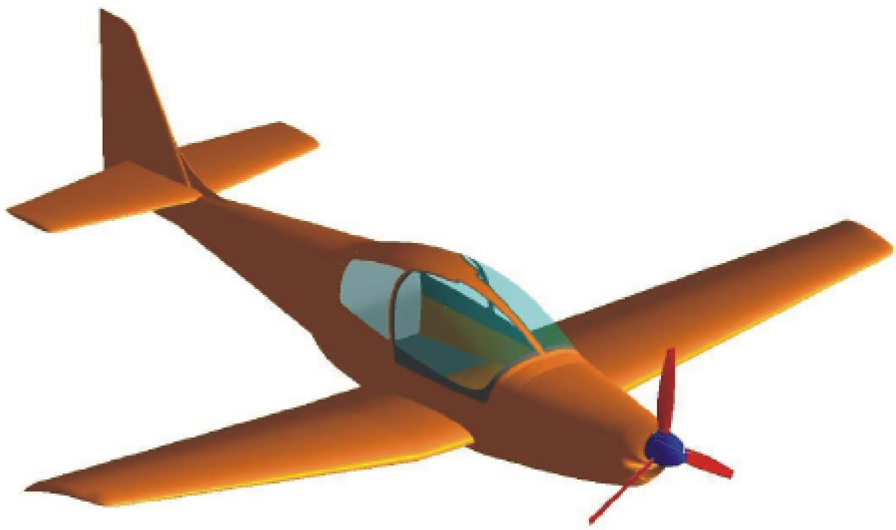
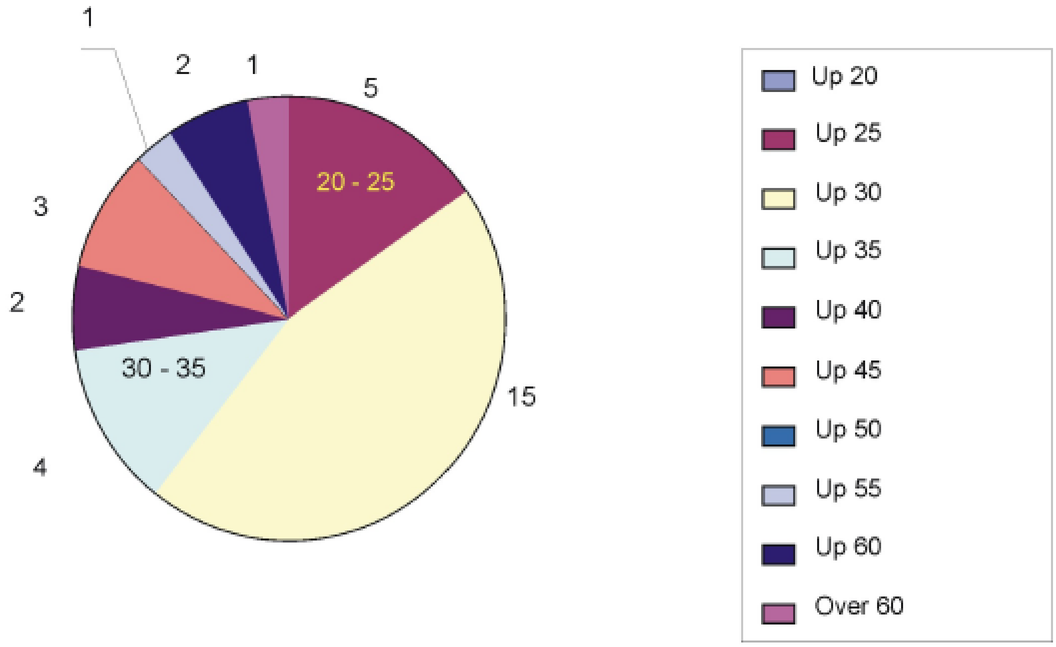


Figure 3 VUT100 – four / five – seat training and tourist aircraft of new generation. CAD – model of aircraft in software UNIGRAPHICS



Age average 34, 33 personnel

Figure 4 Employee age structure of ARC

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