# CONSIDERATION REGARDING OF THE AIRCRAFT INNOVATIVE CONCEPT

**Vasile PRISACARIU, Cătălin CIOACĂ, Mircea BOȘCOIANU**

"Henri Coandă" Air Force Academy Braşov, Romania
(aerosavelli73@yahoo.com, catalin_cioacă@yahoo.com, boscoianu.mircea@yahoo.com)

DOI: 10.19062/1842-9238.2018.16.3.1

***Abstract***: *The development of the aeronautical field has also been phased by a number of innovative projects, some of which have not necessarily led to operational aircraft, and others have been a research base for a number of valid projects that have proven their technological and operating maturity.*

*The article is both an overview of the most important aerodynamic aeronautical concepts and the risks of innovative concepts as well as a presentation of CAD models of aircraft in an innovative concept.*

***Keywords:*** *innovative concept, flying wing, XFLR5, aerodynamic analysis.*

***Acronyms and symbols***

| | | | |
|---|---|---|---|
| AESA | Active Electronically Scanned Array | SEAD | Suppression of Enemy Air Defence |
| ARCA | Romanian Cosmonautics and Aeronautics Association | TRL | Technology Readiness Level |
| BWB | Blended Wing Body | UCAV | Unmanned Combat Aerial Vehicle |
| CAD | Computer Aided Design | VTOL | Vertical Take-Off Landing |
| SAR | Synthetic Aperture Radar | XFLR | XFoil Low Reynolds |

## 1. INTRODUCTION

### 1.1. Evolution

The history of aeronautics shows that aircraft have undergone rapid changes in concept, technology and operation. These changes are focused on performance gains for 1900-1939, minimizing manufacturing costs after the Second World War and on environmental impact after the 1990s. According to the literature after the first 60 years, fewer new projects appeared and the configurations derivatives have evolved from previous concepts and models [1, 2]. However, special bibliographical references provide us with a number of notable landmarks for fixed-wing aircraft in innovative concepts from the most diverse classes that have become operational or have remained at the stage of experimental models or prototypes.

In 1965, NASA developed the tilt wing (VTOL) Chance-Vought XC-142 (FIG. 1) for missions in all weather conditions [3]. The Lockheed D-21B (FIG. 2) was designed for strategic reconnaissance missions, powered by a solid-fuel rocket engine with ramjet engines for take-off [4].

Northrop Tacit Blue (FIG. 3) launched in 1978 by the USAF, the Defence Advanced Research Project Agency and Northrop Corp, had its first flight in 1982 (135 flights) demonstrating invisible radar features [5].

**FIG. 1** Chance-Vought/LTV XC-142A

**FIG. 2** Lockheed D-21B

**FIG. 3** Northrop Tacit Blue

**1.2. The current state of the innovative aeromechanical concepts**

We present in this section concepts and examples of aero mechanically innovative solutions. The diagram in FIG.4 shows innovative concepts according to the life cycle of an aircraft [7].


**FIG. 4** Innovative concept areas

The joined-wing aircraft (FIG. 5) is an innovative concept that joins the main wings at the trailing edge with sweeping forward rear wings. The rear wing or tail is used for pitch control and to support the forward wing. The joined-wing aircraft has some important advantages like lower structural weights and less drag. Further research will be done in order to develop the discoveries [8, 9].

The box wing concept is much appreciated because it has less fuel consumption compared to conventional aircraft. The reduction of induced drag may accomplish the 75 % reduction of $CO_2$. The lighter and smart materials, new technologies and alternative fuels will make the aircraft more efficient [10].

The fuel efficiency, greater endurance in the air and the large airborne tanker have determined the US Air Force to be interested in this concept for the refueling of the military jets [9].

**FIG. 5** Joined-wing concept

**FIG. 6** Blended Wing Body Aircraft

The first aircraft model of the combined body (FIG. 6) was made in 1920. In 1988, Boeing made a BWB tailless construction, the most important result being the reduction of aerodynamic interferences. Aerodynamic performance has been optimized with a fuselage that improves overall lift and reduces wing loading. Nowadays, Boeing Phantom Works, NASA and the Air Force Research Laboratory have come together to study the concept of Hybrid or Blended Body. [11, 12, 13].

The Synergys project goal (FIG. 7) was to build an aircraft which can transport their users from a location to another, in less time and at a lesser cost than airliners or automobiles. The aircraft can carry up maximum six people. The innovative technologies used by the aircraft increased the speed range and because of that Synergy is faster than a supercar but slower than an airliner. The wing-becomes-tail configuration provides outstanding stability and control by reducing drag at low speeds. The Synergy Aircraft provides: greatly reduced travel time, true passenger safety, adaptability to hybrid, electric, and other advanced engine technologies, slow landings at tiny airfields [14].

**FIG. 7** The Synergys concept

**FIG. 8** X-45 UCAV


**FIG. 9** D8 concept

The X-45 (FIG. 8) is an unmanned combat air vehicle design by Boeing in order to be used on strike missions like Suppression of Enemy Air Defence (SEAD), electronic warfare and associated operations.

The swept-wing design accomplished the goal of creating a stealthy UCAV. The aircraft has no vertical or canted tail but it has a blended fuselage and a low-mounted wing in W form.

The X-45 is equipped like Active Electronically Scanned Array (AESA), Synthetic Aperture Radar (SAR) and Raytheon radar. The sensors can identify and locate targets in real time. The UCAV can also be controlled from a ground station designed by NASA [15].

The D8 concept (FIG. 9) is a project founded by MIT in 2010 for the NASA Fundamental Aeronautics Program's N+3. The MIT goal was to reduce emissions and noise.

The D8 is a transportation aircraft which can carry up 180 passengers, with a range of 3,000 nautical miles at Mach 0.72, with low fuel flight. The aircraft matches the Boeing 737 class but the D8's wide body provides more lift than the 737, [16, 26].

**1.3. Romanian innovative concepts**

The IAR-111 (FIG. 10) is a rocket plane created for commercial suborbital spaceflights by The Aeronautics and Cosmonautics Romanian Association (ARCA). The take-off includes high acceleration, followed by a horizontal acceleration, then by a rapid ascension, to the altitude of 48.000 feet. At this altitude the external fuel tank will be dropped. The aircraft capsule can be separated from the fuselage and it's equipped with two rocket propelled parachutes for safety [17].

**FIG. 10** IAR-111 Excelsior

**FIG. 11** Airstrato

An unmanned aircraft designed by ARCA is the Airstrato. The "drone" is powered by using solar cells and internal batteries or using hybrid propulsion with power generator and batteries. The Airstrato can be controlled via satellite or GSM communication. The UAV uses a pneumatically driven catapult which allows to be launched even from ships. The Airstrato (FIG. 11) has a recovery parachute which can be used in case of emergencies. The electric motors that are used to propel the Airstrato can go from zero to full thrust in less than two seconds. The UAV has an on-board transponder that is equipped with GPS and altitude encoder [18].

## 2. ABOUT THE RISKS OF INNOVATIVE TECHNICAL CONCEPTS

Initiating innovative projects into unconventional solutions can generate completely new models or a natural evolution of previous models; these new concepts obviously can generate a high risk potential compared to existing conventional projects that have matured [21].

According to the literature [22, 23], various techniques for identifying and managing risks in technical projects have been developed, these being defined as the probability that objectives, costs or performance will not be met.

The risk assessment can be viewed through the TRL technique, becoming the standard technique for assessing the technological maturity of a project and fitting their availability to be included in the new aircraft systems.

The overall risk of the project under consideration is inversely proportional to the level of TRL, so risk is reduced as TRL increases; this approach provides an optimal framework for global risk management (FIG. 12).

For the TRL1 - TRL3 interval, the risks are high due to the uncertainties related to the development and integration of new and complex technologies. The successful and tested solution is the encouragement of research projects in universities (where there is a human resource suitable for innovation).

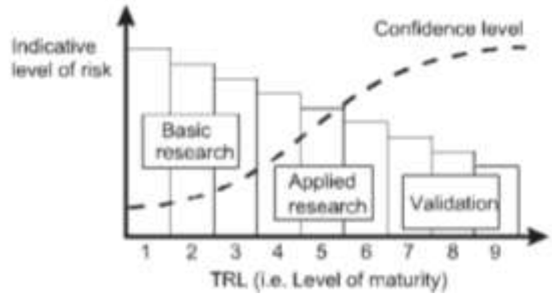


**FIG. 12** TRL vs. level of risk

The TRL4 - TRL7 interval, an intermediate level of risk level, translates from an idea to an operational application using modelling and simulation. The technological solution, once validated and demonstrated, reaches the implementation stage (TRL8 - TRL9) where the risks are less perceived due to the existence of an already functional technology. Thus, the problem of financial support is solved at this stage through the realization of public-private partnerships.

Risk characterization is done by assigning a TRL to assess the maturity level of the chosen project, and the admissible risk level of a project by including new technology or new material. It depends both on the failure of the system receiving the new technology and on the inherent failure of technology that is to be inserted. TRLs can be translated as a probability of failure or, more precisely, the probability that the system will not achieve the required goals, time, or performance values.

The innovation process implies a level of risk to be assumed (which can induce side effects) because novelty elements often rely on insufficiently developed concepts, techniques, technologies and materials, or at the limit of scientific understanding [21].

## 3. MODEL CAD OF THE AERODINAMYCS INNOVATIVES CONCEPT

The current state-of-the-art study of aeromechanical solutions for innovative aircraft has led to the CAD models shown in the figures below. Selected aerodynamic solutions can be analysed by multi-criteria or CFD investigations using freeware such as Javafoil, Qblade or XFLR5 [19, 20]. For the geometry we used the CAD tool of the XFLR5 freeware according to the following steps:

-insertion of the airfoils (FIG. 13) with database or drawing;

-geometric editing of the aircraft, with main menu (FIG. 14);

-fuselage, wing, horizontal tail, vertical tail (FIG. 15-17).

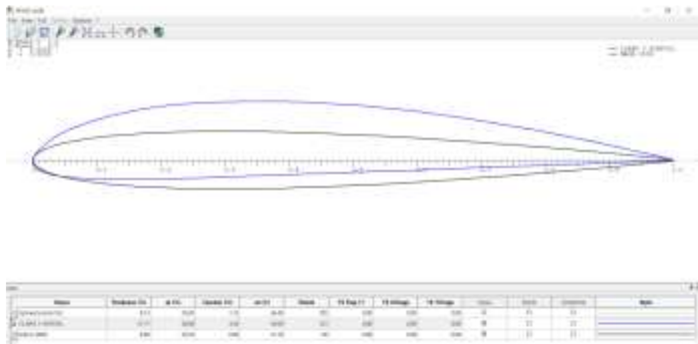

**FIG. 13** Airfoil geometry menu

**FIG. 14** Main menu for CAD design

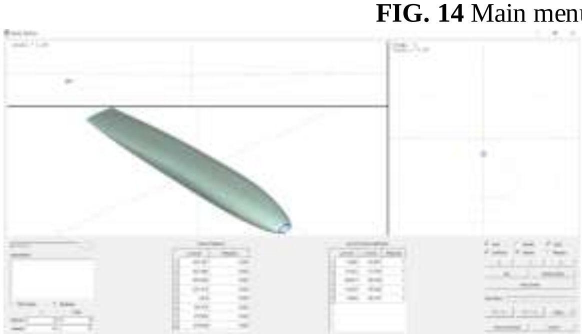

**FIG. 15** Fuselage menu

**FIG. 16** Wing menu

**FIG. 17** Horizontal tail (elevator) menu

**FIG. 18** Vertical tail (fin) menu

Figures 19-22 contain CAD models made using the XFLR5 freeware tool based on the dimensional proportions of real-world aerodynamic designs without the need for geometric accuracy.

2D and 3D freeware tools can be used to build innovative aircraft geometries, such as FreeCad [24] or Google SkechUp [25], which provide sufficient resources and export CAD files for their future use for possible numerical modelling.

**FIG. 19** D21B model CAD

**FIG. 20** Northrop Tacit Blue, model CAD

**FIG. 21** Synergy, model CAD

**FIG. 22** D8, model CAD

For the TRL1 - TRL3 interval, the risks are high due to the uncertainties related to the development and integration of new and complex technologies. The successful and tested solution is the encouragement of research projects in universities (where there is a human resource suitable for innovation).

The CAD configuration with XFLR5 provides possibilities for making 1:1 geometries or reduced scale models for aerodynamic analyses used at aerodynamic concepts or aerodynamic pre-design. XFLR5 provides geometric configuration tools that are accurate enough but with some conceptual limitations on aircraft design, such as a horizontal plane tri-planar plane, asymmetric load lifting surfaces or rotation lifting surfaces (propellers, helicopter rotors). Some of these limitations can be overcome by importing files generated by other CAD tools.

## CONCLUSIONS

Innovative projects are the product of technical creation to the extent that creative processes are tools of convergent thinking focused on solving problems or objectives in part or in full. Projects involving the initiation of innovative solutions provide new multidisciplinary and trans-disciplinary concepts that require significant human, logistical and time consuming resources.

To highlight some optimal aerodynamic features, CFD analysis can be performed taking into account several criteria: flight velocities, range, incidence, aerodynamic mean rope. Free software tools can pave the limits of future CFD analyses powered by resources that provide a higher degree of confidence such as Ansys-Fluent, Floworks/Solid Works.

This type of research, characterized by high risk of failure and high rewards, is encouraged in defence industries that enjoy consistent financial support.

The overcoming of decisional rigidities generated by the unknown ensures the premises of technological domination in a strategic field: aviation.


## ACKNOWLEDGMENT

This article was produced with the support of the "Henri Coandă" Air Force Academy and the documentation of the complex project, acronym MultiMonD2, code PNIII-P1-1.2-PCDDI-2017-0637, contract 33PCCDI / 2018 funded by UEFISCDI.


## REFERENCES


[1] Murman, E. M., Walton, M., and Rebentisch, E.,Challenges in the better, faster, cheaper era of aeronautical design, engineering and manufacturing. The Lean Aerospace Initiative Report, Series RPOO-02, Center for Technology, Policy, and Industrial Development, Massachusetts Institute of Technology, MA, September 2000;

[2] Kroo, I. Innovations in Aeronautics. AIAA Dryden Lecture, 42nd AIAA Aerospace Sciences Meeting, 5–8 January 2004, Reno, NV, AIAA paper 2004-0001, pp. 1–11;

[3] http://upload.wikimedia.org/wikipedia/commons/b/b5/Ling-Temco-Vought_XC-142A.jpg;

[4] http://www.wvi.com/~sr71webmaster/d21~1.htm, accesed at 14.10.2018;

[5] Grier P, The (Tacit) Blue Whale, Airforce Magazine, august 1996, available at http://www.airforcemag.com /MagazineArchive /Documents/1996/August%201996/0896tacit.pdf;

[6] Prisacariu, V. Boşcoianu, M. Luchian, A., Innovative solutions and UAS limits, Review of the Air Force Academy No 2 (26) 2014, 51-58 p;

[7] Harijono Djojodihardjo , Kim Ern Foong, Conceptual Design and Aerodynamic Study of Joined-Wing Business Jet Aircraft, Department of Aerospace Engineering, Faculty of Engineering, Universiti Putra Malaysia, 16 p;

[8] http://orbitalvector.com/Aircraft/Box%20Wing%20Jets/BOX%20WING%20JETS.html;

[9] Schiktanz D., Scholz D.,Box wing fundamentals – An aircraft design perspective , Hamburg Universitz of Applied Sciences, 15 p;

[10] Smith H., Fielding J.P. , New Concepts for Environmentally Friendly Aircraft, Cranfield University UK,24p;

[11] Shilpa Isabella D'souza, An Analysis of the Developments in Blended Wing Body Aircraft for Sustainable Aviation, University of Toronto Institute for Aerospace Studies, 11 p;

[12] Liebeck, R. H., Page, M. A., Rawdon, B. K., Scott, P. W., and Wright, R. A., "Concepts for Advanced Subsonic Transports,", NASA CR 4624, Sept. 1994. 3 Lieb;

[13] https://www.aero-mag.com/box-tail-wing-developments-synergy-aircraft/, accesed at 15.10.2018;

[14] http://www.airforce-technology.com/projects/x-45-ucav/, accesed at 15.10.2018;

[15] Drela M., Development of the D8 Transport Configuration, MIT Aeronautics and Astronautics 29th AIAA Applied Aerodynamics Conference 30 Jun 11;

[16] http://www.arcaspace.com/en/iar111.htm, accesed at 14.10.2018;

[17] http://www.airstrato.com/en/explorer.html, accesed at 15.10.2018;

[18] Hepperle M., Javafoil user's guide, 2014, p24, available http://www.mh-aerotools.de/airfoils/java/ JavaFoil%20Users%20Guide.pdf;

[19] Drela M., Yungren H., Guidelines for XFLR5 v6.03 (Analysis of foils and wings operating at low Reynolds numbers), 2011, available at http://sourceforge.net/projects/xflr5/files;

[20] Young T.M., Aircraft design innovation: creating an environment for creativity, 2007, Proc. ImechE Vol. 221 Part G: J. Aerospace Engineering, DOI: 10.1243/09544100JAERO129;

[21] Chapman, C. and Ward, S. Project risk management: processes, techniques and insights, 1997 (John Wiley & Sons, Chichester, UK);

[22] Crossland, R. J., Sims Williams, J., and McMahon, C. The practical application of design risk assessment models. J. EngngManufact., 2003, 217, 227–234;

[23] https://sourceforge.net/projects/free-cad/, accessed at 16.09.2018;

[24] https://www.sketchup.com/download, accessed at 16.09.2018;

[25] Drela M., Development of the D8 Transport Configuration, Paper 2011-3970, 29th AIAA Applied Aerodynamics Conference, 27–30 June 2011, Honolulu, HI.