FUTURE OF AEROSPACE

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A absolvit în anul 1997 Facultatea de Inginerie Tehnologică la Universitatea „Transilvania" din Braşov, secția Constructii aeronautice. A lucrat ca inginer proiectant la: SC Cambric SRL – Braşov (1998-2000), OMF Aircraft – Germania; INA Schaffler – Germania, CAE Inc – Canada (pentru avionul Airbus A320 şi elicopterul Agusta A109), CTT System AB – Suedia (pentru avioanele Airbus A380 şi Boeing B767), Bombardier Aerospace – Montreal, Canada (pentru avionul Global Express G 5000) şi EADS la Manching în Germania (pentru avionul militar Airbus A400M).

REZUMAT. Lucrarea prezintă aspecte privind stadiul actual şi perspectivele de viitor ale aeronauticii în lume, prin aplicarea în practică a recentelor cercetări din domeniul aeronavelor.

Cuvinte cheie:

ABSTRACT. The paper presents based on the present status, aspects and future prospects of the aircraft in the world, through the practical application of recent research in the aircraft field.

Keywords:

More than a hundred years have passed since first recorded flights.

A few milestones of the "beginnings":

- Clement Ader, France, October 9, 1890 – first manned, powered, heavier-than-air flight
- Otto Lilienthal, Germany, 1891 – first controlled glider
- Orville & Wilbur Wright, United States, December 17, 1903 – first controlled, powered, sustained heavier than air flight.
- Traian Vuia, Romania, March 18, 1906 – first flight by a fully self-propelled, fixed-wing aircraft using a tractor propeller.

Since the beginning of flight, the aviation industry has developed rapidly, evolving to be a very important part of our lives.

Companies producing airplanes are using leading edge technologies, materials and know-how. Nowadays, a flying machine has to be light, powerful, fast, fuel-efficient and environmental-friendly.

One of the first things to keep in mind when designing airplanes is to keep it as light as possible. Light metals such as aluminum and titanium fulfill this requirement and are largely used to produce aircrafts. In the latest years, the use of composite materials such as glass fiber also increased.

1. FUTURE MATERIALS

Composites. Composites are considered to be combinations of materials differing in composition or form on a macro scale. The constituents retain their identities in the composite. The components can be physically identified and exhibit an interface between one another- the reinforcing and matrix materials are combined, compacted and processed.

Natural Fibre Composites . In the 1930's first trials for the usage of composites were made. A cotton fibre phenol formaldehyde matrix composite was developed into the flax reinforced Gordon Aerolite. This material was used to fabricate an experimental wing spar for a Blenheim bomber and a fuselage for a Spitfire - true 'aerospace' applications. However, by the late 1940's, research into natural fibre reinforced composites (NFRCs) had ceased, with the advent of glass-fibre.

Aramid. In the 1970's, Kevlar aramid was introduced. Kevlar is an organic fiber with high specific tensile modulus and strength. This was the first organic fiber to be used as reinforcement in composites.

Today this fiber is used in various structural parts including reinforced plastics, ballistics, tires, ropes, cables, asbestos replacement, coated fabrics, and protective apparel.

Glass. Glass as a structural material was introduced early in the 17th century and became widely used during the twentieth century. Glass fibrous usage for reinforcement was used for commercial and military uses.

These events lead to a wide range of aerospace and high performance structural applications.

Glass is derived from one of our most abundant natural resources: sand. Commercial uses include filtration devices, thermal and electrical insulation, pressure and fluid vessels, and structural products for automotive and recreation vehicles, military and aerospace products as well: asbestos replacement, circuitry, optical devices, radomes, helicopter rotor blades, and ballistic applications.

Aerospace applications. The primary structure of modern airplanes is of composite construction with Aramid Fibre (AFRP), Glass Fibre (GFRP) and Carbon Fibre (CFRP) Reinforced Plastics.

The A320 was the first production airliner to use composites in primary structures, the main structural components of its horizontal tail and fin being constructed from carbonfibre.

Boeing 787's structure is made up of 50 % carbon composite materials and another 15 percent titanium, making it much lighter and fuel efficient than existing jetliners of the same size.

Grob Aerospace, a leader in composites technology, developed an all-composite light jet.

Future civil programs to use composites include the Airbus A350 and the Bombardier C-series.

Composites are also used in military aircraft , for example the A400M military transport aircraft is manufactured using CFRP technology. The airframe of an Eurofighter Typhoon is also made of composites.

Helicopter Tail Rotor made of CFRP.

Ceramic Composites. From both economic and ecological viewpoints efficient and environment-friendly propulsion systems are extremely important for future civil and military aviation. A goal of R&D is the realization of gas turbine engines with improved thermal efficiency combined with lower pollution. This can be achieved by covering the burning chamber wall with high-temperature resistant materials like ceramics, materials which exhibit a high resistance to heat, corrosion and wear. These requirements are met by fiber-reinforced ceramic matrix composites.

Hybrid Material Systems. Metal matrix composites (MMC) combine the properties of metals with those of ceramic fibres.

The strength and stiffness of titanium alloys can be enhanced by the reinforcement with ceramic fibres. These titanium matrix composites (TMCs) are used for highly loaded components to reduce stress peaks locally. By the matrix coated fibre technique reinforcing elements are implemented by diffusion bonding or brazing into the component.

The use of siliconcarbide fibres increases strength and stiffness of titanium alloys by about 100%.

Components with exceptional high thermal and electrical conductivities along with high strengths and moderate thermal expansion can be made by SiC-fibre reinforced copper alloys. As a result high strength components can be produced marked by high thermal conductivity e.g. for heat sinks in fusion reactors or rocket engines.

2. FUTURE ENERGY SOURCES

Solar powered aircraft. While conventional fuel is limited, the total solar energy available to the earth is approximately 3850 zettajoules (ZJ) per year.

A solar cell or photovoltaic cell is a device that converts light into electricity using the photoelectric effect. The first working solar cells were constructed by Charles Fritts in 1883

The Sky-Sailor is an UAV (unmanned air vehicle) that uses only solar energy for propulsion. The programme started to study the feasibility of a Martian atmospheric glider. The first prototype has the wing covered with 216 silicon solar cells in flexible modules that deliver up to 90W, while the aircraft's power consumption is 16W at level flight.

Quantum dot solar cells. Nanocrystal solar cells or quantum dot solar cells, are solar cells based on a silicon substrate with a coating of nanocrystals.

Quantum dot solar cells are twice as efficient as current commercial cells. Nanotechnology may greatly increase the amount of electricity produced by solar cells.

Quantum dot based photovoltaics may also offer advantages such as mechanical flexibility (quantum dot-polymer composite photovoltaics) as well as low cost, clean power generation and efficiency.

Biofuel. With the increasing oil prices and the pollution created by conventional fuel, in the latest years researchers have made efforts to use environmental friendly fuel.

Biofuel is composed of babassu oil from the the babassu tree and coconut oil. Both products are already used in cosmetic products.

Babassu oil and coconut oil are environmentally and socially sustainable, and do not either compete with staple food supplies or cause deforestation.

It needs extensive ground testing by engine manufacturers but do not require any modification to the aircraft or engine.

Synthetic fuel. Airlines are also looking to coal-to-liquid and gas-to-liquid fuels as drop-in replacements for expensive and finite petroleum, and global development of facilities to produce these alternative jet fuels is well underway. Approval is underway for a 100% synthetic jet fuel.

Low-carbon fuel research aims to calculate the environmental impacts of production and use of alternative fuels.

Broadly, synthetic fuel processing could become less polluting than typical jet fuel production. New carbon-capturing methods can store carbon dioxide that streams out of the coal or natural gas conversion plants, which use a process called Fischer-Tropsch.

The synthetic fuel produces 50-80% less particulate matter, or soot, which is good for human health and helps military aircraft elude heat-seeking missiles.

Jet fuel from carbon disassociation. Fuel can be produced by advanced chemical processes, for example CO_2 capture and storage (CCS).The gas carbon dioxide can be transformed into carbon monoxide to produce synthetic fuels. This means pumping the huge amounts of CO_2 produced as a byproduct of the conversion process into geological formations deep underground, for permanent storage or as a means of squeezing out extra crude oil after drilling (called enhanced recovery).

The carbon monoxide and water is combined to produce hydrogen and CO_2. This CO_2 is used to create more carbon monoxide, which is then combined with the previously generated hydrogen to create syngas. The syngas is processed in a reactor to produce heavy paraffinic waxes from which fuels are produced using conventional refinery methods.

The invention holds a real promise of being able to reduce carbon dioxide emissions while preserving options to keep using fuels we know.

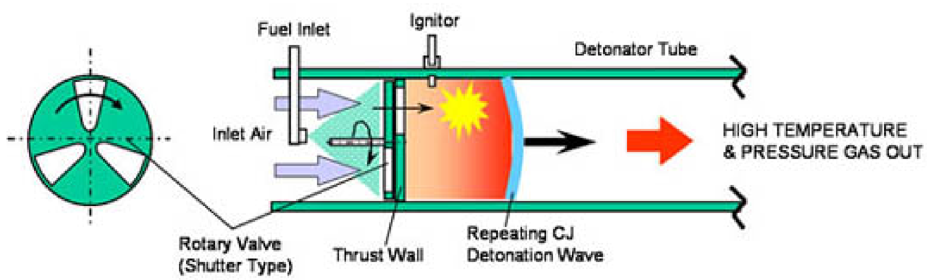
3. FUTURE ENGINE TECHNOLOGIES

Pulse-detonation engine. PDEs operate by injecting a propellant mixture into a chamber that is open at one end. The mixture is ignited by a spark plug and the burning fuel rapidly generates a detonation wave that travels through the chamber before the gas from the combustion has time to expand. The explosive pressure from the detonation pushes the exhaust out of the open end of chamber, providing thrust.

The five-tube PDE is connected directly to a pressurized air supply. The inlet is separated from the unsteady combustion process using special valve. The valve is spun at 18,000RPM and is fed with ethylene, oxygen and compressed air, modulates the firing sequence with each tube.

Potential applications range from supersonic air vehicles and hybrid turbofans.

Benefits of the PDE: low-cost operation and acquisition, almost instant acceleration/deceleration and very few moving parts.



4. NEW WING DESIGN TECHNIQUES

Active wing. Whereas a classical wing is passive with an optimized shape and high-lift devices, an active wing senses the surrounding airflow, analyses and modifies it for optimum efficiency, reduced fuel burn and emissions, noise and systems complexity. The new concepts use advanced materials, design tools and manufacturing methods.

Wing warping. The goal is to obtain optimum wing shape for flight and improved performance.

Many methods of warping wings are under study. One of them is to use articulating winglets to provide improved whole-wing aerodynamics for different phases of flight.

Warping helps to distribute aerodynamic loading along the wing and reduce drag.

The angular position of the winglet relative to the wing can induce torsional forces that warp the wing to the optimum shape for flight. The winglet's angular position would be controllable, providing active warping control. This is expected to improve lift at low speeds. The moving winglet pivotes around an articulation parallel to the aircraft's longitudinal axis to induce the warp.

Smart wings. Another idea is to obtain lift enhancement and optimal transonic cruise using "intelligent" materials and structures to sense changes actively in air speed and pressure, and then change the shape to adapt to the new conditions, like a bird.

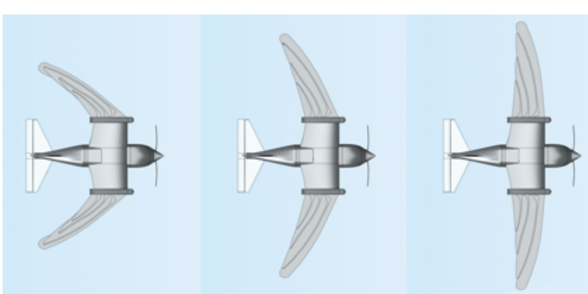
A morphing-wing changes shape using special materials: shape memory alloys, which deform when heated, magnetorestrictive materials which deform under applied magnetic fields, and piezoelectric materials, which deform under applied electric currents. Another way to change the shape is using a thin liquid-crystal polymer skin actuated by light-emitting diodes (LED). The liquid-crystal polymer film is a rubber-like material that has light-sensitive molecules held within its liquid-crystal matrix, which gives all the molecules a single directional order. The polymer starts life in its most extended form and the first time it is irradiated with one wavelength it contracts. Irradiation with a second wavelength will make it extend again.

Auxetic honeycomb structures for morphing wings. An auxetic honeycomb that changes shape using piezoelectric actuators and other sensors embedded in each of the structure's cells could enable lightweight, power-efficient flexing control surfaces for morphing wings. An auxetic material has a negative poisson ratio, meaning its cross-section becomes wider when stretched. The embedded sensors can enable health monitoring and honeycomb cell dimensions could be matched to incoming signals' wavelengths so the structure could, reflect radar, absorb it or even allow it to pass through.

5. MEMS – MICRO ELECTRO MECHANICAL SYSTEMS

Highly miniaturized systems, called Micro Electro Mechanical Systems (MEMS), combine electronic and mechanical constituents. In the use of such microsystems, there is a tremendous optimization potential for engine components like compressors. Already, microsystems have become indispensable to the exact control of various engine elements. They have added much accuracy, for instance, to the endeavor to monitor and influence the highly complex flow inside a compressor, thus allowing engineers to markedly improve the engine's efficiency and operational stability.

MAV's. Micro Air Vehicles (MAV) are miniature aircraft, inspired from insects.



An insect flies at low speeds, can hover, fly upside down, take off and land vertically, and is extremely manoeuvrable at low speed in all directions. Insects are inaudible if their wings beat at less than 20Hz, and experiments show that their power efficiency is typically 30 W/kg, which is five times better than a fixed-wing/forward-thrust aircraft could achieve.

Insect flight dynamics are complex, but their flight control is simple.

MAV must be able to fly and be agile to avoid collisions with obstacles; to hover to allow precise observation; to have zero acoustic signature to remain undetected; to take-off and land vertically on unprepared ground; and to operate autonomously through intelligence or pre-programming.

The wings of a MAV have to reproduce the complex oscillation and rotation displayed by insects, and mimic the mechanical and surface characteristics of the wings that have been shown to contribute to lift, vortex generation and airflow. The wing-beating structure has to be kinematically simple and therefore manufacturable. Stability and control is achieved through the beat-to-beat modification of the coefficient of lift of each wing by active flow-control techniques.

Propulsion of a MAV can be achieved through RCM – reciprocating chemical muscle, in which hydrogen peroxide is mixed with water in a catalytic chamber to create steam. The RCM could also provide high-energy ultrasonic emissions for other applications, dry lubrication of moving parts, and active flow-control over aerodynamic surfaces.

Flying, crawling UAV. A morphing micro air and land vehicle (MMLV) that flies and crawls along the ground is under development. Researchers are now studying the diving techniques of sea birds for their application to an unmanned air vehicle that would fly and become an unmanned underwater vehicle.

The MMLV's design is based on bats and birds with flexible wings and its ground locomotion is like that of a cockroach. The tractor-propeller and crawling mechanisms are powered by different motors as the gearing for a single motor to power both was found to have a negative mass impact. One concept of operations is a larger UAV that carries up to 50 MMLVs and drops them when needed.

Cyborg insects. The development of MAVs and MEMS in the latest years achieved a stage where this can be combined with genetc engineering to produce Cyborgs.

Insect bodies can be modified and embedded with micro-electromechanical systems (MEMS). Mechanical microsystems allow remote control, extend insect life and provide for audio and imaging sensors.

The cyborg insect is remote-piloted to within 100m of a target. Control is achieved using pheromones or mechano-sensor activation and direct muscle or neural interfaces using the embedded MEMS.

6. CLEAN SKY INITIATIVE

The Clean Sky Joint Technology Initiative (JTI) represents one of Europe's largest and most inclusive research programmes ever attempted.

Clean Sky's mission is to bring technologies to a high readiness level and so cannot strictly be regarded as a programme for product development. Clean Sky will simply invent those technologies that will make possible radical shifts in new generation fixed and rotary wing aircraft.

Clean Sky goals:

● **Green Regional Aircraft:** low-weight aircraft using smart structures, low external noise configurations and new technologies such as engines, energy management and system architectures.

● **Green Rotorcraft:** innovative rotor blades and engine installation for noise reduction, lower airframe drag, integration of diesel engine technology and advanced electrical systems to eliminate noxious hydraulic fluids and reduce fuel consumption.

● **Sustainable and Green Engines:** engine demonstrators to integrate low noise technologies and lightweight low pressure systems, high efficiency, low NO_x and low weight cores and novel configurations such as open rotors and intercoolers.

● **Systems for Green Operations :** all-electrical aircraft equipment and systems architectures, thermal management, capabilities for "green" trajectories and missions and improved ground operations.

● **Eco-Design:** green design and production, including aircraft recycling which redues the environmental life-cycle impact.

7. SUPERSONIC RETURNS

Since Concorde's "retirement" flight in November 2003, companies are studying the feasibility of a civil supersonic jet.

The development of a Supersonic Jet faces environmental, regulatory, certification, market and cost issues, enormous difficulties in the design of civil supersonic aircraft. The engine must meet noise, emissions and safety criteria, it must provide supersonic thrust without using an afterburner and have to be fuel efficient. However, certification would be a problem since the supersonic flight overland is illegal in the USA.

There are many possible powerplant solutions: a military engine; a larger, more powerful version of an existing commercial engine; and a redesign of an available powerplant.

Dassault has an extensive supersonic combat aircraft experience. As leader of the HiSAC (high-speed supersonic aircraft) project, Dassault believes that all technologies are within reach: CFD, fly-by-wire flight controls, mixed composite/titanium structures and a synthetic vision system to eliminate the weight of a Concorde-like drooping nose.

Another manufacturer to declare an interest in developing a supersonic jet is Gulfstream Aerospace, which conducts a technical and market feasibility study.

At the same time, Lockheed Martin is looking for support from NASA's HighSpeed Research (HSR) programme, in the form of funding.

Boeing, which has held discussions with Dassault, was also asked by NASA to make proposals for a supersonic plane.

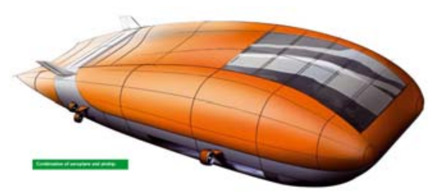
Aerion is developing a Mach 1.6-capable aircraft that will avoid sonic booms by dropping to transonic speed over land. SAI's Quiet Supersonic Transport (QSST), on the other hand, is a technologically more ambitious low-boom aircraft that could cruise supersonically overland.

8. FUTURE CONCEPTS

Advanced vertical take-off and landing (VTOL) and short take-off and landing (STOL) air vehicles are the focus of future research, along with topics relating to aviation in the era of global warming. Bauhaus Luftfahrt also studies the social factors that are likely to influence the aerospace.

The HyLiner concept is the first study to be presented by the aeronautics visionaries: they developed an aircraft that incorporates a novel combination of uplift and forward propulsion technologies. The resulting short take-off and landing capability gives airports a new degree of freedom.

Bauhaus Luftfahrt has identified three basic technical solutions with its “HyLiner” technology platforms (HyLiner is short for Hybrid Airliner): improved uplift in or on box wings, uplift using tilt wings with rotors, and finally – looking much further ahead into the future – a hybrid “as-light-as-air” system that combines the features of an airship and an aeroplane.



The Skycar. Moller has developed the first personal vertical takeoff and landing (VTOL) vehicle.

The M400 Skycar can cruise comfortably at 275 MPH and achieve up to 20 miles per gallon on clean burning, ethanol fuel.

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