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UAVs FOR METEOROLOGICAL SURVEY: COMPROMISE BETWEEN ENGINEERING, LEGISLATION AND A WIDE RANGE OF MISSION PROFILES

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Outline

- Need of UAV/UAS/RPA in exploring/monitoring the atmosphere.
- Overview upon design solutions
- Analysis of twin boom design.
- Analysis of canard design.
- Solutions to be considered in the light of existing legislation concerning UAV/UAS/RPA.
- Choice of the propulsion system.
- Means to ensure high operational efficiency and reliability.
- Conclusions

Need of UAV/UAS/RPA in exploring/monitoring the atmosphere

- There are two main reasons:

1. The lack of flexibility and capability of meteorological satellites to closely follow the rapidly changing events occurring in our more and more troubled atmosphere.
2. A lot of experience is already acquired in building and operating such vehicles from other type of activities, mainly military or related to that.

Need of UAV/UAS/RPA in exploring/monitoring the atmosphere (continued)

- There are also some favouring conditions:

- Similar experience, with some limitations however, exists in the parallel field of modelling.
- Dedicated propulsion systems and micro-actuators for both have a steady development.
- Continuous progress is accounted in the field of advanced materials, enabling production of light structures, with good resistance against corrosive environments.
- Increasing number of software products are available for managing the remote flight control.

Overview upon design solutions

- Historically, the balloons were firstly used. They are still used for fast collection of basic data on a vertical from a sensitive point, e.g. airport.
- Kites are to be considered for easy monitoring of the low levels of the atmosphere.
- *Due to the need of increased monitoring range on the horizontal, unmanned aircrafts, helicopters and zeppelins have been considered.*
- The helicopters are mainly used for vertical explorations, with little extent on the horizontal.
- The zeppelins can be used on large areas, but have a big size and corresponding inertia, creating difficulties in control.

Overview upon design solutions (continued)

- Unmanned aircrafts offer the widest range of solutions, able to respond to any mission profile.
- Conventional and unconventional configurations have been used, inspired from manned aircrafts.
- *Some particular design solutions seem to be better fitted for the purposes of UAVs, especially for those engaged in monitoring atmospheric phenomena.*

- Two of them will be analyzed more in detail.

Analysis of twin boom design

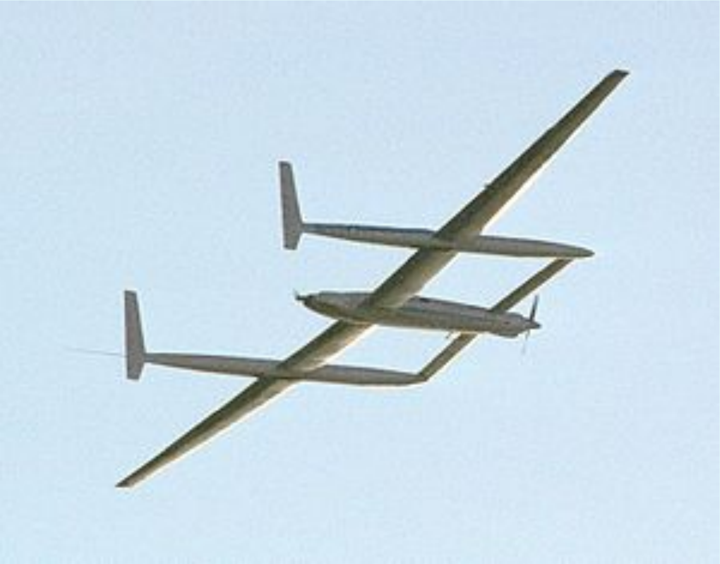
- The twin boom design appeared in aircraft design during WW II, with the aim of creating agile, medium sized, generally powerful and especially highly manoeuvrable military aircrafts.

- The FW 189 Uhu

The P 38 Lightning

Analysis of twin boom design (continued)

- The more recent designs have shown slimmer booms , not supporting engines, which were transferred to the central fuselage.



- The Cessna Skymaster. The Rutan Voyager.

Analysis of twin boom design (continued)

- This tendency was kept for UAV designs, in which generally one rear engine was kept.

- The IAI Heron. The MQ 5B Hunter.

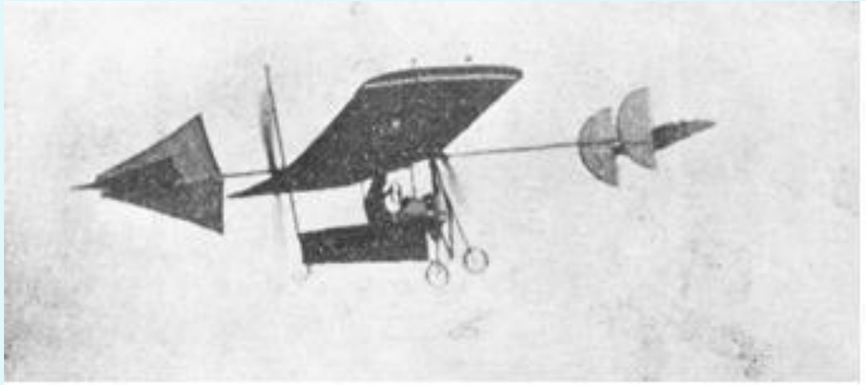
- ....and, of course, the UMARS!

Analysis of twin boom design (continued)

- The advantages of this design solution are:
- High manoeuvrability, due to increased tail surfaces and the well washed horizontal tail.
- Compact, stiff structure, in spite of extra- structural parts.
- Good exposure and access for the instruments placed in the aft central fuselage.

Analysis of canard design.

- Canard design is much older in the aviation history.
- Before the Blériot design, later called conventional configuration, early configurations (Wright, Farman etc.) choose the aft placed elevator, solution appeared more effective for longitudinal control.
- One of them offered an early *three surface configuration* and brought other amazing innovative solutions: contra-rotating co-axial propellers etc.



- The Vlaicu II aircraft.
- (1910)

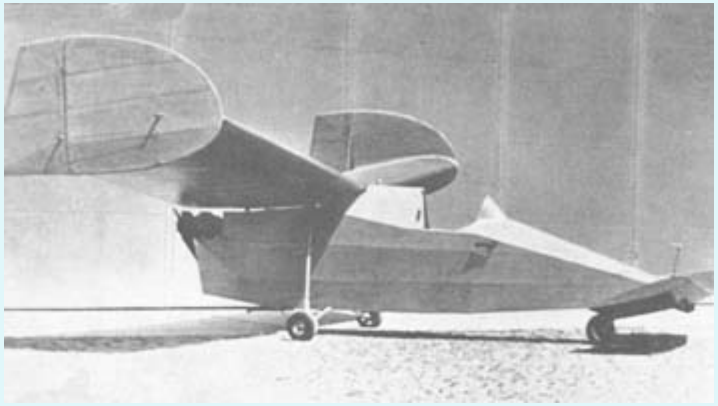
Analysis of canard design (continued)

- The modern *three lifting surface configuration* (3LFC) was patented in 1929 by George Fernic and put in practice in two remarkable products.

- The Fernic Tandem FT9. The Fernic Tandem FT10.
- (1929) (1930)

Analysis of canard design (continued)

- The true modern *canard* (foreplane) solution came later.



- The Miles 39B bomber. The RM 11/12 light aircraft.
- (1943) (1953)
- And, of course, the today designs of Burt Rutan, the “canard guru”…

Analysis of canard design (continued)

- The *3LSC* and *canard* solutions were used by many military aircrafts in the last 50 years, some rather exotic civil ones (Piaggio 180, Beechcraft Starship) but, quite surprisingly, by few UAV designers.

- The Argus XL (2006)
- Some other design proposals were made recently (Coiro et al., ICAS 2002, Goraj et al., ICAS 2004 - Hale PW 111/112).

Analysis of canard design (continued)

- Advantages of the canard solution:
- Compact airframe design.
- Maximum lift ensured in most of flight regimes.
- Possibility of synergistic use of winglets for directional stability, able to counterbalance the low efficiency of the vertical tail.
- Improved pitch stability and control in comparison with aft tail aircrafts.
- Simplified solutions offered for mounting pusher engines.

However, careful balance has to be in view between the foreplane and the wing surfaces and for the flap sizing.

Solutions to be considered in line with existing legislation concerning UAV/UAS/RPA.

- The present legislation ruling the design and use of UAV/UAS/RPA, in vigour in most European states, offers important advantages for light and low powered products.
- Consequently, the above mentioned designs, offering compact, efficient solutions through careful, innovative approach, ensure fulfillment of the ‘easy path’ for airframes required in most mission profiles in atmospheric research/monitoring.

Choice of the propulsion system

- The propulsion system to be chosen for UAV/UAS/RPA ranges from electric motors to jet engines.
- The last system is not to be considered for driving the rather small airframes in question, with small masses and low service speed.

- In comparison with the thermal engines, the electric motors offer some undeniable advantages:
- Large range in power supply, in accordance with the flight regime.
- Low vibration amplitude.
- Low exposure to humidity and volcanic ashes.

Choice of the propulsion system (continued)

- Pushing engine configuration is desirable for ensuring low interference with the sensors.
- Dual engine solution is also to be considered for in service reliability reasons and for being compatible with the large span existing between the needed take off and the cruise regime power supply.
- Combination of batteries and solar cells is to be considered in the future for this two regimes, for electrically driven UAV/UAS/RPA.

Means to ensure high operational efficiency and reliability

- Operational reliability and flexibility of UAV/UAS/RPA could be ensured through some design actions, like

- Providing two engines/motors; that solution offers reliability in case of one engine malfunctioning and flexibility in power supply; electric motors seem to be an advantage in both aspects;
- Combination of batteries and solar cells ensures the highest cruise range and availability for repeated missions;
- Use of composite materials; self healing materials are the top target;
- Use of compact configurations; twin boom and canard configurations are the best suited for that;

Means to ensure high operational efficiency and reliability (continued)

- Good stability, combined with effective manoeuvrability and high aspect ratio; the above configurations are favourites;
- Reduced dimensions and weight, whenever possible, in order to comply with the “soft” regulations; above mentioned choice for configuration, materials and propulsion are favouring this trend;
- A parachute for providing ultimate salvage, and a positioning system for recovering the vehicle and airborne instruments;
- Advanced autopilot software and redundant link with the remote control base for continuous monitoring and control for high altitude and long range UAV/UAS/RPA.

Conclusions

- Atmospheric research using UAV/UAS/RPA has a very promising future, in line with the challenges facing that vast topic, directly linked to meteorology, pollution, wind energy volcanic research and effects on the soil.
- The items used can benefit of a variety of design solutions which can prove their adequacy to various mission profiles in correlation with the engines, materials, sensing instruments and remote piloting software.
- Low weight and, when possible, limited size can benefit from favourable legislation.
- UAV/UAS/RPA dedicated to atmospheric research can be test beds for more ambitious or sophisticated devices.