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Flying Wing Design – Unfolding Potential

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The flight test of the Defence Research and Development Organisation's (DRDO) new autonomous flying-wing technology demonstrator was done on July 03, 2022.[1] It saw a wave of hope and excitement among the Indians who follow security and aviation. It was a demonstration essentially of a scaled-down model of the "Ghatak" autonomous unmanned combat aerial vehicle (UCAV). Developed by the Bengaluru-based Aeronautical Development Establishment (ADE), the aircraft reportedly made a perfect take-off, a short navigational flight, and a smooth landing. Undoubtedly, it is a significant milestone for an important technology in India's quest for indigenisation. While all the airframe systems were developed in-house, the two small turbofan engines that powered the unmanned aerial vehicle (UAV) were Russian made TRDD-50MT.[2] It was initially acquired for "Lakshya" UAVs and also used in cruise missiles. DRDO hopes to replace them with indigenous ones in the near future. Meanwhile, the Indian armed forces await the larger Rustom and Tapas variants for medium and high altitude, long-endurance operations, although they are not flying-wing designs.

The flying wing is essentially a tail-less flying body where the fuselage and wing are blended in such a manner that the entire structure looks just like a wing. Effectively, the cockpit, on-board systems, fuel and payloads are all housed inside the wing. There could be small external protrusions for sensors, weapon stations, or some podded systems. The shape greatly reduces drag in flight, but in the absence of the vertical and horizontal stabilisers, the aircraft's unstable flight requires computer-controlled fly-by-wire or fly-by-light flight controls. The best part is that the entire aircraft structure generates vertical lift, thus increasing efficiency and reducing weight and fuel consumption.

In the early years of aviation, flying designs were conceived with the help from studying the birds. However, the interest in them peaked in race to develop stealth platforms. Northrop Grumman B-2 Spirit[3] stealth bomber was the first operational flying wing. It made its maiden flight on July 17, 1989,

and was inducted into the U.S. Air Force (USAF) in January 1997. Many airlines and large aircraft manufacturers have been showing an interest in flying-wing passenger or cargo aircraft. To date, the flying wing concept has been applied mostly to subsonic aircraft. A scaled-down, remote-controlled model of an airliner was evolved by the Delft University of Technology and KLM Royal Dutch Airlines' aircraft and made its first flight in September 2020.[4] The aim was to have a more efficient and environment-friendly aircraft. However, no such airliners have yet been built.

Any such design is not free from challenges. Finding sufficient accommodation for the aircrew, major systems, and especially the aero-engines is a complex exercise. These would invariably increase frontal area and, in turn, drag. The thickened wing also makes it difficult for supersonic flight, and therefore none has been built for such flight yet. To counter the problem of reduced directional stability, some designs evolved with winglets, but they all added to the weight and drag. Split ailerons, spoilers or combinations of these are also being tried. Modern computer-controlled flight surfaces allow compensation for most aerodynamic and aircraft control drawbacks.

A novel concept of a supersonic bi-directional variable-geometry flying-wing[5] with virtually no sonic boom and ultra-high aerodynamic efficiency is under development by NASA. The proposed plan-form is symmetric around both the longitudinal and lateral axes. It has a long-span subsonic wing and a short-span supersonic wing, joined in the form of an unequal cross. The low-speed wing would have a thick, rounded aerofoil able to contain the payload and a long span for high efficiency, while the high-speed wing would have a thin, sharp-edged aerofoil and a shorter span for low drag at supersonic speed. For supersonic flight, it can have a high sweep angle to reduce drag. For subsonic flight, the aircraft will rotate 90 degrees in flight to achieve better aerodynamic performance. The preliminary computational fluid dynamics (CFD) simulations for a business jet seem favourable. The supersonic performance benefits from the sharp nose and ultra-slender body. The concept is revolutionary and has still to reach a prototyping stage.

The flying-wing design has seen many applications among UAVs. These include the Lockheed Martin RQ-170 Sentinel, the Northrop Grumman Tern (with a vertical tail), and the Chinese Nanning Huishi flying-wing (with winglets). Facebook's solar-powered Aquila flying-wing flew its maiden voyage in 2016.[6] However, the project was called off in 2018. Many flying-wing UCAVs have been produced or are under development. The Dassault nEUROn stealthy autonomous UCAV is a multi-nation project and made its first flight in December 2012. The British equivalent, BAE Systems' Taranis UCAV first flew in 2013. The Taranis and nEUROn programs could be merged into a joint Future Combat Air

System project. The EADS Barracuda is a joint-venture between Germany and Spain. The Boeing autonomous X-45 UCAV concept demonstrator was a part of DARPA's J-UCAS project and first flew in May 2002. Also part of the same DARPA project is the Northrop Grumman X-47B, a blended-wing-body aircraft meant for aircraft carrier operations, which first flew in 2011. The Russian Sukhoi S-70 Okhotnik-B is claimed to be a sixth-generation project which has borrowed technologies from the fifth-generation Sukhoi Su-57 fighter aircraft. It first flew in August 2019. DRDO's "Ghatak" autonomous flying-wing UCAV is still under development and will have an internal weapons bay for carrying missiles, bombs, and precision-guided munitions. The full-scale prototype is expected around 2025.

China's Xian H-20[7], the first indigenous subsonic stealth bomber under development, also has a flying-wing design. It appears to be a copy of the Northrop Grumman B-2 Spirit. The aircraft is in the advanced stages of testing and may be inducted by 2025. The Northrop Grumman B-21 Raider[8] which is part of the USAF Long-Range Strike Bomber program, is a flying-wing design and is likely to enter service around 2027. Russia's next-generation stealth bomber, the Tupolev PAK DA[9] might not be a flying-wing design, although some pictures suggest it could be. It is more likely to have an advanced variable geometry wing, of which Tupolev has significant experience. As humans continue to take inspiration from birds for wing design, the flying-wing design brings us closer to flight perfection. Aeroelastic wing shaping using distributed propulsion is evolving next.

(Disclaimer: The views and opinions expressed in this article are those of the author and do not necessarily reflect the position of the Centre for Air Power Studies [CAPS])

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Notes:

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