Pterosaur-inspired aircraft makes sharper turns

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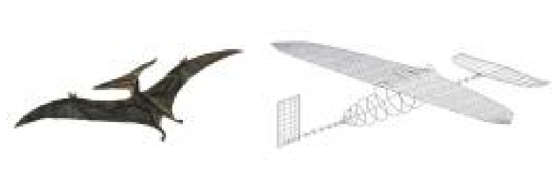

(Left) A pterosaur. Image credit: Logan's Dino World. (Right) A possible configuration for a small aircraft with its vertical tail at the nose. Image credit: Roberts, et al. ©2011 IOP Publishing Ltd.

(PhysOrg.com) -- By morphing and repositioning a small aircraft's vertical tail to resemble the cranial crest of a pterosaur, researchers have shown that the aircraft's turn radius can be reduced by 14%. The ability to make sharper turns is especially important for small aircraft that operate in urban environments and in the presence of obstacles.

The team of researchers, Brian Roberts and Rick Lind from the University of Florida, along with Sankar Chatterjee from Texas Tech University, has published the study on the pterosaur-inspired aircraft in a recent issue of *Bioinspiration & Biomimetics*.

Although birds and bats are the only tetrapods that are currently capable of powered flight, the first vertebrates to achieve flight were pterosaurs. These flying reptiles (not technically dinosaurs) appeared about 225 million years ago and became extinct along with the dinosaurs about 65 million years ago. For those 160 million years, pterosaurs ranging in size from 12 grams to 70 kilograms roamed the skies. One thing they all likely had in common was a large, plate-like cranial crest on the tops of their heads.

While some researchers have suggested that the cranial crest could have had advantages for mating or diffusing excess body heat, the researchers here think that the large, vertical surface must have had an aerodynamic impact. In their study, the researchers developed a model of a small aircraft design that incorporates a vertical tail that is similar to the cranial crest of the pterosaur. Instead of placing the vertical tail at the back of the aircraft, the researchers allowed the tail to move forward all the way to the front of the aircraft.

The researchers' model showed that moving the vertical tail to the nose of the aircraft can reduce the aircraft's turn radius by 14%. This improvement is due to the fact that the conventional position of the tail requires the nose of the aircraft to point away from the direction of the turn, while the position of the tail on the aircraft's nose requires the nose to point into the direction of the turn.

This advantage comes with a tradeoff, which is a decrease in the aircraft's static and dynamic stability. However, the researchers showed that this tradeoff between performance and stability can be addressed by giving the vertical tail a morphing capability that allows it to vary its position during flight.

In the models, the tail could not only range across the entire fuselage of the aircraft, but it could also rotate about its leading-edge axis by 45° in either direction, giving it a greater impact on the aircraft's aerodynamics. For instance, the researchers found that the small aircraft could perform a "Dutch roll," a maneuver that involves rocking from side to side. With these kinds of abilities, the aircraft could have a wide variety of applications.

"The applications of a pterosaur-inspired design cover the spectrum of uses already being adopted for UAVs [unmanned aerial vehicles], such as search and rescue, damage assessment, surveillance, drug interdiction, border security, and communication," Lind told *PhysOrg.com*. "Essentially, the technology has potential benefits for aircraft that need to increase maneuverability and fly among obstacles. The pterosaurs had a vast range in wingspan and crest size, so a correspondingly large range of aircraft may benefit from the biological-inspired design."

While previous studies have looked to birds and bats for inspiration for designing small aircraft, the results of the current study show that the pterosaur is also an appropriate source of inspiration. The results build on previous research, which has found the pterosaur configuration to be highly maneuverable and highly efficient for slower flight speeds.

"The pterosaur project is part of a large on-going effort into biological-inspired design at the University of Florida," Lind said. "We will continue to look into concepts from birds, bats, insects, reptiles and pterosaurs for advancing flight capability. An early prototype has been built that augmented an existing vehicle with 24-inch wingspan by mounting a fixed tail into the nose. Flight tests will be conducted this year on that prototype along with construction of a vehicle with a tail that translates along the fuselage between the back and the front.

"A particularly welcome feature to this project is the ability to attract students from elementary school to college and show them an exciting application of engineering and math. We have several undergraduates that love to design the aircraft and associated morphing mechanisms which helps to teach aerodynamics, control, avionics, structures, and now even biology. The pterosaur project has been invaluable as a teaching tool while addressing a new area of the aviation community."

More information: Brian Roberts, et al. "Flight dynamics of a pterosaur-inspired aircraft utilizing a variable-placement vertical tail." *Bioinsp. Biomim.* 6 (2011) 026010 (11pp)