Revolution in the air

TIM ROBINSON looks at a novel concept in aeronautics that could lead to a whole new class of aircraft — the FanWing.

Genuinely new concepts in aviation are few and far between but the FanWing, developed by an inventor with no formal aeronautical training, may just herald the development of a whole new niche air vehicle. The inventor, an American living in Italy, Patrick Peebles (who has since formed a UK-registered company to develop the concept) had previously invented electric spaghetti forks and a mole repellent but now has succeeded with this new class of air vehicle where others have failed. His invention, the FanWing, has been tested with successful flying scale demonstrators and backed up with wind-tunnel tests which confirm his unique advance. The idea of the FanWing is to fill a large niche between aircraft and helicopters — with a lower cost than either. Mr Peebles outlines the benefits: "The advantage that the FanWing might have over the helicopter will be in mechanical simplicity, lower fuel/power requirements in horizontal flight and probably higher flight speed and lower noise."

The technology

The FanWing uses a large bladed rotor lying on a horizontal axis with the front of the thick wing. This, connected to an engine, rotates, sucking in air and pushing it up and over the wing — greatly increasing the lift and allowing the model he has built to carry twice its own bodyweight. Thrust and lift of the vehicle, as well as steering direction, are controlled by small flaps in front of the fan which controls the angles in which the air hits the fan cages. These are used differentially to increase or decrease lift to individual wings, thus steering the aircraft, without yaw.

The concept of rotating cylinders to increase lift is not new but, in the past, have concentrated on smaller smooth rotating rollers to improve slat or flap performance. In the 1970s NASA tested a roller device in front of the flaps on a YOV-10A Bronco. This allowed the aircraft to fly at extremely slow speeds without stalling. It is also generally known that a rotating cylinder on the leading edge of a wing will boost lift by keeping the airflow attached to the surface of the wing for much longer. If the cylinder is made rough, rather than smooth, the lift coefficient can be increased by as much as 210%.

Mr Peebles' concept in the FanWing takes this aerodynamic effect and scales it up to bigger proportions so that the smooth roller is replaced by a large, bladed fan, which simultaneously provides lift and thrust and is billed as "the first horizontal-rotored lift and propulsion wing in history to sustain flight." If a propeller-driven aircraft is analogous to screw-driven ships, the FanWing immediately reminds one of Mississippi paddle steamers — using horizontal blades to push air over and on to the wings and generate lift. However, while on the face of it, the FanWing seems a retrograde technology, similar to some of the Heath Robinson-style inventions in the early years of flight, it boasts a number of

Left: The latest 2·2m FanWing UAV demostrator flying.

advantages which make this breakthrough especially suitable for some practical applications.

Advantages

These advantages are…

Quietness First, it is quiet — meaning it is especially suited to urban operations where environmental concerns are paramount. This gives it a benefit over existing helicopters whose operations over built-up areas tend to be limited by noise concerns. A low noise signature is also beneficial in both unmanned surveillance and military tactical transport roles.

Stability The FanWing is also, as the videos of the unmanned scale demonstrator show, extremely stable in turbulence because the leading edge is insensitive to the angle of oncoming air. It is therefore ideal for surveillance, search and rescue, fire-fighting or other roles such as crop spraying which needs ultra-stable, slow low-level flight to perform a mission. UAV missions, which would involve smaller air vehicles and the need to carry highly sensitive sensors with little vibration, would also seem an ideal application for this technology.

Cannot stall The unique design, says its inventor, means it is stall-proof, with no drastic separation of airflow from the wing. This confers immense safety and operational advantages to the FanWing and, says the designer, makes it ideal for a highly safe ultralight aircraft.

Slow flight The FanWing's slow-flight regime make it suited to operations where speed is not of the essence. It therefore makes a good cost-effective alternative to helicopters for law enforcement, surveillance and other 'loitering' missions. The newly reformed Iraqi Air Force's first aircraft, for example, is the Seeker, a slow-flying observation aircraft for pipeline patrol.

Efficient The aerodynamics mean that the FanWing is an extremely efficient design. Although the fan turns slowly, at less than 1,000rpm, the lift generated is impressive. FanWing research shows that at slow speeds the FanWing claims a 35% improvement in efficiency over helicopters. Mr Peebles expands on the efficiencies: "Helicopters lift about 50 Newton per kw in hover and about 75N/kw when moving forward at best cruise speed. This efficiency goes way down as they approach top speed. The FanWing in horizontal flight will lift close to 250N/kw. If we go to VTOL the FanWing will lift about 25 to 30N/kw in hover."

Tests predict, that with a 100hp engine, it could lift a two tonne load — giving incredible lifting power and estimates of performance indicate that the FanWing could be twice as load efficient as similarly powered conventional fixed-wing designs.

Short take-off The FanWing can take off in a remarkably short field length with only small amounts of thrust. Mr Peebles calculates that 120hp would be needed for a 400kg aircraft to attain true vertical take-off. This VTOSL performance means the FanWing may have applications in search and rescue, utility or as a military tactical transport to operate from unprepared strips.

Low cost The FanWing, at the moment uses few hi-tech materials (the rotor fan will probably be made of carbon fibre in future versions) or technology to achieve its unique performance. The scale demonstrator at Farnborough was of similar construction to a model aircraft. The blades, because they do not turn very fast, can be made of wood, again keeping down the cost. The FanWing's immediate rival in some of its projected missions is the helicopter, which is an extremely complex machine and therefore expensive to construct and operate. FanWing believe its alternative scores highly in this key aspect.

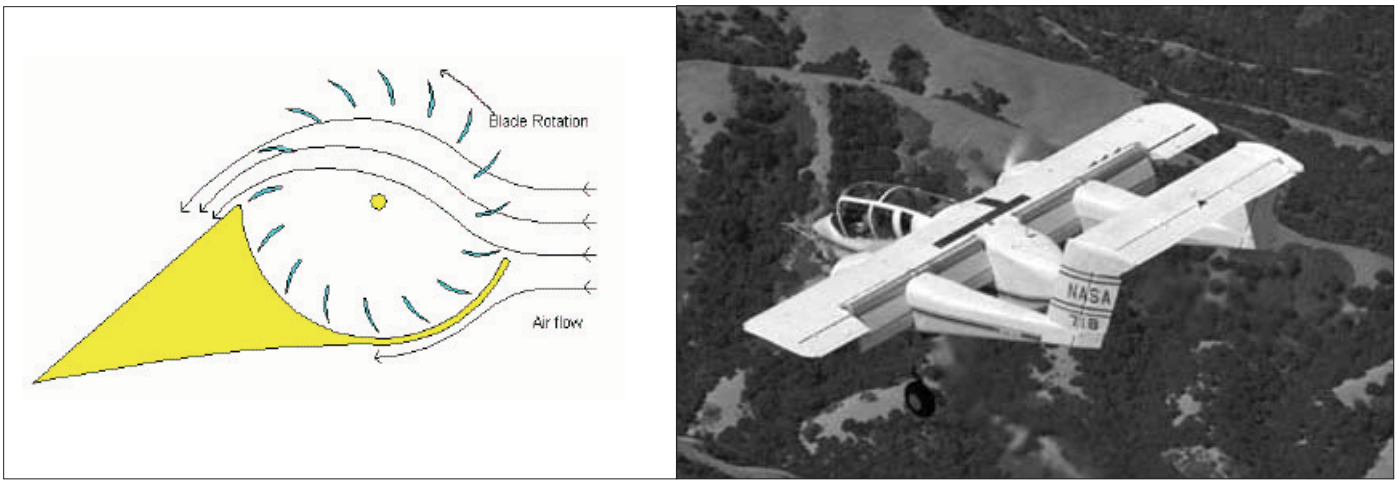
Potential drawbacks

However, while there are a number of unique advantages the FanWing can deliver, there still remain some potential issues that need investigation in this new form of powered flight.

Power-off operations While the FanWing cannot stall, its power-off characteristics, which involve a form of autorotation (similar to a helicopter) mean the glide ratio is 1-in-4 (compared to 1 in 10 for a typical light aircraft). Mr Peebles and the FanWing team are now working on improving the performance in this aspect so that, although the glide angle will be steep, there will be enough lift for a flare and safe landing at the bottom. To increase safety margins Mr Peebles says that the first manned FanWing (in microlight form) will probably have two engines and a ballistic parachute of the kind fitted to a growing number of GA aircraft today.

Top speed While one of the key selling points is the FanWing's low speed performance (a microlight version would fly at 70km/h) the broad front area of the rotating fan would seem to limit its horizontal maximum speed. For some applications,

Below left, the airflow through the rotating fan produces massive lift. Right, NASA experimented with rolling cylinders to improve flap performance in a related concept to the FanWing.



Above: The latest FanWing UAV demonstrator added winglets to the design.

this may not matter but, for others (e.g. military tactical transport) a higher top speed may be extremely desirable. Higher speed wings, says FanWing, are being worked on and in the period from January 2004 to June 2004 top speed rose by 50%. Mr Peebles confirms that the rotor can be scaled down and even enclosed in the wing in future designs to increase the top speed.

Bird strike Bird strikes are a common problem for all aircraft, especially in the low-level flight regime. In most aircraft the vulnerable areas are cockpit and engines. With the FanWing, the large frontal area presents a potential issue in ingesting birds into the fan cage. Whether this can be mitigated by grills, wire or other systems (without affecting the type's extraordinary lifting capabilities) remains to be seen. However, it may be that because of the FanWing's slow speed, bird strike will be less of a problem for this air vehicle. FanWing plan to design the rotor to be able to handle a limited bird strike — relying on the ballistic parachute for extensive damage. Higher speed FanWings with smaller or faster turning rotors would, one assumes, be more resiliant to such strikes.

Ground handling On a related note, it may also be that the giant combine-harvester style blades of the FanWing might present special ground handling issues if a commuter or freight version enters service. Already for jet engines, a danger zone extends in front and behind the powerplant. While standing behind a FanWing powering up may be the equivalent of being underneath a helicopter and thus considerably safer than being behind a jet exhaust, the suction effect of being in front of such a large fan is unknown.

De-icing For the concept to become really practical, flight into icing conditions will also have to be addressed. This may not matter for some applications like UAV or microlight uses. However, for search and rescue, emergency and especially military operations, the issue of potential icing on the blades will have to be investigated and solved.

Configuration flexibility At the moment, the scale model demonstrators have all exhibited the same basic configuration of podded fuselage underneath the wing and high T-tail clear of the rear of the wing. While concepts on the FanWing website show airliner-style fuselages with the wing attached on top, it is unknown yet how flexible in configuration the FanWing could prove to be. Could the basic concept support pods, weapon pylons, sensor blisters, floats or other protuberances that may affect the airflow into the fan?

Below: Inventor Patrick Peebles in his workshop with his FanWing demonstrator.

Development history

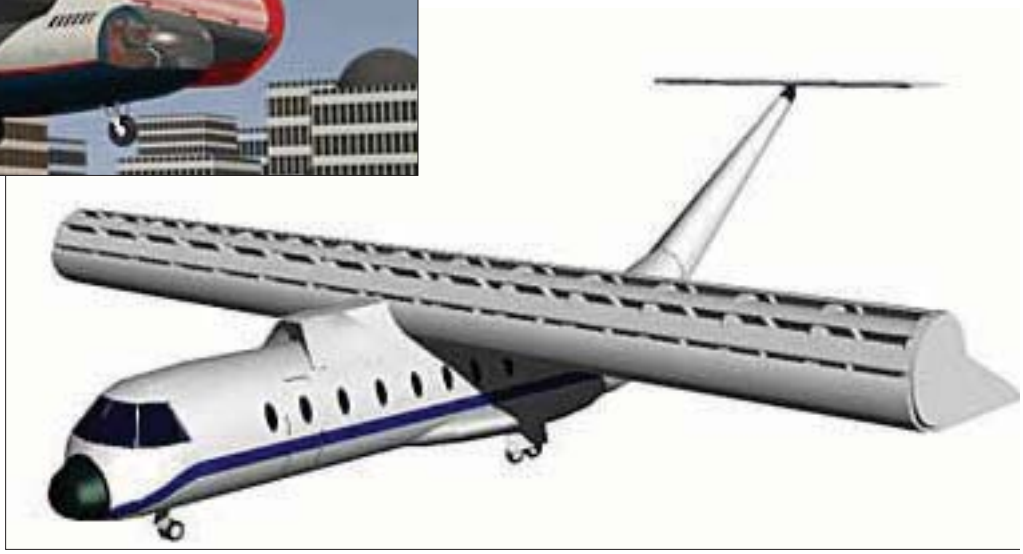
The first FanWing model successfully flew in 1998, with wind-tunnel tests at Imperial College, London, confirming the types' highly efficient design. Further models followed with larger wingspans. In 2002 the FanWing was nominated for an 'Outstanding Achievement in Aerospace Award' from the Royal Aeronautical Society. Further wind-tunnel tests at Imperial College were carried out in February 2002 under the supervision of Professor Mike Graham, head of aeronautics. The tests, with a one metre wing section, showed the impressive lifting efficiency of the FanWing and went some way towards solving the autorotation issue. This work was carried out as part of a £60,000 SMART award from the UK government. Mr Peebles also received help from a small business initiative scheme from Business Link Wessex which set up 'The Virtual Company', allowing him to draw on marketing and financial brainpower in return for shares in the venture once it is profitable.

In September 2003 the first test flights were made of the 2·2m UAV prototype. In November 2003, the UAV FanWing SMART 2·2m prototype made test flights with new winglets which enhanced the craft's performance. This is the technology demonstrator that was on display at Farnborough. In June 2004 the FanWing was nominated for a World Technology Award — an award backed by CNN, Microsoft, NASDAQ, Science magazine and Time magazine for innovation. In 2004, Mr Peebles' latest FanWing 2·2m wingspan demonstrator made its début at the Farnborough International Airshow (see Show Report, Aerospace International, September 2004) where there was much interest in the concept. In particular he reported that there was a great deal of US curiosity in the FanWing, which is not surprising given the US's forward-looking agenda in adopting UAVs for all kinds of tasks, from anti-terrorism to environmental protection. Indeed, FanWing says that Farnborough was "in every sense a turning point for us" and while small share sales in the company keep it going, there is now serious interest from the US government, UK MoD and universities interested in the FanWing.

Applications

The potential applications for a highly efficient, short-take off and landing air vehicle which is quiet and highly stable in flight are listed below but further missions and roles may evolve once the technology has developed further and matured.

UAV One of the first roles that the FanWing is being thought suited to is development in UAV roles for surveillance or reconnaissance. The slow speed of the FanWing, plus its impressive lift capability and gust-resistance, means for a drone carrying sensors it



Above and right: Two concepts for future FanWing designs — an urban city hopper and a commuter transport.

would be ideal for civil, paramilitary and military requirements. Furthermore, the short (or vertical) take-off and landing capabilities would increase its operational flexibility away from prepared airstrips — making it especially useful for a tactical UAV.

Ultralight The first planned human-carrying configuration of the FanWing will be a two-man ultralight, says FanWing. The short-take off, low-cost construction and operations and lack of stall will be especially suitable for this niche and will enable its inventor to assess handling qualities and any human factor issues before bigger and more costly applications.

Cropdusting/fire-fighting Scaling up the design, a slightly larger FanWing would have immediate applications for fire-fighting and crop-dusting missions. Its remarkable carrying capability would mean a high payload of water or pesticides and indeed in the case of the crop-dusting role, it would be a simple matter to introduce the pesticides into the fan and let the FanWing's integral configuration deliver the chemicals, rather than necessitating a separate spraying bar as used today.

Search and rescue The FanWing's short-take off and heavy lift capability would also be extremely useful for search and rescue or EMS (emergency medical services) now being performed mainly by helicopters. Law enforcement (with lower operating costs than helicopters) could also be an application for the FanWing, especially as its quiet operation would fit it for operations over urban areas.

City-hopper transport Its unique short take-off capability, quiet noise profile allied with lower cost than helicopters, might make the FanWing the perfect 20-seat urban city transport beloved by science fiction artists. While it has competition in this regard from the tiltrotor, it may be that the FanWing may eclipse this competing technology due to simpler (and therefore less costly) mechanical links. However, even if it could be proved to be economic and the demand existed, the FanWing would still have to negotiate the complex tangle of red tape to start city shuttle operations successfully.

Tactical transport Finally, the FanWing may also find a niche in military service as a short/vertical take-off tactical transport for transporting troops or supplies However, the militaries may desire a higher top speed to exit 'hot' landing zones which, if it involves a reduction in fan size to reduce the frontal area, would seem to involve a trade-off between maximum speed and lifting ability. Further developments of the FanWing in the future perhaps may make it feasible for a twisting variable-sized fan to expand and contract for different flight regimes.

Conclusions

From small beginnings the FanWing invention is now gathering pace rapidly, with bigger and bigger models, more test data and a higher public profile. It is a sign of the exciting nature of the aerospace industry that even 100 years after the first manned powered flight, new ways of propelling heavier-than-air craft through the sky can come from almost nowhere. Like the Wright brothers, Patrick Peebles is self-taught but his tests with scale models have demonstrated the soundness of his ideas.

Dr Raj Nangia, consulting engineer, who has done extensive work on unconventional configurations, including the SensorCraft, commented: "It's an interesting concept in terms of aerodynamics." He added: "It will be interesting to see if the concept can be developed toward more practical higher-speed configurations."

Certainly, in the past 100 years there have been many false dawns and the FanWing faces stiff competition from both established technology and hybrid developments like tiltrotors and other exotic ducted-fan flying vehicles. However, its advantages certainly appear real and the enterprise seems to have made a breakthrough in credibility. While issues remain, none of these looks unsurmountable and in this century it may be that the FanWing becomes as common as the helicopter. ◆

Below: Wind-tunnel tests at Imperial College, London, confirmed the FanWings' potential.