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FLIGHT INTERNATIONAL

Driven by a dream

Why Honda wants to join the jet set

OPENING DOORS

A rare glimpse inside Honda's aircraft research and development facility underlines how seriously the car giant is taking its first venture into aviation

GRAHAM WARWICK / GREENSBORO

The modest grey buildings at Greensboro, North Carolina's Piedmont Triad International airport were, until recently, unmarked. Now a pair of small fabric banners identify this corner of the south-east US regional airport as the home of Honda Aircraft Company – formally established in August to commercialise the HondaJet light business jet, the Japanese car giant's first venture into aviation.

Honda provided an unprecedented glimpse inside its global research and development organisation late last year when it allowed the aviation press inside the Greensboro facility, where the proof-of-concept HondaJet was assembled and is being flight tested and where design of the production aircraft is getting under way.

The overall impression is underwhelming – and deliberately so. "This is the first time we have opened the doors of one of our [research and development] facilities, but if you went to Honda R&D in Japan you would have the same impression of understatement," says American Honda Motor assistant vice-president Jeffrey Smith, adding: "It's a little on the modest side, but Honda is first and foremost an engineering company."

Honda Aircraft (HAC) started life as a research facility, established at Greensboro in 2000 by Honda R&D Americas, and it has the functional feel of a laboratory. "We have spent a lot to create a product, but not on buildings," says Michimasa Fujino, president and chief executive of Honda Aircraft and the man behind the unique design of the HondaJet.

For a long time the only clue to the facility's existence was the rows of Honda cars in the parking lot. Then on 3 December 2003 the proof-of-concept HondaJet – fabricated in Japan, then assembled and tested in Greensboro – taxied out to make its first flight from Piedmont Triad International. The aircraft made its public debut at the Oshkosh show in July 2005 and a year later, at the same general aviation Mecca, Honda ended all speculation by announcing plans to produce the HondaJet in the USA.

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Mock-up shows larger Garmin G1000 displays planned for production HondaJets

Orders top 100

Honda Aircraft was formed in August, opening its orderbook at the National Business Aviation Association show in mid-October, and by year-end had "well over 100" orders for the $3.65 million light jet. That is more than a year's production at the planned 70-aircraft annual rate revealed by Honda chief executive Takeo Fukui in his year-end round- up. These aircraft are to be assembled at a Honda-owned plant in the USA, with selection of the location now under way.

While the car giant's venture into aviation has met with scepticism in the aerospace and automotive sectors, the HondaJet is off to a strong start and the quality of the proof-of-concept aircraft and thoroughness of the testing behind the design make clear the company is serious. The design is a "pure home-grown effort", says Fujino, and HAC has a "full in-house capability to develop the aircraft", from design through assembly to ground and flight test.

This is clear from a tour of the Greensboro facility, where the proof-of-concept HondaJet was assembled and completed extensive ground testing before being flown. In addition to the design offices and flight-test control room, the buildings house structural test rigs where the airframe was proof tested and a fixed-base flight simulator, developed in-house, that is used for engineering and testing.

Honda will not reveal how many people work in the Greensboro facility, but all of them sit at workstations with dividers that are only waist-high, to encourage open communication. "A very small team developed the aircraft, and we have a very flat organisation," says Fujino. "Everyone is on the same floor: management, engineers and technicians."

Fujino has an unusual approach to improving communication – he bans meetings. "People come to meetings without preparation. They talk, or shout, then leave," he says. "I ordered no, or minimum, meetings. Instead people have to find who makes the decision, or has the information they need. They become very efficient. They go to the real spot, understand the real situation, and make the decision."

The Greensboro facility reflects this philosophy, with the design, assembly and test rooms grouped conveniently around the hangar. "The engineers always go to the

hangar, and the technicians can propose any modification to improve the design," says Fujino. Although he appreciates this philosophy will have to be adapted to the more complex task of obtaining US Federal Aviation Administration certification for the HondaJet, Fujino says the design and development team will still be much smaller than in traditional aircraft programmes.

Fujino is unusual in that he is not only chief executive of the company, but also designer of the aircraft. He graduated from Tokyo University with a degree in aeronautical engineering, but says there were no interesting jobs in Japan's aircraft industry, which was focused on licence manufacture, so instead he joined Honda R&D in 1984, and began working in automobile research.

Two years later, Fujino joined Honda's embryonic aircraft research effort. The HondaJet is his third project. The first two – the MH01 all-composite turboprop single and MH02 six-passenger twinjet – were experimental aircraft assembled and tested in the USA with the participation of Mississippi State University.

The MH02 could be seen as a precursor to the HondaJet, not least because of its similarly unusual layout. Flown for a total of 170h between March 1993 and August 1996, the MH02 had two Pratt & Whitney Canada JT15D turbofans mounted above a high-set, forward-swept wing. The design was optimised for runway performance, and is claimed by Honda to have been the first all-composite small business jet.

In 1997, Fujino drew the first concept sketch for the HondaJet, and proposed the project to top management. After two years developing the basic technology, the configuration was frozen in 1999. The design has several unusual features, not least mounting the engines above the wing.

Making room

"I had the idea around 1996," says Fujino. "The cost of a business jet is very high. To reduce the cost, you have to reduce the size of the aircraft, but then you sacrifice comfort. I wanted to make the aircraft smaller, but not sacrifice the cabin." Most business jets have the engines mounted on the rear fuselage, and moving the structure and systems to support the engines out of the fuselage would maximise space inside the cabin without increasing the size of the aircraft, he believed.

"I had to find a location for the engines," Fujino says. "Under the wings was not possible, because of ground clearance, but we were taught never to put anything above the wing. It's the first lesson – it's been tried before and the design flopped; stay away from it." Analysis and testing proved the lesson to be wrong, however. "If you position the engine to get favourable interference between the nacelle and the wing you can reduce high-speed drag and increase range," he says.

Proof-of-concept HondaJet has most of the systems planned for production aircraft

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The problem with an overwing engine is that interference between the nacelle and wing can accelerate the airflow and cause a strong shockwave, reducing the drag rise Mach number – the airspeed at which shockwaves form and drag begins to rise rapidly. Fujino says computational analysis and windtunnel testing enabled Honda to find a "sweet spot", an overwing engine location that minimises the shockwave. The result, he says, is a 5% better lift-to-drag ratio – aerodynamic efficiency – in the cruise than a rear-engined aircraft.

Finding the sweet spot was not simple, and required some sophisticated aerodynamic and aeroelastic design tools and comprehensive testing. A crucial campaign in Boeing's transonic windtunnel, in 1999, convinced Honda that it had the answer and, says Fujino, also converted Boeing's engineers from sceptics to

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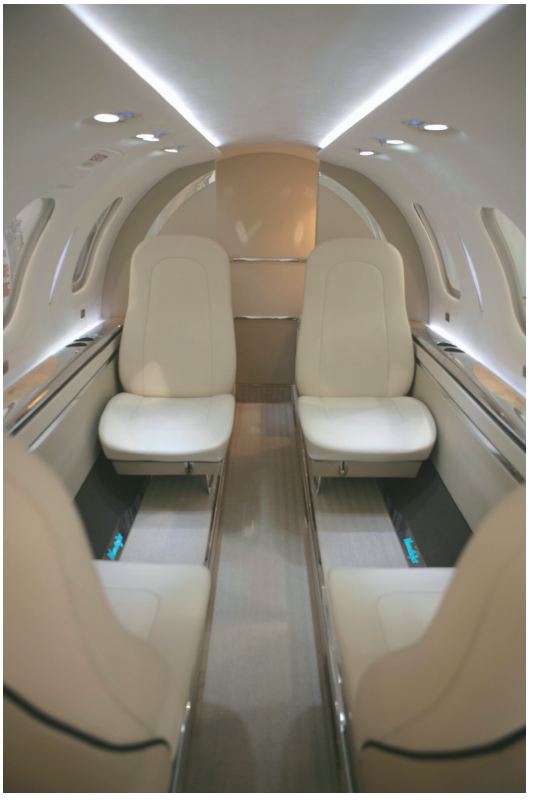
MICHIMASA FUJINO, HONDA AIRCRAFT



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Wide cabin provides generous club seating and fully enclosed lavatory

believers in the company's design ideas.

He shows a video of another key windtunnel test, to determine the effect of the overwing engine on flutter. Careful design is required to avoid making flutter worse. To confirm the design margin, a dynamically scaled model was tested to destruction – with dramatic effect: the pylon vibrating so violently that the nacelle separated and flew down the tunnel. But Fujino is confident he now knows the HondaJet's flutter margin to within 5% – greater accuracy than usual at this stage.

The result of this effort is a design in which the engine is mounted above, but almost entirely behind, the wing. Positioned over the trailing edge, the inlet is shielded by the wing, which reduces the fan noise reaching the ground and makes the HondaJet noticeably quieter. The nacelle is offset inwards on its pylon to provide easy access to the engine from the ground. And the pylon itself has complex curvature, to avoid producing a side load in the cruise.

In the HondaJet, the over-the-wing engine mount is combined with natural laminar flow – the art of maintaining smooth airflow over as much of the airframe as possible to minimise drag. Laminar flow requires smooth surfaces and a favourable (increasing) pressure gradient, and explains the HondaJet's unusual bulged nose. This shaping maintains laminar flow over the lower fuselage almost to the entry door and offsets drag from the wide fuselage. The bulged cockpit, meanwhile, increases headroom, says Fujino.

The company has developed its own laminar-flow aerofoil section for the HondaJet, designated SHM-1. This maintains a favourable pressure gradient to around 40% chord on the upper surface and 60% on the lower surface. The wing has to be exceptionally smooth, and an integrally machined upper skin avoids rivets that would disturb the flow. Careful design allows laminar flow between the engine pylon and fuselage, Fujino says, and the winglet is canted, but not blended, to maintain laminar flow out to the tip.

Composite fuselage

Structural design is equally important for weight and cost. The wing is metal, to maintain the contour required for laminar flow, but the fuselage is composite for lower weight and easier manufacture. The nose and tail are of honeycomb sandwich construction, because of the compound curves, but the constant-section cabin is monolithic carbonfibre. The integrally stiffened structure maximises cabin internal diameter and also minimises noise transmission, says Fujino: "It behaves just like aluminium."

The fuselage for the proof-of-concept HondaJet was produced by hand lay-up, and the same technique is planned for production aircraft as the rates do not justify automation, says Fujino. Technology developed by Honda to co-cure the composite skin panels, frames and stringers will be transferred to the outside supplier selected to fabricate fuselages for production HondaJets, he says.

This combination of aerodynamic and structural technologies results in an aircraft that is difficult to categorise. With a maximum take-off weight below 4,535kg (10,000lb), the HondaJet gets grouped with very light jets like Cessna's $2.6 million Citation Mustang, but its cabin is larger than that of the $4.3 million Citation CJ1+ entry-level jet while its price is between the two. In most areas the promised performance is better than that offered by the CJ1+, Honda claiming a 30-35% greater specific range.

Fujino calls the HondaJet an "advanced light jet", and it may be in a category of its own. Compared with its closest rival, the CJ1+, the HondaJet cabin has 51mm (2in) more height and width; 350mm more length, which allows club seating without overlapping feet; and a fully enclosed aft lavatory with the optional six-passenger air taxi interior. There is 0.6m (21ft) more baggage space in the nose and tail.

Projected maximum cruise speed is 420kt (780km/h) on two 1,880lb-thrust (8kN) General Electric/Honda HF120 engines, compared with just under 390kt for the CJ1+. The proof-of-concept aircraft has reached 412kt on two 1,670lb-thrust HF118 prototype engines and "would far exceed 420kt with HF120s, so we may slightly limit the engine", Fujino says. Calculated ranges are slightly shorter than those of the CJ1+, but airfield performance is similar despite the HondaJet's much smaller wing – at 12.15m, span is shorter even than the Mustang's – thanks to powerful double-slotted flaps.

Honda Aircraft is continuing to flight test the proof-of-concept HondaJet at Greensboro as it selects a US location for the certification and production programme. Fujino says four test aircraft will be assembled at the new location. US certification and first deliveries are scheduled for 2010.

Greensboro is bidding to host Honda's first aircraft factory, but competition is fierce. Whatever the outcome, this modest corner of Piedmont Triad International will always be known as the birthplace of the HondaJet. ■

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Overwing engine combined with laminar flow gives HondaJet its edge