

Building technology

Lean manufacturing is making its mark in the business aviation market

GRAHAM WARWICK/WASHINGTON DC

GENERAL AVIATION manufacturing traditionally involves riveting thousands of pieces of metal together to produce an aircraft that, hopefully, is cheap to buy and fun to fly. But manufacturers and customers have become more sophisticated. From lightweight piston singles to heavyweight business jets, new designs are setting new standards in price and performance, and advances in manufacturing technology are the key.

Most obvious are the composite construction techniques which have allowed newcomers like Cirrus and Lancair to produce light aircraft with new levels of performance. More significant are the changes being wrought in the way business jets are designed and built.

Two new programmes at opposite ends of the spectrum illustrate those changes: the Eclipse 500 personal jet and Bombardier Continental super mid-size business jet. One sells for under \$1 million, the other for over \$15 million, but they both benefit from advances in design and manufacturing technology.

Bombardier has honed its design, production and certification skills over many programmes. The result is a schedule of just 42 months from launch to delivery of the first "green" Continental – the fastest all-new aircraft programme the company has ever attempted.

Eclipse Aviation, by contrast, is a newcomer. The Eclipse 500 is the company's first aircraft and, while its schedule is less aggressive, the programme involves the first certification of a new manufacturing technology, friction stir welding (FSW), which will replace conventional riveting to reduce costs. Albuquerque, New Mexico-based Eclipse faces a challenge. At \$837,500, the twin-turboprop Eclipse 500 is priced well below competing single-turboprop aircraft. Some of the cost difference is due to the aircraft's Williams EJ22 small turboprops. Much is due to the way it will be built.

Chief executive Vern Raburn attributes the Eclipse's low cost to a "mindset". Rather than adopt the traditions of light aircraft production, the company has looked to car manufacturers

for inspiration. "General aviation aircraft are built out of bits and pieces – the automotive industry hates bits and pieces," he says. As a result, Eclipse will use integrated parts. "This radically reduces parts count and assembly time."

Integrated parts require extensive use of available design and modelling tools, Raburn says. "It is far more complex from an engineering viewpoint. It's a parametric issue: squeeze in one spot and it pops out in another." Eclipse selected Unigraphics' computer-aided design software because of its parametric capability – a change made in one area is automatically reflected throughout the design.

Potentially, the biggest breakthrough in the design is the use of friction stir welding. The Eclipse 500 will be the first application of the technique to thin panels and its first use in a certificated aircraft. Developed by The Welding Institute in the UK, FSW is used by Boeing in production of Delta launch vehicles.

COMPELLING REASON

For a programme that already combines a new airframe with a new engine, adopting a new manufacturing technology seems foolhardy. But Eclipse has compelling reasons for taking on the burden of certifying FSW.

In FSW, a pin rotating at high speed is moved along the joint between two pieces of aluminium alloy, creating frictional heat which softens and plasticises, but does not melt, the metal and fuses it into one piece. The fuselage pressure vessel, for example, will be three sections stir-welded together. Eclipse plans to produce a fuselage in a day, compared with two to three days for conventional construction.

"What FSW brings is efficiency in manufacturing," says Raburn. "Not only are the man-hours required reduced, but also the cycle time between operations." Both riveting and bonding were rejected as too time-consuming and expensive. Automatic riveting was too slow and bonding required clean room conditions and lengthy cycle times. Composite construction was rejected for similar reasons. "Composites can't cook faster," he says.

Pioneering a new manufacturing technology

is a major undertaking for a new, small company like Eclipse. But the firm is well funded compared with most new entrants into general aviation. "You can reduce your recurring expenses by investing in non-recurring expenses, but that requires capital," says Raburn.

Opting for FSW has added cost to the programme, but less than would have been involved if Eclipse had stayed with its original plan of building a composite aircraft, Raburn says. "Early in the programme we thought this would be a composite aircraft, but we concluded there was no way we could hit our production goals with the same material system as Cirrus."

Cirrus and others use thermoset composites, whereas the automotive industry uses thermoplastics. "The cost of developing and certifying a thermoplastic system was easily \$50 million, and if we weren't successful, there was no fallback," Raburn says. The cost of certifying FSW is "nowhere near \$50 million" and Eclipse can fall back on conventional riveted construction, although this would increase cost.

"We added effort and risk to the programme, but the risk/reward ratio was appropriate," says Raburn. Eclipse is close to deciding whether to proceed with FSW. "We have agreed the certification basis and demonstrated our methodology. We understand the limitations of the process and it looks very positive." Parts manufacturing must begin in four months if Eclipse is to meet its June 2002 first flight and August 2003 certification targets.

Bombardier is comfortably within the schedule it has set for certification of the Continental. The first aircraft will roll out in April and the remaining two flight-test aircraft soon afterwards. The secret, says executive vice-president engineering and product development John Holding, "is to do more work up front. It saves time and definitely saves money."

The company leads the industry in using partners to share the risks and rewards of aircraft development, and has refined the process for involving its suppliers in design. The Continental was the first programme to have a pre-launch joint concept definition phase. "We brought people in a lot earlier and made them part of the definition of the aircraft," says Holding. The aim was "to get it right first time" and minimise changes during design.

Previously Bombardier had brought its partners together after launch for a joint definition phase. With the Continental, the goal was to spend more time up front defining the product, "then go like hell and make it", Holding says. Most of the partners are on their third or fourth

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