BOEING

A 7E7 model in the wind tunnel. Its nickname, Dreamliner, might appeal to passengers, but is also code for better economics lighter weight promises beleaguered airlines.

Boeing's plastic model

Designers are pushing the envelope in the 7E7 with skin, structure of composites

Light and strong, they will boost aircraft economics, comfort too *By Rachel Ross*

Every kid has a plastic plane. With simulated engine noises and hand-powered propulsion, those little toys can fly to every corner of our imagination.

Now Boeing has dreamed up a plastic plane of its own and the company plans to fit nearly 300 people inside.

Built from a plastic material known as carbon composite, the Dreamliner 7E7 will be a significant leap forward in airplane design.

Strong and light, carbon composites have been used in aircraft for decades but are generally limited to the smaller parts.

With the 7E7, Boeing Commercial Airplanes plans to use more carbon composite than ever before. The Chicago-based company, which builds most of its aircraft in Seattle, Wa., (though important 7E7 components will be made in Winnipeg), said more than 50 per cent of the plane's parts by weight will be made of the material.

"It's a really great material for aerospace structures," said Tom Cogan, Boeing's chief project engineer for the 7E7.

Ultimately, carbon composites could do more than make planes tough and durable. The structural material could give airplanes brawn, and brains as well, by becoming an electronic component.

Richard Aboulafia, vice-president of analysis for the aerospace consulting firm Teal Group Corp., said it's the first time a commercial plane has used carbon composites for primary structures such as the fuselage.

"The whole body will be plastic, basically," he said.

Unlike the flimsy plastic that held together your toy plane, Boeing's material was specially engineered to withstand the forces of flight.

Composites, such as the one being used to make the 7E7, are made of two or more materials: fibres and some kind of gluey substance that binds them all together. The binding material, which is often a plastic, is called the matrix.

The most common fibres used for planes are made of carbon or glass (as in fibreglass). Boeing typically uses carbon composites that come in tape-like strips. The fibres are embedded in the tape, which is also impregnated with matrix. Layers of tape are added, one on top of another and the final form is put into an autoclave where it is cured under high pressure and heat.

Carbon-fibre composites are especially useful in aircraft because they are strong yet light.

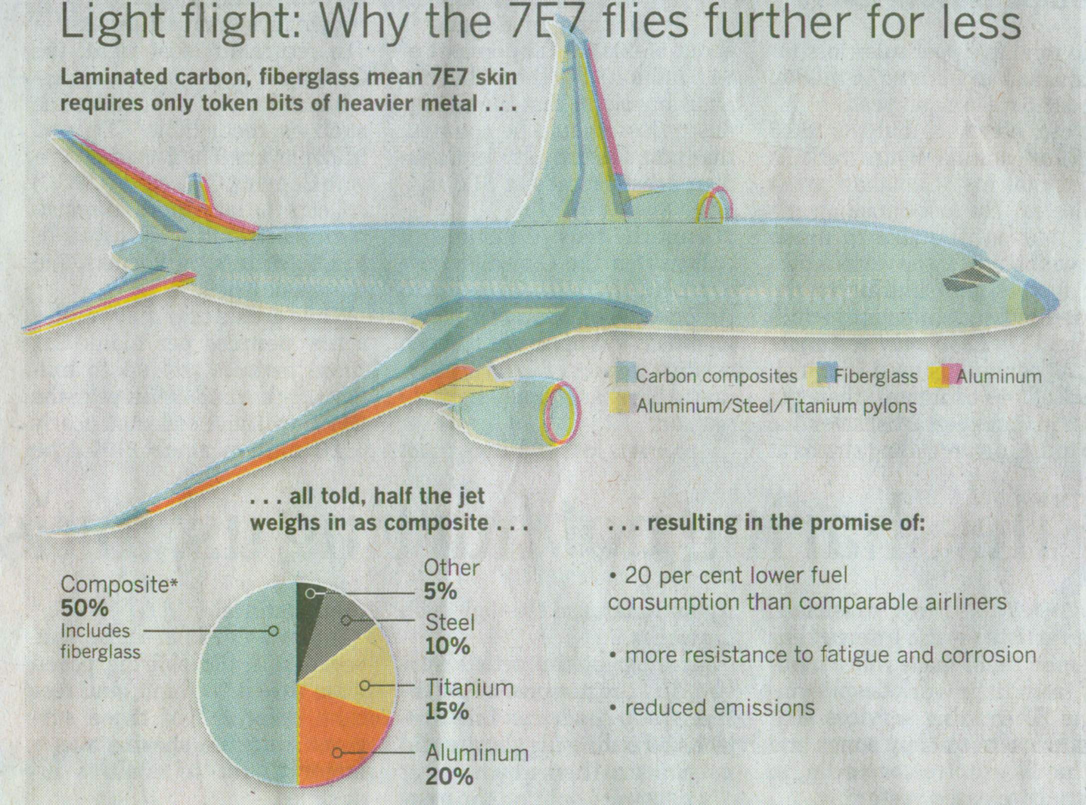
"It has a 30 per cent better weight-to-strength ratio than the aluminium that we use," Cogan said. "It has very good fatigue characteristics and it doesn't corrode."

Metals such as aluminium will suffer fatigue over time and crack.

But the aligned, continuous fibres in a strip of carbon composite reinforce the strip in a particular direction, much like visible fibres in a piece of strapping tape. One tape layer might be applied with the fibres running in a vertical direction while the next layer might have the fibres running in a horizontal direction. By varying the direction of the fibres in each layer engineers can build an airplane part that it is reinforced against common kinds of stress. Any cracks that do develop in a carbon composite can't grow very large because of the continuous fibres

➤ Please see **Dreamliner, D3**

Light flight: Why the 7E7 flies further for less



. . . resulting in the promise of:

- 20 per cent lower fuel consumption than comparable airliners
- more resistance to fatigue and corrosion
- reduced emissions

SOURCE: Boeing

TORONTO STAR GRAPHIC

➤ Dreamliner From D1

and the way the tape is layered.

"Composites are the way to go today and in the future of aviation," said Airbus spokesperson Mary Anne Greczyn.

Airbus currently has its own composite commercial craft in development. The Airbus A380 won't have nearly as much of the stuff, however. Carbon composites will be limited to secondary structures, such as the tail fin, on that plane.

Greczyn said it's possible that Airbus could use more carbon composites for future airplanes, "but it takes years of testing to make sure composite structures work in a certain application."

Boeing also has a leg up on the competition — a special production process that's making it easier than ever before to work with composites. Cogan said that historically, building large plane parts out of carbon composite was too expensive because there was a lot of hand labour involved. It's only since Boeing found a way to automate the tape-laying process that large composite parts became economically efficient to produce.

Money is, after all, the driving force behind the transition to lightweight composites.

The lighter the plane, the lower your fuel costs. Boeing estimates a 20 per cent improvement in fuel performance per passenger.

Using composites also means Boeing can make the plane out of bigger parts. The company estimates that will cut the time it takes to build the airplane by 30 to 40 per cent.

The benefits of carbon composites will reach far beyond the mighty dollar.

Less spent fuel translates into lower environmental costs as well, because of a reduction in airplane exhaust.

"It could also eliminate the horrors of a dry airplane," said Aboulafia.

Model shows Dreamliner in colours of launch customer All Nippon Airways of Japan. The plane looks like many others, but composite materials are poised to alter the shape of flight. "We will be able to experiment with novel forms of aircraft design," says one analyst.

Metal planes have to be kept rather dry to keep the body from corroding. Carbon composites, however, can handle a little moisture so the air inside the plane could be made more humid.

The strength of composites also allows engineers to design planes with bigger passenger windows.

In the long term, the building material could make planes a lot more intelligent.

Deborah Chung, a professor in the department of mechanical and aerospace engineering at the University at Buffalo, is devising ways to make materials "smart" by tapping into the electrical properties of carbon composites.

"A lot of work has been done on building structural materials just for structural sake. But relatively little work has been done on non-structural attributes," Chung said.

Chung has already found a way to detect damage in the carbon composite formulas used by the aerospace industry. Electrical contacts hooked up to the composite can detect damage to the airplane part by sensing changes in electrical resistance caused by broken fibres. As fibres are broken the electrical resistance increases, and a message is sent to a central computer to alert staff. The contacts could be permanently embedded in the part for real-time damage detection, Chung said, or manually attached just for safety checks.

Chung is already in the process of commercializing the technology, which she estimates will take another three years.

Today's airplanes are checked for damage using an ultrasound system but Chung says her technique would be able to sense much finer cracks.

"We can even see slight debonding between the fibre and the matrix," she said.

Boeing has similar plans for their own smart parts. But Cogan said there's still some debate over the best way to use such a system. It might be best used, he suggested, to determine the extent of any known damage as opposed to a damage alert system. He said the company also hasn't determined whether such sensors will be built into the Dreamliner 7E7, which is slated to go into service in 2008.

The question of safety is paramount with any new building material. Engineers can build in a fancy damage sensing system but in an aircraft it's fundamentally more important that the material itself is sound. You can't make a lot of repairs in the air.

A single accident, three years ago had a lot of people asking questions about carbon composites.

On Nov. 12, 2001, American Airlines flight 587 took off from Kennedy International Airport. Moments later, 265 people were killed when the plane's rudder and tail fin separated from the rest of the plane. The crash of the Airbus A300 prompted questions regarding the safety of carbon composites, which were used to make parts of the plane. The pilot had been navigating the aircraft through severe turbulence in the wake of another plane.

"This inquiry was raised and dismissed more ways that I can count," Airbus' Greczyn.

But after a lengthy investigation —- including an examination of the manufacturing process for the stabilizer — the U.S. National Transportation Safety Board ruled that pilot error likely caused the crash. According the NTSB, the pilot used excessive and unnecessary movements to try to control the rudder, which put the tail fin under more stress than it could handle. The carbon composite wasn't to blame, however.

"The Board found that the composite material used in constructing the vertical stabilizer was not a factor in the accident because the tail failed well beyond its certificated and design limits," read one statement issued by NTSB concerning the crash. Improved pilot training regarding rudder control was ultimately recommended by the board.

Given the NTSB findings and decades of experience with carbon composites in military aircraft, airplane manufacturers have no qualms about the increased use of the material.

"We're absolutely confident that composites can be used very, very safely in an airplane without compromising the integrity of the plane," Boeing's Cogan said.

Pilots feel safe flying the plastic planes, too.

Tom Phillips, chair of the aircraft design and operations group of the Air Line Pilots Association International, said the material is certainly "acceptable" as it has passed all the requisite testing for use in both primary and secondary plane structures. The association represents 64,000 commercial airline pilots in the U.S. and Canada. Phillips said the material hasn't presented any special safety problems and he can't tell the difference between flying a plane made of composites from one made of aluminium.

The Teal Group's Aboulafia is happy with the weight loss achieved so far through composites. But the industry analyst says the real changes are yet to come, as the next step for commercial airplane manufacturers involves a significant redesign.

"You take out the aluminium and build advanced structures that truly take advantage of the tensile and compressive strengths of carbon composites," he said. "We will be able to experiment with novel forms of aircraft design."

If Aboulafia is correct, the commercial planes of tomorrow might not look much like the bulky birds we fly today thanks to a lot of well-laid tape.