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

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 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.

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

Light flight: Why the 7E7 flies further for less

Laminated carbon, fibreglass mean 7E7 skin requires only token bits of heavier metal ...

...all told, half the jet weighs in as composite ...

...resulting in the promise of:

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

Composite 50%
Includes fiberglass

Other 5%
Steel 10%
Titanium 15%
Aluminum 20%

SOURCE: Boeing

TORONTO STAR GRAPHIC

> Please see Dreamliner, D3
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 Grezyn.

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.

Grezyn 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
airplane parts out of carbon
composites was too expensive becaused 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 it will cut the time
takes to build the airplane by 30
to 40 per cent.

The benefits of carbon
composites will reach far beyond
the passenger.

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
eplanes 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 rela-
tively 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
cause 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 technol-
yogy, which she estimates will
take another three years.

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

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

Boeing has similar plans for
their own smart parts. But
gan said there’s still some de-
bate over the best way to use
such a system. It might be best
used, he suggested, to deter-
mine the extent of any known
damage as opposed to a damage
alert system. He said the com-
pany 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 para-
mount with any new building
material. Engineers can build in
a fancy damage sensing system
but in an airplane it’s fundamen-
tally 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 com-
posites.

On Nov. 12, 2001, American
Airlines flight 587 took off from
Kennedy International Airport.
Moments later, 265 people were
crashed when the plane’s rudder
tail fin separated from the
rest of the plane. The crash of
the Airbus A380 prompted
questions regarding the safety of
carbon composites, which were
used to make parts of the
plane. The pilot had been navigat-
ing the aircraft through se-
vere turbulence in the wake of
another plane.

"This inquiry was raised and
dismissed more ways than I can
count," AirBus’ Grezyn.

But after a lengthy investiga-
tion — including an examina-
tion of the manufacturing pro-
cess for the stabilizer — the U.S.
National Transportation Safety
Board ruled that pilot error like-
ly caused the crash. According
the NTSB, the pilot used exces-
sive and unnecessary move-
ments to try to control the rudder,
which put the tail fin under more
stress than it could han-
dle. 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 certified 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 car-
bon composites in military air-
craft, airplane manufacturers
have no qualms about the in-
creased use of the material.

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

Pilots feel safe flying the plastic
planes, too.

Tom Phillips, chair of the air-
craft design and operations
group of the Air Line Pilots As-
Sociation International, said
the material is certainly "accep-
table" as it has passed all the
requisite testing for use in both
primary and secondary plane
structures. The association rep-
resents 64,000 commercial air-
line pilots in the U.S. and Cana-
ada. Phillips said the material
wasn’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 com-
posites. But the industry analyst
wasited the tests are yet to
come, as the "next step for com-
mercial 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 com-
posites," 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.