FLIGHT OF THE FUTURE

Words Mike Farmery

IS SUSTAINABLE FUEL FOR AVIATION AN ACHIEVABLE GOAL OR A FLIGHT OF FANCY? *SUBLIME* EXPLORES THE OPTIONS FOR THE FUTURE OF SKY TRAVEL

I make no apologies; I am an aviation enthusiast. I think the take-off of an Airbus A340-500 from Singapore to fly to New York represents a fantastic human achievement. It carries not only two hundred or so passengers and their luggage, but also all the stuff you need for an 18-hour flight: fuel, meals, champagne, movies, beds, even high-quality moisturiser. The flight brings together amazing human skills such as single crystal turbine blades that would melt instantly without their internal cooling, advanced aerodynamics that minimise drag but require very fast computers to maintain stability, satellite navigation systems that measure signals from different satellites to fractions of a nanosecond, just in time logistics and internationally agreed regulations all-in-one activity. And it just doesn't happen once like some sort of moon shot – the aircraft stays in New York for a couple of hours and then does it again, and then again. Engines stay on the wing for more than five years between overhauls. It's routine, safe, glamorous and boring all at the same time.

IT'S HARD TO IMAGINE INTERNATIONAL travel without aviation. Apart from a few fast trains, alternative modes are at least ten times slower. How many people would go to a business meeting in Singapore if it took six days to get there? And that's the problem; because we can, we do. Aviation is a victim of its own success. For the human race, sufficiency does not come naturally; we cannot stop inventing and developing. Up to now, if we can, we do.

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Over the last half century, commercial aviation has become very efficient. Fuel consumption has reduced by 70 per cent since the Boeing 707 that started jet travel. Nowadays, fuel used per passenger kilometre is roughly the same as with a modern car, but the snag is that aircraft fly long distances quickly. In one business trip, an executive will generate a carbon footprint equivalent to driving their car for a whole year.

Not surprisingly, people view aviation in different ways. I see it as the pinnacle of human technology and international cooperation. The International Air Transport Association (IATA) like to picture it as the great enabler for global travel, business, trade and tourism. Others see aviation as a rapidly growing monster, a major contributor to climate change with the potential to destroy the planet.

At an esoteric level, you could say that the rapid development of aviation has been fuelled by the imagination and ingenuity of engineers coupled with the romance and excitement of aviators determined to defy gravity. At a more mundane level, commercial aviation is fuelled by kerosene, the same product that is used extensively in the East for lighting and heating, and which sits between gasoline (petrol) and diesel fuel in the distillation of crude oil. Although yields vary widely, on average kerosene represents around 10 per cent of a barrel of crude oil. If you add in all the other sources of carbon-based fossil fuels, such as coal and natural gas, CO_2 emissions from aviation kerosene account for about 2 per cent of total anthropogenic CO_2 emissions – a fact widely quoted by the aviation industry when defending itself. But there are two problems with this simplistic view.

FIRSTLY, AVIATION CONTINUES TO GROW AT A RATE OF AROUND 5 PER CENT a year, and is predicted to double in the next 20 years. If other areas cut back CO_2 emissions, critics claim that in 20 years the current 2 per cent contribution will become more like 25 per cent for some countries. However, much depends on how effectively other industries curb their own emissions. More realistic estimates, for example from the Intergovernmental Panel on Climate Change (IPCC), put aviation as only 3 to 4 per cent of global CO_2 by 2050.

The second problem with the simplistic approach is that aviation's impact on global climate is not just the CO_2 from burning kerosene. Both engine NOx emissions and condensation trails can contribute to warming. However, the atmospheric chemistry is complex and the effects are hard to model accurately. For example, during the day clouds can reflect sunlight and thus cool the Earth, whereas at night clouds keep the heat in. At the moment, the best estimate is that the total global warming effect of aviation could be around two and a half times the basic CO_2 effect.

Because fuel has always formed a significant part of overall operating costs for an airline (currently about 30 per cent), aircraft and engine manufacturers have been forced to reduce fuel consumption. And they have been spectacularly successful – a reduction of 70 per cent since the 707. Further reductions are

possible: for example, the Boeing 787 will be 20 per cent more fuel efficient than the aircraft it replaces. However, the reductions are incremental and, unfortunately, cannot keep up with growth.

THE IATA'S VISION IS FOR CARBON NEUTRAL GROWTH and, ultimately, zero carbon emissions in 50 years' time. This will not be achieved by incremental improvements in fuel efficiency; we need to do something radical with the fuel. This is exciting because jet fuel has not really changed for the past 40 years, but it is not going to be easy: kerosene is a great aviation fuel and has many properties that make it ideal for aviation. Also, because the aviation industry is focused on safety, changes don't happen quickly.

For jet fuel, the options for alternative fuels are rather restricted compared to ground-based fuels like automotive fuels and the consensus is that kerosene will remain the principal aviation fuel for the foreseeable future (20 to 30 years). The main reasons for this view are that it works well, there is a large legacy fleet of aircraft and aviation needs a single fuel. Fuelling global aviation on a special fuel simply won't work in the same way that it can for buses or taxis in the road transport sector: limited, local supply of speciality fuels for specifically modified vehicles is simply not an option when aircraft fly multiple routes with global reach.

In addition to the drive to reduce CO_2 emissions, the other driver for developing alternative fuels for aviation is diversifying supply. The days of easy oil are over and there is now strong competition with diesel for the middle distillate fraction. New sources of kerosene molecules will be welcome even if they are not renewable.

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SO, WHY MIGHT THE AVIATION INDUSTRY APPEAR SLOW to use a renewable biojet type fuel? Well, the easy biofuels such as vegetable oil esters in biodiesel and ethanol in gasoline are not suitable for aviation. They carry a weight penalty (linked to their oxygen content) which, together with performance and handling problems, make them unattractive for aviation.

Producing kerosene-like molecules from biosources is tricky: effectively, you need to remove the oxygen to leave a hydrocarbon. At the moment, there are two potential processes but others are being developed. The biomass to liquids (BTL) process takes any biomass (e.g. biowaste such as waste wood or straw), gasifies it and then synthesises a hydrocarbon. The result is a great jet fuel but it is a costly process that is still in demonstration mode. The other process, hydrogenating vegetable oils, is less energy-intensive but the vegetable oil feedstock is expensive and can be controversial. Competition with food and deforestation are critical issues linked to these vegetable oil feedstocks and some people believe the solution is worse than the problem.

The idea of producing the vegetable oil from algae gets many people excited. They see it as a route to sequester CO_2 and produce hydrocarbons at the same time. Yields per hectare are estimated at up to two hundred times those of conventional crops and farms can be on arid land and use saline water – a renewable fuel nirvana! Unfortunately it is early days and there are many technical problems to overcome in the next couple of decades.

IT IS WORTH NOTING THAT HYDROGEN IS FREQUENTLY PROPOSED as the aviation fuel of the future but it is hard to see how this will come about in the next 30 years. Not only is there huge inertia against any fundamental switch of fuel type (from liquid to cryogenic), hydrogen itself comes with many unresolved technical issues. Questions such as how to pump at high-flow velocities without cavitation and vapour lock, and how to manufacture large volumes via sustainable routes – would any reduced CO_2 bonus be lost in a higher cirrus/contrail contribution to global warming? – are problematic. On top of this remember that not one of today's commercial jets could be modified to use hydrogen even if it were available: every single aircraft would have to be replaced.

So where have we got to? We know that using new fuels to reduce environmental impact is more complicated for aviation than for ground transportation because of the extra focus on safety and the more demanding performance requirements. Fortunately the industry has a great track record in technological innovation and has many good ideas and exciting projects in play. Realistically, however, fuels are not going to change quickly; in the short to medium term, we will have to rely on the incremental improvements that will come from improved aerodynamics, increased use of lightweight composites, improved air-traffic management and more fuel-efficient engines. Some of us may also need to fly less – difficult words for a self-confessed enthusiast!

***Mike Farmery** is an expert in alternative fuels and aviation fuel efficiency. He recently received an IATA award for Outstanding Contribution to the Aviation Industry.*