DISCOVER ENGAGE IMPACT

NEED FOR SPEED

UQ scientists are taking giant leaps for mankind in hypersonic flight research. And while travelling between Sydney and London in two hours may be off in the horizon, rumblings about UQ's plans for small satellite launches using scramjet engines are being felt across the globe.

... Three, two, one. We have lift-off!

Sixty years after the world's first satellite was launched into space, those words continue to excite and intrigue those wondering what else is out there.

The space age officially began on 4 October 1957, when the then-Soviet Union launched the first artificial satellite, Sputnik 1. This space craft lasted just three months in orbit before burning up in the Earth's atmosphere.

Now, hundreds of satellites are launched across the globe each year. But the rockets that detach after launching the satellites are often unable to be used again.

That's where UQ comes in.

Scientists at the University's Centre for Hypersonics have been conducting research into all aspects of hypersonic flight for more than 20 years.

While there is no quick and easy way of launching satellites into space, Professor Michael Smart from UQ's School of Mechanical and Mining Engineering believes a reusable scramjet launcher could reduce launch costs and improve launch-date flexibility.

"A scramjet is a supersonic combustion engine that uses oxygen from the atmosphere, making it lighter and more fuel-efficient than rockets," says Professor Smart.

"The advantage of that is you could fly long distances over the Earth very, very quickly, but it's also useful as an alternative to a rocket for launching satellites into space."

"We've worked on scramjet engines at UQ for more than 20 years, and we've developed them to the point where they can be used in a space-launch system."

Professor Smart says all current satellites are launched by a rocket, but once launch systems have travelled their designated trajectory, they drop away and fall into the ocean.

"A scramjet is like a plane. When it has accelerated to its maximum velocity, the upper-stage rocket carrying the satellite blasts off its back, and the scramjet simply turns around and flies back to base. We can then re-fuel and launch it again."

Professor Smart says there's an opportunity for UQ to leverage its world-leading scramjet technology for commercial use.

"A lot of profitable companies have developed businesses using small satellites, that is satellites weighing less than about 200 kilograms. But the problem for these businesses is that there is no 'dedicated launch' capability for small satellites," he says.

"They have to do what's called a 'tag along', where their satellite is sent into orbit as part of a bigger launch, and they are simply tossed out the side on the way up. They are also constrained to the schedule of the main launch customer. It's very frustrating.

"We'd like to provide them with a dedicated launch. We'd launch a couple of small satellites for a particular company – quickly and in exactly the right spot – and later when that satellite reaches its end-of-life and is de-orbited, we'd do it again for them.

"There's a real commercial opportunity, and that's where a scramjet can be more cost-effective than a rocket because it can be used many times over.

"UQ has developed the SPARTAN small satellite launcher concept to do just that."

ROCKET SCIENCE

UQ's Centre for Hypersonics was formally established in 1997 by the Departments of Mechanical Engineering (now the School of Mechanical and Mining Engineering) and Physics (now the School of Mathematics and Physics).

It has become widely recognised as the leading university-based research group in the field of hypersonics and has active collaborations with international universities and research groups, including those in France, Germany, Belgium, the United Kingdom, the United States, Japan, and India.

The Centre's areas of expertise lie in the development of test facilities based on shock-wave generations (shock tunnels, expansion tunnels, light-gas guns, blast generators), scramjet propulsion (experiment, analysis and design), and rocket-launched flight testing.

The Centre also conducts research on aerothermodynamic experimentation and analysis, advanced instrumentation for aerodynamic measurements, computational fluid dynamic analysis of high-speed transient and steady flows, and optical diagnostics for hypervelocity superorbital flows.

In May 2016, Professor Smart and other UQ researchers were part of an international team that successfully launched a hypersonic test flight from the Woomera Test Range in South Australia.

The experimental rocket, called HiFiRE 5B, hit targeted speeds of Mach 7.5 (9200km/h) and reached a height of 278 kilometres above the earth.

Researchers from UQ, the Defence Science and Technology Group of Australia, the US Air Force Research Laboratory, and Boeing were involved in the flight as part of the HiFiRE (Hypersonic International Flight Research Experimentation) Program.

Professor Smart says HiFiRE 5B is one of 10 experimental flights that are part of the international collaboration which is investigating the physical phenomenon of flying at hypersonic speed – or faster than five times the speed of sound. More test launches are scheduled for later this year.

"The knowledge gained from these experiments will be applied to develop future flight vehicles and the development of advanced air-breathing hypersonic propulsion engines, like scramjets."

HYPERSONIC FLOW IN THE LAB

The jewel in the crown of scramjet research at UQ is the T4 Free-Piston Driven Shock Tunnel (T4 Shock Tunnel).

It was developed by Australia's first professor of space engineering, Emeritus Professor Ray Stalker, and with it scientists at the Centre for Hypersonics can re-create the exact conditions of hypersonic flight high in the sky.

There have been more than 12,000 shots in the T4 Shock Tunnel since it was commissioned in 1988, and numerous institutions have copied its design. So much so that this type of facility is now known internationally as a 'Stalker Tube'.

The experiments have ranged from fundamental studies of how combustion occurs in supersonic flows, to the first ever scramjet that produced positive thrust in 1995.

The HyShot research project, which demonstrated the possibility of supersonic combustion under flight conditions, was also conducted in the T4 Shock Tunnel. The scramjet engine that flew on HyShot 2 was the first ever to produce supersonic combustion in flight.

More recently, the T4 Shock Tunnel has been used to test state-of-the-art three-dimensional scramjet engines for SPARTAN, a project designed to deliver satellites weighing up to 250 kilograms into orbit and allowing them to be monitored nationally or internationally. These tests started in 2006 at speeds of Mach 8, and culminated with tests at speeds of Mach 12 in 2013.

Without the ability to recreate the exact velocity, temperature and pressure of hypersonic flight in the laboratory, UQ would not be the world leader in scramjet research that it is today.

REACHING NEW HEIGHTS

Hypersonic flight has the potential to provide immense social and economic benefits and could revolutionise global air travel, such as flying from Sydney to London (17,000 kilometres) in just two hours.

Flying over long distances at hypersonic speed (Mach 5 and above) requires a supersonic-combustion ramjet, or scramjet engine.

Instead of the rotating compressor and turbine in a jet engine, air is compressed by a system of shockwaves as it enters the scramjet. Once compressed, fuel must mix and burn with the very high speed air that passes through the engine. The most difficult aspect of this is to complete the 'supersonic combustion' within a short distance.

While the idea of flying between Sydney and London in two hours is appealing, Professor Smart admits the reality is still a long way off.

"The use of hypersonic technology in commercial flights is more difficult than using a scramjet to launch small satellites," he says.

"The limitation of a scramjet is that you can't take off from the runway with it.

"It requires a means to reach speeds of Mach 5, and the easiest thing to do is to use a rocket ... but not many people would want to fly from Sydney to London via rocket.

"Flying people internationally at hypersonic speed requires the combination of a scramjet with a jet engine in some way. The aircraft could take off with a jet engine and then switch over to a scramjet engine, but that's actually more complicated than the space application."

uq.edu.au/research/impact:

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THE STORY SO FAR:

1975: Australia's first professor of space engineering, Emeritus Professor Ray Stalker, joins UQ from Australian National University

1988: The T4 Free-piston Driven Shock Tunnel is commissioned at UQ

1995: The first scramjet to provide positive thrust is reported after a test is conducted in the T4 shock tunnel. The X2 Super-Orbital Expansion Tube is commissioned at UQ

1997: The HyShot Flight Program begins. The program is an experiment designed to determine the accuracy of pressure measurements made of supersonic combustion in the T4 shock tunnel compared to those observed in flight

2001: The X3 Free-piston Driven Expansion Tube is commissioned at UQ

2002: HyShot 2 is launched and is the first scramjet flight test that produces supersonic combustion

2006: HyShot 3 and 4 are launched. Defence Science and Technology Organisation's applied hypersonics group forms with researchers from the UQ HyShot flight team. The first test of a three-dimensional scramjet is conducted at UQ

2007: The joint Australian/US HIFiRE Program commences. The program investigates the science of hypersonics technology and its potential for next-generation aeronautical systems

2009: HIFiRE 0, the first flight of HIFiRE Program is launched

2012: Professor Michael Smart receives an ICAS award for International Co-operation in Aerospace as part of the HIFiRE team

2013: A Mach 12 scramjet is tested in T4 shock tunnel

2014: The SPARTAN small satellite launcher is conceived

2015: HIFiRE 7 is flown with two UQ-designed three-dimensional scramjets from the Andoya Space Center in Norway at speeds of Mach 8

2016: HiFiRE 5B, hits targeted speeds of Mach 7.5 (9200kmph) and reaches a height of 278 kilometres from earth, after it is launched from the Woomera Test Range in South Australia

2017: Centre for Hypersonics Director Professor Richard Morgan receives the American Institute of Aeronautics and Astronautics (AIAA) Hypersonic Systems and Technologies Award