

Sustainable, affordable access to space

Alexandra Cooper sits down with David Waterhouse, co-founder and managing director of Hypersonix Launch Systems, to uncover how they are using scramjet technology and clean energy to form the basis for the manufacture of hypersonic vehicles.

INTERNATIONALLY, there are plans for around 50,000 small satellites to launch by 2030, according to McKinsey. With vessels such as the Space X Falcon 9 polluting the atmosphere with over 425 metric tonnes of CO2 per launch – the equivalent of 395 transatlantic flights – this does not bode well for the environment. However, the current global market for hypersonic technology is valued at \$5.41 billion; and for one Australian manufacturer, these statistics pointed to a solution that they could provide.

In 2018, after many years of research in their separate fields of engineering, David Waterhouse and Michael Smart combined their respective knowledge of satellites

and aerospace to form Hypersonix Launch Systems – an Australian “new space” engineering, design and build company that specialises in scramjet technology: the fastest and most efficient way of flying through the atmosphere.

With Waterhouse’s expertise in electrical engineering and Smart’s capabilities in mechanical engineering, they built a team of aerospace and composite specialists focused on building hypersonic aircrafts that are both sustainable and more affordable.

According to NASA, sound waves travel at around 340 metres per second on the ground. Any faster than this is supersonic, and five or more times faster is hypersonic. A

scramjet engine is defined by the supersonic airflow within the engine, which is greater than the speed of sound.

As a start-up company, Hypersonix has been able to benefit from multiple technological evolutions. One of them is low-cost access to great computing power.

“In bottling hypersonics, while it’s still aerodynamic, because you’re travelling at those speeds it’s much more complex than just modelling how a plane flies,” Hypersonix co-founder and managing director David Waterhouse said. “That computing power is really necessary not just for how it flies, but also the thermal properties and how the heat dissipates through the structure,

which is a major factor of what we do.”

The second element is that high temperature materials have been made readily available, commercially, and at a reasonable cost. Another contributor is the hydrogen economy as it becomes dominant in the automotive sector in certain global markets, such as Europe and Japan. This means that Hypersonix has been able to attain lower cost access to hydrogen as a fuel and components such as fuel tanks, valves and filling procedures are already in place.

According to Waterhouse, these evolutions in technology has enabled Hypersonix to address certain market issues, such as the explosion in the market for low Earth orbit satellites.

“We launched more satellites last year than in the entire history of humankind – and it’s just going to get bigger and bigger,” he said. “That’s created this huge market and we particularly fit that market well because we’re high cadence, which means we can launch frequently. We’re green and reusable, which is going to be a big driver going forward because I can reuse my vehicle hundreds of times, not just one or two times, and because we’re using green hydrogen, we don’t produce any pollution, methane gas or CO2.

“The other thing is because we’ve got a vehicle with wings, we can launch in any direction and then change our orientation to fit into any orbit. If you’re trying to do that with a rocket – if you can do it at all – it burns a lot of fuel. What that means in practice is you must have multiple launch sites to service a particular network. Our technology fits that really well.”

In providing the tools and the means for extending the technology, Waterhouse says that Hypersonix’s design is aiding the holistic development of hypersonic technology. It also encourages people in the industry to be more conscious around the environmental impacts of launching vehicles that produce high emissions. This is an especially valuable commodity because the global airline industry contributes over one billion metric tonnes of CO2 into the atmosphere per year, according to Worldindata.

“People are now more conscious. I think the airline industry has put out about 2.5 per cent of the world’s CO2 emissions,” Waterhouse said. “Not only is there a pollution element to this, but there’s the speed of travel. If I can jump on a plane and fly from Sydney to New York in two and a half hours, it certainly beats the 26 hours it currently takes me; this includes freightage as well. So, speed adds to the whole global economic efficiency side of things as well.”

Sustainable processes and products

With an underlying focus on sustainability throughout their operations and processes, hydrogen



David Waterhouse, co-founder and managing director of Hypersonix Launch Systems.

“What we’re trying to do is make that whole thing as reusable as we can. We have a first stage we’re calling Boomerang and that basically has a deployable wing system. We’re able to do that with wings rather than the rockets that SpaceX does because we’re only travelling to 20 kilometres in altitude.

fuel is at the heart of all of Hypersonix’s technologies. According to Waterhouse, the fuel has a high ISP, burns cleanly and its only by-product is water. By pulling the hydrogen from the water using solar power, no CO2, methane, or noxious gases are produced.

“The problem is, historically rocket companies have been looking at other ways of doing things. For a lot of them, the solid rockets are frankly just burning plastic. That wasn’t an issue if you were doing a dozen launches a year, but now they’re looking at putting around

50,000 satellites into orbit over the next few years. Even SpaceX’s Falcon 9 has the equivalent of about 395 transatlantic flights in terms of emissions.”

Additionally, by creating reusable components Hypersonix can fundamentally change the impact that such vehicles have on their environment.

“When looking at the carbon footprint, you actually have to take into account the manufacturing side of things as well, including the manufacturing of the materials and the transport,” Waterhouse said.

“Most rocket companies just throw their rockets away after a single use – so there’s a huge CO2 footprint, let alone a pollution footprint, because they are either burning it up in the atmosphere causing pollutants or dumping it in the ocean causing pollution, or a combination of both.

“What we’re trying to do is make that whole thing as reusable as we can. We have a first stage we’re calling Boomerang and that basically has a deployable wing system. We’re able to do that with wings rather than the rockets that SpaceX does because we’re only travelling to 20 kilometres in altitude. Also, because we’re only travelling at about Mach 5, if you compare that with a normal rocket, it could be travelling up to 120 kilometres to speeds of between Mach 10 or Mach 15; then it’s a much harder problem to bring it down safely.”

Manufacturing launch systems

In manufacturing scramjet technology and hypersonic vehicles, there are three challenges that Hypersonix was faced with on

starting the company: temperature, cadence, and cost.

“First and foremost, we have to manage the high temperatures we’re dealing with, and these temperatures get up to about 1300oC depending on the part of the plane and what sort of flight profile you’re using,” Waterhouse said. “Another thing is cadence and finally, cost. What we wanted to be able to do is manufacture something quick, reliable, cheap.”

“To get away with only using Inconel, we slightly changed our flight profile. If you’re flying at a higher altitude, there’s less temperature to worry about because there’s less air resistance. But also, we were able to have a look at using the hydrogen fuel for regenerative cooling.

The first avenue that Hypersonix trialled was using ultra-high temperature ceramic matrix composites (UHTCMCs). These were attractive due to their reusability and low thermal expansion, or their ability to handle the high temperatures. However, there was an issue in producing these within Australia.

“The big problem is that industry is still very nascent and particularly in Australia, while we do some really good stuff with composites, we haven’t really got into the high temperature composites,” Waterhouse said. “You often must bake these things up to five times in

your special vacuum autoclaves, so you can inject inert gases in there. The skill set around this is just starting off Australia, it’s not really there at a production level right now.”

While the company was able to commission a European aerospace company to build the first prototype of the scramjet engine from UHTCMCs, they also sought out a different high temperature composite that could be manufactured

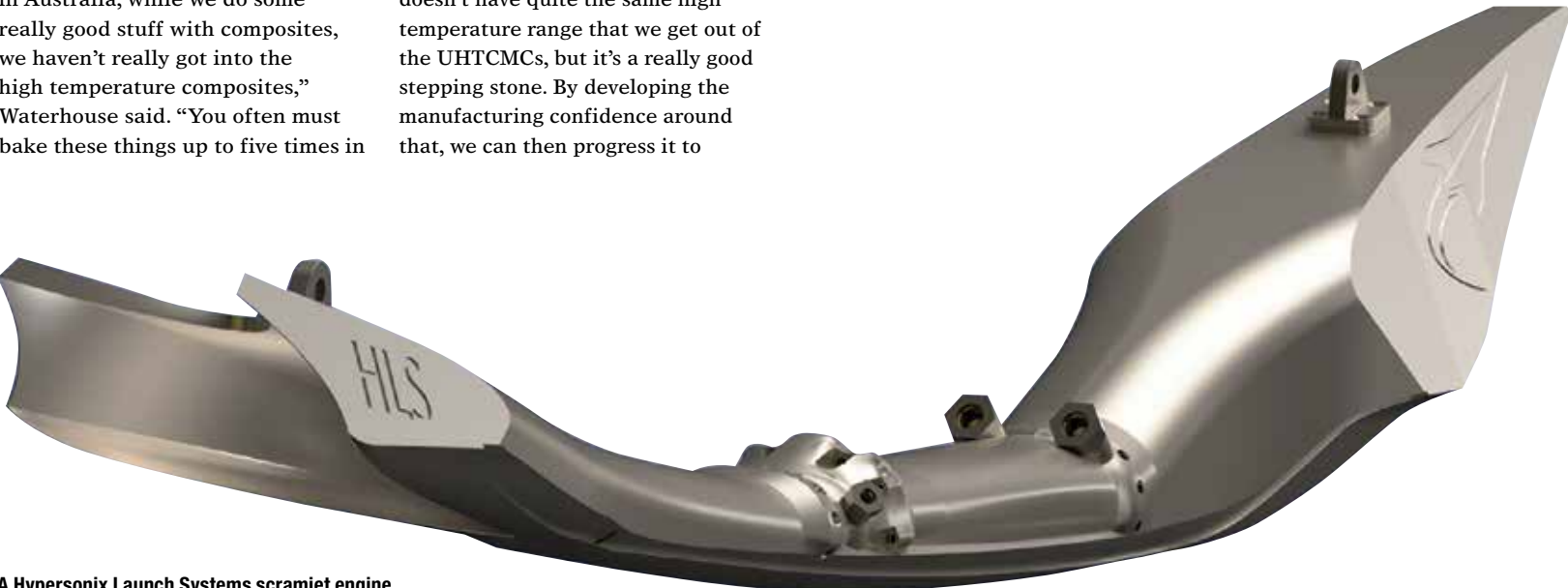
the next step – and that’s the work we’re doing with the University of Southern Queensland.”

Another avenue that they determined as more presently commercially viable, using Australian manufacturing, lay in 3D printing a scramjet engine using Inconel – a high temperature metal that can handle up to 800oC. Hypersonix sourced a Victorian company called Amiga Engineering for the purpose.

“To get away with only using Inconel, we slightly changed our flight profile,” Waterhouse said. “If you’re flying at a higher altitude, there’s less temperature to worry about because there’s less air resistance. But also, we were able to have a look at using the hydrogen fuel for regenerative cooling. To do that, you must put these cooling channels integral with the scramjet engine, and 3D printing was really ideally suited to that. The trade-off we made is by using the high temperature alloys, yes, it expands with temperature, but it all expands in the same way and in the same direction.

Inconel is also efficient in that it creates very low wastage and the powders required are able to be produced in Australia, which better supports local supply chains as a value-added export.

“Also, because we can 3D print it, we can do this very, very quickly. We 3D printed that engine in six



A Hypersonix Launch Systems scramjet engine.

weeks; we’re currently looking at 3D printing the entire vehicle, which will be a three-metre vehicle. That’s the sort of thing that hasn’t been done before and that fits our industrial capability today – and we can do that all made in Australia.”

Current projects

One of the recent Hypersonix projects that has brought a great deal of media attention is the Delta Velos project, having received an Accelerating Commercialisation grant valued at almost \$1 million from the federal government in August 2020 to manufacture the components. As part of the Delta Velos project, there are three products currently under development including Orbiter, Demonstrator and DART AE.

The Delta Velos Orbiter, due to be completed in three years, is a zero emissions hypersonic spaceplane that is capable of deploying small satellites into low Earth orbit. Both sustainable and reusable, the Orbiter flies at hypersonic speeds between Mach 5 and Mach 12 and functions using hydrogen fuel.

The Delta Velos Demonstrator is a 30 per cent smaller version of the Orbiter, which Hypersonix is using as a testbed for high temperature composite flight through the atmosphere at hypersonic speed. Demonstrator is anticipated to be completed in two years, with the

“What we’re starting to find with some of the better universities, they are trying to get at least to that TRL 5-9, so the programs we’re doing with universities are around CRC-Ps, and the CRC-P programs is where industry leads the research.

prototype build of the engine already underway.

DART AE is a 3D printed hypersonic drone designed to be launched at a very low cost. With plans to launch DART AE in the first half of 2023 in partnership with Kratos Defense & Security Systems, it is being made in Australia, powered by a single SPARTAN scramjet engine which is hydrogen fuelled. The launch will be using a sounding rocket that spins at 5 Hertz and DART AE will be used as a test platform for the other facilities on a plane, such as guided navigation control and audio subsystems. It is a technology demonstrator.

Future plans

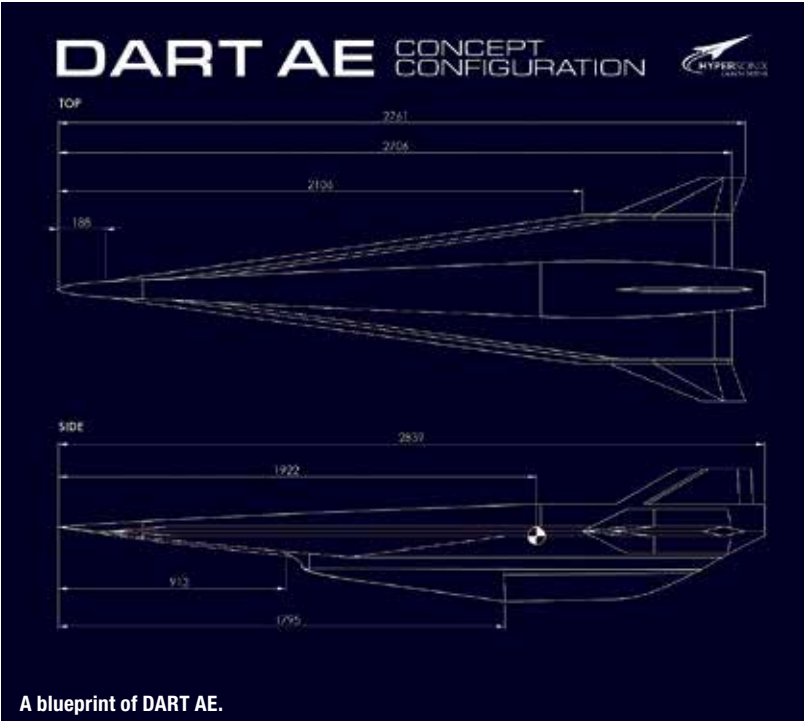
In partnering with universities, such as the University of Sydney and University of Southern Queensland, Hypersonix has plans to work towards closing the gap between research and development and commercialisation.

“What we’re starting to find with some of the better universities, they are trying to get at least to that TRL 5-9, so the programs we’re doing with universities are around CRC-Ps, and the CRC-P programs is where industry leads the research. So, it’s designed with a specific commercial outcome in mind. As part of our long-term industry capabilities plan, we want to support that in Australia because that helps us in many ways for everything from supply chain to cost to knowledge of management know-how. That’s why we wanted to build that capability up and we’re happy to help the universities steer that later level research towards an industrial outcome.”

As a start-up, the company is

seeking to bring together the right investors who will help deliver their deep technologies through the middle range of TRLs – an issue that many start-ups face within Australia.

“A start-up can have great ideas, a great team and everything else, but you still have to get that product to market – and finding the appropriate funding for that is often quite a challenge,” Waterhouse said. “If we’re going to maintain an industrial sovereign capability, industry needs more support. I think there needs to be incentives for private equity to be part of that financial ecosystem as well. If you look at the Organisation for Economic Co-operation and Development (OECD), Australia has some of the highest academic published papers in the world; but if you look at patents and inventions,



A blueprint of DART AE.

we’re not the best. We’ve got to fill that gap somehow and we are a part of that picture.”

Having completed their \$1 million Accelerating Commercialisation grant project in March, Hypersonix is also working to further expand the industry’s knowledge around the concept of clean hypersonic technology and how it can be actioned to facilitate a positive change for Australia and the world.

“We’re participating in several shows and conferences, we’re going out there and evangelising green space and hypersonics in general. We’re trying to make people aware of the market potential of our technology.” **M**

	Fuel	CO ₂	CO ₂ /tonne payload	Production CO ₂	Water Vapor	SOOT	NOx	Inorganic Chlorine
 Delta-Velos	Hydrogen	0	0	9	2	0	0	0
 TITAN II	Hypergolic	36	10	106	16	0.2	0.3	0
 Soyuz FG	RP-1 + Hypergolic	243	35	2318	64	13	0.4	0
 Atlas V N22	SRB + RP-1 + Hydrogen	259	20	8942	111	2.1	0.8	21.4
 Falcon 9	RP-1	425	27	480	152	30	1	0
 Delta IV Heavy	Hydrogen	0	0	1227	632	0	0.5	0
 Space Shuttle	SRB + Hydrogen	443	16	1667	976	4.2	7	250
 Starship + Super Heavy	Methane	2683	27	1288	2199	0	1.7	0

The emissions produced by other hypersonic vessels, compared with Hypersonix Launch Systems’ Delta Velos vehicles.