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HYPERSONICS - SERIOUS SCIENCE

'Hypersonic' platforms are defined as those travelling at Mach five or above; a minimum of five times the speed of sound. In July 2006, Pathfinder 49 introduced us to a future with hypersonic platforms and discussed some of the implications of the technology. It listed a number of challenges, risks and benefits likely to be faced by military forces introducing such systems and in meeting the forever-altered nature of threats if they were owned by an adversary. Importantly, most of the challenges and risks still do not have effective solutions. When hypersonic platforms finally become operational they will dramatically alter the nature of force projection from the third dimension.

Hypersonic is still considered by many to be a disruptive technology. Defined simply, a disruptive technology is one that unexpectedly displaces an established technology in such a way that revolutionary change takes place—the internal combustion engine is an example. Hypersonics is a disruptive technology as it has the potential to render large proportions of established military inventory and tactical doctrine obsolete, radically and forever altering the way warfare is conducted. Those who lead in this field could gain a formidable advantage.

X-15 in flight

Hypersonics is not a new science. In 1949 a US version of the German V-2 rocket reached 5,150 miles per hour. In May 1961 Russian Major Yuri Gagarin became the first human to travel at hypersonic speed during the world's first piloted orbital flight. In June the same year Major Robert White exceeded Mach 5 in the X-15, a US research aircraft; in November he broke his own record reaching Mach 6.04.

Despite advances since those pioneering flights, hypersonics continues to be a challenging science. At Mach 5 the temperature in the boundary layer on the surface of the vehicle rises to 1,000°C, and dynamic pressure increases to 25 times atmospheric pressure. This alters the state of the particles within that layer dramatically. The pressure and heat cause molecules to dissociate, meaning molecular bonds are broken and they become plasma; a soup of individual atoms and electrons where chemical reactions cause new compounds to be formed. The complexity of atmospheric effects increases and aerodynamic behaviour begins to diverge from conventional subsonic and supersonic principles. These complex conditions of flight and the massive energy levels required to achieve such speed demarcate hypersonic from supersonic, and challenge scientists to extend the application of this field to practical use.

For the last 50 years, development of air-breathing hypersonic platforms has remained in the experimental domain with, until recently, only marginal progress. The successful launch of an experimental hypersonic vehicle incorporating a promising new technology in 2002 was a breakthrough that indicated the transition of hypersonics from hypothetical future to foreseeable reality. Nations world-wide have committed more resources to the development of hypersonics technology. Notably, India and Russia have recently embarked on project BrahMos-2, which aims to build hypersonic missiles to be fitted to Sukhoi SU-32 aircraft and, most likely, naval vessels. Clearly, the threat of hypersonics in our battlespace must be considered as an emerging reality. It is therefore imperative that we consider its impact on emerging capability systems and our approach to conducting warfare as a priority.

Scientists at the University of Queensland (UQ) have been actively progressing the field of hypersonics for the past 20 years. The Defence Science & Technology Organisation (DSTO) recently enhanced its 'hypersonic' links with UQ by funding a Hypersonics Chair at the University and committing to collaborative development of the 'T4 shock tunnel'—the University's ground test facility for modelling of hypersonic flight—another step in realising practical applications of the technology.

DSTO launches a TALOS rocket carrying the HyCAUSE scramjet payload at Woomera, June 2007.

The collaborative efforts of UQ and DSTO will focus on the supersonic air-breathing engines known as SCRAMJETs. Together, UQ and DSTO accomplished the world's first successful flight of a SCRAMJET or Supersonic Combustion Ramjet during the launch of HyShot II at Woomera, South Australia on 30 July 2002. HyShot III, launched successfully in 2006, reached speeds in the order of Mach 7.6 and HyCAUSE (pictured) reached Mach 10 in 2007.

The development of SCRAMJETs seeks to overcome a major limitation of rockets: their reliance on fuel and oxygen carried on-board. Because a SCRAMJET draws oxygen from the air through which it travels, it can be smaller than a rocket capable of achieving a similar range and speed.

In military applications, a hypersonic air breathing weapon can be much smaller than a comparable supersonic weapon or short range ballistic missile (SRBM). For a given platform size, hypersonics can improve weapon effectiveness by reducing time of flight and/or increasing stand-off range, and also increase the weapon effect markedly due to the massive increase in kinetic energy.

Fitting hypersonic weapons to conventional air platforms however, will remain problematic. Even with the size reduction, such systems are unlikely to fit into fighter-sized aircraft due to the size of the initial booster system required to reach the high supersonic speeds necessary for combustion to begin in the SCRAMJET.

Countering offensive hypersonic systems presents another demanding challenge. Their tremendous speed means the window of opportunity to detect, identify, track and respond will generally be far too short for current-day defence systems. Even if a system could respond quickly enough, the time available to launch and accelerate the defence weapon to a suitable intercept speed will be insufficient. Additionally, achieving the targeting accuracy and manoeuvrability required to bring the two hypersonic projectiles to a common point in space will be a problem well beyond the capability of current systems.

Directed Energy (DE) weapons have, in the past, been proposed as viable defences. In fact, these systems would face similar targeting and engagement dilemmas. It is a popular misconception that since directed energy weapons transmit energy at the speed of light they have an almost instantaneous effect. In reality, they operate by dwelling on the target and raising its temperature sufficiently to cause failure. This would be particularly difficult against a hypersonic target because they are hard to track, very resistant to external heating—considering their own requirement to withstand very high temperatures—and offer very little dwell time for the directed energy to take effect.

The difficulty in countering hypersonics works in favour of a force that understands and can employ the technology. With DSTO and UQ on the task, we can reasonably anticipate improvements in hypersonic system design, further expansion of the research and, hopefully, practical application of the technology. Australia is now well-placed as a nation in the global, hypersonic race.

- *The realisation of hypersonics into practical air power applications may revolutionise air warfare.*
- *Despite recent advancements, development of the technology needed for practical hypersonic systems continues to be problematic.*
- *University of Queensland and DSTO are well positioned to collaboratively lead the way in the progression of hypersonic systems*

"The first essential of the air power necessary for our national security is pre-eminence in research. The imagination and inventive genius of our people--in industry, in the universities, in the armed services, and throughout the nation--must have free play, incentive, and every encouragement."

'Hap' Arnold

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