"It's a high time for Hypersonic Missiles" – their impact on geopolitics and the end of Mutual Assured Destruction

"It's a high time for Hypersonic Missiles"[1] is a line from one of Sam Fender's best-selling songs. Looking at the line in the context of the song, it is a plea to society to do something meaningful with their lives because hypersonic missiles have the potential to destroy life as we know it. For example, a hypersonic missile launched from Moscow now could strike London with a nuclear warhead in under 10 minutes. Such missiles are disrupting the relative security that the world has felt since the end of the Cold War. Since ex-United States Secretary of Defence Robert McNamara's suggestion of Mutual Assured Destruction (MAD) in the 1960s the world has been living in relative comfort in the belief that no superpower will strike another for fear of 'Mutual Destruction'. Hypersonic missiles may allow any country who has them to make a nuclear strike with more success. Mutual Assured Destruction relies on different countries' military forces being equal - hypersonic missiles disrupt this balance because of the reduced response time and difficulty of defending against them. They have put the world in a precarious position; the 'Destruction' in Mutual Assured Destruction may not be 'Mutual' at all. Is it therefore time to look for a new way forward which will give the world a new era of relative peace?

To give a little more background, a hypersonic missile is a missile that travels at above Mach 5, or 1,700 metres in a single second. Using this definition, the existing Intercontinental Ballistic Missiles (ICBMs) are also hypersonic missiles because they can reach speeds of Mach 20. However, the hypersonic missiles this essay refers to are different because they have increased manoeuvrability and follow a different trajectory to ICBMs, making them much harder to track and ultimately defend against. They fly within the atmosphere manoeuvring to avoid detection and strike their target. The current detection systems that are in place are searching for the arc of an ICBM, not the complex trajectory of a new hypersonic missile. The new capabilities have provided fresh engineering challenges and so it is not known which countries possess hypersonic missiles.

There are many engineering challenges that need to be overcome to produce these missiles. For example, the method of propulsion must overcome incredible resistive forces of drag. The drag force is proportional to the square of the velocity and is governed by the equation:

$$F_d = \frac{1}{2}\rho v^2 C_d A.$$

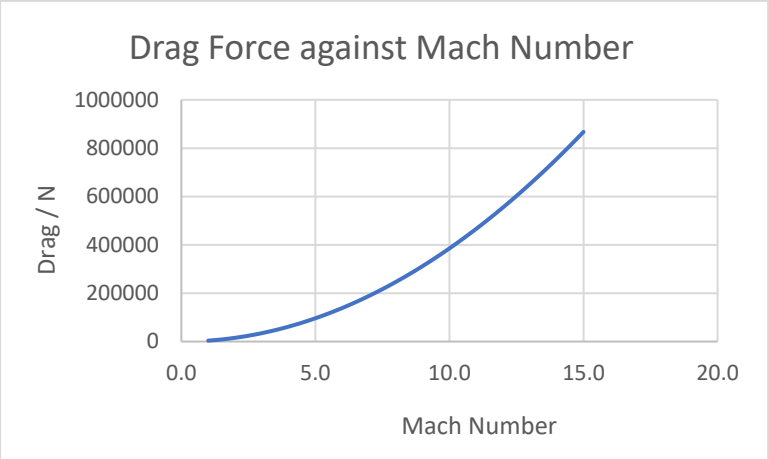

Figure 1

Where ρ is the density of air, C_d is the coefficient of drag for a particular projectile and A is the cross-sectional area of that projectile. Using this formula, the drag force on a current supersonic missile can be calculated if it was travelling at hypersonic speeds. ρ was taken to be 1.204 kg/m^3, the value of the air density in the atmosphere where hypersonic missiles are likely to operate. The cross-sectional area of an MGM-140 ATACMS missile (a supersonic missile operated by the US military and their allies) was used. A graph was then plotted showing Drag Force in Newtons against Mach number (Figure 1).

This graph shows that as the Mach number increases, the drag force increases by the square of the velocity increase. If this missile was travelling at Mach 15 (which it cannot), the drag force would be 225 times higher than if it was travelling at Mach 1.

According to Newton's Second Law:

$$\sum F = ma.$$

The sum of all forces is equal to the mass of the object times the acceleration. So, the thrust must be higher than the drag force to get the object to accelerate. To allow the missile to travel at Mach 15 it

must overcome forces of over 800kN. This is not possible with current methods of propulsion; a jet engine can only reach up to a maximum of Mach 3. One solution is a supersonic combustion ramjet engine (scramjet). A scramjet engine works by removing the moving parts of a jet engine and combusting the air at high pressure, temperature, and supersonic speeds. This is achieved by using a gradual diffuser to increase the pressure and temperature without slowing the speed down too much. This high energy combustion reaction then allows a high velocity stream of air to propel the missile forward. The development of scramjet technology has unlocked a new realm of speed for missiles, and due to these difficulties in manufacturing hypersonic missiles, we do not know who has these missiles and what stages of development they may be in. This causes more instability on the global stage.

Given the additional issues in defending hypersonic missiles it is inevitable that their emergence will have an impact on war and the geopolitical stage. The situation can be likened to the emergence of nuclear weapons and the Cold War. When the United States dropped an atomic bomb on Japan in 1945, the world awoke to the devastating nature of them and a race to create the best warheads and missiles followed. This created a period of incredible tension between the East and West, the Cold War. By the 1960s both sides had missiles that were capable of carrying nuclear warheads at 7km/s. The adoption of McNamara's proposal of Mutual Assured Destruction provided world leaders with a way forward that led to a period of relative peace enabled by progress in the detection systems of ICBMs, albeit still punctuated with periods of huge geopolitical tension.

When thinking about the geopolitical landscape, it is interesting to note the correlation between political tensions and defence spending as a percentage of GDP; hence the impact that ICBMs had and now the impact hypersonic missiles will have on the geopolitical landscape. For example, the Cold War period of high political tension is reflected in the high defence spending by the US as a proportion of GDP. The spending by the USSR would most likely have been equally high. The period after the year

2000 was more peaceful with nuclear engagement being less of a threat. Again, this is reflected by the decrease in military spending.

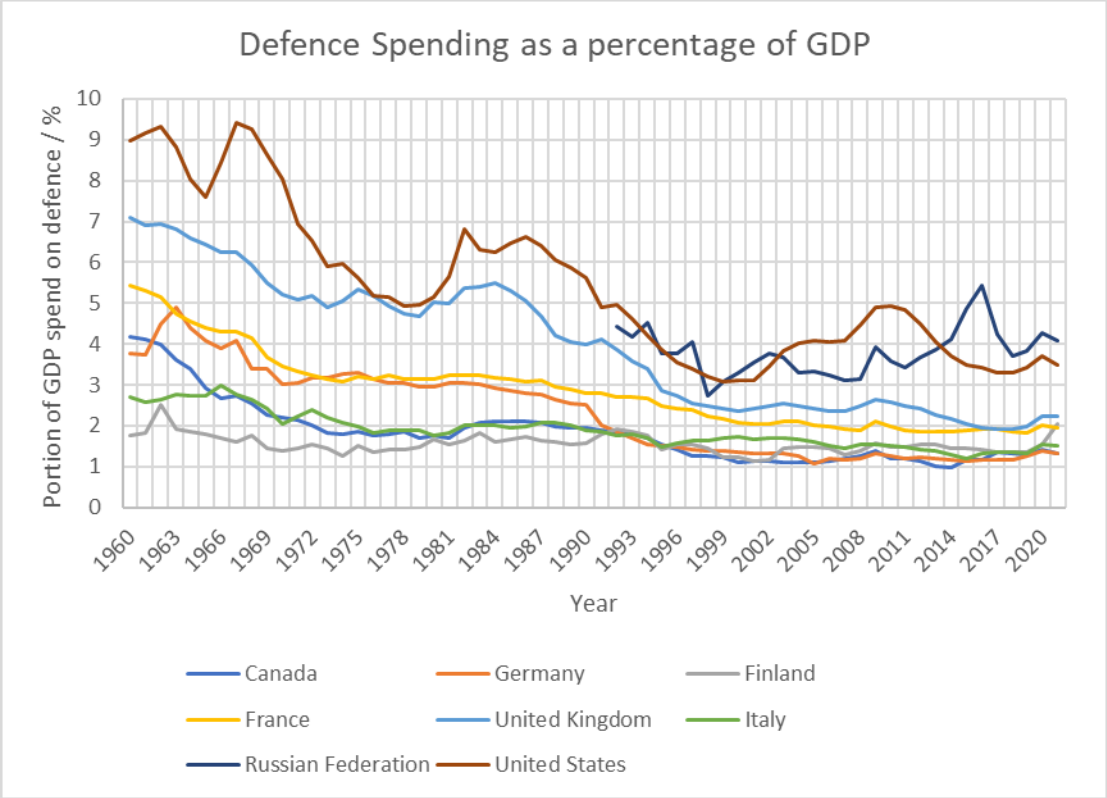

Figure 2

The graph above stops in 2020 and therefore does not show the recent increased spending by miliary powers in relation to the new hypersonic missiles. However, research shows that the United States Department of Defence (DoD) spending in 2023 increased by $50 billion (bn) from 2019[2]. In a statement from the DoD, within the 2024 fiscal year budget request, $29.8bn is set aside for 'missile defeat and defence programs'[3] and $11bn is set aside '"to deliver a mix of hypersonic and long-range subsonic missiles"'[3], $1.2bn of this is a contract with Lockheed Martin to integrate hypersonic missiles into the US Navy's new Zumwalt-class destroyer. Additionally, according to The Telegraph, NATO spending was up 2.2% in 2022 and yet the head of NATO, Jens Stoltenberg, has 'urged member states to up their defence spending'[4]. It is therefore clear to see that not only is there a general increase in spending but as seen by the DoD's statement, there is a specific focus on hypersonic missiles. Another

example of this is the UK's pledge to invest £6.6bn into 'novel military research'[5]. These statistics are a clear indication of the beginning of a new arms race and a period of heightened political tension.

For example, war is brewing in the Far East, where China is flexing its muscles specifically in relation to Taiwan. The US has pledged support to Taiwan if China invades (Taiwan Relations Act of 1979) partly because of the Taiwanese domination of the microchip market: they produce 60% of all microchips and over 90% of the most advanced ones according to The Economist[6]. These microchips are in everything we use, from microwaves to computers to hypersonic missiles. They are the backbone of the technological age, and the US does not want China to gain control of their production. The recent military drills that China has been conducting in and around Taiwan's airspace show that China is serious in its aim to take back Taiwan. This is no surprise as there is legislation in China called the "Anti-secession Law"[7], which states that "Taiwan is a part of China"[7]. Furthermore, the legislation states that "China can employ non-peaceful means"[7] to reunify the two countries and it is the "sacred duty of all Chinese people"[7] to do that. This is relevant to the topic of hypersonic missiles because China already possesses missiles that apparently have the speed and improved manoeuvrability of hypersonic missiles (the DF-17) and can travel above Mach 5; the DF-17 missile is a hypersonic glide vehicle with a range of up to 1,800 kilometres with manoeuvrability which therefore pose a huge threat to Taiwan and could destroy any defending US ships. This could lead to direct war between two superpowers as opposed to the proxy wars that have been fought in the middle East between the US and Russia. That said, the exact capabilities of the DF-17 have not been openly demonstrated it is not possible to say if this missile is a game changer. This 'unknown' has been highlighted recently in Ukraine when Putin's, in his words "undefeatable"[8], Kinzhal hypersonic missile was shot down by the PAC3 MSE Patriot air defence system. Taiwan has these defence systems and, although the DF-17 is different and most likely more effective than the Kinzhal, the Patriot systems are helpful in deterring China. Even so, China's production of the DF-17 and the threat this brings is one of the key reasons for the high tensions around the South China Sea.

Another potential flashpoint due to hypersonic missiles is the Middle East. Israeli and Iranian tensions have been rising dramatically over the last few years and in May 2023 Israel threatened Iran with a pre-emptive strike if Iran did not close down its nuclear programme[9]. It has also been reported recently that Iran has successfully tested an indigenous hypersonic missile[10]. According to Iranian General Amir Ali Hajizadeh[10], this missile is capable of striking Israel and travels at speeds of Mach 12-13 whilst manoeuvring to beat their air defences. The Iranian production of hypersonic missiles has worsened already fragile relations with Israel and is a constant threat in this part of the world.

As has been mentioned, the acceptance of Mutual Assured Destruction led to a period of relative stability, however there were still moments of high tension within this period, and examples of moments where a single person's decision stopped a nuclear war. For example, The Cuban Missile Crisis of 1962 which brought the US and USSR terrifyingly close to nuclear war but Vasili Arkhipov's rational decision stopped a Russian submarine firing a nuclear torpedo. Today's hypersonic missiles, with their superior technology, makes the threat of nuclear destruction ever more real as Mutual Assured Destruction is no longer guaranteed. Therefore, as the world enters a new era of increased tension a new geopolitical mechanism is needed to bring some stability to the world.

The concept of Mutual Assured Security could provide this comfort. Mutual Assured Security is a doctrine based on the defence of missiles rather than Mutual Assured Destruction's security created by the threat of offensive weapons. The concept of Mutual Assured Security is that no country will attack another if every country has effective defensive systems which can intercept hypersonic missiles. This is much safer than Mutual Assured Destruction for two reasons. Firstly, the defences of any nation should be able to defend against a nuclear attack with hypersonic missiles and secondly there would be less incentive to attack when every country is transparent about their military capabilities. Mutual Assured Security would rely on international treaties and inspections which would lead to the depletion of offensive systems stock and the instead increased funding of defensive systems. However, the road to reaching Mutual Assured Security is very long and would require many

international treaties and a completely new outlook on war and national defence, not to mention the technological progress that would need to be made. This new outlook would propose the idea that all countries are allowed to have a small number of offensive nuclear weapons, but they would be able to have much larger amounts of defensive systems. Lots of investment would be needed to produce these defensive systems for hypersonic missiles and other potential threats.

Hypersonic missiles could be defended in a variety of ways, notably a rail gun or lasers. However, the first technology that could be used is an invention that came at the end of the Second World War. In anti-aircraft gun rounds engineers places a radar transmitter and a receiver. When the transmitted wave is reflected by a target plane, hence being in close proximity, the round would explode and damage the aircraft. This could be extended to take down hypersonic missiles. A round like this could be fired towards an incoming missile until the received signal is strong enough to cause an explosion. This could be improved by firing this round out of a rail gun. A rail gun could accelerate a projectile up to speeds of Mach 20 using the electromagnetic force. A magnetic field is created inside the barrel and the magnetic round is propelled out of it at incredibly high speeds. If this round was equipped with a radar system that is described above, it could be effective at taking down missiles. The incredibly high speeds of the round would mean there is less position change that would need to be accounted for in the aiming.

However, the most promising avenue for defending against hypersonic missiles is lasers. Lasers are beams of light and so travel at the speed of light and the distances involved are so negligible in this case that we can treat this as instantaneous. The laser transmits a huge amount of energy to the missile causing it to either completely vaporise or ablate, either way the missile is completely destroyed or disabled. Rafael, the state funded defence company of Israel, are already producing a laser defence system called the Iron Beam however lots more work is required to make the system reliable. All these systems do however require the detection and tracking of hypersonic missiles. This is not possible with the current infrastructure as the essay mentions before. This could be fixed with

the increased funding that would come from the funding that is normally directed to offensive weapons. Mutual Assured Security would require no increase in funding, instead a change in view from the leaders of the world and with technologies like the ones I have discussed these leaders could definitely achieve it.

As a globe, we are entering a dangerous period of not being covered by Mutual Assured Destruction. "The tensions of the world are rising higher"[1] and the only way to stop the uncertainty is Mutual Assured Security. The Cold War near misses would be negated, the tensions and the killing capabilities of countries would be reduced. Mutual Assured Security is the way to secure the future of our planet and allow us to solve other potential existential crises.

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