Pugwash Briefing Paper

Hypersonic Weapon Series

#8

How to counter Hypersonic Weapons?

Background

The Pugwash Foundation supported an international Pugwash workshop on hypersonic weapons, which took place in Geneva on 9 and 10 December 2019. The meeting brought together 30 international participants from various continents, including current and former government officials, scientists, engineers, academics and experts from think tanks and other non-governmental organisations.

The workshop aimed at fostering a constructive exchange of views on hypersonic weapons. Participants discussed factors driving the development, roles and purposes of hypersonic weapons, as well as the risks associated with their deployment and use.

Based on the workshop's discussions, the Pugwash Foundation produced a series of briefing papers on hypersonic weapons. The series covers the following themes:

- What is a hypersonic weapon?
- What technical challenges do hypersonic weapon raise?
- What are the current hypersonic weapon development programmes?
- Why do States develop hypersonic weapons?
- What are the roles and missions of hypersonic weapons?
- What are the risks associated with hypersonic weapons?
- How to mitigate the risks associated with hypersonic weapons?
- How to counter hypersonic weapons?

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How to counter hypersonic weapons?

Countering HCMs and HGVs is a two-step process. The first step is to detect and track the missile either before it is launched or during its flight, and the second step is to intercept the missile.

Detection and tracking

It is doubtful whether existing systems are capable of detecting and tracking a HCM or HGV for the entire duration of their flight.

Ground-based radars

Due to the earth's curvature, the low cruising and gliding altitude of HCMs and HGVs make them visible to ground-based radars only a few minutes before arriving on the target.

Even within the field of vision of ground-based radars, the layer of plasma around the missile could absorb and deflect some electro-magnetic waves (depending on the frequency of the radars) and thus reduce the effectiveness of ground-based radars to detect and track HCMs and HGVs.

Over-the-horizon radars

Over-the-horizon radars may prove more effective at detecting and tracking HCMs and HGVs as they are not as much affected by the earth's curvature as traditional ground-based radars.

However, the layer of plasma around the missile could absorb and deflect some electro-magnetic waves (depending on the frequency of the radars) and thus reduce the effectiveness of over-the-horizon radars to detect and track HCMs and HGVs.

Space-based sensors

Space-based sensors could detect HGV launches because they emit as much rocket plumes in their boost phase as traditional ballistic missiles.

However, the HGV could disappear from "sight" when it starts gliding because it emits less infrared radiation during its mid-course phase.

The infrared radiation of a HGV or HCM in its mid-course phase is likely about $1/10^{th}$ that of its boost phase.

It was not clear whether existing space-based sensors would be able to pick up such a dim signal or whether new sensors, especially in the infrared spectrum, would be needed.

The possible discrepancy in the efficacy of ground-based sensors and space-based sensors in detecting and tracking HGVs and HCMs during the mid-course portion of flight could incentivize States that lack space-based capabilities to develop them.

Interception

In-flight interception of HCMs and HGVs would also present some serious technical challenges:

Kinetic means

Ground-based interceptors

Existing ground-based interceptors are supposed to be able to intercept ballistic missile re-entry vehicles flying at Mach +20.

It is thus not the speed of HCMs and HGVs that would pose problems to missile defence systems. Rather, it is HGVs' and HCMs' manoeuvrability which could allow them to evade incoming interceptors (with the caveat that incoming interceptors be detected and that the evading manoeuvre be initiated in time).

Space-based interceptors

Space-based interceptors could be an option but they are technically very challenging to do in practice.

For the intercepting warhead to undertake its de-orbiting manoeuvre at the correct time, an accurate prediction of the hypersonic vehicles' trajectory/flightpath and position would be required well in advance.

Such systems would also have limited temporal coverage due to orbital mechanics, unless there is a large number in orbit to provide full temporal coverage.

In addition, space-based systems would raise several legal and strategic issues, and they would also have a high cost and be very vulnerable.

Non-kinetic means

Laser

While a laser would be fast enough to intercept HGVs and HCMs, there are too many question-marks around their accuracy, mobility and power to contemplate laser-technology as a reliable countermeasure.

Moreover, the aerothermal protection required by hypersonic vehicles would also provide thermal protection from a directed energy weapon such as a laser.

Interference

Spoofing and jamming of navigation and guidance systems would also be technically challenging, especially considering that the layer of plasma around the missile may reduce the effectiveness of any spoofing or jamming attempt.

At this moment, it seems that no effective defence against HCMs and HGVs exist. Given the difficulties existing missile defence systems face with traditional ballistic and cruise missiles, developing effective defence systems against HCMs and HGVs would require enormous and sustained investment with speculative guarantees of success.

Conclusion

Countering HCMs and HGVs is a two-step process. The first step is to detect and track the missile either before it is launched or during its flight, and the second step is to intercept the missile.

It is doubtful whether existing systems are capable of detecting and tracking a HCM or HGV for the entire duration of their flight:

- Ground-based radars are limited by the earth's curvature
- Over-the-horizon radars may prove more effective as they are not as much affected by the earth's curvature
- It is not clear whether space-based sensors would be able to pick up the infrared radiation of a HGV or HCM

In-flight interception of HCMs and HGVs would also present some serious technical challenges:

- HGVs and HCMs manoeuvrability could allow them to evade existing ground-based interceptors
- Space-based interceptors could be an option but they are technically very challenging to do in practice
- There are too many question-marks around their accuracy, mobility and power to contemplate laser-technology as a reliable countermeasure
- Spoofing and jamming of navigation and guidance systems would also be technically challenging, especially considering that the layer of plasma around the missile may reduce the effectiveness of any spoofing or jamming attempt.

At this moment, it seems that no effective defence against HCMs and HGVs exist. Given the difficulties existing missile defence systems face with traditional ballistic and cruise missiles, developing effective defence systems against HCMs and HGVs would require enormous and sustained investment with speculative guarantees of success.

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