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Current status and prospects of terminal guidance laws for intercepting hypersonic vehicles in near space: a review

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Background

- Hypersonic vehicles exhibit several advantages over traditional flight vehicles.
- The emergence of hypersonic vehicles represent a critical challenge for existing defense systems.

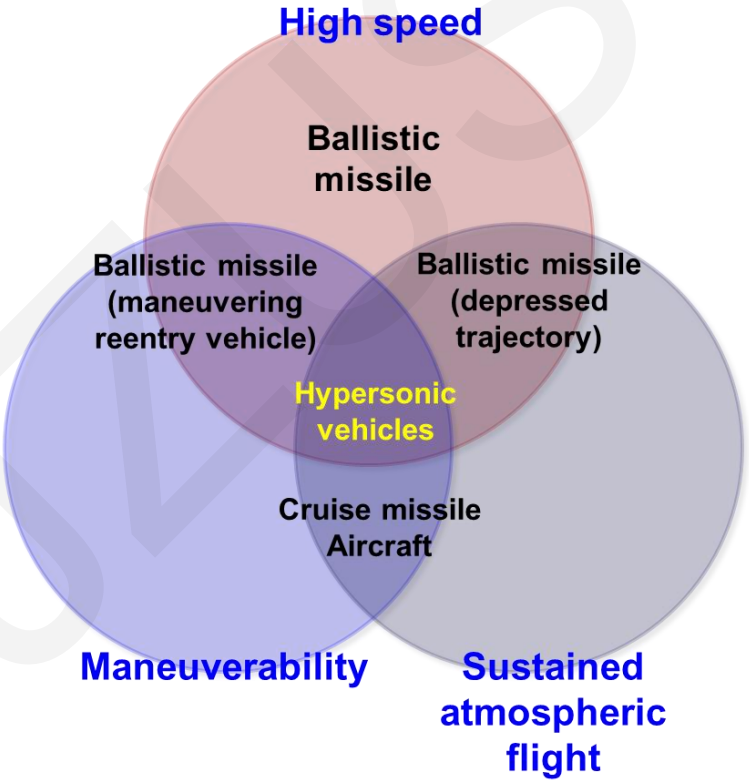


Fig. 1. Characteristics of hypersonic vehicles

Methods

- **Overall, hypersonic vehicles exhibit five advantages**

(1) Speed advantage

The speed advantage allows for changes in the time-space relationship and has introduced the age of the “second kill” in warfare.

(2) Mechanism advantage

The mechanism advantage can lead to realization of “exponential kill”.

(3) Agility advantage

The agility advantage refers to the generation of responses to the opponent’s actions.

(4) Application advantage

The application advantage is evident with regard to both deterrence and hit capabilities.

(5) Cost advantage

The cost advantage pertains to an asymmetric counterweight effect.

Methods

Difficulties in intercepting hypersonic vehicles

Hypersonic vehicles, with their unique advantages, are expected to have a profound impact on the battlefield environment. Defensive operations in near space encounter four specific difficulties: **discovery, detection, tracking, and interception.**

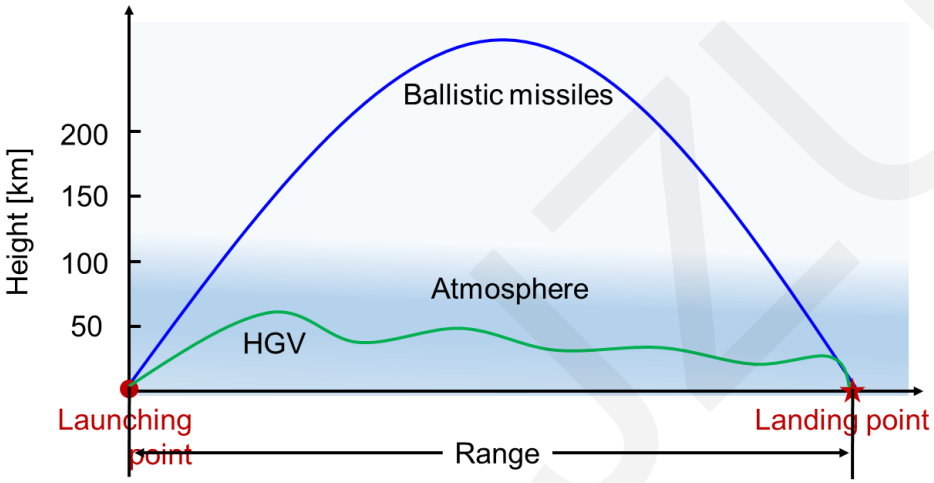


Fig. 2. Flight profiles of hypersonic gliding vehicles (HGVs) and ballistic missiles

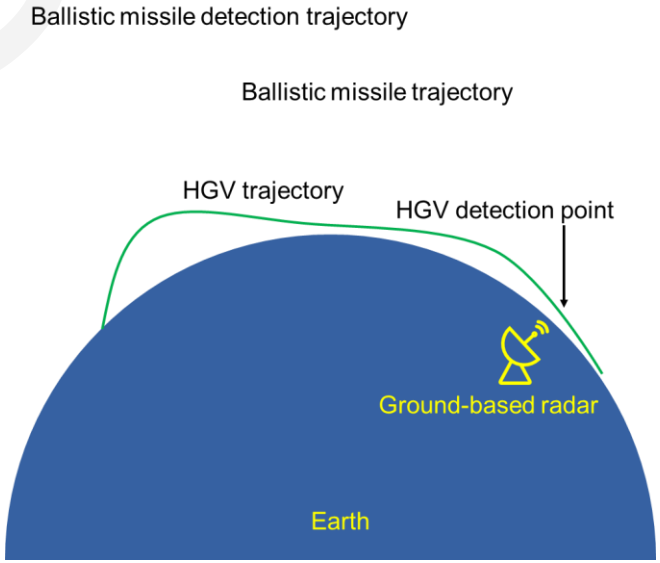


Fig. 3. Ground-based radar's detecting the difference between HGVs and ballistic missiles

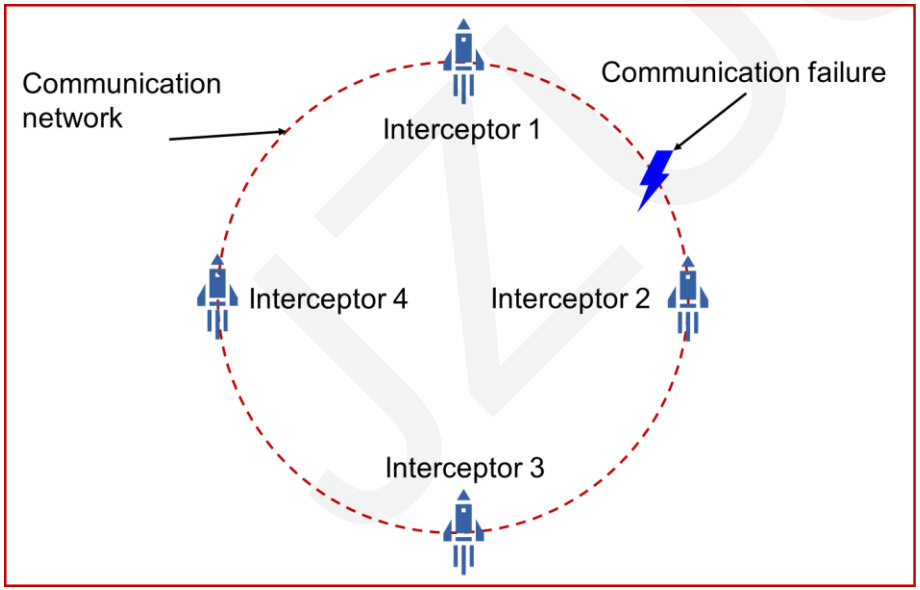
Methods

Future work outlook

We highlight several technologies that will be important when developing terminal guidance laws that can facilitate multi-interceptor cooperative interception of hypersonic.

(1) Design based on the information domain

Inter-interceptor communication is the key for a successful mission.



- Reconfigure the communication link between the interceptors
- Adopt the relative navigation method

Fig. 4. Cooperative guidance law based on the information domain

Methods

Future work outlook

(2) Design based on the space domain

Each interceptor can effectively intercept part of the maneuvering area of the hypersonic vehicle.

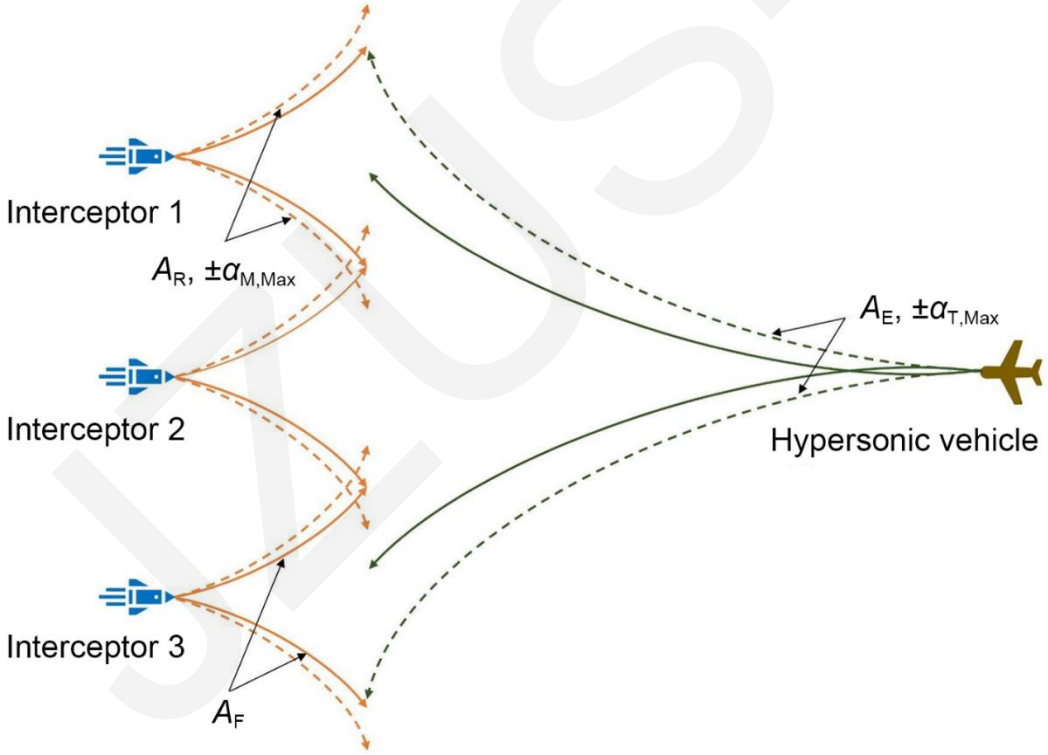


Fig. 5. Cooperative guidance law based on the space domain

Methods

Future work outlook

(3) Design based on the physical domain

Interceptors can be distinguished by their function, that is, by the source component of the detection information.

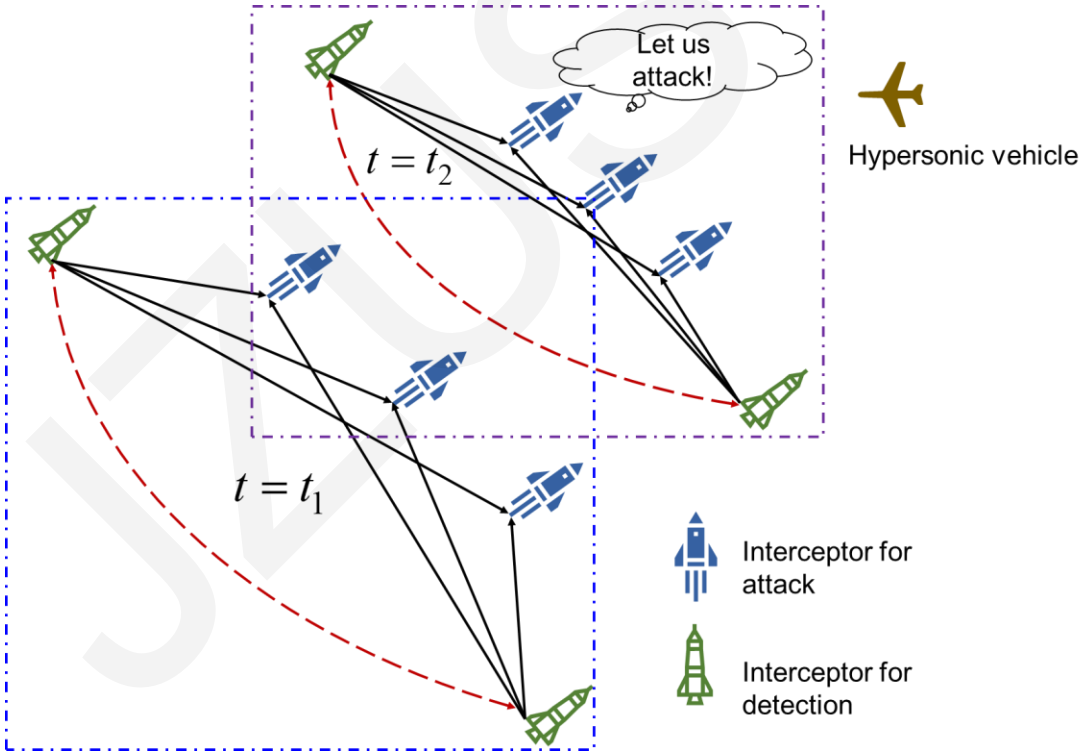


Fig. 6. Cooperative guidance law based on the physical domain

Methods

Future work outlook

(4) Design based on effect-cost ratio

Future battlefield environments are expected to involve system-to-system confrontation. In the context of intercepting hypersonic vehicles, the attack effect of 1+1>2 can only be achieved by ensuring interception accuracy and optimizing the number of interceptors and the performance index.

Conclusions

Hypersonic vehicles exhibit excellent concealment and surprise-defense capabilities, allowing them to surpass existing defense systems. We looked at the potential of four future technologies to facilitate multi-interceptor cooperative interception of hypersonic vehicles; and we believe this paper will provide a useful reference for future research on near space interceptor terminal guidance technologies.