



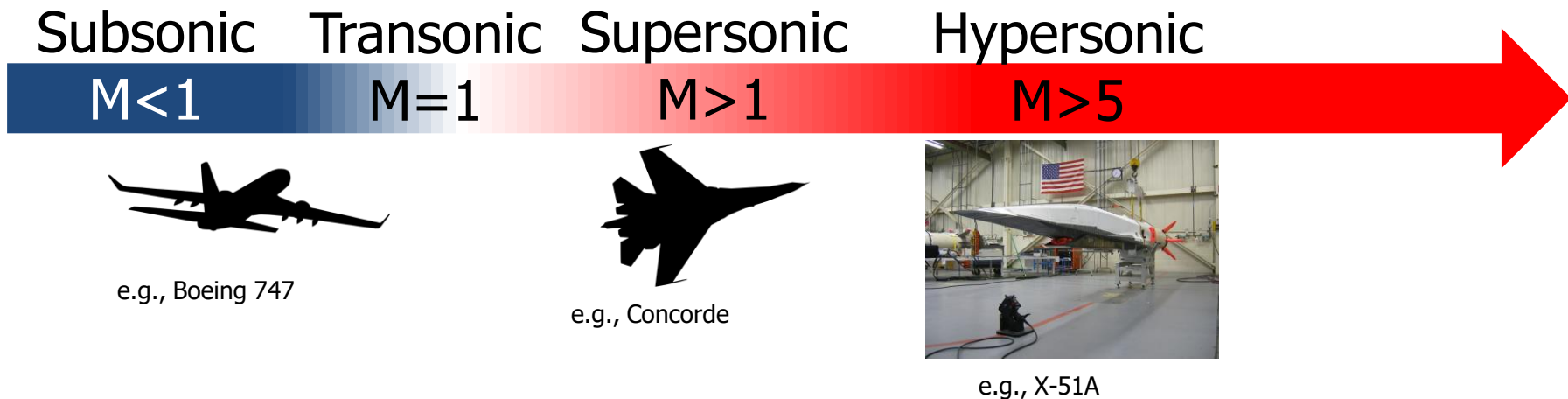
Hypersonic Cost Questions for ICEAA Members

RAND Corporation
May 2020

Hypersonic Weapons are Missile Systems that can Travel Faster than Mach 5 – More than 1 Mile per Second

$$\text{Mach number} = \frac{\text{Vehicle Speed}}{\text{Speed of Sound}}$$

- Speed of sound = 761 mph or 1,100 feet per second on a standard day at sea level



Sources: Wright-Patterson AFB,
NASA Glenn Research Center

Two Main Types of Hypersonic Weapons are Boost-Glide and Boost-Cruise Missiles

- Boost-Glide Missiles
 - Also called hypersonic glide vehicles (HGV)
 - No internal propulsion system
 - Propelled to high speed by rocket booster – and then glides to target from high altitude
 - Expected to fly at altitude of 25 to 60 miles
 - Longer range and higher speed than boost-cruise Missile
- Example
 - AGM-183 Air-launched Rapid Response Weapon (ARRW) – USAF/Lockheed Martin
 - Launched by B-52 bomber

Sources:

<http://www.article36.org/wp-content/uploads/2019/06/hypersonic-weapons.pdf>;

<https://crsreports.congress.gov/product/pdf/R/R45811>

<https://www.gao.gov/assets/710/701369.pdf>

<https://www.forbes.com/sites/sebastienroblin/2020/04/30/the-pentagons-plans-to-deploy-an-arsenal-of-hypersonic-weapons-in-the-2020s/#21fa3a293a5d>

Two Main Types of Hypersonic Weapons are Boost-Glide and Boost-Cruise Missiles

- Boost-cruise missile
 - Also called hypersonic cruise missile (HCM)
 - Has internal propulsion system: air-breathing scramjet engine
 - Boosted by rocket to ~Mach 4, and then scramjet takes over and powers missile until it reaches target
 - Expected to fly at altitude of 12 to 19 miles
 - Shorter range, lower speed than boost-glide Missile
- Example
 - Hypersonic Air Breathing Weapon Concept – USAF/DARPA/Lockheed Martin
 - Launched by B-52 or other supersonic-capable combat aircraft

Sources:

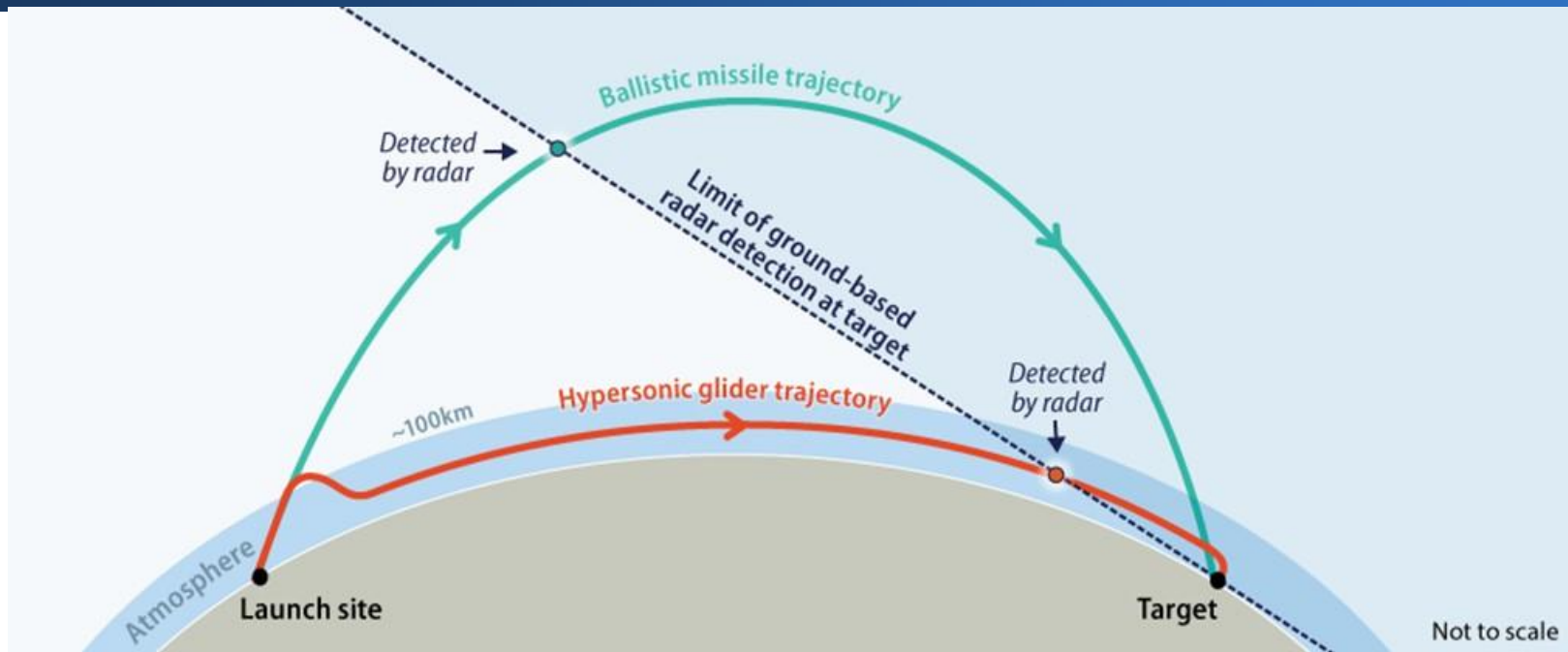
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Hypersonic Weapons Advantages



High speed, maneuverability, unusual altitudes

Speed: 1-5+ mi/s (6-25+ Airliners' speeds)

Altitude: 10-100 km

Source: <https://crsreports.congress.gov/product/pdf/R/R45811> -- page 3

We Would Like to Ask you Some Questions about Hypersonic Weapon Systems

- An earlier version of this question set was used in an ICEAA webinar
 - If you completed the earlier version, please let us know (in your response to the first question). Your input is still welcome!
- We will provide a link on SurveyMonkey shortly
- All responses will be anonymous
- Results will only be provided in aggregate form
- In case any clarification is needed, we will be here to answer questions
- We will make a summary of results available via the ICEAA website in early June
- Contact information:

Lisa Colabella pelled@rand.org; Éder Sousa esousa@rand.org

Notional Assumptions and Ground Rules *Strictly for the Purpose of this Exercise (Question Set)*

- Notional Assumptions about Boost-Glide and Boost-Cruise Systems (strictly for exercise today; not based on actual plans)
 - Both air-launched
 - Same payload
 - Same quantity and rate of production
 - Same mission

- Ground Rules
 - Consider all costs when responding to questions (labor, materials, & other)
 - When responding to questions about Development, you can think of the Development phase as Research, Development, Test & Evaluation activities (e.g., materiel solution analysis, technology maturation, Engineering and Manufacturing Design) preceding production

We Would Like Your Thoughts on the Cost Implications of Boost-Glide (“Glider”) and Boost-Cruise “Cruiser” Hypersonics

- Questions will focus on high level work breakdown structure elements for
 - Glider Missile
 - Airframe
 - Guidance, Navigation, & Control
 - Cruiser Missile
 - Airframe
 - Propulsion
 - Guidance, Navigation, & Control
 - Booster
 - Airframe
 - Propulsion
 - Guidance, Navigation, & Control
 - Platform Integration
 - System Test & Evaluation
- Questions will ask about
 - likelihood element is a **primary** cost driver of development
 - likelihood element is a **primary** cost driver of production
 - Uncertainty of cost of development
 - Uncertainty of cost of production

If you responded to an earlier set of questions for this study, please let us know. (We still welcome your input during this round!)

1. Did you complete an earlier version of this questionnaire? (We welcome your input even if you completed an earlier version - but need this information for data analysis purposes.)

Yes

No

A few initial questions ask about your cost estimating experience

Questions for Cost Estimating Community Members

Hypersonic Cost Study ICEAA Members

General Questions

2. How many years have you been involved in cost estimating?

- 1 to 5 Years
- 6 to 10 Years
- 11 to 20 Years
- 21 to 30 Years
- 31 to 40 Years
- More than 40 Years
- Do not wish to answer

Questions include high-level work breakdown structure elements and ask you to rate them on a 1-7 scale

WBS, Part 1

5. Below is a partial WBS for a hypersonic vehicle that flies above Mach 5. What is the likelihood that the following will be a primary cost driver of development? Click in the appropriate circle in each row. 1 refers to "Not Likely at All" and 7 "Extremely Likely".

	1	2	3	4	5	6	7	Unknown
Glider: Airframe - Structural framework that provides the aerodynamic shape, mounting surfaces, and environmental protection for the air vehicle components.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Glider: Guidance, Navigation, & Control (aka Avionics) - Hardware and software components of the vehicle responsible for maneuvering vehicle and engaging/acquiring target.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cruiser: Airframe - Structural framework that provides the aerodynamic shape, mounting surfaces, and environmental protection for the air vehicle components.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Questions include high-level work breakdown structure elements and ask you to rate them on a 1-7 scale

WBS,
Part 2

	1	2	3	4	5	6	7	Unknown
<p>Cruiser: Airframe - Structural framework that provides the aerodynamic shape, mounting surfaces, and environmental protection for the air vehicle components.</p>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<p>Cruiser: Propulsion System - Provides thrust to propel the air vehicle on its intended flight. The glider does not have a propulsion system; the cruiser has an air breathing propulsion system.</p>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
<p>Cruiser: Guidance, Navigation, & Control (aka Avionics) - Hardware and software components of the vehicle responsible for maneuvering vehicle and engaging/acquiring target.</p>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Questions include high-level work breakdown structure elements and ask you to rate them on a 1-7 scale

WBS, Part 3

	1	2	3	4	5	6	7	Unknown
Booster: Airframe - Structural framework providing aerodynamic shape, mounting surfaces, and environmental protection for the air vehicle components.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Booster: Propulsion System - Provides thrust to propel the air vehicle on its intended flight. The booster has a solid rocket motor.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Booster: Guidance, Navigation, & Control (aka Avionics) - Hardware and software components of the vehicle responsible for accelerating and maneuvering vehicle.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Questions include high-level work breakdown structure elements and ask you to rate them on a 1-7 scale

WBS, Part 4

	1	2	3	4	5	6	7	Unknown
Platform Integration: Platform Integration, Assembly, Test, & Checkout - Technical and engineering services to develop the interfaces with multiple host vehicle subsystems.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
System Test & Evaluation: Any equipment, sensors, infrastructures, or personnel necessary for executing the test of a system. Does not include the test article itself—and does not include any rework or other effort if the system fails a test.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

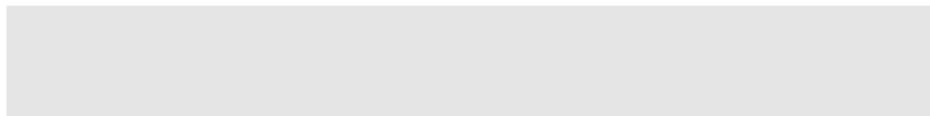
We have also included an open-ended question

Hypersonic Cost Study ICEAA Members

Primary Tools

We would like to gather some general information about SME cost-estimating approaches related to space and missile systems or other complex systems. **Please do not provide your name or other identifying information when responding to these questions.** (Responses will be used in a high-level summary of general approaches; we will not be using identities of respondents.)

9. What estimating tools (models, information systems, data, or other sources) would you use to estimate the costs of new systems with emerging technologies?



PREV

DONE

<https://www.surveymonkey.com/r/PW6CF27>

Please use the link provided to respond to our questions.
Results will be posted next week.

<https://www.surveymonkey.com/r/PW6CF27>





DRAFT – Work in Progress- Do Not Cite