■ National Security

Closing the Hypersonic Testing Loop

Masao Dahlgren

SUMMARY

It is now common knowledge that successful hardware enterprises win by testing early and often. Whether at Toyota or SpaceX, testing creates critical feedback for early engineering decisions, uncovering mistaken assumptions before they become costly.

This virtuous cycle is often unrealized for priority defense projects. While the Department of Defense (DOD) has invested nearly $12 billion in new hypersonic weapons since 2018, hypersonic engineers still contend with yearslong waiting periods to test designs in wind tunnels or in flight.

The US is now racing to fix hypersonic testing, with more dollars for workforce development and plans to increase the number of flights from five to more than 50 a year. But Congress and the new administration should do more to build hypersonic test infrastructure and integrate nontraditional testing approaches.

PROBLEM

As China multiplies its naval, air, and missile forces to threaten its neighbors, the US needs standoff weapons to defeat targets from outside the range of Beijing's missile arsenal. It is difficult to concentrate and project traditional forms of power on the future battlefield. Raising the cost of an attack on Taiwan, while surviving massed air and missile attack, simply demands more and better missiles.

Hypersonic weapons will be a key piece of these cost-imposing strategies. Their combination of speed, maneuverability, and low altitude not only make such weapons challenging to intercept; they may one day be more affordable than subsonic cruise missiles, replacing complex turbomachinery for engines without moving parts. These reasons are why China has raced ahead in hypersonic development, and why they have now become a DOD priority.

Why has China outpaced the US? Setting aside the cyclical pattern of US hypersonic research funding, China has learned lessons from successful US procurement efforts, echoing Aegis mastermind Wayne Meyer's dictum to "build a little, test a little, and learn a lot." China's advantage in hypersonic testing—20 times more frequently than in the United States—enables its staggering progress in designing and deploying novel weapons.

Shortfalls in testing hypersonic systems bottlenecks America's race to catch up. In 1959, NASA and the Air Force performed nearly 200 tests to develop the X-15, the first manned hypersonic aircraft. But today, the cadence of hypersonic flight testing barely exceeds once every quarter. The rate of hypersonic flight testing simply does not keep pace with the priority accorded to building hypersonic systems.

Monthslong, or even yearslong, wait times are common for hypersonic wind tunnel and flight test opportunities, with industry participants stating that "nearly every wind tunnel facility suitable for hypersonic testing is booked a year or more in advance." Opportunities for flight test compete with established programs of record for limited space and resources, safety analyses and instrumentation can take months to prepare, and permitting challenges can threaten capacity increases. Worse still, these delays are self-reinforcing: faced with long and uncertain wait times, contractors are incentivized to cross-shop different ranges, creating duplicate review processes that further bog down the system.

Equally challenging is the shortfall in US ground test capacity. A strategy of flying full test articles without proving individual parts increases the risk of "dumb mistakes"—basic fin separation, booster duds, and other banal failures—that have wasted costly flight tests. There is a tidal wave of heat shields, thermal tapes, sensor windows, and other subsystems that need validation before moving from science experiment to weapons system.

Yet the roughly 40 ground test facilities suitable for hypersonic development—wind tunnels, thermal chambers, and test tracks—are often decades old, with minimal production bases for replacement parts and outdated data collection infrastructure. More strikingly, the number of operational arcjet wind tunnels, crucial for confirming hypersonic weapons' heat shielding and basic shape, can be counted on one hand. Instead of using flight tests to demonstrate basic lessons on component performance, design-

ers should use them as SpaceX does: to prove new and immature systems and push the engineering envelope. Doing so will necessitate a manyfold increase in US hypersonic ground test capacity.

There is momentum to build on. Beginning in 2025, the DOD's Test Resource Management Center (TRMC) plans to increase flight tests to roughly 50 yearly for its Multi-service Advance Capability Hypersonics Test Bed (MACH-TB) project, largely with more flexible commercial testing platforms. It is replacing its "string of pearls," a series of range instrumentation ships that take days to emplace, with Skyrange, a network of rapidly deployable drones. And collaboration with Australia through AUKUS Pillar II (SCIFiRE) and the preceding HIFiRE program have unlocked more basic research, wind tunnels, and a test range larger than Pennsylvania. Yet more can be done.

SOLUTION

Executive

- Expand TRMC's gap survey to include an updated review of major hypersonic tunnel facilities, and instrumentation; survey data on hypersonic flight test and tunnel wait times; and final recommendations for Congress on specific facility and budgetary needs.
- In the Government Accountability Office's review of Federal Aviation Administration (FAA) licensing processes, assess FAA's capacity for reviewing commercial hypersonic launches, including an analysis of modeling and simulation needs.
- Issue requests for information on new technical and contracting approaches to building arcjet and quiet tunnels at scale.
- Conduct a NASA-led study on next-generation autonomous flight termination systems (AFTS), for the purpose of enhancing the safety of overland flight testing.

Congressional

- After evaluating outcomes in fiscal year 2025, resource the MACH-TB effort as a program of record.
- Resource the construction of a second hypersonic test track at Holloman Air Force Base.
- Fund infrastructure modernization on Kwajalein Atoll to the extent identified in the forthcoming National Defense Authorization Act-mandated Defense Science Board study on Kwajalein infrastructure challenges.
- Request a TRMC report on the cost of constructing a new high-speed flight corridor at White Sands Missile Range.
- Request and fund a study on novel approaches and leapfrog technologies for hypersonic ground testing.

JUSTIFICATION

These recommendations would extend Congress's recent directive to "address deficiencies and capacity constraints with the existing hypersonic test infrastructure."

First, if TRMC's MACH-TB and Skyrange pilots prove successful, Congress and the administration should work to establish MACH-TB as a formal program of record with a dedicated funding line in the defense budget. Such a designation is crucial for acquisition success—not only for ensuring stable funding for flight tests, but for nudging industry to make long-lead investments in hypersonic workforces and supply chains.

Second, policymakers should explore less traditional methods to accelerate the flight test cadence. Given their cost, hypersonic flights typically happen after the DOD pays for them: the Pentagon issues prototyping contracts to firms, which then search for sponsorship at a DOD test range, contracting them for the safety analyses needed for final approval. But with the influx of private capital into defense firms, the hypersonic enterprise should examine where to emulate the commercial space industry, where companies develop prototypes on their dime and profit from the results. To that end, the administration should consider how FAA licensing processes used in commercial space launches could be adapted for commercial hypersonic flight tests. Firms willing to stake their capital on hypersonic testing should not face higher licensing barriers than those that do not.

Third, the administration should expand its efforts to collect data on hypersonic test capacity. Some studies are straightforward—updated data on test delays, institutions, or wind tunnel infrastructure would create the evidence base needed for smart budget decisions. Others are less obvious, but still impactful: potential upgrades to flight termination systems or simulation software could make preflight safety calculations more precise, shrinking the keepout zones needed to conduct tests.

Lastly, Congress must directly resource test infrastructure. As emphasized by the Senate Armed Services Committee, it will be necessary to repair aging facilities, housing, and hospitals on Kwajalein Atoll, one of the few sites equipped for supporting long-range hypersonic, ballistic missile, and missile defense tests. Construction of a second hypersonic test track, meanwhile, would not only support the hypersonic enterprise but a wide variety of defense applications, from ejection seat testing to nuclear modernization. The nation would similarly benefit from new flight test corridors, wind tunnels, and instrumentation—the literal airspace and equipment needed to increase test capacity. ■

FURTHER RESOURCES

- Fiscal 2025 President's Budget for USAF Hypersonics Prototyping
- Fiscal 2025 President's Budget for ONR
- Fiscal 2025 President's Budget for TRMC
- Fiscal 2025 National Defense Authorization Act
- House Armed Services Committee: US and Adversary Hypersonic Capabilities, 2024

- Congressional Research Service, "Hypersonic Weapons: Background and Issues for Congress," 2024
- NDIA, Hypersonics Supply Chains: Securing the Path to the Future, 2023
- USAF: An Exploratory Analysis of the Chinese Hypersonics Research Landscape, 2022
- CSIS: "Hypersonic Strike and Defense: A Conversation with Mike White," 2021
- Hudson Institute, "The Future of US and Allied Hypersonic Missile Programs," 2024
- CSIS, "Complex Air Defense: Countering the Hypersonic Missile Threat," 2021
- CSIS: "Getting on Track: Space and Airborne Sensors for Hypersonic Missile Defense," 2023
- Stratolaunch: "Introduction to Hypersonic Flow," 2021
- NASA, "Facing the Heat Barrier: A History of Hypersonics," 2007
- US–China Economic and Security Review Commission, Hearing on China's Pursuit of Defense Technologies, 2023

Masao Dahlgren is a Fellow at the Center for Strategic and International Studies, where he writes on space, missile defense, and emerging technologies.