Breaking New Barriers

The Rise of Hypersonics

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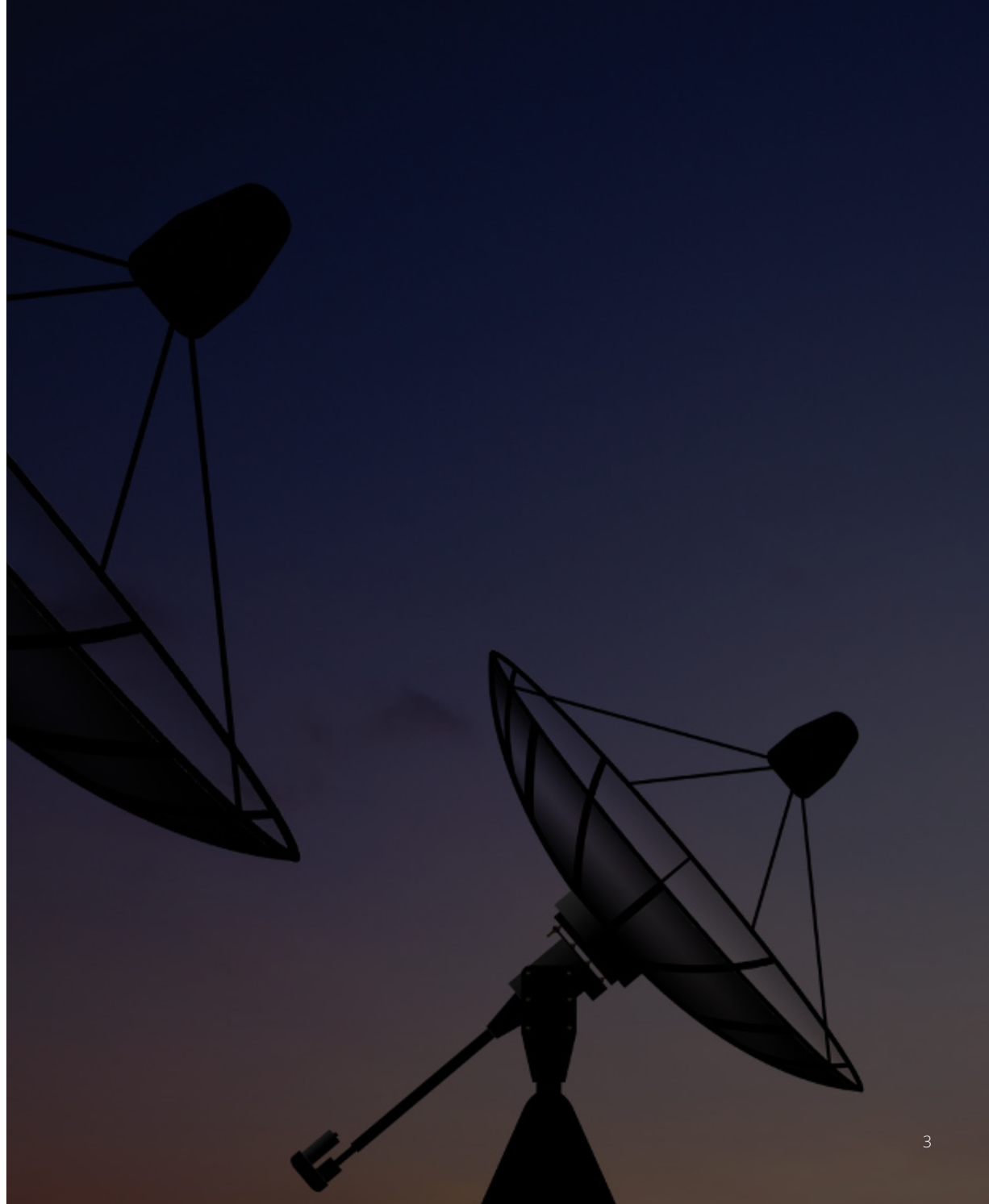
CONTENTS

Image: Creative Commons, United States Navy
first-ever ground test of a full scale, fully integrated hypersonic cruise missile using conventional liquid hydrocarbon fuel

RADAR CHECK

As the Aerospace & Defense (A&D) industry enters the 2020s, it will likely see numerous major developmental programs become a reality. Some examples of these are likely to include: several classified programs to take advantage of new technologies in unmanned systems, machine learning, and artificial intelligence; and finally, hypersonics. Hypersonics could have the potential to transform the industry in a manner not seen since the introduction of supersonic flight in 1947 and supersonic transport in the late 1960s. While hypersonic travel, weapons, and defenses are just starting to be discussed more frequently, it is likely that some will be ready for use within the next year. By understanding what hypersonics are, the market for it, major industry players, and the types of hypersonic products, A&D firms can better position themselves to capture their share of a sizable new market opportunity in the years to come. Furthermore, the introduction of hypersonics will likely require a need for A&D firms to make changes in four key areas of their business: market strategy, design and engineering, manufacturing and talent.



THE IMPLICATIONS OF SPEED

The term hypersonic means "moving at a speed greatly in excess of the speed of sound, usually meaning greater than Mach 5."[1] This roughly translates into traveling at 60 miles per minute (or the equivalent of a four-minute commute from Washington, D.C. to New York), which would significantly reduce flight duration for commercial passengers. In a defense setting, it will dramatically compress response times for military commanders. Put simply, the ramifications of these potential advances on the global economy and foreign policy are significant.

Traveling through the atmosphere at speeds exceeding Mach 5 (3,836 mph), hypersonic airframes would have to adapt to an environment of extremes. Two key engineering challenges facing hypersonic engineers today are heat management and drag management, both of which are essential to ensuring a survivable airframe.[2] To date, hypersonic airframes are primarily being built out of nickel-based alloys and/or ceramic composites[3] using two main frame designs: waverider and winged bodies. The waverider rides on the shock wave generated by hypersonic flight, providing a fuel-efficient method of propulsion. The winged body is constructed to generate propulsion from the shape of its wings and fuselage.[4] Regardless of airframe style, the future of hypersonic flight will require continued development and integration of a flight control system that is both agile and automated. This "neural network" would have to produce instantaneous adjustments in response to the surrounding and rapidly changing flight conditions.[5] While the potential impact of hypersonic technology will be revolutionary, there are still significant testing and design hurdles that must be cleared by the aerospace community.

1 www.definitions.net.
2 "Facing the Heat Barrier: A History of Hypersonics." NASA, (2007).
3 "Get ready for the era of hypersonic flight — at five times the speed of sound", Los Angeles Times, 2018.
4 "System Design and Optimization of a Hypersonic Launch Vehicle." San Jose State University, (2014).
5 "A Sparse Neural Network Approach to Model Reference Adaptive Control with Hypersonic Flight Applications." American Institute of Aeronautics and Astronautics, (2018).

MARKET POTENTIAL

In the US, the broader hypersonics market is still largely concentrated on national defense: offensive weapons and associated countermeasures. Annual unclassified defense spending requests for hypersonic technology are already over $2.6 billion, with a 26 percent compound annual growth rate since 2014. This includes $157.4 million for hypersonic defense programs in fiscal year 2020.[6] This annual spend is expected to grow to $5 billion by 2025.[7] Also, the international hypersonic market is predicted to grow at a compound annual growth rate of 7.23 percent between 2018 and 2022.[8]

Additionally, the hypersonic market has received approximately $328 million in venture capital investment since 2015. Top venture investment recipients include: Reaction Engines, a pioneer in both combined-cycle, air-breathing rocket engines and proprietary heat-exchanger technology; and Hermeus, a company driven to create a commercial hypersonic airframe.[9] This type of investment in hypersonic technologies will likely flourish in coming years in response to market demand and an increase in available funding to include: small business innovation research (SBIR) grants, seed capital from Department of Defense (DoD)-backed accelerators, and the investments from the venture capital community.

6 Analysis based on data from the Department of Defense (DOD), Research, Development, Test, and Evaluation (RDT&E) database, https://budget.dtic.mil.
7 CNBC, https://www.cnbc.com/2018/09/26/jp-morgan-hypersonic-missiles-are-the-pentagons-next-big-bet.html website.
8 PR Newswire, https://www.prnewswire.com/news-releases/the-global-supersonic-and-hypersonic-missiles-market-is-forecasted-to-grow-at-a-cagr-of-7-23-during- the-period-2018-2022--300731252.html website.
9 Analysis based on information from Pitchbook, www.pitchbook.com.

THE PLAYING FIELD

Lockheed Martin and Raytheon appear to be leading the race thus far. Lockheed has captured $3.68 billion in hypersonic contracts from the US government since 2014 across the Army, the Navy, the Air Force, the Defense Advanced Research Projects Agency (DARPA), and NASA.[10] Platforms include both glide vehicles and hypersonic cruise missiles. Raytheon has current investments in both offensive programs and counter-hypersonic programs. Raytheon forecasted $300 million in revenue from their hypersonic programs during FY2019.[11] Most other defense contractors are also making investments in the hypersonics market.[12]

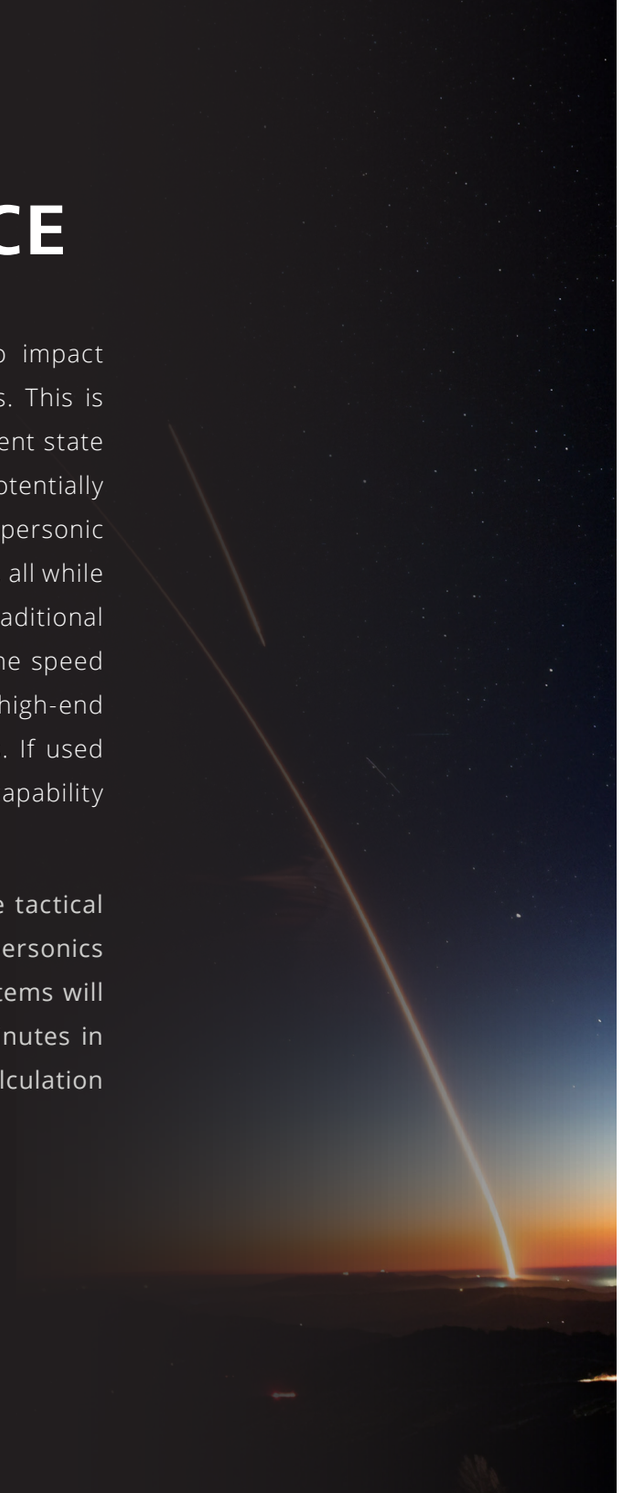
DoD's efforts to claim global hypersonic parity is underpinned by several key parallel R&D programs. Running point for this research campaign is DARPA. DARPA has multiple hypersonic programs in various stages of testing and development to include: The Tactical Boost Glide Vehicle (TBG), the Advanced Full Range Engine (AFRE), the Hypersonic Air-breathing Weapon Concept (HAWC), Operational Fires (OpFires), and finally the Glide Breaker program.[13] Due to the cost and complexity of hypersonic technology research, DoD agencies collaborate to share their advances in wider communities while also sharing costs. One example of this collaboration is the Air-Launched Rapid Response Weapon (ARRW), an air-launched hypersonic platform that is being jointly developed by the US Air Force and DARPA.[14] The diversity of hypersonic development programs demonstrates that the DoD is not solely concerned with the quality of their platforms relative to near peer militaries, but that they are also concerned with the ability to maintain redundant hypersonic strike options. The upside of this is that the market is unlikely to become a 'winner take all' proposition.

10 Analysis based on data from The Bureau of the Fiscal Service of the U.S. Department of Treasury, www.usaspending.gov.
11 Anthony F. O'Brien – Vice President and Chief Financial Officer of Raytheon Company, Quarter 2 Earnings Call, 25 July 2019.
12 Analysis based on data from The Bureau of the Fiscal Service of the U.S. Department of Treasury, www.usaspending.gov.
13 DARPA, www.darpa.mil website.
14 DARPA, https://www.darpa.mil/program/hypersonic-air-breathing-weapon-concept website.

STRATEGIC SIGNIFICANCE

Hypersonics are considered game-changing due to their ability to impact decision making and to mitigate adversaries' capability advantages. This is significant because these weapons can, as they mature, render even current state of the art defenses largely ineffective. This means that hypersonics could potentially shift the global balance of power and the existing capability gap. Hypersonic weapons allow for greater range, greater survivability, and faster response, all while carrying conventional or, in some cases, nuclear warheads. Compared to traditional intercontinental ballistic missiles and cruise missiles, hypersonics combine speed exceeding that of intercontinental ballistic missiles, along with the high-end maneuverability of a cruise missile and additional deception capabilities. If used by adversaries, these two factors could potentially overcome an existing capability advantage in global military reach.[15]

The implications of shortened reaction times and decision cycles at the tactical and strategic levels will be far reaching. With dynamic flight paths, hypersonics will be even more difficult to defeat in flight. Additionally, defense systems will need to determine the origin of a launch in a matter of seconds or minutes in order for a response to be effective. All of this increases the risk of miscalculation and unintended escalation.



> "We don't have any defense that could deny the employment of such a weapon against us."
>
> Gen. John Hyten, Vice-Chairman of the Joint Chiefs of Staff and former Commander of US Strategic Command[16]

15 "Hypersonic Weapons: Background and Issues for Congress." Congressional Research Service, 17 September 2019.
16 Gen. John E. Hyten, Vice-Chairman of the Joint Chiefs of Staff and former Commander of U.S. Strategic Command, Senate Armed Services Committee, March 2018.

TECHNOLOGY LANDSCAPE

The offensive military application of this technology comes in two primary forms, the boost glide system and the hypersonic cruise missile. In a boost glide system, a rocket booster accelerates its payload to high speeds and detaches the glide vehicle. The rocket booster, or in some cases a ballistic missile frame, delivers the glide vehicle into upper layers of the atmosphere. Once separated from the rocket, the vehicle glides unpowered to its destination. On the other hand, the cruise missile variant is a guided munition that maintains a constant speed and state of self-propulsion. Hypersonic cruise missiles could be deployed from any platform (e.g. aerial, maritime, land); however, they cannot produce thrust from standstill. As such, they require the assistance of a booster rocket or other propulsion mechanism to reach hypersonic speeds.[17]

The potential threat of glide vehicles and hypersonic cruise missiles has led to the initial development of counter-hypersonic systems. DARPA has begun working with commercial prime contractors to develop the "glide breaker" hypersonic defense platform.[18] While systems like the THAAD, S-500, and Arrow counter-ICBM system may prove effective against hypersonic weapons, they are not economically viable for the defense of an entire nation.[19]

17 "Hypersonic Missile Nonproliferation: Hindering the Spread of a New Class of Weapons." Rand Corporation (2017).
18 DARPA, www.darpa.mil website.
19 "Hypersonic Missile Nonproliferation: Hindering the Spread of a New Class of Weapons." Rand Corporation (2017).

Image:
Creative Commons, United States Air Force, Chad Bellay

TIME TO TARGET

Who will be the 'winners and losers' in the hypersonics market race? Given that the first hypersonics products are entering the market now, time is of the essence. In addition to having a proprietary technological edge, we believe that there are four key imperatives that must be correctly addressed in order to secure an early and sustained advantage:

1 | Deliberate Capability and Market Strategy

2 | Rapid Engineering and Development

3 | Agile Production System

4 | Critical Skills and Talent

20 "2018 Deloitte and The Manufacturing Institute Skills Gap and Future of Work Study," https://www2.deloitte.com/us/en/insights/industry/manufacturing/manufacturing-skills-gap-study.html

21 "Hypersonic Weapons: Background and Issues for Congress" Congressional Research Service, https://crsreports.congress.gov/product/pdf/R/R45811

Image: Creative Commons, United States Air Force

1 | Defining Market Strategy & Aligning Your Portfolio

It sounds easy, but having a deliberate market strategy and understanding your points of competitive differentiation will be key. A few questions to ask yourself: Are you funding the necessary internal R&D investments to lead the market? If not, have you or are you in the process of conducting commercial diligence to create a solid pipeline of companies to consider for inorganic growth opportunities to enter the market? Does your current operating model and organizational structure support the technology, processes, and skilled workforce that will be required to compete in the hypersonics market?

2 | Designing & Prototyping in Digital Space

The customer will expect and require shorter and shorter development cycles for hypersonics. And while the engineering and design space has seen considerable advancement in recent years, the adoption and benefits associated with this evolution have not been widely enjoyed. In order to develop and prove out hypersonic product concepts more quickly, companies will need to accelerate their use of model-based definition and digital twins. Simulated flight tests, survivability, lethality, etc. should all be known with high degrees of confidence before the first physical prototype is ever constructed. While many companies are making investments in this space, they are not redesigning their engineering function to take advantage of these advancements.

3 | Responding to Demand & Scaling to Rate Production

Being able to ramp production to meet customer needs is always important, but given the strategic imperative present with hypersonics it will be a critical decision factor for future contract awards. A scalable, agile and digital manufacturing strategy will be tablestakes. Questions to ask yourself: Have you verified your manufacturing processes before investing in capital? Do your design processes support producibility requirements? Are your manufacturing assets versatile and rapidly scalable (e.g., not overly reliant on manual processes)? Is your supply base poised to scale with you? Firms that are able to execute on these manufacturing strategies will be in a position to respond to the customer needs and absorb market share.

4 | Acquiring the Right Talent

Companies will need to consider how they design and execute a workforce strategy that builds the right talent, with the right skills, and deploys them at the right time in the hypersonic lifecycle. In an already competitive talent market, facing a growing manufacturing skills gap,[20] companies should consider: How can they partner with existing hypersonic academic programs (i.e., Purdue University and the University of Notre Dame)[21] to advance an R&D talent pipeline? What other workforce development strategies can organizations employ to drive multi-year manufacturing talent pipelines (e.g., pre-secondary education, vocational programs, public-private partnerships, and geographic empowerment zones)?

APPROACH VECTOR

The adoption of hypersonic flight will be a transformational event. The associated technological advancements could revolutionize everything from international commerce to the command-and-control of militaries to geopolitical dynamics. While it's likely that hypersonic technology will arrive in fast fashion, it's not too late for companies to position themselves to play a key role in and capture their share of the market.

We believe that the "hypersonic boom" will continue into the future and will serve as the catalyst for a period of significant technological advancement in aerospace. In order to succeed, companies will need not only novel and differentiated technology offerings, but also a strategy and operating model that supports the speed and scale that the market requires.

OUR TEAM

Deloitte can offer informed perspectives on this and other topics related to the defense industrial base

For more information, contact a member of our Aerospace & Defense consulting team:

KEVIN BRANNON

Principal
Deloitte Consulting LLP
kbrannon@deloitte.com

KERRY MILLAR

Principal
Deloitte Consulting LLP
kmillar@deloitte.com

BEN BROOKS

Senior Manager
Deloitte Consulting LLP
bebrooks@deloitte.com

JOHN HAGY

Senior Consultant
Deloitte Consulting LLP
jhagy@deloitte.com

Deloitte.