Wallace Bow, A4H article
HPC Annual Report
Version 3.0
Writer: Whitney Lacy

SAND2018-8888R

Autonomous Hypersonics

A new race is emerging among nuclear powers: the hypersonic weapon. Hypersonics are flight vehicles that travel at Mach 5 (five times the speed of sound) or faster. They can cruise in the atmosphere, unlike traditional exo-atmospheric ballistic missiles, allowing stealth and maneuverability during midflight. Faster, lower, and stealthier means the missiles can better evade adversary defense systems. The U.S. has experimented with hypersonics for years, but current investments by Russia and China into their own offensive hypersonic systems may render U.S. missile defense systems ineffective. For the U.S. to avoid obsolescence in this strategically significant technology arena, hypersonics—combined with autonomy—needs to be a force multiplier.

Achieving an autonomous hypersonic missile, however, that can intelligently navigate, guide, and control itself and home-in on targets ranging from traditional stationary systems to targets that are themselves hypersonic vehicles—with all the maneuverability that this entails—may sound far-fetched. But to Sandia's Autonomy for Hypersonics (A4H) team, this dream is one step closer to reality.

The A4H team is the winner of Sandia's first "Mission Campaign" fund, a new type of transient LDRD investment area championed by NTESS. The A4H Campaign will research and develop autonomous system technologies that will significantly enhance the warfighting utility of hypersonic vehicles by exploiting artificial intelligence (AI) to shorten mission-planning timelines and enable adaptive targeting decisions. This new capability will provide in-flight flexibility to adapt hypersonics to conditions such as:

1. Newly designated targets (e.g., engagement of secondary targets after the successful engagement of primary targets by leader vehicles)
2. Evolving terminal engagement conditions (e.g., mobile target with changing geodetic location)
3. New threats (e.g., emerging countermeasure capabilities presented during flight)
4. Unexpected flight conditions (e.g., adapting to sensor information that indicates a notable departure in environment and vehicle properties).

High-performance computing (HPC) will be a key player in the success of A4H and will address the need for hypersonic engagement strategies beyond simulated scenarios. Current hypersonics rely on long-lead planning, scripted modeling, and simulation to provide mission plans tailored to specific circumstances; this is a time-consuming and significant research challenge. Sandia's HPC capabilities will be instrumental in overcoming this challenge. "We'll be teaming with HPC developers to allow for this kind of modeling and simulation, utilizing billions of calculations to find the best tactics and solutions," said Wallace Bow, A4H Campaign Manager.

HPC will help A4H leverage modern machine learning (ML) and AI to enable quick-turnaround mission planning and analysis and to allow rapid extrapolation and generalization from previously analyzed scenarios to new and unpredicted environments. Through groundbreaking autonomy research in adversarial learning using the modeling and simulation power of Sandia's HPC, the A4H Campaign will enable transformational hypersonic capabilities that allow the U.S. to regain and retain leadership in this strategically significant arena, strengthen national security, and inform what is possible for next-generation projects.

Wallace Bow, A4H article
HPC Annual Report
Version 3.0
Writer: Whitney Lacy

Caption: Hypersonic Vehicle

Wallace Bow, A4H article
HPC Annual Report
Version 3.0
Writer: Whitney Lacy

SENSE-THINK-ACT

Autonomous systems are characterized by use of a closed-loop "*SENSE-THINK-ACT*" operation to achieve their desired goals. Today, hypersonic flight vehicles can and do *ACT* on their own. However, they require up-front, rules-based programming and they rely solely on GPS for their terminal accuracy, which significantly limits their operational relevance. A4H aims to give these systems the ability to *SENSE* and *THINK* so that they can extract information from their surroundings and intelligently adapt to changing circumstances and elusive targets. Closing the *SENSE-THINK-ACT* loop will provide onboard intelligence that significantly improves the ability to engage diverse targets in contested environments.

AUTONOMOUS CAPABILITIES

Hypersonics represents one of the hardest—if not THE hardest—national security problem spaces for autonomy. The need to carry out sophisticated operations in high-consequence, adversarial environments represents a primary difference between national security and commercial applications of autonomy. Building a strong foundation in high-consequence autonomy will position Sandia to support other national security needs. The developed autonomy capabilities will extend to other Sandia flight and sensing systems in support of missions such as airborne intelligence, surveillance and reconnaissance (ISR), space resilience, and contested space. They will also extend to other classes of hypersonic systems (e.g., air-breathing vehicles), other advanced flight systems (e.g., maneuvering reentry), and adverse-environment autonomous systems in general.