Outsmarting Agile Adversaries in the Electromagnetic Spectrum

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ISSUE

Superiority in the electromagnetic spectrum (EMS) is increasingly important for securing military advantage. Adversaries and competitors are seeking to offset the United States' ability to operate within and through the EMS by making their systems more complex and adaptable—and therefore more difficult for U.S. platforms to detect, identify, evade, and counter threats.

This presents an enormous challenge to the U.S. Air Force (USAF) electronic warfare integrated reprogramming (EWIR) process, which relies on key organizations such as the National Air and Space Intelligence Center and the 350th Spectrum Warfare Wing. The USAF's EWIR enterprise is responsible for the fully integrated operations of compiling intelligence on adversary threats that emit in the EMS (in particular, radars and jammers) and configuring[1] electronic warfare (EW) equipment to enable aircraft or other USAF resources to react and/or respond to adverse changes in the EMS environment. Until recent years, EMS threats did not change very quickly. The EWIR enterprise could execute mission data file (MDF) updates as well as months-long operational flight program updates without a negative impact to operations. With the growing advancements in U.S. adversaries' electronic warfare assets, however, enabling complex and diverse EMS capabilities, identifying, tracking, and responding to these assets requires much faster updates than the EWIR enterprise was designed for.

APPROACH

RAND Project AIR FORCE (PAF) considered how adversary capabilities in the EMS are evolving, how fast EW-related software reprogramming needs to be to keep pace with threats, what obstacles exist within the current intel-to-reprogramming process, and what advanced technologies are needed to achieve necessary improvements. PAF's work is centered on what is currently known as EWIR but is scoped to cover the broader range of issues related to the role of data and software in enabling EMS operations.

To conduct this work, PAF relied on subject-matter expert interviews and field observations (e.g., of air component rehearsal of concept drills), process analysis, technology forecasting analysis, and vignette

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[1] This configuration is generally done digitally and may include new uploads of data, software code, and firmware. Therefore, it is termed *reprogramming*. However, we note that it may also include changes to switches, dials, and other manually manipulated controls of the EW equipment.

development. Central to the methodology was the development of four interrelated technology case studies that together comprise the fundamental elements necessary for developing a near-real-time, autonomous, inflight software reprogramming capability and, more specifically, artificial intelligence–enabled *cognitive electronic warfare*.[2]

CONCLUSIONS

- To remain competitive and adapt to changing threats, USAF systems that operate in the EMS must be capable of rapid reprogramming (including evaluating the environment, detecting adversary activity, and synthesizing an appropriate response), at least on the order of seconds to minutes.
- Agile software solutions, hardware upgrades, data engineering, and interoperability with other systems are all required to achieve the needed speed.
- Accompanying changes in policy, organizational mission alignment, personnel and computing availability, and personnel professional development are also needed.

RECOMMENDATIONS

- The USAF should start working today to *accelerate and integrate technologies needed to realize cognitive EW*. Steps include supporting a shift toward software architectures, such as containerized microservices, that would allow faster deployment of capabilities and upgrades to increase the reprogramming speed and provide support for the deployment of cognitive EW algorithms on platforms in the future; enhancing onboard high-performance computing; expanding experimentation and early technology adoption; prioritizing policies and technologies that will allow better data collection, standardization, classification, access, and integration processes; and ensuring coordinated investment and implementation of these activities given high interdependencies among key technologies.
- The USAF should also take immediate steps to *adopt new software deployment architectures to enable faster fielding of capabilities and implement rapid and airborne MDF updates in theater*. This necessitates important changes to existing policy; personnel professional development; technological reviews; and investments in software architecture standards, onboard processing, and computing and connectivity at the "edge" of combat (i.e., by the aircraft during the mission).

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[2] *Cognitive electronic warfare* is the use of machine learning algorithms that enable USAF platforms to learn, reprogram, adapt, and effectively counter threats in flight.

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