WHITE PAPER

Key Considerations for Radar Test

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Many trends are driving innovation to advance technologies across multiple industries. Software-driven and multipurpose platforms are changing how people interact with their phones, thanks to more than two million iPhone applications and more than 3.8 million Android applications now available. Low-latency processing is creating opportunities for people to interact differently with the world through virtual reality and gesturing technology. We are experiencing a more connected world due to the big data processing and exposure to information to help companies to optimize logistics and empowering doctors to make medical advancements. Machine learning and artificial intelligence are allowing the recognition of pattern in data sets larger than any one human could process and making autonomous vehicles possible. These same trends advancing technologies in commercial products are evolving radar and electronic warfare (EW) systems that incorporate sensor fusion, hypersonic weapons, multistatic sensors, drones, a networked electronic order of battle, cognitive radar, and cognitive or predictive EW.

Radar and Electronic Warfare Trends

In radar and EW specifically, the operating environment and requirements for military radars are changing rapidly, and trends such as the following are increasing the complexity of these systems to new extremes:

- Radar architecture proliferation, such as active electronically scanned array (AESA), bistatic, and passive radar, with a seemingly infinite number of software-defined techniques within "cognitive" radar and low-probability-of-intercept radar, is increasing the range of testing required by test systems.
- Platform miniaturization is driving the consolidation of RF systems. Future radars, EW receivers, and communications likely will share the same sensor platform and be tested as a unit.
- Autonomy similar to the commercial-vehicle market will drastically increase the amount of testing required across multisensor and multiplatform systems to ensure safety and reliability.

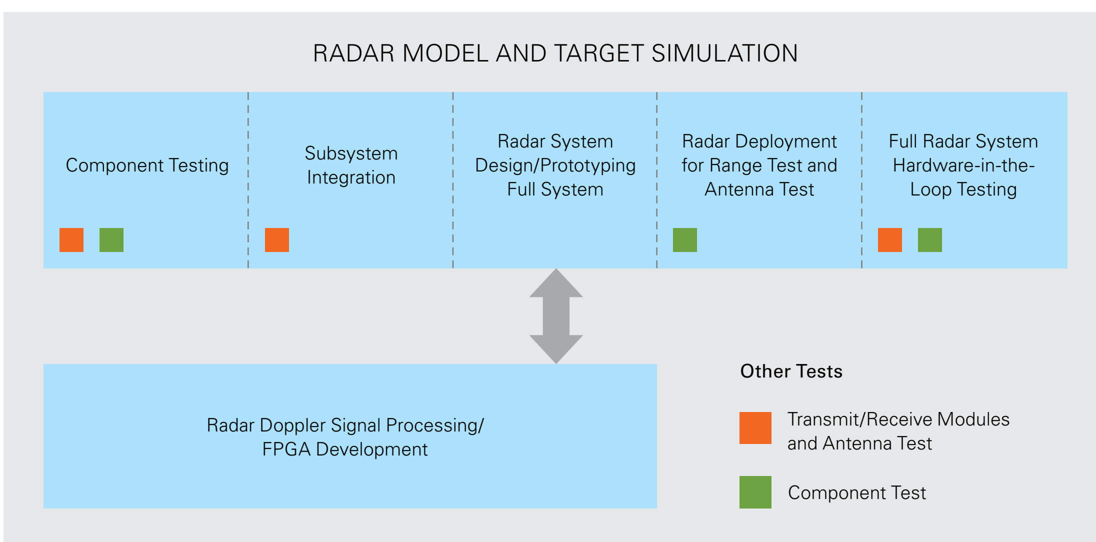

Figure 1. Radar and EW trends demand radar modeling and target simulation across all stages of the design process unlike other types of testing which only occurs at certain stages in the design process.

Radar modeling and target simulation is the only type of test that can be applied throughout the design process. The increased complexity of radar systems makes flexible radar modeling and simulation during development critical to decreasing the cost of expensive full-system testing, finding and resolving design problems earlier in the process, and reducing schedule risk.

New Radar and EW Component- and System-Level Test Considerations

Larger industry trends such as software-driven and multipurpose platforms, low latency, a connected world, big data, and machine learning and artificial intelligence are accelerating new radar and EW system innovation. With all of this innovation, you need to be familiar with some of the test challenges ahead so that you can address them early in the test design process. This involves understanding the initial component- and system-level test considerations for the following new innovations in the radar and EW industry: fifth-generation jet fighter, hypersonic weapons, multi static sensors and drones, networked electronic order of battle, and cognitive radar and cognitive or predictive EW.

The fifth-generation jet fighter is a software-driven aircraft made with more than 10 million lines of code to control and connect a series of sensors working together so that the aircraft can make quicker flight modifications. For systems that combine data from a group of sensors and make software-driven adjustments based on that data, two main component tests are critical: Waveform variance test for antennas and signal integrity test for system inputs and outputs (I/O). Because antennas are multipurpose, you need to test them to account for waveform variance and verify that their isolation and directivity are both high. Due to the mix of sensors and the data these sensors are generating, the system I/O is complex. You need to conduct signal integrity testing to ensure and maintain high data throughput and the ability to use customizable system I/O. For system-level test, the heavy software suite and integration require further testing with a series of multifunction simulations to ensure that the software is ready and able to manage potential error or unexpected inputs.

Figure 2. With complex radar and EW systems, you need to conduct component- and system-level testing to confirm system robustness after making modifications to meet increased I/O, software, connectivity, and system-adaptability needs.

Hypersonic weapons systems and reacting platforms need dependable low-latency systems to adapt quickly enough to the environment. As a result, radar and EW systems have higher range requirements, so their antenna systems at the component level must feature more elements per antenna for the radar to conduct more precise beam steering with phase and amplitude control. At the system level, you need low-latency testing; specifically, quick update rates for simulations, to ensure that your system can keep up with the hypersonic speeds and decision-making of the weapons or anti weapon system. To help simulators update more quickly and test these faster systems, you need test systems that can process data quickly and update the current state of models to accurately represent the simulation environment.

The requirement to know more information earlier about smaller radar targets or an environment has led to greater demand for multistatic systems and drones, which must work together to operate effectively in a more connected world. Having connected systems at the component level drives the need for wider-band components that are linear and that might require you to understand and test nontraditional impairments. For elements on phased array antennas, high gain and directivity guarantee that each element has higher performance over a smaller area, while the entire system of elements ensures the correct coverage for the overall phased-array antenna. Having high directivity and tighter beams means that the radar can find targets that are further away and smaller. At the system level, high resolution and wideband low-latency testing, with tightly aligned synchronization across multiple channels, are critical. To test the power and accuracy of these radar systems, you need to balance more channels with high-density and detailed EW simulation.

The connected world and big data trends also have inspired a networked electronic order of battle, which is a series of new types of sensors and devices working together to identify, locate, and classify other groups' movements, capabilities, and hierarchy. With the wide array of sensors used, testing at the component level requires more complex I/O analysis. The system level encompasses aggregated test structures that need parallel testing and high-speed data analysis. Systems also need intricate simulators that can provide higher fidelity and handle more complex threat scenarios.

All of these systems are producing more data at faster rates with a series of sensors working together to use software to control the systems. As more data is generated at a higher rate, you need systems that are faster than humans at making decisions and organizing the data. This is why cognitive radar and cognitive or predictive EW systems were invented. For these systems, component and subsystem test program sets involve a wider range of frequencies and bandwidths than other systems. Also, traditional parametric testing is likely not enough to fully understand system performance, which means that you need to conduct modeling and simulation testing early in the test process. At a system level, open-loop simulators aren't a viable option anymore, and test assets need to more accurately emulate targets and environments instead of relying on traditional threat databases that do not assess all cognitive-radar-system capabilities.

As increasing system complexity drives new technology advancements, you need component- and system-level instrumentation that adapts. You also need a well-thought-out test methodology to meet new requirements, ensure system robustness, and maintain test schedules.

Test Instrumentation Considerations and Trends

There are four traditional approaches to radar system integration and test: Delay lines; commercial off-the-shelf (COTS) FPGA-enabled instrumentation or RF System-on-Chips (RFSoCs); COTS target generators; and turnkey test and measurement solutions. Each of these test methods presents its own strengths and weaknesses.

Delay lines are powerful and cost-effective solutions that are easier to buy and develop and that meet very low-latency requirements. However, they have very limited capabilities and only work for simple system-functionality testing. They don't offer electronic counter-countermeasure (ECCM) techniques and simulations of real-world environments or scenarios that modern radars experience, such as clutter and interference.

COTS FPGA-enabled instrumentation or RFSoCs feature low capital cost, low-latency capabilities, and the flexibility to be tailored for complex systems with unique requirements. But they require large human-related costs such as nonrecurring engineering costs in initial development. Due to coding complexity, this instrumentation can be difficult to maintain and not always dependable. Typically, it is not true test equipment, so you have to do a lot of firmware and software work to get the system up and running effectively at the beginning of all new test programs.

Figure 3. The industry trends rapidly changing new radar and EW technology also are making test instrumentation highly adaptable, software driven, and modular to address the need for more modeling and simulation testing.

COTS target-generator systems have a lower nonrecurring engineering cost investment because of their higher-level software starting point and ability to be tailored to specific application needs. Domain experts can use their knowledge earlier in the test-system design process. However, COTS target generators typically cost more, require support to upgrade and maintain, and lack flexibility because a larger part of their functionality is already defined. Their test capabilities are evolving more slowly, so you have to rely on test vendors to implement new modes or functionality for these generators.

Closed or turnkey test and measurement solutions are defined and delivered as full solutions, which results in great dynamic range, well-calibrated and well-known support based on a core COTS model, and quick utilization across multiple programs. But turnkey test and measurement solutions are limited to vendor-defined functionality and are difficult to configure for unique system needs. They also produce higher latency because they are not optimized for a specific test, typically not phase coherent, and often prescripted or open-loop systems. Because of these challenges, you must rely on vendors to add new functionality for rapidly changing requirements, which results in a system that is very difficult to scale to multichannel RF systems for technologies such as AESA and interferometry and limits your ability to conduct closed-loop test.

The industry trends affecting new radar and EW technology are also driving new test instrumentation trends such as industry convergence, software-defined platforms, test-system maintainability, and test-system architectures.

Test-equipment vendors are typically serving more than one industry, so they use instruments across industries such as automotive, 5G, and defense. As the technologies and testing for these industries converge in our newly connected world, test instrumentation must expand frequency coverage and work at larger operating bandwidths with higher channel counts. Test and measurement vendors are investing more in software platforms to run their instruments and earning more revenue as customers quickly choose the flexibility, test speed, and reliability of software over previously manual test systems. In comparison to other closed-loop options for radar test, test equipment vendors can utilize their equipment across multiple industries and see economies of scale driving down test-instrumentation cost while creating more capable test instrumentation.

The industry is showing that boxed instruments for test need to last eight to 12 years. Firmware updates are required at 18- to 24-month intervals, and hardware upgrades likely occur every 18 to 36 months. Boxed instruments are emulating cell phones devices by incorporating touch screens with fewer physical buttons. To increase flexibility, boxed-system manufacturers are incorporating modular devices for easier upgrades. They also are creating "super boxes," or collections of boxed instruments, for larger test coverage from single systems.

Modular instruments are seeing the most growth in the industry, with an increase in radio front ends, multiprocessor architectures, and reporting and storage needs. By using modular hardware and software platforms, you can adapt your test systems for a wide variety of needs, from faster design, to reduced schedule risk, to compliance with future and more-complex system requirements. New modular systems are seeing improved flexibility with FPGA and RF hardware in the same device. This means that you can use the same instrument to perform more types of test by switching between devices such as a real-time processor, spectrum monitor, channel simulator, and DUT controller. With modularity comes the trade-off of highly dense test systems for high-performance test systems. You can include multipurpose instrumentation in your modular systems if you can sacrifice test performance capabilities for additional functionality. Multipurpose modular measurement instruments also offer improved measurement IP, better components (especially analog-to-digital converters and digital-to-analog converters), advances in signal processing, and better software accessibility and architectures. In addition, modular test instrumentation has led to more compact test systems, so more than one box-instrument functionality can fit into a smaller, PXI-based modular instrument or system.

Overall, test instrumentation is evolving to meet the needs of new radar and EW technology by utilizing and adapting to industry convergence, software-defined instrumentation, multipurpose test instrumentation, and modular test instruments.

Meet New Industry Expectations by Introducing Simulation Early in the Design Process with Modular Test Instrumentation

Many trends are driving technology advances across multiple industries, including radar and EW. Software-driven and multipurpose platforms, low-latency requirements, a connected world, big data processing and information exposure, and machine learning and artificial intelligence are inspiring test innovation at both the component and system levels. To accelerate the rate of technology advancements in radar and EW and ensure design flexibility, manufacturers are adapting traditional test and measurement equipment to meet new requirements. With modular instruments and more modeling and simulation during different test phases, you can address these radar and EW system trends. Modeling and simulation also reduce expensive full-system testing and help you identify and solve problems earlier in the testing process to reduce schedule risk. With new types of radar and EW technology on the horizon, you need to address new test challenges earlier in the test design process to find the right flexible test system that can meet new requirements and your application-specific needs.

Learn More

View the RADAR Test Resource Guide

Learn How to Address the Challenges of Multichannel Phase-Aligned RF Systems

Learn More about the Virtual Signal Processor Family