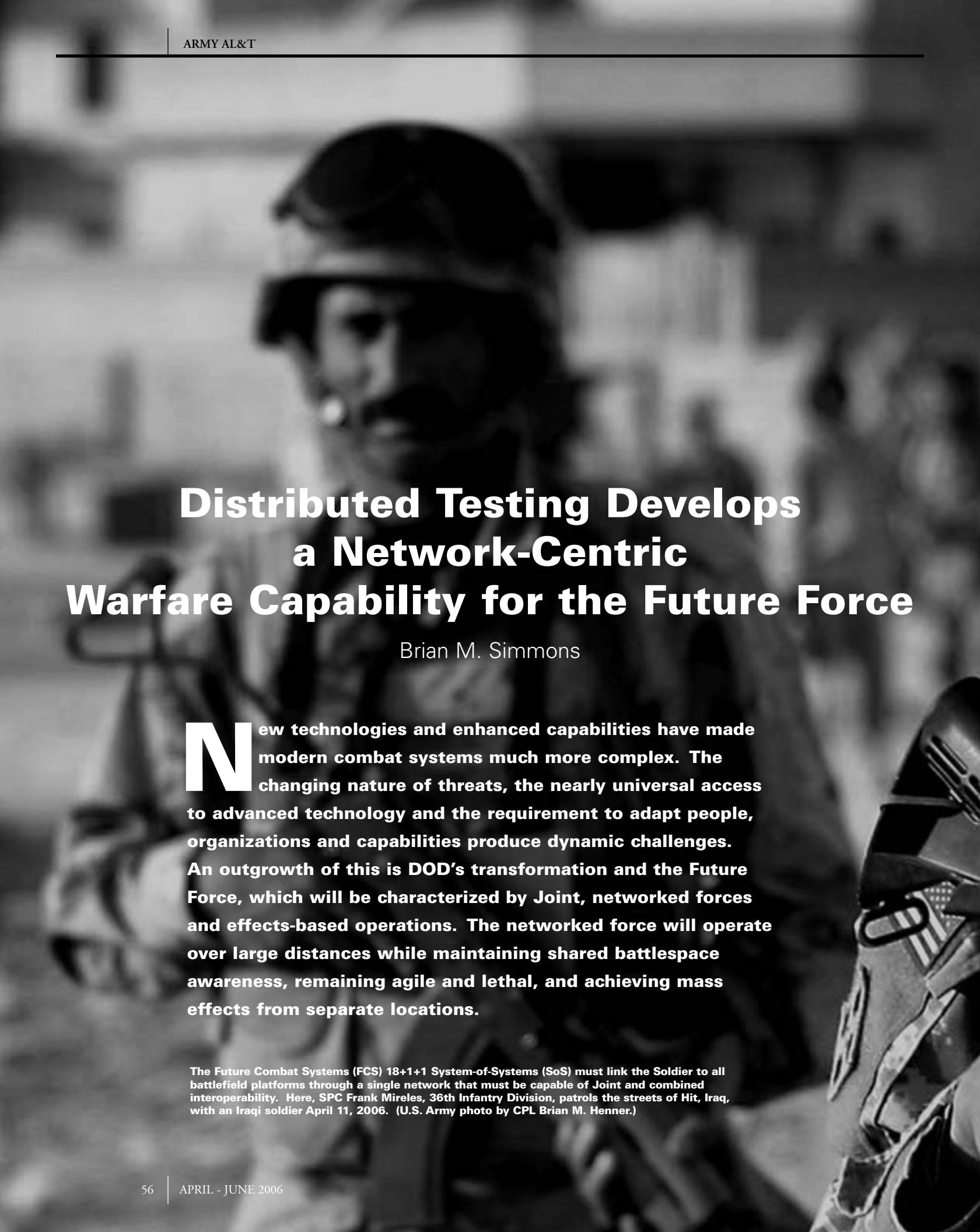
Distributed Testing Develops a Network-Centric Warfare Capability for the Future Force

Brian M. Simmons

New technologies and enhanced capabilities have made modern combat systems much more complex. The changing nature of threats, the nearly universal access to advanced technology and the requirement to adapt people, organizations and capabilities produce dynamic challenges. An outgrowth of this is DOD's transformation and the Future Force, which will be characterized by Joint, networked forces and effects-based operations. The networked force will operate over large distances while maintaining shared battlespace awareness, remaining agile and lethal, and achieving mass effects from separate locations.



The Future Combat Systems (FCS) 18+1+1 System-of-Systems (SoS) must link the Soldier to all battlefield platforms through a single network that must be capable of Joint and combined interoperability. Here, SPC Frank Mireles, 36th Infantry Division, patrols the streets of Hit, Iraq, with an Iraqi soldier April 11, 2006. (U.S. Army photo by CPL Brian M. Henner.)

Battlefield network-centric warfare (NCW) systems can comprise thousands of platforms and are much more complex than commercial and cellular networks. NCW systems must provide battlefield network connectivity within the military services while enabling them to be interoperable. The services' overarching networks — the Army LandWarNet, Navy FORCEnet, and the Air Force Command and Control (C2) Constellation Net — must interoperate as the Global Information Grid's service components. They must provide interconnected, end-to-end sets of information capabilities, associated processes and personnel for collecting, processing, storing, disseminating and managing information on demand to warfighters, policymakers and support personnel. The heart of the transformed Army forces will be the FCS Brigade Combat Team (FBCT).

FCS is an 18+1+1 SoS linking the Soldier, at the heart of FCS, to 18 battlefield platforms through a single network. The platforms comprise eight manned ground systems, four unmanned air systems, six unmanned ground systems, various unattended munitions and ground sensors.

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Army development is focused on FCS, as is the Developmental Test Command (DTC), the Army Test and Evaluation Command's (ATEC's) technical tester. DTC's focus on distributed, networked military capabilities stems from the Army's top priorities:

- Win the war on terrorism while sustaining the all-volunteer Army.
- Accelerate the Future Force strategy.
- Accelerate military transformation and process improvements.

Testing FCS

These priorities also are driving distributed testing, which is the most efficient and effective method for testing a network-centric SoS. DTC is committed to making it a value-added part of the acquisition process. DTC has traditionally conducted serial developmental testing of independent platforms by performing tests, gathering data and then moving the system to the next test center. Evaluation would also typically be serial. This has worked well for today's systems, including the recent Stryker program. But for FCS, the integration of systems within systems, interoperability and networking are prime concerns. Consequently, DTC had to reconsider testing requirements.

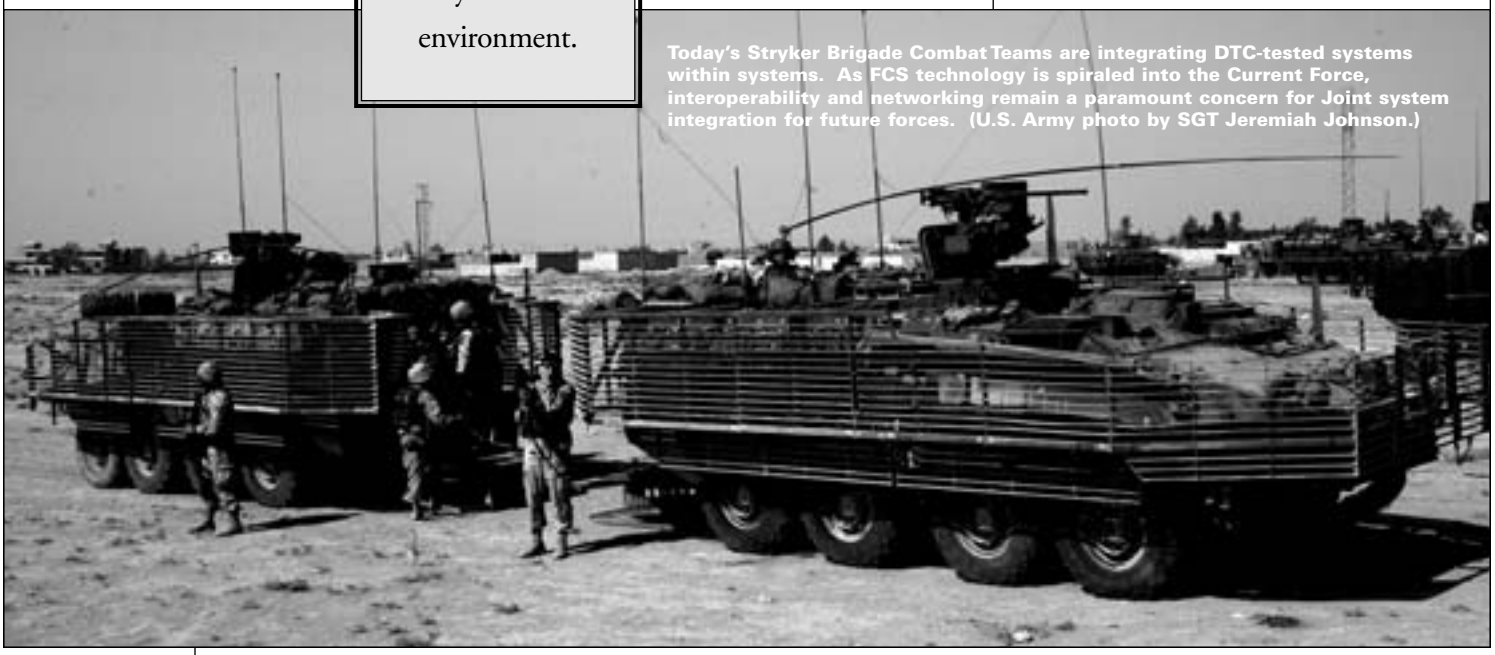
Realistic FCS operations exceed the area of a single test range, but it can be expanded by linking ranges with live, virtual and constructive entities interoperating in real time. Customer system integration laboratories can also be linked into the distributed test capability by providing access before there is hardware to test. DTC's distributed test capability is providing a tactically relevant environment for the systems. It links all of DTC's test center instrumentation, modeling and simulation (M&S) and stimulation tools with those presented by the customer, creating a network-centric test environment.

Technologies will not all be delivered at once, but will be weaved into the Current Force as they become available. Because systems won't be available, M&S must play a key role in test and evaluation by providing realistic environments and stimuli. A mix of live, virtual and constructive simulation capabilities is used to immerse the FBCT into an operationally realistic, complex synthetic environment.

FCS has many network nodes and platforms, and every entity is a potential node. The network requires testing along with all network nodes. Technologies will not all be delivered at once, but will be weaved into the Current Force as they become available. Because systems won't be available, M&S must play a key role in test and evaluation by providing realistic environments and stimuli. A mix of live, virtual and constructive simulation capabilities is used to immerse the FBCT into an operationally realistic, complex synthetic environment. Platforms will be tested as usual, but we recognize that they must be tested as more than just hardware-in-the-loop. The platform now can produce, consume and relay information as a node in the FCS network.

Building a Distributed Capability

DTC's distributed testing began with its Virtual Proving Ground (VPG) following an approach that led from the simple to the complex. The components of a complex synthetic environment existed across the command, and DTC test centers were connected, making the most effective use of developing simulation capabilities. Early efforts, such as the Combat Synthetic Test, Training and Assessment Range (Combat STTAR) and Project Constellation, used point-to-point telephone modems to link a small number of players in limited interaction simulations. Each test center achieved an initial operational capability in 1998, with the focus centered on integrating



Today's Stryker Brigade Combat Teams are integrating DTC-tested systems within systems. As FCS technology is spiraled into the Current Force, interoperability and networking remain a paramount concern for Joint system integration for future forces. (U.S. Army photo by SGT Jeremiah Johnson.)

those capabilities using the Defense Research and Engineering Network (DREN).

Subsequent experience came from the VPG's Synthetic Environment Integrated Testbed (SEIT), designed to be a high-resolution representation of the natural and man-made environment leveraging existing M&S and live capabilities. Using SEIT, the VPG conducted six demonstrations in five events beginning in March 2003 and culminating with Distributed Test Event 5 (DTE 5) Aug. 22-Sept. 2, 2005. During the first week of DTE 5, Army, Navy, Air Force and Marine participants executed three Joint tasks within a sample FCS scenario, preparing the battlefield for incursion of Army forces. The Army was the only service participating in the tactical scenario during week two, when the Current and Future Force brigades' performances were examined.

Every test center now has a baseline simulation capability that connects across the DREN to support testing. A Distributed Test Control Center at each DTC test center manages interactions among them. DTC's IRCC at White Sands Missile Range, NM, gives a commander or test officer a bird's-eye view of SoS testing.

Every test center now has a baseline simulation capability that connects across the DREN to support testing. A Distributed Test Control Center (DTCC) at each DTC test center manages interactions among them. DTC's Inter-Range Control Center (IRCC) at White Sands Missile Range (WSMR), NM, gives a commander or test officer a bird's-eye view of SoS testing. The IRCC gives the tester sufficient situational awareness of the assets and players, ensuring the test progresses as designed. The IRCC serves as the single point of entry for the FCS Lead Systems Integrator by providing the test execution interface between ATEC and the FCS SoS integration laboratories.

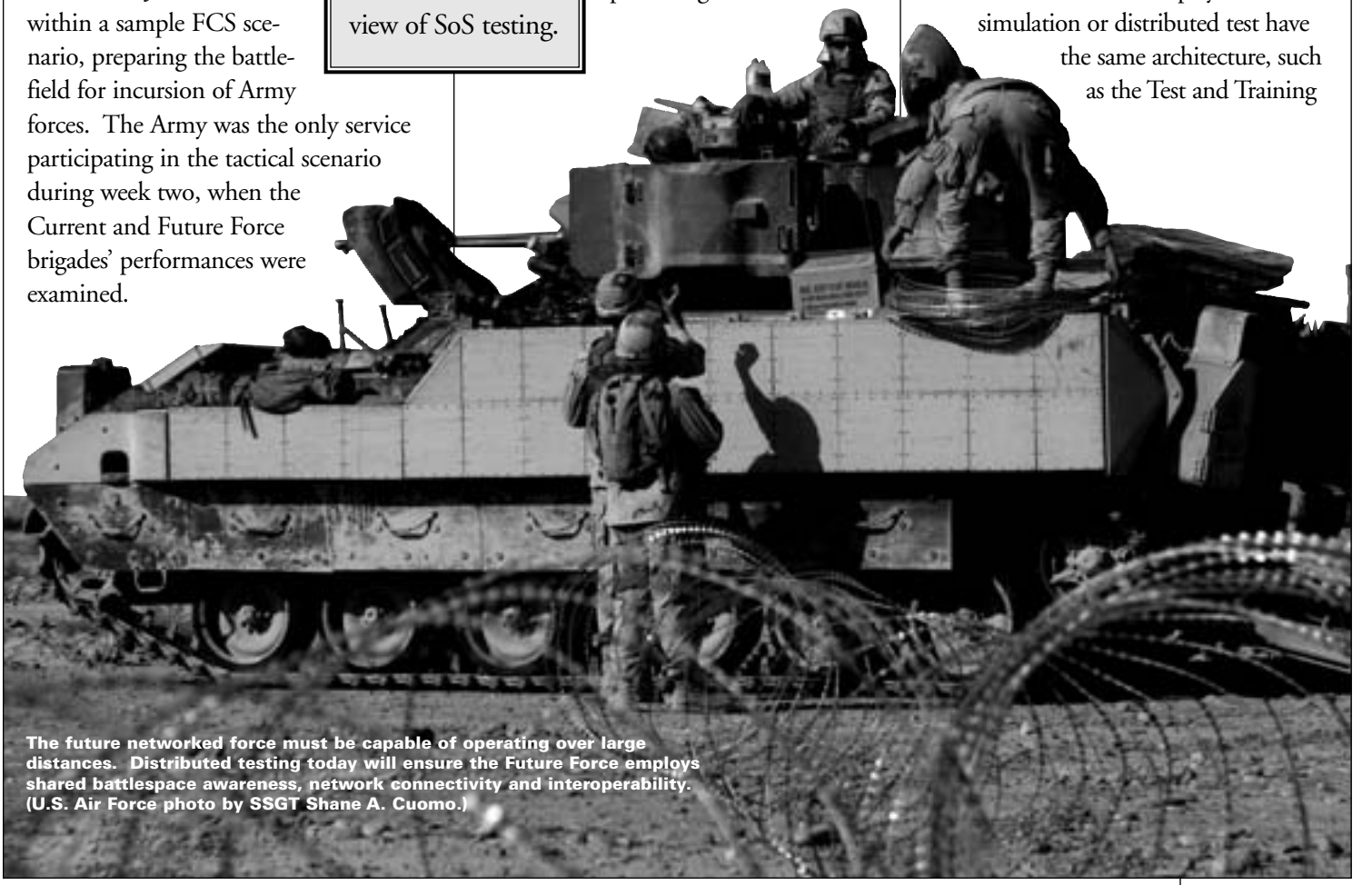
Lessons Learned

Many distributed testing lessons learned date back to Combat STTAR and Project Constellation. They underscore four requirements:

- Define the architecture first.
- Stand up a network.
- Develop test tools and processes.
- Establish test management and control.

Spiral development, a cyclical approach in which customers evaluate early results and engineers identify potential trouble spots before the system progresses to the next level, is key to the FCS acquisition program.

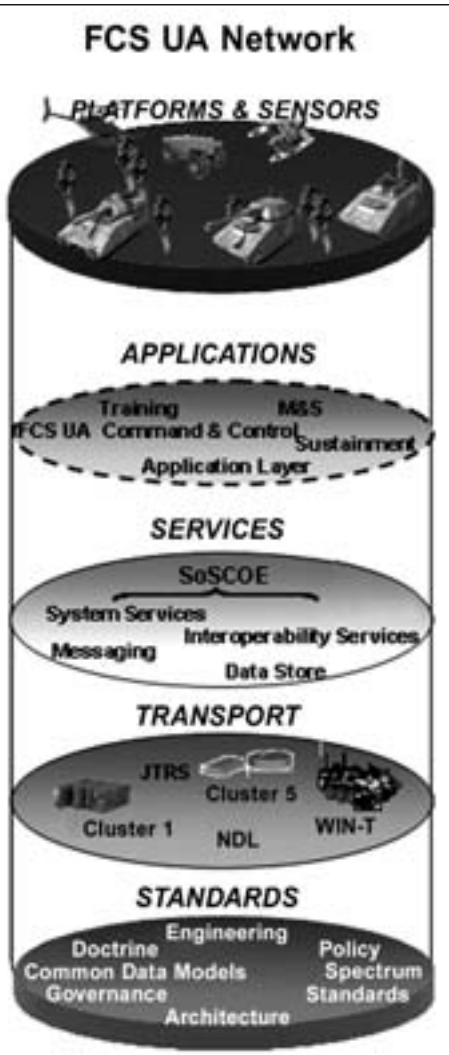
The desired architecture is visualized as an end state achieved after a series of intermediate states. All players in a simulation or distributed test have the same architecture, such as the Test and Training



The future networked force must be capable of operating over large distances. Distributed testing today will ensure the Future Force employs shared battlespace awareness, network connectivity and interoperability. (U.S. Air Force photo by SSGT Shane A. Cuomo.)

Enabling Architecture (TENA) — the middleware for test and training range instrumentation and simulation standard interfaces. In practice, test resources are a combination of distributed interactive simulation, high-level architecture and TENA linked into a mixed architecture. It will take several years to migrate the test range architecture to TENA.

The DoD Architecture Framework (DoDAF) descriptions for documenting range capabilities and interfaces can be extremely complex and time-consuming to fully document, so it is expedient in the interim to focus on key views to define and communicate that architecture to partners. These intermediate states exist because we must continue to support customers with existing capabilities.



With multiple entities, it's easy to envision the network as a wide area network (WAN) for long-haul, center-to-center connectivity with local networks in a test center. The DREN is the WAN of choice because of its high bandwidth, security and reliability. It is Internet protocol-based and available at all DTC test centers, ATEC and several Operational Test Command ranges. DTC has made substantial investments for local networks, especially funding installation of range-wide fiber optic cable and investing in encryption devices as well as network characterization and monitoring tools.

The FCS network is a network-of-networks, not necessarily tiered or layered, with many of them overlaying in the infrastructure, though each have distinct functions. Networks for intelligence, C2/maneuver and logistics share the same space for propagation of signals.

The network is often the most important part of a distributed capability. The cost, time, expertise and effort required to build and validate a network make it necessary to have a persistent network. For the customer to have confidence in the data from a distributed test, the network must function properly before the test. Additionally, the test must be closely monitored and the results documented, so impacts on the test data are known and corrected. The network will make or break distributed testing on any SoS program.

Validated and supported tools and processes are essential for executing distributed tests and analyzing results. More than 100 such tools have been produced through the VPG, including software for collecting, analyzing and reporting data; stimulating C2 messages; estimating radio frequency propagation loss; and network monitoring and analysis. A major tool for simulating the necessary environmental conditions is the 4-D weather model used at all DTC test centers.

Testing the FCS and Test Networks

The FCS network is a network-of-networks, not necessarily tiered or layered, with many of them overlaying in the infrastructure, though each have distinct functions. Networks for intelligence, C2/maneuver and logistics share the same space for propagation of signals. With the Joint Tactical Radio System (JTRS), they may exist as different channels in the same radio set, yet they will have distinct frequencies and cryptography to control access. The FCS tactical network will provide tactical interfaced communication for prototypes, surrogates, emulators and simulations. The FCS tactical voice network will occupy part of the tactical network spectrum via JTRS to provide voice communications.

Testing this complex network-of-networks is a great challenge that requires a crucial test resource — the test network. Its performance must be identified, quantified and isolated from the FCS network.

The FCS network is conceived as having a five-layer structure as depicted in the figure at left. Each platform and sensor represents the network terminus where the mission is accomplished. Applications are computer programs allowing Soldiers to perform training and C2 tasks. Services, especially the

Communications systems must be tested by real Soldiers on real terrain during actual missions. Existing events must be used to test Joint service interoperability. Here, SSGT Aamir Greene (right), 2nd Marine Division, communicates with pilots providing close air support from his PRC-117 radio. Army SSG Jimmy Rogers, 1st Cavalry Division, remains in radio contact with his scout team during a "presence patrol" in Avon Park, FL, April 5, 2006, during Exercise Atlantic Strike III. (U.S. Army photo by SSG Ashley S. Brokop.)

System-of-Systems Common Operating Environment (SOSCOE) and databases, allow the applications to interoperate. SOSCOE is middleware that permits developers to quickly integrate new applications with common interfaces. Transport, JTRS and the Warfighter Information Network-Tactical (WIN-T) carry the information. Standards include JTRS standard waveforms, standard message formats such as the U.S. message text and Joint variable message formats, DoDAF architecture standards and *Army Regulation 5-12, Army Management of the Electromagnetic Spectrum*. These rules must be followed to ensure that the FBCT can work with anyone, anywhere, at any time.

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Testing the FCS network means explicitly testing the five layers. For platforms and sensors, network simulation will be used to test the network during platform testing. End-to-end testing must begin immediately in the program. Mission threads are used as test drivers to assess application performance. Real Soldiers on real terrain must be engaged in early testing. Existing events will be used to test Joint service interoperability. Ideally, JTRS and WIN-T must be included in all FCS network tests under mission conditions because they bond the diverse FCS players.

Finally, existing test standards and methods will be used to test the FCS network. DTC must prepare technology for testing before complete systems are created and the technology must be ready and validated before test articles arrive. This can be achieved only by connecting the developer, tester and trainer from the outset and providing access to developing software, hardware, systems, processes and procedures. DTC's distributed testing uniquely addresses these challenges.

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