

Systems Integration Facility: Past, Present, and Future

David P. Andersen
SSC San Diego

Karen D. Thomas
Digital Wizards, Inc.

The Systems Integration Facility (SIF) opened in 1990 in Building 600 at SSC San Diego to support the Navy's first Joint Tactical Information Distribution System (JTIDS) developmental test program. Developed out of a need for a controlled, repeatable test environment to verify JTIDS terminal performance and combat systems interoperability, the SIF has become the Navy's leading laboratory for tactical data link interoperability testing.

Sharing near-real-time tactical data in a distributed, interoperable, and secure environment is a critical segment of warfighter universal information access. Tactical data links, specifically Link-11 and Link-16, now the Department of Defense's primary data link, and the future Link-22, provide this capability to Navy, Joint, and Allied forces.

SSC San Diego has been involved with tactical data link development, test, evaluation, integration, and life-cycle support since the early 1960s. Under sponsorship of the Space and Naval Warfare Systems Command's Advanced Tactical Data Links Program Office (PMW 159), the SIF has played an integral role as the central node of a complex stimulation/simulation environment for land-based testing and evaluation of Link-16 components and systems and integration with other data link systems. SIF operations are part of SSC San Diego D45, the Tactical Systems Integration and Interoperability Division.

The first- and second-generation Link-16 uses the JTIDS data terminal, which provides multiple-access, high-capacity, jam-resistant digital data and secure voice communication, navigation, and identification information to various command and control and weapons host platforms. The JTIDS terminals encompass software, radio frequency (RF) equipment, and the waveform they generate. Link-16 requires JTIDS terminals and host combat systems such as the Advanced Combat Direction System (ACDS) or Aegis Command and Decision (C&D), processors such as the shipboard Command and Control Processor (C²P) or the F14-D Mission Computer, Link-16 antennas, other hardware, software, and displays. The C²P was developed at SSC San Diego to provide data forwarding and translation between Link-16, Link-11, and Link-4A.

Using Time Division Multiple Access communications architecture, Link-16 terminals transmit information in the Tactical Digital Information Link-Joint (TADIL-J) message format. A common communications net is thus provided to a large community of airborne and surface elements within line of sight, and the network can be extended to platforms beyond line

ABSTRACT

This paper traces the development of SSC San Diego's Systems Integration Facility (SIF) and the Combined Test Bed (CTB) that, together, provide a flexible, fully integrated multi-platform test capability used by dozens of multi-service and multinational testing organizations to ensure the interoperability of tactical data link systems. The paper describes unique PC-based Data Link Test Tools vital to Link-16 testing components. It also chronicles work of the major command, control, communications, computers, and intelligence (C⁴I) interoperability testing organizations, such as Naval Sea Systems Command's Distributed Engineering Plant (DEP), and describes how the SIF/CTB will continue to support future tactical data link testing.

of sight by using one or more members of the net, or any Link-16 terminal, as relays.

When the Navy JTIDS developmental test program was established to verify the technical adequacy of the JTIDS terminal and the integration of Link-16 into designated Navy host combat platforms, a land-based laboratory environment for terminal specification testing and multi-platform integration/interoperability testing was needed as a cost-effective precursor to live platform testing and to allow problem resolution.

The SIF was designed to utilize a complex multi-computer simulator/stimulator connected to eight JTIDS terminals linked together by an RF network that introduced propagation delays and attenuation into tactical message traffic. The test bed also included external communications equipment, an antenna, test scripting, data storage, reduction, and analysis equipment, and various interfaces.

By September 1991, the SIF provided a fully integrated multi-platform functional testing capability. The SIF/Combined Test Bed (CTB) used intermediate processors to tie together the SIF and the Combat Direction System Development and Evaluation Site (CDES) laboratory in the same building, the E-2C Software Support Activity (SSA) laboratory in Building C-60, and the F-14D Mission Computer Subsystems Software Development Laboratory at Pt. Mugu, California. The CDES contains shipboard combat system configurations and programs for testing CV, LHD, Aegis CG/DDG, and LHA platforms. It also serves as the primary development and testing laboratory for the C²P. The E-2C laboratory consists of actual E-2C Airborne Tactical Data System (ATDS) software and hardware components. The F-14D facility consists of actual F-14D software and hardware components.

By early 1993, the CTB was extended to the Aegis Combat Systems Center, Wallops Island, Virginia, for testing and integrating Aegis combat systems. Later, to support developmental testing of the new generation of Link-16 terminals, the Multifunctional Information Distribution System (MIDS), the F/A-18 Advanced Weapons Laboratory at the Naval Air Warfare Center, China Lake, California, was added to the CTB.

The SIF is the central node of the CTB, providing a central script controller to run the test information and direct it to real or simulated host systems that control the appropriate terminal type in the SIF terminal farm. The unique JTIDS RF simulation environment in the SIF provides connectivity between the SIF terminals, with digital propagation delays and attenuation matched to a scripted scenario. To support exercises that require live transmission rather than SIF RF network simulations, two



The early SIF. Many of the original components of the Systems Integration Facility shown in this 1992 photo have since been replaced by "New SIF" distributed components hosted on personal computers, enabling an infinite number of system configurations that can be tailored to support a large number of test and training scenarios.

JTIDS antennas were installed on the roof of Building 600. Mobile JTIDS vans and portable JTIDS units, called mini-racks, were developed by the SIF team for deployment in other test locations or for installation on surface vessels. As tests were conducted, other SIF systems enabled collection of the test data for later replay and analysis.

The concept for JTIDS development and integration was to proceed through increasingly complex testing, from technical evaluation of the terminal to integration with the C²P, then with the ACDS, and, finally, with air programs. Following the initial terminal testing program in the early 1990s, the SIF/CTB and D45 test and evaluation team members played major roles in the JTIDS and C²P technical evaluation (TECHEVAL) processes that paved the way to a major milestone in the Link-16 program—the successful completion in 1994 of the required operational evaluation (OPEVAL) of the JTIDS and C²P development program during the USS *Carl Vinson* (CVN 70) Battle Group's deployment to the Persian Gulf. This important step in the introduction of Link-16 and the C²P into the Fleet was the culmination of years of development work by Navy activities and supporting contractors. It was also the beginning of new challenges for the SIF/CTB.

Early in the development of the SIF test bed, it was realized that significant modifications would be needed to support emerging test requirements. New capabilities were being added to Link-16 terminals. The new MIDS program was being planned, and the SIF would be the lead laboratory for terminal testing and integrating MIDS into Navy platforms, under sponsors PMW 159 and the MIDS International Program Office (PMW 101). The MIDS is a smaller, lighter weight terminal that maintains all JTIDS functionality. C⁴I interoperability testing needed to expand to support Joint service and multinational interoperability scenarios, and interoperability testing needed to support operations in multi-link environments.

While the SIF/CTB had provided valuable feedback to the Navy's JTIDS Program Office concerning the functional performance of Link-16 terminals and integration of the terminals with combat systems, its capability to support multi-service and multinational integration and interoperability testing was somewhat limited. A method of easily interfacing multi-service and multinational host combat systems was needed, as well as a system for addressing multi-link issues. These requirements led to the next developmental phase of the test bed.

Cost/benefit studies conducted by systems engineers from SSC San Diego and supporting contractors concluded that while the equipment in the



Shipboard combat system equipment in the Combat Direction System Development and Evaluation Site (CDES) laboratory in 1992. The CDES is an integral part of the Systems Integration Facility/Combined Test Bed for data link testing.

SIF was capable, it was costly to maintain and difficult to modify. The long-range functional requirements for the SIF/CTB could best be met by a complete re-engineering of the test bed's systems.

In the mid-1990s, development began on "New SIF" architecture. Its goal was to be a system with greater capability that could respond quickly and cost-effectively to the rapid evolution in functional requirements and could provide cost-effective test and evaluation support to any tactical platform, regardless of location or terminal availability. The "New SIF" would use commercial-off-the-shelf IBM-compatible personal computers and the OS/2 operating system that accommodated the robust multi-tasking required by the systems and provided a friendly graphical user interface. "New SIF" systems would be based on common software architecture to allow rapid development and flexibility when requirements changed.

By 1995, the Link-16 Gateway, now known as the Data Link Gateway (DLGW) system, was developed by D45 with contractor support to connect hosts at remote laboratories to the JTIDS and MIDS terminals in the SIF. The versatile PC-based Gateway system permitted the interfacing of multiple terminal farms, development laboratories, software support activities, live assets, and certification and simulation activities, forming a single extended Link-16 network for testing and integration. The Gateway system is composed of multiple DLGW units linked by secure dial-up phone lines or higher speed communications systems. Each DLGW can function as a host emulator, as a terminal emulator, or as a network monitor. The Gateway software provides a suite of functions that allows users to participate in data link exercises, and monitor, control, record, and analyze data from the exercises.

Other PC-based Data Link Test Tools were developed, including the following:

- Script Controller for executing test scripts on the SIF script network.
- Simulation Interface Units (SIUs) for translating scenario data in SIF format to the format and protocol needed by specific simulation systems.
- TADIL-J Host Simulator, a scenario-driven or real-time tactical data system emulator that creates realistic participants for testing and training.
- Link-16 Engine to support interconnection of non-Link-16-capable systems to the Gateway system.
- Script Generator for creating test scripts that pass events to various Data Link Test Tools for processing on a Link-16 network.
- Data Analysis and Reduction Tool (DART) for post-test analysis.

The original SIF systems were replaced by the "New SIF" distributed components hosted on PCs and communicating through Transmission Control Protocol/Internet Protocol (TCP/IP) on an Ethernet local area network (LAN). Because the new systems were interconnected to operate as a single distributed system, the re-engineered test bed offered an infinite number of system configurations that could be tailored to support a large number of test and training scenarios.

Each of the systems comprising the "New SIF" is a complex system in its own right, and each has evolved and continues to evolve to meet various new functional requirements. The SIF/CTB is a meta-system whose components are interconnected and mutually supporting. Within the SIF itself, systems communicate over the Script Net LAN. The remote sites are connected in a wide area network by the DLGW system, which

multiplexes Link-16 and scenario data between sites. At the remote sites, SIUs convert the scenario data into the form needed by the site-specific simulation system so that all systems are not only communicating in the same link environment, but also participating in a single coordinated scenario.

By 1996, the "New SIF" began to evolve into a major hub for Joint and multinational C⁴I interoperability testing and training, as well as a facility for testing new Link-16 terminal types such as the MIDS. Today, Data Link Test Tools provide Link-16 connectivity between the SIF and more than 100 Joint and international test and software support facilities, as well as all SSC San Diego C⁴I laboratories, including the Research, Evaluation and Systems Analysis (RESA), the Reconfigurable Land-Based Test Site (RLBTS), and the Global Command and Control System (GCCS). By installing a DLGW system at each of the remote facilities and linking them by telephone lines or high-speed circuits, a Gateway network is created. This connectivity enables a worldwide TADIL and systems interoperability test capability.

In addition to the unique combination of assets in the SIF/CTB, key to the success of the TADIL testing programs is one of the most experienced and knowledgeable Link-16 engineering and test and evaluation (T&E) teams in the world. The D45 T&E team has supported at-sea testing and engineering programs since the early 1990s. The team's extensive hands-on engineering experience from early Navy JTIDS terminal testing to the complex interoperability test programs of today has provided a valuable resource for testing and integration programs.

Today, a wide variety of JTIDS and MIDS testing activities are offered by the SIF/CTB, including terminal functionality and specification testing, pre-installation testing and checkout, relative navigation performance evaluation, JTIDS terminal network load testing, TDS-to-TDS interoperability testing, multi-TADIL/multi-platform interoperability testing, TADIL network performance evaluation, TADIL trouble report testing, TADIL standards certification testing, new TADIL "proof-of-concept" analysis, and live fleet service support. In addition, the test bed supports production testing of JTIDS terminal firmware upgrades for the Command and Control Fleet Engineering Division's JTIDS/MIDS SSA (SSC San Diego D64), and Product Acceptance Testing (PAT) and Functional Interoperability Testing (FIT) for the C²P SSA.

Scores of testing organizations have used the SIF/CTB resources. One of the first to use the DLGW systems and the "New SIF" for integration and interoperability was the Theater Missile



The SIF today. PC-hosted Data Link Test Tools communicating via TCP/IP protocols on an Ethernet local area network have replaced the original systems in the SIF, which is now the Navy's leading laboratory for tactical data link interoperability testing.

Defense System Exerciser (TMDSE), a program of the Ballistic Missile Defense Organization (BMDO) to integrate the entire TMD family of systems and test interoperability issues between the various TMD systems. The SIF/CTB supports certification testing programs conducted by the Joint Interoperability Test (JIT) network directed by the Joint Interoperability Test Command (JITC) and by the Navy Center for Tactical Systems Interoperability (NCTSI). The SIF is the lead laboratory for the ongoing MIDS Low Volume Terminal (MIDS-LVT) and MIDS on Ship (MOS) test and evaluation programs. The SIF/CTB and the D45 T&E teams have played a significant role in the North Atlantic Treaty Organization (NATO) program to test the Standard Interface for Multiple Platform Link Evaluation (SIMPLE), and the test bed has been used in many of the Navy's Commander, Operational Test and Evaluation Force (COMOPTEVFOR) testing programs. The SIF has been accredited by COMOPTEVFOR for operational testing of the rehosted C²P and the MOS terminal.

The SIF/CTB is a development and land-based testing and evaluation environment for the C²P, the rehosted C²P, the Common Data Link Management System (CDLMS) and, most recently, for the Multi-TADIL Capability (MTC) Global Command and Control System-Maritime (GCCS-M) program. The MTC will provide a standard and interoperable data link capability for exchanging information on TADIL-A, TADIL-B, TADIL-J, and Satellite TADIL-J (S-TADIL-J) across the entire Joint environment. The SIF has been equipped with computer systems dedicated to the MTC program, currently developed for use with GCCS-M. To support interoperability and integration testing of Aegis ship classes and related subsystems, the Integrated Combat System Test Facility (ICSTF), a field activity of Naval Sea Systems Command (NAVSEA) located at SSC San Diego, has located its Aegis 5.3.7 test bed in the CDES.

The SIF/CTB has supported the Cooperative Engagement Capability (CEC) "Road to OPEVAL" integrated testing program since 1996. The world's most technically advanced air defense system, the CEC has been a top priority for the Navy to achieve its vision of network-centric warfare, and has involved many systems interoperability issues during its development. Support is also provided for the JTIDS Range Extension (JRE) program, which involves transferring Link-16 live satellite and S-TADIL J transmissions through the C²P. S-TADIL-J was developed by the Navy to provide Link-16 connectivity when that connectivity is lost or affected by range limitations.

The SIF/CTB and Data Link Test Tools have become integral components of the extensive land-based Battle Group test bed of the Distributed Engineering Plant (DEP), a NAVSEA program designed to improve fleet readiness by identifying and resolving interoperability issues before deployments. The DEP connects, in real-time, land-based combat and



The team today. The D45 government and contractor teams for SIF/CTB operations, Data Link Test Tools development and support, and data link testing and evaluation.

battle management systems located in various Navy testing facilities across the U.S. The SIF is now home to the DEP's TADIL Operations Center (TOC). Information is exchanged among battle groups through Link-16 and Link-11, and DLGW Terminal Emulators located at each DEP Link-16 host site provide the Link-16 message exchange capability for the test bed. D45 provides the DEP TADIL team leaders.

To support government qualification testing of MIDS-LVT (PMW 101) production terminals, an environmental testing chamber is being installed in the SIF. First Article Qualification Testing (FAQT) of MIDS-LVT vendor terminals will include functional performance, interchangeability, and terminal compatibility tests. Following successful FAQT testing, the vendors will be allowed to competitively bid on full-rate production of the MIDS-LVT.

Today, more than 100 operational, test, training, and development sites around the world use the unique combination of interconnected Link-16 terminals, operational hardware and software, Data Link Test Tools, simulation systems, ship and air laboratory connectivity, live transmit/receive facilities, robust Link-11 capability, and the SIF's engineering, evaluation, and integration expertise to assist in the development and operational evaluation of tactical data systems.

Once begun as a single centralized JTIDS test bed with three remote development and test sites, the SIF/CTB has now become a powerful distributed network providing comprehensive operational testing and training support to the C⁴I community worldwide. As additional data links are developed and as interoperability programs are expanded and new programs begin, this unique test bed is well prepared to accommodate the future needs of the Navy, Joint, and Allied nation testing communities it serves.



David P. Andersen

BS in Mathematics, San Diego State University, 1985

Current Work: Link-16 (Joint Tactical Information Distribution System [JTIDS]/Multifunction Information Distribution System [MIDS]) Test and Evaluation Business Area Manager.



Karen D. Thomas

BA in Journalism, San Diego State University

Current Work: Principal Analyst/Writer; computer systems engineering.