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NORTHROP GRUMMAN

Understanding Link 16

A Guidebook for USAF Operators

September 2008

U.S. AIR FORCE

Understanding Link 16

A Guidebook for USAF Operators

September 2008

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Dedication

This guidebook is dedicated to the airmen, soldiers, sailors, and other Service and support professionals who have employed Tactical Data Links in military operations. The exemplary efforts of everyone involved in data link operations, taking advantage of lessons learned and experiences gained, have supported the continued growth in the use of data links as part of our warfighting capability. Although we have made significant strides, it will take continued perseverance, teamwork, and dedication to maintain the tactical edge so that our warfighters are provided the secure, reliable information they need to effectively execute missions and ensure their safe return.

Link 16 has become the global standard for a modern Command and Control architecture, and it is used by both US and Allied nations in daily operations worldwide. To support our operators in the field and their continuing quest for excellence, this guidebook strives to provide an up-to-date and accurate source of reference. I encourage all who want to add to your knowledge and gain a deeper appreciation of the intricacies of Link 16 to take the time to study these pages.

A special thanks to the members of the AF Link 16 Network Design Facility team on leading the effort in getting this second edition of the AF guidebook published.

Colonel Burt "Hands" Miller
HQ ACC/A3Y
Chief, C2ISR Operations Division

About This Guidebook

This guidebook, *Understanding Link 16*, has been developed for use by operators of the Unites States Air Force. It is designed to be used both for reference and review. Detailed information is presented in the text, with important points summarized in blue notes and in the figure captions. The format of this guidebook incorporates the following features:

- **Bold Type** — Important terms are printed in **bold** typeface the first time they appear, and a definition is given.
- **Blue Notes** — Key points are summarized in the *blue notes*, which are captured in horizontal lines and printed in blue. You are encouraged to add your own notes as well.
- **Illustrations** — Figures and diagrams are intended to complement the text. Their captions, also printed in blue, summarize important points.
- **Tables** — Facts are collected and summarized in tables to allow for quick lookups and comparisons.

Recommended procedures are highlighted throughout the text as "rules of thumb."

You can use this guidebook in either of two ways: for review or for reference. You can review the most important concepts simply by reading the blue notes and figure captions. A list of references, a list of acronyms, a glossary, a summary of training opportunities, and an index may be found at the back of the guidebook to enhance its use as a reference.

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Introduction

Link 16 is the designation of a Tactical Data Link (TDL) that is being fully integrated into operations of the Joint Services, the forces of the North Atlantic Treaty Organization (NATO), and other Allies. It is anticipated that the number of Link 16-equipped platforms will approach 5000 by the year 2015.

This chapter summarizes the Link 16 TDL capabilities, and discusses those utilized by the US Air Force, Army, Navy, and Marine Corps platforms. You will learn what is provided by the Link 16 message structure and waveform.

Section A

Overview

The general purpose of Link 16 is the exchange of near-real-time tactical data among military units. Link 16 does not significantly change the basic concepts of tactical data link information exchange supported for many years by Link 4A, Link 11, and Link 11B. Rather, Link 16 enhances tactical employment of all equipped platforms and provides certain technical and operational improvements to existing tactical data link capabilities, which include:

- Nodelessness
- Jam resistance
- Improved security
- Increased data rate (throughput)
- Increased volume and granularity of information exchange
- Reduced data terminal size, allowing installation in fighter and attack aircraft
- Digitized, jam-resistant, secure voice capability
- Relative navigation
- Precise Participant Location and Identification (PPLI).

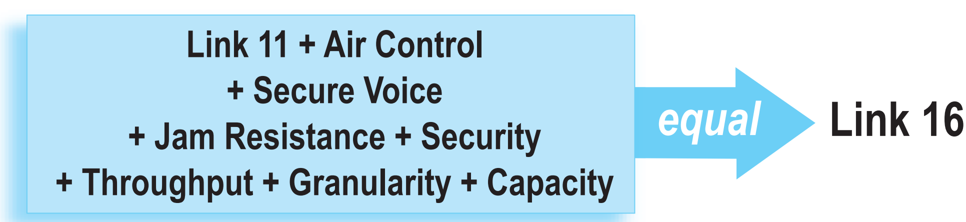

Figure 1-1. Whereas Link 16 is functionally similar to the capabilities of Link 11, it provides technology and capabilities not available in this legacy link.

Link 16 History

Air Force Beginnings

The Tactical Data Links (TDLs), formerly known as Tactical Digital Information Links (TADILs)[1], were developed in conjunction with digital computers to permit Joint and Coalition forces to exchange information across a digital interface. Link 11 (the former TADIL A) and Link 11B (the former TADIL B) were designed to enable eight-bit computers to share near-real-time surveillance and command data among functionally supporting units in the performance of their missions. Link 16, formerly known as TADIL J, was developed as a modernized, replacement upgrade to these links to reflect later 16-bit requirements.

Link 16 development began in the 1970s. Link 16 initially became operational in the United States Air Force (USAF) during the mid-to-late 1980s, with the introduction of the Class 1 Joint Tactical Information Distribution System (JTIDS) terminal in the Airborne Warning and Control System (AWACS) community and the Adaptable Surface Interface Terminal (ASIT) van in the Tactical Air Control System (TACS). Although these platforms processed only the Interim JTIDS Message Specification (IJMS), this was the beginning of the USAF Link 16 evolution.

The JTIDS Class 2 terminal was designed to be installed in multiple types of platforms. Initially, the terminal was integrated into the F-15C as a test-only implementation to support a terminal developmental and operational evaluation, which took place during 1986 and 1987. After a successful test, an integration kit and software were developed for operational implementation of Link 16 into the F-15C. For a variety of reasons, however, in the late 1980s the USAF decided to limit the deployment of Link 16 to its Command and Control (C2) platforms, including the RC-135 Rivet Joint (RJ) and the E-8 Joint Surveillance Target Attack Radar System (JSTARS).

In early 1992, the Air Combat Command (ACC) decided once again to look at the utility of data links in fighters and initiated a data link Operational Special Project

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1 *DISA ICP TM00-019.*

(OSP). JTIDS Class 2 terminals[2] were installed in the F-15Cs of the 390th Fighter Squadron (FS) at Mountain Home AFB, Idaho, using the already developed integration kits and software. The success of this OSP led the Air Force to reevaluate plans regarding data links in nonC2 platforms for both fighters and bombers.

By the mid 1990s, the USAF had committed to the deployment of Link 16 terminals in the F-15 A-D, F-15E, F-16 Block 40/42/50/52, F-22A[3], F-35A, B-1B, B-2, B-52, and Airborne Laser (ABL). Today, Link 16 fielding on USAF fighters and bombers, except for the F-35A, B-1B and the B-52, is virtually complete.

In the late 1990s, the JTIDS Class 1 terminal on AWACS was replaced with the JTIDS Class 2H terminal, and the JTIDS Class 1 terminal in the Control and Reporting Center (CRC) system was replaced with the JTIDS Class 2 Modular Control Equipment (MCE) terminal. Additionally, Link 16 was implemented on Cobra Ball (CB), Combat Sent (CS), Compass Call (CC), Senior Scout (SS), and the Distributed Common Ground Station (DCGS). Link 16 has also been implemented on Link 16 Alaska (LAK), at the Continental US Air Defense Sectors, and on the Pocket J remote elements.

■ Navy Beginnings

For the United States Navy (USN), Link 16 development began with the JTIDS Class 2 terminal, using the Distributed Time Division Multiple Access (DTDMA) protocol. This development was cancelled in 1985 in favor of the USAF development with Link 16's current protocol, Time Division Multiple Access, or TDMA. In February 1994, JTIDS Class 2 terminals, which processed J-series messages, were installed aboard the aircraft carrier *USS Carl Vinson* (CVN 70) and two Guided Missile Cruisers of its Battle Group: *USS Antietam* (CG 54) and *USS Arkansas* (CGN 41). Because the Carl Vinson Battle Group installations in 1994 were considered to be Test and Evaluation (T&E) installations, a Technical Evaluation (TECHEVAL) was conducted during this deployment, and Link 16's Operational Evaluation (OPEVAL) was completed soon after their return. Installation aboard the carrier *USS Constellation* (CV-64), which was completed in January 1994, marked

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2 *Beginning in FY 2007, the JTIDS Class 2 terminals were replaced with MIDS LVT-3 terminals.*

3 *The F-22A is a receive-only platform.*

the first production installation of Link 16 on US ships under the Fleet Modernization Program (FMP). Full production for USN Link 16 implementation was begun in 1995.

Army Beginnings

The US Army joined the Link 16 community in the late 1980s, when the Army spearheaded the development of a variant of the JTIDS Class 2 terminal, designated the Class 2M. The Class 2M incorporated a unique interface for Army systems based on the Position Location Reporting System/JTIDS Hybrid Interface (PJHI), subsequently known as the Army Data Distribution System Interface (ADDSI). The Army chose this interface to minimize changes to existing platforms that already used the Enhanced Position Location Reporting System (EPLRS) radios. Subsequently, in 1996, the US Army fielded their first Link 16 capability with the installation of JTIDS Class 2M terminals in their Patriot system. Shortly thereafter, JTIDS Class 2M terminals were installed in Forward Area Air Defense (FAAD) Command, Control, and Intelligence (C2I) systems, first as receive-only systems, and eventually as full participants on Link 16 networks. JTIDS Class 2M terminals were also installed in the Joint Tactical Ground Station (JTAGS) systems and were purchased for use with the Terminal High Altitude Area Defense (THAAD) system, which is currently under development.

Emergence of MIDS Terminals

It was originally planned that after 1999, new installations of Link 16 would employ Multifunctional Information Distribution System (MIDS) terminals. These second-generation Link 16 terminals were being developed by an international MIDS consortium (MIDSCO) with representation from US and NATO defense and aerospace companies. The contract for the engineering and manufacturing development of this Command, Control, Communications, and Intelligence (C3I) program was awarded in March, 1994 by the US Navy on behalf of France, Germany, Italy, Spain, and the United States. At that time, three MIDS Low-Volume Terminal (LVT) variants had been identified: the MIDS LVT-1 for aircraft and shipboard integration, the MIDS LVT-2 for Army land-based host platform integration, and the MIDS LVT-3 (also known as the Fighter Data Link terminal, or FDL) for the Air Force F-15 fleet. Since then, many more MIDS LVT variants have been produced. These are discussed in detail in Chapter 2 of this guidebook.

☐ *US Services' Link 16 Implementation Status*

■ US Navy

USN ships that now have Link 16 include all aircraft carriers (CVs and CVNs), AEGIS cruisers (CGs), AEGIS destroyers (DDGs), and amphibious assault ships (LHDs and LHAs). Since the 1990s, Link 16 aboard USN ships has been undergoing implementation in two phases:

- Aboard **AEGIS** platforms (CGs and DDGs), these phases relate to the AEGIS Command and Decision (C&D) tactical system, and are designated **Model 4** and **Model 5**.
- Aboard **non-AEGIS** platforms (CVs, CVNs, LHDs, LHAs, and LCCs), these phases have been related to a different type of tactical system, called the Advanced Combat Direction System (ACDS), and are designated **Block 0** and **Block 1**.

For both general platform types—AEGIS and non-AEGIS—their two phases of Link 16 implementation differ greatly in the capabilities they provide.

All CV and CVN platforms were originally installed as ACDS Block 0, as are the LHAs and the earlier LHDs. Newly constructed carriers, such as *USS Ronald Reagan* (CVN 76), however, are being installed with a new tactical system, called the Ship Self-Defense System (SSDS), as well as with the Common Data Link Management System (CDLMS), which will replace the Command and Control Processor (C2P). These modifications constitute a new Block 1 configuration. *USS Nimitz* (CVN 68) has already been back-fitted with SSDS, and other carriers will soon follow. It is planned for all Navy platforms eventually to be of either the Block 1 or the Model 5 configuration.

Link 16 has also been installed aboard the two Command ships—*USS Mount Whitney* (LCC 19) and *USS Blue Ridge* (LCC 20)—and the San Antonio Class LPDs, beginning with *USS San Antonio* (LPD 17) in 2004.

The Navy aircraft currently equipped with Link 16 include the E-2C Hawkeye Group II, the Hawkeye 2000, the F/A-18C/D Hornet, and the F/A-18E/F Super Hornet. Link 16 will also be installed on the EA-6B, EA-18G, P-3C, P-3C_BLK_

3m, P-3C_MSA, and the EP-3E Aries II. Some Link 16-capable Navy aircraft are equipped with the JTIDS Class 2 terminal. The Link 16 capability of most airborne platforms, however, is provided by the MIDS LVT-1 terminal, Platform Type A. Link 16 on the EP-3E will be provided by the type of JTIDS Class 2 terminal that the USAF has implemented aboard its JSTARS aircraft.

■ US Marine Corps

The Marine Corps employs the JTIDS Class 2 terminal in support of the Tactical Air Command Center (TACC), Tactical Air Operations Center (TAOC), and Air Defense Communications Platform (ADCP). The interface between these host systems and their terminals is a MIL-STD-1553B interface. The JTIDS interface for the TAOC is through the ADCP shelter, which contains the JTIDS Class 2 terminal. The JTIDS interface for the TACC is through the Communications Data Link System (CDLS), which is a variant of the Air Defense System Integrator (ADSI®).

Link 16 will also be incorporated into the new USMC platform—the Common Aviation Command and Control System (CAC2S), which will employ the MIDS terminal, and the CH-53K medium-heavy lift helicopter, which will employ the MIDS Joint Tactical Radio System (JTRS).

The Marine Corps aircraft equipped with Link 16 are the F/A-18C/Ds, as well as the F/ A-18A+ and F/A-18B+ versions. These aircraft will employ the MIDS LVT-1 terminal.

■ US Army

Currently, Army Air Defense systems utilize the JTIDS Class 2M and MIDS LVT-2 terminals to provide the Link 16 capability in support of air and missile defense missions. The Air Defense platforms include the Air and Missile Defense Planning and Control System (AMDPCS), the Air Defense Airspace Management (ADAM) Cells, the FAAD C2I platform, the JTAGS system, the Patriot Information Coordination Central (ICC) and the Patriot Battery Command Post (BCP). JTIDS and/or MIDS terminals will also be fielded with the THAAD system, the Joint Land Attack Cruise Missile Defense Elevated Netted Sensor (JLENS) system, the Surface Launched Advanced Medium Range

Air-to-Air Missile (SLAMRAAM) system, and other Link 16-capable Army platforms under development or scheduled for fielding.

Plans are underway to standardize Army platforms with MIDS LVT-2 terminals, but JTIDS will still be in the field until at least 2010. Today, the Army has approximately 50 fielded JTIDS Class 2M terminals and over 300 MIDS LVT-2 terminals, with many more planned. Army Aviation platforms are also mandated to have the Link 16 capability by 2014. Possible alternative solutions are the MIDS JTRS and the Tactical Air Control Party (TACP) JTRS radios, which are still under development.

Additionally, the Army has developed a Joint Range Extension Application Protocol (JREAP) system to provide its Air Defense Artillery (ADA) ground platforms the capability to exchange Link 16 data beyond line of sight (BLOS). The Common Data Link Interface (CDLI) was developed in response to lessons learned from Operation Enduring Freedom (OEF), where communications over vast geographic areas were exceeding RF LOS capabilities. CDLI provides the capability to exchange data via several protocols and media, such as JREAP B point-to-point communications, JREAP C, which utilizes a TCP/IP Ethernet protocol, and Satellite TDL J (SAT-J). CDLI is currently being fielded in Patriot ICCs, THAAD, and JTAGS.

■ US Air Force

The Air Force currently employs Link 16 aboard its AWACS, JSTARS, RJ, CB, CS, CC, and SS aircraft, and in its ground-based, AOC, DCGS and CRC, LAK, Continental US Air Defense Sectors, and Pocket J remote element platforms. Additionally, Link 16 is employed as a Ground Tactical Data Link System (GTS) by many Fighter Wings using LVT-6 or LVT-3 terminals with the Battlefield Operations Support System (BOSS™).

The F-15C/D and F-15E fighters are also equipped with Link 16, employing the MIDS LVT-3 terminal. The F-16 Fighters Block 40/42 and 50/52 are also employing the MIDS LVT-6 terminal. The F-22A is a receive-only platform, and its JTIDS terminal functions are built into the avionics system. The B-2 is also equipped with MIDS LVT-7 terminals. ABL will be fielded with a MIDS LVT-7 terminal. The F-35A will be fielded with a hybrid terminal embedded in its avionics system. The AC-130 and the B-1B will be fielded with MIDS terminals beginning in FY 2008. Fielding for the B-52 has not been determined as of this writing.

In the near future, Link 16 will be fielded on Air Support Operations Center (ASOC) Gateways for TACP and Special Operations Forces (SOF) units.

Terminology

Link 16

Throughout this guidebook, the term "**Link 16**" refers to the tactical data link that is specified in the Message Standard for Link 16, the MIL-STD-6016 series. All information about Link 16 contained therein applies equally to Joint Service and NATO operations. You may also have heard the term "TADIL J." This term, which is no longer in use, was synonymous with the term "Link 16."

Link 16 Host

A Tactical Data System (TDS) that incorporates Link 16 functionality can sometimes be referred to as a "**Link 16 Host**" platform.

Link 16 Network

A Link 16 Network is an accumulation of TDSs participating in a predefined exchange of tactical data via radio frequency (RF) signals operating within line of sight (LOS) of other participants in the network.

Link 16 Terminal

The word "**terminal**" is used throughout this guidebook to refer generically to a number of radio sets that are used to transmit and receive tactical data to and from a Link 16 RF network.

- The acronym "**JTIDS**" refers to the Joint Tactical Information Distribution System, the first-generation Link 16 terminal. It encompasses the Class 1 and Class 2 terminals' software, hardware, and RF equipment, as well as the high-capacity, secure, antijam waveform that they generate.
- The **Multifunctional Information Distribution System** (MIDS) **Low-Volume Terminal** (LVT) is the second generation of Link 16 terminals. Many variants of this terminal, designated LVT-1 through LVT-11, have been produced, each unique in its interface and programming.
- The next generation of Link 16-capable radios will be the **Joint Tactical Radio System** (JTRS) and **MIDS JTRS**.

JTIDS or MIDS is the software, hardware, RF equipment, and waveform of Link 16.

TDL Messages

Link 11 messages, designated the **M-series messages**, are preformatted messages used to convey tactical data on Link 11. Link 16 messages, or **J-series messages**, are preformatted messages used to convey tactical data on Link 16. **IJMS Messages** are formatted according to the early Interim JTIDS Message Specification (IJMS), which was implemented in the first JTIDS Class 1 terminals.

IJMS is not fully compatible with modern Link 16.

JREAP

The **Joint Range Extension Application Protocols** (JREAP)[4] are designed to support BLOS operations over most communications media (JRE media). Each JRE medium has unique characteristics. As of this writing, only three JREAP protocols have been defined:

- **JREAP A**, which is similar to S-TDL J, utilizes the same radios and satellites but with a slightly different protocol than S-TDL J. JREAP A utilizes military ultrahigh frequency (UHF) satellite and terrestrial radio frequency (RF) communications that are half-duplex and use announced token passing.
- **JREAP B** is a full-duplex, point-to-point communications protocol similar to Serial J that can use media such as military super high frequency (SHF) satellite communications (SATCOM), landlines (telephone lines), or fieldwire between shelters.
- **JREAP C** utilizes the Internet Protocol (IP) User Datagram Protocol (UDP) in Unicast and Multicast modes, as well as Transmission Control Protocol (TCP) to exchange encapsulated messages over wide and local area networks. JREAP protocols can be adapted to support almost any message set, but the exchange of J-series messages is currently their most prevalent use.

4 *MIL-STD-3011 defines these application protocols.*

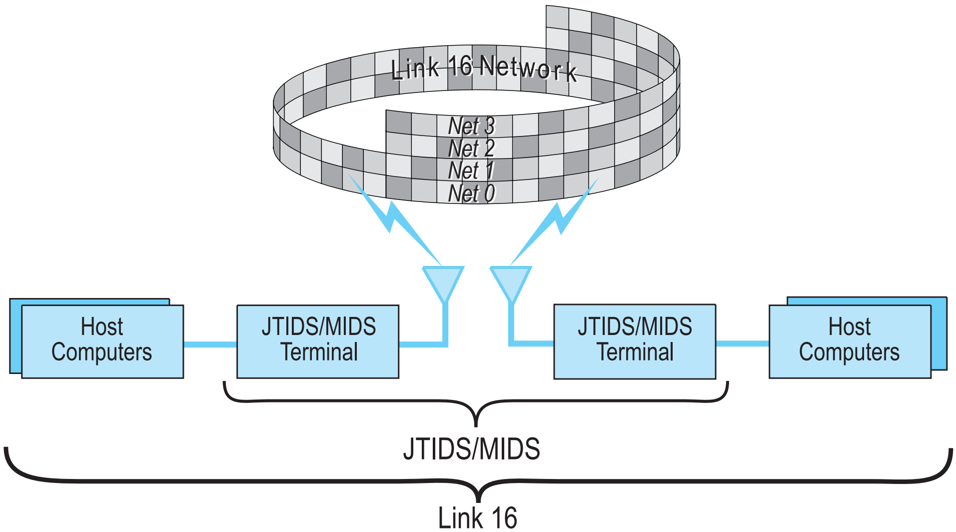

Figure 1-2. Tactical data is shared among friendly units equipped with Tactical Data Systems over Link 16 using JTIDS and MIDS terminals

■ Serial J

Legacy point-to-point (as opposed to netted) communications protocols that use J-series messages are termed **Serial J**. Serial J represents the upgrade of Link 11B to replace the M-series messages with their J-series equivalents. Serial J does not support JTIDS terminal function messages (for example, synchronization and navigation) or certain functional areas (such as fighter-to-fighter and secure voice). It consists chiefly of situational awareness and command data similar to what is contained on Link 11B.

■ S-TDL J

S-TDL J is the term used by the Navy to describe the use of J-series messages over a satellite link. S-TDL J is not performed by a JTIDS or MIDS terminal, but instead uses existing UHF, SHF, or extremely high frequency (EHF) satellites, and satellite modems.

■ Socket J

Socket J is an unofficial term that is used to characterize the moving of Link 16-compatible data over a TCP/IP network. Socket J has data elements similar to those found in a J-series message, but it does not follow J-series protocol.

■ Link 22

Link 22 is a secure, electronic countermeasures (ECM)-resistant, medium-speed TDL. Tactical data may be selectively exchanged among Link 22 participants within communities of interest, which are defined by functional requirements. Link 22 operates in the HF and UHF frequency bands. Link 22 is a primarily a maritime data link that has been adopted by NATO. As of this writing, the Air Force has no plans to implement Link 22.

Section B

The Link 16 J-series Messages

Like other tactical data links, Link 16 conveys its information in specially formatted messages. These message formats are composed of sets of fields, each of which is composed, in turn, of prescribed numbers of bits that may be encoded into predetermined patterns to convey specific information. The messages exchanged over Link 16 between participating Link 16 units are called the **J-series messages**.

Link 16 is the exchange of tactical data using J-series message formats.

☐ Message Structure

Each J-series message format is identified both by a label and a sublabel. For a J12.6 Target Sorting message, for example, the "**J**" indicates Link 16, the "**12**" is the message label, and the "**.6**" is the message sublabel. Since the label field is five bits wide (for 32 labels) and the sublabel field is three bits wide (for eight subcategories), there are 256 possible message definitions ($32 \times 8 = 256$). Not all 256 possible label and sublabel combinations, however, represent actual messages, as you will observe in Figure 1-3.

Up to 256 different J-series messages may be defined.

J-message Type	Message Sub-labels							
	x.0	1.1	x.2	x.3	x.4	x.5	x.6	x.7
J0.x	J0.0	J0.1	J0.2	J0.3	J0.4	J0.5	J0.6	J0.7
J1.x	J1.0	J1.1	J1.2	J1.3	J1.4	J1.5	J1.6	J1.7
J2.x	J2.0	J2.1	J2.2	J2.3	J2.4	J2.5	J2.6	J2.7
J3.x	J3.0	J3.1	J3.2	J3.3	J3.4	J3.5	J3.6	J3.7
J4.x	J4.0	J4.1	J4.2	J4.3	J4.4	J4.5	J4.6	J4.7
J5.x	J5.0	J5.1	J5.2	J5.3	J5.4	J5.5	J5.6	J5.7
J6.x	J6.0	J6.1	J6.2	J6.3	J6.4	J6.5	J6.6	J6.7
J7.x	J7.0	J7.1	J7.2	J7.3	J7.4	J7.5	J7.6	J7.7
J8.x	J8.0	J8.1	J8.2	J8.3	J8.4	J8.5	J8.6	J8.7
J9.x	J9.0	J9.1	J9.2	J9.3	J9.4	J9.5	J9.6	J9.7
J10.x	J10.0	J10.1	J10.2	J10.3	J10.4	J10.5	J10.6	J10.7
J11.x	J11.0	J11.1	J11.2	J11.3	J11.4	J11.5	J11.6	J11.7
J12.x	J12.0	J12.1	J12.2	J12.3	J12.4	J12.5	J12.6	J12.7
J13.x	J13.0	J13.1	J13.2	J13.3	J13.4	J13.5	J13.6	J13.7
J14.x	J14.0	J14.1	J14.2	J14.3	J14.4	J14.5	J14.6	J14.7
J15.x	J15.0	J15.1	J15.2	J15.3	J15.4	J15.5	J15.6	J15.7
J16.x	J16.0	J16.1	J16.2	J16.3	J16.4	J16.5	J16.6	J16.7
J17.x	J17.0	J17.1	J17.2	J17.3	J17.4	J17.5	J17.6	J17.7
J18.x	J18.0	J18.1	J18.2	J18.3	J18.4	J18.5	J18.6	J18.7
J19.x	J19.0	J19.1	J19.2	J19.3	J19.4	J19.5	J19.6	J19.7
J20.x	J20.0	J20.1	J20.2	J20.3	J20.4	J20.5	J20.6	J20.7
J21.x	J21.0	J21.1	J21.2	J21.3	J21.4	J21.5	J21.6	J21.7
J22.x	J22.0	J22.1	J22.2	J22.3	J22.4	J22.5	J22.6	J22.7
J23.x	J23.0	J23.1	J23.2	J23.3	J23.4	J23.5	J23.6	J23.7
J24.x	J24.0	J24.1	J24.2	J24.3	J24.4	J24.5	J24.6	J24.7
J25.x	J25.0	J25.1	J25.2	J25.3	J25.4	J25.5	J25.6	J25.7
J26.x	J26.0	J26.1	J26.2	J26.3	J26.4	J26.5	J26.6	J26.7
J27.x	J27.0	J27.1	J27.2	J27.3	J27.4	J27.5	J27.6	J27.7
J28.x	J28.0	J28.1	J28.2	J28.3	J28.4	J28.5	J28.6	J28.7
J29.x	J29.0	J29.1	J29.2	J29.3	J29.4	J29.5	J29.6	J29.7
J30.x	J30.0	J30.1	J30.2	J30.3	J30.4	J30.5	J30.6	J30.7
J31.x	J31.0	J31.1	J31.2	J31.3	J31.4	J31.5	J31.6	J31.7

Message Labels

Figure 1-3. The possible J-series messages are shown. Light cells denote defined messages, and gray cells denote messages that have not yet been specifically defined.

Within the J-series message set are messages for network management, friendly status, surveillance, electronic warfare, weapons employment, imagery, and track management. The currently defined messages are described in Figure 1-4.

In both ground-based and airborne systems, the J-series messages are processed directly by the tactical or mission computer. Certain ground-based systems, such as the CRC, can also perform a second function: the forwarding of data in both directions between Link 16 and Link 11/11B.

MSG	MESSAGE TITLE	PURPOSE
J0.0	Initial Entry	Provides the data elements, in a known time slot, required for net entry.
J0.1	Test	Used for terminal test and performance evaluation.
J0.2	Network Time Update	Adjusts the system time to a standard time.
J0.3	Time Slot Assignment	Permits dynamic assignment of time slots.
J0.4	Radio Relay Control	Provides the means for the JTIDS Unit (JU) responsible for relay control to assign and deassign the paired slot radio relay function to a terminal and to control the relay function parameter.
J0.5	Repromulgation Relay	Requests that those messages in the same time slot containing the J0.5 message be relayed by all JUs receiving the message.
J0.6	Communications Control	Initiate or terminates specific transmissions to control communications, and requests network management actions.
J0.7	Time Slot Reallocation	Provides the capability for a JU to request a percentage of time slots from a shared pool and disseminate the requests of other JUs.
J1.0	Connectivity Interrogation	Solicits direct or indirect connectivity of the addressed JUs to support route establishment.
J1.1	Connectivity Status	Disseminates direct or multilevel connectivity of the source JUs.
J1.2	Route Establishment	Establishes a route for relay/destination control.
J1.3	Acknowledgment	Used by a JU involved in ground-to-ground communications to respond to messages that require machine receipt/compliance.

Figure 1-4. The J-series messages (continued on next page)

MSG	MESSAGE TITLE	PURPOSE
J1.4	Communicant Status	Used by JUs to report the connectivity quality of its direct communicants to Net Control Station (NCS) and other direct communicants.
J1.5	Net Control Initialization	Provides a number of initial terminal parameters required to allow a terminal to actively participate in an established net under the control of a dynamic net manager.
J1.6	Needline Participation Group Assignment	Used by the designated NCS to assign an addressed JU its associated destination Source TNs with PG numbers to form Needline PGs.
J2.0	Indirect Interface Unit PPLI	Provides Participating Unit/Reporting Unit/Generic Unit information on the Link 16 network when network participation status, identification, and positional information is forwarded from Link 11/11B.
J2.2	Air PPLI	Provides all JUs information about airborne JUs on the Link 16 network. It is used by airborne JUs to provide network participation status, identification, positional information, and relative navigation information.
J2.3	Surface PPLI	Provides all JUs information about surface JUs on the Link 16 network. It is used by surface JUs to provide network participation and relative navigation information.
J2.4	Subsurface PPLI	Provides all JUs information about subsurface JUs on the Link 16 network. It is used by subsurface JUs to provide network participation status, identification, positional information, and relative navigation information.
J2.5	Land Point PPLI	Provides all JUs information about stationary ground JUs on the Link 16 network. It is used by stationary ground JUs to provide network participation status, identification, positional information, and relative navigation information.
J2.6	Land Track PPLI	Provides all JUs information about mobile ground JUs on the Link 16 network. It is used by mobile ground JUs to provide positional information, and relative navigation information.
J3.0	Reference Point	Used to exchange tactical information about geographic references.
J3.1	Emergency Point	Provides the location and type of an emergency that requires search and rescue.

Figure 1-4. The J-series messages (continued on next page)

MSG	MESSAGE TITLE	PURPOSE
J3.2	Air Track	Used to exchange information on air tracks.
J3.3	Surface Track	Used to exchange information on surface tracks.
J3.4	Subsurface Track	Used to exchange information on subsurface tracks and Datums.
J3.5	Land Point/Track	Used to exchange tactical surveillance information on land points and tracks.
J3.6	Space Track	Exchanges information on Space and Ballistic Missile tracks.
J3.7	Electronic Warfare Product Information	Provides the means to exchange tactically significant information that has been derived from electromagnetic sources.
J5.4	Acoustic Bearing/Range	Used to report acoustic bearing and range of subsurface contacts.
J6.0	Amplification	Used to exchange amplifying information, including threat information, within the interface.
J7.0	Track Management	Used to transmit information necessary to effect management actions on tracks being reported within the interface. Management actions include dropping tracks, reporting environment/category and identity conflicts, changing environment/category and identity, changing alert status, and changing strength.
J7.1	Data Update Request	Used to request tactical information that has been locally generated by units participating within the interface.
J7.2	Correlation	Used to resolve a dual designation problem by identifying one track to be retained and another to be dropped.
J7.3	Pointer	Used to transmit a geographic position to an addressed unit within the interface.
J7.4	Track Identifier	Used to transmit special identification numbers associated with the reference TN.
J7.5	IFF/SIF Management	Used to transmit IFF/SIF information or a special code on a referenced track. Provisions are available to obtain the most current information by exchanging, clearing, or updating IFF/SIF data between units within the interface.
J7.6	Filter Management	For NATO Use

Figure 1-4. The J-series messages (continued on next page)

MSG	MESSAGE TITLE	PURPOSE
J7.7	Association	Used to transmit information, on two or more TNs, that has been automatically or manually associated when the information is deemed to pertain to the same contact. When a determination is made that the relationship above no longer exists, there is a provision for terminating this information association.
J8.0	Unit Designator	Used to transmit to a terminal (from its NCS) the unit designator associated with the TNs in the terminal's Participation Group assignments. The message will also be used to inform an NCS of a terminal's unit designator.
J8.1	Mission Correlator Change	Used to add, delete, or change Mission Correlators on a specific aircraft or flight of aircraft.
J9.0	Command	Provides the means to transmit threat warning conditions, alert states, and weapons condition orders, to direct weapon system engagement for air defense and air support, and to direct Anti-Submarine Warfare (ASW) operations.
J9.1	Engagement Coordination	Provides the means for two or more elements to coordinate engagement, to conduct more efficient engagement, and to reduce the probability of wasted resources.
J9.2	ECCM Coordination	Provides the means to coordinate and direct Electronic Counter-Countermeasures activities among C2 JUs.
J10.2	Engagement Status	Provides the status of an engagement between the Reference TN and the Target TN.
J10.3	Handover	Used to transfer control of aircraft and remotely piloted vehicles/ missiles between controlling units.
J10.5	Controlling Unit Report	Used to identify the JU that is controlling the track and to provide the Mission Correlator and/or voice call sign.
J10.6	Pairing	Provides a means to indicate a pairing (not engagement status) between a friendly track and another track or point.
J11.0	Weapon Response/ Status (1)	Provides weapon compliance responses to controller directives.
J11.1	Weapon Directives (1)	Provides controller directives to a weapon.

Figure 1-4. The J-series messages (continued on next page)

MSG	MESSAGE TITLE	PURPOSE
J11.2	Weapon Coordination (1)	Used to coordinate the transfer of control authority and the delegation of third party source.
J12.0	Mission Assignment	Used by C2 JUs and optionally by nonC2 JUs to assign missions, designate targets, and provide target information to nonC2 platforms. NonC2 JU acknowledgement of this message is through Receipt/ Compliance (R/C) action.
J12.1	Vector	Used by C2 JUs to send vector information and vector discretes specifically to air units operating on its net. Vectors are given for interception of air targets, navigation, and air traffic control.
J12.2	Precision Aircraft Directions	Used by controlling units for operations requiring precise control positioning of mission aircraft (for example, ground-directed release of ordinance, automatic carrier landing operations, etc.)
J12.3	Flight Path	Used by controlling units to provide air units with multiple-leg flight path information.
J12.4	Controlling Unit Change	Used to provide new control agency information to an aircraft prior to handoff to the new control agency. It is also used by a tactical aircraft to initiate control procedures with a new controlling unit or to effect a change of controlling unit in response to a CUC Order or by a C2 JU to initiate control by own unit.
J12.5	Target/Track Correlation	Used by controlling C2 JUs to: • Correlate a target and a track, • Decorrelate a target and a track, and • Correlate multiple targets with a track.
J12.6	Target Sorting	Used to: • Enable nonC2 JUs to exchange targets and targeting information among themselves, • Pass sensor data to C2 JUs and among nonC2 JUs, • Pass nonC2 JU engagement status information between nonC2 JUs and from nonC2 JUs to C2 JUs, and; • Provide control among nonC2 JUs.
J12.7	Target Bearing	Used by nonC2 JUs to: • Exchange target reports using polar coordinates, and may include range, bearing, elevation, rate, and uncertainty data, and; • Pass sensor data to JUs.
J13.0	Airfield Status	Reports operational status of airfields, runways, airfield facilities, and aircraft carrier flight decks.

Figure 1-4. The J-series messages (continued on next page)

MSG	MESSAGE TITLE	PURPOSE
J13.2	Air Platform and System Status	Provides the current status of an air platform including ordnance load, fuel, operational status, and on-board systems' status.
J13.3	Surface Platform and System Status	Provides the current status of a surface platform including ordnance load, operational status and on-board systems' status.
J13.4	Subsurface Platform and System Status	Provides the current status of a subsurface platform to include operational status and on-board systems' status.
J13.5	Land Platform and System Status	Provides the current operational weapons and equipment status of a land platform.
J14.0	Parametric Information	Provides the means to exchange parametric information that has been derived from electromagnetic sources.
J14.2	EW Control/ Coordination	Provides the means for Electronic Warfare (EW) participants to coordinate EW activities among themselves.
J15.0	Threat Warning	Provides the capability for threat warning to targeted friendly platforms, including Threat Type, Threat Posture, Position/Relative Position, Altitude, and Speed.
J16.0	Image Transfer Message	Provides the capability to transmit and receive imagery.
J17.0	Weather Over Target	Provides the current weather conditions over a target area.
J28.0	US National 1 (Army)	Purpose is specified in the appropriate US Army documentation.
J28.1	US National 2 (Navy)	Purpose is specified in the appropriate US Navy documentation.
J28.2	US National 3 (Air Force)	Purpose is specified in the appropriate US Air Force documentation.
J28.2 (0)	Text	Provides the means to convey alphanumeric text information via data link.
J28.3	US National 4 (Marine Corps)	Purpose in specified in the appropriate US Marine Corps documentation.
J28.4	FR National 1	Purpose is specified in the appropriate French documentation.
J28.5	FR National 2	Purpose is specified in the appropriate French documentation.

Figure 1-4. The J-series messages (continued on next page)

MSG	MESSAGE TITLE	PURPOSE
J28.6	US National 5 (NSA)	Purpose is specified in the appropriate National Security Administration (NSA) documentation.
J28.7	UK National 1	Purpose is specified in the appropriate United Kingdom documentation.
J29.1	UK National 2	Purpose is specified in the appropriate United Kingdom documentation.
J29.2	UK National 3	Purpose is specified in the appropriate United Kingdom documentation.
J29.3	SP National 1	Purpose is specified in the appropriate documentation from Spain.
J29.4	SP National 2	Purpose is specified in the appropriate documentation from Spain.
J29.5	CA National 1	Purpose is specified in the appropriate Canadian documentation.
J29.7	AU National 1	Purpose is specified in the appropriate Australian documentation.
J30.0	GE National 1	Purpose is specified in the appropriate German documentation.
J30.1	GE National	Purpose is specified in the appropriate German documentation.
J30.2	IT National 1	Purpose is specified in the appropriate Italian documentation.
J30.3	IT National 2	Purpose is specified in the appropriate Italian documentation.
J30.4	IT National 3	Purpose is specified in the appropriate Italian documentation.
J30.5	FR National 3 (Army)	Purpose is specified in the appropriate French documentation.
J30.6	FR National 4 (Air Force)	Purpose is specified in the appropriate French documentation.
J30.7	FR National 5 (Navy)	Purpose is specified in the appropriate French documentation.
J31.0	Over-the-Air Rekeying Management	Used to exchange cryptonet management information for rekeying the KGV-8.
J31.1	Over-the-Air Rekeying	Used to transmit the new cryptovariables.
J31.7	No Statement	Used to fill out the remainder of a transmission opportunity when the messages to be transmitted do not require the full number of Reed-Solomon code words.

Figure 1-4. The J-series messages (continued on next page)

MSG	MESSAGE TITLE	PURPOSE
Rount-Trip Timing		
RTT-A	Round-Trip Timing Interrogation – Addressed	Provides the means for a terminal to synchronize with system time using the active synchronization procedure. A specific terminal is interrogated and responds with the RTT Reply.
RTT-B	Round-Trip Timing Interrogation – Broadcast	Provides the means for a terminal to synchronize with system time using the active synchronization procedure. The RTT-B is not addressed to any particular terminal. Any terminal that meets the specified requirement for time quality level responds with the RTT Reply.
RTT-REP	Round-Trip Timing Reply	Provides the means for a terminal to support the active synchronization procedure of another JU by providing time-of-arrival data in response to either an RTT-A or RTT-B Interrogation.

Note:

(1) As of this writing, ICP TM06-093 is being processed to include these Network Enabled Weapons messages

Figure 1-4. The J-series messages convey tactical information in preformatted messages.

Section C

Overview of Link 16 Architecture

Link 16 uses the principle of **Time Division Multiple Access** (TDMA), an automatic function of the Link 16 terminal. The TDMA architecture uses time interlacing to provide multiple and apparently simultaneous communications nets. All JTIDS Units, or JUs, are pre-assigned sets of time slots in which to transmit their data and in which to receive data from other units. Each time slot is 1/128 second, or 7.8125 milliseconds (ms), in duration.

One second contains 128 times slots.

Fifty-one frequencies are available for JTIDS transmissions. The frequency is not held constant during the time slot but is changed rapidly (every 13 microseconds) according to a predetermined pseudorandom pattern. This technique is called **frequency hopping**.

Link 11 uses one frequency; Link 16 uses 51 frequencies.

☐ Networks and Nets

A Link 16 **network** is a collection of participants, all of which are in synchronization and share a common understanding of where the time slot boundaries occur. The set of all time slots held by all participants can also be considered a network.

A network is the superset of all time slots and all users in synchronization.

A **net**, on the other hand, is a subset of time slots belonging to a Link 16 network, as well as the participants that share this subset of time slots. Link 16 nets are differentiated by their frequency-hopping patterns. Multiple nets in a network can be "stacked" or "multinetted" by allowing time slots to be used redundantly, with the data transmitted in each net on different frequencies. Each net is assigned a number that designates a particular hopping pattern[5].

A net is a subset of the network's time slots, and its particular users.

A Link 16 network may consist of one or more nets. The operable nets are numbered from 0 to 126, providing up to 127 operable nets in a Link 16 network, although typically, no more than three to six are ever utilized at one time during network execution. During any given time slot, therefore, a unit is either transmitting or receiving on one of a possible 127 nets.

Theoretically, a network can have up to 127 simultaneous nets.

The operable Link 16 net numbers are downloaded to the terminal automatically, with the network design. Net number 127, however, is reserved for a special use. When a network design specifies "Net 127," this means that an operator using this net will find its actual specification elsewhere—normally, in the Operational Tasking Data Links (OPTASK LINK) message—and will have to manually set the net number during terminal initialization to a net number between 0 and 126.

"Net 127" requires operator action. Find the actual net numbers for "Net 127" functions in the OPTASK LINK.

5 *Stacked nets are discussed in Chapter 3, Section A.*

Figure 1-5. JTIDS units (JUs) automatically transmit, receive, and relay data at pre-assigned times on pre-assigned nets based on instructions given to their terminals when they are initialized. These pre-assignments are determined in advance of operations to support the expected information exchange requirements of the force.

Data Exchange

Transmission Types

Link 16 transmits 3, 6, or 12 Link 16 data words during a 7.8125-ms time slot, depending on whether it uses the Standard, Packed-2, or Packed-4 data packing structure.[6] A Link 16 data word is analogous to a Link 11 frame. Each Link 16 **data word** contains 70 bits of data. Details are provided in Chapter 3.

Four types of transmissions are possible:

- Fixed Word Format (FWF)
- Free Text (FT)
- Variable Message Format (VMF), and
- Round-Trip Timing (RTT).

J-series messages are always sent in fixed-format transmissions.

The FWF transmissions exchanged over Link 16 contain the **J-series messages**. All J-series messages, which are transmitted in FWF transmissions with parity bits and Reed-Solomon (R-S) error detection and correction (EDAC) encoding, have effective tactical data rates of 26,880; 53,760; or 107,520 bits per second (bps), depending on two factors:

- How many tactical data words are contained in the time slot, and
- Whether or not the terminal transmits them redundantly within the time slot.

The Link 16 data rate is much greater than the legacy Link 11 and Link 11B data rates.

6 *Packing structures are more fully described in Chapter 3, Section C.*

■ Data Rate and Data Volume

These data rates represent tactical data, as well as the parity bits, and the extra bits required for the R-S EDAC encoding. A time slot with R-S encoding holds 210 bits of tactical information at Standard packing (three 70-bit words), 420 bits of tactical information at Packed-2 (six 70-bit words), and 840 bits of tactical information at Packed-4 (twelve 70-bit words). To calculate the average data rate for any type of Link 16 message exchange, multiply the number of tactical information bits per slot by 128, which is the number of time slots per second.

Although FWF transmissions are most commonly used to communicate the J-series messages, the USAF also uses them to implement its text exchange capability, using the J28.2 message.

The FT transmission format may be employed for various functions. Currently, the USAF's operational use of FT transmissions consists of voice, which it transmits at either 2.4 kilobits per second (kbps), with *or* without error encoding, or at 16 kbps without error encoding. FT transmissions can also be used to contain other types of data, such as images, but they never contain J-series messages.

Free Text transmissions are not the same thing as Text messages!

When EDAC bits are not used, each time slot of unencoded information communicates 450 bits at Standard packing, 900 bits at Packed-2, and 1800 bits at Packed-4. However, each time slot of unencoded data can actually hold 465 bits at Standard packing, 930 bits at Packed-2, and 1860 at Packed-4, and all bits are available for generic free text.

Because of the increased JTIDS/MIDS data rate, far more data can be transmitted on Link 16 than on Link 11 during the same period of time. Recognizing this, the developers of the Link 16 J-series message standard have added J-series data elements that cannot currently be exchanged over Link 11. As a result, the Link 16 J-series messages allow the reporting of two to three times as much tactical information as Link 11.

Link 16 allows you to report 2 to 3 times as many tactical data elements as Link 11.

The nearly 54-kbps tactical data rate for the Packed-2 structure is actually the instantaneous rate, determined by assuming that 420 data bits (six 70-bit words) are transmitted during 1/128 second, on a single net. However, the capacity of the JTIDS network can be increased further by using multinetting techniques. Statistical analysis has shown that approximately 20 to 30 different nets can be co-located without mutual interference. Another option is to allow simultaneous transmissions. The first transmission received, that of the nearest unit, is always the only one processed.

A terminal processes the first transmission it receives in a time slot.

■ Factors Affecting Data Rate

The actual increase in the rate at which tactical data is exchanged is not as great as a straight comparison of the effective data rates of Link 11 and Link 16 might indicate. There are several reasons for this:

- A portion of the time slots in every network is allocated to functions that are not included in Link 11, such as Air Control and Voice.
- The number of time slots allocated to tactical data may be increased to satisfy relay requirements.
- Not all time slots that are assigned are necessarily always used.
- Finally, the terminal automatically adjusts the density of message packing to support the quantity of data it has to transmit.

Effectively, Link 16's data rate is 4 times faster than Link 11's.

■ Effective Tactical Data Rates

The effective tactical data rate of Link 16, assuming a single-hop relay throughout a Link 16 network and the Packed-2 packing structure, is far greater than that of Link 11.[7] Consider a flight of four fighters. Typically, an F-15 transmits Precise Participant Location and Identification messages (PPLIs) in contention access mode[8] at a rate of six time slots per frame,[9] at Packed-2 (435 bits including the header with the Source Track Number, or STN), control messages in contention access at a rate of 8 slots per frame at Standard packing (225 bits including STN), and fighter-to-fighter messages in contention access at a rate of 32 time slots per frame at Packed-2 (435 bits including STN), for a total of 1.5 kbps for that single fighter. Four fighters, therefore, transmit about 6 kbps per frame—which exceeds the typical Link 11 fast data rate of 4.8 kilobits per second.

The actual capacity of any given Link 16 network, however, will depend on how many participants are transmitting in how many time slots per frame, as well as the other factors cited above. It is sometimes useful to estimate the system capacity of Link 16 in bits per second. For a rough estimate, multiply the number of time slots actually in use each second (maximum of 128) by the number of bits transmitted in each time slot (225 or 450), and multiply the result by the number of nets in operation. To be realistic, however, the values used in this calculation should consider the reductions in capacity that can occur because data is relayed, the packing structure changes, time slots that go unused, and some time slots that belong only to single nets.

Regardless of how great the system capacity is estimated to be, however, the throughput of any one terminal is limited to a single set of 128 time slots every second.

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7 *Relay hops are discussed in Chapter 5, Section H. Packing is discussed in Chapter 3, Section C.*

8 *Contention access may not be authorized by all Frequency Clearance Agreements. In areas where the use of contention access is not permitted, dedicated access is used. Access modes are more fully described in Chapter 5, Section B.*

9 *For the definition of a frame refer to Chapter 3, Section A.*

TDL	Architecture	Protocol	Message Standard	Data Rates (kbps)			
				Tactical		With Parity	With EDAC
Link 11	Netted	Polling by Net Control	M-series	Fast	1.80	—	2.250
				Slow	1.09	—	1.364
Link 11B	Point-to-Point	Handshake	M-series		1.80	—	2.250
Link 16	TDMA	Assigned Time Slots	J-series	Standard	26.88	28.8	59.520
				Packed-2	53.76	57.6	119.040
				Packed-4	107.52	115.2	238.080

Figure 1-6. Link 16 supports the functions of Link 11, as well as additional functions such as voice, relative navigation, and an expanded electronic warfare capability. Its data rate, regardless of the density of its data and its error detection and correction (EDAC) bits, is also greater than that of Link 11. Link 16 provides the capability to exchange free text without EDAC, and it can readily be seen that without the additional EDAC bits, the effective data rates will increase.

Section D

Features of the Link 16 Architecture

The features of the unique Link 16 architecture that result in improved communication are described in this section.

☐ Nodelessness

A node is a unit required to maintain communications. On a Link 11 net, for example, the Net Control Station (NCS) is a node. If the NCS goes down, the link goes down. In Link 16 there are no nodes. Time slots are pre-assigned to each participant, and the link will function regardless of the participation of any particular unit. The closest thing in Link 16 to a node is the Network Time Reference (NTR). An NTR is needed to start up a network and for a new unit to synchronize with and enter a network.

Link 16 was designed to operate without a single point of failure.

After a network has been established, a Link 16 participant can operate for hours when an NTR is lost, if its clock is sufficiently warmed up. Time quality declines rapidly, however, and with it, navigation quality also declines. Since F-15Cs rely on Link 16 navigation, the USAF encourages relative time-based networks to maintain an NTR at all times so that time qualities remain sufficiently high to navigate, with transitions in the NTR role held to about 10 minutes or less.

☐ Security

Both the message and the transmission are encrypted. The message is encrypted by the KGV-8 encryption device for JTIDS, in accordance with a cryptovariable specified for **message security**, or **MSEC**. **Transmission security**, or **TSEC**, is provided by the same cryptovariable or by a second cryptovariable, which controls the specifics of the JTIDS/MIDS waveform. For MIDS, the MSEC and TSEC are provided by a circuit board embedded in the terminal.

One important feature of this waveform is its use of frequency hopping. The hopping pattern is determined by both the net number and the TSEC cryptovariable. The instantaneous relocation of the carrier frequency spreads the signal across the spectrum. The TSEC cryptovariable also determines the amount of jitter in the signal, as well as a predetermined, pseudorandom pattern of noise that is mixed with the signal prior to transmission.

Cryptovariable	Type of Security
MSEC	Encryption of message data
TSEC	Encryption of JTIDS waveform: • Jitter • Pseudorandom noise • Frequency-hopping pattern

Figure 1-7. Link 16 uses two types of security: both the message and the transmission are encrypted.

☐ Network Participation Groups

The time slots of a net can be parceled out to one or more Network Participation Groups (NPGs). An NPG is defined by its function, and thus also by the types of messages that will be transmitted on it. The currently existing NPGs are shown below. Their complete descriptions are found in Chapter 4.

NPG	Functional Group
1	Initial Entry
2 and 3	Round-Trip Timing (RTT)
4	Network Management
5 and 6	Precise Participant Location and Identification (PPLI); Platform and System Status
7	Surveillance
8	Mission Management/Weapons Coordination
9	Air Control
10	Electronic Warfare (EW)
11	Imagery

Figure 1-8. Network capacity (continued on next page)

NPG	Functional Group
12	Voice Group A
13	Voice Group B
14	Indirect PPLI
17	Unassigned
18	Network Enabled Weapons (1)
19 and 20	Fighter-to-Fighter Communications
21	BMD Operations (2)
22	Composite A
23	Composite B
25	Reserved for Future Joint Uses
26	Unassigned
27	Joint PPLI
28	Distributed Network Management
29	Residual Message (Fixed-Format Text)
30	IJMS Position and Status
31	IJMS Messages
32 through 511	Needlines

Notes:

(1) As of this writing, an ICP is being coordinated for approval of NPG 18.

(2) Name changed from Engagement Coordination by ICP TM06-07 Ch1.

Figure 1-8. Network capacity is allocated into functional groups, called NPGs, which are dedicated to specific purposes.

This division of the network into functional groups allows JUs to participate on only the NPGs used for functions that they perform.

☐ *Stacked Nets and Multinetting*

Theoretically, Link 16 can support up to 127 possible nets (numbered 0 – 126), each operating in the same network at the same time. However, only between 20 and 30 can coexist without interfering with one another during actual operations. To achieve this multiple net capability, either of the two techniques described below may be employed.

Stacked Nets

Transmission in the same time slots, the same NPG, but on different operator-selectable net numbers, is known as **stacked nets**. The affected time slots will share the TSEC, and may also share the MSEC, cryptovariables. Stacked nets are always designated by their assignment to “Net 127” in network description documents. By convention, designating a net number “127” indicates that the operator will select the actual net number later, from specific instructions in the OPTASK LINK message. NPG 9 (Air Control) and NPGs 12 and 13 (Voice) are examples of stacked net applications, where operators can perform the same function on different nets.

Stacked nets: data transmitted in the same time slots and NPG, but on different nets.

For each time slot, a JU is either transmitting or receiving on one net. To use the stacked net structure, the participants on each net must be mutually exclusive. Stacked nets are particularly useful for air control purposes with mutually exclusive sets of controlling units and controlled aircraft. They are also used for voice communications, providing a potential for 127 different, operator-selectable voice circuits for each of the two voice NPGs.

Multinetting

Transmission in the same time slots, but on different net numbers, is known as **multinetting**. *These transmissions may or may not be on different NPGs*. C2 platforms exchanging electronic warfare (EW) data at the same time fighters are exchanging fighter-to-fighter data is an example of multinetting.

The separation of data is accomplished by each different net number using a different, distinct frequency-hopping pattern, which is determined by the TSEC cryptovariable and the net number.

Multinetting: data transmitted in the same time slots, but on different NPGs and net numbers.

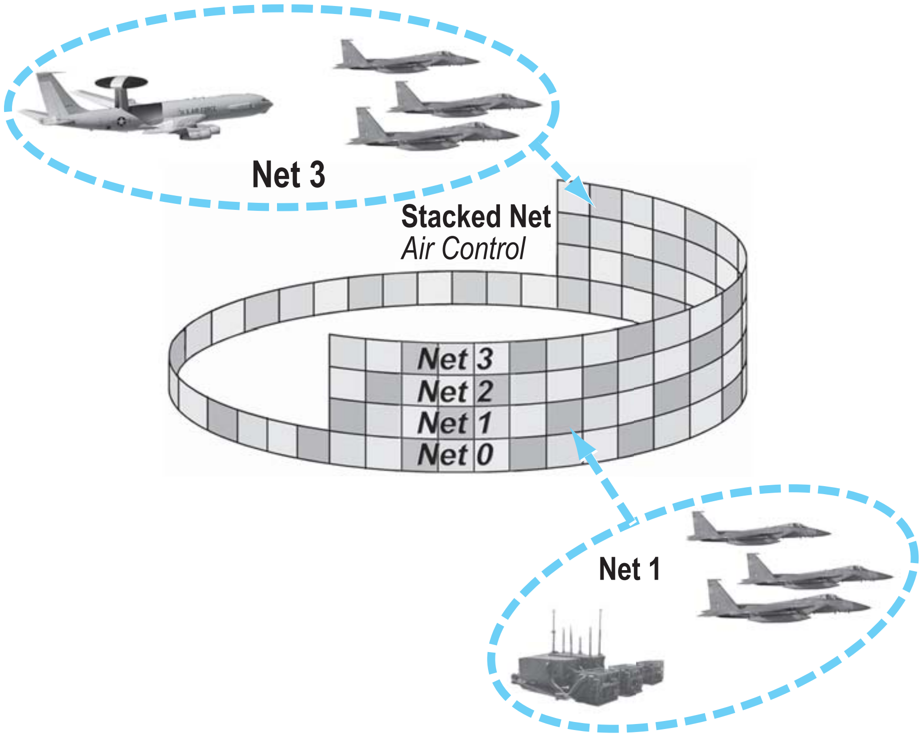


Figure 1-9. Simultaneous multiple nets are useful for separating out information that participants on the main net do not need to receive.

Section E

Summary of Additional Capabilities

The Link 16 J-series messages allow the reporting of two to three times as much exchangeable tactical information as the Link 11 and Link 11B M-series messages. Some of the field sizes have been increased to allow an improved degree of precision in the reporting of data. Some new functions are defined. Areas in which major improvements or changes have been made include:

- Unit Addresses
- Track Numbers
- Track Quality
- Track Identification
- Friendly Status
- Increased Granularity of Measurement
- Lines and Areas
- Geodetic Positioning
- Relative Navigation
- Electronic Warfare
- Land Points and Tracks.

A Link 16 address may be 5 characters long.

Unit Addresses

Each participant is assigned a unique address. In Link 16, the JU addresses are five-digit octal numbers in the range 00001–77777_8, whereas the Link 11 Participating Unit (PU) addresses are two-digit addresses in the range 01 to 76_8 and the Link 11B Reporting Unit (RU) addresses are three-digit addresses in the range of 001 to 175_8. However, to accommodate multilink communication, C2 JUs must always be assigned addresses *below* 00177_8. The Link 16 addresses 00001 to 00177_8 are equivalent to the Link 11/11B addresses 001 to 177_8. An address in this range can be assigned only to one unit, whether it is a C2 PU, RU, or JU. NonC2 JUs—for example, fighters—use only the addresses 00200 through 77776_8. The address 77777_8 uniquely identifies the Network Manager.

Link 11 has PUs; Link 16 has JUs. They are sometimes referred to by their Source Track Numbers (STNs), aka Unit Addresses.

The address 00034 used on Link 16 is the same as address 034 used on Link 11B. When a unit operates on both links at the same time, it uses the same address on both links.

□ Track Numbers

Link 16 employs a five-character alphanumeric Track Number (TN) within the range 00001 to 77777_8 or within the range 0A000 to $ZZ777_8$, allowing up to 524,284 TNs.[10] Link 11 uses a four-digit TN in the range 0001 to 7777_8, allowing only 4,092 TNs. Link 16 cannot be operated in a TN pool mode, as can Link 11, in which a common pool of track numbers can be shared by several PUs. On Link 16, each JU is allotted its own distinct track block. The TDMA architecture does not permit proper TN accountability in a pool. Therefore, a much larger number of Link 16 TNs is necessary to permanently or semi-permanently allocate adequate blocks of TNs to each of the many units that will eventually be equipped for Link 16.

Link 16 TNs are 5 characters long and may contain two alphabetic characters.

10 *For alphanumeric TNs, the first two characters may be numeric (0–7) or alphabetic (A–Z, excluding the letters I and O).*

It is important to understand that, for TN allocation and assignment purposes, the Link 11 TNs 0200 to 7777_8 are considered to be the same TNs as the Link 16 TN/Addresses 00200 to 07777_8. For example, TNs 0200 and 00200 are the same TN and cannot be assigned to two different tracks.

The track or JU reported as TN 00200 on Link 16 is the same track as that reported as TN 0200 on Link 11/11B.

Track Quality

Link 16 uses a four-bit Track Quality (TQ) field whose values can range from 0 through 15. Each TQ value is defined by a specific positional accuracy range. The highest Link 16 TQ value requires better than 50-foot accuracy. By comparison, Link 11 uses a three-bit TQ field, whose highest TQ value is 7. A Link 11 air track can have a TQ of 7 with a positional accuracy worse than 3 nautical miles (nm).

Link 16 TQ goes up to 15; Link 11 TQ only goes up to 7.

☐ Track Identification

The Track Identification (ID) reporting capabilities of Link 16 have been greatly expanded. Tracks are reported on Link 16 with a detailed ID that includes Platform, Activity, Specific Type, and Nationality. In addition, a provision has been made for an identity of "Neutral," and "Unknown, Assumed Enemy" has been changed to "Suspect." In Link 11, track identification is limited to three fields: Identification, Primary Amplification, and ID Amplification.

Track IDs	
Link 11/11B	**Link 16**
Pending	Pending
Unknown	Unknown
Assumed Friend	Assumed Friend
Friend	Friend
	Neutral
	Suspect
Hostile	Hostile

Figure 1-10. Link 16 introduces two additional, primary track IDs—Neutral and Suspect—to the Link 11 and Link 11B capabilities.

Link 16 introduces two new primary IDs to the data link world.

☐ Friendly Status

The Link 16 messages allow much more detailed reporting of the status of friendly aircraft, including the following, which cannot be reported at all on Link 11: equipment status, exact ordnance inventory, radar and missile channels, fuel/fuel available for transfer, gun capability, and estimated times of arrival and departure (ETAs and ETDs, respectively) to and from station. On Link 16, a unit can also report its inventory of specific surface missiles.

Friendly status is more detailed on Link 16 than on Link 11.

Increased Granularity of Measurement

Granularity is a measure of how precisely a data item can be reported in the data link messages. The major Link 16 granularity improvements are in track positions, air track speeds, altitudes, and lines of bearing.

Position and Air Speed are more precise on Link 16.

Lines and Areas

Link 16 messages allow the reporting of multi-segmented lines, as well as areas of all sizes and descriptions. Link 11, by contrast, does not allow lines, and it allows only areas of limited size that are circles, ellipses, squares, or rectangles.

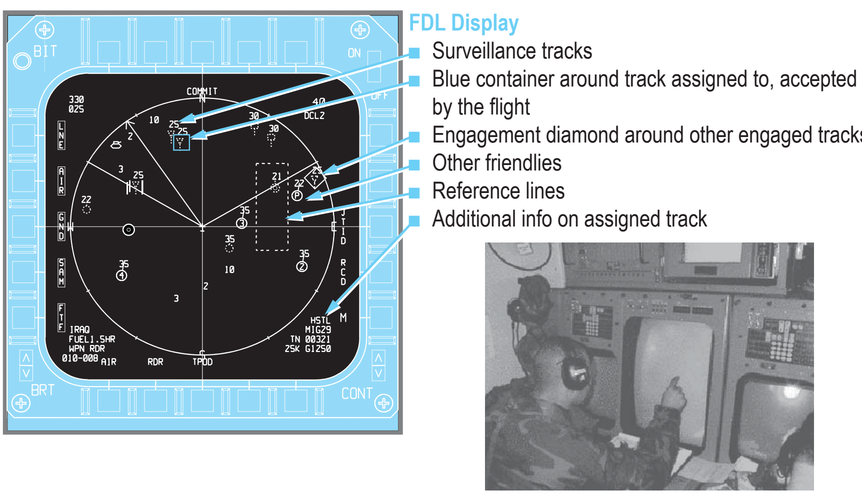


Figure 1-11. Link 16 allows corridors and areas of all shapes and sizes to be reported.

☐ Geodetic Positioning

The Link 16 messages implement a three-dimensional geodetic coordinate system using latitude, longitude, and altitude. This allows positions to be reported anywhere in the world, subject only to display and database limitations. By contrast, Link 11 uses a two-dimensional Cartesian coordinate system, and allows track reporting only within a limited range of the reporting unit. The basis of the geodetic coordinate system is the World Geodetic Survey 1984 (WGS-84).

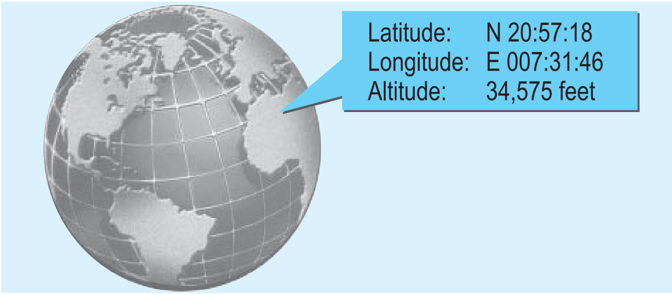


Figure 1-12. With three-dimensional geodetic positioning, a location anywhere in the world can be reported on Link 16.

Relative Navigation

Link 16's synchronous nature provides the basis for individual JUs to determine their location relative to other JUs in the network. When two or more JUs have an accurate, independently derived knowledge of their geodetic position, the relative navigation function provides all JUs with accurate geodetic position data.

RELNAV is an automatic function of the Link 16 terminal.

The JTIDS/MIDS terminal uses an automatic function, Relative Navigation (RELNAV), to determine the distance between itself and another JU by measuring the time of arrival (TOA) of the other JU's received PPLI and correlating this with the latitude and longitude reported in his PPLI. Automatic RELNAV is in constant operation in all JTIDS/MIDS terminals, providing information that allows terminals in the network to remain synchronized.

Terminals are constantly "RELNAV-ing" off each other.

A terminal uses both a geodetic grid (latitude, longitude, altitude) and a relative grid (x, y, z) to determine its own position. The geodetic grid is based on WGS-84. The RELNAV function is based on the multilateration techniques illustrated in Figure 1-13. A JU will determine his own position in three dimensions based on the measured TOAs of PPLI messages from the other three JUs and their positions, as reported in their PPLI messages.

However, the accuracy of this technique is affected both by relative JU clock errors and the fact that the TOA measurements are not made simultaneously. Therefore, the TOA measurements are combined through a recursive filter process to determine own unit position, movement, and clock corrections. For mobile JUs, dead reckoning data are used to extrapolate position data between filter operations. In addition, the dead reckoning data are also supplied to the filter, for optimum mixing with the movement data derived from successive position estimates. A JU selects the TOA measurements to be used in the filter process based on the estimated accuracy (quality) of its own position and time data, as well as that of the other JUs, as reported in their PPLIs.

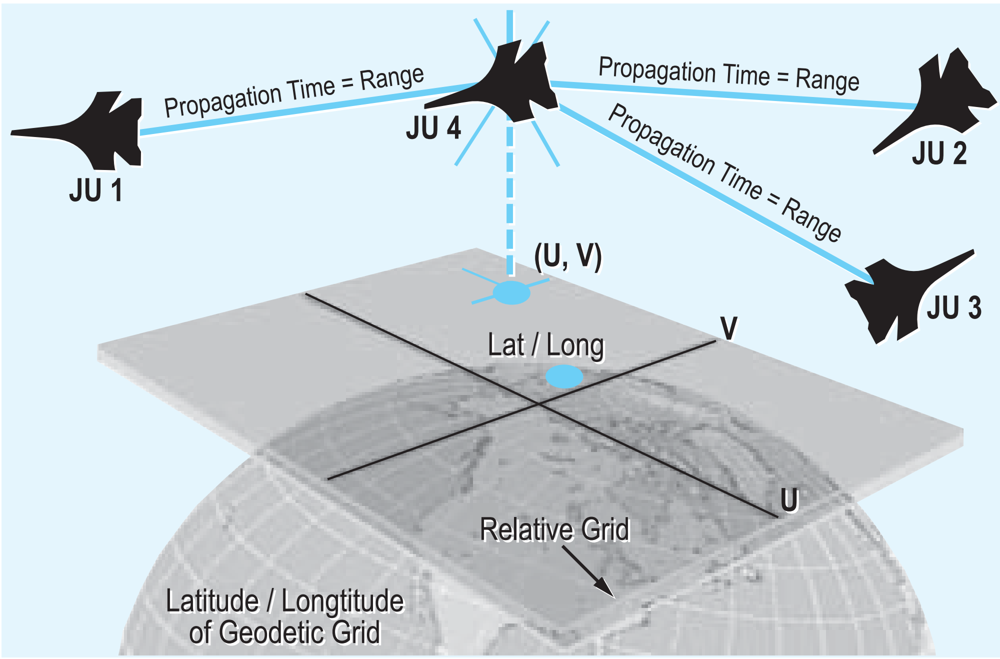


Figure 1-13. A terminal uses both a geodetic grid (latitude, longitude, and altitude) and a relative grid (x, y, z) to determine its own position. The relative grid is a flat plane that is tangent to the earth's geodetic grid.

Electronic Warfare

Link 16 allows the exchange of EW orders, a greater exchange of EW parametric information, and a wider range of EW control. EW units exchange parametric data and orders on NPG 10 (EW) and EW product information on NPG 7 (Surveillance).

Link 16's EW capabilities are far greater than Link 11's.

Land Points and Tracks

The Link 16 messages add Land as a track category, a category not currently available on Link 11. On Link 16, some of the Special Points currently reported on Link 11 are reported as Land Points, while others are reported as Reference Points. Land Points describe stationary physical objects, such as buildings, whereas Reference Points are used for theoretical constructs, such as waypoints or stations. A Land Track is simply a mobile Land Point, such as a tank. USAF implementation of land points and tracks is increasing to include JSTARS, AWACS, AC-130, ASOC Gateways, F-15E, and F-16.

Link 16 introduces Land Tracks to the TDL world.

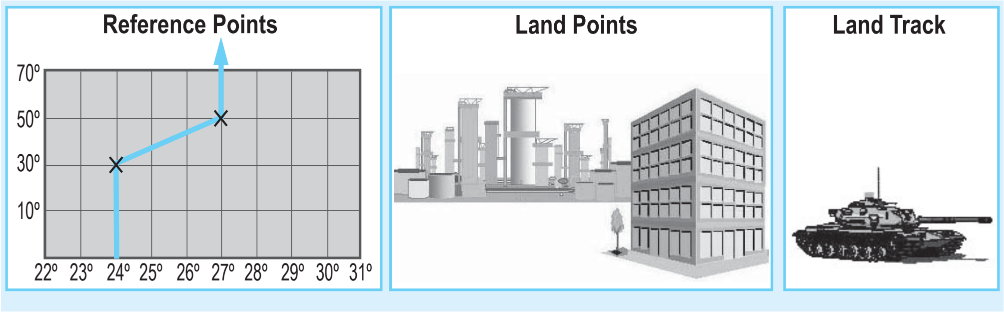


Figure 1-14. The Link 16 messages add land as a track category. Land tracks describe mobile objects. Land points describe stationary objects. Reference points describe theoretical constructs.

Comparison of Information Exchange		
	Link 11	**Link 16**
Addresses	01 – 76 (Link 11) 001 – 176 (Link 11B)	00001 – 77777
Track Numbers	0200 – 7777	00200 – ZZ777
Track Quality	0 – 7	0 – 15
Track Identification	Identity Primary Amplification ID Amplification	Identity Platform Specific Type Activity Nationality
Status Information	Limited	Detailed
Position Granularity	500 yds	32 ft
Air Speed Granularity	28 dmh	2 dmh
Lines and Areas	No	Yes
“Playing Field”	512 × 512 nm	Worldwide
Relative Navigation	Limited	Detailed
EW		Detailed

Figure 1-15. Link 16 adds to the capabilities of Link 11 by offering improved identification, Lines and Areas, and increased granularity of measurement.

Link 16 Summary

Architecture

- TDMA
- Nodelessness
- Message and Transmission Engcryption
- Frequency Hopping
- UHF, L_x Band
- Line of Sight

Message Types

- Fixed Format (J-series)
- Free Text (Voice)
- Variable Format

Operational Use

- Surveillance
- EW
- Mission Management
- Air Control
- Fighter-to-Fighter
- Secure Voice
- Navigation
- Positive Identification

Figure 1-16. Link 16 is a high-capacity, multifunctional, secure, jam-resistant tactical data link.

Introduction

The interface between a Link 16 terminal and its tactical host or mission computer is defined by input and output messages, which vary depending on the terminal in use. This chapter describes the Link 16 terminals currently developed—JTIDS and MIDS—and in use by tactical data systems participating in Link 16 worldwide. The flow of data between the terminals and the tactical host and the flow of data within the terminals are explained. It’s okay to skip this chapter if you’re not interested in the nitty-gritty details of how the tactical data gets from the tactical system computers to the processor that actually transmits it on the network ... as long as you realize that it may take several steps and may require computers, a terminal, and sometimes, other systems.

Section A

Link 16 Data Terminals

The Joint Tactical Information Distribution System (JTIDS) and the Multifunctional Information Distribution System (MIDS) Low Volume Terminals (LVTs) are part of a Joint, international, and interoperable family of Link 16 terminals. Although the JTIDS terminals are nearing the end of production, they are still being sustained and are currently fielded with a variety of US and allied platforms. The second generation of Link 16 terminals, the MIDS, is a multinational, multiservice cooperative program sponsored by five NATO countries (the United States, France, Germany, Spain, and Italy). These terminals are reduced in size and cost from the original JTIDS terminals, and are interoperable with the secure JTIDS waveform. Development of the MIDS Joint Tactical Radio System (JTRS) terminal will represent the next generation of Link 16-capable radios.

☐ JTIDS Terminals

The first JTIDS terminals to be developed were the **JTIDS Class 1** terminals. These terminals were large, rack-mounted units that connected to the Link 16 host system through a MIL-STD-1553B interface. The JTIDS Class 1 terminals employed an early version message protocol called Interim JTIDS Message Specification (IJMS), which processed limited Track (T) and Position and Status (P) messages. These terminals are no longer used in US systems, although they are still in use by NATO Control and Reporting Centers (CRCs).

The first Link 16 communications terminals that transmitted and received J-series messages were the **JTIDS Class 2** terminals. The JTIDS Class 2 terminal was designed to be installed in multiple types of platforms using the MIL-STD-1553B interface. The JTIDS Class 2 system is composed of a 200-watt Receiver/Transmitter (R/T) and a Data Processor Group (DPG). The JTIDS Class 2 terminal transmits and receives both Link 16 data and voice and has an integrated Tactical Air Navigation (TACAN) system. Many JTIDS Class 2 terminals implement the IJMS protocol in addition to the Link 16 J-series message set. Terminals that can translate between IJMS messages and J-series messages are said to be “bilingual,” but not all bilingual terminals are translators. For example, both the AWACS and CRC JTIDS Class 2 terminals are “pass-through” bilingual terminals, which pass messages to their host to perform the IJMS and/or Link 16 interpretation. AWACS supports both IJMS and Link 16 in its host, so it is capable of true concurrent participation in each link. The CRC’s host, however, cannot interpret IJMS messages, and therefore has no effective bilingual capability. The CRC bilingual terminal can, however, relay IJMS messages.

When the High Power Amplifier (HPA) group is part of the JTIDS Class 2 suite, the terminal is designated the **JTIDS Class 2H**. Class 2H terminals are essentially similar to the JTIDS Class 2, except that the HPA can boost the terminal’s output power to 1000 watts.

The **JTIDS Class 2M** terminals were designed specifically for US Army Air Defense operations. These terminals have neither Voice nor TACAN capabilities, and they include their own integral cooling and power supply assemblies. The JTIDS Class 2M terminal is also the type of “bilingual” terminal that translates IJMS messages to J-series equivalent messages for processing by the host. JTIDS Class 2M terminals interface with the host platform and its terminal initialization device using the **Army Data Distribution System Interface (ADDSI)**, as opposed to the MIL-STD-1553 protocol implemented by other JTIDS Class 2 terminals. The ADDSI protocol is a version of the X.25 Consultative Committee International Telegraph and Telephone (CCITT) protocol that was also adopted for use with the Army Enhanced Position Location and Reporting System (EPLRS) radios. Some JTIDS Class 2 components and the JTIDS Class 2 terminal are shown in Figure 2-1.

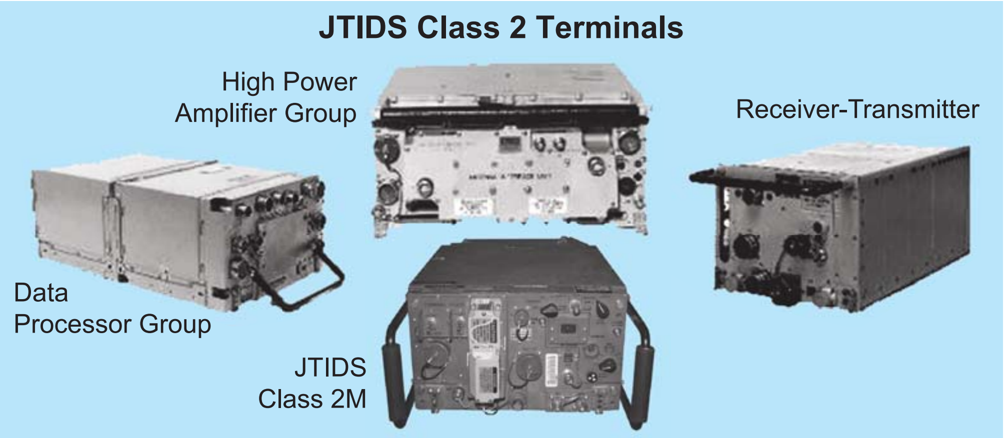


Figure 2-1. Different JTIDS terminals are shown in this figure. The Data Processor Group (DPG) and the Receiver/Transmitter (R/T) are components of the JTIDS Class 2 terminal. Some platforms, notably AWACS, add the High Power Amplifier Group (HPAG) to their Class 2 terminals. The JTIDS Class 2M terminal is part of the Army Data Distribution System Interface (ADDSI).

TERMINAL TYPE	HOST INTERFACE	TACAN	VOICE	HPA	APPLICATION
JTIDS Class 1	MIL-STD-1553B	X	X		NATO CRCs
JTIDS Class 2	MIL-STD-1553B	X	X		RJ, JSTARS, CB, CS, SS, CC
JTIDS Class 2H	MIL-STD-1553B	X	X	X	USMC ADCP, TACC, TAOC USN C2 Ships; E-2C USAF E-3 AWACS, MCE, TAOM
JTIDS Class 2M	ADDSI (X.25)				US Army Air Defense Platforms

Figure 2-2. Several "classes" of JTIDS terminals have been produced that vary in size, capability, and host interfaces.

MIDS Terminals

The MIDS LVT terminals are reduced in size and cost from the original JTIDS terminals. With their secure JTIDS waveform, they are fully interoperable with other Link 16 terminals. As with the JTIDS terminals, there are several variants of the MIDS terminal that differ in size, capabilities (as defined by installed subassemblies), and data bus interfaces to their host platforms. Additionally, “Platform Type” interfaces are defined based on the type of messages exchanged between the host platform and the terminal. As of this writing, Platform Types A through P have been defined.

LVT-1

The **MIDS LVT-1** terminal is intended for airborne application. This terminal transmits and receives both data and voice, and also has an integrated TACAN system. The LVT-1 is composed of a main terminal (MT) and a separate remote power supply (RPS). The LVT-1 implements four different interfaces that may be used to convey the data to and from the Link 16 host:

- A MIL-STD-1553B low-speed avionics data bus
- A STANAG 3910 high-speed avionics data bus
- An ISO X.25-compliant data bus, and
- An Ethernet data bus used for testing and data recording.

Variants of the LVT-1 terminals, designated LVT-4 through LVT-10, have been developed to accommodate the needs and interfaces of specific host platforms, including shipboard applications. These terminals are variants of the basic LVT-1, excluding the TACAN and/or voice capabilities, but incorporating different interfaces for data bus, Platform Type, and power, and possibly utilizing an HPA to accommodate a specific platform’s needs.

■ LVT-2

The MIDS LVT-2 terminal is intended for ground-based installation. It was designed to be a "form, fit, and function" (FFF) replacement for the JTIDS Class 2M. The LVT-2 has neither voice nor TACAN capabilities. The terminal is composed of a main terminal, a power supply, and a cooling unit that are integrated on a single chassis. The LVT-2 implements three different types of interfaces for exchanging information between the terminal and the host:

- A dual-channel ADDSI X.25-compliant data bus
- Ethernet TCP/IP (Platform Type J protocol)
- Ethernet TCP/IP (JREAP C protocol).

A variant of the LVT-2 terminal, which is designated the LVT-11, has the Voice capability.

■ LVT-3

The MIDS LVT-3 is commonly referred to as the **Fighter Data Link (FDL) terminal**, a designation derived from the MIDS terminal's implementation aboard the F-15A-E. As with the LVT-2, the LVT-3 was designed as an FFF replacement for the JTIDS Class 2 terminal in the F-15. The FDL is composed of a Main Terminal and a Remote Power Supply, but it weighs much less than the LVT-1 terminal. The FDL implements the MIL-STD-1553B interface, but it has neither the voice nor the TACAN capabilities.

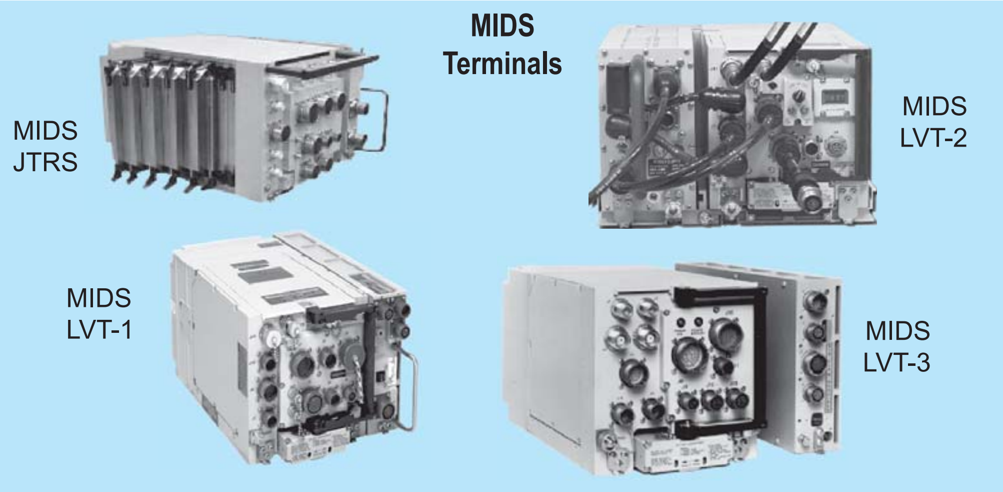


Figure 2-3. Examples of the MIDS and MIDS JTRS terminals are shown in this figure. The first MIDS Low-Volume Terminal (LVT-1) was originally intended for airborne applications but has also been adapted for shipboard use. The MIDS LVT-2 is installed in Army ground-based units and will eventually replace the Army's JTIDS Class 2M terminals. The MIDS LVT-3, aka Fighter Data Link (FDL), is installed aboard the F-15A-E fighter aircraft. The MIDS JTRS terminal, which is based on the LVT-1, will add three programmable channels to run various communications, navigation, and Command and Control waveforms.

TERMINAL TYPE	HOST INTERFACE	TACAN	VOICE	HPA	APPLICATION
MIDS LVT-1	1. MIL-STD-1553B (Platform A) 2. STANAG 3910 (Platform C) 3. Ethernet (Platform D) 4. X.25 (Platform E) [nonfunctional]	✓	✓		FA-18, EA-6B, EA-18G, Eurofighter 2000, Rafale
MIDS LVT-2	1. Dual ADDSI X.25 2. Ethernet (Platform J) 3. Ethernet (JREAP C)				US Army Ground C2 units USAF Ground Systems Canada Air Force and Army Ground Stations
MIDS LVT-3	1. MIL-STD-1553B				USAF F-15A-E
MIDS LVT-4	1. MIL-STD-1553B 2. Ethernet (Platform D)		✓		NATO Air Command and Control System (ACCS) (Spain/Germany) Ground C2 (Italy) Ship (Italy)
MIDS LVT-5	1. MIL-STD-1553B (Platform B)		✓	✓	USN Ships (aka MIDS-on-Ship)
MIDS LVT-6	1. MIL-STD-1553B (Platform A) 2. Ethernet (Platform D)	✓			USAF F-16, EPAF F-16
MIDS LVT-7	1. MIL-STD-1553B 2. Ethernet (Platform D)				B-2, ABL
MIDS LVT-8	1. MIL-STD-1553B 2. Ethernet (Platform D)		✓	✓	Army/Ship & Ground C2 (France)
MIDS LVT-9	1. MIL-STD-1553B 2. Ethernet (Platform D)		✓		Surface-to-Air Missile Operations Center (SAMOC) (Germany)
MIDS LVT-10	1. MIL-STD-1553B 2. Ethernet (Platform D)				Ship (Spain)
MIDS LVT-11	1. Dual ADDSI X.25 2. Ethernet (Platform J) 3. Ethernet (JREAP C)		✓ ✓		Canada Air Force Ground Stations USAF Ground Platforms USAF JICO Support System

Figure 2-4. The MIDS LVT variants shown here have been produced to accommodate varying host interfaces and capabilities.

■ MIDS JTRS

MIDS JTRS, an engineering change proposal to the MIDS LVT, uses the same form factor as the LVT-1. The initial product baseline will provide the current MIDS Link 16 and TACAN functions, with three additional programmable channels to run various communications, navigation, and command and control waveforms. The MIDS JTRS terminal will be capable of running next-generation communication protocols, including the Wideband Networking Waveform (WNW) and a low-latency communication subnetwork for time-critical applications. The terminal will also be able to host and provide the necessary computer processing to run routing and platform-specific applications, allowing for lower cost integration into host platforms.

Section B

Terminal Functional Architecture

☐ JTIDS Terminal Architecture

■ Class 2 and Class 2H

The **Class 2 and 2H** terminals consist of three functional components:

- An **Interface Unit (IU)**, which interfaces the terminal to the Link 16 host platform
- A **Digital Data Processor (DDP)**, which performs the JTIDS functions, and
- A **receiver/transmitter (R/T)** with associated antenna system.

Input messages from the host are received by the **Subscriber Interface Computer Program (SICP)**, which executes within the IU component of the terminal. Output messages are transmitted by the terminal to the tactical host or mission computer over the same interface.

Within the DDP is the **Network Interface Computer Program (NICP)**, which accomplishes synchronization, encryption, and passing data to and from the transceiver. The DDP also contains either a Plain Text Processor (PTP) and a Cypher Text Processor (CTP), or a single Common Signal Processor (CSP). The transfer of information among these processors is accomplished through shared Global Memory. The data exchanged between the SICP and the NICP is defined by data transfer blocks (DTBs), as explained later in Section E. Information exchanged between the NICP and PTP or CSP is defined by means of housekeeping words also written in Global Memory, as explained in Section F.

■ Class 2M

The Army **Class 2M** terminal's data processing section consists of a central processing unit (CPU) and associated memory. The CPU handles network interface functions via the Network Interface Program Group (NIPG), the same function performed by the Class 2 and Class 2H NICP. The NIPG also provides an interface, via

Terminal Global Memory, to the Subscriber Interface Program Group (SIPG). The SIPG interfaces with the host processor and performs Army-unique functions, such as Variable Message Format (VMF) message handling, over-the-air initialization, and coordinate conversions. Like the SICP, the SIPG performs IJMS – J-series message translations. The SIPG, however, is not tailored to any particular Army host platform. The SIPG and NIPG together comprise the Data Processor Computer Program (DPCP). In fact, the NIPG is identical to the Class 2 and Class 2H NICP, but was renamed simply so it could be combined with the SIPG into the DPCP.

In the Joint environment, there exist multiple variants of the SICP software, because other services have employed different host interfaces to their JTIDS terminals. The Army DPCP ensures that the Class 2M terminal will communicate properly with these other terminals regardless of SICP version. Consequently, software modifications to the Army SIPG are relevant only to the JTIDS Class 2M terminal and its ADDSI Host interface. By the same token, changes to the Air Force's E-3 version of the SICP are applicable only to the Air Force's Class 2H terminal.

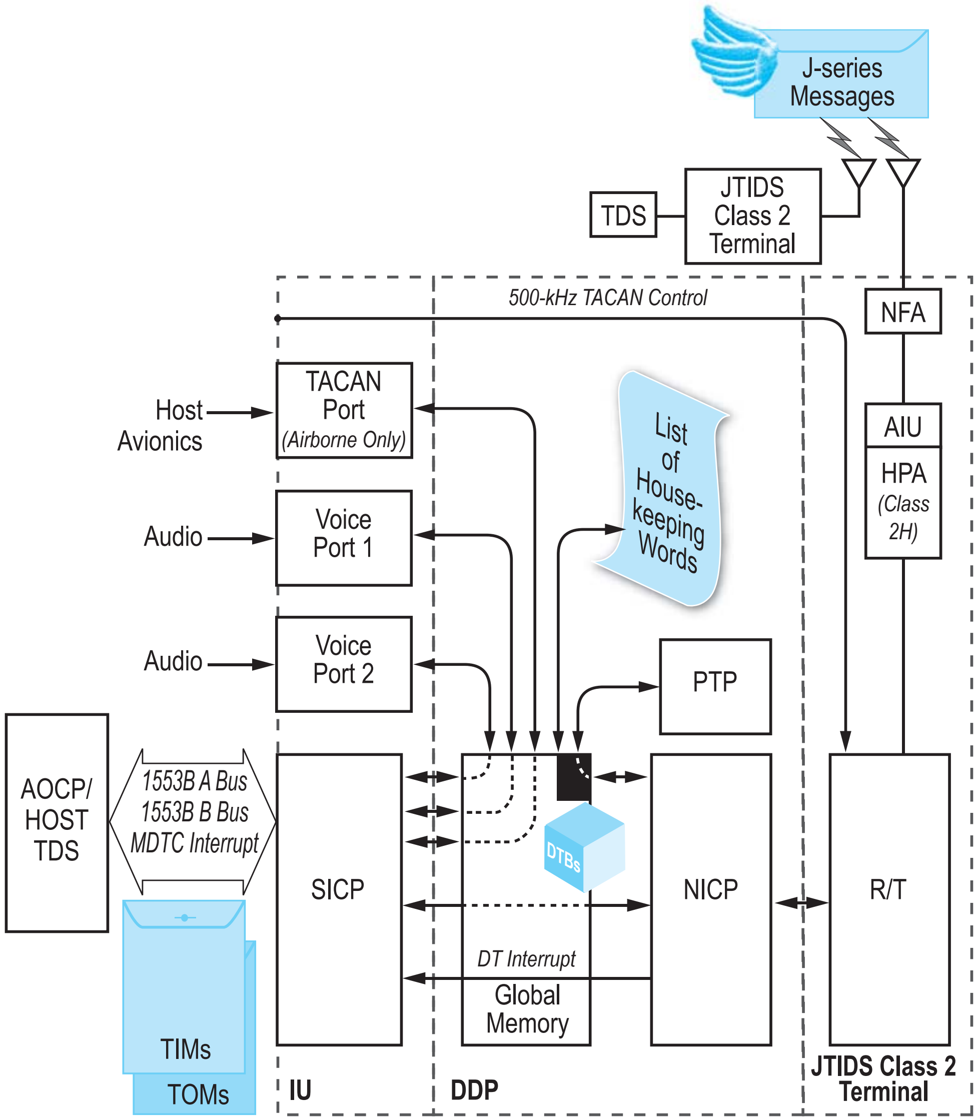


Figure 2-5. JTIDS Class 2/2H terminal architecture. Note: Class 2M architecture is similar, with differences noted in the description below.

MIDS Terminal Architecture

Within the Main Terminal of the MIDS are three functional sections: a terminal Input/Output (I/O) section that handles data transfer between the terminal and the host platforms; a data processing section that provides signal and message processing; and a radio frequency (RF) section for transmitting and receiving the RF signal.

Input messages from the host are received via the I/O section of the terminal. The I/O section provides a data path between the host interface and the data processing section. The computer programs operating within the I/O section vary dependant upon the LVT variant: for the LVT-1 the interface is provided by the Tailored Input/Output (TIO) computer program; the ADDSI computer program for the LVT-2/11, and the FDL Input/Output (FIO) for the LVT-3. The input messages are passed through the I/O section to the Core computer program in the processing section. The LVT-2/11 terminals have an additional Core–Subscriber Interface Army (CSIA) that converts the ADDSI X.25 messages to a format similar to the output of the TIO, so that it can be processed by the Core. Messages are then passed to the Signal/Message Processor (SMP) for encoding and conversion to RF signals and subsequently passed through the RF Amplifier and the I/O section to the antenna for transmission.

The transfer of information among processors within the terminal is accomplished through shared VME memory and is defined by Data Transfer Blocks (DTBs), as explained later in Section E.

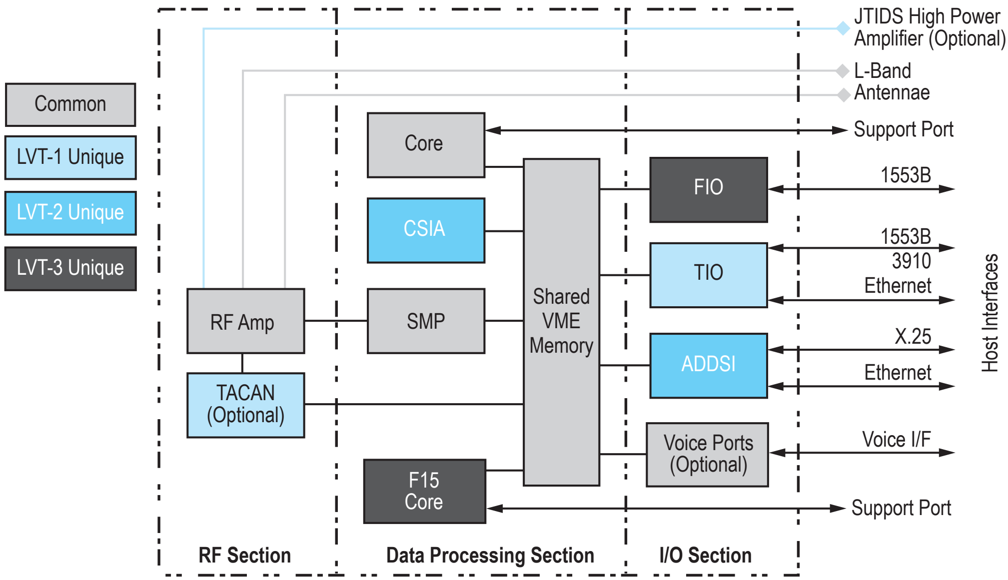


Figure 2-6: The MIDS LVT-1 and LVT-2 functional hardware layout is shown.

Section C

Terminal Message Transfer

Message transfer between the host and the JTIDS Class 2 and 2H terminals over the MIL-STD-1553B multiplex bus is defined by Terminal Input Messages (TIMs) and Terminal Output Messages (TOMs). MIDS LVT data exchange, on the other hand, consists of separating functional exchanges from physical exchanges. A MIDS functional data exchange is defined by Functional Input Messages (FIMs) and Functional Output Messages (FOMs) (which are similar to the JTIDS terminals' TIMs and TOMs) that pass data between the Host and the Terminal, the rules to exchange them, and associated application-level protocols. FIMs and FOMs are aggregates of data elements, grouped by function. The definitions of FIMs and FOMs also contain the layout of these data elements. FIMs and FOMs do not depend on the medium used to convey them. The physical message exchange is defined by Bus Input Messages (BIMs) and Bus Output Messages (BOMs). A BIM or BOM can contain one or more FIMs or FOMs. The two exceptions to MIDS terminal FIMs and FOMs is the MIDS LVT-3 terminal, which exchanges JTIDS-formatted TIMs and TOMs, and the LVT-2 and LVT-11, which exchange ADDSI data packets on the X.25 interface.

☐ Message Transfer from Host to Terminal (Except ADDSI)

TIMs and FIMs are the data structures sent from the tactical host or mission computer to the Link 16 terminal. They contain the host's own tactical data to be transmitted on the network, as well as initialization, status, navigation, and other data types. Typically, these data words contain tactical data going out from the local unit to the network, but they may also contain data specifically for the terminal itself.

TIMs and FIMs transfer data from the host to the terminal.

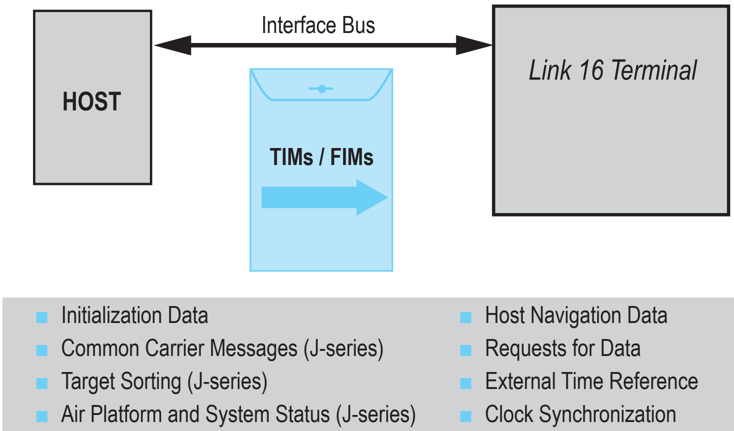


Figure 2-7. The host sends information to the terminal using TIMs or FIMs. On airborne platforms, the host is the mission computer; at ground-based installations, the host is the tactical computer.

Message Function	JTIDS Class 2 (CRC)	MIDS LVT-6 (Platform A)	MIDS LVT-2 (Platform J)	MIDS LVT-3 (FDL)
Initializes the terminal	TIM 1	FIM 2	FIM 2	TIM 1
Conveys initialization data changes	TIM 1	FIM 3, 27, 28	FIM 3	TIM 1
Conveys status data request	Varies by Platform	FIM 2	FIM 2	TIM 7
Carries outgoing J-series ("Common Carrier" messages) from own unit's tactical or mission computer to the terminal on an as-required basis, using as many TIMs/FIMs as needed	TIMs 2 - 11	FIM 1	FIM 1	TIMs 2, 29, 30
Conveys host and operator requests for data on Terminal control settings (such as IPF or NAV reset), TN updates, PPLI data, Aircraft model, Operator acknowledgments	Varies by Platform	FIM 2	FIM 2	TIM 7

Figure 2-8. Certain TIMs and FIMs (continued on next page)

Message Function	JTIDS Class 2 (CRC)	MIDS LVT-6 (Platform A)	MIDS LVT-2 (Platform J)	MIDS LVT-3 (FDL)
Provides navigation data from own unit's navigation system to the terminal	Varies by Platform	FIM 10	FIM 10	TIM 8 (F-15A/B/C/D) TIM 9 (F-15E)
Used by the Host to reprogram the value of the Terminal Maintenance Parameters		FIM 21	FIM 21	
Provides terminal with precision position data from EGI blended solution	Varies by Platform	FIM 10	FIM 10	TIM 10 (F-15E)
Interrogates specific locations in the terminal's memory	TIM 16 TIM 18 (Class 2M)			TIM 7
Provides terminal with the MUX bus data word time of synchronization to the mission computer's clock.	TIM 30			TIM 11 (F-15E)
Conveys an external time reference, such as Coordinated Universal Time (UTC) from the GPS to the terminal	TIM 18	FIM 4	FIM 11	TIM 28 (F-15E)
Performs MUX control	TIM 29			TIM 29
Used by a Host to (de) register the FIMs/FOMs that it will allow to be exchanged for the associated connection			FIM 55	
Used by a Host to (de) register desired FOM 01 characteristics (Free-Text, IJMS, label/sublabel) for the associated connection			FIM 56	
Used to open, maintain and terminate a connection between a Host (client) and Platform J Terminal (server).			FIM 58	
TACAN Control Type 1		FIM 12		

Figure 2-8. Certain TIMs and FIMs convey J-series messages from a unit's own tactical or mission computer to the network at large. Other TIMs and FIMs convey incoming tactical data from the network, as well as both operator-input and other data types, such as navigation data and Global Positioning System (GPS) time. The F-15, JSTARS, and Rivet Joint (RJ) all use the TIMs defined in the FDL (F-15) interface.

Message Transfer from Terminal to Host (except ADDSI)

TOMs and FOMs are the data words sent from the Link 16 terminal to the tactical or mission computer. They typically contain Link 16 data (J-series messages) received from the network. They may also contain terminal status information, performance statistics, confirmation of control setting changes made by the operator, and data destined for an optional instrumentation data-recording device. Also available are the status of transmission and the receipt/compliance status of certain messages.

TOMs and FOMs transfer data from the terminal to the host.

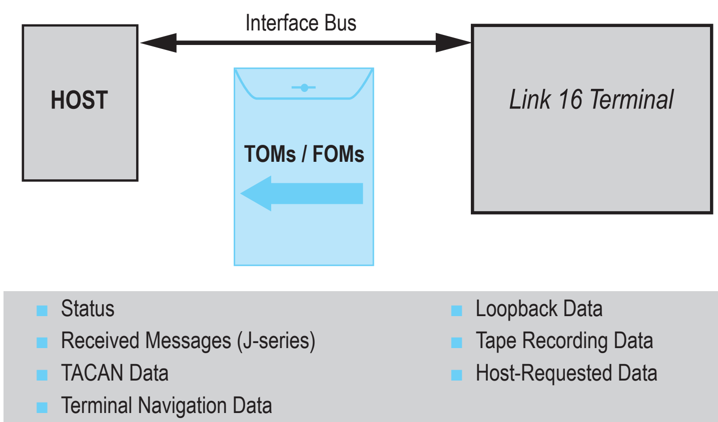


Figure 2-9. The terminal transfers information to the host using TOMs or FOMs.

Message Function	JTIDS Class 2 (CRC)	MIDS LVT-6 (Platform A)	MIDS LVT-2 (Platform J)	MIDS LVT-3 (FDL)
Convey J-series messages from the Link 16 network to own unit's tactical or mission computer	TOMs 2 – 20	FOM 1	FOM 1	TOMs 2 – 20
Report message transmission status and R/C responses to FIMs requiring R/C	TOM 1	FOM 2	FOM 2	TOM 1
Convey BIT status information, global results of BIT, 1st approach to fault isolation, init and sync states	TOM 1	FOM 3	FOM 3	TOM 1
Convey initialization and status data response	TOM 1	FOM 4	FOM 4	TOM 29 (F 15E)
Report acknowledgement status on the acceptance of initialization data changes on the Current Use Set		FOM 5	FOM 5	
Notify the Host of changes made to the Current Use Set by sources other than the Host (OTA, support port, etc.)		FOM 6	FOM 6	
Report to the Host changes to time slot reallocation (TSR) pools.	TOM 1	FOM 7	FOM 7	TOM 1
Convey TACAN data type 1		FOM 9		TOM 29
Convey transmission queue status		FOM 12		
Navigation Status Data	TOM 30	FOM 17	FOM 17	TOMS 21 – 27
Recording Data	TOMs 21 – 27	FOM 18	FOM 18	TOMs 21 – 27
Common BIT		FOM 29	FOM 29	
Acceptance/rejection in response to FIM 55 list of FIMs/FOMs the Host has (re) designated for			FOM 58	
Acceptance/rejection of FOM 01 characteristics the Host has (de) registered for via FIM 56			FOM 59	
Terminal response to each FIM 58 client Connection Request			FOM 61	
Transmit Slots Reporting	TOM 27	FOM 31		TOM 28

Figure 2-10. TOMs and FOMs (continued on next page)

Message Function	JTIDS Class 2 (CRC)	MIDS LVT-6 (Platform A)	MIDS LVT-2 (Platform J)	MIDS LVT-3 (FDL)
Provides information requested by host's interrogation of specific location in terminal's memory	TOM 28			TOM 28
Provides net selection status and mission-related data	TOM 29			TOM 29
Provides terminal multiplexing (MUX) status	TOM 30			TOM 30
Time of Day strobe beginning each network second		FOM 8		

Figure 2-10. TOMs and FOMs convey J-series messages from the Link 16 network to a unit's tactical or mission computer. The MIDS LVT-3 FDL TOMs are sent from the fighter's terminal to its mission computer. The F-15, JSTARS, and RJ all use the TOMs defined in their individual interface control documents.

☐ ADDSI Message Transfer

The JTIDS Class 2M and the MIDS LVT-2 and LVT-11 have all implemented the ADDSI X.25 interface for use with Army Air Defense Systems. Each terminal is configured with a Dual Port ADDSI card that allows two simultaneous serial Conditioned Diphase (CDP) connections. The first port, the host channel, is used by the host computer for exchanging J-series messages, initialization, and status data. The second port, the control channel, is used to initialize, control, and monitor the terminal.

Although these functions can be accomplished via the host channel, most systems prefer to use the control channel with a dedicated initialization device running Common User Interface (CUI) software developed by the Army specifically for that purpose. The ADDSI interface typically operates at a 64 kbps baud rate for both the host and control channels; however, the host channel can vary between 8 kbps and 1024 kbps if desired.

J-series messages are exchanged over the host channel via data packets containing up to 128 bytes per packet. Data packets are normally preceded by Control Data packets (Q-bit packets), which contain information needed by the host system or terminal to allow for the proper processing of the forthcoming data packet that contains J-series messages. The J-series messages are grouped by Network Participation Group (NPG), such as Surveillance or Air Control.[1]

When a Class 2M terminal receives RF data, it transmits it to the host over the ADDSI interface on **Logical Channel Numbers (LCNs)**. LCNs on the ADDSI interface can be thought of as permanent virtual circuits, some of which correspond to a particular NPG. LCN 224 is reserved for NPG 0, and LCNs 225 – 255 correspond to NPGs 1 – 31 sequentially. Therefore, LCN to NPG mapping can be determined by adding the NPG number to LCN 224. For example, J-series messages relating to tracks and track management would be transmitted over RF on NPG 7, the Surveillance NPG. Those same messages would then be transmitted to the host over LCN 231 (LCN 224 + 7).

The ADDSI interface separates J-series messages into logical channels, called LCNs.

Likewise, a host will transmit an outbound J-series message and control data over the LCN corresponding to the NPG that the terminal will use to transmit the message. When a J-series message is received in an unassigned timeslot, the terminal will transmit that message to the host on LCN 4, which is the default LCN for received messages when the NPG is not known.

Typically, LCNs 0, 3, and 4 are always active on the ADDSI interface. LCNs greater than 224 are active based on initialization and Radio Control Parameter (RCP) data. Generally, an LCN will be active when a valid transmit or receive assignment corresponds to a particular NPG. LCN 0 is used for low-level communications only. LCN 3 is used to transmit data requests and responses for initialization, status, and RCP data. Figure 2-12 shows the types of messages exchanged, and their functions, across the ADDSI X.25 interface.

1 *The NPGs are discussed in Chapter 5, Section A.*

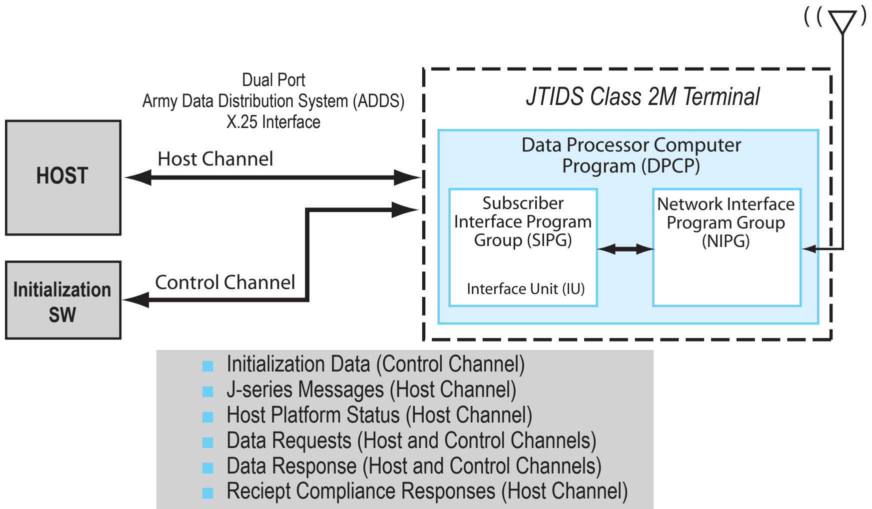


Fig 2-11. Army Air Defense Platforms communicate with JTIDS Class 2M or MIDS LVT-2 and LVT-11 terminals via an Army Data Distribution System (ADDS) Conditioned Diphase X.25 Interface. The terminals are configured with a dual-port serial interface card to accommodate both the host and control interfaces. Initialization and control of the terminal is accomplished using the Common User Interface, software running on a stand-alone computer such as a Maintenance Support Device (MSD) laptop or as a stand-alone executable running on the host computer. With the exception of the Air Defense Systems Integrator (ADSI®), most Army Air Defense platforms do not forward data between Link 16 and Link 11 or Link 11B.

JTIDS Class 2M and MIDS LVT-2 and 11 ADDSI X.25 Host Interface Message Exchange			
Host-to-Terminal Msgs	**Function**	**Terminal-to-Host Msgs**	**Function**
LCN 3 Packets		**LCN 3 Packets**	
Receipt Compliance Response Blocks	Response to a FWF Msg requiring a response	**Message Transmission Status Data**	Message transmission status will be provided to the host whenever the internal status of an interrogated message changes
Data Request Blocks	Request for current values of Initialization, RCP, and Status Data	**Data Request Response Blocks**	Responses for current value of initialization, RCP, and Status data
Initialization Data Request	Periodic request of the initialization data the host uses for its own processing	Initialization Data Request Response	Provides the host with initialization data such as Time Slot Assignments for its own processing
Radio Control Parameter Data Request	Periodic request of RCP data for each NPG with a valid transmit assignment	Radio Control Parameter Data Request Response	Provides the host with RCP data for each NPG which has a valid transmit assignment for its own processing
Status Data Request	Request to periodically poll the terminal for current status	Status Data Request Response	Provides the host with the current status of the terminal
Control Data Packets	Sent by the host to temporarily overwrite the RCP parameters governing the transmission of FWF messages and request Msg transmit status for R/C responses	**Control Data Packets**	The terminal will send FWF Control Data packets preceding each FWF Data packet
Data Packets		**Data Packets**	
FWF Message Data	Link 16 Message Data sent to the terminal for transmission	**FWF Message Data**	Link 16 Message Data sent to the host for processing

Figure 2-12. J-series messages are exchanged across the ADDSI X.25 interface via Data Packets containing Fixed Word Format (FWF) messages. Other message types are also exchanged using Control Data packets (Q-bit packets) and Logical Channel Number (LCN) 3 packets.

Section D

The Multiplex Cycle

An orderly MUX cycle prevents the host and the terminal from attempting to access the same data buffer at the same time. Between a tactical host and a terminal using the 1553B interface, the exchange of input and output messages takes place cyclically, during what is called the multiplex (MUX) cycle. TIMs/FIMs may be sent to the terminal at any time during this cycle, but access to the TOM/FOM buffers is controlled to avoid collisions between the host and terminal. Which system has access is governed by an interrupt, which is called the MUX Data Transfer Complete Interrupt (MDTCI). For the 10 milliseconds immediately following this interrupt, the terminal has authorization to update the output message buffers. The buffer for each output message type is updated only when required. Following this 10-ms interval, the host may read the data for as long as necessary. When the host has finished reading the buffers, it signals its completion by writing a TIM 29 message, causing another MDTCI to be generated and the start of the next MUX cycle. The length of each cycle varies, but must be at least 20 milliseconds.

The terminal sends its host a complete status update once per frame.

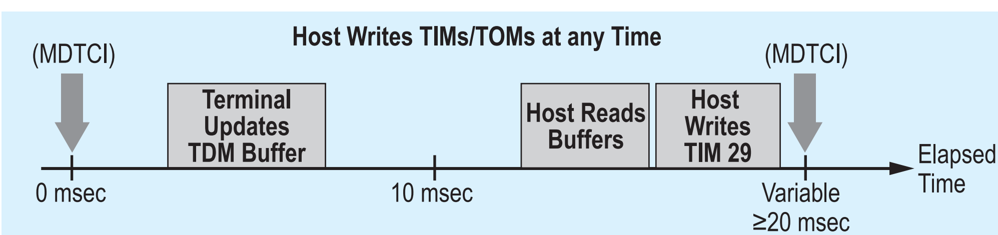


Figure 2-13. Host-generated interrupts define the timing of the MUX cycle and control the exchange of data and status information between the host and terminal.

Section E

Data Transfer Blocks

☐ JTIDS Data Transfer Process (DTBs)

J-series messages contained in the TIMs passed from the host to the JTIDS terminal's SICP must next be passed to the NICP executing in the DDP. Global Memory within the DDP is used for this purpose and is accessed by the SICP and the NICP using the Plain Text Bus (PTB). Information is exchanged between these two programs in data transfer blocks, or DTBs.

J-series messages are transferred back and forth within the terminal in DTBs.

DTBs sent from the SICP to the JTIDS terminal's NICP may contain messages for transmission, initialization data, status information, or navigational data. Those sent from the NICP to the SICP, may contain received messages, looped-back messages, navigational data, network configuration information, or message status. In addition, every 12 seconds the NICP generates a complete status report, which includes the quality measurements as well as tabulations of successful and unsuccessful transmissions, receptions, loopbacks, and test messages.

The JTIDS NICP and SICP take turns exchanging data during every time slot.

DTBs are passed from the NICP to the SICP using two sets of buffers. The NICP reads and writes its data immediately following the End-of-Slot (EOS) interrupt, which occurs at the end of each time slot, every 7.8125 milliseconds. After the NICP has filled the first set of buffers with DTBs for the SICP, it generates a Data Transfer Interrupt (DTI) to the SICP. This interrupt is generated even when the NICP has no data for the SICP. The SICP receives this interrupt and reads the buffers. It then writes into a second set of buffers containing DTBs for the NICP.

The End-of-Slot interrupt and the DTI each occur once during every time slot. Together they control the orderly exchange of information in both directions between the NICP and SICP. By counting the DTIs, the SICP is able to maintain a slot count.

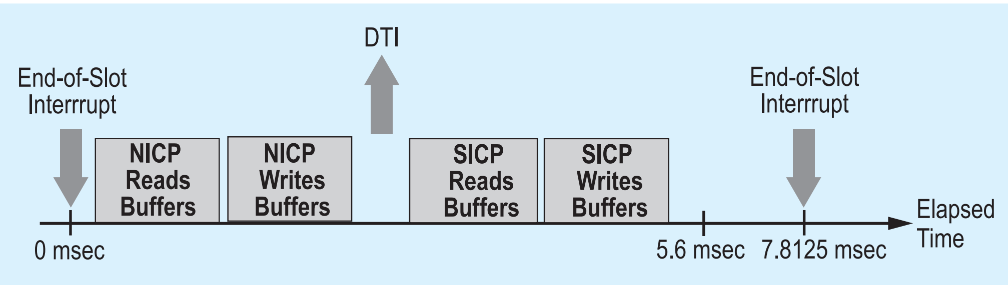


Figure 2-14. End-of-Slot Interrupts and Data Transfer Interrupts (DTIs) control the exchange of data between the NICP and SICP.

□ MIDS Data Transfer Process (DTBs and IDBs)

Because of their structure, MIDS terminals operate differently than JTIDS terminals. Following the EOS interrupt, the I/O processor (TIO for LVT-1, ADDSI for LVT-2, and FIO for LVT-3) reads data from the host input data buffers and the Core output data buffers, and processes the host input data. It then transfers the processed host input data to the Core input buffers, processes the Core output data, and transfers the Core output data to the host output data buffers. Simultaneously, the Core reads data from the Core input buffers, as well as from the output buffers of the Signal Message Processor, Voice Processor, and Ground Processor, and processes the data as required. It then loads data into the Core output buffers for the TIO, SMP, and GP.

Remember that in the LVT-1 and variants—the Core, TIO, SMP, and GP—are running in parallel, on independent processors. In the case of the LVT-2 and LVT-11, the Core and CSIA share the same processor.

Section F

JTIDS Housekeeping Words

Within the JTIDS Class 2 terminal, the PTP has access to Global Memory by means of the PTB. During every time slot, the NICP provides the PTP with 35 "housekeeping words," which contain:

- Decryption information for slot *n*
- Encryption information for slot *n*+1
- Transmission control information, such as the message header, source track number (STN), secure data unit (SDU) locations for Message Security (MSEC) and Transmission Security (TSEC) cryptovariables, and time adjustments for antenna cable delays
- Input status, including message-received indicator, antenna identification, and SDU status
- The terminal's SDU serial number
- External time references
- A relay tag
- A unique variable update number
- The built-in test (BIT) status of the Receiver/Transmitter (R/T) and PTP.

The exchange of information between the NICP and PTP, which is strictly controlled, is based on an end-of-slot interrupt signal from the DDP. The NICP reads the 18 words from the PTP and writes the 35 housekeeping words for the PTP during every slot, within 5.6 ms of the interrupt. Between 5.6 and 7.8 ms after the interrupt, the PTP reads the 35 words from the NICP and writes the 18 words for the NICP. The location in Global Memory of the data received in time slot *n* will be written to the buffer by the PTP in time slot *n*+1, and retrieved by the NICP in time slot *n*+2.

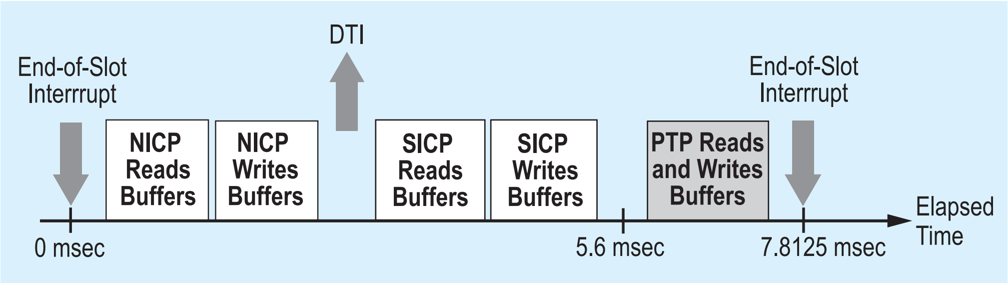


Figure 2-15. The PTP reads and writes data for the NICP in the period between 5.6 ms and 7.8 ms after the end-of-slot interrupt. The NICP retrieves this information when it reads buffers during the next time slot.

Section G

Voice Transmission and Reception

Most Link 16 terminals support two secure voice channels, or ports. JTIDS Class 2 terminals (except the Class 2M) support 2.4 kbps encoded and unencoded voice, and 16 kbps unencoded voice, for both ports. In general, the MIDS terminals (except for the LVT-2, LVT-3, and LVT-6) also support Link 16 voice communications.

Both Link 16 secure voice channels are push-to-talk (PTT).

Voice audio is Reed-Solomon encoded (for 2.4-kbps voice) and digitized. However, the JTIDS Class 2 terminals employed in the CRC platforms use external voice encoders (vocoders) on both ports, rather than the voice encoding function in the IU of the terminal. Control of each voice channel is provided by a push-to-talk (PTT) protocol. Note that even though the digitized voice is not encoded for error correction, it is still encrypted, and is therefore secure.

When the operator presses the PTT button, two voice buffers are alternately filled with digitized voice data.

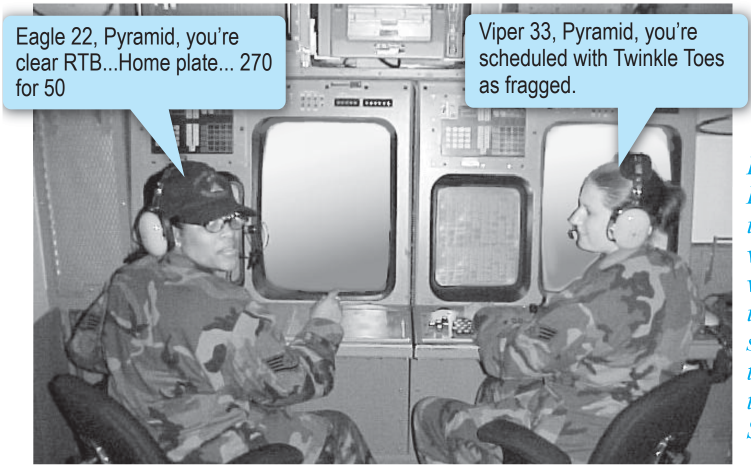


Figure 2-16. The Link 16 network may include two secure voice ports operating without error encoding at 16 kilobits per second. Voice continues to operate when the terminal is set to Data Silent.

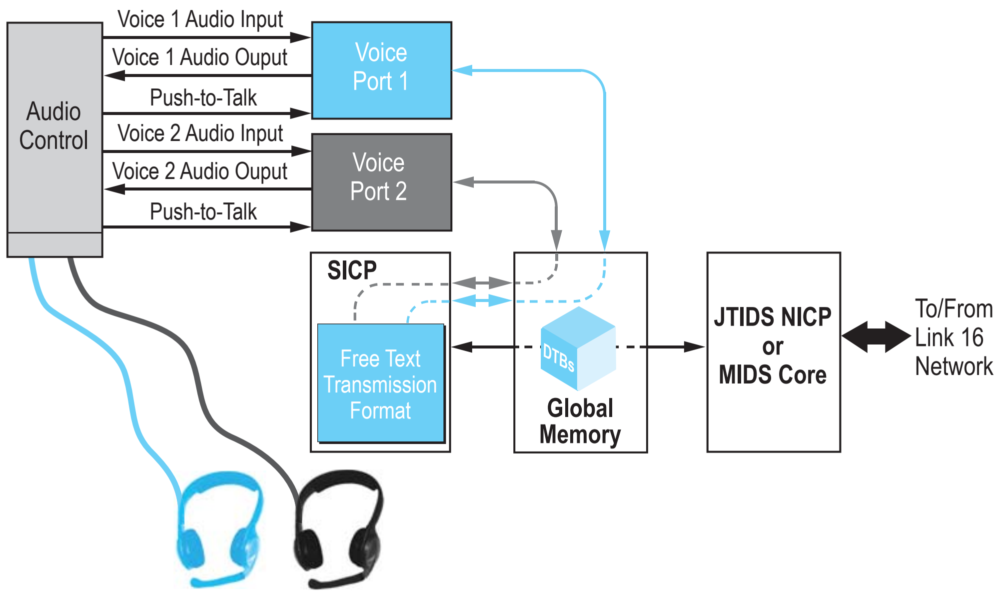
During voice reception, digitized data is converted back to audio.

In the JTIDS Class 2 terminals, digitized voice data is transferred between the SICP and the two digital voice ports through several buffers located in Global Memory. The SICP supplies two transmit buffers and two receive buffers for each voice port. The voice buffers hold a maximum of 450 bits, as required for non-error-corrected digitized data. Upon a PTT command, the voice port obtains the transmit buffer address from Global Memory and starts loading the buffer with digitized voice. When the buffer is full, it sets a flag to notify the SICP and, if the PTT signal is still present, begins loading the second transmit buffer. The SICP unloads the data and transfers it in a DTB to the NICP for transmission. After the second buffer is full, the voice port signals the SICP and switches back to the first. Alternately switching back and forth between the two buffers continues until the PTT is removed. When the PTT is removed, the voice port switches to reception processing.

Unencoded JTIDS secure voice degrades more quickly than encoded JTIDS data.

When the SICP receives a voice message from the NICP, it stores the received digital data in the first voice receive buffer and sets a flag for the voice port. The voice port retrieves the digitized data as it becomes available. The SICP alternates between the first and second buffers until there is no more data, or until the PTT is issued locally.

Practical experience indicates that JTIDS voice remains understandable with up to a 10 percent bit error rate in the reception, compared to a 50 percent bit error rate for encoded data. Therefore, JTIDS voice will degrade and become unusable before JTIDS data.



	Port 1	Port 2
Optional External Vocoder	2.4 kbps Encoded	2.4 kbps Unencoded
	16 kbps Unencoded	16 kbps Unencoded

Figure 2-17. Voice audio is digitized and is passed through Global Memory to the SICP for output to the network as Free Text messages. Voice messages received on the network by the NICP are passed to the SICP. The SICP transfers the digitized voice through Global Memory to the voice port, where it is converted back to audio.

Section H

The JTIDS TACAN Port Interface

Used by the airborne platforms, TACAN is one of the functions supported by most JTIDS/MIDS terminals. The TACAN port of the terminal provides the interface between the host avionics systems and the terminal R/T and DDP.

JTIDS TACAN operates even in Data Silent mode.

On these platforms, the TACAN function of the R/T normally employs a 500-kHz serial channel clock. Synchronized to this clock are serial input and output channels. R/T mode and channel tuning information, as well as zero-distance calibration information, are provided on the input channel. Bearing, range, and range rate are provided on the output channel. There is also an audio Morse code output signal providing the TACAN station identification. F-16 fighters have replaced their ARN-118 TACAN systems with the MIDS LVT-6 TACAN capability.

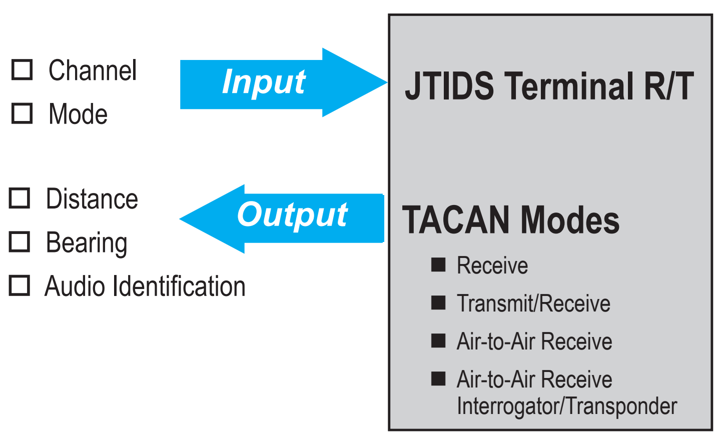


Figure 2-18. The R/T component of the JTIDS terminal provides an independent TACAN function.

Information received from the R/T by the TACAN port is written into Global Memory for the host avionics systems. This information can include range, bearing mode and channel, status, an odometer (distance) reading, range rate, bearing rate, and a BIT summary. Control of the TACAN function from the SICP consists of the TACAN mode and channel, as well as Distance Measuring Equipment (DME) calibration data. The DME calibration data includes delays for antennas A and B and identifies the information the operator desires. TACAN continues to operate when the terminal is set to Data Silent.

Time Division Multiple Access Architecture

CHAPTER 3

Introduction

This chapter describes the Link 16 communications architecture known as Time Division Multiple Access, or TDMA. The Link 16 TDMA architecture includes time slots, sets, and recurrence rate numbers, or RRNs. It also describes the general data structures supported by the network architecture (Fixed Word Format data, Free Text data, header data, Reed-Solomon encoding, and Round-Trip Timing messages, or RTTs), and the modulation techniques employed for encoding this data onto a carrier for transmission during the time slots (cyclic code-shift keying, or CCSK, continuous phase shift modulation (CPSM), pulses, and frequency hopping).

Section A

TDMA and the Link 16 Network

The Link 16 network employs a communications architecture known as Time Division Multiple Access, or TDMA. This architecture uses time interlacing to provide multiple and apparently simultaneous communications circuits. Each circuit, and each participant on the circuit, is assigned specific time periods during which to transmit and in which to receive. This TDMA architecture forms the framework of Link 16 communications.

☐ Epochs, Slots, and Sets

Every 24-hour day is divided by the JTIDS/MIDS terminal into 112.5 **epochs**. An epoch is 12.8 minutes in duration. An epoch is further divided into 98,304 **time slots**, each of which is 7.8125 milliseconds (ms) in duration.

The time slot is the basic unit of access to the Link 16 network.

The time slot is the basic unit of access to the Link 16 network. These basic units, the time slots, are assigned to each participating **JTIDS Unit (JU)** for particular functions. A JU is assigned either to transmit or to receive during each time slot.

A JU is either transmitting or receiving in each time slot..

The time slots of an epoch, in turn, are grouped into three **sets**, named **set A**, **set B**, and **set C**. Each contains 32,768 time slots numbered from zero to 32,767. This number is called the **slot index**. (Three sets × 32,768 time slots = 98,304, the total number of time slots in an epoch.) The time slots belonging to set A, for example, are identified as A-0 through A-32767. By convention, the time slots of an epoch are named in an alternating pattern. The time slots of each set are interlaced, or **interleaved**, with those of the other sets in the following repetitive sequence:

A-0, B-0, C-0,
A-1, B-1, C-1,
A-2, B-2, C-2,
.
.
.
A-32767, B-32767, C-32767

This sequence, ending with slot C-32767, is repeated for each epoch.

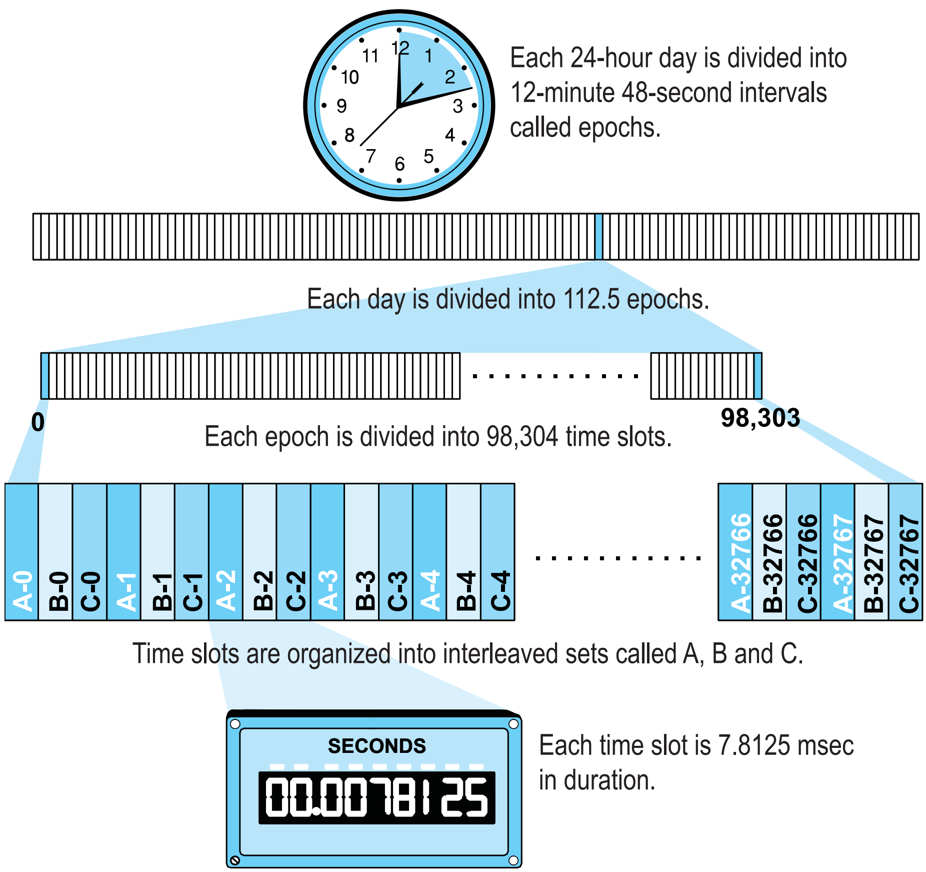


Figure 3-1. The Link 16 TDMA architecture divides a 24-hour day into epochs, sets, and time slots.

☐ Powers and Logarithms

Notice that the number of slots in each set of an epoch is a power of 2. This is not a coincidence, but a consequence of the binary nature of the computers that are used to generate and process messages for Link 16.

n	2n
0	1
1	2
2	4
3	8
4	16
5	32
6	64
7	128
8	256
9	512
10	1024
11	2048
12	4096
13	8192
14	16384
15	32768

Figure 3-2. Powers of 2 are represented by 2n. The powers of 2 relevant to Link 16 are those where n takes on values between 0 and 15.

The *n*th **power** of 2 is calculated by multiplying 2 by itself for n times. By convention, 2 to the 0^{th} power is defined to be 1. The number 2 is called the **base** and number *n* is called the **exponent**. The reverse operation, which converts the power number back to an exponent, is called the **logarithm to the base 2**. Thus, the logarithm (to the base 2) of 16,384 is 14.

☐ Recurrence Rate

The logarithm of the number of slots in the time slot block is called the **recurrence rate number (RRN)**. The recurrence rate indicates how many time slots are in the block and, since they are evenly distributed, how often they occur. The entire set of time slots in set A is 32,768 or 2^{15}. It is distributed every third slot and is identified by the notation A-0-15. Half of the slots in set A would be 16,384 time slots. They would occur every sixth slot and would be designated by an RRN of 14. Half of these would occur every twelfth slot and would be designated by an RRN of 13.

The relationship between RRN and the interval between slots both in number of slots and in time is provided in Figure 3-3. Note that as a consequence of the three-set interleaved structure, 3 is the minimum spacing between slots in the same set. The time between slots can be calculated by multiplying the number of slots in the interval by 7.8125 milliseconds.

The RRN is used to assign how often a JU accesses the Link 16 network.

RRN	Number of Slots per Epoch	Slot Interval		
		Slots	Time	
15	32768	3	23.4375	Milliseconds
14	16384	6	46.8750	
13	8192	12	93.7500	
12	4096	24	187.5000	
11	2048	48	375.0000	
10	1024	96	750.0000	
9	512	192	1.50	Seconds
8	256	384	3.00	
7	128	768	6.00	
6	64	1536	12.00	
5	32	3072	24.00	
4	16	6144	48.00	
3	8	12288	1.6	Minutes
2	4	24576	3.2	
1	2	49152	6.4	
0	1	98304	12.8	

Figure 3-3. The relationship between recurrence rate numbers (RRNs) and the number of time slots per epoch is shown. The recurrence rate is the logarithm to the base 2 of the number of slots in the block. Since the time slots are evenly distributed, both the number of slots and the interval between them can be determined from the RRN.

Frames

The 12.8-minute epoch is too unwieldy a time interval for describing the rapid communications required by Link 16, so a smaller, more manageable, time interval is defined. This basic recurring unit of time in the Link 16 network is called a **frame**. There are 64 frames per epoch. Each frame is 12 seconds in duration and is composed of 1,536 time slots: 512 belonging to set A, 512 belonging to set B, and 512 belonging to set C. The time slots of a frame are numbered from 0 to 511 and are interleaved in a repetitive cycle such that A-0, B-0, C-0 are followed by A-1, B-1, C-1 and are preceded by A-511, B-511, C-511. Frames occur repeatedly, with one following another, for as long as the link is operational. For this reason, a frame is often illustrated by a ring in which slot A-0 follows slot C-511.

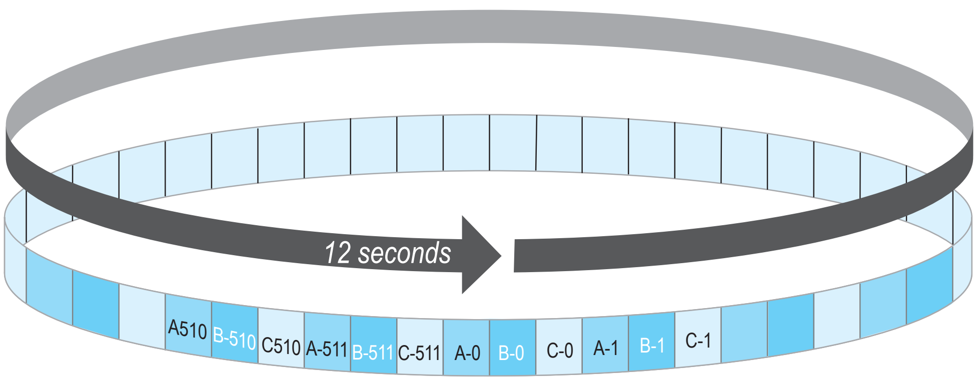


Figure 3-4. A frame consists of 1,536 time slots grouped into interleaved sets A, B, and C, with each set containing 512 time slots numbered from 0 to 511.

RRN	Number of Slots per Epoch	Slot Interval			
		Within Set	Within Interleaved Set	Time	
15	32768	1	3	23.4375	Milliseconds
14	16384	2	6	46.8750	
13	8192	4	12	93.7500	
12	4096	8	24	187.5000	
11	2048	16	48	375.0000	
10	1024	32	96	750.0000	
9	512	64	192	1.50	Seconds
8	256	128	384	3.00	
7	128	256	768	6.00	
6	64	512	1536	12.00	

Figure 3-5. The RRNs relative to the frame are shown. Since one epoch consists of 64 frames, the number of slots per frame is found by dividing the number of slots per epoch by 64. An RRN of 15 represents every slot in a set: 32,768 in the epoch, 512 in the frame. Because the three sets are interleaved, the interval between slots in any one set is actually 3, not 1.

☐ Time Slot Blocks

Time slots are assigned to each terminal in the network as blocks of slots. This block of slots, known as the time slot block (TSB), is defined by three variables: a set (A, B, or C), a starting number or index (0 to 32,767), and the recurrence rate. Up to 64 TSBs may be assigned. RRNs of 6, 7, and 8, which correspond to reporting intervals of 12 seconds, 6 seconds, and 3 seconds, are used most often in TSB assignments.

A terminal's time slot usage is specified by up to 64 TSB assignments.

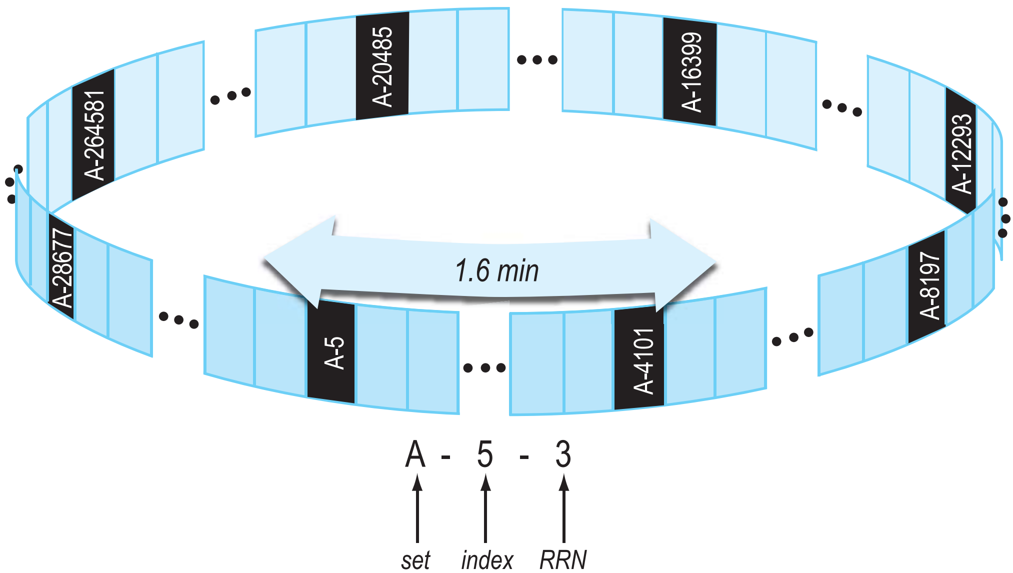


Figure 3-6. Time slots are assigned in blocks by specifying a set, index, and RRN.

■ Mutually Exclusive Sets

For example, the TSB A-2-11 represents the block of time slots belonging to set A that occur every 16th slot within the set beginning at slot 2. (We obtain the value 16 for an RRN of 11 from Figure 3-5.) These are the slots A-2, A-18, A-34, A-50, A-66, ... A-498. In general, they are represented by the expression (2+16*n*), where *n* = 0, 1, 2...31 for the 12-second frame. Similarly, TSB B-2-11 contains the slots B-2, B-18, B-34, B-50, B-66, ... B-498. Observe that although TSB A-2-11 and TSB B-2-11 have identical starting slot indices and RRNs, they nevertheless have no slots in common. They are therefore said to be **mutually exclusive**.

TSBs specifying different sets are mutually exclusive.

The TSB A-7-11 represents the block of time slots belonging to set A that occur every 16th slot beginning with slot 7. These are the slots $(7+16n)$, $n = 0$ through 31: A-7, A-23, A-39, A-55, A-71, ... A-503. Observe that TSB A-2-11 and A-7-11 have no slots in common. These TSBs are also mutually exclusive.

> ***TSBs having the same RRN but different indices are mutually exclusive.***

Notice also that if the index of a time slot block is even, all the time slot numbers in that block are also even. If the index of a time slot block is odd, all the time slot numbers in that block are also odd.

> ***If one index is even and one index is odd, the TSBs are mutually exclusive, regardless of their RRNs.***

Inclusive Sets

Now consider TSBs C-7-11 and C-7-10. From the RRNs it is clear that C-7-10 contains half as many slots as C-7-11. Since the slots are distributed evenly, C-7-10 consists of every other slot of C-7-11. This is clearly shown by listing the slots in each:

C-7-11 contains C-7, C-23, C-39, C-55, C-71, ...
C-7-10 contains C-7, C-39, C-71, C-103, C-135, ...

> ***TSBs having the same set and index but different RRNs are not mutually exclusive. The one with the smaller RRN is a subset of the one with the larger RRN.***

■ Tree Architecture

Time slot blocks interrelate in a tree-like structure. For example, TSB A-0-15 contains every time slot in set A: A-0, A-1, A-2, A-3, and so on. If this block is divided in half (RRN = 14), the two subsets thus formed are denoted by A-0-14 and A-1-14. TSB A-0-14 contains the time slots A-0, A-2, A-4, A-6, and so on. TSB A-1-14 contains A-1, A-3, A-5, A-7, and so on. If these blocks are each divided in half again, the RRN is 13. TSB A-0-14 contains blocks A-0-13 and A-2-13. TSB A-1-14 contains blocks A-1-13 and A-3-13. Continue this process and you will see that the TSB A-5-12 contains time slots that are also contained in the TSBs A-1-13, A-1-14, and A-0-15.

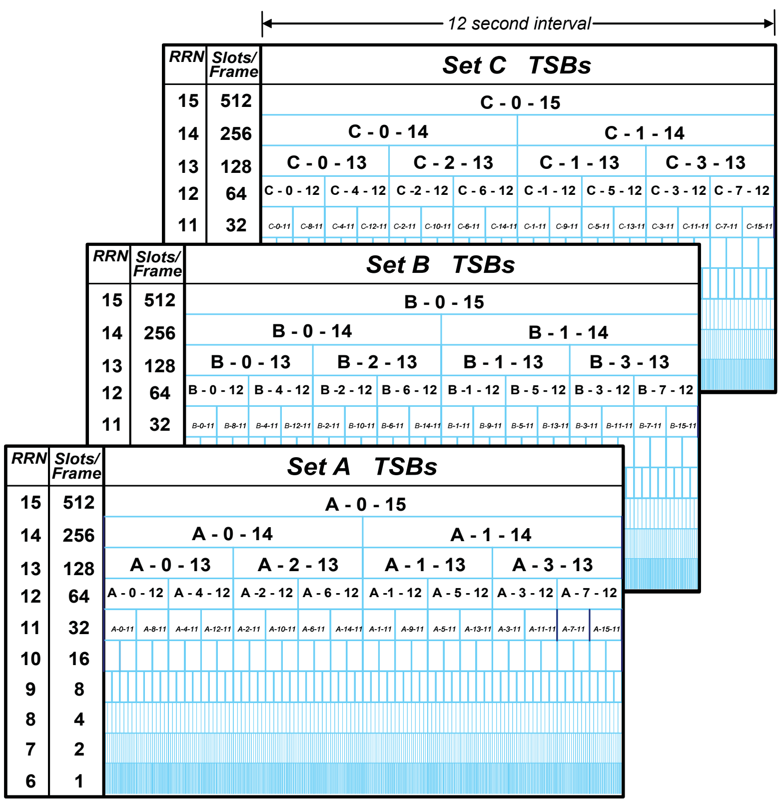


Figure 3-7. Time slot blocks are interrelated in a tree-like structure. Simultaneous transmissions can occur when TSB assignments intersect.

This interrelationship of TSBs is important to remember when making assignments of time slots to participants. Suppose TSB B-196-7 is assigned to one participant for his transmissions and B-4-9 is assigned to another. If the TSBs were not mutually exclusive, both participants would transmit simultaneously.

One way to determine whether the TSBs are mutually exclusive is to list all the slots in each block. The slots represented by an RRN of 7 occur within a set at intervals of 256. Thus, TSB B-196-7 contains the slots numbered ($196+256n$): B-196 and B-452. The slots represented by an RRN of 9 occur within a set at intervals of 64. Thus, TSB B-4-9 contains the slots numbered ($4+64n$): B-4, B-68, B-132, B-196, B-260, B-324, B-388, and B-452. These TSBs are not mutually exclusive; B-196-7 is a subset of B-4-9.

Another way to look at this is to consider the family of TSBs to which a given slot belongs. For example, slot A-52 belongs to the TSB A-52-6, which consists of the single slot. It also belongs to A-52-7, A-52-8, A-52-9, A-20-10, A-4-11, A-4-12, A-0-13, and so on. How do we know the index for each successive RRN? The new index is the original index (52) modulus 2 ($15-r$), where r is the RRN. Thus, A-52 is a member of the TSB with the RRN 10, having the index (52 mod (25)) = 52 mod 32 = 20.

The network structure described above represents only a single net. This is the architecture of the network when the terminal is set to Mode 2. In Mode 2, only the frequency 969 MHz is used, and all messages are assigned to time slots on Net 0.[1]

Recall that synchronized participants exchanging messages is a **network**. By contrast, the time slot structure discussed thus far represents a single Link 16 **net**, which is a unique frequency-hopping pattern for all time slots, used by collection of platforms exchanging information on the same NPG, such as Air Control.

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1 *Further information on communication modes can be found in Chapter 4, Section A.*

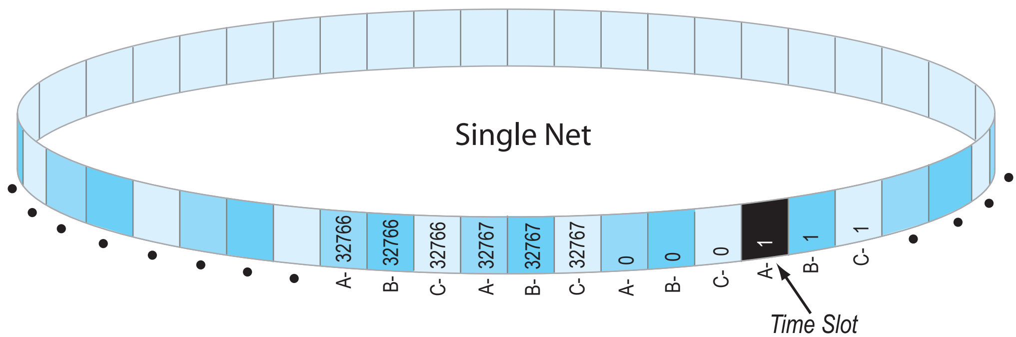

Figure 3-8. The Link 16 single net architecture divides each 12.8-minute epoch into 98,304 time slots.

☐ Multiple Simultaneous Nets

Multiple nets can be constructed by “stacking” several single nets, as illustrated in Figure 3-9. The time slots of these nets are synchronized so that a time slot of one net coincides exactly with the corresponding time slot of every other net. Thus, the multinet architecture contains 98,304 time “slices” per epoch.

Link 16 supports multiple, simultaneous nets.

This multinet architecture allows several groups of participants to exchange messages independent of the other groups, during the same time slot. The 7-bit net number allows a network of up to 128 nets to be constructed. One of these numbers, **net number 127**, is reserved to indicate a stacked net configuration. The remaining nets are numbered from 0 to 126. In a stacked net configuration, the operator selects which net to use during operations. Each net is assigned a unique frequency-hopping pattern for its transmissions. Although it is theoretically possible to define a network containing 127 nets, statistical studies have shown that operating about 20 – 30 nets simultaneously in the same geographical area can cause some degradation in communications.

Each net has a unique pattern of frequency hops.

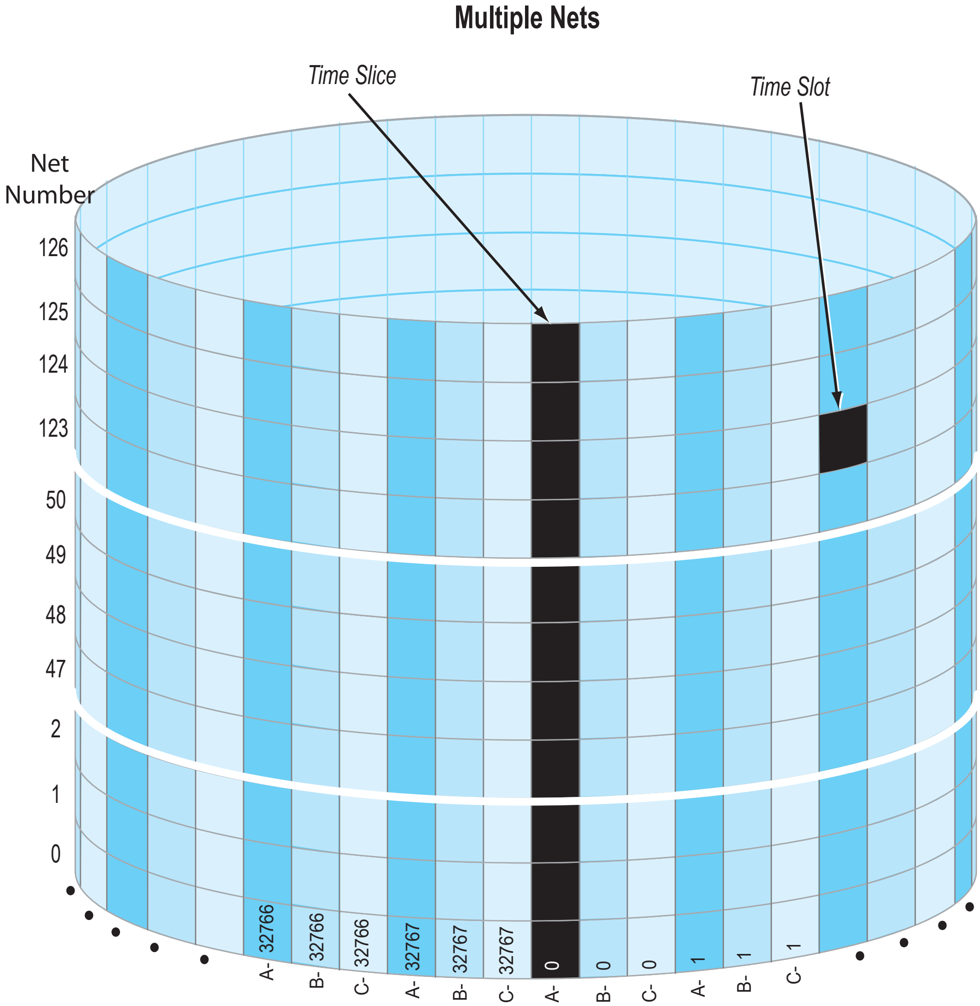

Figure 3-9. The Link 16 multinet architecture stacks 127 of these single net structures with their time slot boundaries aligned. This multinet architecture can be conceptualized by imagining a cylinder of 98,304 time slices.

Synchronization

Networks are currently being operated using a relative time base. With a relative time base, one terminal is designated to be **Network Time Reference** (NTR), and terminals synchronize their time with that of the NTR.[2] The time maintained by this designated terminal defines the **system time** of the Link 16 network. As the reference, this time defines the beginning and end of time slots and ensures the alignment of time slices in the multiple nets. Periodically, the NTR transmits a net entry message to assist other terminals in synchronizing with the network and thereby acquiring system time.

The JTIDS/MIDS terminal automatically synchronizes to the system time of the NTR.

Synchronization, an automatic function of the JTIDS/MIDS terminal, is achieved in two steps. **Coarse synchronization**, the first step, is achieved when a net entry message is successfully received. **Fine synchronization**, the second step, occurs when the terminal has successfully exchanged several RTT messages with the NTR to refine its clock error sufficiently so that it will not adversely affect the network when it begins to transmit data.[3]

Synchronization occurs in two steps: coarse and fine.

Thereafter, each terminal maintains a measure of how accurately it knows system time, called its **Time Quality** (Q_t). The NTR has a Q_t of 15, the highest possible value. A terminal continuously refines its knowledge of system time by periodically transmitting RTT messages and by measuring the time of arrival (TOA) of all received messages.

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2 *Networks can also be operated with an absolute time base, using GPS Coordinated Universal Time (UTC) time as an external time reference (ETR). When an ETR is used, the nature of NTRs changes significantly.*

3 *The technique for synchronizing without RTT transmission, called passive synchronization, is described in Chapter 5, Section D. Platforms that do this are designated Secondary Users; refer to Chapter 5, Section C for details.*

The NTR's Q_t is always 15 by definition.

External Time Reference (ETR)-Enabled Terminals

ETR-enabled Terminal Performing NTR Duty

A terminal that has been provided with an ETR capability is provided GPS time as a continuous stream of precise time pulses. When the terminal has ETR enabled and has been selected as NTR^E, at start net entry the terminal will use the GPS pulse stream to determine its clock correction model and achieve fine sync. After it achieves fine sync, the NTR^E-enabled terminal can then participate fully in the Link 16 network. It will begin to transmit initial entry messages and PPLIs, which will carry a Q_t consistent with the accuracy of time coming from its GPS receiver. This Q_t may or may not be the Q_t value 15.

ETR-enabled Terminal Not Performing NTR Duty

A terminal that has ETR enabled and has not been selected as NTR can enter the network only by first receiving an Initial Entry message. Reception of the initial entry message synchronizes the terminal with network time to within the propagation time between the terminal upon which it entered and itself. This stage of the synchronization process is termed **coarse sync**. Then the terminal will either transmit **Round-Trip Timing interrogations** (RTT-Is) to already synchronized terminals of higher Q_t than it estimates for itself, or it will use the GPS pulse stream to build its clock correction model, whichever results in the higher Q_t. When the correction model is good enough, the terminal declares fine sync. The terminal can then participate fully in the Link 16 network. It will subsequently either use RTTs or the GPS pulse stream, depending on the Q_t of each, to maintain fine sync with the best Q_t. Like that of the NTR^E, its Q_t may or may not be 15.

ETR-enabled Terminal Differences

Once an NTR^E terminal has achieved synchronization using the GPS pulse stream, it too will maintain sync by either RTT-ing to already synchronized terminals of higher Q_t, or by using the GPS pulse stream, whichever results in the higher Q_t. That is to say, an ETR-enabled NTR behaves exactly like an ETR-enabled non-NTR, *except* *for initial net entry.* So, the function of NTR in an ETR-enabled terminal is entirely different from the function of NTR in a non-ETR enabled terminal.

The NTR function works differently in an NTR^E.

♦ Time Source and Time Quality

The true source of time in an ETR network is GPS-derived Coordinated Universal Time (UTC), rather than an NTR's internal clock. Thus it is possible for an ETR-enabled NTR to have a Q_t less than 15, or for an ETR-enabled participant who is not NTR to have a Q_t of 15. In fact, *when GPS performance is good,* it is likely that all ETR-enabled participants will have a Q_t of 15, *whether or not they are performing the NTR duty.*

Since the true source of network time is GPS UTC time rather than an NTR's own internal clock, there is no reason why there cannot be more than one NTR^E participant in an ETR network. In fact, there are good reasons why multiple NTR^E participants in an ETR network may be the norm. ***We need to stop thinking about NTRs in ETR networks like we do in relative-time-based networks.***

It is not necessary that all terminals in an ETR network be ETR-capable or ETR-enabled. A non-ETR-capable/enabled terminal can exchange RTT messages with an ETR-enabled participant to achieve and maintain fine sync with an ETR network. Such a participant should never be NTR, however, and this participant's terminal will never have a Q_t of 15.

☐ *Components of the Time Slot*

Recall that the basic unit of access to the Link 16 network is the time slot. Each time slot is 7.8125 ms in duration. Within every 12-second frame, 512 time slots are distributed uniformly among sets A, B, and C, totaling 1,536 time slots per frame. A platform is assigned either to transmit or receive in each time slot. Each time slot is, therefore, a transmission opportunity. Several components comprise a time slot. From beginning to end, these components are:

- Jitter
- Synchronization
- Time refinement
- Message header and data
- Propagation

Data is transmitted within the time slot as a series of information-carrying pulse symbol packets. A **pulse symbol packet** is a 13-microsecond (µs) period during which the carrier is modulated for 6.4 µs. This is followed by 6.6 µs of dead time.

There are 128 time slots per second.

Jitter

The slot starts with a delay or dead time, called **jitter**, in which no pulses are transmitted. The duration of jitter varies from time slot to time slot in a pseudorandom way that is determined by the TSEC cryptovariable. Jitter contributes to the antijam nature of the signal by making it difficult for a part-time jammer to know when to turn on the jamming signal. However, jitter has no effect on a full-time jammer.

Jitter contributes to transmission security by causing the start time of a transmission to vary.

Synchronization, Time Refinement, Header, and Data

Jitter is followed by two sets of predetermined pulse symbol packets called **synchronization** and **time refinement**. These patterns are used by the receiver to recognize and synchronize with the signal. The message portion of the transmission is next. These pulses carry **header** and **data** information.

A guard period at the end of the time slot provides time for the signal to propagate.

♦ Propagation Period

Finally, the end of the slot is marked by a guard period, which allows for the **propagation** of the signal. The propagation guard time allows for a **normal range** of 300 nautical miles (nm) or an **extended range** of up to 500 nm, depending on the network's range setting.

☐ *Quick TDMA Summary*

In summary, the Link 16 TDMA architecture divides network time into epochs, frames, and time slots. The time slot is the basic unit of access to the network. With a duration of 7.8125 ms each, there are 128 time slots in every second. A JU is assigned either to transmit or to receive in each time slot. Pulses encoded with information are transmitted during the time slot. Transmissions from multiple units during the same time slot are permitted.

TDMA Period	Equivalence
1 Day	= *24 hours* = 112.5 Epochs
1 Epoch	= *12.8 minutes* = 64 Frames = 98,304 Time Slots = 32,767 Time Slots/Set
1 Frame	= *12 seconds* = 1,536 Time Slots = 512 Time Slots/Set
128 Time Slots	= *1 second*
1 Time Slot	= *7.8125 milliseconds*

Figure 3-10. The Link 16 network employs a communications architecture known as Time Division Multiple Access. Network time is divided into epochs, frames, and time slots.

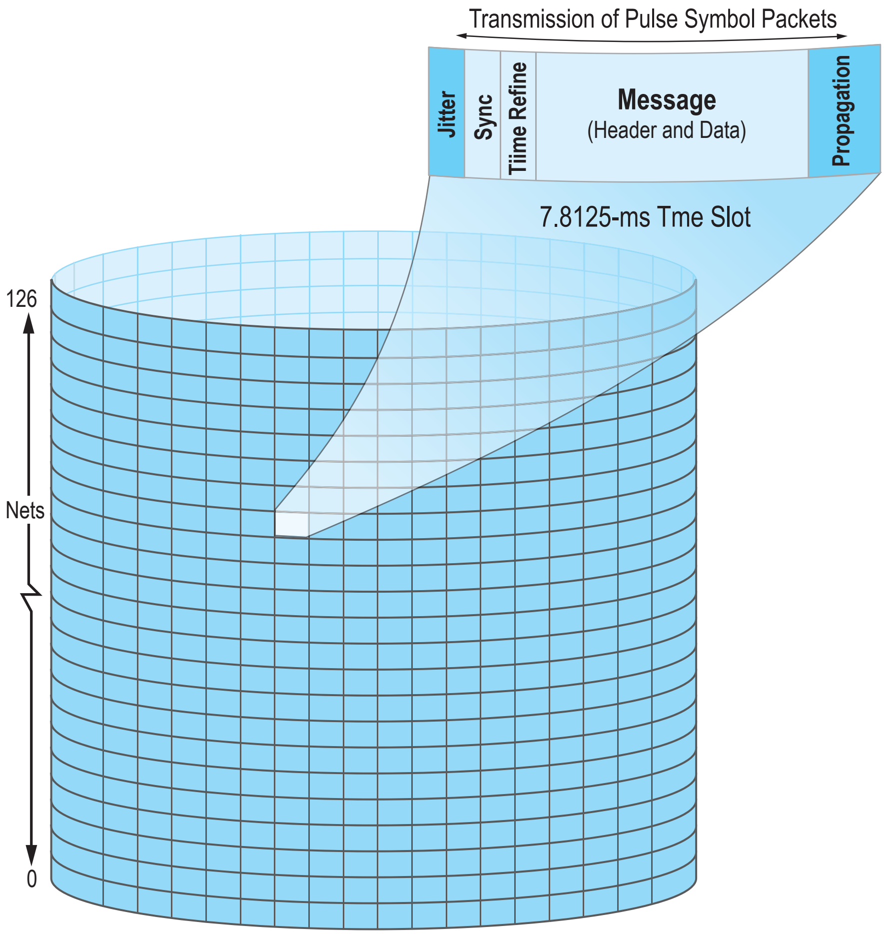


Figure 3-11. The Link 16 fixed word format messages may contain an initial word, one or more extension words, and one or more continuation words.

Section B

Link 16 Terminal Message Types

Link 16 messages are exchanged during the TDMA time slots of the Link 16 network. Each message consists of a **message header** and **message data words**. The message header, which is not considered part of the message structure, is identically formed for IJMS, JTIDS, and MIDS. The message header specifies the type of data being transmitted and identifies the source track number of the transmitting terminal.

Four types of terminal transmission types are defined:

- Fixed Word Format (FWF)
- Variable Message Format (VMF)
- Free Text (FT)
- Round-Trip Timing (RTT).

FWF messages are used to exchange the J-series messages. VMF messages provide a general way to exchange any type of user-defined messages. FT messages are used for digitized voice. RTT messages are used for synchronization with the network.

The data contained in these transmissions is always transmitted as fixed-length, three-word blocks of 225 bits each. These three-word blocks may be packed into a time slot at different densities: Standard (one three-word block), Packed-2 (two three-word blocks), and Packed-4 (four three-word blocks).

Fixed Word Format Messages

The Fixed Word Format (FWF) messages consist of one or more data words. Each word consists of 75 bits, of which 70 are data, four are used for parity checks, and one is reserved as a spare. Three types of data words are defined: the **initial word**, the **extension word**, and the **continuation word**. Every J-series message begins with an initial word. Depending on the intent of the message, one or more extension words may be required. Extension words must be sent in order (for example, I, E0, E1; not I, E1.) In addition, one or more continuation words may be required.

Continuation words are labeled, and may be sent out of order (for example, I, E0, C2). FWF messages may consist of an initial word, one or more extension words, and one or more continuation words. If there are an insufficient number of 75-bit words to fill a transmit block, the terminal "pads" the block with **No Statement (NS)** words. Message metering in the host computer helps to minimize the number of NS words inserted by the terminal.

The FWF messages are used to exchange tactical and command information over Link 16. These are the messages commonly referred to as the J-series messages. The US Services reference the MIL-STD-6016 Series message standards documents for the Link 16 J-series message and data item definitions.

The fixed word format messages are the J-series messages!

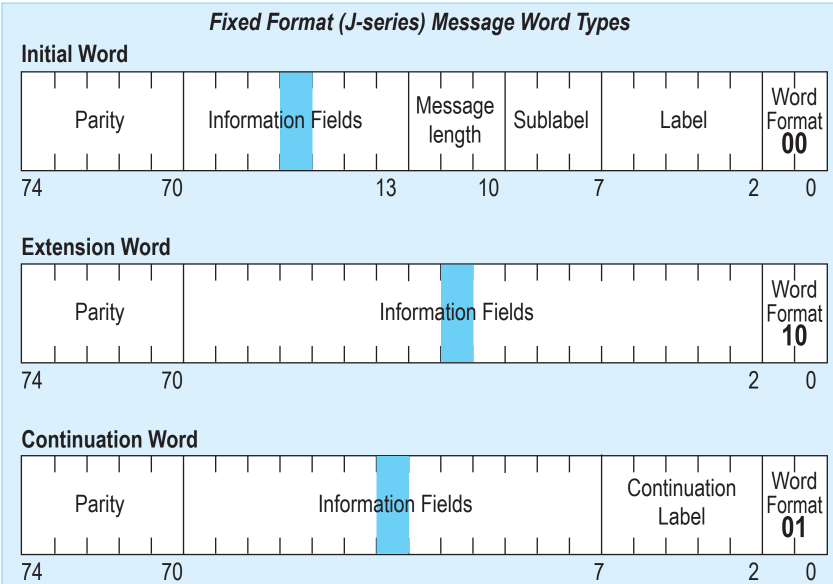


Figure 3-12. The Link 16 fixed-format messages may contain an initial word, one or more extension words, and one or more continuation words. Up to eight words may be used to create a single J-series message.

■ Parity Checking

FWF messages are always encoded for parity checking. Bits 4 through 18 of the message header, which contain the source track number, are used in conjunction with the 210 data bits of the three data words to calculate a 12-bit parity value. These parity bits are distributed at bit positions 71 through 74 of each 75-bit word. Bit 70 of each word is reserved as a spare.

■ Error Detection and Correction

FWF messages are also always encoded for error detection and correction. The encoding scheme is an algorithm known as **Reed-Solomon (R-S) encoding**. Sixteen error detection and correction bits are added for every 15 bits of data, so that 15 bits of actual data become 31 bits in the transmitted message. R-S encoding can detect and correct up to 8 bits in error. The notation (31, 15) is sometimes used to describe this encoding algorithm. R-S encoding transforms the 75-bit sequence, therefore, into a 155-bit sequence. These bits are then taken in groups of five to create 31 **symbols**. Thus, R-S encoding transforms each 75-bit Link 16 word into a 31-symbol **R-S codeword**.

☐ Variable Message Format Messages

Like FWF messages, Variable Message Format (VMF) messages consist of 75-bit words. Link 16 VMF is not to be confused with the K-series messages defined in MIL-STD-6017. VMF messages, however, may vary both in content and length, and fields within the message can cross word boundaries. Information within the message itself identifies the fields and their length.

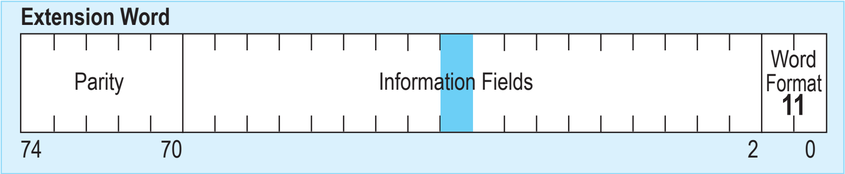


Figure 3-13. VMF messages vary in content and length.

☐ Free Text Messages

Free Text (FT) messages are independent of any message standard. They are unformatted and utilize all 75 bits in the data word—all 225 data bits in the 3-word block.

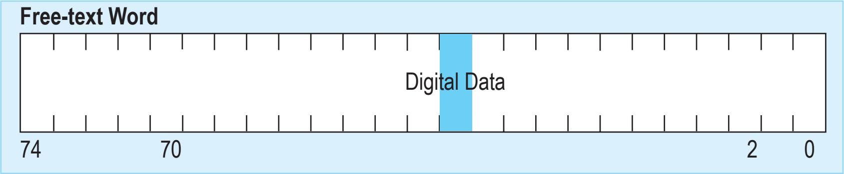


Figure 3-14. Free Text messages are independent of any message standard. All bits in the word are used for data.

No parity processing is associated with Free Text messages. They may or may not be Reed-Solomon encoded for error correction. When R-S encoding is used, the 225 bits of data are mapped onto 465 bits for transmission. When R-S encoding is not used, all 465 bits are available for generic, Free Text data, although only 450 of these bits are used for unencoded voice. This allows a single assignment of slots to be compatible with standard line rates (2400 bits per second [bps], 4800 bps, etc.). The Free Text format is used for transmitting Link 16 voice.

RRN	Slots/Frame	Slots/Sec.	Bits/Slot	Bits/Sec
13	128	10-2/3	225 (R-S encoded) 450 (unencoded)	2400 4800

Figure 3-15. A single assignment of slots containing Free Text messages can support standard serial line baud rates. A typical RRN is shown.

☐ Message Packing

Message words may be taken in groups of three words, six words, or twelve words to form transmissions. If there are an insufficient number of words to complete a group, the terminal fills in with a “No Statement” word. The processing of a group of three words is called **Standard (STD)** format. The processing of a group of six words is called **Packed-2 (P2)** format. The processing of twelve words is called **Packed-4 (P4)** format.

Message Header

The message header specifies whether the message to follow is Fixed Word Format, Variable Message Format, or Free Text. It identifies whether the message is encoded or unencoded, and which packing structure has been used. It also identifies the serial number of the Secure Data Unit (SDU) and the source track number (STN) of the terminal.

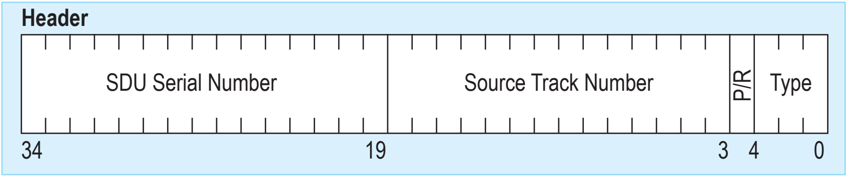


Figure 3-16. The message header specifies the type of data and identifies the source track number of the transmitting terminal. The bits of the header are also used in the calculation of parity for each three-word group. P/R, the Type Modifier bit, provides packing or relay information.

The message header contains 35 bits. Header bits are R-S encoded with a (16, 7) algorithm such that the 35 bits become 80 bits. These are taken five at a time to form an **R-S header codeword** containing 16 symbols.

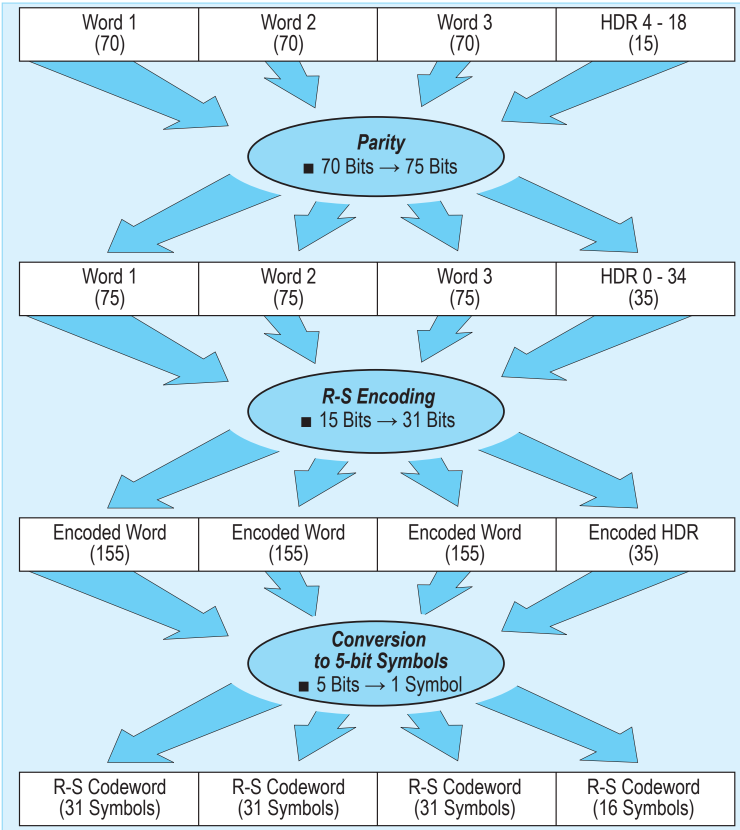


Figure 3-17. Data undergoes several ordered operations in its transformation from Link 16 words to JTIDS/MIDS symbol packets: parity checking, Reed-Solomon (R-S) encoding, and conversion to 5-bit symbols. Here, the process is illustrated for the Standard packing structure.

☐ Symbol Interleaving

The packing structure is specified in the header, along with the STN—which is required for parity checking. Ah-ha! A jammer could interfere with the exchange of data by jamming the header—if he could find it.

Interleaving the symbols of all codewords of the message contributes to message security and to the antijam (AJ) margin of the Link 16 signal. The number of symbols to be interleaved depends on the number of codewords in the packing structure. The three packing structures contain the following numbers of symbols:

- Standard (STD) format's 3 codewords contain 93 symbols
- Packed-2 (P2) format's 6 codewords contain 186 symbols
- Packed-4 (P4) format's 12 codewords contain 372 symbols.

For each packing format, the 16 symbols of the header are interleaved with its data symbols in a predetermined sequence.

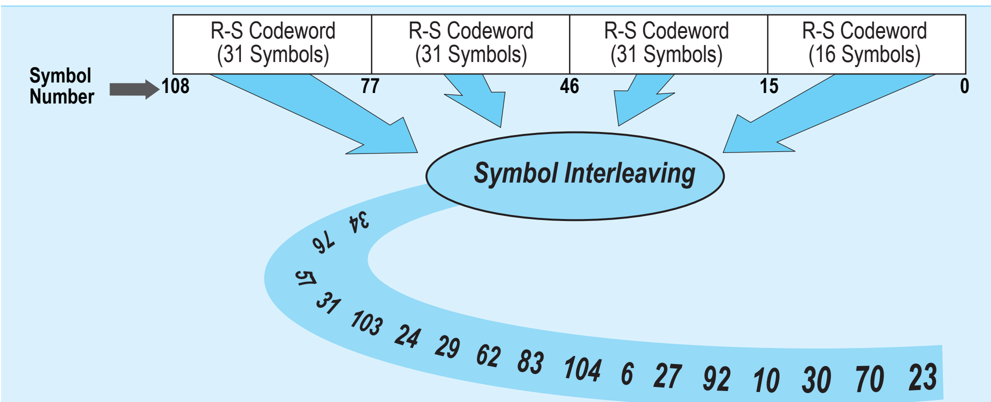


Figure 3-18. Symbols of message data and header data are interleaved.

□ Round-Trip Timing Messages

Recall that the network consists of time slices whose alignment is established by one Link 16 unit, the NTR. To receive and transmit on a Link 16 network, a terminal must be synchronized with the network.

The acquisition and maintenance of system time is called **synchronization**. Special sets of messages are defined to support this function. These are the Round-Trip Timing (RTT) messages. They represent the only exception to the rule that a terminal can transmit or receive, but not both, in a given time slot. With the RTT messages, a terminal can transmit an interrogation and receive a reply within a single time slot.

RTTs enable the terminal to refine its system time.

The initial exchanges of RTT messages enable the terminal to synchronize with the network. Subsequent exchanges allow the terminal to refine its measurement of system time—that is, its Q_t. Each terminal reports its own Q_t over the network. It also maintains an internal table of the terminals that are within its line of sight (LOS) and which have the highest values of this parameter. Entries in this internal table help the terminal choose which participant to interrogate for its next RTT message.

RTTs are exchanged within a single time slot.

■ RTT Interrogation

The RTT interrogation (RTT-I) may be either addressed (RTT-A) or broadcast (RTT-B). The RTT-A consists of a header message addressed to the unit that reports the highest time quality. It is transmitted in a dedicated time slot, and only the terminal that has been addressed will reply.

RTT-As are transmitted on NPG 2; RTT-Bs are transmitted on NPG 3.

Every terminal keeps track of the Q_t of up to four other sources (terminals) in the network whose Q_t values are greater than its own. For the RTT-A process, the interrogating terminal begins by interrogating the source with the highest time quality. If it receives no reply after two interrogations addressed to that source, it selects the source with the next highest Q_t, and begins the process again.

The net number of an RTT-B is the desired Q_t.

An RTT-B, on the other hand, contains only the interrogator's time quality. It is not addressed to a specific recipient. The RTT-B interrogator transmits on the net whose number matches the Q_t from which it is requesting a reply. There are two source tables, one for RTT-As and one for RTT-Bs. The RTT-B source table stores the top four time qualities only. For its first request, it selects the highest Qt in its stored table and transmits its nonaddressed RTT-B on the net whose number corresponds to the time quality. The RTT-B, therefore, is used with a stacked net structure.

An RTT-I is transmitted at the very start of its time slot.

The RTT-I is very similar to the message header. It contains 35 bits and is R-S encoded. But it is not followed by data, and its symbols are not interleaved: they are transmitted in consecutive order. Moreover, the transmission begins at the very beginning of the time slot. No delay or dead time (jitter) is associated with the RTT messages.

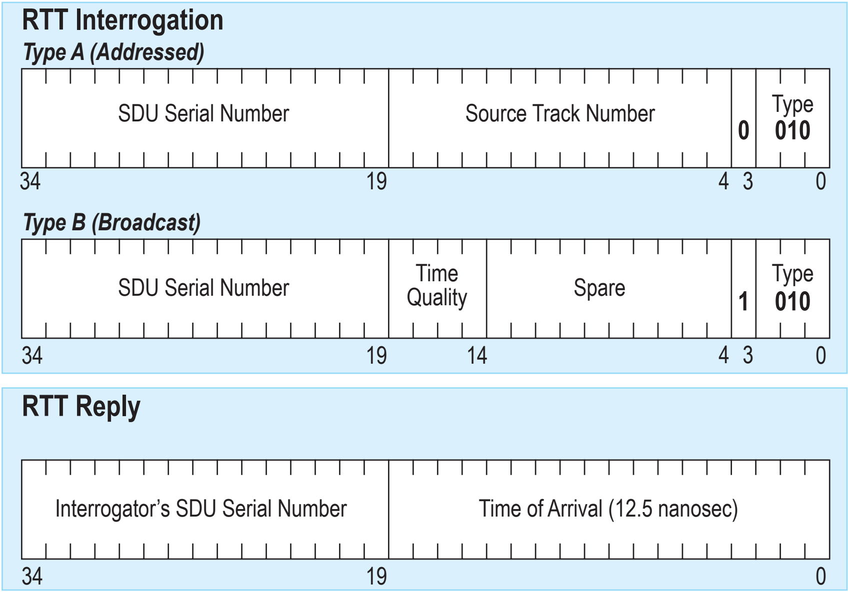


Figure 3-19. The Round-Trip Timing interrogation and reply messages are part of a procedure to establish and maintain synchronization with the net.

■ RTT Reply

The reply to an RTT-I is transmitted 4.275 ms after the beginning of the time slot, as measured by the receiving terminal. The reply contains the time that the last symbol of the interrogation was received. This TOA is measured at the antenna and is reported in units of 12.5 nanoseconds.

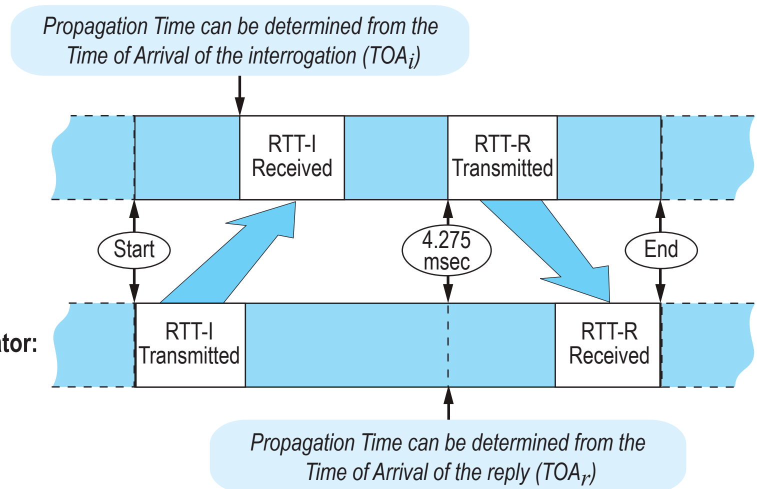


Figure 3-20. The RTT-R message is transmitted during the same time slot as the interrogation. No jitter is associated with either message, and the reply is transmitted precisely 4.275 ms after the start of the time slot.

The interrogating terminal uses the reported TOA along with its own measurement of the TOA of the reply to calculate a correction to its system clock. Suppose, for example, that the error in the interrogating terminal's system time is such that its time slot boundary is late by a duration *E*. The duration of this clock error *E* can be calculated from three pieces of information:

- The TOA of the interrogation (TOA$_i$), as reported in the reply
- The TOA of the reply (TOA$_r$), as measured directly by the interrogating terminal
- The knowledge that the reply was transmitted exactly 4.275 ms into the time slot.

By exchanging RTT messages with a unit that has a more accurate system time—that is, a higher Q_t value—a unit can improve the accuracy of its own system time.

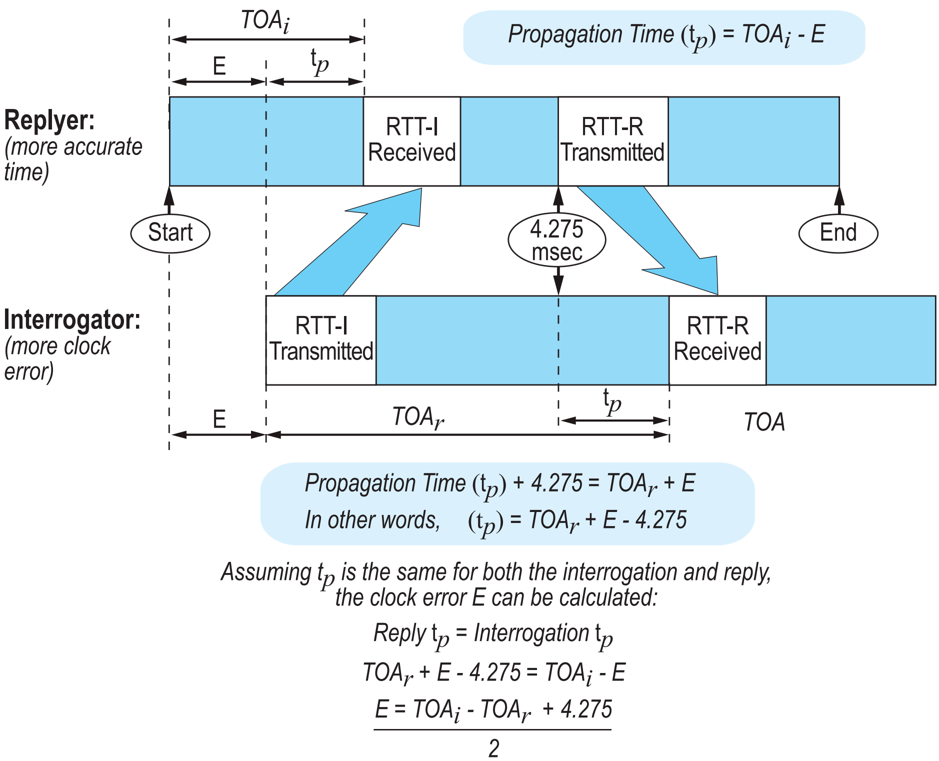


Figure 3-21. The exchange of RTTs allows the interrogating unit to improve its estimate of system time by calculating the error in its clock.

Section C

Inside the Time Slot

In order to communicate digital information over a radio, the RF carrier must be modulated with the digital data. The method used to encode digital data onto the JTIDS/MIDS carrier signal has two parts: Cyclic Code Shift Keying (CCSK) and Continuous Phase Shift Modulation (CPSM).

☐ CCSK and Chipping Sequences

CCSK is applied to the 5-bit interleaved symbols of the R-S codewords. Each 5-bit symbol is represented by a 32-bit sequence. The bits of this sequence are called **chips** to avoid confusion. These 32-chip sequences are derived by shifting an arbitrary starting sequence number left one place each time. The arbitrary starting chip sequence, which is designated **S0**, is:

01111100111010010000101011101100

In effect, each 5-bit interleaved symbol points to a specific chipping sequence, as shown in Figure 3-22. Since the 5-bit symbol's binary value can vary from 0 to 31, there are 32 unique chipping sequences. These chipping sequences, also called **symbol packets**, represent phases of a 32-bit direct-sequence spreading code used to create the JTIDS/MIDS spread spectrum signal. They are numbered S0 through S31.

5-Bit Symbols	32-Chip Sequence (CCSK Codeword)
00000	S0 = 01111100111010010000101011101100
00001	S1 = 11111001110100100001010111011000
00010	S2 = 11110011101001000010101110110001
00011	S3 = 11100111010010000101011101100011
00100	S4 = 11001110100100001010111011000111
⋮	
11111	S31= 00111110011101001000010101110110

Figure 3-22. The CCSK chipping sequences are derived by shifting S0 left by an amount equal to the 5-bit symbol it represents. A bit shifted off the left end is inserted on the right end. This pattern is mathematically designed so that the original 5-bit symbol can be deduced even if several places are missing in the received 32-chip sequence.

Detection consists of computing the cross-correlation between the received sequence and each of the valid sequences in turn until a threshold is exceeded. The original 5-bit symbol can be retrieved perfectly in the presence of several chip errors in the 32-chip sequence.

Pseudorandom Noise

To increase the transmission security of the JTIDS/MIDS signal, the 32-chip sequence is exclusively-or'd (XOR'd) with a 32-chip sequence of pseudorandom noise (PN). The resulting chipping sequence is often called a **transmission symbol**. The PN code, which is determined by the TSEC cryptovariable, is continuously changing. As a result, when the data is finally transmitted, it looks like incoherent noise.

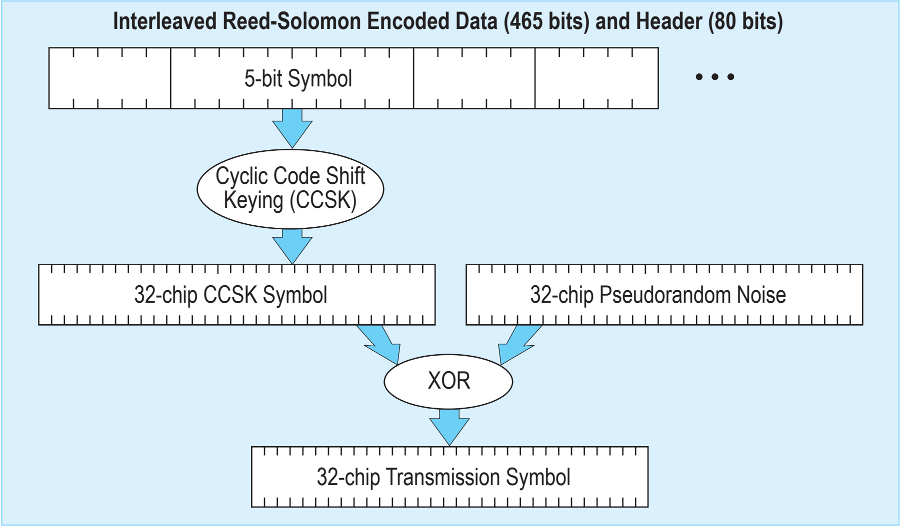


Figure 3-23. The CCSK 32-chip code is masked by pseudorandom noise.

Carrier Modulation

The waveform is generated by CPSM of the carrier frequency at a 5-megabit-per-second rate, using the 32-chip sequence of the transmission symbol as the modulating signal. With a 5-MHz chipping rate, the duration of each chip is 200 nanoseconds (ns), or 0.000000200 seconds.

A chip is 200 ns. A 32-chip sequence is 6.4 microseconds.

Two frequencies are used in the modulation process. The periods of these frequencies differ by half a wavelength every 200 nanoseconds. Thus, the transition from one frequency to the other at the end of a 200-ns period is phase continuous.

These two frequencies are used to represent a *change* in chip value, rather than an absolute chip value. The n^{th} chip is transmitted at the lower frequency when it is the same as the $(n{-}1)^{th}$ chip, and at the higher frequency when it is different. The frequency transmitted for the first chip is arbitrary, since noncoherent detection methods are used in the receiver. This CPSM technique can also be described as phase-coherent binary Frequency Shift Keying (FSK) modulation.

A transmission consists of multiple pulses, with one chipping sequence per pulse.

At the lower frequency, there are an exact number of complete cycles in the 200-ns period. At the higher frequency, there is exactly an additional half cycle in the 200-ns period. The time required to modulate the carrier with the entire 32-chip sequence is 200 ns $\times$ 32 = 6400 ns, or 6.4 microseconds.

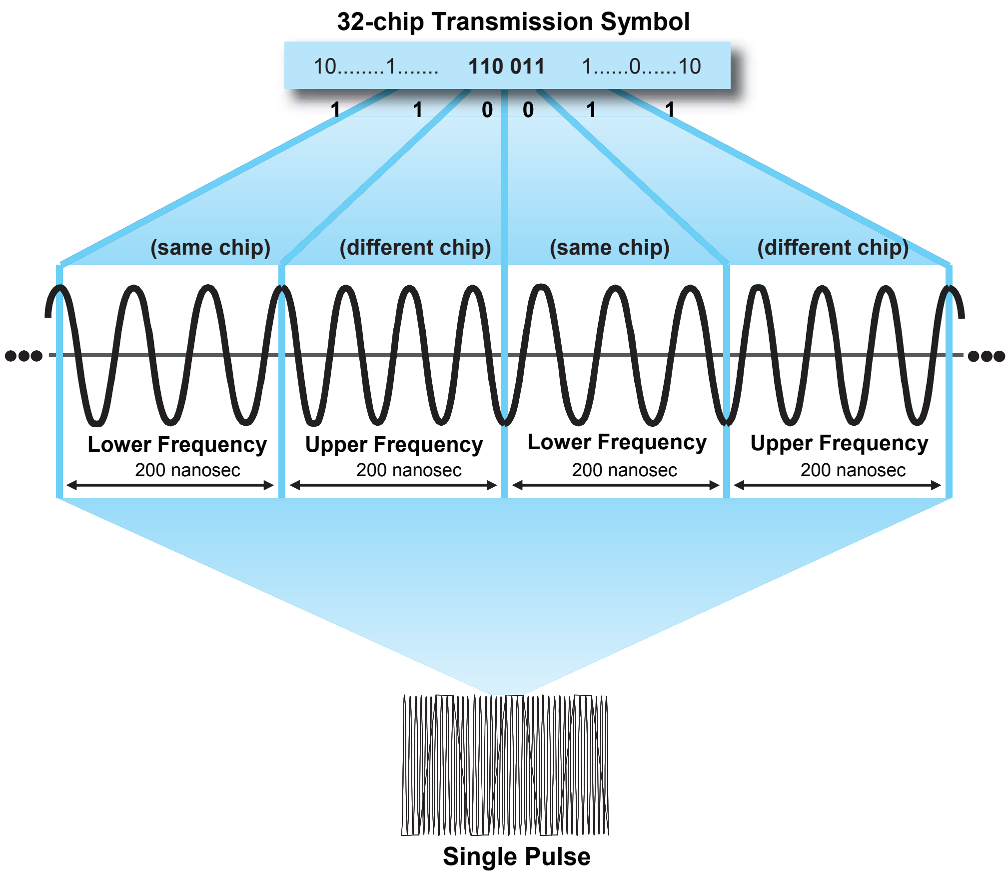


Figure 3-24. The carrier is encoded with the chipping sequence by shifting the modulating signal between two frequencies. The frequencies are chosen so that the modulating signal is phase-continuous. If the chip is the same, the lower frequency is used. If the chip is different, the upper frequency is used.

Pulses: Single and Double

The **single-pulse symbol packet** consists of one 6.4-µs pulse of modulated carrier followed by a 6.6-µs dead time, for a total pulse symbol packet duration of 13 microseconds.

Each pulse of the double pulse symbol packet conveys the same information.

The **double-pulse symbol packet** consists of two single pulses both modulated with the same transmission symbol. The double pulse has a duration of 26 microseconds. Although the two pulses contain identical information, the carrier frequencies for each are chosen independently.

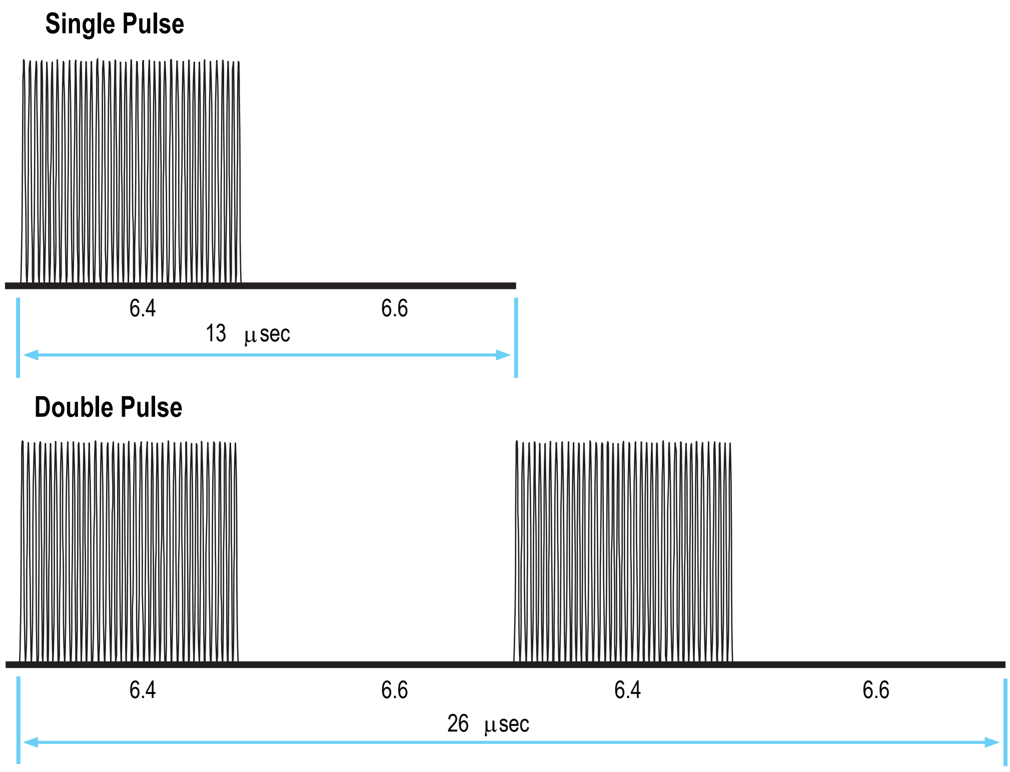


Figure 3-25. Either the single- or the double-pulse structure is used to transmit Link 16 data. The double-pulse structure provides redundancy and increases the antijam capability of the link.

The JTIDS/MIDS terminal uses 51 different carrier frequencies, hopping from one to another for every 6.4-µs pulse. This frequency-hopping technique makes the data very difficult to locate at any given instant, giving it a **low probability of intercept (LPI)** during any given pulse in the time slot. It also contributes to the reliability of the link. Data that is transmitted as double pulses is not only output twice, but on two different frequencies! This makes the signal doubly difficult to jam, and far less likely to be subject to multipath interference.

Synchronization Pulses

The synchronization component of the time slot follows the jitter dead time and contains a fixed pattern of 16 double-pulse symbols. The total time taken to transmit the synchronization symbols is 416 microseconds. These 32 pulses are transmitted on eight different carrier frequencies.

The synchronization and time refinement components of the time slot are always transmitted redundantly—in the double-pulse format.

Time Refinement Pulses

The time refinement component of the time slot contains four double-pulse S0 symbols. The total time taken to transmit the time refinement pulses is 104 microseconds.

There are four time-refinement pulses lasting 1.04 µs.

Header and Data Pulses

The header and data component of the time slot may be packed in one of three ways: STD (3 words), P2 (6 words), and P4 (12 words). The STD format is always transmitted with the double-pulse structure. The P2 format may be transmitted either with the single-pulse or the double-pulse structure. The P4 format is always transmitted with the single-pulse structure. Thus, there are four packing options for Link 16 data:

- Standard Double Pulse (STD-DP)
- Packed-2 Single Pulse (P2SP)
- Packed-2 Double Pulse (P2DP)
- Packed-4 Single Pulse (P4SP)

The header always uses the double-pulse format, but the packing structure of the data can vary for each time slot. Part of the information specified in the header is the packing structure of the data.

			Unencoded						R-S Encoded					
			Wds:	data bits	+ parity	= total data	Total Output	Type (Modifier)	Wds:	data bits	+ parity	= total data	Total Output	Type (Modifier)
Fixed Word Format	RTT	SP												
		DP							0	0	0	0	0	2(0) 2(1)
	STD	SP												
		DP							3:	210	+ 15 =	225,	465	4(r)
	P2	SP							6:	420	+ 30 =	450,	930	3(r)
		DP							6:	420	+ 30 =	450,	930	5(r)
	P4	SP							12:	840	+ 60 =	900,	1860	7(r)
		DP												
Free Text	STD	SP												
		DP	N/A:	450	+ 15 =	225,	450*	0(0)	3:	210	+ 15 =	225,	465	6(0)
	P2	SP	N/A:	900	+ 30 =	450,	900*	0(1)	6:	420	+ 30 =	450,	930	6(1)
		DP	N/A:	900	+ 30 =	450,	900*	1(0)	6:	420	+ 30 =	450,	930	2(0)
	P4	SP	N/A:	1800	+ 60 =	900	1800*	1(1)	12:	840	+ 60 =	900	1860	2(1)
		DP												

*Only 450 of each 465 bits are used for voice, so that a single assignment of time slots is compatible with standard time rates of 2400 bps, and so on.

(r) = relay indicator
N/A = not applicable

Figure 3-26. Using the Type and Type Modifier fields, the header defines the packing structure of the data that follows. This table summarizes the number of words and data bits for Fixed Word Format and Free Text, unencoded, and encoded messages for each type of packing structure.

The following illustrations of the time slot packing structures are not to time scale. The header and data are shown separately to illustrate clearly the increased data capacity associated with each packing structure. In actuality, of course, the header and data symbols are interleaved.

■ Standard Double Pulse

The STD-DP header and data portion of the time slot consists of 109 interleaved symbols. This represents 225 bits of encoded information, or 465 bits of unencoded data. Recall that the header and data portion of a STD message consists of three 75-bit data words and one 35-bit header. These are R-S-encoded to 465 bits and 80 bits, respectively. These bits are then taken five at a time to generate 93 32-chip transmission symbols for the data and 16 32-chip transmission symbols for the header. The data and header symbols are interleaved. The total time taken to transmit 109 double-pulse symbols is 2.834 milliseconds.

The redundancy of the STD-DP packing structure makes it the most reliable type of transmission.

Jitter	S	TR	H	D_1	Propagation
	16 × 2	4 × 2	16 × 2	93 × 2	

S = Sync **TR** = Time Refinement **H** = Header **D** = Data

Figure 3-27. The STD-DP time slot structure contains a variable amount of jitter, 3.354 ms of symbol packets representing synchronization, time refinement, header, 225 bits of encoded Link 16 message data, and a variable amount of propagation time. The header and data are actually interleaved.

■ Packed-2 Single Pulse

The P2SP header and data portion of the time slot consists of 16 double-pulse header symbols and 186 single-pulse data symbols. The header and data symbols, which are interleaved, represent 35 bits of header data and 450 bits of encoded Link 16 message data (or 930 bits of unencoded Free Text data). The total time required to transmit the header and data portion of the timeslot in the P2SP structure is 2.834 ms, the same as the time required for the STD structure. Note that the P2SP is not as jam-resistant: although the header information is still transmitted redundantly, the doubling of the data capacity is achieved by transmitting the data only once.

By sacrificing redundancy, the P2SP packing structure can contain twice as much data as the STD-DP structure.

Jitter	S	TR	H	D_1	D_2	Propagation
	16 × 2	4 × 2	16 × 2	93 × 1	93 × 1	

S = Sync **TR** = Time Refinement **H** = Header **D** = Data

Figure 3-28. The P2SP time slot structure contains a variable amount of jitter, 3.354 ms of symbol packets representing synchronization, time refinement, header and 450 bits of encoded Link 16 message data, and a variable amount of propagation time. The header is transmitted redundantly (double pulses), the data is transmitted only once (single pulses).

■ Packed-2 Double Pulse

The P2DP header and data portion of the time slot consists of 202 interleaved double-pulse symbols: 16 for the header information and 186 for the 450 bits of the six encoded Link 16 words (or 930 bits of unencoded Free Text data). The total time required to transmit the header and data portion of the time slot in the P2DP structure is 5.252 milliseconds. The additional time required to transmit the data redundantly is obtained by eliminating the jitter period at the beginning of the time slot. A transmission in the P2DP format begins immediately at the start of the time slot.

In the P2DP packing structure data redundancy is restored, but jitter is sacrificed.

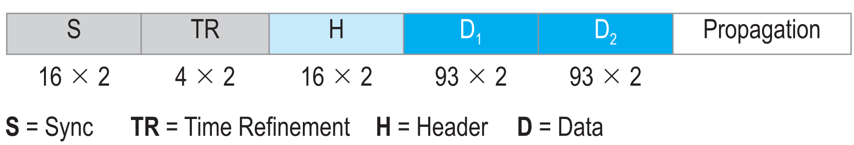


Figure 3-29. The P2DP time slot structure contains no jitter. The 5.772 ms of symbol packets represent synchronization, time refinement, header, and 450 bits of encoded Link 16 message data. The remaining time is reserved for propagation.

■ Packed-4 Single Pulse

The P4SP header and data portion of the time slot consists of 16 double-pulse header symbols and 372 single-pulse data symbols. The header and data symbols, which are interleaved, represent 35 bits of header data and 900 bits of encoded Link 16 message data (or 1860 bits of unencoded Free Text data). The total time required for transmitting the header and data portion of the timeslot in the P4SP structure is 5.252 ms, the same as the time required for the P2DP structure. Note that the P4SP structure is the least jam-resistant of all. There is no jitter, and the data is transmitted only once.

Both jitter and data redundancies are sacrificed so that the P4SP packing structure can contain four times as much data as the STD-DP structure.

S	TR	H	D_1	D_2	D_3	D_4	Propagation
16 × 2	4 × 2	16 × 2	93 × 1	93 × 1	93 × 1	93 × 1	

S = Sync **TR** = Time Refinement **H** = Header **D** = Data

Figure 3-30. The P4SP time slot structure contains no jitter. The 5.772 ms of symbol packets represent synchronization, time refinement, header, and 900 bits of encoded Link 16 message data.

☐ Message Packing Limitations

The throughput, range, and antijam (AJ) ruggedness of Link 16 transmissions depend on the packing structure. Throughput is determined by the density of message packing: 3, 6, or 12 data words can be packed into a single time slot.

Extended range cannot be used with the P2DP and P4SP packing structures.

Range can be normal or extended. The **normal range** of 300 nm can be accommodated by all the packing structures. **Extended range** networks can utilize P2DP and P4 packing structures; exchanges with these packing structures, however, will take place only within 300 nautical miles. In other words, when using the extended range mode, only STD and P2SP messages can be exchanged at extended range, beyond 300 nm up to 500 nautical miles. The P2DP and P4 message exchanges remain constrained to 300 nautical miles.

In extended range mode, the jitter dead time is shortened to allow a longer period for propagation of the signal. Because the structure of the time slot depends on the range, all units participating in the network must have range mode set identically. Some AJ capability is lost with extended range.

Throughput increases at the expense of AJ margin.

The AJ ruggedness of the Link 16 transmissions depends on, among other things, the variation in time slot start times (jitter) and redundancy (double pulses). The amount of AJ margin decreases as throughput increases, with P4SP providing the greatest throughput with the least amount of AJ margin. The terminal is designed to use the highest AJ margin, which is provided by the STD packing structure, wherever possible. As the message load increases, however, it will automatically give up AJ margin in favor of throughput.

The terminal selects time-slot packing based on data volume.

The packing structure to be used is selected by the terminal in the following order of preference: STD, P2SP, P2DP, and P4SP. One of the terminal initialization parameters, the **Upper Packing Limit**, places an upper limit on how far down this list the terminal can go. In other words, the Upper Packing Limit specifies how much AJ margin can be given up during any particular time slot. The host can override this limit for specific time slots, however, with a Terminal Input Message.

Introduction

The use of Link 16 is governed by frequency restrictions within the boundaries of participating nations. In addition, the use of aeronautical navigational equipments, both ground-based and airborne, places limitations on where and when Link 16 terminals are permitted to radiate. This chapter provides information on the Link 16 operating limitations and the procedures for the use of Link 16 terminals worldwide.

Section A

Link 16 Frequencies

Link 16 terminals operate within the frequency band 960 to 1215 Megahertz (MHz), which is designated worldwide for aeronautical radionavigation purposes. Peacetime use of Link 16 in this band is strictly regulated to insure compatibility with aeronautical radio-navigation systems operating in this band.

☐ Use of Link 16 in the United States and Possessions

In the United States and its Possessions (US&P), the Link 16 frequency band is controlled by the National Telecommunications and Information Administration (NTIA) and administered by the Federal Aviation Administration (FAA). All Department of Defense (DOD)-supported users of this frequency band are required to comply with the Chairman Joint Chiefs of Staff Instruction (CJCSI) 6232.01 for geographic area pulse deconfliction. This document contains the operational restrictions and limitations stated in the Link 16 spectrum certification,[1] as well as coordination procedures summarized in this chapter.

☐ International Use of Link 16

Link 16 operations occur throughout the world, with an increasing number of countries allowing operations within their borders. Each country establishes Link 16 operating restrictions based on testing between their navigational aids (NAVAIDs) and Link 16. As a result, national Frequency Clearance Agreements (FCAs) differ from the US&P certification. Regardless of the restrictions placed on JTIDS/MIDS operations by a foreign government, visiting US forces must comply with the national frequency clearance and procedures established for that country's FCA.

1 *The restrictions are described in the Interdepartment Radio Advisory Committee (IRAC) Document 33583 (2004), which supersedes the previous 21167 (1979), 27439 (1991), and 28843 (1994) IRAC documents.*

The Aeronautical Radionavigation Band

The JTIDS/MIDS terminals operate in the portion of the frequency spectrum between 960 and 1215 megaHertz (MHz), which is called the Aeronautical Radionavigation Band. The primary users within this band are civilian and military air navigation systems, including civil Distance Measuring Equipment (DME) and military Tactical Air Navigation (TACAN) equipment. DME and TACAN channels occur **every 1 MHz** within this band.

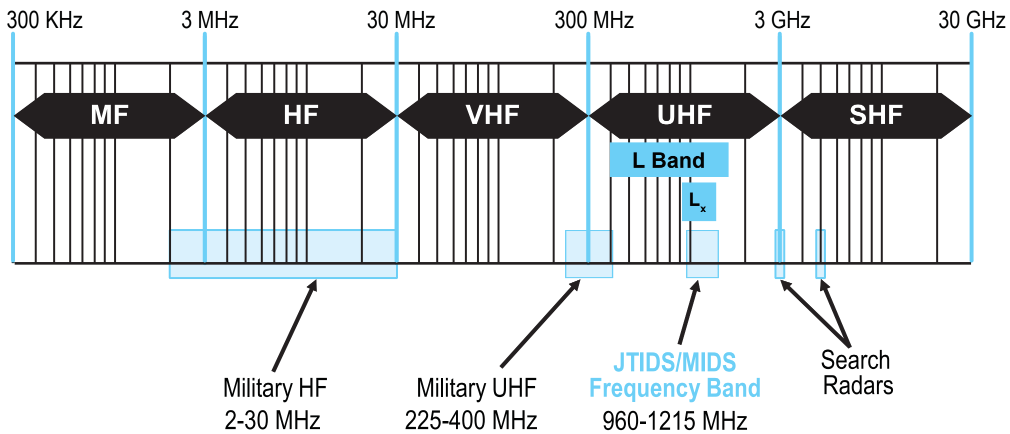


Figure 4-1. The portion of the spectrum used for Link 16 communications is in the UHF band. UHF communications are line of sight. The portion of the frequency spectrum between 950 MHz and 1150 MHz is called the L_x band. The JTIDS/MIDS terminal operates partially, although not entirely, within this band—that is, the L_x band and the JTIDS/MIDS band do not completely overlap, as shown here.

Link 16 Frequencies

The 51 frequencies assigned to Link 16 for TDMA transmissions are those between 969 MHz and 1206 MHz, spaced 3 MHz apart. Two notches, which are centered on 1030 MHz and 1090 MHz, are excluded, because these frequencies are used by Identification Friend or Foe (IFF) and Traffic Collision Avoidance System (TCAS) equipment. The fact that Link 16 and TACAN pulse emissions tend to be uncorrelated in time tends to protect TACAN operation.

Link 16 operates in the 960 – 1215 MHz band, with JTIDS/MIDS frequencies occurring every 3 MHz between 969 and 1206 MHz.

Frequency Number	Frequency (MHZ)	Frequency Number	Frequency (MHz)	Frequency Number	Frequency (MHz)
0	969	17	1062	34	1158
1	972	18	1065	35	1161
2	975	19	1113	36	1164
3	978	20	1116	37	1167
4	981	21	1119	38	1170
5	984	22	1122	39	1173
6	987	23	1125	40	1176
7	990	24	1128	41	1179
8	993	25	1131	42	1182
9	996	26	1134	43	1185
10	999	27	1137	44	1188
11	1002	28	1140	45	1191
12	1005	29	1143	46	1194
13	1008	30	1146	47	1197
14	1053	31	1149	48	1200
15	1056	32	1152	49	1203
16	1059	33	1155	50	1206

Figure 4-2. For every pulse, the JTIDS/MIDS carrier is changed to one of 51 possible frequencies. The nominal frequency-hopping rate is greater than 33,000 hops per second.

JTIDS/MIDS Communication Modes

Three operator settings control the communication mode used by the JTIDS/MIDS terminal. Mode 1 is the normal operational mode. Modes 2 and 4 represent a reduction in capacity and capability. Mode 3 is an invalid mode; it is not implemented in the JTIDS Class 2 terminal, and it is not recognized by the NATO Standardization Agreement (STANAG) on MIDS.

- **Mode 1:** This is the normal JTIDS/MIDS mode of operation. It includes frequency-hopping with full MSEC and TSEC processing. Mode 1 operation is required by the current spectrum certification.
- **Mode 2:** No frequency-hopping. All pulses are transmitted on a single frequency. Peacetime constraints on slot usage are eliminated. Requires a frequency assignment waiver prior to use.
- **Mode 4:** No frequency-hopping. Some communications security processing is eliminated to allow the terminal to function as a fairly conventional data link. Requires a frequency assignment waiver prior to use.

Mode 1, the normal operational mode required by the current spectrum certification, allows full MSEC and TSEC processing and multinetting.

Section B

Navigation Systems

Distance Measuring Equipment

Distance Measuring Equipment (DME) is a civilian navigation system consisting of an airborne interrogator and a ground transponder. The interrogator transmits about 30 pulse-pairs per second on one of 126 channels between 1025 and 1150 MHz. The transponder replies on one of 126 channels between 962 to 1024 and 1151 to 1213 MHz. An indicator in the aircraft's cockpit displays the transmit-to-receive time on a meter calibrated in nautical miles.

DME frequencies occur every 1 MHz between 962 MHz and 1213 MHz.

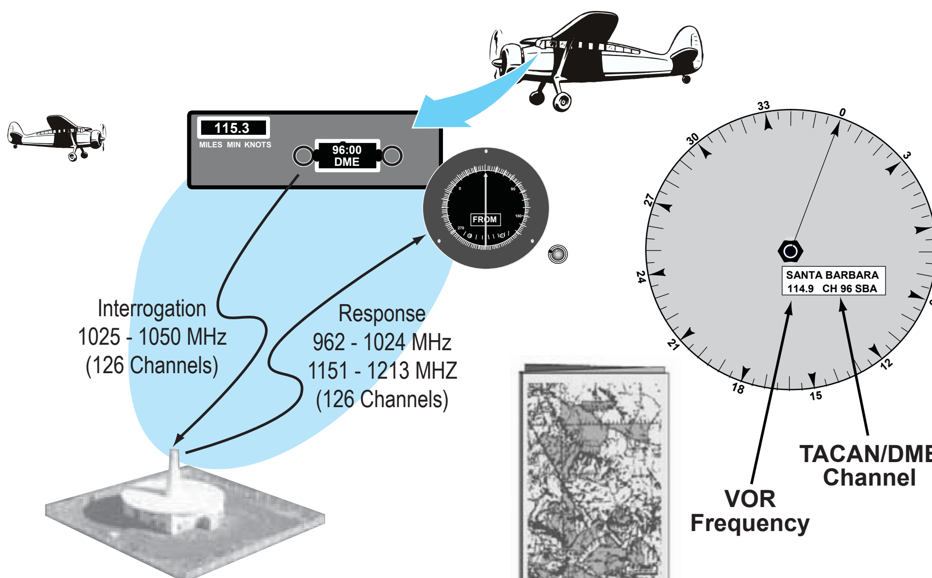
The DME ground transponder is often co-located with a **VHF Omnidirectional Range (VOR)** transmitter to provide an aircraft with both distance and direction. The VOR operates on frequencies outside the JTIDS/MIDS band, between 108 and 118 MHz.

Tactical Air Navigation

Tactical Air Navigation (TACAN) is a military navigation system that combines the distance and direction function into a single system. The TACAN ground unit transmits a DME beacon for distance, to which is added a rotating cardioid antenna pattern plus a nine-lobed pattern for direction. The cardioid pattern rotates fifteen times a second while generating a 15-Hz course-bearing signal. The nine lobes rotating fifteen times per second generate a 135-Hz fine-bearing signal. Military aircraft translate the received signal into a visual presentation of both azimuth and distance in a bearing distance heading indicator (BDHI).

Thousands of VORTAC stations throughout the US provide civilian and military aircraft with the distance and directional information necessary for navigation.

In the US and certain other countries, the distance-and-direction navigation system is often implemented by co-locating VOR and TACAN stations to create a **VORTAC** station. The VORTAC is a unified navigational aid for civilian and military use. Both components operate simultaneously at all times to provide three services at one site: VOR azimuth, TACAN azimuth, and TACAN distance (equivalent to DME).



	JTIDS TDMA	TACAN/DME
Frequency (MHz)	969 - 1206	962 - 1213
Channel Spacing (MHZ)	3	1
Power Output	200 watts	500 watts

Figure 4-3. Link 16 shares a portion of the L_x Band with civilian and military navigation systems.

The airborne JTIDS and MIDS terminals have an integrated TACAN function, which can provide TACAN interrogation and reply processing. The F-15s' FDL terminals do not have an integrated TACAN capability; these aircraft use the ARN-118 TACAN equipment, which is connected to the FDL terminal via the MIL-STD-1553 bus. The FDL terminal controls all power and switching functions between FDL and TACAN. The FDL terminal utilizes the TACAN antennas for its transmission and reception, arbitrating their use between itself and the TACAN. This will not be the case, however, for future platforms, when the ARN-118 is eliminated and future versions of the MIDS LVT terminal will embed the TACAN function. There are no future plans to integrate TACAN into the FDL terminal.

Air Traffic Control Radar Beacon System/ Identification Friend or Foe

The **Air Traffic Control Radar Beacon System (ATCRBS)/ Identification Friend or Foe (IFF)** uses notches centered on 1030 and 1090 MHz. Interrogations are transmitted at 1030 MHz at about 400 pulse-pairs per second. Replies from aircraft transponders are received at 1090 MHz, pulse-coded with identity, altitude, and other information essential in identifying the aircraft.

Mode Select Beacon System IFF

The **Mode Select Beacon System (Mode S)** IFF is a combined beacon radar and ground-air-ground data link system that replaces the ATCRBS. It is backward compatible with ATCRBS, using the same frequencies for interrogation and reply. Mode S also interrogates for surveillance and altitude, but in addition, it has a data link capability. Mode S has over 16 million possible address codes, permitting a unique address for each aircraft. It has been installed at 140 airports across the United States, where it is intended to provide a reliable communications capability as well as accurate surveillance in dense traffic conditions. It is capable of selective interrogation, single-scan interrogation, all-call interrogation, error detection and correction, and monopulse beam splitting.

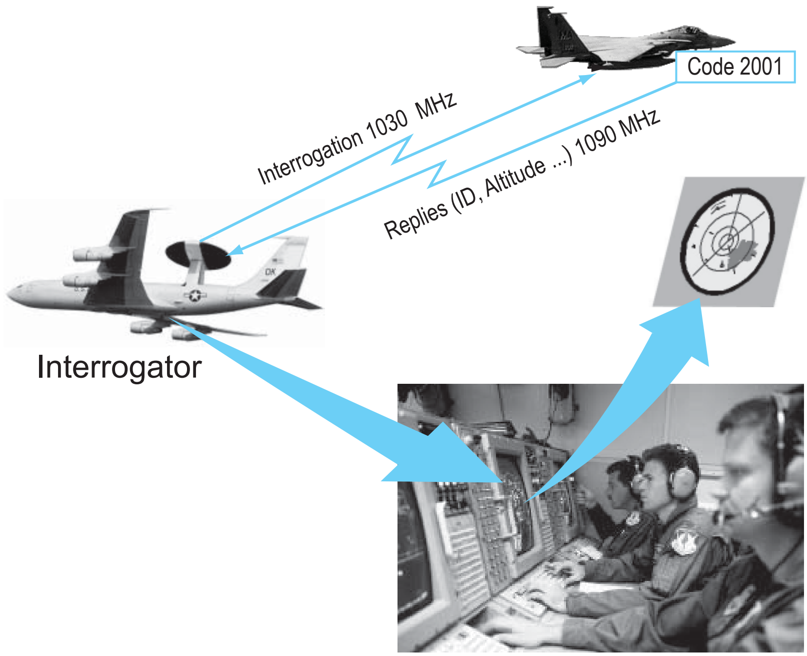


Figure 4-4. Notch filters on the JTIDS/MIDS terminal's transmitter prevent the Link 16 signal from encroaching on the ATCRBS/IFF bands.

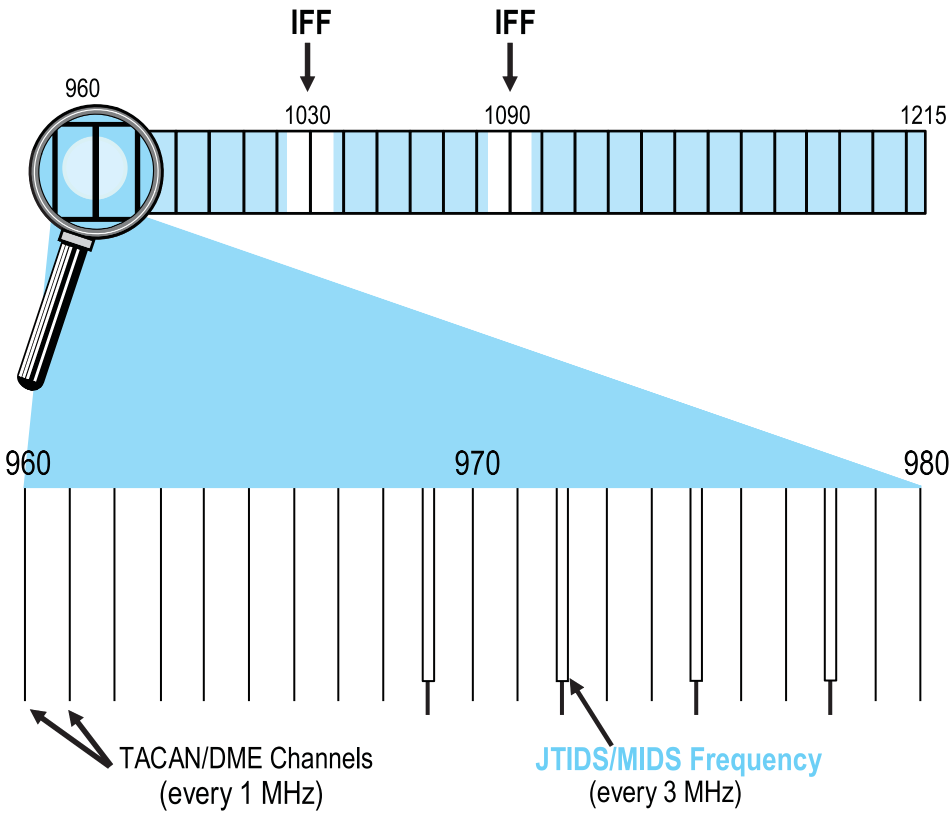


Figure 4-5. Link 16, IFF, TACAN, and DME transmissions use the same frequency band, although Link 16 does not begin transmissions until 969 MHz to avoid interference. Within this band, TACAN and DME channels occur every 1 MHz. The Link 16 center frequencies occur every 3 MHz, with notches centered on 1030 MHz and 1090 MHz for the IFF bands.

Global Navigation Satellite Systems

The use of the **Global Navigation Satellite System (GNSS)** in the aeronautical radionavigation band is being added to the existing systems. The Global Positioning System (GPS) is part of GNSS, and it will add a civilian safety-of-life signal, the L5 frequency (1176.45 MHz), to this band. The inclusion of the GPS L5 frequency will require protection from the Link 16 signal and is included in the current spectrum certification beginning in 2008. The European Union's Galileo and Russian Global Orbiting Navigation Satellite System (GLONASS) are other satellite systems with capabilities similar to GPS, which are being introduced around the world.

Traffic Collision Avoidance System

The **Traffic Collision Avoidance System (TCAS)** involves communication among all aircraft equipped with an appropriate transponder. Each TCAS-equipped aircraft interrogates all other aircraft in a determined range about their position via the 1030 MHz radio frequency, and all other craft reply to these interrogations via the 1090 MHz frequency. This interrogation-and-response cycle may occur several times per second. Through this constant back-and-forth communication, the TCAS system builds a three-dimensional map of the aircraft in its airspace, incorporating their bearings, altitudes, and ranges, and determines whether a collision threat may exist.

Section C

Spectrum Regulations

☐ Spectrum Certification

The process of approving spectrum use is performed to ensure that the requesting system conforms to the type of service allocated for the specific portion of the spectrum. For Link 16 use within the aeronautical radionavigation band, significant testing was conducted to ensure that Link 16 would not interfere with the primary user in the band for aeronautical radionavigation services.

Form DD-1494, Application for Equipment Frequency Allocation,[2] initiated the process of granting Link 16 use in the spectrum. The approved spectrum certification was released by NTIA as an Interdepartment Radio Advisory Committee (IRAC) document[3] and included the operational limits for the use of Link 16 in the US&P.

The IRAC document applies to military services, Joint staff, the activities and agencies reporting to the Joint Chiefs of Staff, and all contractors and commercial enterprises engaged in terminal research, development, testing, and evaluation that operate in the US&P. It also applies to foreign and coalition units operating with US forces within 200 nautical miles of the coastal US&P. Subsequent sections of this chapter highlight Link 16 operating restrictions, such as time slot duty factor (TSDF), geographic area limits, and deconfliction requirements.

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2 *As of this printing, the current DD1494 is dated 23 January 2004. The DD 1494 includes the terminal and platform configurations and is used to calculate the separation distance between JTIDS/MIDS terminal antenna operations and NAVAID receivers. This information is included in CJCSI 6232.01 and the JTIDS/MIDS Spectrum Users Guide (JSUG).*

3 *As of this printing, the current IRAC Document 33583 is dated 25 March 2004.*

Frequency Assignment

The use of JTIDS/MIDS terminals also requires approval to operate the equipment within a specified area. The approval is requested through the requestor's frequency management chain of command, using a **Request for Frequency Assignment (RFA)**. Many locations already have an approved permanent frequency assignment, which can be accessed through your installation's spectrum manager.[4]

The permanent RFA, which can be referenced by serial number, provides information on the JTIDS/MIDS equipment, location, and any additional restrictions for the intended area of operations. Any specific FAA-imposed restrictions contained in a particular frequency assignment always take precedence over the restrictions in previous assignments or the spectrum certification. The RFAs normally include an operating radius for airborne platforms and specific coordinates for a ground transmitter. Each ground station antenna requires a specific RFA for the location of the antenna.

Frequency Assignment Waivers

Waivers to existing frequency assignments are handled on a case-by-case basis to support training, exercises, testing, or other events that exceed the frequency assignment restrictions. The most common use of waivers is for relaxation of TSDF requirements higher than 100/50[5] percent. Requestors should allow additional time in advance of the intended operations to coordinate the approval of the waiver.

4 *The JSUG provides additional details on frequency assignments.*

5 *A discussion of time slot duty factor may be found in Section E of this chapter.*

Frequency Clearance Agreements

The restrictions for Link 16 operations outside of the US&P are included in National Frequency Clearance Agreements (FCAs).[6] These agreements detail the conditions and controls placed on JTIDS/MIDS operations, as agreed to between national civil and military authorities based on their national testing, or on test results provided by other nations and agencies. As a result, FCAs, as well as visiting forces' procedures, vary among nations.

FCAs provide the approval authority for the use of Link 16, and in this sense are equivalent to the US&P spectrum certification and frequency assignment. In many cases, these FCAs will be more restrictive than the US&P spectrum certification. Link 16 network designs must be designed to meet the national FCA restrictions, which may result in changes to Link 16 employment planning. Additionally, prior coordination may be needed if a specific USAF platform configuration has not been approved to operate in accordance with the subject national FCA.

Most national FCAs require real-time monitoring of Link 16 operations by a national JTIDS/MIDS **Data Link Management Cell (DLMC)** to ensure compliance with FCA restrictions. Advanced notification to a nation's DLMC is required for approval to operate and radiate within its national airspace.

6 *A list of the current Link 16 FCAs have been included in the JTIDS/MIDS Multi-National Ad Hoc Spectrum Support Working Group notebook, which is available on the JCS website at http://www.jcs.mil/j6/cceb.*

Section D

Interference Protection Features

☐ Introduction

JTIDS and MIDS terminals must operate on Link 16 in the presence of interfering signals from the IFF interrogator, the ATCRBS IFF Mark XII System (AIMS) transponder, TACAN interrogators, and its own built-in TACAN function, as well as interfering signals from TACAN interrogators aboard adjacent platforms. An airborne TACAN interference environment might consist of as many as 60 interrogators in search mode and 540 interrogators in track mode. These interfering signals are distributed uniformly in frequency over the entire TACAN band. A ground beacon environment typically has a beacon on every ground-to-air channel, each transmitting 3600 pulse-pairs per second.

The Link 16 frequency band is flooded with low-level RF signals. Link 16 transmissions must not interfere with the operation of the systems relying on these signals.

Always consult the JTIDS Spectrum Users Guide for the latest separation requirements!

☐ Terminal Emissions Requirements

To prevent the JTIDS/MIDS terminal's RF transmissions from interfering with the normal operations of other systems, its pulse power spectrum and out-of-band emission characteristics are strictly specified. The pulse power spectrum is unrestricted within 3 MHz of the center frequency, but it must be 10 decibels (dB) down at ±3 MHz, 25 dB down at ±6 MHz, and 60 dB down ±15 MHz. The out-of-band emission characteristics, including broadband noise, sideband splatter, harmonics, and other spurious emissions, must be kept below –65 dBm per kiloHertz (kHz).

☐ Interference Protection Feature

Because Link 16 transmissions could potentially interfere with national air navigation and flight safety, all JTIDS and MIDS terminals are equipped with an **Interference Protection Feature (IPF)** to monitor their terminal transmissions. The IPF function monitors its transmitter output for:

- Out-of-band transmissions
- Transmissions in the IFF notches
- Improper frequency-hopping distribution
- Incorrect pulse lengths
- High receiver/transmitter (R/T) thermal level
- High Power Amplifier (HPA) operation, and
- TSDF.

Any one of these infringements constitutes an **IPF failure**. Normally, if authorized levels are exceeded, the IPF function will automatically disable the terminal's transmissions for up to one frame.

An IPF failure is an FAA violation!
FAA violations are subject to fines.

The Link 16 terminal implements two sets of protection features. The first feature imposes **peacetime constraints** on the terminal's operation in Mode 1. (These limitations are automatically overridden in the less capable Modes 2 and 4.) The second feature automatically monitors the terminal transmissions to ensure that it does not interfere with navigation systems.

■ JTIDS Class 2 IPF

The IPF mode is identified in the initialization data load (IDL) for the current operation or exercise. If necessary, the operator of a JTIDS Class 2 terminal may change the IPF mode, but must remain in compliance with the frequency assignment restrictions for the area of operations. The IPF mode restricts pulse density—the number of pulses relative to time—of the network and its participating platforms. Currently, the four possible IPF modes for a JTIDS Class 2 terminal are:

- Off, 100/20
- Exercise
- Combat
- Off, 100/50

To prevent potential interference, each terminal monitors its own transmissions.

The fractions above indicate the pulse densities allowed for the network as a whole and for own unit's terminal. Each fraction represents the density of network pulses over the density of own unit's terminal's pulses, respectively.[7]

♦ "Off, 100/20" Mode

The terminal will operate in the "Off, 100/20" mode, unless one of the other three IPF override modes is explicitly selected during initialization. The network's pulse density is limited to 100 percent, and own unit terminal's pulse density is limited to 20 percent. In this mode, the terminal will inhibit TDMA transmissions if it

7 *Further details concerning measurements of pulse density are discussed in Section E.*

detects an IPF failure. Under ordinary circumstances, the operator may reset each transmission inhibit.[8]

The JTIDS default IPF mode is "Off, 100/20."

♦ Exercise Mode

The **Exercise Mode** IPF setting provides partial interference protection. The peacetime constraints are overridden to allow contention access,[9] a TSDF of 100/50, and high power output by those C2 units that are equipped to do so.[10]

The E-3 and the CRC are equipped with the HPA, which can boost outgoing transmissions to 1000 watts. Among the other Services, USN shipboard and the airborne E-2C terminals also allow the high power setting. Since normal, 300-nm connectivity is provided with normal power (200 watts), the HPA is provided for "burn-through" against jamming. In this setting, the terminal continues to monitor the signal characteristics of its transmissions, including pulse spread, invalid frequencies, and nonuniform frequency distribution. The JTIDS Class 2 terminal and the MIDS LVT-1/LVT-2 terminals also have medium power 42-watt and 25-watt settings, respectively.

The authorization required for Exercise Override is provided by the Commander, Joint Forces or the Joint Interface Control Officer (JICO), often as part of a military message called the Operational Tasking Data Links, or OPTASK LINK. This message provides detailed instructions for establishing and operating the tactical data links to be employed for an operation or exercise.

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8 *Details are described in paragraph 3.2.1.3.18.3 of the System Segment Specification 15 April 1999, for Joint Tactical Information Distribution System Class 2 Terminal.*

9 *The current spectrum certification allows peacetime use of contention only in full protect mode. Until the full protect modes are changed to support contention, the use of contention in exercise mode requires specific authorization in RFAs.*

10 *Contention access is described in Chapter 5, Section B.*

♦ Combat Mode

With IPF set to Combat Mode, all protection features are overridden. The relevant authority for override will be based on situation and geographic location, but as a rule, it is not authorized for peacetime operations in current frequency assignments. This setting should be used only when continued operation is imperative to accomplish combat operations.

> ***The use of Combat Mode is not authorized in the current US frequency assignment.***

In normal operations, terminals occasionally experience “nuisance” IPF failures that can occur either as a result of fleeting, spurious terminal emissions or erroneous IPF monitor trips. In such cases, pilots must reset the IPF shutdown. This can happen at inopportune times, such as while receiving SAM data from RJ.

♦ “Off 100/50” Mode

The terminal will operate in the “Off 100/50” mode only when this mode is explicitly selected during initialization. The “Off 100/50” mode will operate exactly like the “Off 100/20” mode, except for the indicated TSDF limitations: the network pulse density is limited to 100 percent, and own unit terminal’s pulse density is limited to 50 percent.

MIDS IPF (LVT-1/2/3 and NATO)

Just as with Class 2 terminals, MIDS IPF is set in the network IDL, but the operator of a MIDS platform can change the setting. Currently, the four possible IPF modes for a MIDS terminal are:

- 0 = Full EMC[11] Protection (100/50)
- 1 = Exercise EMC Protection (100/50)
- 2 = Combat EMC Protection
- 3 = Full EMC Protection (100/20)

These modes have definitions that correspond to those of the appropriate JTIDS IPF modes.

JTIDS and MIDS Comparison

The currently permitted values for the IPF Override function in the JTIDS Class 2 and the MIDS LVT terminals do not match.

The allowable IPF override settings for these terminals are shown in the following figure. Because MIDS will become the common terminal within NATO, the MIDS interpretations are currently being discussed for adoption by the JTIDS Spectrum Users Group for JTIDS Class 2 terminals.

JTIDS	
Value	**Interpretation**
0	Off, 100/20
1	Exercise
2	Combat
3	Off, 100/50

MIDS	
Value	**Interpretation**
0	Full EMC Protection, 100/50
1	Exercise EMC Protection
2	Combat EMC Protection
3	Full EMC Protection, 100/20

Figure 4-6. The currently permitted values for the IPF Override setting differ between the JTIDS Class 2 and the MIDS terminals. The Link 16 community expects all IPF override specifications to match, as shown here for MIDS, and to be implemented in the future.

11 *EMC refers to electromagnetic compatibility.*

Section E

Time Slot Duty Factor

TSDF was developed as a way of quantifying Link 16 transmissions as a measure of pulse density. The calculated TSDF values are used as part of the scheduling process to ensure that planned operations do not exceed frequency assignment restriction limits.

TSDF is normally a two-factor number written as a fraction: for example, 100/50. The first number represents the total percentage of potential pulses in a geographic area, and the second number represents the percentage of pulses that can be transmitted by the highest single user. Each TSDF number is based on the percentage of base value, which is represented by 396,288 pulses per 12 seconds. The example of 100/50, above, represents a geographic area where the total number of potential pulses is 396,288 (100 percent of 396,288), and the highest single user is 198,144 pulses (50 percent of 396,288).[12]

TSDF values are percentages.

If a third number is included in the TSDF fraction (for example, 100/50/(300)),[13] it represents the additional TSDF percentage allowed for all the platforms in an area defined within an annulus between a 100-nm circle and a 200-nm circle around each Link 16 terminal, for a total of 400 percent TSDF.

Managing TSDF enables compliance with IRAC restrictions that place various TSDF limitations on JTIDS/MIDS operations. The most obvious are the two geographic areas that establish the maximum number of pulses permitted within a geographic radius around each JTIDS/MIDS terminal (currently 100 and 200 nm). To determine

12 *The value 396,288 represents transmission of STD or P2SP packing in every one of the 1,536 time slots in the frame. STD and P2SP transmissions contain 258 pulses per frame: thus, 258 × 1536 = 396,288.*

13 *Approved geographic area limit in IRAC 33583.*

the TSDF within the present 100-nm geographic area, select any terminal and add the unit TSDF to the unit TSDF of all the JTIDS/MIDS terminals within this 100-nm radius. The sum TSDF becomes the first number, and the highest single user within the 100-nm radius becomes the second.

The remainder of this section describes the calculations needed for meeting US&P spectrum certification requirements. National FCAs also require the consideration of TSDF in coordinating Link 16 operations.

☐ Calculating TSDF

TSDF calculations are based on a standardized method included as part of the supporting documentation in IRAC Document 33583.[14] The TSDF values are derived from the assigned transmit time slots and represent all of the opportunities for a platform to transmit.

☐ TSDF Table

Every Link 16 network description document is published with a TSDF table, similar to Figure 4-7, which contains the platform TSDF for all network participants. Additionally, Internet tools are being developed by the individual Service NDFs to automate the calculation process. The Service NDFs are the authoritative resources for assisting users in determining their TSDF calculations.

Platform	TSDF	Relay	Voice	Total
E-2C	18.2%	9.0%	12.55%	39.75%
Ship	12.2%		12.55%	24.75%
E-3	18.6%	9.8%	12.55%	40.95%
CRC	10.8%		12.55%	23.35%
F-15	3.1%			3.1%

Figure 4-7. A TSDF table is included in every Link 16 network description document. The calculations in each network's table are based on platform participation and the transmit time slots included in the given network design. A sample table is shown here.

14 *The IRAC document (33583) includes, as an attachment, SPS WG-1 TR 02-002, Description of Contention Transmissions. That document provides the agreed TSDF calculation method.*

Platform TSDF

The platform TSDF forms the basis for the calculations required for deconfliction and scheduling operations. The connectivity matrix, also provided as part of the network description documentation, contains all the necessary information to calculate TSDF. This matrix represents the 12-second frame and depicts all the platforms' time slot assignments. Each non-RTT time slot in a network can contain either 258 or 444 pulses.[15] The third type of pulse count configuration is for RTT time slots, which use 144 pulses. To calculate the unit TSDF, the number of assigned time slots is multiplied by the total number of pulses in each time slot, divided by 396,288, and then multiplied by 100 to yield a percentage value. This provides the TSDF for a single platform. The following formula illustrates the calculation:

$$\text{TSDF} = [(\text{ pulses per time slot} \times \text{assigned time slots per frame})/396{,}288] \times 100$$

The platform TSDF for a specific event is calculated using the platform line in the TSDF table. Platform variables such as relay are provided as separate values to allow maximum flexibility in calculating TSDF totals. In Figure 4-7, above, the column labeled "Total" represents the total transmit time slots assigned in the network. When calculating TSDF, include only the column values that are actually planned to be used. For example, if the E-2C is designated as the only relay platform, the E-3 would not include relay, thus reducing its total TSDF by 9.8 percent to 31.15 percent.

The TSDF for the highest single user is determined by using the individual platform calculations from the TSDF Table, or as identified if an automated TSDF calculator tool is being used. In determining the highest single user for an event, use only the platforms scheduled to participate. In Figure 4-7, the E-3 represents the highest single user. However, if the E-3 were not participating, the platform TSDF for the E-2C would be used instead, since the E-2C would then be the highest single user.

Machine-controlled contention transmissions (RTT-B, PPLI, Net Entry, Air Control Uplink, Air Control Backlink, and Fighter-to-fighter) are permitted in the US&P certification (and a growing number of other nations) and must be included in the

15 *STD and P2SP transmissions have 258 pulses per time slot; P2DP and P4 transmissions have 444 pulses per time slot.*

TSDF calculations. The calculations are based on the time slot group access mode[16] from the platform participation in these contention pools. This platform machine-controlled contention TSDF is already included for platform TSDF totals, in the TSDF tables of the network description documents provided by the network design facilities.

The platform TSDF will include the transmissions for Time Slot Reallocation (TSR), if this is part of the network design, and will be included in the platform values in the network description document's TSDF table. The platform TSDF for TSR equals the TSDF of the TSR pool in which the platform could transmit.

☐ Geographic Area TSDF

The geographic area TSDF will require other calculations in addition to the platform TSDF (described in the last paragraph) to meet US&P restriction limits. In addition to the platform TSDF, calculations for voice and contention must also be made.[17]

■ Platform TSDF

Platform TSDF is calculated by adding the individual platform TSDFs for all the platforms operating within the geographic area. The voice calculation is not included in the platform TSDF when calculating the geographic area total. Relay is included only for those platforms actually planned to perform the relay duty.

■ Voice TSDF

The voice TSDF contribution is added to the overall geographic area TSDF calculation. This TSDF is based on the number of voice nets in use, multiplied by the voice TSDF times a **use factor**. The use factor is based on the number of network voice participants. For up to 12 voice participants, the use factor is 1; for between 13 and 20 participants, this factor is 2; and for more than 20 participants, this factor is 3.

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16 *For a description of time slot access modes, refer to Chapter 5, Section B.*

17 *The contention transmission TSDF includes the values calculated for machine-controlled contention, TSR, and repromulgation relay. Since repromulgation relay is not used by US services, it was not addressed in this section.*

For the following example in calculating the voice TSDF contribution, the voice TSDF value of 12.55 percent (for 16-kbps voice at P4SP [112 time slots × 444 pulses = 49,728, or 12.55 percent]) will be used. Using an example of a single net with the voice TSDF value of 12.55 percent, the TSDF contribution for 12 or fewer platforms is 12.55 percent (single net × 12.55 × use factor of 1); between 13 and 20 participants, the contribution would be 25.10 percent (single net × 12.55 × use factor of 2); greater than 20 participants would be 37.65 percent.

An example TSDF for a two-platform network is shown in Figure 4-8. The first platform is assigned 20 percent of the available 396,288 pulses contained in a 12 second frame for data transmissions. The second platform is assigned 30 percent of the available 396,288 pulses in the same 12-second frame for data transmissions. Both platforms also participate in a single net voice pool. It is assumed that all platform connectivity requirements could be met by the allocation of the TSDF mentioned. Since there are no more than 12 platforms participating in the voice pool, the single voice net geographic area TSDF contribution would be 12.55 percent. 12.55 percent is then added to each platform's data TSDF to calculate the total TSDF for each platform, and to identify the platform with the single highest TSDF. In this case, the platform with the single highest TSDF is platform 2 at 42.55 percent (30% + 12.55%). The total geographic area TSDF in this hypothetical network, therefore, is 62.55 percent, with the single largest user assigned 42.55 percent. This would represent a 62.55/42.55 TSDF network.

Platform 1	Platform 2	Voice	Total
20%	30%	12.55%	62.55%

Figure 4-8. Platform TSDF data and voice assignments contribute to total TSDF. A two-platform TSDF example is shown here. For a network consisting of only two platforms, the use factor is 1.

■ Contention TSDF

A third required calculation is contention TSDF, which consists of summing the values for machine-controlled contention, TSR, and repromulgation relay. The spectrum certification limits the amount of contention in a geographic area to 25 percent, and/or to 33 percent for fast-moving aircraft. The resulting percentage is normally much less than 33 percent for each network. If more than one network is operating in the same geographic area, the total of the machine-controlled contention network value added together cannot exceed 33 percent. This information is included in the TSDF table with each network description document.

The TSDF for machine-controlled contention is calculated by first multiplying the time slots in each contention participation group by the packing limit, and then adding the result from all of the contention pools and multiplying times one half. This calculation is done independent of the number of participants in the pool or the time slot access mode.

The use of TSR by service platforms is being added to future network designs and can be done in either centralized or dissemination mode. For centralized TSR, the TSDF contribution will equal the total TSDF for all the centralized TSR pools. For TSR in the dissemination mode, the TSDF will equal the total of all the TSR pool time slots times a factor *X*. Factor *X* will equal either 1.25 or 1.33, depending on whether the number of TSR participants exceeds the capacity of the reallocation message.

Section F

Geographic Area Coordination

The Chairman of the Joint Chiefs of Staff Instruction (CJCSI) 6232.01 directs that geographic area coordination—also known as pulse deconfliction—be completed prior to operating any JTIDS/MIDS terminal within the US&P. This instruction applies to the military services, Joint Staff, combatant commands, and those activities and agencies reporting to the Chairman of the Joint Chiefs of Staff who operate JTIDS/MIDS-equipped systems within 200 nautical miles of the coastal US&P. It also applies to foreign and coalition units operating with US forces within 200 nautical miles of the coastal US&P. This section is devoted to explaining the deconfliction process within the US&P.

Military services operating outside of the US&P should review guidance from the respective theater combatant command deconfliction authority.

☐ The JTIDS/MIDS Deconfliction Server

The **JTIDS/MIDS Deconfliction Server (JDS)**, which is administered by the US Joint Forces Command–Joint Interoperability Division (USJFCOM-JID), is the Web-based database application tool designated by the Joint staff instruction for the scheduling and deconfliction of Link 16 operations. JTIDS/MIDS users—or their representative points of contact (POCs)—must ensure that their TSDF requirements are given to the respective deconfliction coordinator in a timely manner. Individual users may also access the server, with viewing privileges only, to examine scheduled JTIDS/MIDS activities.

■ Service Deconfliction Coordinators

The deconfliction coordinator is a designated representative of an organization tasked with the scheduling of JTIDS/MIDS operations for their platforms. Coordinators schedule JTIDS/MIDS operations within a geographic area, encompassing one or more frequency assignment authorization areas. Deconfliction coordinators must be aware of the frequency assignment for the area of operations they are scheduling on the JDS[18].

Figure 4-9 shows the relationships between the various organizations responsible for JTIDS/MIDS pulse deconfliction in accordance with the CJCSI 6232.01.

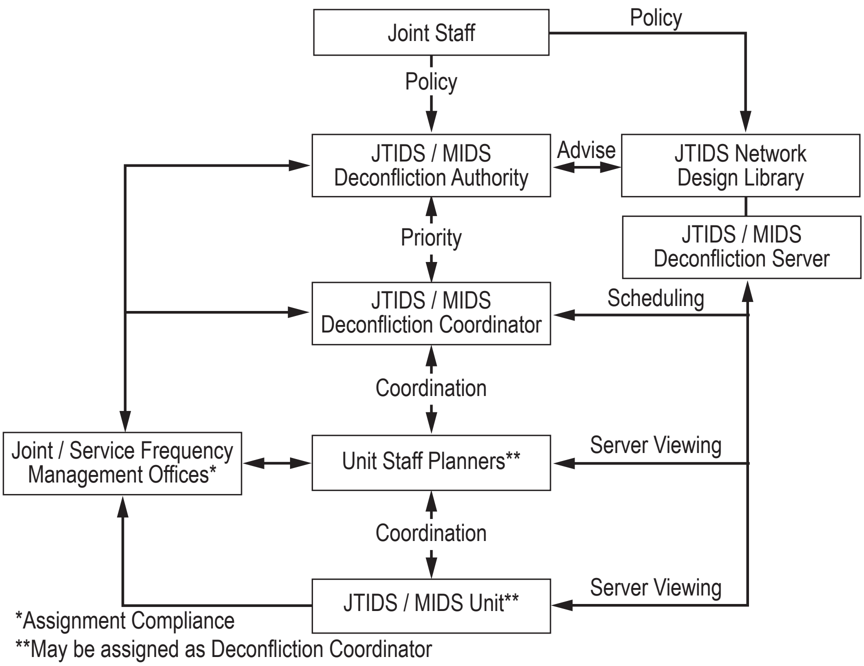


Figure 4-9. Geographic area coordination is required before operating any JTIDS/MIDS terminal within the US&P. The deconfliction organizational relationships promulgated in CJCSI 6232.01are shown here.

18 *To use the on-line JTIDS/MIDS JDS, deconfliction coordinators must obtain a login identification (ID) and password from the deconfliction server administrator. The server address is http://jndl.forscom.army.mil.*

Unit/Staff Communications Planners

Planners of existing and future JTIDS/MIDS operations, exercises, training, and tests must complete the following tasks before radiating with a JTIDS/MIDS terminal:

- **Coordinate with the appropriate JTIDS/MIDS deconfliction coordinators** to satisfy all frequency assignment authorization restrictions. JTIDS/MIDS deconfliction is similar to, and may be done as, part of the same process as coordinating airspace or operations areas.
- **Submit a temporary frequency assignment request**, in accordance with existing frequency management directives, if a permanent JTIDS/MIDS frequency assignment does not exist or cannot support the mission for the desired area of operation. Note that this requires at least a 30-day lead time.
- **Ensure all participating JTIDS/MIDS forces are included** in the coordination process and are briefed as to specific frequency assignment restrictions.

Managing a Geographic Area

In managing a geographic area, the designated coordinator must remember that all users have a requirement to operate JTIDS/MIDS equipment, and the coordinator must determine a user's current requirements. This means that the coordinator must communicate with the users or requestors of JTIDS/MIDS operations, which could include a carrier group or a single unit.

It is important to prioritize JTIDS/MIDS equipment use in a given geographic area. The following list is intended to assist in identifying types of operations. Remember that all aspects of the operation must be examined and judged on their merits. *This list is not intended to suggest a priority, but rather highlights aspects for consideration.*

- **Workups** are generally known months in advance and are done prior to deployment for units heading into areas where there may be potential hostilities. If this is not the case, however, the POC of the workups should notify the coordinator.

- **Joint or Combined exercises** are usually known well in advance. These exercises often have TSDF requirements and normally do not allow for any adjustments because of 24-hour operations.
- **Single-service exercises** are typically known well in advance and may be used for short-notice deployment to a global “hot spot.” The exercise POC must inform the coordinator of event needs. A 100/50 TSDF network assignment may not be needed at 100 percent throughout the exercise. It is important for the exercise or Service POC to maintain close contact with the coordinator, therefore, to accommodate the needs of all users in the geographic area.
- **Contractor trials and testing** are characteristically known well in advance. Sometimes contractors, or the people closest to the trial or test, may not be aware of their responsibilities to coordinate their activities or test and schedule changes. This can cause short-notice requirements that may conflict with those of the operational community. The best resolution for this problem is to schedule the requirement early. Although contractor trials or testing benefits the operator, any trial delays can have a cost impact on the Department of Defense. Therefore, coordinators must make every effort to provide the resources required. By the same token, however, the contractor must make the coordinator aware of the requirements as early as possible. Early notification gives the coordinator the option to move one operation farther away or to limit the TSDF during certain time periods without causing an adverse impact on operations. The key factor is advance knowledge, which entails communicating that information to the appropriate deconfliction coordinator.
- **Routine training** is an ongoing requirement with varying needs. Its location often determines whether training is affected by other JTIDS/MIDS operator requirements. Southern California (SOCAL), for example, is a heavily congested geographic area, and scheduling difficulties are normal for routine training there. On the other hand, training in Bath, Maine traditionally operates on a regular basis with few scheduling problems. Because assignment problems can occur in any location, users are advised to schedule early and accommodate other operator training needs.

- **Safety/Search and rescue** operations are normally unscheduled and are always highest priority. Safety always comes first. Any TSDF requirement for search and rescue efforts using JTIDS/MIDS equipment is granted. The organization or unit leading the search and rescue effort informs the designated coordinator of the applicable area.

If a POC schedules requirements accurately, honestly, and in a reasonable time frame, but the requirements exceed the allowable TSDF authorization, a temporary frequency assignment or waiver to an existing assignment in excess of 100/50 TSDF can be requested for the period necessary to accommodate all users. Although this is time-consuming, it remains an option.

A coordinator may also ask the POC of the requesting unit whether a reduction in TSDF is possible for all or portions of the required time. For example, a Fighter Wing (FW) doing a large force exercise (LFE) can have a week-long, 100/50 TSDF network requirement. During the same period, an Air Control Squadron (ACS) unit can also have a two-week 100/50 TSDF assignment. Clearly the two are incompatible in the same geographic area (for example, VACAPES). The coordinators should contact the POC of each operation to determine the specific time when the full requirement (100/50 TSDF) is necessary. It is possible that the FW needs 100/50 TSDF for only a part of the week, or for selected intervals during its requested one-week period. The ACS unit may need 100/50 TSDF for only three days. So by working directly with the unit POCs, the coordinators may be able to work out a schedule that accommodates both services' requirements.

Communication is the key to reserving and accommodating geographic area transmission requirements for JTIDS/MIDS use!

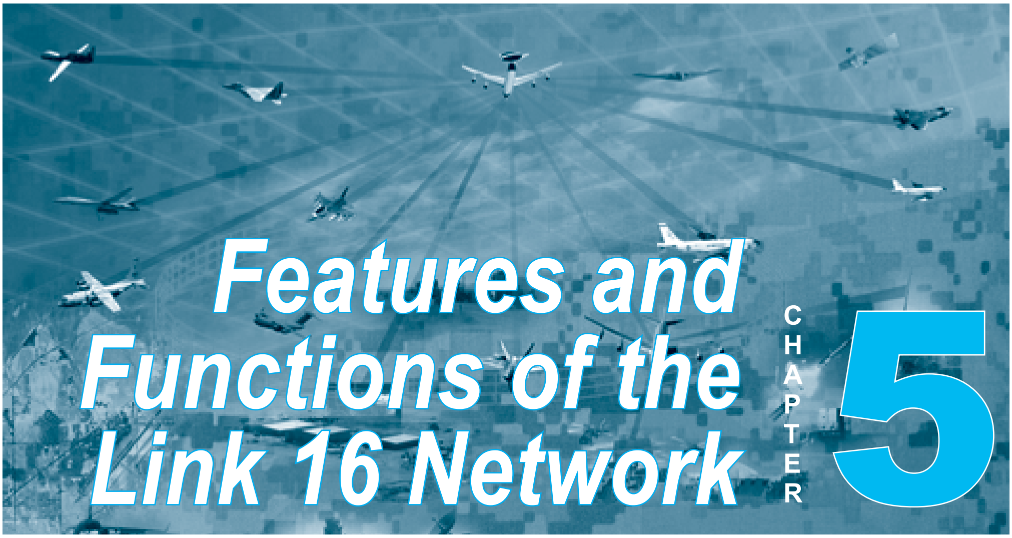
The key factor is communication, not only between the respective POCs and the coordinators, but also among the POCs themselves. The coordinators should assist in facilitating this discussion as soon as it has been determined that a conflict exists. If time does not permit requesting a temporary frequency assignment and the unit POC is unwilling or unable to reduce his unit's requirement, then a coordinator must require a separation between the exercises—or else deny one exercise the permission to operate.

The separation of operations is based on two factors: time and distance.

- Utilizing the *time factor*, the only option available is to allow one operation authorization while the other operation must be silent. Obviously, this is an all-or-nothing approach. Failure to reach an agreement between the requesting units' POCs leaves the coordinator with little more choice than this option.
- The *distance factor* option is also difficult, because the connectivity requirements typically needed between ground-based, airborne, and naval units means this option would also be very difficult to implement. The distance factor is currently based on the pulse density within a 200-nm radius around each terminal. A coordinator may need to separate each operation, therefore, by as much as 200 nautical miles. It is a difficult task to move an entire operation to satisfy pulse density requirements.

For all instances of Link 16 radiation in the US&P, plan well ahead for scheduling and deconfliction!

In conclusion, all users must identify their JTIDS/MIDS operational requirements to their respective coordinator in a timely manner. An operation may need a 100/50 TSDF frequency clearance for only a portion of the time that the clearance was authorized. This provides some degree of flexibility for the coordinator to permit other users to radiate within the same geographic area. It is important that all users provide the coordinators with the best information available to successfully accomplish pulse deconfliction scheduling.



Introduction

The previous chapters focus on the physical structure of the Link 16 network. The focus of this chapter is on its logical structure. The logical structure is mission-oriented and is based on platform requirements. Many different logical structures are possible. These are currently designed by the US Armed Services' own **Network Design Facilities (NDFs)**.[1] To allow the operator to effectively utilize the network structure, an understanding of how it is designed and how it works is helpful in recognizing problems and diagnosing their probable cause. Knowledge of the logical structure of the network also enables an operator to distinguish between the limitations that are inherent in the Link 16 waveform and those that are part of the design of a particular network.

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1 *USAF Initialization Design Loads (IDLs) are maintained at the following Website: https://www.my.af.mil/gcss-af/afp40/USAF/ep/globalTab.do?command=org&pageId=681742&channelPageId=-1717014. Select Section A3YJ, then click on the link to the AF Link 16 Network Design Facility Knowledge Now Community of Practice (CoP). Individuals can also contact the AF NDF at DSN 574-8328 or 574-8329 to request a desired IDL.*

Section A

Participation Groups

Superimposed on the physical structure of the Link 16 network is a logical structure that allows it to be adapted to specific operational environments or needs. This adaptation is accomplished by apportioning the network capacity among multiple "virtual circuits" whose transmissions are dedicated to a single function. Participants are then assigned to these circuits, or functional groups, as required by their mission and their capabilities. In addition to friendly force identification and position reporting, functional groups can include:

- Surveillance
- Fighter-to-fighter target sorting
- Air control
- Imagery
- Network Enabled Weapons
- Ballistic Missile Defense (BMD) Operations
- Electronic Warfare (EW) reporting and coordination
- Mission management and weapons coordination, and
- Two secure voice channels.

There are also functional groups that support the operation of the network, including **Initial Entry** and **Round-Trip Timing (RTT)**. All of these functional groups are known as network participation groups, or NPGs. The transmissions on each NPG consist of messages that support its particular function.

This functional structuring allows JTIDS Units (JUs) to participate on only the NPGs necessary for the functions they actually perform. It is likely that all Command and Control (C2) platforms will operate on all applicable NPGs at all times. A maximum of 512 participation groups are possible. Of these, 30 have been allocated for subject-oriented functions, and 22 of these are currently defined. The Air Force employs between 11 and 15 NPGs. NPGs 30 and 31 are specifically dedicated to IJMS messages and are only used in NATO Networks.

The NPGs 32 through 511 are assigned for the Needline participation groups. Because no US Armed Services employ these groups, they are not discussed further in this guidebook. All further references to NPGs will refer to the subject-oriented Network Participation Groups.

NPG	Purpose	USAF	USA	USN	USMC
2	RTT-A	✓	✓	✓	✓
3	RTT-B	✓	✓	✓	✓
4	Network Management	✓	✓	✓	✓
5	PPLI and Status A	✓	✓	✓	✓
6	PPLI and Status B	✓	✓	✓	✓
7	Surveillance	✓	✓	✓	✓
8	Mission Management & Weapons Coordination	✓	✓	✓	✓
9	Air Control	✓	✓	✓	✓
10	Electronic Warfare	✓	✓	✓	✓
11	Imagery	✓		✓	✓
12	Voice Group A	✓		✓	✓
13	Voice Group B	✓		✓	✓
14	Indirect PPLI			✓	
18	Network Enabled Weapons			✓	✓
19	Fighter-to-Fighter Net 1	✓		✓	✓
20	Fighter-to-Fighter Net 2	✓		✓	✓
21	BMD Operations	✓	✓	✓	✓
29	Residual Message	✓	✓	✓	✓
30	IJMS P Messages	✓			
31	IJMS T Messages	✓			

Figure 5-1. Air Force network designs employ subsets of the total number of available NPGs. Each J-series message is mapped to a specific NPG.

Each J-series message is mapped to a specific NPG. The JTIDS Class 2 terminal permits the assignment of 64 time slot blocks to as many as 32 participation groups drawn from 512 possible selections. The chosen NPGs have an "external" number, which is the number (between 1 and 511) assigned, and an "internal" number, sequenced from 1 to 32. Each NPG is associated with a particular set of J-series messages. For example, the J3.*x* set of messages is transmitted on NPG 7.

The NPGs

NPGs support operational communications needs. They allow the network designer to separate the functions implemented in the J-series messages. Network capacity is first allocated to NPGs, and then to the users that participate in that NPG. The following paragraphs briefly describe each NPG that is currently defined. NPGs can be divided into two basic categories: those used for the exchange of tactical data, including voice, and those required for network maintenance and overhead.

Network capacity is assigned first to NPGs, and then to users participating in them.

In general, networks are designed to support particular operational goals. The NPGs described here may or may not be included in a given network, depending on the mission objectives and functional requirements that the network was designed to meet.

NPG 1: Initial Entry

This NPG supports coarse synchronization and entry onto the network. The JU assigned as Network Time Reference (NTR) periodically transmits the Initial Entry message, J0.0, on this NPG, which is then used by other terminals in acquiring system time.

The Initial Entry message is transmitted in slot A-0-6.

Initial Entry messages are also transmitted by all active relays, and also by any JU defined to be an Initial Entry JU (IEJU).

Initial Entry JTIDS Unit

Note that when the NTR transmits this message, it transmits it once per frame. When the IEJU transmits the J0.0 message, however, it does so only every *other* frame.

The JTIDS Class 2 terminal and the MIDS terminals transmit the Initial Entry message in the A-0-6 time slot on Net 0, unless an alternate net entry slot is designated. Slot A-0-6 is the first time slot of every 12-second frame, and its use preempts any other assignment that might have been made during initialization. Because this NPG supports coarse synchronization and entry onto the network, it is required for all networks. Every JU participates on this NPG.

The J0.0 Initial Entry message is transmitted by the NTR, IEJUs, and all active relays!

■ NPG 2: RTT-A (Dedicated)[2]

RTT messages are exchanged between JTIDS/MIDS terminals on this NPG, called Addressed RTT (RTT-A), to support fine synchronization. This NPG also supports network entry and facilitates relative navigation (RELNAV) computations. The time slots in this group are dedicated for use by specifically identified JUs, and the RTTs they exchange are RTT-As.

RTTs allow new units to synchronize quickly with the network.

When this NPG is not specifically included in the network design, the RTT messages preempt occasional time slots on NPG 5 or 6. During synchronization, JTIDS/MIDS terminals transmit up to three RTT-As within 12 seconds to units whose received J0.0 message contains the highest values for time quality. After fine synchronization is achieved, these terminals exchange RTT messages about once per minute.

Terminals in fine sync exchange RTTs about once per minute.

■ NPG 3: RTT B (Contention)[3]

This NPG, called Broadcast RTT (RTT-B), performs the same function as NPG 2, but its time slots are shared by a group of JUs using the contention access method, in which all units can transmit. In RTT-B, each terminal builds an internal record of

2 *Dedicated access is discussed in Section B of this chapter.*

3 *Contention access is discussed in Section B of this chapter.*

received time qualities when entering the network. These are then assigned to the net numbers corresponding to values of the Time Quality (Q_t) parameter, whose values range from 0 to 15.[4] This enables a terminal entering the network to determine the best source to establish fine synchronization.

■ NPG 4: Network Management

This NPG permits the redistribution of network capacity through commands issued over the network. In addition, since a cryptovariable can be loaded by the terminal into its secure data unit (SDU) in response to a J31.1 Over-the-Air Rekeying (OTAR) message, rekeying can be accomplished using NPG 4. This provides the capability to issue new cryptovariables in connection with dynamic restructuring of the network, to rapidly recover from compromise situations and to facilitate routine changing of cryptovariables without the use of rollover. All JTIDS/MIDS terminals are capable of receiving and processing network management messages. This capability is currently being implemented, and is being tested by Navy fighter aircraft, as part of the Dynamic Network Management capability. The J-series messages associated with the Network Management NPG are shown below.

Network Management Messages	
J0.1	Test Message
J0.2	Network Time Update
J0.3	Time Slot Assignment
J0.4	Radio Relay Control
J0.5	Repromulgation Relay
J0.6	Communication Control
J0.7	Time Slot Reallocation
J1.0	Connectivity Interrogation
J1.1	Connectivity Status
J31.0	OTAR Management
J31.1	OTAR

Figure 5-2. All JTIDS and MIDS terminals are designed to receive and process the Network Management J-series messages on NPG 4. This NPG permits the redistribution of network capacity and the rekeying of terminals.

4 *For further details on Time Quality, refer to Section E of this chapter.*

■ NPG 5: PPLI and Status, Pool A

This NPG is used by nonC2 units in conjunction with NPG 6. By using time slots assigned to both NPGs 5 and 6, fast-moving fighter aircraft are able to transmit Precise Participant Location and Identification (PPLI) messages containing their location with a High Update Rate (HUR). For example, Air Force fighters operating in dedicated access use four NPG 5 time slots plus two NPG 6 time slots to achieve a two-second update rate.

Position, identification, and status reports are automatically generated by the terminal.

Ground platforms need not update their position as often as aircraft, so this NPG is not assigned to them. Periodically, terminal status messages containing information such as fuel and weapons status are also broadcast automatically by each terminal in these PPLI NPGs. Both PPLI and Status messages are automatically generated by the JTIDS/MIDS terminal according to the NPG (either 5 or 6) specified in the network design.

■ NPG 6: PPLI and Status, Pool B

This NPG is used by all JUs, both C2 and nonC2 alike, for identification, synchronization, and RELNAV. In addition to identification and detailed positional information, each unit's PPLI includes the Voice and Air Control net numbers that it is using. Most JUs can display any JU's PPLI. By default, when an RTT NPG has not been separately defined, the JTIDS terminals will exchange RTTs on this NPG as well.

Platform status messages are transmitted in PPLI time slots.

Data from this NPG can be forwarded to Link 11 and Link 11B. The J-series direct PPLI messages are shown in the next figure, along with the corresponding J-series Status messages, which are periodically transmitted in the same time slots in place of the PPLIs. Like the PPLI and Status messages of NPG 5, those of NPG 6 are issued automatically by the JTIDS/MIDS terminal.

Own unit's PPLI and Status messages are transparent to the operator!

Direct PPLI Messages	
J2.2	Air PPLI
J2.3	Surface PPLI
J2.4	Subsurface PPLI
J2.5	Land Point PPLI
J2.6	Land Track PPLI

Platform and System Status Messages	
J13.0	Airfield Status
J13.2	Air Platform and System Status
J13.3	Surface (Maritime) Platform and System Status
J13.4	Subsurface Platform and System Status
J13.5	Land Platform and System Status

Figure 5-3. NonC2 units transmit PPLIs on both NPG 5 and NPG 6. C2 units transmit PPLIs on NPG 6. Periodically (depending on the platform), a unit transmits its status message in an NPG 6 time slot, taking the place of the PPLI that is normally transmitted at that time.

NPG 7: Surveillance

Surveillance consists of searching for, detecting, identifying, and tracking objects that have tactical significance to the force. These objects, each of which is assigned a unique track number, include land points, bearings, and fixes, as well as air, surface, and subsurface contacts acquired from radar, Identification Friend or Foe (IFF), sonar, and other sensors. Other types of information, however, are also exchanged on the Surveillance NPG: theater ballistic missiles (TBMs), launch and impact points, Undersea Warfare (USW) points, acoustic bearings, intelligence information, and processed EW fixes, as well as the messages that manage track information. In addition, the Marine Corps, Air Force, and Army all use the Surveillance NPG to forward data from Link 11B onto Link 16.

All C2 platforms participate in the surveillance function.

Since all C2 platforms participate on NPG 7, procedures exist to limit the reporting of a contact to a single unit. This unit is said to have **reporting responsibility (R2)** for the track. This minimizes the volume of tracks reported, while allowing each unit to track all contacts.

Track Reporting

The concept of track reporting on Link 16 is identical to that of Link 11, with the new addition of land tracks. JUs originate tracks and assume R2 for Air, Surface, Subsurface, and Land tracks using exactly the same rules as Link 11. Furthermore, in a multilink force with JUs, Participating Units (PUs), and Reporting Units (RUs), which communicate with each other through a Forwarding JTIDS Unit (FJU), track reporting is homogeneous within the entire force. Only one Interface Unit (IU)—a PU, an RU, or a JU—will have R2 for a particular track at any given time. Specifics will be supplied in the OPTASK LINK.

The automatic R2 rules help to reduce the use of Link 16 bandwidth.

Besides providing for the reporting of "real pieces of metal," Link 16 fully supports the concept of "Train the Way You Fight" by allowing platforms to report training entities on NPG 7. Accordingly, two special message indicators in track reports provide this capability:

♦ Exercise Tracks

The Exercise indicator[5] signifies that a track is actually a Friend acting as the link-reported Identity for the purpose of the exercise. Friendly aircraft, ships, submarines, or emitters providing opposition in exercises can be identified thereby as Exercise Hostile (Faker), Exercise Suspect, Exercise Assumed Friend, Exercise Unknown, or Exercise Neutral. All other data normally reported for tracks, such as Platform, Activity, and Specific Type, can also be reported artificially for exercise tracks. Thus, an actually friendly track can be fully identified, just as though it were a genuine enemy track.

Exercise tracks are real pieces of metal.

♦ Simulated Tracks

Both Link 16 and Link 11 enable full training scenarios to be conducted. Simulated tracks, based on simulated video (radar inputs), may be initiated either with or without the presence of actual live tracks. Both links allow the simulated video to be distributed to all platforms of the force. The Simulation Indicator specifically identifies link tracks as simulated, not live. This capability proves quite valuable during link testing, and especially for TBM interoperability testing.

Simulated tracks are not real pieces of metal.

5 *The Exercise Indicator for fighters must be enabled in the IDL.*

♦ Amplification Message

In addition to tracks, the J6.0 Amplification message is also reported on NPG 7. Employed for years among most US Armed Services, the Link 16 amplification reporting capability is essentially identical to that of Link 11. The basic concept of data link amplification reporting is to amplify link-reported tracks, either real-time or nonreal-time, with tactical information gained by intelligence sources through means other than the traditional radar, sonar, and Electronic Support Measures (ESM). The information may be reported for any track by any such source, regardless of which platform has reporting responsibility for the track.

Intel is reported on NPG 7.

Reportable types of amplification information are the detailed identification and activity of the track, which can include hostile actions either imminent, planned, or in progress.

Intel reporting on Link 16 is at the operator's discretion.

Nowadays on Link 16, this information can be gained and transmitted by a variety of Joint and Allied sources. Acceptance of the intelligence information for inclusion in track reports is at the discretion of tactical operators, such as the Track Data Coordinator (TDC), or the platform's tactical display operators.

♦ Lines and Areas

Also on NPG 7, Link 16 provides the capability to exchange lines and areas of any geometric description. The lines and areas either may be defined by a series of connected reference points, which are referred to as multisided lines and areas, or they may be described as regular circles, ellipses, squares, or rectangles centered on a single point.

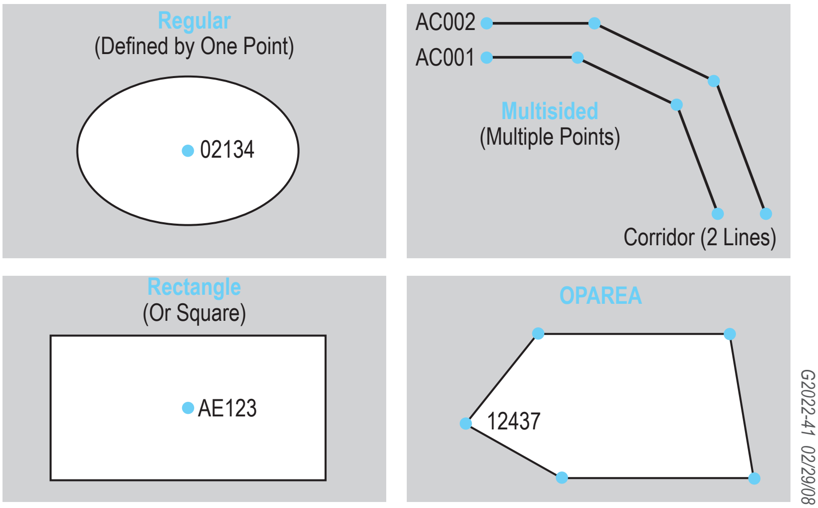

Figure 5-4. Lines and areas allow JUs to share a complete picture of the tactical theater of operations, including geographic boundaries, operating areas, air corridors, transit lanes, and other geometric descriptions.

The purpose of this capability is to allow JUs to share a complete picture of the tactical theater of operations, including geographic boundaries, operating areas, restricted areas, air, surface, and subsurface transit lanes (for example, air traffic control corridors), Airspace Control Means (ACMs) and defended areas. Certain units will be designated to enter onto their displays and into their databases the lines and areas of mutual tactical interest, and then to transmit them to all JUs on the Surveillance NPG.

♦ Indirect PPLIs

For all Services *except the Navy*, indirect PPLIs are also transmitted on the Surveillance NPG in J2.0 messages. These are position messages that contain position updates for the units that are not participating directly on Link 16. Newly approved Link 16-to-Link 16 data forwarding rules described in MIL-STD-6020 specify that J2.0 messages may now also be used to forward serial and satellite J2.x messages onto the Link 16 radio frequency (RF) network.

Indirect PPLIs are forwarded from units on other links.

Instead of NPG 7, the Navy uses NPG 14 for this purpose. The shipboard Command and Control Processor (C2P) can forward data between Link 16 and Link 11, as well as between Link 16 and Satellite Link 16, and Link 11 and Satellite Link 11. Satellite Link 16 units that are forwarded onto the line-of-sight (LOS) Link 16 network are also sent using J2.0 Indirect PPLI messages. Note that these messages may also be forwarded from serially connected participants as specified in MIL-STD-6020.

All the J-series messages transmitted on Surveillance are shown in Figure 5-5, which reveals the breadth and variety of information that may be exchanged on this NPG.

Surveillance (NPG 7) Messages	
J2.0	Indirect Interface Unit PPLI
J3.0, J3.1, J3.2, J3.3, J3.4, J3.5, J3.6. J3.7	Reference Point, Emergency Point, Air Track, Surface (Maritime) Track, Subsurface (Maritime) Track, Land (Ground) Point/Track, Space Track, and EW Product Information, respectively
J6.0	Amplification Information
J7.0, J7.2, J7.3, J7.4, J7.5, J7.6, J7.7	Track Management messages, Correlation, Pointer, Track Identifier, IFF/SIF Management, Filter Management, and Association messages
J7.1	Data Update Request
J8.0	Unit Designator
J8.1	Mission Correlator Change
J15.0	Threat Warning

Figure 5-5. Surveillance tracks, ASW information, track management messages, intelligence information, threat warnings, and the PPLIs of indirect IUs may all be exchanged on the Surveillance NPG. For the Navy only, the PPLIs of indirect IUs are exchanged on NPG 14.

■ NPG 8: Mission Management and Weapons Coordination

NPG 8 provides a means for a command-designated unit to coordinate platform weapons and order weapons engagements, and for all C2 JUs to report Engagement Status, controlling unit status, and tactical pairings. The next figure presents the J-series messages supporting these functions. As shown in the Figure 5-6, NPG 8 is also used for Electronic Counter-Counter-measures (ECCM) coordination, handovers, and controlling unit reports. Data from NPG 8 can be forwarded to Link 11 and Link 11B.

Commands and Engagement Status are exchanged on NPG 8.

Navy C2 platforms use NPG 8 for reporting engagement status. Marine Corps C2 platforms will use NPG 8 to transmit all mission assignment and weapons coordination messages.

Mission Management and Weapons Coordination (NPG 8) Messages				
J9.0	**Command**	**J9.2**	**ECCM Coordination**	
0	Weapons Free	**J10.2**	**Engagement Status**	
1	Weapons Tight	2	2	Weapons Assigned
2	Engage	3	3	Tracking/Locked On
3	Assign	4	4	Firing
4	Cease Engage	5	5	Effective (Target Destroyed)
5	Hold Fire	6	6	Partially Effective
6	Cease Fire	7	7	Not Effective
7	Cover	8	8	Engagement Broken
8	Salvo	9	9	Heads Up
9	Assume Control9	10	10	Engagement Interrupted
10	Attack	11	11	Investigating/Interrogating
11	Cease Attack	12	12	Shadowing
12	Not used	13	13	Intervening
13	Not used	14	14	Weapons Covering
14	Proceed to Point	15	15	Undefined
15	Cease Proceeding to Point	**J10.3**	**Handover**	
16	Conduct Procedures Indicated	**J10.5**	**Controlling Unit Report**	
17	Cease Conducting Procedures Indicated	**J10.6**	**Pairing**	
18	Assume Duties Indicated			
19	Cease Duties Indicated			
20	Transfer Control			
21	Return to Base			
22	Launch Alert aircraft			
23	Investigate/Interrogate			
24	Intervene			
25	Shadow			
26	Undefined			
27	Engage TN Objective with Specified Number of ASM/SSM to Meet Impact Time Indicated			
28	Priority Kill			

Figure 5-6. Many different J-series message types, including commands, weapons coordination, engagement status, ECCM coordination, handovers, controlling unit reports, and pairing, are exchanged on NPG 8.

■ NPG 9: Air Control

This NPG provides the means for C2 JUs to control nonC2 JUs. It is divided into two components, each of which is configured as a stacked net: the **uplink** and the **backlink**.

Air Control is configured as a stacked net with two parts: the uplink and the backlink.

Each net is assigned to a specific C2, either ground or airborne, and the fighter aircraft being controlled. The controlling unit provides mission assignments to fighter aircraft on the time slots assigned to the uplink.

The "Net 127" assignment requires operator action!
Check the OPTASK LINK for your
Air Control net number.

For example, the C2 JU assigns a flight leader to an air track or Ground Point/Track via the NPG 9 uplink. The flight leader responds with WILCO or CANTCO—and for WILCO, its continuing engagement status—to the C2 JU via backlink. Some aircraft have the capability to backlink battle damage assessments, self-assignments, and deassignments by the flight leader in backlinked Engagement Status messages.

Fighters downlink Mark Points to their controllers.

The C2 JU can also direct handover commands to another C2 JU and to a flight leader on the uplink. The flight leader responds with WILCO or CANTCO on the backlink. After WILCO, the flight manually changes control net number, and no check-in is required.

Fighters that receive tracks for their cockpit displays from monitoring the Link 16 Surveillance and Weapons Coordination NPGs are in compliance with the Air Control Revision (ACR) Interface Change Proposal (ICP), and they are said to be

ACR-compliant. Fighters that receive tracks for their cockpit displays from their controller's uplink are said to be non-ACR-compliant.

Marine Corps, Air Force, and Navy Common Data Link Management System (CDLMS) Model 5-controlled fighters are all ACR-compliant. They receive Link 16 air tracks, ground points, and ground tracks on the Surveillance NPG. By contrast, the Navy is in the process of implementing the ACR ICP for all of its fighters, but this process is not yet complete. Some F/A-18E/Fs currently receive a processed and correlated tactical picture from their controlling unit on the NPG 9 uplink.

The next figure presents the J-series messages exchanged on the Air Control NPG. You will notice that target weather information is also exchanged on NPG 9.

Air Control (NPG 9) Messages	
Air Control	
J12.0	Mission Assignment
J12.1	Vector
J12.2	Precision Aircraft Direction
J12.3	Flight Path
J12.4	Controlling Unit Change
J12.5	Target/Track Correlation
J12.6	Target Sorting
J12.7	Target Bearing
Weather	
J17.0	Weather Over Target

Figure 5-7. The Air Control (NPG 9) messages allow for the exchange of uplink and back-link information, as well as target weather information, between nonC2 units and their controllers.

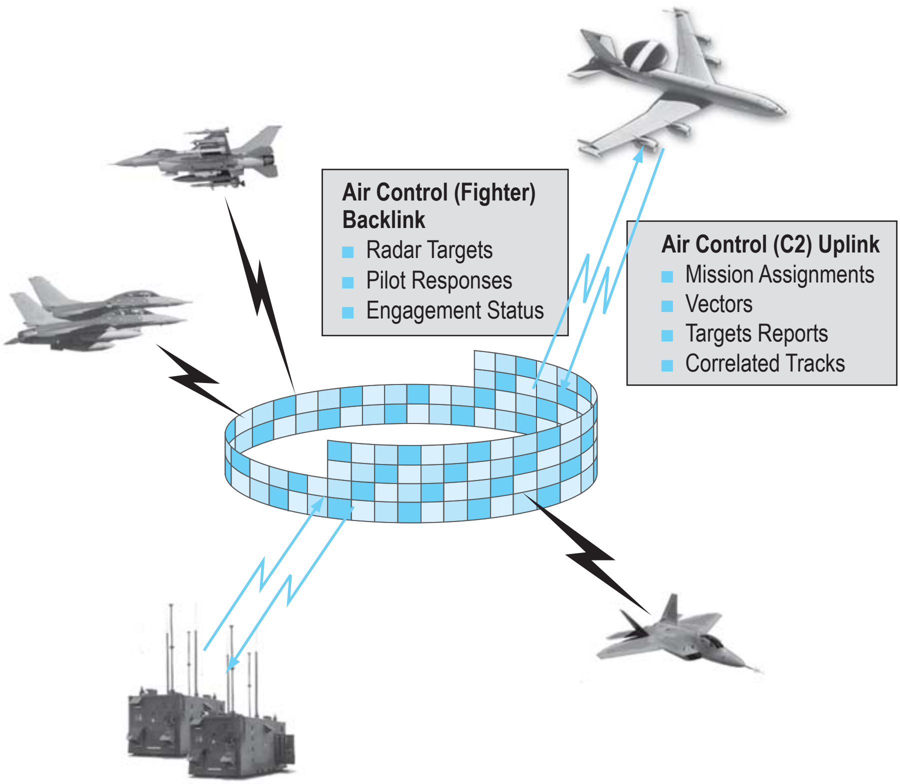

Figure 5-8. NPG 9 is configured as a stacked net, with an uplink and a backlink. Here, the CRC and AWACS are uplinking their messages, and the fighters are downlinking their responses.

■ NPG 10: Electronic Warfare

Link 16 is designed to support the concepts of cooperative EW and data fusion. EW data is of two types: parametric and product. **Parametric data** (J14.0 messages) consists of raw, unevaluated EW intercepts and parameters received from systems such as the Automatic Electronic Emitter Location System (AEELS) aboard Rivet Joint. These include data on fixes, areas of probability (AOPs), and lines of bearing (LOBs). **Product data** (J3.7 messages) is evaluated data. Normally, this means that an EW coordinator or other qualified operator has evaluated the intercepts from one or more participants and has developed a product that is deemed to be of general tactical significance.

EW parametric data can be shared over the network.

Two different NPGs support the exchange of EW data:

- The EW NPG, and
- The Surveillance NPG.

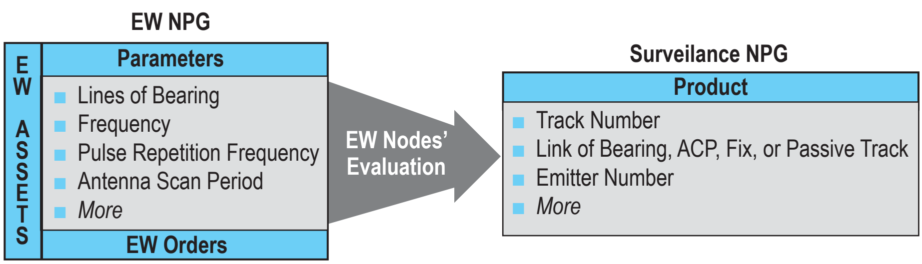

Figure 5-9. Two NPGs support the distribution of EW parametric and product data.

To achieve cooperative EW, the EW NPG is intended for use by all JUs that have a significant passive EW capability for exchanging detailed parametric data about EW detections, including Electronic Support (ES) and Radio Direction Finding (RDF) intercepts and Electronic Attack (EA) jamstrobes. The intent is that all participants transmit essentially raw (unevaluated) data direct from their passive sensors onto the EW NPG. To achieve data fusion, certain systems capable of processing large amounts of EW data from various sources receive, correlate, and evaluate the reported data and develop the EW products—that is, the evaluated LOBs, the AOPs, and Fixes.

Only evaluated EW data is reported on NPG 7.

These evaluated products are then reported on the wide-area Surveillance NPG to all participating JUs. Individual JUs that have developed evaluations of their own

EW sensor data are not prevented from reporting evaluated product data on the Surveillance NPG, if an operator selects an EW product for such a transmission

The EW NPG also allows an EW Coordinator (EWC) to coordinate and control the reporting of EW data by selectively directing actions by participating JUs. Link 16 enables approximately 30 different EW Orders, only 15 of which can be transmitted on Link 11.

■ NPG 11: Image Transfer

The J16.0 Image Transfer message supports the nonreal-time dissemination of tactically significant image data among weapon systems whose primary (or only) digital link is Link 16. The anticipated uses of the J16.0 Image Transfer message image file transfer include:

- Tactical commanders using target images from strike aircraft before authorizing weapons release
- Images from strike aircraft for Battle Damage Assessment (BDA).

The J16.0 image file transfer message supplements, when necessary, messages from other functional areas—such as Surveillance and Air Control—to provide necessary information about mission execution. Transmitters and planned receivers of the image files are JSTARS and the Air Operations Center (AOC), the F/A-18, and the F-15E Suite 5 and F-15E Suite 6.

Many file formats are available for storing imagery. To ensure interoperability between the sender and the receiver, each image file to be transferred must comply with the prescribed format. Currently, the only allowable format is the National Imagery Transmission Format Standard (NITFS) 2.1 Tactical Profile. NITFS is a group of standards specifying the format, compression, and communication of image files and amplifying information such as text, graphics, and location. Image files that use the NITFS 2.1 Tactical Profile must comply with NITFS version 2.1, Notice 2, dated 01 March 2001.

Images are transmitted in J16.0 messages.

Image file transfer is performed by transmitting a series of J16.0 messages containing data from the image file. Therefore, the image file needs to be divided up into pieces, called packets, which can fit into the J16.0 message. On receiving all the packets in a transfer, the receiver can then reconstruct the image file by assembling all the packets in the correct order.

■ NPG 12: Voice Group A

This NPG provides a secure, digitized voice channel for use by all JUs. A Link 16 network does not have to include a Voice NPG. When it does, however, it is usually configured as a stacked net with 127 possible subcircuits. A net initialized with the 128th number, net number 127, is understood by the terminal to mean "currently undefined."

Voice NPGs may be assigned interchangeably to either port.

During operations, the terminal uses a number supplied by the operator. The operator can change this number at will. Thus, Voice nets initialized with net number 127 feature a "dial-a-net" capability.

"Net 127" requires operator action! Check the OPTASK LINK for your Voice net numbers.

Voice remains active in data silence.

Voice Group A may be assigned to either Port 1 or Port 2 of the JTIDS terminal. Note that voice circuits remain active when the terminal is set to Data Silent, but that voice transmission stops in Long Term Transmit Inhibit (LTTI) mode. All Navy and Marine Corps Link 16 platforms that are equipped with either the JTIDS Class 2H or the MIDS LVT-1 terminal have Voice capability. Not all JTIDS/MIDS terminals have it, though; for example, the Army Class 2M, the MIDS LVT-2, and the MIDS LVT-3 terminals do not have Voice capability.

NPG 13: Voice Group B

This NPG provides a second voice channel with the same characteristics as NPG 12. Either or both NPG 12 and NPG 13 may be implemented in a given network design.

Either NPG 12 or NPG 13, or both, may be included in a network design.

NPG 14: Indirect PPLI

This NPG supports multilink operations by providing time slots in which a USN FJU will transmit PPLIs containing position and identification information for Link 11 PUs that are not participating directly on the JTIDS network, but whose data is being forwarded to Link 16 by the FJU. It is used solely by the USN for transmitting indirect PPLIs; it is not currently used for transmission by the other Services, although their platforms can receive indirect PPLIs from the Navy on this NPG.

Only the Navy transmits on NPG 14.

NPG 15 and NPG 16

These NPGs are reserved for future Joint use.

NPG 17

This NPG is currently unassigned.

■ NPG 18: Network Enabled Weapons

As of this writing, an Interface Change Proposal (ICP) is in coordination for the approval of Network Enabled Weapons (NEW) using this NPG for Link 16 data. Anticipated uses of NPG 18 for NEW will include:

- Transmission of Weapon Inflight Track (WIFT) data by the weapon
- Transmission of In-Flight Target Update (IFTU) data by the controller
- Transmission for IFTU Acknowledgement/Nonacknowledgement by the weapon
- Transmission of Bomb Hit Indication (BHI) data by the weapon.

■ NPG 19: Fighter-to-Fighter Net 1

NPG 19 provides for the reporting of fighter-derived sensor information. This includes the radar targets reported by the fighter's host computer and their associated identification information (for example, Unknown or Hostile). The NPG 19 exchange is typically assigned to a net number, and although it is technically not a stacked net configuration, it is used in a similar way. Pilots can change the net number as required—from 0 to 126—to suit operational needs. Fighters that need to share their target information must select those targets as candidates for display and must operate on the same net number. C2 units, such as the E-3 and the CRC, that wish to display NPG 19 data from the fighters' J12.6 Target Sorting messages must also select the same net number as the fighters for their NPG 19 receive assignments. Although NPG 19 is not assigned as a "Net 127" stacked net configuration, a fighter net must still be selected as required by the mission.

Fighters that share target information must select the same net number, and then select the targets for display!

USAF, Navy, and Marine Corps fighters use their NPG 19 time slots in contention access mode unless the frequency clearance does not permit the use of contention access, in which case fighters will operate in the dedicated access mode.[6]

■ NPG 20: Fighter-to-Fighter Net 2

NPG 20 provides a second medium for fighter-to-fighter data exchange. The NPG 20 exchange is typically assigned to a net number, and although it is technically not a stacked net configuration, it is used in a similar way. Pilots can change the net number as required—from 0 to 126—to suit operational needs.

■ NPG 21: Ballistic Missile Defense Operations

Ballistic Missile Defense (BMD) Operations allow two or more systems with common or shared defense responsibilities within an area of operations or a theater to coordinate their actions without affecting larger-area air defense or theater-wide network activities. BMD Operations include engagement coordination, such as determining the method of fire (for example, single shot, multiple shots, shoot-look-shoot), as well as data streams to provide more accurate, timely and data-rich information for engagements supported by a remote sensor. Other data-intensive functions to support engagements, such as enhanced discrimination, are also performed on this NPG.

■ NPG 22: UK Composite A

This NPG, which is currently unassigned, will be used by United Kingdom (U.K.) services to convey the messages of NPGs 4 (Network Management), 8 (Mission Management), and 9 (Air Control).

■ NPG 23: UK Composite B

This NPG is also currently unassigned. It will be used by U.K. services to convey messages on NPGs 7 (Surveillance) and 10 (EW parametric data and orders).

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6 *Time slot access modes are also discussed in Section B of this chapter.*

NPG 24

This NPG is currently unassigned.

NPG 25

This NPG is reserved for future Joint use.

NPG 26

This NPG is currently unassigned.

NPG 27: Joint PPLI

When implemented, identification and location information will be exchanged during Joint operations on this NPG. Currently it is not used.

NPG 28: Distributed Network Management

This NPG is currently not used. It is reserved for indeterminate future requirements.

NPG 29: Residual Message

This special NPG is provided to ensure a transmission opportunity for messages that are not assigned to one of the other NPGs. Such a leftover, or residual, message could occur when the particular NPG with which the message is usually associated is not included in the network design, or when the message is not normally assigned to a particular NPG. The J28.x series of proprietary messages, for example, which permit the exchange of free-text, character-oriented messages, are transmitted on this NPG. The USAF implements the J28.2 message for this purpose.

Messages may be transmitted on NPG 29 when their NPG is not included in a network design.

■ NPG 30: IJMS Position and Status

The IJMS Position and Status messages, or P-messages, are transmitted on this NPG. Only NATO platforms still use IJMS. Among the US Services, AWACS, whose JTIDS Class 2H terminal is bilingual, can process and understand the NATO IJMS messages.

NPGs 30 and 31 are used only by NATO platforms.

■ NPG 31: IJMS Messages

All IJMS messages except for position messages and Voice are transmitted on this NPG. These are the IJMS T-messages (track reports). Only NATO CRC platforms still use IJMS, and among US Platforms, only AWACS can interpret IJMS messages.

Section B

Time Slot Assignments

The amount of network capacity assigned to a given NPG depends on communications priorities and information exchange requirements. Examples are:

- The number and types of participants
- How often these participants need access to each NPG
- The expected volume of data
- The update rate of the information, and
- Relay requirements.

The number of time slots that must be allocated within the NPG to each participant depends on the type of unit and its method of accessing the time slot.

Unit Types

JUs are of two basic types: the Command and Control (C2) JUs and the non-Command and Control (nonC2) JUs. C2 JUs are those platforms that have the requisite equipment, mission, and personnel to exercise command and control authority. They direct the activities of other platforms. In the USAF, the C2 JUs include Control and Reporting Centers (CRCs), as well as the Airborne Warning and Control System (AWACS), Joint Surveillance Target Attack Radar System (JSTARS), Rivet Joint (RJ), Cobra Ball (CB), Combat Sent (CS), Compass Call (CC), and Senior Scout (SS). The nonC2 JUs are those whose activities are controlled or monitored by the C2 JU; these are typically fighter and bomber aircraft.

C2 and nonC2 units have different missions and different requirements in terms of the NPGs on which they participate and how often their data must be updated. The primary C2 functions are surveillance, EW, weapons coordination, air control, and network management. The primary nonC2 functions are target sorting and engagement.

Service	C2	NonC2
USAF	AOC, CRC, AWACS, JSTARS, RJ, CB, CS, CC, SS, ASOC Gateway	F-15C/D, F-15E, F-16, B-1B, B2
USA	FAAD, SHORAD, Patriot ICC	Air Defense Units
USN	CV, CG, DDG, LHD, LHA, E-2C	FA-18, EA-6B, EA-18G
USMC	TACC, TAOM, ADCP	FA-18, EA-6B, EA-18G

Figure 5-10. The primary functions of a C2 JU are surveillance, EW, weapons coordination, air control, and management of the network. The primary functions of a nonC2 JU are target sorting and engagement.

Time Slot Access Modes

Within each NPG, the time slots assigned to each unit are evenly distributed over time and generally occur every three seconds, every six seconds, and so on. These slots are assigned using **time slot blocks**, which specify a set, index, and recurrence rate, as previously described, as well as a net number. Time slot block assignments are numbered from 1 to 64. The terminal is limited, therefore, to a maximum of 64 time slot block assignments.

A terminal may be assigned up to 64 time slot blocks.

While several different access modes for each time slot block have been proposed at one time or another, three are currently in use:

- Dedicated Access
- Contention Access
- Time Slot Reallocation.

Dedicated Access

The assignment of time slots to a uniquely identified unit for transmission purposes is known as **dedicated access**. Only the assigned JU is permitted to transmit during that time slot. If that JU has no data to transmit, the slot goes unused. The advantage of dedicated access is that it provides each JU on an NPG with a predetermined portion of the network's capacity and a guarantee that there will be no transmission conflicts, at least not in a single-net environment.

Only one JU transmits in a dedicated access time slot.

One of the disadvantages of dedicated access is that assets are not interchangeable. One aircraft, for example, cannot simply replace another aircraft. If this were necessary during an operation, its terminal would first have to be reinitialized to transmit and receive during time slots matching those of the unit it would be replacing.

Dedicated access ensures that simultaneous transmissions will not occur.

Dedicated access can pose a problem for conducting handovers, as well. Recall the stacked nets used for air control. Fighters are assigned specific time slots during which to transmit back to their controller. The same time slots are used for the different fighter groups, but on separate nets. Net 1 can have eight fighters (1 through 8) and Net 2 can have eight fighters (1 through 8). Suppose, for example, that Control Unit A on Net 1 wants to hand Fighter 5 over to Control Unit B on Net 2. On Net 2, the new Fighter 5 will use the same time slots as the existing Fighter 5, causing simultaneous transmissions on what is supposed to be a dedicated time slot. A fighter cannot change groups unless there is a vacancy in the new net with the same number, or unless its terminal is reinitialized over the air.

■ Contention Access

In contention access, the number of slots chosen is determined by the access rate.

The assignment of time slots to a group of units as a pool for transmission purposes is known as **contention access**. In contention access, each unit randomly selects a time slot from the pool during which to transmit. The frequency of a terminal's transmission depends on the access rate assigned to that terminal.

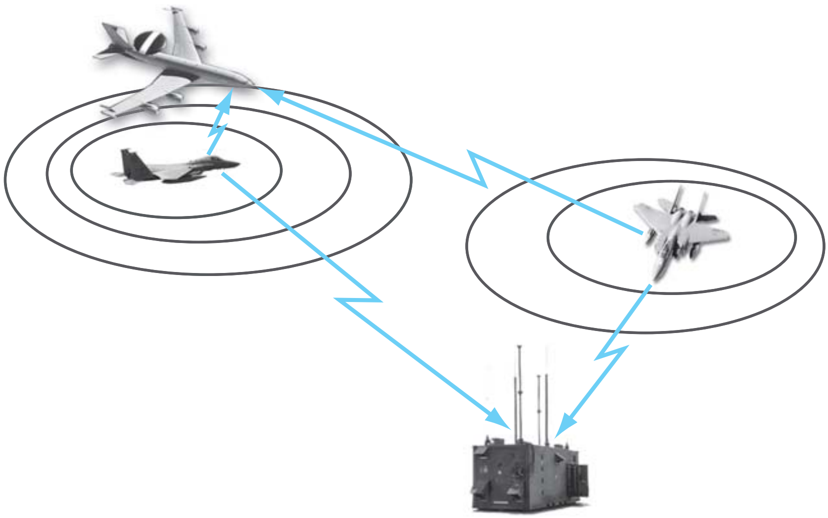
Several JUs may transmit simultaneously in a contention access time slot.

The advantage of contention access is that each terminal is given the same initialization parameters for this time slot block. This simplifies the network design and reduces the network management burden. Since specific assignments for each JU are unnecessary, JUs are interchangeable. This facilitates the inclusion of new participants and allows units to be easily replaced. This is particularly important for aircraft, and the USAF uses contention access routinely. The disadvantage of contention access is that there is no guarantee that a transmission will be received.

Because the time slot is not dedicated to one user, simultaneous transmissions are possible with contention access. The likelihood of simultaneous transmissions depends on the number of time slots in the pool, the number of units in the group, and the frequency with which they must transmit. If two units do transmit simultaneously during the same time slot on the same net, whether in dedicated access or contention access, this condition is called time slot reuse. Whenever this occurs, receivers will always hear the unit closest to them. In some situations, time slot reuse can provide additional throughput and connectivity.

A probability of reception can be calculated for units exchanging data in contention access.

The probability of reception from a particular unit within LOS depends on how many intervening units are operating in contention, their access rates, and the volume of their message traffic. One significant use of contention access is for voice, where the push-to-talk (PTT) protocol serves to prevent multiple units from transmitting simultaneously. Contention access may also be used for RTTs.



Number (RRN)	Simultaneous Transmissions	Average Period (Seconds)
1	2 slots per 48 sec	24.0
2	2 slots per 48 sec	16.0
3	2 slots per 24 sec	12.0
4	3 slots per 24 sec	8.0
5	2 slots per 12 sec	6.0
6	3 slots per 12 sec	4.0
7	4 slots per 12 sec	3.0
8	6 slots per 12 sec	2.4
9	8 slots per 12 sec	1.50
10	12 slots per 12 sec	1.00
11	16 slots per 12 sec	0.75
12	20 slots per 12 sec	0.60
13	26 slots per 12 sec	~ 0.46
14	32 slots per 12 sec	~ 0.38
15	64 slots per 12 sec	~ 0.19

Figure 5-11. Contention access allocates NPG capacity as a pool of time slots to a group of JUs. Simultaneous transmissions are possible. These are avoided in the voice NPGs by the incorporation of a push-to-talk (PTT) protocol. If time slot reuse should occur—that is, if two units transmit simultaneously in the same time slot on the same net—the transmission from the closest unit will be the one that is received.

■ Time Slot Reallocation

Time Slot Reallocation (TSR) is an access mode that allows the network capacity of an NPG to be assigned dynamically, based on the projected needs of its participants. It is intended to support a fluctuating demand from a varying group of users. TSR allows network capacity to be distributed where it is needed, by periodically allocating time slots from a pool to each participant, based on need.

Each platform that participates in the TSR pool reports its transmission needs over the network, and algorithms within the terminal redistribute the pool of time slots to meet these needs. If the need exceeds the available capacity, the time slots are redistributed to participating units in proportion to their reported needs so that there is a graceful degradation of the link. TSR will be implemented on AWACS, JSTARS, and the CRCs in FY 2008.

□ *Assignment of Network Capacity*

The first step in defining a JTIDS network is the assignment of network capacity to NPGs. The next step is the assignment of NPG capacity to JUs. NPG capacity is assigned by specifying time slot blocks and access modes for each participating JU.

Several additional parameters must be specified in order to use these time slots. These include the MSEC and TSEC cryptovariables and an indication of whether to receive, relay receive, transmit, or relay transmit during the time slot. These are specified at the time the network is designed. Air Force initialization design loads (IDLs) are stored at the USAF Link 16 Network Design Facility (NDF) at Langley AFB and are available on the Internet, where they are made available for review to all Link 16 users.

Selections of predesigned networks are available from the USAF NDF.

For Link 16 operations, one of these network designs—the one that best meets operational requirements—is designated for use. This information is conveyed to the CAF in a United States Message Text Format (USMTF) document called the

OPTASK LINK. The OPTASK LINK also specifies the net numbers for stacked nets, associates each platform with its JU address and track block, and assigns key network roles to certain participants, and identifies the crypto short title(s) used for TSEC and MSEC.

☐ Dynamic Network Management

The JTIDS/MIDS terminal has been designed to accept initialization commands over the network, and a limited capability for over-the-air terminal reinitialization has been implemented. Expansion of these over-the-air reinitialization commands, currently in the planning stages, could allow time slots currently allocated to a JU that is leaving, has left, or was never part of the network, to be reassigned to other JUs who have requested more capacity, or to new JUs that wish to join the network. Dynamic network management has not yet been implemented for the USAF.

The JTIDS terminal accepts reinitialization commands over the air.

☐ Option Pools

Requestors of a network design may require the flexibility to reallocate time slots in their Op Areas, according to the nature of their missions. Option pools allow this flexibility in the field. An **option pool** is a pool, or group, of time slot assignments that may be apportioned in several different, specific ways among a group of participants. The functions for which option pools may be designated in a network design are:

- Surveillance (NPG 7)
- Air Control (NPG 9) (Navy only), and
- Fighter-to-Fighter communications (NPG 19) (Navy only).

Option pools allow flexibility in assigning time slots.

The total number of available time slots in the pool remains constant. However, within a given option pool, each sequence number contains some particular percentage of these time slots. Each option pool may have multiple sequence numbers. Each sequence number, therefore, actually contains a subset of the total number of time slots in the option pool. The total number of time slots in all the subsets (that is, in all the sequence numbers) adds up to the total number of time slots in the option pool, as shown in Figure 5-12.

Option pool participants share the same Option Number for a particular NPG.

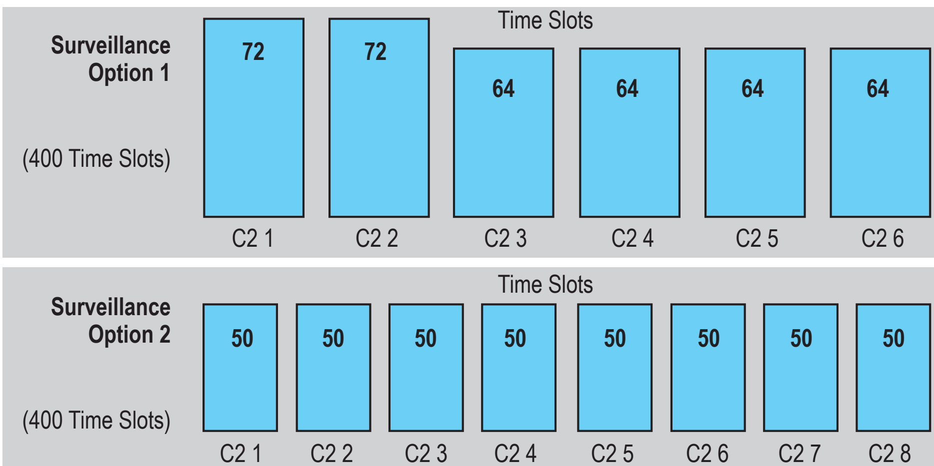


Figure 5-12. Option pools provide flexibility in assigning time slots for the Surveillance, Air Control, and Fighter-to-Fighter functions. In this example, the network design provides two Surveillance options pools, distributing 400 time slots among differing numbers of C2 platforms.

Currently all services use Surveillance Option Pool. The Navy has discontinued the use of Air Control and Fighter-to Fighter Option Pools in favor of using contention access for NPG 9 and NPG 19, except where dedicated access is required.

The OPTASK LINK will specify Option Numbers and Sequence Numbers for the platforms that use them.

Section C

Network Roles

Network roles are functions assigned to a JU, either by initialization or by operator entry. A network role can support one or more of the following functions: synchronization, navigation, and data forwarding. Roles are assigned to C2 or nonC2 units and are made on the basis of platform capabilities and expected platform position. With the exception of Network Manager, all roles are terminal functions. They may be changed during operations and include:

- Network Time Reference
- Position Reference
- Initial Entry JU (Net Entry Transmit Enable) Terminal
- Navigation Controller
- Secondary Navigation Controller
- Primary User
- Secondary User
- Forwarding JU
- Network Manager.

Network roles are assigned in the OPTASK LINK. A JU should hand off its assigned role(s) to another unit before it inhibits transmissions or goes data silent.

Hand off your assigned network role before going data silent!

Network Time Reference

The most essential role in establishing the Link 16 System Time Reference Network (STRN) is that of Network Time Reference (NTR). A single JU is assigned to be NTR for a given network. The time established by this unit is, by definition, the network system time. This system time is propagated to all other units by means of the Initial Entry (J0.0) messages that are transmitted by the NTR. All other units use these messages to synchronize with the network. By definition, the NTR is the only unit that has the maximum time quality, 15. All units periodically adjust their internal clocks to maintain synchronization with the NTR. Once established, networks can continue to operate for hours without an NTR.

By definition, the Initial Entry messages are transmitted by the NTR to establish the network's timing.

Handing Over the NTR Role

One situation common in the USAF is the handover of the NTR function between two E-3s, one going off station and the other coming on. Suppose a network has an E-3 as NTR, F-15s are operating with it, and a relief E-3 arrives. The relief E-3 will have already joined the network as a Primary User, but not as the NTR.

As the relieved E-3 begins to depart from the area, it should deselect itself as NTR. The new E-3, meanwhile, should designate himself the new NTR. However, suppose that the departing E-3 forgets to deselect the NTR role. The new E-3 will have synchronized with the network, and therefore with the original E-3, as it flew into the area. When the relief E-3 selects itself as NTR, it uses network time. This provides for a continuous network time as NTR changes occur. Each NTR now believes it has perfect network time, and they each tell that to the other participants via the value for Q_t in their PPLIs. (Recall that the NTR's value for Q_t is 15.) At first their time estimates will be quite close, so the "lie" does not cause a serious problem for the other network participants.

So having multiple NTRs for a *short period* during NTR handover is allowable. In cases such as this, however, the old NTR's clock and the new NTR's corrected clock will begin to drift apart. This will tend to pull the network apart into two networks:

one following the original NTR and the other following its relief. NTR handover, therefore, should be carefully coordinated so that this "dual NTR" condition does not exist for more than a few minutes.

Very brief periods of "dual NTR" are tolerable.

Moreover, having no NTR for a short time during NTR handover is also permitted, and will not cause the network to deteriorate. The time quality of the entire network will slip without an NTR, of course, but it will take a long time to slip so significantly as to preclude communication. However, this does not mean that a network should be operated for a prolonged period without an NTR. Some platforms, such as the F-15C, are critically dependent on JTIDS navigation, and navigation quality is directly related to time quality. So participants should attempt to maintain as great a value for Q_t as possible to support JTIDS navigation, and a network should not go without an NTR for more than a few minutes. JTIDS navigation support is also the principal reason that networks should not have more than one NTR active for more than a few minutes. The confusion resulting from two NTRs will not only split a network, but will also compromise JTIDS navigation.

Once established, Link 16 networks do not necessarily require an NTR.

Assign NTR to a C2 unit that will be present throughout the operation and that will have LOS connectivity with as many other units as possible.

■ Position Reference

By definition, a Position Reference (PR) is a unit that does not correct its initialized position through Time of Arrival (TOA) calculations. Initializing a unit as a PR, in fact, turns off this correction. This correction function, called RELNAV, allows a terminal to compute its range from other units based on the TOAs of their received PPLIs. Thus, turning off the processing of TOAs from received PPLI messages ensures that the PR terminal's own geodetic navigation solution will not be influenced by any other terminal in the network.

Consider that designating your terminal as a PR is a double-edged sword: it protects your terminal from having its position corrupted in the remote possibility that another participant is "dishonest"—that is, the other participant reports a high geodetic position quality in its PPLI message when there are large errors in its actual position—but it also prevents your terminal from improving its own position when there are network participants that know their positions more accurately than your own terminal does. It is not recommended however, that operators select the PR mode only because of the remote possibility of position corruption. Moreover, designating a terminal as a PR will not prevent a "dishonest" terminal from corrupting other network participants' terminals.

A PR is typically a well-surveyed site.

Never assign the role of PR to an airborne unit!

■ Radio Silence and PR

PRs cannot maintain passive sync in radio silence. It is important to understand that when a ground unit is initialized as a PR, it can no longer maintain passive synchronization in radio silence.[7] This is because its RELNAV processing, which is based on TOA calculations, has been turned off by the PR function. Losing the ability to perform synchronization updates in radio silence will also cause its time quality to deteriorate. If the PR terminal is, however, placed in radio silence, it needs to remain synchronized only well enough to be able to continue receiving messages.

A PR terminal, depending on how long it has been operating since initialization, can go for as long as several hours without losing synchronization. (The longer it has been operating, the greater the duration of its remaining in sync.) Its position will not degrade, and when it leaves radio silence, it should quickly recover highly accurate

7 *Passive synchronization is defined in Section D of this chapter.*

time synchronization through transmitting RTTs. It will then be able to serve again as an accurate navigation source to other network participants. Only when it is anticipated that radio silence may last for hours (say, more than five hours) should the non-PR mode be considered for the terminal.

When placing a PR terminal in radio silence for several hours, consider reinitializing as a non-PR for the duration of the radio silence period.

Initial Entry JU

An Initial Entry JU (IEJU) assists in the propagation of system time to units that are beyond line of sight of the NTR. After the IEJU has become synchronized with the NTR, it also transmits Initial Entry messages once *every other* frame—that is, once every 24 seconds. A unit not within LOS of the NTR can then synchronize with the network by synchronizing with the IEJU. Any active terminal can perform this function, and any number of IEJUs may be active at one time. The IEJU function can be performed by both surface and airborne units and can be selected by the operator. The IEJU is also referred to as a Net Entry Transmit Enable (NETE).

The IEJU provides system time to units beyond LOS of the NTR.

Assign the role of IEJU to all active units.

☐ Navigation Controller

The Navigation Controller (NC) is not a required role. An NC is designated only when a **relative grid** is desired. The relative grid is a three-dimensional coordinate system used by JUs to report their position from the grid origin. The **relative grid origin** is the origin calculated by the NC, which includes any geodetic navigation errors made by the NC. The NC acts as the reference unit for the grid and is assigned a relative position quality (Q_{pr}) of 15. The relative grid becomes operational as soon as it is established by the NC.

The relative grid is established by the NC.

The NC should be mobile, present for the duration of the operation, and have good LOS connectivity to as many units as possible.

When a relative grid is established, the RELNAV function of the terminal will provide accurate relative positions between JUs, even when some JUs hold inaccurate geodetic data for their own positions. For the USAF, the unit assigned the role of NC must be a unit that is both mobile and in active synchronization. For the USAF, there can be only one NC.

If the NC becomes stationary, hand off the role!

Secondary Navigation Controller

The Secondary Navigation Controller (SNC) provides stability to the relative grid. There is only one SNC unit, and it must be in active synchronization within LOS of the NC. Either a mobile or a stationary unit can serve as the SNC. There should be relative motion, however, between the NC and SNC. The NC and the SNC must remain separated by more than 50 nm to meet the low angular motion criteria.

Note, however, that even when an NC has been designated for a network, the SNC role is not a necessity. In fact, USAF fighters, although they use the NC role, do not use an SNC.

Primary User

All JUs, except the NTR, are said to be Primary Users (PRUs) if they routinely transmit RTT messages to achieve and maintain fine synchronization with the network. Although other Services' NDFs may produce designs limiting the number of PRUs in a given network, there is no typical upper limit on the number of PRUs of USAF network designs.

A PRU transmits RTTs to actively maintain synchronization with the network.

Secondary User

A JU operating passively is said to be a Secondary User (SU).[8] Units can enter the network passively, or an operator can select passive operations after entering the network actively. Either of two passive modes can be selected by an operator:

- Long Term Transmit Inhibit
- Data Silent

Long Term Transmit Inhibit, or LTTI, is radio silence—*all* transmissions are inhibited. In **Data Silent** mode, SUs can receive messages, but they do not transmit PPLIs or RTTs. Relays are inhibited; however, voice remains active, and TACAN (in air platforms) operates normally. If a JU inhibits transmissions or goes data silent, the terminal transmits one last PPLI with its user identification set to SU. It can return to operation as a PRU by resuming active synchronization.

An SU does not transmit RTTs or PPLIs. Synchronization with the network is maintained passively.

8 *Passive synchronization is defined in Section D of this chapter.*

Forwarding JU

A JU designated to forward data between links is called a **Forwarding JU (FJU)**. The FJU that translates and forwards data between Link 11 and Link 16 is a **Forwarding JU-TDL A (FJUA)**. A unit that communicates on both Link 16 and Link 11B, and that translates and forwards data between them, is an **FJUB**.

The FJU translates and forwards data between tactical data links.

Data transmitted on the PPLI, Mission Management, Weapons Coordination, EW, and Surveillance NPGs of Link 16 may be translated and forwarded to Link 11 by the FJU. Similarly, Link 11 data may be forwarded to Link 16, with PPLIs provided for the Link 11 units automatically by the FJU and transmitted on NPG 7. The CRC is the only USAF unit capable of performing the FJU function, and it may serve as FJUA and FJUB.

For USAF, only the CRC can perform the FJU role.

Ideally, only one FJU is assigned for the entire force, but an alternate may be designated. The alternate FJU participates in the Link 16 network and monitors the Link 11 net. Whenever it detects that the active FJU has stopped transmitting on either link, it automatically alerts an operator, who must then decide whether or not to assume the FJU function.

If a network design allocates time slots for two simultaneously active FJUs, these units cannot share the same time slots. If they did, other participants listening to them would receive only a partial tactical picture, at best, from the forwarded units on the other data link. One technique to ensure this will not happen is to assign both FJUs to the same Surveillance option pool, but to different Sequence Numbers—one unit with an odd Sequence number, the other unit with an even Sequence number.

Section D

Network Entry

Protocol for entering the Link 16 network is handled by the terminal. One unit is designated to be the system time reference. As we learned from the previous section, this unit is the NTR. It transmits the net entry message on NPG 1, Net 0, using the default TSEC and MSEC cryptovariables in the first time slot (A-0-6) of every frame.

Network Entry is performed by the terminal.

The net entry message for Link 16 is the Initial Entry message, J0.0. The time at which this message is transmitted defines the system time and the start of each Link 16 frame. The body of the net entry message includes the time quality, RTT radio silence status, and the current default net number. It may also contain voice, PPLI, and RTT time slot assignments on the default net for the next epoch. Depending on the transmitting terminal's antijam (AJ) Communications Mode setting, the terminal may automatically append extension or continuation words to the message.

The Initial Entry message is J0.0.

The process of acquiring system time is called **synchronization**. It can be performed actively or passively. Each method requires several steps. Since the process starts with an estimate of the current time, network entry can be simplified for everyone if the NTR uses Coordinated Universal Time (UTC) from the Global Positioning System (GPS).

You cannot transmit data until you have synchronized with the network.

Simplify network entry by having the NTR use GPS for UTC.

☐ Coarse Synchronization

Initializing the terminal requires several steps. Among them are obtaining a current time hack and making the time uncertainty setting, which tells the terminal how many seconds of uncertainty to use in listening for the NTR's initial entry message to achieve coarse synchronization.

The time and time uncertainty period are operator settings.

After making these settings, the operator's first step is to start network entry. The process of entering a network means acquiring synchronization. The JTIDS/MIDS terminal first uses an estimate of the current time and an estimate of its own clock error (time uncertainty) to choose a time slot from the A-0-6 time slot block that it is certain has not yet occurred. The terminal then begins listening for an Initial Entry message. It starts listening one time-uncertainty period before the expected time slot, and continues to listen through one time-uncertainty period afterward. If the uncertainty estimate is correct, it should receive the message. If the message is not received, the terminal automatically tries again. If the message is received, the time of receipt is used to correct the terminal's system time. This adjusted system time may still include an error due to propagation time.

After the Initial Entry message has been received, the terminal is declared to be in coarse synchronization. When a terminal has achieved coarse synchronization, it knows the system time to within one slot-time, and it can begin to transmit RTT interrogations.

The only transmission made by a terminal in coarse sync is the RTT interrogation.

Fine Synchronization

After achieving coarse synchronization, the terminal transmits an RTT interrogation to the NTR, or to the terminal with the highest time quality in its internal table. The receiver of the RTT-I responds during the same time slot with a reply. This reply contains the time of arrival of the interrogation at the receiving platform. Then, using both the measured time of arrival of the reply and the reported time of arrival of the interrogation, the terminal can further adjust its estimate of system time to remove the error due to propagation time. The terminal is then declared to be in **fine synchronization**. The terminal of a PRU must be in fine synchronization to fully participate in the network.

The terminal must be in fine sync to transmit data on the network.

The error in the clock maintaining system time is estimated continuously by the terminal. Even the temperature of the terminal components, as estimated by the length of time the terminal has been powered up, is considered. If the current clock frequency will keep the terminal's clock error to within 36 µs during the next 15 minutes, fine sync can be confirmed. If the clock error exceeds a threshold setting by as little as 54 µs, the terminal's status is downgraded from **fine sync confirmed** to **fine sync in process**. Terminals in fine sync can maintain time with sufficient accuracy to continue operating for up to three hours.

Active vs. Passive Synchronization

The process of transmitting RTTs to refine the terminal's estimate of system time is known as **active synchronization**. If a terminal is within LOS of the NTR or an IEJU, and if their RTT time slot assignments are the same, it should take only seconds for this unit to become active on the network. Otherwise, the unit will not achieve fine synchronization.

Passive sync must be performed when the terminal is in radio silence.

It is also possible, however, to acquire system time passively—that is, without transmitting on the network. **Passive synchronization** must be used when the LTTI mode is enabled and the terminal is in radio silence. Instead of transmitting RTTs after coarse synchronization has been established, the terminal listens for position messages on the PPLI NPGs. Using the position of the unit reported in the PPLI message and the knowledge of its own position from its navigation system, the terminal can estimate the propagation time required for the message. By comparing the expected time of arrival with the actual time of arrival, the terminal can then adjust its estimate of system time to remove the propagation error. Time-of-arrival measurements are made to the nearest 12.5 nanoseconds.

Section E

Precise Participant Location and Identification

JTIDS terminals employ relative navigation techniques to constantly fix their platform's position. This information is transmitted periodically, along with other identification and status information, in the Precise Participant Location and Identification (PPLI) message. The PPLI is the "friendly unit reporting message." It can be used to determine link participants and data forwarding requirements, as well as to initiate air control.

Only friendlies transmit PPLIs.

It also supports passive synchronization. PPLIs are transmitted periodically by all JUs that are active on the network on NPG 5 and/or NPG 6. For most Services, including the USAF, Indirect PPLIs generated for Link 11 and Link 11B units by the FJU are transmitted on NPG 7; the USN, however, transmits them on NPG 14. Note, however, that in the near future the USN will also transmit Indirect PPLIs on NPG 7.

☐ Precise Location

Location is reported as a three-coordinate geodetic point having latitude, longitude, and altitude. Current course and speed are also provided. This information is used by the receiving terminal's RELNAV function, along with other information such as the quality reports, RTTs, and local navigation inputs, to refine its calculations of its own position.

☐ Positive Identification

Each participant on Link 16 is assigned a unique JU address or Source Track Number (STN), which consists of five octal digits between 00001_8 and 77777_8.

In addition to the JU address, the PPLI message can contain information such as IFF codes, platform type, mission, location and movement information, and link activity information. Note that at the present time, USAF platforms' PPLIs do not include their Modes 1, 2, or 3 IFF codes.

USAF PPLIs do not contain IFF codes.

☐ Status

Host platforms provide detailed equipment and ordnance status and inventory data to the terminal for periodic inclusion with the PPLI data. The specific numeric inventory of force defense missiles and aircraft weapons, as well as operational, degraded, or nonoperational status of all relevant shipboard and aircraft systems, is also reported. This will allow automatic compilation and display of complete force status to appropriate operational commanders, as well as a summary of the status of selected units, such as the Link 16 aircraft under control.

Detailed fuel, weapons, and equipment statuses are reported in status messages on the PPLI NPG.

Status information reported in a platform's PPLI also includes its air control and Link 16 voice net numbers, or other UHF voice frequencies that it is currently using. Although this information may be present in messages from given platforms, however, certain systems may not display these data to their operators.

Status information is helpful in establishing voice communications or initiating air control operations. There is also an indicator in track messages that allows a unit to assume reporting responsibility for an inactive JU and informs participants that the ID is based on previous receipts of PPLI messages from the JU with that track number.

In addition to identification and position, the PPLI message reports air control and voice net numbers, time quality, and position qualities.

□ Time Quality

Each terminal estimates how well it knows system time. This estimate is based on its clock drift, the accuracy with which the terminals replying to its RTT interrogations know system time, and the time since it last completed an RTT exchange. This estimate is used to set its **time quality (Q_t)**. Values of time quality range from 0 to 15. By definition, only the NTR has a Q_t of 15. Each terminal provides its own Q_t to the network in every PPLI message that it transmits, as well as in the RTT message and any Initial Entry message that it transmits.

Only the NTR has a Q_t of 15.

Time Quality (Q_t)	Standard Time Deviation (Nanoseconds)
15	≤50
14	≤71
13	≤100
12	≤141
11	≤200
10	≤282
9	≤400
8	≤565
7	≤800
6	≤1130
5	≤1600
4	≤2260
3	≤4520
2	≤9040
1	≤18080
0	>18080

Figure 5-13. Time quality is a value between 0 and 15 indicating the accuracy with which a unit knows system time.

Position Quality

Position quality is a value between 0 and 15 indicating the accuracy with which a unit knows its geodetic position (Q_{pg}) and its relative position (Q_{pr}). **Geodetic position** is measured in latitude, longitude, and altitude. Geodetic position is provided by navigation sources, and the value entered by the system manager should be consistent with the platform's navigation equipment. A Q_{pg} of 15, which is assigned to stationary Position References, indicates accuracy of position within 50 feet.

Geodetic position is measured in latitude, longitude, and altitude.

Sometimes the network uses a relative grid instead of a geodetic one. In this case, one unit is designated as the NC, and all positions are measured **relative** to this reference unit. A Q_{pr} of 15 is assigned to the NC in this case.

Relative position is measured with respect to the unit designated as the NC.

Positional accuracy is important not only for track correlation and the prevention of dual designations, but also for systems using remote data for over-the-horizon targeting, as well as for remote intercept control.

Position Quality	Position Uncertainty (ft)	Error Bound (3 Std Deviations) (ft)
15	<50	<150
14	71	213
13	100	300
12	141	423
11	200	600
10	282	846
9	400	1200
8	565	1695
7	800	2400
6	1130	3390
5	1600	4800
4	2260	6780
3	4520	13560
2	9040	27120
1	18080	54240
0	>18080	>54240

Figure 5-14. Position quality is a value between 0 and 15 that indicates the accuracy with which a unit knows its own position.

☐ PPLIs and Passive Synchronization

The PPLI message is essential to the process of passive synchronization. Using the position of a unit reported in the PPLI and knowledge of its own position, a unit operating passively can estimate the range, and therefore the propagation time, required for the message. Combining this information with the actual arrival time, and taking into consideration the time quality and position quality reported in the PPLI, the terminal in passive sync can make adjustments to its estimate of system time.

Secondary users are in passive synchronization.

Section F

Link 16 Navigation

The situational information displayed on fighter aircraft multipurpose cockpit displays (MPCDs) is useful only when it is accurate and easy to interpret. For F-15 pilots, inaccurate information can be worse than no information. Several factors can affect the accuracy of this display:

- Sensor accuracy
- The degree of accuracy with which participants' host computers derive accurate Link 16 target reports from their own radar information, and
- The accuracy of every participant's relative position.

But the accuracy of any fighter's own position, which is reported in his PPLIs and Status messages, is paramount, particularly in relation to the positions of the other participants. This is because the targets on a fighter's MPCD are displayed *in reference to his own position*. Own unit positional accuracy, therefore, directly affects the utility of his display.

Ownship positional accuracy affects target correlation.

One important reason for accurate positioning is shown in Figure 5-15, in which two F-15s have locked onto the same target. Each automatically reports this target's position on Link 16, and each receives the other's target report. To avoid confusion on the MPCD, the two target reports should be displayed as a single symbol.

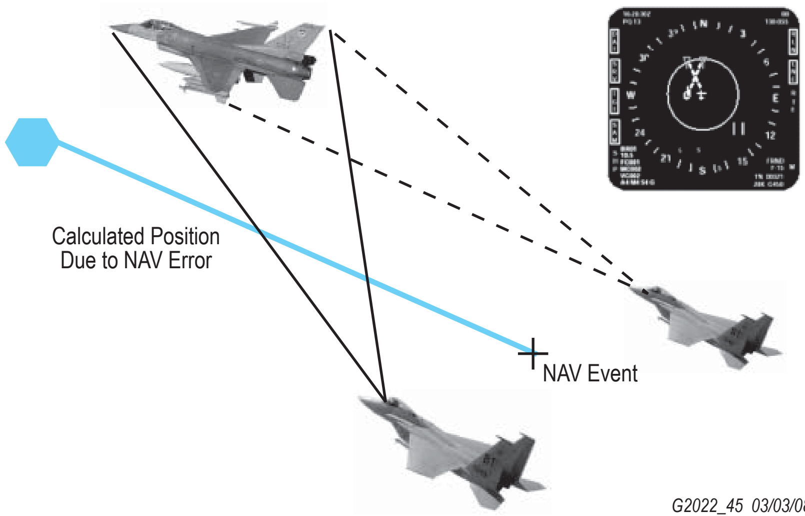


Figure 5-15. An F-15's central computer calculates the latitude and longitude of a target's position using its own position, the radar range, and the radar angle. You will realize readily that if the F-15's relative position is in error, target position errors will be introduced, and correlation may fail—resulting in more than one symbol for this target on the cockpit display.

The F-15's target correlation algorithm supports this. During the correlation process, its central computer compares the target positions in the two reports; if they are within a certain distance—and if the ID correlation criteria are met—the computer correlates them as a single target, and they will appear as only one symbol on the display.

The F-15C's inertial navigation system (INS) is quite accurate, but it may not always be accurate enough to support the correlation process. In Figure 5-15, the F-15 on the right has an inertial navigation error that results in his target's being reported to the left of its actual position, represented by the blue hexagon. His error is great enough to have caused the two reported target positions to fail to correlate, so two targets—rather than one—are shown on the display.

The more accurate your relative position, the more effectively you can correlate targets!

Using Link 16 for Navigation

Link 16 terminals, including the F-15's FDL, have a very accurate RELNAV capability, and the F-15C may employ it to support the accurate exchange and display of information. The pilot may select Link 16 navigation with a button action on his MPCD. When he does so, Link 16 provides an additional navigation source, and it is usually the most accurate one. The Link 16 corrected position is then used for both own unit position on the MPCD and for calculating the position of the radar targets he reports on the link. Corrections fed to the F-15 by its FDL terminal are used to correct the position supplied by the INS. Continued Link 16 navigational accuracy, however, depends on the FDL terminal's remaining synchronized with the network.

Link 16 navigation is usually more accurate than platform NAV systems.

Pilots select Link 16 navigation for any of the following reasons:

- To adjust setups to maximize their navigational accuracy
- To adjust the position of units within formations
- To support a more accurate exchange of targets, or
- To obtain better mutual support for night and weather operations.

Terminal Relative Position

Whether or not the pilot selects Link 16 navigation, every Link 16 terminal will always perform the automatic RELNAV function, in which it continuously calculates its own position by measuring the times of arrival (TOAs) of all the PPLI and Status messages it receives. This function, known as passive synchronization, allows the terminal to calculate an accurate value for the range between itself and another transmitting Link 16 unit.[9] This very accurate range measurement is possible because of the precise timing the terminal must maintain after achieving synchronization with

9 *Passive synchronization is discussed in Section D of this chapter.*

the network. The terminal's accurate range measurements become available to the pilot, however, only when he selects Link 16 navigation.

Figure 5-16, below, illustrates how the terminal calculates its own relative position. First, consider a terminal that receives a PPLI from another unit. The upper left part of the figure represents a PPLI received from a single source. From the PPLI's TOA, the receiver can calculate that its position is somewhere on the circle whose radius is the calculated range. In the upper right of the figure, the position source has also provided a value for position quality, or Q_p, in its PPLI. From the TOA and the Q_p, the receiver can calculate that its own position is somewhere within the outer shaded area of the circle, and its range is somewhere between the inner and outer edges of the shaded area, the width of which defines its position uncertainty.

Now consider a terminal that receives PPLIs from two units. As shown in the lower left part of this figure, the terminal can calculate that it is located at one of two positions where the two range circles intersect. With a rough knowledge of position—such as from the F-15's inertial navigation system—the terminal can then decide which of these positions is the correct one.

Receiving PPLIs from additional units further contributes to the terminal's positional accuracy. The lower right part of the figure shows the calculation with Q_p from the two units. The shaded intersection with the solid dot represents the terminal's own position, as well as a measure of its own Q_p. The value for Q_p can range from 0 (indicating that its position uncertainty is greater than 18,080 feet) to 15 (indicating that its position uncertainty is within 50 feet).[10] The terminal will then transmit this calculated value for Q_p in its own PPLI—until it calculates a different value based on different TOAs and Q_p values from the other network units from which it receives messages.

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10 *Further details may be found in Section E, where geodetic position quality and its associated values and position uncertainties are discussed.*

The terminal uses its relative navigation capability to perform two types of navigation:

- **Geodetic navigation**, or the exchange of position through actual latitude and longitude coordinates in PPLIs. This type of navigation provides position with respect to the ground. For geodetic navigation to be accurate, however, some network participants must have a very good knowledge of their own position—for example, a well-surveyed land site (such as a PR), or an E-3 equipped with a GPS. The terminal *always* performs geodetic navigation.
- **Relative grid navigation**, which the terminal performs only when properly initialized for this function. The terminal should be initialized for relative grid navigation whenever the network contains no PR and none of the participants have highly accurate knowledge of their own position, such as from a GPS source.

The F-15 can use either type of navigation, but the pilot chooses between them. The parameters affecting this choice, as well as more detailed descriptions of navigational types, are beyond the scope of this guidebook. What you should take away from this general discussion, however, is that the F-15's targeting accuracy can take advantage of its terminal's accurate relative location, which, in turn, depends on the highly accurate timing of a Link 16 network.[11]

11 *For in-depth discussion of navigation types and procedures for the F-15C, refer to F-15C JTIDS/ Link 16 Guide, paragraph 4.18 ff., MITRE Corporation, June 2000.*

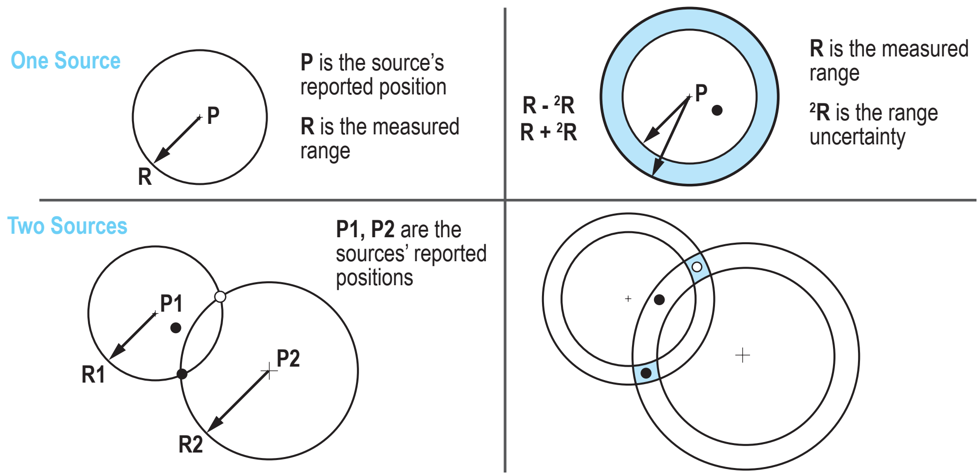


Figure 5-16. The process by which a Link 16 terminal calculates its range and range uncertainty from one or more other units is shown here. The greater the number of units from which a terminal receives PPLIs, and the higher their reported position qualities are, the more accurately the terminal can calculate its range from them, as well as its own position relative to them.

Geometric Dilution of Precision

An important prerequisite for the accuracy of calculated position—the accuracy of own transmitter's position—is discussed above. But calculated positional accuracy is also a function of the geometry among units.

Force geometry affects the accuracy of calculated positions.

As shown in the next figure, the accuracy of calculated position will be greater for a geometry between units approaching ninety degrees (Case 1) than for other geometries (Cases 2 and 3). In other words, the precision is more diluted the farther the geometry deviates from ninety degrees—either more widely, by an obtuse angle (Case 2), or less widely, by an acute angle (Case 3). This effect is known as the **geometric dilution of precision (GDOP)**. The shaded areas in the figure represent the degree of positional uncertainty. It can readily be seen that the larger the area, the greater the uncertainty.

Calculated positional accuracy increases as the geometry approaches 90 degrees!

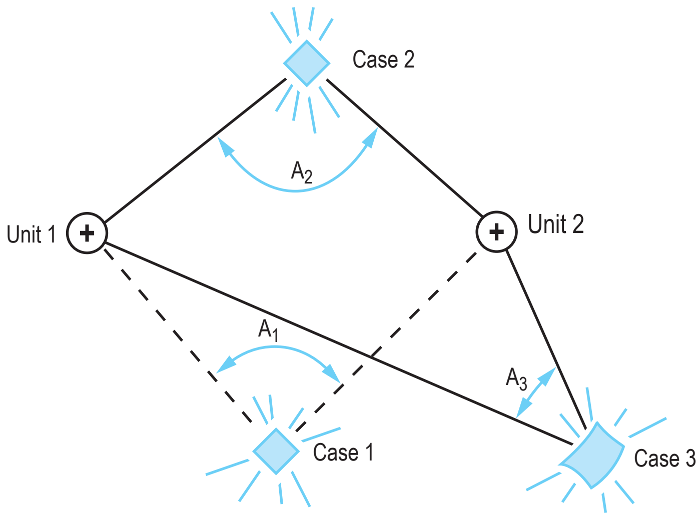


Figure 5-17. The GDOP effect refers to the effect that the geometry among units has on the degree of positional uncertainty. The most accurate positions are those approaching ninety degrees. As can be seen here, Unit 1's position with respect to Unit 2 is most accurate in Case 1.

Squadron managers may exploit the GDOP effect to help them determine where available ground sources or GPS-equipped surveillance platforms should be located with respect to fighter routes and Combat Air Patrols (CAPs).

In this figure, with aircraft at all three locations, those in positions 2 and 3 will benefit from the good position quality achieved by the aircraft in position 1. It has been observed during exercises that position improvements can be propagated among multiple aircraft.

Be aware of your geometry with respect to PRs and GPS-equipped air platforms!

Section G

Receipt/Compliance

Certain messages require acknowledgment to indicate that the message was received. Two levels of acknowledgement, called **receipt/compliance (R/C)** processing, are performed. The first level of acknowledgement, called **machine receipt (MR)**, is performed automatically by the system. The second level of acknowledgment is a response *from the operator* and indicates an intention to comply (WILCO) or not to comply (CANTCO). In Link 11, the machine receipt portion of the R/C processing is performed by the host computers. In Link 16, however, it is an automatic function performed by the JTIDS/MIDS terminals. Other responses, such as “Have Complied (HAVCO)” and “Cannot Process (CANTPRO),” are possible as well.

Machine receipts are issued by the terminal as required.

In Link 11, Link 11B, and in Link 16, a message is automatically retransmitted if its MR is not received. This process can occur several times. The appropriate operators are informed if the message is not MR’d after several retransmissions have been issued.

☐ *The Donated Slot*

Special time slots do not need to be assigned for R/C processing. Whenever a terminal transmits a message that requires an acknowledgement, the terminal donates one of its assigned transmit slots for the response. By donating its own time slot for the MR, the transmitting terminal knows where to look for it and ensures that the response is timely. The location of the donated slot is specified in the transmitted message's R/C recurrence rate field. The donated slot must be within 16 to 1,536 slots of the slot in which the message was received. JTIDS/MIDS terminals other than the one addressed note the position of the donated slot as well, and lock out transmissions in that slot.

Whenever a terminal transmits a message that requires an acknowledgement, it donates one of its assigned transmit slots for the response.

☐ *Link 16 Receipt/Compliance Using JREAP*

For certain J-series messages, MIL-STD-6016 specifies an automated process that provides an indication back to the source terminal and operator as to whether or not the message has been successfully received. The Link 16 process is based on the LOS characteristics of the Link 16 network. On Link 16, when a terminal sends an addressed R/C message to one of the initialized primary or secondary TNs in an addressed terminal, it expects the addressed terminal to send a Link 16 MR response. If no response is received, the sending terminal will retransmit the message up to three times before informing the operator that the message has not been received by the addressed terminal. Operator acknowledgments are sent as addressed R/C messages, and it is the operator's responsibility to send a message again if no operator acknowledgment is received.

Take action to retransmit a message that is not acknowledged by the addressee's operator!

This process, however, was originally designed to work with a single Link 16 relay. Support of R/C procedures using multihop Link 16 relay is cumbersome and requires excessive Link 16 bandwidth. Currently, Link 16 terminals have a capability for 16 secondary TNs, and the Modular Control Equipment (MCE) and Navy Ship terminals have a capacity for an additional 126 secondary TNs below 177_8 octal to support the Link 16 R/C process.

The JREAP capability can add one or more JREAP media links to the system architecture. The characteristics of an architecture containing JREAP links greatly affect the system's ability to comply with MIL-STD-6016 timing constraints for R/C. Confirmation of delivery is a necessary feature for the JRE application protocols, and all MIL-STD-6016 timing requirements must be met. To accomplish this, a slightly modified version of the Link 16 process is used that does not affect the LOS Link 16 networks. To support this process, three elements must be in place:

1. The JREAP link must provide for guaranteed delivery through an acknowledgment technique.
2. The JREAP processor must recognize the Link 16 R/C messages and must properly interface with the Link 16 networks at the source and destination.
3. Link 16 Net Management must provide the Secondary Track Numbers of the Link 16 addressees to the applicable JREAP processors that expect Link 16 R/C support.

Section H

Relays

Link 16 is strictly a UHF LOS communications system. For air-to-air, or ground- to-air, this is approximately 300 nautical miles. Between ground units, this is closer to 25 nautical miles. Because of this, relays are almost always required for large Op Areas. Relays are established during network design, and time slots are allocated specifically for this purpose. As many JUs as possible are preassigned as conditional, unconditional, or suspended relays. Time slots are allocated for the relay function as part of the network design and can be changed only by time slot reassignment.

Relays extend Link 16 connectivity BLOS.

☐ General Requirements

The JU designated to be a relay must be provided with the capacity to transmit the relayed message. Messages received in one time slot are relayed at a later time in a specified, preallocated slot. The original message and the retransmitted message are referred to as a relay pair. Paired **time slot blocks** (TSBs) are assigned as part of each NPG that requires relay support. The number of time slots required depends on the number of relay hops required to reach the destination.

The network is designed with specific time slots designated as relay pairs, and specific JUs designated to perform the relay function.

In addition, the relaying unit must be in fine sync and in the same range mode. Reed-Solomon (R-S) error correction is performed by the relaying terminal on messages prior to retransmission. Messages with uncorrectable errors are not retransmitted.

The most basic type of relay technique is called the paired slot relay. The originating terminal transmits a message. The relaying terminal receives it, stores it, and retransmits it. The transmit slot is paired with the receive slot by a fixed offset called the **relay delay**. The **relay delay** must be greater than five and less than 32 time slots. The net number on which the relay transmits does not have to be the same as that on which it received. For example, the JTIDS/MIDS terminal of the relaying unit can be initialized to relay-receive on Net 0 and relay-transmit six time slots later on Net 1. The assignment of a relay pair counts as one TSB assignment. By doubling the time slot requirements, therefore, relays reduce the potential capacity of an NPG by 50 percent.

The use of relays reduces the potential capacity of an NPG by 50 percent.

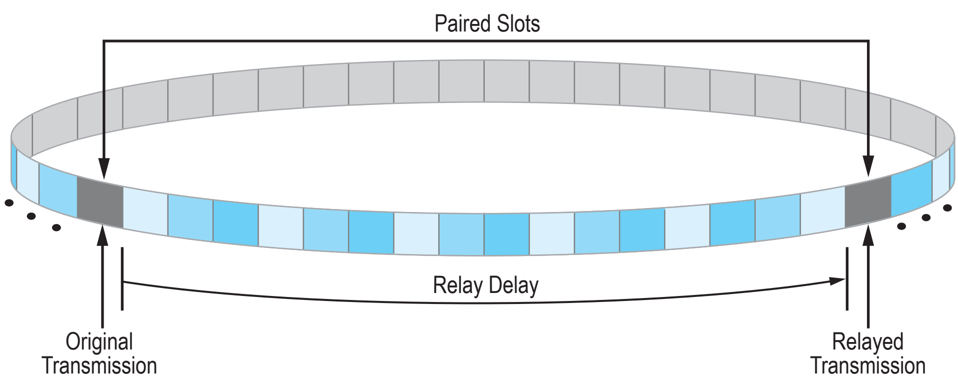


Figure 5-18. In the paired slot relay, the slot of the original message is paired with a slot for the relay retransmission of the message by specifying the original slot and a relay delay.

Relay Types

The type of paired-slot relay is specified in the message itself, and it provides additional information to the terminal about the information to be relayed. The following types are defined:

- Main Conditional/Unconditional
- Voice Conditional/Unconditional
- Control Conditional/Unconditional
- Zoom
- Directed
- Message Directed
- Participation Group.

The **main net** is the net on which housekeeping and overhead functions are performed. These include the exchange of RTT and PPLI messages, and the main net is usually, but not always, on Net 0, depending on the network design. Voice and air control nets are usually defined as stacked nets. The **zoom relay** allows selected portions of the main net to be relayed on another net. The zoom net number must be specified with this relay type. The message-directed relay allows a particular message to be directed to a particular NPG. And, finally, messages from an entire NPG can be specified for relay.

All time slots assigned to a particular NPG can be specified for relay.

If the relay is defined to be an **unconditional relay**, the terminal relays messages in accordance with the receive and relay transmit time slot assignments provided at initialization time. The relay will always occur, unless the terminal is not in fine sync or has been set to data or radio silence.

The **conditional relay**, on the other hand, requires the terminal to selectively activate or deactivate the relay function based on which JU can provide the most efficient coverage. The conditional relay becomes active if its geographic coverage is greater than that of the current relay. Geographic coverage is determined from the height and range data provided in the relay unit's PPLI. In general, the unit with the greater altitude is assumed to be in a better relay position. For stacked nets such as the voice and control nets, the net numbers of the originator and the relay must match. For example, an F-15 on voice net 11 can relay only voice net 11, not all voice nets. Several units can be assigned to relay the same NPG in the conditional mode.

The conditional relay depends on geographic coverage.

A unit can be assigned to relay-receive on one net and relay-transmit on a different net. A relay can be **suspended** by placing the terminal in the suspend mode.

■ Flood Relay

Paired-slot **flood relay** is a strategy designed to improve connectivity to units out of LOS with each other. When USAF operators are linking with USN units, they will observe that every ship is a relay unit. This technique is currently employed in large contingency networks such as Operation Enduring Freedom (OEF). In the flood relay, any NPG designated to be relayed in the network design is relayed by everyone! Here's how it works: the originating terminal transmits the message in the original time slot—and in all paired relay slots as well. All units receiving the original message will transmit it in all remaining paired relay slots. For multiple hop relays, units receiving the relayed transmission on the first hop will transmit it in any remaining relay slots (checking to ensure there is no relay beyond the designated number of hops). Flood relay is slot reuse to the max! Flood relay is allowed only under the 100/50 IPF rule.[12]

In the flood relay, all units act as unconditional, multiple relays.

12 *The Interference Protection Feature (IPF) is discussed in Chapter 4, Section D.*

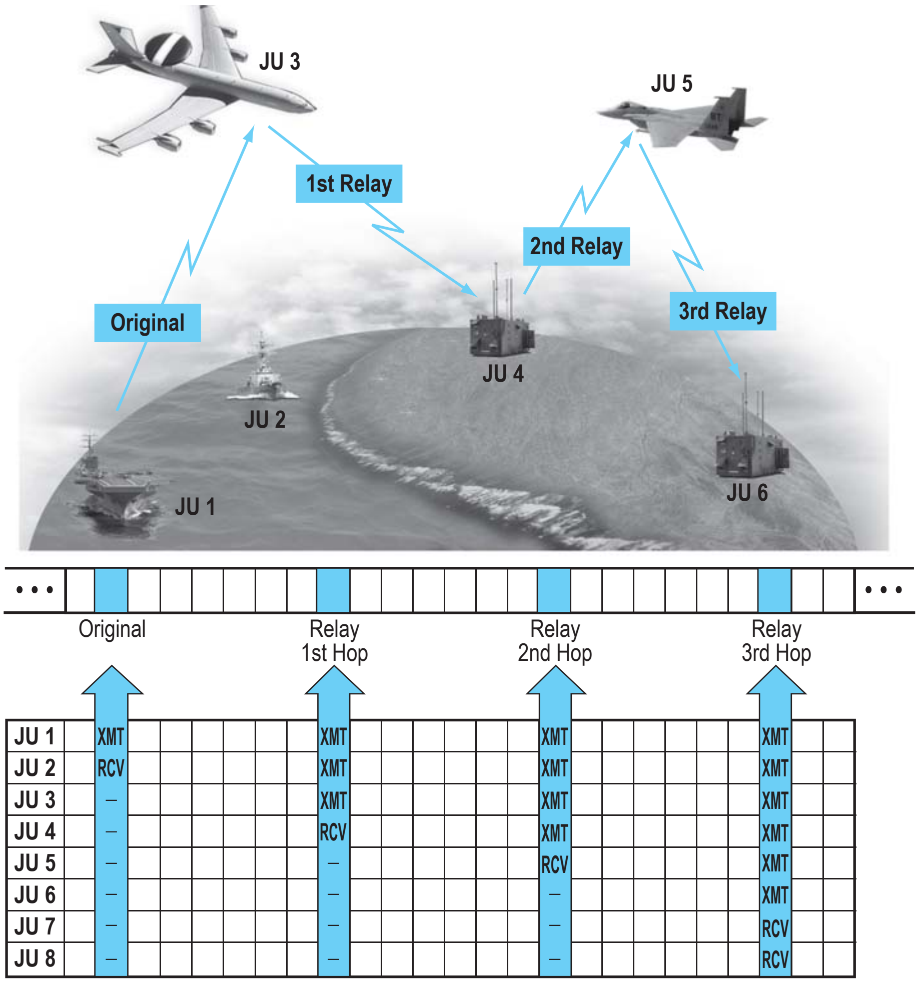


Figure 5-19. In the flood relay, all units receiving the original message as well as the message originator will retransmit it in all remaining relay slots.

■ Repromulgated Relay

The **repromulgation ("reprom") relay** is useful for moving ground units in situations where LOS to other units changes. After a source transmits, any initialized receiver will relay the message in the next time slot. The message header contains the information required for a reprom relay, including a reprom indicator, the original hop count, and the current hop count. If the receiving terminal has not already relayed the message, it decrements the current hop count and retransmits the message in the next time slot. The source can specify how many times the message should be retransmitted by specifying the desired hop count. Thus, messages are relayed out from the originator by whatever connectivity paths exist, hopping from unit to unit.

Repromulgation relay headers contain the hop count.

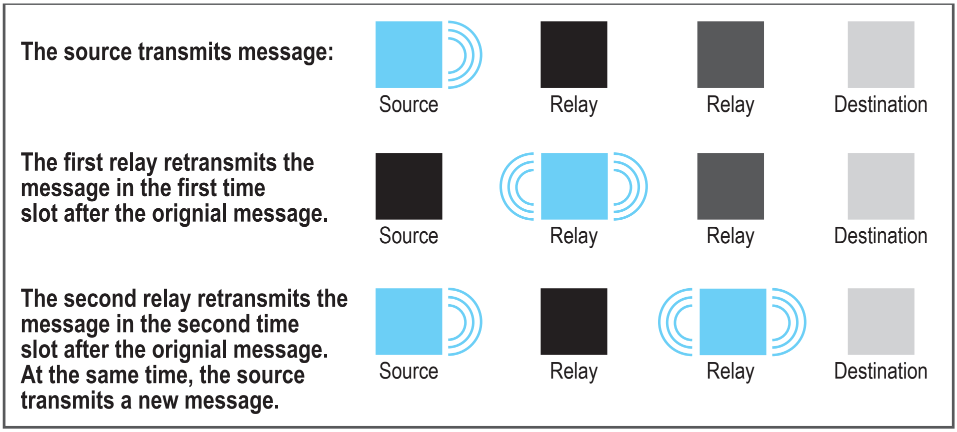


Figure 5-20. The reprom relay accommodates up to nine hops. Like Paired Slot relays, the reprom relay doubles the slot requirements for a message. After the first relay hop is completed, however, the originator can transmit another message. The first message continues to be relayed outward in the mean time.

■ Blind Relay

A relay assignment in which the relaying unit is unable to decrypt the message contents is known as a **blind relay**. The relaying unit has the correct TSEC cryptovariable, so it is able to receive and transmit the message, but it does not have the correct MSEC cryptovariable necessary to determine the message contents.

The relay unit cannot decrypt its blind relays.

■ Operational Considerations

JTIDS operates in the UHF frequency spectrum, which limits communications to LOS. With aircraft at 30,000 feet, however, LOS communications can occur at distances greater than 300 nautical miles (nm). Setting up an aircraft as a relay can extend LOS communications to nearly 600 nautical miles. With ship-to-ship LOS communications limited to about 25 nm, it is easy to see the importance of a Link 16 aircraft.

Maximum practical LOS range for air-to-air communications is about 300 nm.

Acting as relays, Link 16 aircraft perform a vital role in extending the JTIDS radio horizon. The range of LOS communications is limited by the curvature of the earth. The distance to the geometric horizon increases with altitude. UHF radio transmissions actually travel further than the geometric horizon because of refraction, or bending, of the signal by the atmosphere. The path of this refracted signal may be represented by straight-line propagation of the radius of the earth is modified so that the relative curvature between the signal and the earth remains unchanged. The new radius of the earth, known as the **effective earth radius**, defines the **radio horizon**.

By operating as relays, Link 16 aircraft extend the network's radio horizon.

The ratio between the effective earth radius and the true earth radius, denoted by the symbol K, can vary between 1/2 and 5. The average value of K in temperate climates, however, is approximately 4/3. Using this value for the effective-radius factor, and assuming that the altitude of a transmitter is much smaller than the radius of the earth, a good approximation of the distance to the radio horizon (in miles) is $\sqrt{2h}$, where h is the altitude measured in feet.

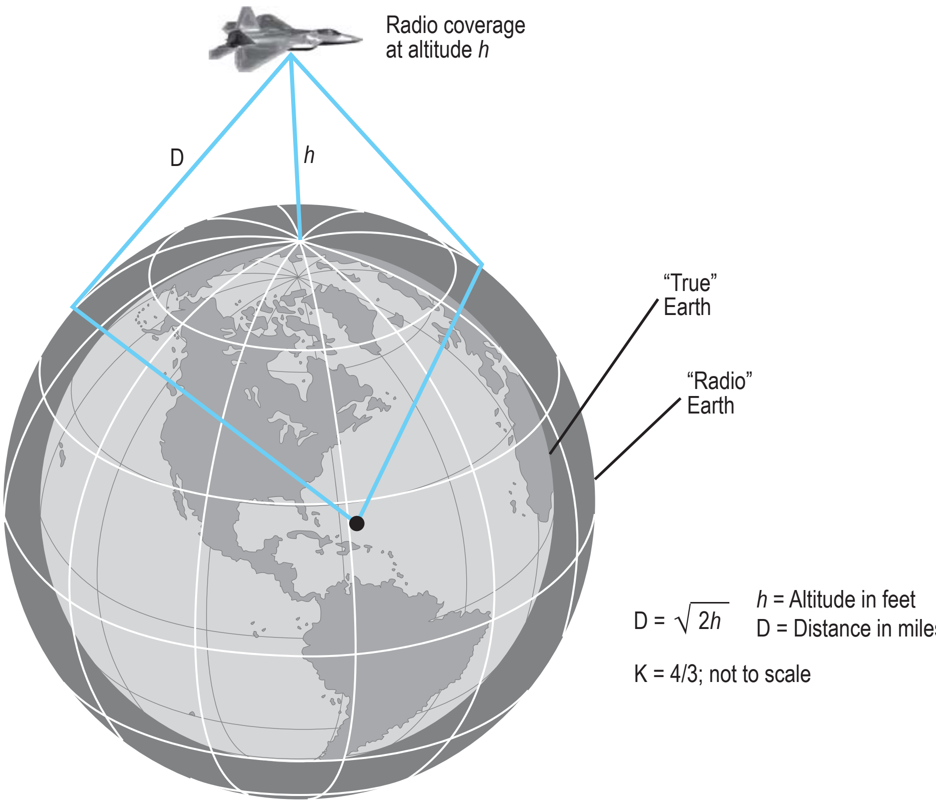


Figure 5-21. The range of LOS communications is limited by the curvature of the earth. UHF radio transmissions actually extend beyond the geometric horizon because of refraction, or bending, of the signal by the atmosphere. This increase in range can be approximated by an enlarged earth. Using an effective-earth-radius factor suitable for temperate climates, the distance D in miles to the radio horizon for a transmitter at height h is feet can be approximately $D = \sqrt{2h}$.

The nomogram in Figure 5-22 gives the maximum radio path length between a transmitting antenna at one altitude and a receiving antenna at another.[13] The distance to the radio horizon can be found by using the value 0 for one of the antennas.

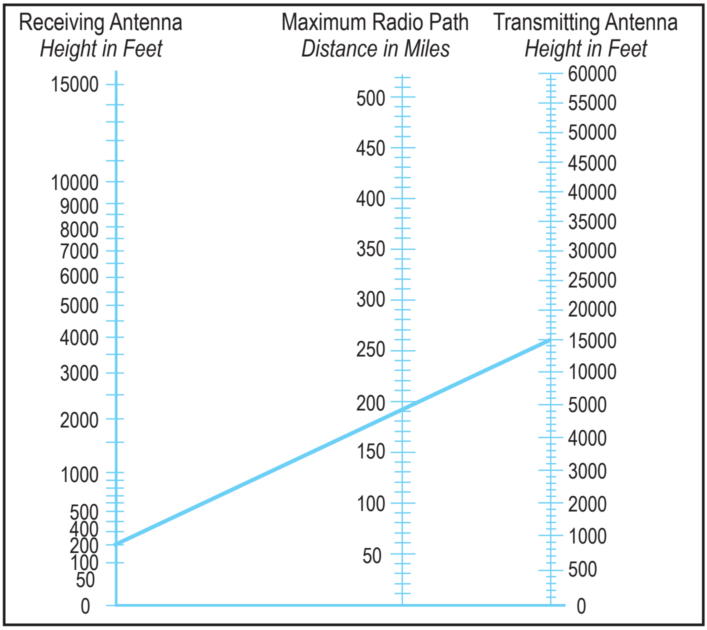


Figure 5-22. The maximum radio path length in miles between antennas at different heights is given in this nomogram. In this example, the height of the receiving antenna is 200 feet, and the height of the transmitting antenna is 15,000 feet, giving a maximum radio-path length of 190 miles. To obtain the distance to the radio horizon, use the height value of 0 feet for one of the antennas.

13 *The figure is based on nomograms in the sixth edition of Reference Data for Radio Engineers.*

Section I

Communications Security

Communications security (COMSEC) entails several layers of encryption. Different pieces of hardware handle these on JTIDS and MIDS terminals.

☐ Cryptovariable Control

A cryptovariable (CV) is a binary key used to encrypt and decrypt data. CVs are not referred to directly but are given a label. This **cryptovariable logical label (CVLL)** is a number between 0 and 127. The network designer assigns a CVLL to each time slot. CVLLs are used during network design to segment or isolate portions of the network into cryptonets. When loaded into a terminal, CVs provide TSEC and MSEC.

An electronic key or the contents of a paper tape may be loaded into the desired cryptofill device, such as the KYK-13, the KOI-18, the CZY-10, or the PYQ-10 (Simple Key Loader, or SKL), which is then applied to the terminal at its corresponding fill port.

SDU Memory Location		CPD	CPD = 0	CVLL	CV
1st Pair	0	0	Today	6	01001 . . . 11
	1	1	Tomorrow	6	01011 . . . 10
2nd Pair	2	0	Today	1	00101 . . . 01
	3	1	Tomorrow	1	00111 . . . 01
3rd Pair	4	0	Today	23	10101 . . . 10
	5	1	Tomorrow	23	10001 . . . 11
4th Pair	6	0	Today	2	01011 . . . 01
	7	1	Tomorrow	2	00010 . . . 01

CCPD for
July 7, 1994 is 0

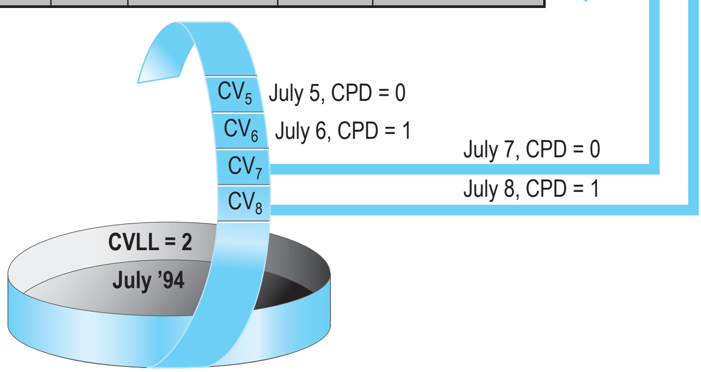


Figure 5-23. The SDU memory locations contain pairs of cryptovariables used to encrypt and decrypt the message data. These CVs are assigned a label, or CVLL, used by the Network designer to assign the CV to each time slot. The Current Cryptoperiod Designator (CCPD) identifies which of the pairs to use.

■ JTIDS Class 2 Terminals

A Secure Data Unit (SDU) encryption device, designated the KGV-8, attaches directly to the JTIDS Class 2 terminal and has memory locations available for eight cryptovariables. The SDU provides the TSEC and MSEC for Link 16 transmissions.

JTIDS Class 2 terminals have attached encryption units.

■ MIDS Terminals

For the MIDS terminals—including the MIDS/LVT-3 (FDL)—the Government provides a circuit board-mounted SDU embedded within the terminal. The FDL's SDU provides TSEC and MSEC and contains interfaces for both the control and loading of cryptovariables. The SDU interface is provided as a secure path for the exchange of messages between the SDU and an external data transfer or loading device. The FDL terminal is capable of accepting encrypted and unencrypted keys over this SDU interface.

MIDS terminals have embedded encryption units.

■ Loading Crypto

Within a terminal's SDU are eight memory locations, organized as four **today/ tomorrow pairs**. Each location is associated with a CVLL. It is also associated with a **crypto period designator (CPD)**. The even-numbered locations are assigned a CPD of 0, and the odd-numbered locations are assigned a CPD of 1.

The USAF's today/tomorrow pairs are loaded into positions 0 and 1.

Crypto personnel load the appropriate CVs into the appropriate SDU locations. The standard procedure is for the personnel to load two CVs, called the today/tomorrow pair, whenever they load crypto into the terminal. The designation of which CVLL is loaded into which member of the pair is not happenstance. Every day is assigned a

CPD, beginning with 0 on January 1, 1985, and alternating between 0 and 1 for each day thereafter. The **Current CPD (CCPD)** is established by the calendar date on which the terminal is being initialized. The CCPD is either 0 or 1, and it designates to the terminal which one of the pair to use for today. The other one is then automatically used for tomorrow. An additional parameter, the **sequence number**, which varies between 0 and 7, indicates how long the CVs will be used.

Help prevent rollover breakdown! Always load two crypto positions – today and tomorrow – EVERY day.

CPD Prediction Table — Leap Years

	2008, 2016			2004, 2012		
	Month	Day is		Month	Day is	
		Odd	Even		Odd	Even
Leap Years	Jan	0	1	Jan	1	0
	Feb	1	0	Feb	0	1
	Mar	0	1	Mar	1	0
	Apr	1	0	Apr	0	1
	May	1	0	May	0	1
	Jun	0	1	Jun	1	0
	Jul	0	1	Jul	1	0
	Aug	1	0	Aug	0	1
	Sep	0	1	Sep	1	0
	Oct	0	1	Oct	1	0
	Nov	1	0	Nov	0	1
	Dec	1	0	Dec	0	1

CPD Prediction Table — Non-Leap Years

	2010, 2013, 2015, 2018			2009, 2011,2014, 2017		
	Month	Day is		Month	Day is	
		Odd	Even		Odd	Even
Non-Leap Years	Jan	1	0	Jan	0	1
	Feb	0	1	Feb	1	0
	Mar	0	1	Mar	1	0
	Apr	1	0	Apr	0	1
	May	1	0	May	0	1
	Jun	0	1	Jun	1	0
	Jul	0	1	Jul	1	0
	Aug	1	0	Aug	0	1
	Sep	0	1	Sep	1	0
	Oct	0	1	Oct	1	0
	Nov	1	0	Nov	0	1
	Dec	1	0	Dec	0	1

Figure 5-24. Each time slot is assigned a cryptovariable (CV) using a CVLL. These CVs are loaded into the KGV-8 memory in today/tomorrow pairs. Associated with each calendar day is a CPD of either 0 or 1, which designates which one of the pair to use. The highlighted example shows that the CPD for 4 July 2008 is 1. The CVs for this day are located in the odd memory locations.

MSEC and TSEC

Two layers of communications security are provided: **MSEC** and **TSEC**. The MSEC CV (pointed to by the MSEC CVLL) is used to encrypt the message data prior to the R-S encoding, interleaving, and pulse generation.

MSEC encryption occurs before R-S encoding.

The TSEC CV (pointed to by the TSEC CVLL) determines the amount of jitter in the time slot and the 32-chip pseudorandom noise variable. The TSEC CV, together with the net number and time slot number, also determines the frequency-hopping pattern of the carrier.

MSEC and TSEC can be either the same or different.

Two **encryption modes** are distinguished:

- When the MSEC and TSEC CVLLs are the same, the **common variable mode (CVM)** is in effect.
- When MSEC and TSEC have different CVLLs, the **partitioned variable mode (PVM)** is in effect.

Each NPG is assigned two CVLLs, one to be used for MSEC and one to be used for TSEC. In addition, a default net number, a default MSEC, and a default TSEC are also assigned. When the terminal has nothing to transmit, it defaults to receive using these default parameters.

MSEC is message security; TSEC is transmission security. These are part of the network design load.

Section J

Multinetting

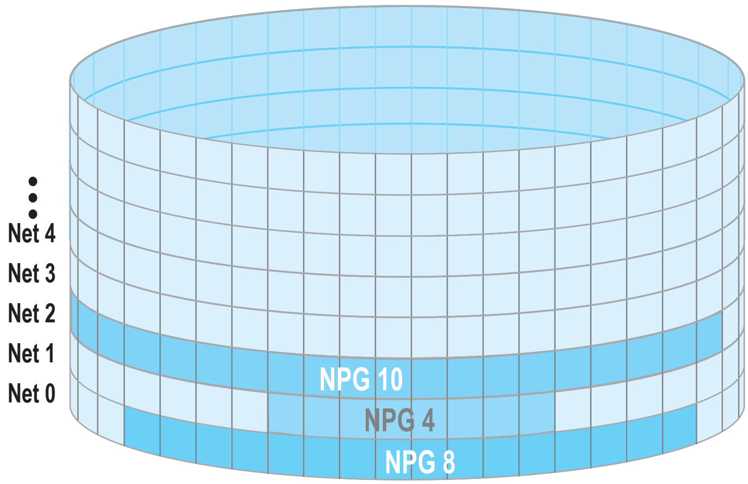
The JTIDS waveform allows for the definition of 127 different nets, numbered 0 to 126. The net number, along with the TSEC CV and time slot number, determines the carrier frequency-hopping pattern. These different hopping patterns are what keep the nets separate and distinct and allow multiple nets to operate concurrently. Multiple nets can be established simply by specifying different net numbers for a particular NPG, without changing the TSEC and MSEC CVs. If the MSEC and TSEC CVs are changed, several variations of multinetting are possible, including blind relays. Transmission in the same time slots, but on different NPGs and different net numbers from the main (default) net, is known as multinetting.

MSEC	TSEC	Net Number	Type of Multinetting
Same	Same	Same	Not Multinetting!
Same	Same	Different	Stacked Net
Same	Different	Same	Crypto Net
Same	Different	Different	Crypto Net
Different	Same	Same	Crypto Net (Blind Relay)
Different	Same	Different	Crypto Net (Multiple Nets)
Different	Different	Same	Multiple Networks
Different	Different	Different	Multiple Networks

Figure 5-25. The blind relay, a type of multinetting, occurs when two JUs are assigned the same TSEC CV and the same net CV number, but a different MSEC CV.

☐ Multiple Nets

Multiple nets can be established simply by specifying different net numbers. The SDU of a JTIDS/MIDS terminal holds up to eight CVs stored as today/tomorrow pairs, any one of which could be used at any one time. Using one of these CVs in conjunction with 127 possible net numbers allows a potential of 508 different hopping patterns, or independent nets, for any given time slot block. Although hundreds of nets are possible, any given terminal can transmit, receive, or relay on only one of them for each time slot.



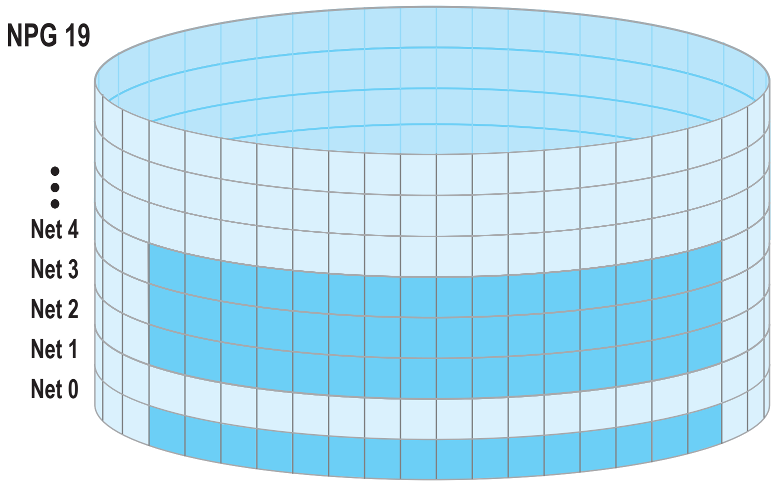
Note: The time slots of each TSB are actually interleaved, not contiguous.

Time Slot Block	NPG	Net #	MSEC	TSEC
A-8-10	8	0	1	1
A-40-9	4	1	1	1
A-0-12	10	2	2	1

Figure 5-26. Multiple nets can be established simply by specifying different net numbers.

☐ Stacked Nets

A stacked net is created by assigning the same group of time slots to the same NPG with the same TSEC parameter, but with selectable or different net numbers. The time slots must have the same set, initial slot number, and recurrence rate. They may have different net numbers and the same crypto keys, or different net numbers and different crypto keys. The voice nets and the air control nets are examples of stacked nets.



Note: The 16 time slots of TSB A-8-10 are actually interleaved, not contiguous.

Time Slot Block	NPG	Net #	MSEC	TSEC	Participants
A-8-10	19	0		1	CV + 8 F/A-18s
A-8-10	19	2		1	E-3 + 8 F-15Cs
A-8-10	19	3		1	E-3 + 4 F-15Es
A-8-10	19	4		1	E-3 + 8 F-16s

Figure 5-27. A stacked net is created by assigning the same time slots to the same NPG with the same TSEC parameter, but with different net numbers.

Stacked nets are often defined to the terminal with a net number of 127. This indicates “No Statement” (NS), or no definition, and allows the operator to specify a net number during operations. If the cryptovariables of the stacked nets are the same, an operator can “dial-a-net” by entering the desired net number.

□ Cryptonets

Isolation between networks or between network users is created by configuring the terminal's CVs with different CVLLs. Only authorized users—those with the correct TSEC and MSEC CVs—will be able to exchange information. **Cryptonets** are created by assigning a different TSEC CV and/or MSEC CV to a group of users.

A group of JUs can be isolated from other JUs by assigning them a different MSEC and/or TSEC CV.

If the TSEC CV is the same and only the MSEC CV is different, unauthorized users can receive the signal, error correct it, and retransmit it. But they cannot decrypt it, and this configuration of CVs is used to establish blind relays. The net consisting of the participants with the correct MSEC is sometimes referred to as a cryptonet with CVLL = n, where n is between 1 and 127. If the TSEC CV is different, unauthorized users cannot even receive the signal. If both the TSEC and MSEC are different, complete isolation is established.

Network Deconfliction

A Link-16 network is a group of participants in time synchronization that exchange information. Planning is required to ensure that different networks (encompassing different participants and/or purposes) do not cause mutual interference. There are three ways to ensure successful independent network operations:

- **Geographic separation**, such that synchronization cannot be achieved between two different networks,
- **Different keys** (cryptographic differentiation), and
- **Network time offset**.

When independent operations are sufficiently close that inadvertent synchronization between networks is possible, use of a different key (that is, a different short title) is the preferred method for resolving independent networks. Network time offset of not more than ± 60 minutes may be used only for training operations, unless otherwise approved by the Joint Interface Control Officer (JICO) and stated in the OPTASK LINK message. Time offsets must be managed to ensure that no single terminal reuses a key. For example, a terminal using a forward time offset cannot revert to a standard (zero) time offset or a negative time offset network using the same key, and then commence transmissions, until the difference in time between networks has expired. But conversely, a terminal operating in a negative or zero time offset can commence transmitting in a positive time offset network immediately. Network deconfliction will become a less frequent option as external time reference networks are directed that rely on tight coupling to a UTC source.

With multiple independent networks, each network has its own NTR.

Section K

Range Extension Techniques

The most common method of extending JTIDS range beyond line of sight (BLOS) is the employment of airborne relays. This is not always feasible, however, due to the lack of airborne assets or conflicting mission requirements. Several means of employing satellite communications to extend the range of Link 16 are under development as part of the Joint Range Extension Application Protocol (JREAP) program. Various connectivity devices using Ethernet or serial protocols have been developed as well to support testing and training over landlines.

☐ Satellite Methods

Satellite resources include Military Strategic and Tactical Relay Satellite (MILSTAR), the UHF Follow-On (UFO), the Defense Satellite Communications System (DSCS), and Fleet Satellite (FLTSAT). These satellites provide communications in three frequency bands: UHF, super high frequency (SHF), and extremely high frequency (EHF).

■ S-TDL J

Satellite TDL J (S-TDL J) is a Navy design for extending the range of Link 16 using satellites. Aboard Navy ships, S-TDL J requires a modification to the tactical system to accommodate new cabling from the C2P or C2P Rehost to Demand Assigned Multiple Access (DAMA) equipment via a KG-84A encryption device. The Navy's C2P, in turn, requires new software for this implementation. The Marine Corps' Common Data Link System (CDLS) also implements S-TDL J, as will the new Common Aviation Command and Control System (CAC2S) when it is fielded.

S-TDL J is the USN's Link 16 satellite technique.

A platform may operate on both the Link 16 network and the satellite concurrently. Transmissions on the satellite are generally delayed with respect to the Link 16 network, and data received from the Link 16 network is given precedence by the platform over data received from the satellite. When a JU "drops out," as evidenced by no PPLI reception for 60 seconds, the platform automatically and seamlessly takes data for that JU from the satellite.

S-TDL J implements most of the J-series messages, although those required for time-critical functions—such as network management, air control, and national use—are not implemented. It uses a token-passing, round-robin network protocol. Data to be transmitted over the satellite is conveyed over a completely separate path out of the C2P that does not pass through the JTIDS/MIDS terminal. The KG-84A and compatible cryptos are used for most standard serial data protocols.

The net cycle time associated with S-TDL J depends on the number of satellite JUs (SJUs), as well as on track volume. Clearly, data rates over satellite links at 2400 baud or 4800 baud are much lower than conventional Link 16 rates, and data latency is a potential problem. For example, a four-unit network exchanging information on 180 tracks at 2400 baud is estimated to require 24 to 26 seconds, rather than the 20 seconds discussed in the S-TDL J specification and observed during real-world experience. There is also a token-passing switching delay estimated to be two seconds per unit. Higher data rates will become available, however, as the EHF median data rate (MDR) satellite communications provided by MILSTAR become operational.

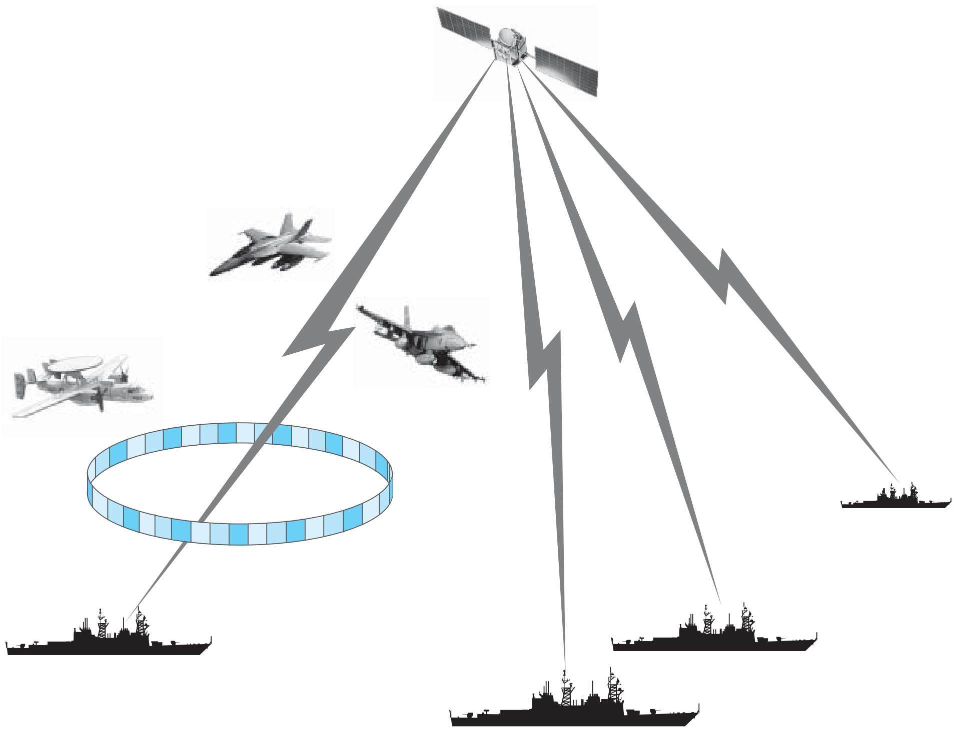


Figure 5-28. S-TDL J is a Navy technique for extending the range of Link 16 using a satellite and separate modulation techniques. The new Marine Corps CAC2S will also implement S-TDL J.

■ Joint Range Extension Application Protocol

JREAP is a method for extending Link 16 coverage across "zones" to include multiple networks that cover an entire theater. Units within LOS or connected by airborne relay or satellite and employing the same network design define a **zone**. JREAP "gateways" are associated with each zone, and may be equipped with Link 16 terminals, EHF SATCOM terminals, and application software to perform Link 16-to-Link 16 forwarding. As delineated in the JREAP point-to-point application standard, MIL-STD-3011B, the protocols available for joint range extension, and therefore the forwarding of J-series messages, include:

- Half-Duplex Announced Token Passing Protocol
- Full-Duplex, Synchronous Or Asynchronous Point-To-Point Connection Protocol, and
- Encapsulation over Internet Protocol (IP).

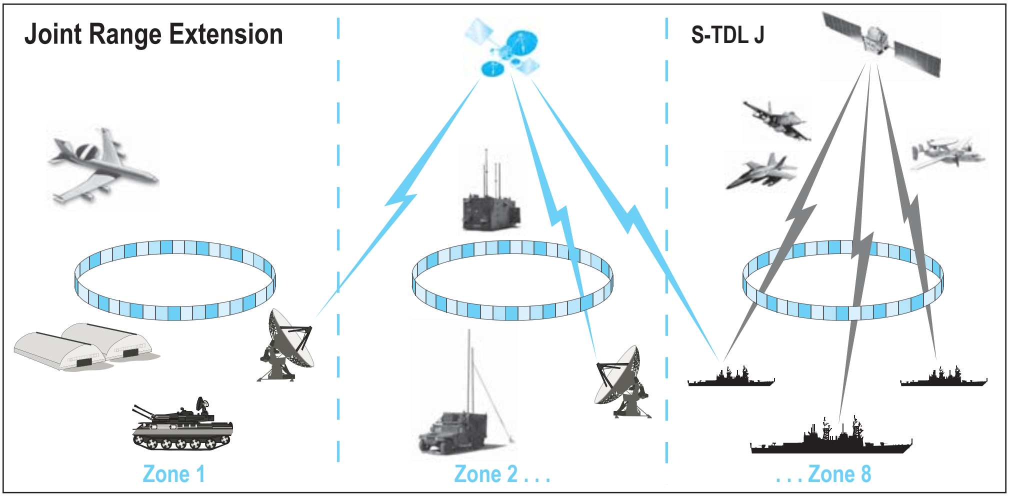


Figure 5-29. JREAP uses satellite communications to extend the range of Link 16 beyond LOS.

JREAP is another means to extend Link 16 networks beyond LOS.

Issues such as track block assignments within and across zones, the impact on RELNAV of forwarded PPLIs containing position and time quality measurements that conflict with TOA measurements from the transmitting unit, and how to perform receipt compliance, are being identified and addressed. Note that all US Services have developed plans to implement MIL-STD-3011 in specific systems to achieve BLOS linking capability.

■ Army CDLIM

The Common Data Link Interface Module (CDLIM) is a Lower Tier Project Office (LTPO) Common Software Module (CSM), which the Army has implemented to perform Joint Range Extension. CDLIM extends the range of RF networks beyond the line-of-sight limitations of the JTIDS and MIDS radio terminals. The CDLIM consists of common software for implementing and managing data links, message formats, and electronic and physical interfaces with associated transmission media.

The CDLIM forwards data between data links of the same type in accordance with MIL-STD forwarding rules. In addition, it can translate between message formats to provide the exchange of data between dissimilar data links. The CDLIM is deployable on a broad variety of weapon platforms, and has been proven operationally with systems such as Patriot, Terminal High Altitude Area Defense (THAAD), and the Joint Tactical Ground Station (JTAGS). The CDLIM augments each platform's organic communication capabilities with minimal changes to weapon system and radio hardware configurations. CDLIM software functionality is transparent to the host weapon system software as well.

Candidate platforms for future CDLIM deployment include the Joint Land Attack Cruise Missile Defense Elevated Netted Sensor (JLENS), the Integrated Battlefield Control System (IBCS), and the Surface-Launched Advanced Medium Range Air-to-Air Missile (SLAMRAAM).

Figure 5-31, below, depicts a CDLIM solution that provides BLOS Link 16 capability to the Patriot Information and Coordination Central (ICC). This solution has the following benefits:

- The CDLIM system co-located in the Tactical Command System (TCS) acts as a terminal emulator to the Patriot Host computer.
- The CDLIM allows Patriot to exchange Link 16 messages via Satellite Link16 (SAT-J) as a network participant.
- Tactical data can be exchanged via SIPRNET, or via STE/STU.
- Use of the CDLIM requires no software changes to Patriot.

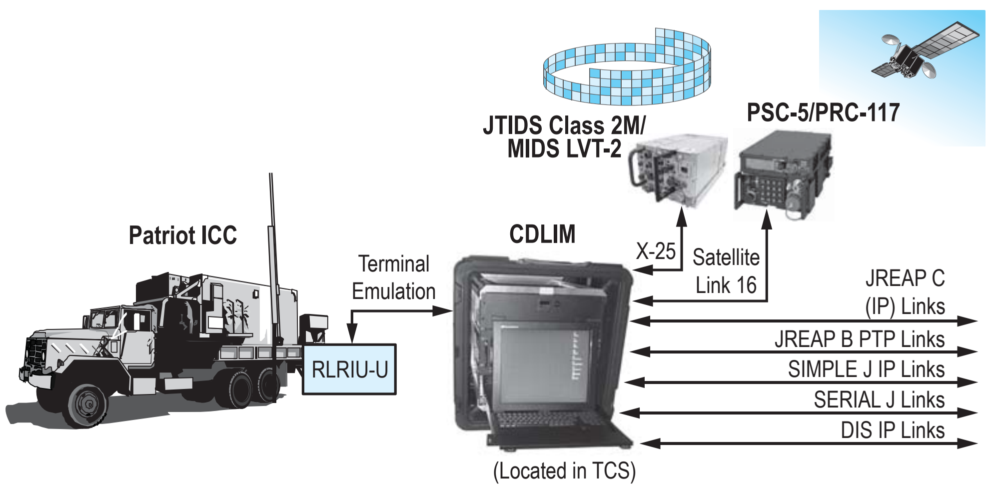


Figure 5-31. A Typical BLOS Solution for a Patriot Information and Control Central (ICC) is shown here. The CDLIM system acts as a data forwarder between the Patriot ICC and other data links, including satellite BLOS links.

Additional capabilities that the CDLIM provides the warfighter include:

- Reduced network loading
- Redundant communication links
- Data forwarding between similar data links in accordance with MIL-STD forwarding rules
- Translating messages between different protocols, and
- User-interactive initialization and configuration.

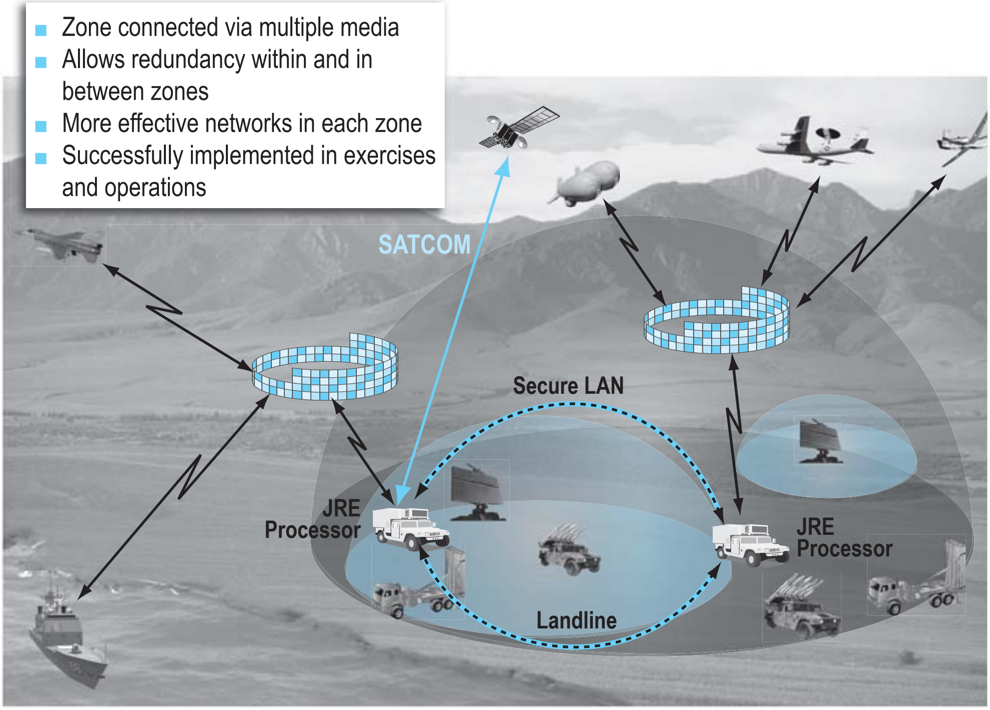


Figure 5-32. CDLIM's JRE processor provides many benefits. As shown above, it can connect multiple Link 16 networks, as well as other BLOS and landline linkages.

Allied Use (UK)

The United Kingdom's Satellite Tactical Data Link (STDL) was the first implementation of satellite Link 16. It provides the means for the Royal Navy to exchange Link 16 tactical data using SHF satellite communications. Three modes of operation are used: a network mode, a group mode, and a broadcast mode. TDMA architecture permits participation by up to 16 transmitting Satellite Units (SatUs) in the network mode, forwarding from an STDL network to a Link 11 or Link 16 network by Forwarding Satellite Units (FSatUs) in the group mode, and transmission by one unit to other SatUs in the broadcast mode. In the network mode, propagation and processing delays are taken into consideration in order to synchronize satellite transmissions with the SHF TDMA slot. Data rates up to an aggregate of 19.2 kbps are provided.

STDL is the UK Royal Navy's scheme for satellite Link 16.

Serial Link 16 Connectivity

Several devices have been specifically designed to provide serial connections to "patch together" tactical systems in real time, at remote locations. These systems employ serial interfaces and secure telephone lines. For operators, these serial Link 16 devices include:

- The Gateway Manager (GM)
- The Improved Multi-TDL Distribution System (IMTDS)
- The MIL-STD-3011 Appendix C Device
- Other emerging capabilities in new weapons systems.

Various serial interface protocols have been devised. An effort to standardize serial protocol has been proposed, and this is known as the **Standard Interface for Multiple Platform Link Evaluation (SIMPLE)**. The IMTDS implements its own, proprietary protocol, called "Serial J." The GM is capable of being configured by an operator with various protocols, including SIMPLE and Serial J.

Serial Link 16 connectivity can be employed wherever it is possible for a remotely located unit to be connected to an operational Link 16 network over a telephone line.

As such, it can readily be employed in place of other range-extending methods such as relays, satellite means, or Roll-on, Beyond Line of Sight Enhancement (ROBE). The serial technique requires two serial Link 16 connectivity devices (such as the GM or IMTDS), one on each end of the connection. A telephone baud rate of 14,400 bps is normally sufficient to sustain real-time Link 16 communications. Two secure telephone equipments (STEs), one at each end, provide the required encryption.

For example, the USMC NDF at Camp Pendleton, California may wish to participate in a live Link 16 test being conducted at the Joint Interoperability Test Command (JITC) at Fort Huachuca, Arizona. For this purpose, a host in a laboratory at the USMC NDF can be serially connected to one of the live systems at JITC. Note that the host in the NDF lab will obtain a remote picture over the telephone line from Arizona, rather than a live RF picture from a local network.

This serial connection works as depicted in Figure 5-33. In Arizona, the serial device uses an interface to connect between the live JU's tactical host computer and its JTIDS or MIDS terminal. The serial device reads the bus traffic between the host and the terminal, and sends the J-series messages out through its serial interface onto the telephone line via a STU.

Meanwhile, the second serial device, in California, is connected to the NDF's host via a STU on the telephone line. Using this method, Link 16 data is exchanged in both directions, in real time, between the JU in the live Arizona UHF LOS network and the host in the NDF lab located hundreds of miles away in California.

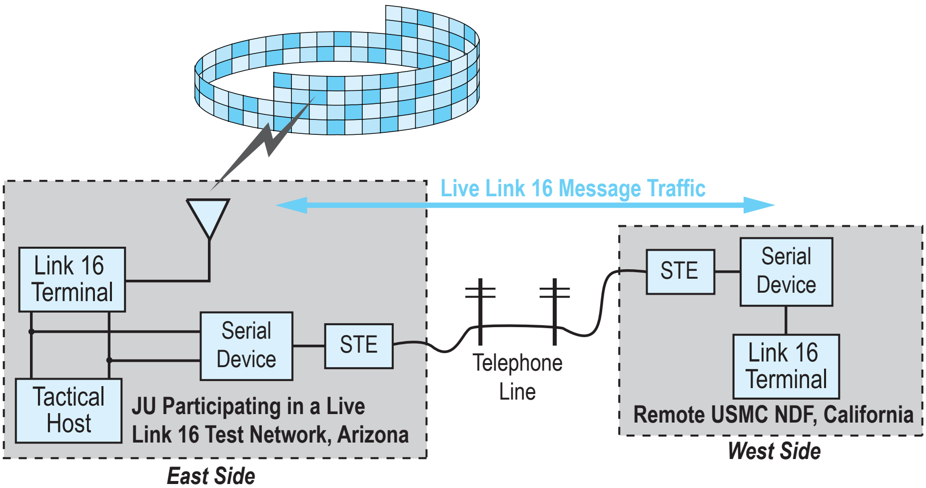


Figure 5-33. On Link 16, serial Link 16 can be employed wherever it is possible to connect a remote unit to an operational Link 16 network over a telephone line. Serial connectivity requires two serial Link 16 connectivity devices, one on each end of the connection, communicating through secure telephone units (STUs). Under most conditions, a 14,400 baud rate is sufficient for real-time Link 16 communications. In this example, a host in a laboratory at Camp Pendleton, California is receiving its remote tactical picture serially, from a test site in Arizona.

Section L

Situation Awareness Data Link

The Situation Awareness Data Link (SADL) is a secure, spread-spectrum, frequency-hopping waveform using TDMA for an air-to-air and air-to-ground data-link capability. SADL uses a modified version of the U.S. Army Enhanced Position Location Reporting System (EPLRS) digital radio to provide both ground and air situational awareness to pilots. As such, SADL is an airborne variant of EPLRS, using the waveform, transmission, and antijam characteristics with a built-in secure data unit to preserve data security and TDMA architecture.

SADL radios are essentially airborne EPLRS radios.

SADL-equipped aircraft share and display flight and targeting information, and display friendly position locations with the Army Digitized Battlefield-Tactical Internet to reduce the possibility of fratricide. The F-16 (Block 25/30) and the A/OA-10 aircraft are implementing SADL to provide position/location, platform status, and digital targeting data in the cockpit. As does Link 16, SADL provides for multiple stacked nets. SADL aircraft share position, performance, and radar targeting information on the air-to-air net.

SADL currently supports up to twenty separate, 16-unit air-to-air networks. When part of a ground network, SADL aircraft receive PPLI data from EPLRS-equipped ground maneuver forces. The positions of the friendly forces appear on the heads-up display and tactical awareness display of SADL-equipped fighters. Other SADL nets currently support SADL digital forward air control and the Link 16/SADL gateway functions.

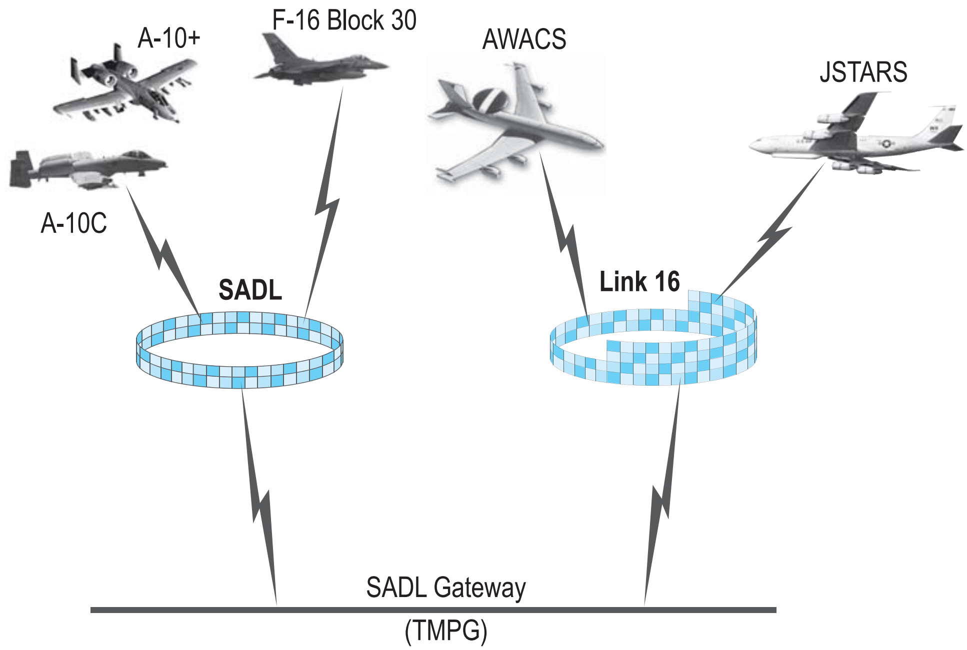


Figure 5-34. SADL is used to provide interoperability between Link 16-equipped platforms and SADL-equipped aircraft, such as F-16s and A-10s. TMPG denotes the Transparent Multi-Platform Gateway.

SADL-equipped Aircraft

The USAF's SADL-equipped aircraft are the F-16 Block 30, the A-10C, and the A-10+. These aircraft use an EPLRS radio to exchange critical messages between Link 16 platforms via the Transparent Multi-Platform Gateway (TMPG). The TMPG translates between selected Link 16 messages and SADL messages in both directions. The TMPG may be hosted by a C2 platform, such as a CRC or TAOM, as part of the Joint Range Extension TMPG Equipment Package (JTEP).

The platform hosting the TMPG/JTEP equipment must be assigned an adequate number of time slots to accommodate the transmission of its own surveillance tracks, as well as the PPLIs for each SADL-equipped aircraft operating on the interface.

For ROBE Spiral 2, SADL and the TMPG will be incorporated into the ROBE capability. To accommodate this upgrade, the JICO or Link 16 Manager must assign sufficient JU addresses in the OPTASK LINK to support the number of SADL-equipped aircraft operating on the interface. In the EPLRS radio version 11.XY, the TMPG software will be embedded in the radio. It is very important to note that the 11.X and 11.XY EPLRS radios are not interoperable.

EPLRS 11.X and 11.XY versions are not interoperable!

SADL Data Exchange

SADL-equipped aircraft transmit PPLIs via the TMPG on Link 16. SADL units receive PPLIs, surveillance tracks, track management messages, and mission assignment discretes, as well as free-text messages of up to nine lines from IUs operating on Link 16 via the TMPG.

Air Force Link 16 Platforms

CHAPTER 6

Introduction

This chapter presents the Link 16 capabilities of current and planned USAF implementations. Among the current Link 16 implementations, the Command and Control (C2) platforms are discussed in separate sections first: the Airborne Warning and Control System (AWACS), the Joint Surveillance Target Attack Radar System (JSTARS), the intelligence, surveillance, and reconnaissance (ISR) platforms (Rivet Joint, Cobra Ball, and Combat Sent), the Control and Reporting Center (CRC), and the Air and Space Operations Center (AOC). These are followed by the currently implemented nonC2 platforms: the F-15C/E, the F-16, the F-22A, the B-1B, the B-2, the Airborne Laser (ABL), the Roll-on Beyond Line of Sight Enhancement (ROBE) for the KC-135 tanker, and the Unmanned Aerial Vehicles (UAVs). Discussions of future implementations—the F-35 Joint Strike Fighter (JSF), the Air Support Operations Center (ASOC), and the Battle Command and Control Center (BC3)—follow at the end of the chapter. Tables summarizing the messages transmitted and received on Link 16 by each platform may be found at the end their respective sections. Studying these capabilities will help you to understand how each platform performs on Link 16.

Section A

Overview

This chapter presents the Link 16 capabilities of current and planned USAF platform implementations. The USAF has recognized that Link 16 plays a prominent role in establishing and maintaining tactical situational awareness (SA), conducting tactical Command and Control (C2) and weapons operations, increasing survivability, and leveraging offboard sensor and intelligence information to specifically attack an adversary's strategic center of gravity.

Using Link 16 results in a great advantage to our Forces.

The incorporation of Link 16 has been shown to allow fundamental changes in counterair tactics, with a corresponding advantage to our Link 16-equipped forces. The dominance that this increased capability provides to SA is evident in the operational exercises conducted by Link 16-equipped units. The USAF has committed to incorporating this capability into its front-line fighter and bomber aircraft over the next ten years, including:

- The F-15A-D and F-15E fighter aircraft
- The F-16 fighter aircraft, Blocks 40 and 50
- The F-22A fighter aircraft
- The new F-35, also known as the Joint Strike Fighter (JSF)
- The B-1B and B-2 bombers
- The Rivet Joint (RJ), Cobra Ball (CB), and Combat Sent (CS) airborne intelligence, surveillance, and reconnaissance (ISR) platforms.
- The KC-135 tanker aircraft equipped with the Roll-on Beyond-Line-of-Sight Enhancement (ROBE) system
- The Airborne Laser (ABL), and
- The Unmanned Aerial Vehicles (UAVs).

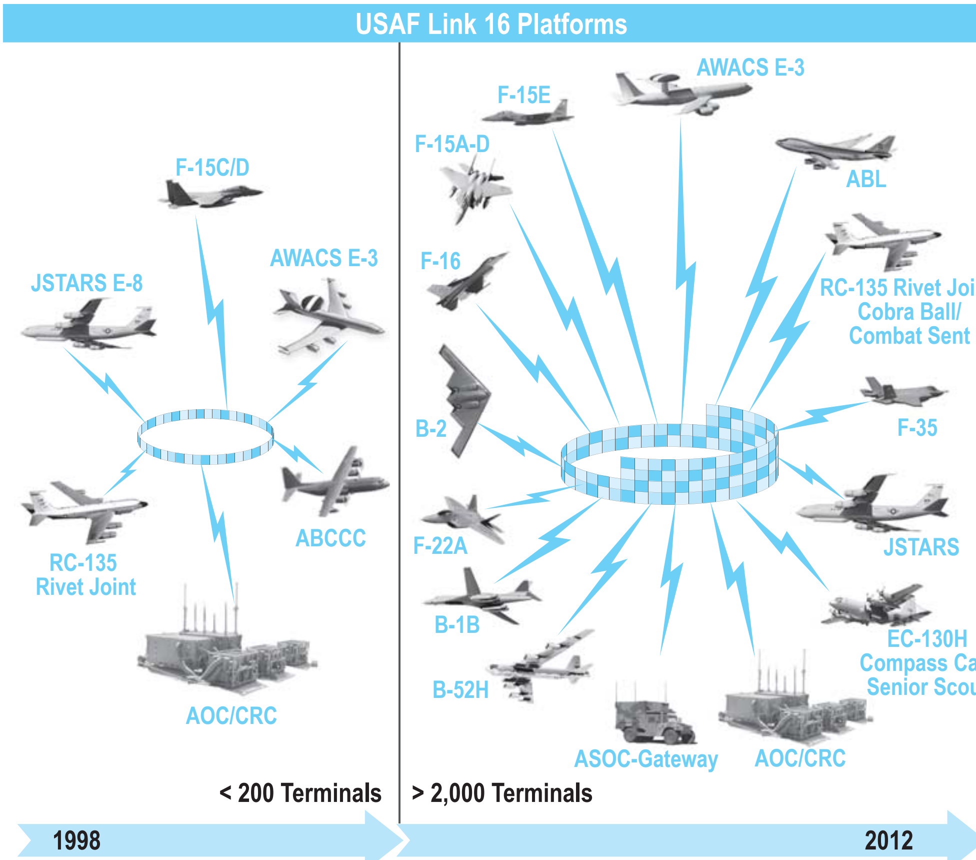


Figure 6-1. Air Force Link 16 platforms today and platforms to be added by the year 2012.

The USAF's Link 16 capability is based on a time-phased approach that involves approximately 22 different individual platforms, each of which has its own development and update cycle. The transition to Link 16 began in the early-to-mid 1990's, with upgrades to C2 platforms that incorporated the JTIDS Class 2 terminal. The first operational JTIDS Class 2 terminal on an E-3 was delivered to the 552th Air Control Wing (ACW) in the summer of 1995. Today, the Class 2 terminal is used aboard AWACS, JSTARS, RJ, CB, CS, CC, SS, and the CRC C2 platforms. In the future, the Battle Control System – Mobile (BCS-M) will replace the CRC and will utilize the LVT-11 terminal.

The USAF initiatives have directed that Link 16 be implemented in weapons systems beyond these C2 platforms. Today, the MIDS LVT-3 (aka “Fighter Data Link,” or FDL) terminal is used aboard all F-15A-D and F-15E aircraft, and the MIDS LVT-6 terminal is used aboard all F-16 Blocks 40 and 50 aircraft. The MIDS LVT-1 terminal has been integrated into the ABL and the B-2 aircraft, and the Joint Tactical Radio System (JTRS) will be integrated into the B-1B. The F-22A aircraft has a receive-only implementation of Link 16 integrated into its avionics. The F-35 JSF will use the JTRS terminal.

The information in the following sections is current as of this printing. This will continue to evolve, however, with the implementation of future interface control documents and other platform specifics.

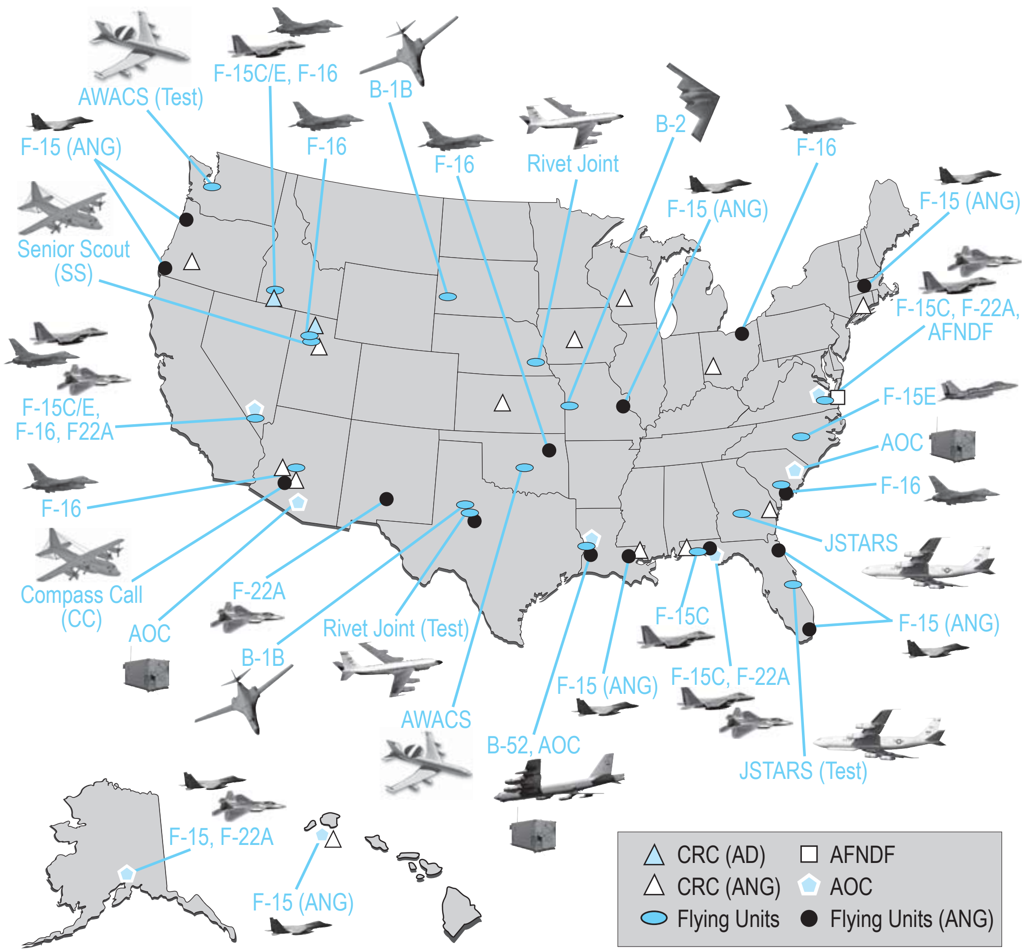


Figure 6-2. Future US JTIDS and MIDS platform locations are shown. Note the inclusion of the AOC and F-16. ANG denotes units belonging to the Air National Guard.

Section B

AWACS

The **Airborne Warning and Control System (AWACS)** E-3 Sentry aircraft, shown Figure 6-3, employs a high-capacity radar station, as well as a command, control, and communications center, aboard a modified Boeing 707-320B airframe. Thirty-four of these aircraft were built for the USAF, eighteen were built for NATO, and fifteen were built for the Royal Saudi Air Force, the British Royal Air Force, and the French Ministry of Defense.

The AWACS initial Link 16 implementation was based on the Link 16 message standard as it existed in 1988. At that time, the primary purpose of deploying Link 16 on the aircraft was for reporting air surveillance information, a function that was modeled chiefly on the Interim JTIDS Message Specification (IJMS) capability that existed previously in the Block 20/25 AWACS. With the upgrade to Block 30/35 AWACS and the implementation of Link 16 in fighters, the capabilities of Link 16 fighter control has greatly increased.

Link 16 Fighter Control capabilities in AWACS have increased as a result of the USAF decision to field Link 16 in fighters. Recent organic additions have improved the battle management, threat warning, and fighter control capabilities of the AWACS Link 16 implementation. AWACS Link 16 implementation has evolved with expanded fighter control capabilities to include all five correlation levels of tracks with fighter sensor targets, additional mission assignment discretes (MADs), and air-ground messages supporting precision engagement of time-sensitive targets (TSTs).

□ Mission

During peacetime, the AWACS's mission provides the **Combat Air Forces (CAF)** with an airborne system and personnel for surveillance, warning, and control of strategic, tactical, and special mission forces. AWACS provides all-altitude "deep look" surveillance, early warning, control, and airborne management roles in a variety of tactical, strategic, and special missions. During time of war, the E-3 can support missions and roles as a battle management platform, including counter-air, counter-land, counter-sea, strategic attack, **combat search and rescue (CSAR)**, EW Intelligence, Surveillance, and Reconnaissance (EW/ISR), C2, airlift, and special operations. It can also provide tactical warning and assist in threat assessment, characterization, and neutralization. In the event that land-based command and control facilities become inoperative, the AWACS can assume the command and control functions of the CRCs.

During wartime, AWACS serves as a C2 unit and can function as a CRC.

Location

The AWACS aircraft operated by the Air Combat Command's 552 ACW are based at Tinker Air Force Base (AFB), Oklahoma. AWACS aircraft are also based at Elmendorf AFB, Alaska, and Kadena Air Base (AB), Japan. Additionally, AWACS aircraft have been deployed to a number of overseas locations, including Iceland, Germany, Saudi Arabia, the Sudan, the Mediterranean, the Pacific, Turkey, Italy, Bosnia, and Kosovo. The NATO AWACS aircraft are based primarily at Geilenkirchen in Germany, with other Forward Operating Bases (FOBs) in Norway, Turkey, Greece, and Italy.

AWACS is deployed throughout the world.

Description

The AWACS's most prominent external feature is its rotodome. This feature, 30 feet in diameter and mounted 14 feet above the fuselage, contains the AN/APY-1 or APY-2 surveillance radar antenna and the Identification Friend or Foe (IFF) antenna, as well as auxiliary and cooling equipment. During operation, the rotodome is driven at 6 revolutions per minute (rpm). The radar can operate as a pulse and/or pulse-Doppler radar for detection of airborne and surface targets.

Figure 6-3. The AWACS is a high-capacity radar station and command and control center in an airborne platform. It augments existing ground radars by providing enhanced low-level detection and by extending the existing radar coverage.

The aircraft's initial version, designated the AWACS E-3A, was delivered in 1977. It was later modified to the AWACS E-3B (US/NATO Standard) to increase the number of radios, upgrade the computer, and enhance the capabilities. All existing USAF AWACS E-3s have been upgraded to the new standard.

The current US AWACS versions are the AWACS E-3B/C.

The current USAF AWACS variants are the E-3B and E-3C. The E-3B uses the APY-1 radar and the E-3C uses the APY-2 radar. This gives the E-3C a more robust maritime detection capability due to the addition of a dedicated maritime processor not found on the E-3B APY-1 version.

Facilities aboard the aircraft include bunks for the crew and a galley. The maximum unrefueled time aloft is 8.5 hours, with a typical on-station time of six hours. The aircraft can be refueled aloft, which extends mission time to 22 hours. The maximum level speed is 460 knots, and the typical operating altitude is 29,000 feet.

AWACS can participate on both Link 16 and Link 11.

AWACS can participate in both Link 11 and Link 16 networks, either separately or simultaneously. Simultaneous multilink operations are referred to as concurrent interface operations (CIU). In fact, although rarely used today, AWACS retains the capability to operate a third simultaneous link, IJMS.

The AWACS carries both a flight crew and a mission crew. The crew can vary between 24 to 40 members, depending on the mission. The Communications System Operator (CSO) is responsible for initializing the Link 11 software and hardware configuration, while the Communications Technician (CT) is responsible for the initialization of the JTIDS Link 16 terminal. Each position is respectively responsible for the external coordination necessary to establish the link. The Air Surveillance Officer (ASO) or Senior Surveillance Technician (SST) assumes the link management and external coordination functions after the link becomes operational.

☐ Equipment Configuration

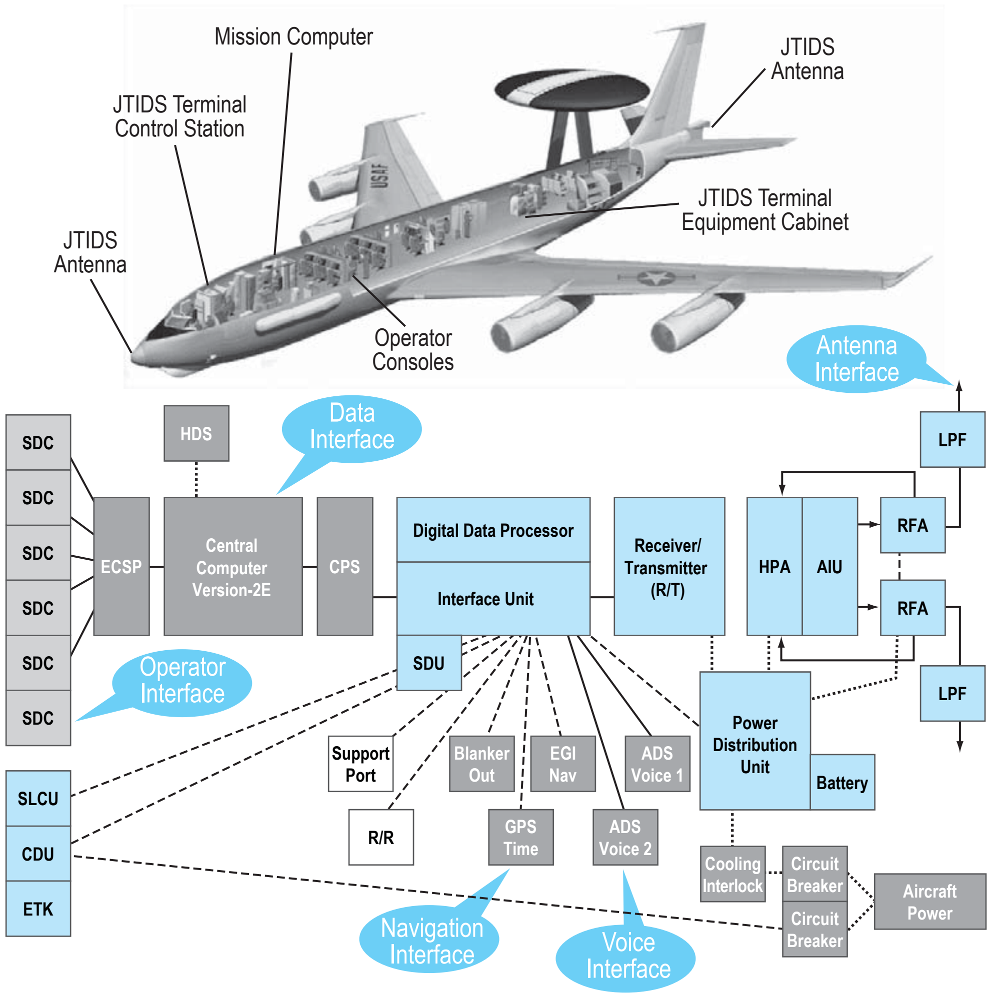
The E3's Link 16 equipment configuration is illustrated in Figure 6-4. For Link 11, the HF transmitting antennas are located on the wing tips, and the HF receiving antenna is located on the vertical stabilizer. The UHF transmitting and receiving antennas are located on the bottom of the fuselage. The JTIDS antennas are positioned in the nose and fin cap portion of the tail.

Operational Considerations

Factors to consider when operating Link 16 with the AWACS include the following:

- The AWACS must have the current release of the OPTASK LINK, the comm plan, the EMCON plan, the requisite current crypto. A uniquely assigned track block in the low TN range (less than octal 07777), equivalent to its TN assignments on Link 11 and IJMS is preferred. With version E-18A software, however, the E-3 will have a second, noncontiguous TN block for Link 16 high track numbers. Whether operating CIU or Link 16 only, the E-3's design requires a Link 11 Data Link Reference Number (DLRN) block be internally assigned.
- Normal procedures require that the AWACS be at operational altitude before activating its radar systems. So although you may receive its PPLIs, you may not receive its surveillance picture until it has arrived on station.
- While the AWACS is refueling, safety considerations require that the aircraft's radar be put in the Standby mode of operation. Link 16, however, may remain operational. Therefore, during KC-135 refueling, AWACS relies on the other network participants to update its tactical database and to keep its tactical picture current.
- Be aware that there may be differences between AWACS' altitude in its PPLI (which is primarily Global Positioning System (GPS)-based) and the barometric altitude available in the cockpit. These differences can approach 2000 feet.

AWACS Link 16 behavior differs during refueling.



ADS = Audio Distribution System	EGI = Embedded GPS/INS Unit	RFA = Radio Frequency (RF) Amplifier
AIU = Antenna Interface Unit	ETK = Electronic Typewriter Keyboard	R/R = Recorder/Reproducer
CDU = Control Display Unit	HDS = Hard Disk Subassembly	SDU = Secure Data Unit
CPS = Control Power Supply	HPA = High Power Amplifier	SDC = Situation Display Console
ECSP = Electronic Command Signals Program	LPF = Low Pass Filter	SLCU = SDU Load Control Unit

Figure 6-4. The AWACS's Link 16 equipment consists of a mission computer, a JTIDS Class 2 terminal, a high power amplifier group (HPAG), and two rectangular horn JTIDS antennas, positioned in the nose and fin cap portion of the tail of the aircraft.

Figure 6-5. Members of the E-3 mission crew are shown at their situation display consoles.

☐ Link 16 Implementation

■ Network Management Messages

The AWACS implementation of digital network management messages was designed so that dynamic network management would normally be performed by a ground environment. As a result, the capability to generate and transmit Network Management messages is currently only a backup, rather than a primary AWACS capability. The network management-related functions are accessed by the CT. However, although AWACS can act as a backup dynamic network management facility, this function is rarely exercised by operators.

For the Network Management function, consider AWACS only as a backup.

♦ Initial Entry and Time Synchronization Messages

AWACS may be designated as Network Time Reference (NTR) in the OPTASK LINK. When the operator initializes the terminal with this network role, it accordingly transmits the J0.0 Initial Entry message on NPG 1, in every frame, time slot

A-0-6, to allow other platforms to join the network. The E-3's JTIDS terminal is tied to the airplane's GPS and can also operate in External Time Reference (ETR) mode.

AWACS can function as NTR or as ETR/NTR.

♦ Dynamic Network Amendment

AWACS can transmit dynamic network amendment messages on NPG 4 by updating a series of tabular displays (TDs). The data entered into these displays is formatted for transfer to the JTIDS terminal. In normal operations, it would be unlikely that AWACS would be employed in this form of management. The following individual actions, however, are possible:

■ Time Slot Assignment

Time Slot Assignment (TSA), or the ability to amend the transmit or receive time slot assignments for another unit, is provided by a TD that allows an operator to formulate J0.3 TSA messages. These messages contain the new transmit/receive time slot blocks (TSBs) for other units.

AWACS can assign and reassign time slots.

■ Time Slot Reallocation

The E-3 is fielding Time Slot Reallocation (TSR) with E-18A software. AWACS will then have the capability to process the J.07 message. For TSR, the terminal predicts the number of words to be transmitted in the next reallocation period, a period of time whose default is 12 seconds. The TSR host demand is estimated in accordance with MIL-STD-6016C. Inputs demand once per subcycle (2.35 – 2.8 seconds), if change is required. Currently this change affects only NPG 7, Surveillance.

AWACS can participate in a TSR network

■ Relay Functions

Relay functions, using the J0.4 Radio Relay Control and J0.5 Repromulgation Relay messages, allow the AWACS to set up both paired slot (radio) and repromulgation relay activities, including the modification of other participants' relay slot assignments. The actual relayed data, however, conforms to the message types and NPGs of the original transmissions. For example, AWACS will relay J3.2 Air Track messages in its own time slots within NPG 7, Surveillance.

AWACS can set up and perform the relay function.

■ Over-the-Air Rekeying

AWACS can transmit Over-the-Air Rekeying (OTAR) management and instructions using the J31.0 OTAR Management and J31.1 OTAR messages. The purpose of rekeying is to transmit new cryptographic keys.

AWACS can rekey other units over the air.

■ PPLI and Platform Status Messages

The AWACS automatically reports its ID, platform type, and platform activity (Airborne Early Warning) in the J2.2 Air PPLI message, once per frame, on NPG 6 (PPLI and Status B). However, AWACS does not transmit its IFF codes in its PPLI.

AWACS PPLI is contained in the J2.2 message.

♦ PPLI Information

The AWACS can receive and process the J2.0 Indirect Interface Unit, J2.2 Air, J2.3 Surface (Maritime), and J2.5 Land/Ground PPLI messages. From these PPLIs, its mission computer extracts user network status, unit type, platform activity, identification, relative and geodetic position, and certain miscellaneous data items, such as Flight Leader Status and Voice Call Sign. It also extracts reported IFF codes from the direct PPLIs. With E-18A software AWACS implements the new Indirect PPLI J2.0 message.

AWACS can process both direct and indirect PPLIs from many unit types.

AWACS uses this received positional information to support remote tracks in its database. The data is displayed to the operator on the situation display as if it were a remote track or network participant symbol, depending on whether it applies to a C2 or a nonC2 JU.

Under certain conditions, AWACS will take actions based on PPLI content, or the absence of a unit's PPLI, as discussed in the following paragraphs.

■ Bailout Indicator

If a J2.2 Air PPLI message is received from an aircraft with its Bailout Indicator set, the operator is alerted to initiate a J3.1 Emergency Point at the crew's bailout location, which can include the number of personnel involved. AWACS then reports the J3.1 Emergency Point message on the surveillance NPG, to alert the other participants of the problem. The operator can also create a downed track at the aircraft's last received position, containing the aircraft's speed, heading, altitude, and position, with an A/C Down switch action. Not all JUs set the bailout indicator automatically, but these same procedures can be accomplished whenever a bailout is recognized.

■ Surveillance Track on PPLI

When AWACS holds a local sensor track that is correlated with another unit's PPLI, and either this unit has switched to radio silent (which is indicated by the Network Participation Status field in his PPLI), or the unit is inactive, AWACS will automatically assume reporting responsibility (R2) for it by transmitting the appropriate Surveillance Track message (J3.x) containing that platform's JU address as its track number. AWACS will automatically relinquish R2 for this track when it again receives a PPLI message from the unit. The AWACS operator is alerted whenever the JU declares itself to be radio silent or has not transmitted its PPLI message in a period of time.

♦ Platform Status Information

The AWACS can receive and display Link 16 JU Platform Status information for Air Platforms (J13.2), Surface (Maritime) Platforms (J13.3), and Land Platforms (J13.5). The operator may view this information in tabular format.

AWACS transmits its own unit Platform Status in the J13.2 message and processes Platform Status from many unit types.

The AWACS transmits its own platform status in the J13.2 Air Platform and System Status message, in its PPLI time slot on NPG 6. When it does, it replaces the AWACS PPLI for that frame. None of the information contained in the AWACS Platform Status message is from an automated source; instead, it all derives from operator inputs or from terminal initialization.

AWACS also issues J13.2 messages for radio silent aircraft under its control.

AWACS can also transmit J13.2 Air Platform and System Status messages on behalf of a Link 16-equipped fighter that is radio silent. This action is initiated either by operator or system action—for example, when the fighter goes radio silent.

♦ Airfield Status Information

AWACS will implement transmission and reception of Airfield Status data (the J13.0 message) in E-19A software, expected by late summer 2009.

Look for AWACS' own unit Platform Status messages in its PPLI time slot, about every 3.2 minutes!

■ Surveillance, Amplification, and Electronic Warfare Messages

The surveillance function is AWACS' primary role in an operational environment, and it employs the Link 16 surveillance messages extensively.

♦ Tracks

Tracks initiated by an AWACS operator on sensor data from the surveillance radar, IFF or Electronic Support (ES) subsystems are automatically transmitted on Link 16, subject to active filters. The operator may also nominate radar jam strobes and ES lines of bearing (LOBs) for transmission. The association of tracks with ES and jamming data is a manual function, and these associations are transmitted only as a result of operator action.

AWACS automatically transmits operator-initiated tracks.

Associating tracks with ES and jamming depends on operator action!

AWACS reports its air and surface tracks in the J3.2 Air Track and J3.3 Surface (Maritime) Track messages on NPG 7 (Surveillance). The mission computer calculates their track quality (TQ), based on the volume of a sphere whose radius is a value for the confidence level of the track's position. A track entry in the AWACS database is built from the following information:

TQ is calculated by the mission computer and inserted in the track report.

- The operator initiates the track from synthetic sensor data that provides track position, course, and speed. For air tracks, it also provides altitude.
- The operator may then further develop the track data by entering other parameters—when they are known—such as Identity (ID), Platform Type, Size (count), EW Identity Amplification, Platform Activity, Exercise Status, and Special Processing Status. AWACS implements all seven unique Link 16 track IDs.
- The track's IFF codes can be added to its database entry—either automatically by the software from interrogation responses, or manually by the operator.

Received information about a track from a J3.2 Air or J3.3 Surface (Maritime) message is presented to the operator as a symbol on the situation display. The operator may view further information on the track TD. If AWACS internally correlates a local track with a remote track, it then consolidates the display, giving preference to the local track's positional information.

♦ Fighter Sensor Data

Beginning with AWACS Airborne Operational Computer Program (AOCP), version E-18 AWACS receives and processes the J12.6 Target Sorting message from Link 16-equipped fighters. AWACS can also receive and display air sensor targets from F-15Cs and other air-to-air fighters, as well as designated ground targets such as from F-15E Strike Eagles. Currently and with version E-17A, these fighter sensor targets may be correlated with local or remote surveillance tracks. AWACS implements all levels of MIL-STD-6016C target/track correlation, and this fighter sensor target information is used to enhance operator SA and for sensor cueing. AWACS can also process and display lock lines and missile-in-flight lines from fighters under AWACS control. With E-18A software, the AWACS operator can view additional J12.6 information in a TD, including the specific type and results of fighter Mode 4 interrogations.

AWACS implements fighter sensor data processing.

♦ Points

The AWACS operator can define and transmit J3.1 Emergency Point messages, as well as a wide range of J3.0 Reference Point messages. These points are transmitted on NPG 7 and are displayed as symbols on the situation display. The operator may view additional information associated with local and remote points on a TD.

The operator can initiate Emergency and Reference Points.

AWACS also transmits and receives J3.5 Land/Ground Point messages on NPG 7, but normally only receives J3.5 Land/Ground Track messages (for example, from JSTARS). AWACS has the ability to transmit J3.5 messages with high precision coordinates and elevation to air-to-ground fighters for accurate targeting of ground targets.

♦ Lines and Areas

AWACS does not receive or process Reference Lines and Areas from J3.0 messages.

AWACS does not implement Link 16 Lines and Areas.

♦ Electronic Support Processing

AWACS supports three types of EW Product Information exchange:

- "Raw" ES intercepts, under the control of the Electronic Combat Officer (ECO), who processes the data before it is transmitted on the Link 16 network in the J14.0 Parametric Information message on NPG 10. Alternatively, it may be transmitted automatically via the communications setup of the passive detection system (PDS).

AWACS supports EW parametric and product communications on Link 16.

- EW products, such as ES, electronic attack (EA), or EW fixes, deemed to be of interest to the general surveillance community, which are transmitted on NPG 7.
- Threats and TSTs detected by the AWACS PDS are reported to fighters and C2 units by transmitting them in J3.5 Land/Ground Point messages on NPG 7.

Parametrics are transmitted on NPG 10; products are transmitted on NPG 7.

The AWACS ES implementation provides an initial "Heads Up" to Link 16 participants of the presence of an emitter within or beyond their sensor range, the identification and localization of active contacts, and localization of passive tracks. The AWACS

ES Link 16 implementation, however, supports a degree of semi-automated, as well as manual, cross-cueing between AWACS units or with other platforms.

The ECO selects the passive tracks or source of emissions for transmission.

In the first case above, the PDS equipment performs the ES data processing and transfers it to the AOCP for display at the operator's console. After the ECO has assessed this information, it may be released for transmission onto the Link 16 network, subject to filters in effect. Through the PDS communications TD, the ECO specifies which ES data should be transmitted over the link.

♦ EW Product Information

The J3.7 EW Product Information message transmits EW information of tactical interest to the wider surveillance community. Supported J3.7 products include LOBs and fixes. Other messages transmitted in support of EW reporting are:

■ Parametric Information Message (J14.0)

AWACS transmits specific information regarding the evaluation of emitters or parametric data in this message. Through the PDS communications TD, the ECO can specify which emitters, hierarchies, and frequencies are to be transmitted and received. Parametric information may also be sent in response to an EW Control/ Coordination request message (J14.2).

■ EW Control/Coordination (J14.2)

AWACS employs this message to request another platform to transmit either all ES or all EA information within a specified sector. The AWACS implementation is initiated by a switch action, and no manual receipt/compliance (R/C) processing occurs. Because the search is not parameter specific, AWACS assumes that all contacts within the sector are to be reported. The ECO can specify the information to be received.

No R/C is used with EW Control and Coordination processing.

♦ EA Strobes

When the operator forms a passive track using the raw strobe data on his situation display, the J3.7 EW Product Information message reports an EA strobe.

The operator initiates EA strobes as passive tracks.

♦ EW Fixes

When the operator initiates self-triangulation of an EA strobe source or an ES line of bearing, the J3.7 EW Product Information message also reports EW Fixes. An exception to this reporting method is when the source is judged to be a ground jammer; the operator must first validate this before it can be reported on the network. In this case, the transmitted J3.5 Land Point message contains the ground jammer fixes.

Ground jammers are considered to be Land Points.

♦ EW Intelligence Data

AWACS holds a store of local and remote EW Intelligence (EW/I) data, which is transmitted and received in J6.0 Amplification messages. Transmitted messages containing this information are generated from a TD at any EW/I-capable surveillance operator console. Conflicts between the local and remote information are indicated to the operator with an asterisk in the TD, and the local data is retained.

EW intelligence is reported in the J6.0 message.

■ Information Management

The management of track data is essential within the Link 16 network to ensure that a consolidated surveillance picture is maintained.

♦ Track Management

AWACS transmits the Track Management message (J7.0) on NPG 7 for several different functions, each of which is indicated by a value of the Action Code setting within the message. These functions are described below. The mission computer will generate the appropriate Action Code for this message based on the operator's request. The J7.0 Track Management messages are transmitted on NPG 7 (Surveillance).

Track Management messages are transmitted in NPG 7, Surveillance.

■ Drop Track Report (J7.0, Act. 0)

Any mission crew operator may, by switch action, manually drop any local track or point when it can no longer be supported or is no longer of interest. Any surveillance operator may establish Automatic Track Drop areas, within which tracks will be dropped automatically. If a track is locally dropped, a flashing attention is placed on the track on the situation display to inform other operators that the track is in the process of being dropped.

When a remote unit drops an entity that AWACS is tracking, AWACS assumes R2.

If a track enters an active filter area, the system automatically transmits the J7.0 Drop Track message on the track before ceasing to report it. If AWACS receives a Drop Track message on a remote track while it is actively tracking it, the system will automatically assume R2 for that entity.

■ Difference Report (J7.0, Act. 1)

When both local and remote data exist for a particular TN, and the remote unit holds R2, the AWACS operator can change the ID or the Environment/Category of the local track. Doing so triggers the transmission of a J7.0 Difference Report.

The operator can challenge a remote track's Category and/or ID.

Change Data Order (J7.0, Act. 2)

If AWACS holds Change Data Authority, the operator may initiate the transmission of a J7.0 Change Data Order (CDO). This message forces the remote unit to change his track's ID or Environment/Category. When a track is the subject of a received ID conflict, a flashing track attention on the situation display will inform the operator. AWACS can filter receipt of CDOs for JUs that have no CDO authority.

With the proper authority, AWACS can issue the CDO.

Emergency and Force Tell Reports (J7.0, Act. 3/4)

If the operator modifies the Emergency or Force Tell status of an entity in the AWACS database, this new status is transmitted in the J7.0 Track Management message with Action Code 3 or 4, respectively. When AWACS receives Emergency or Force Tell Reports, a flashing attention is placed next to this entity on the situation display.

The AWACS operator may modify Emergency and Force Tell status.

Strength Change Report (J7.0, Act. 5)

The AWACS operator may modify the strength (for example, its count or flight size) of tracks for which it has R2 by a manual switch action. This update is then transmitted over the data links in a J3.2 or J3.3 message, but this does not transmit the J7.0 Act. 5 message. The operator may also request a computer-estimated raid size for a track. This count, however, is held internally; it is not transmitted over the links unless manually updated as stated above. With E-18A software, the E-3 processes received J7.0 Act 5 messages, and alerts the operator to accept or reject the change.

The operator cannot challenge a remote track's strength.

Exercise Status Order (J7.0, Act. 6)

When AWACS holds the authority, the operator may initiate a global J7.0 Exercise Status Order change with Action Code 6 (Information Difference/Change Report), which is then transmitted to the Link 16 network. Local to AWACS, the actions undertaken are identical, whether AWACS has transmitted or received this message: all exercise tracks have their IDs reset to Friend, exercise weapons engagements are terminated, exercise Emergency Points are deleted, and wherever applicable, exercise data is reset to No Statement. Currently, however, AWACS does not support exercise Platform Status data, and an exercise reset will not clear artificial data of this type.

The Exercise Status Order reverts all Exercise tracks to Friends.

■ Monitor Tracks

A Monitor track is a local track which is held in common with a remote track that is being reported on the link by a remote facility. Put another way, a Monitor track is a local track for which the E-3 does not have R2. The E-3 operator must initiate Monitor tracks to establish common tracks. Monitor tracks may be established on remote tracks and PPLIs, although the E-3 will not take R2 of a PPLI unless it becomes inactive.

Monitor tracks should be initiated in overlapping track production areas (TPAs) and at TPA boundaries. Monitor tracks are also required for the AWACS to assume Link 16 digital control of nonC2 JUs. With E-18A software, the mission computer initiates the Monitor track automatically during J12.0, J9.0, or J7.0 actions.

♦ Data Update Requests

The AWACS operator may manually generate a J7.1 Data Update Request (DUR), containing Action Code 1 and a TN, to request another JU for information concerning its Points, EW/I data, or engagement status. When AWACS receives a DUR, however, it responds only with Points and EW/I data items.

AWACS can respond only to Point DURs.

♦ Correlation (J7.2)

AWACS supports full MIL-STD-6016C Automatic Correlation/Decorrelation for Air and Surface tracks utilizing transmission and reception of the J7.2 Correlation message. AWACS can adjust variable correlation parameters with operator action, should the Joint Interface Control Officer (JICO) make a change during the mission. The AWACS operator also retains the capability to manually correlate and decorrelate tracks.

♦ Track Identifier

For each entity in its database, AWACS maintains a Link 11 DLRN, as well as an IJMS System Reference Number (SRN) and a Link 16 TN. AWACS announces the association between these numbers (and, when needed, its NATO Track Number, or NTN) on Link 16 by transmitting a J7.4 Track Identifier message for each new entity in its database.

The AWACS database keeps several identifiers for each TN.

When AWACS receives a J7.4 Track Identifier message, it uses it to maintain a cross-reference between the TNs, DLRNs, and SRNs for the remote entities in its database. When AWACS has not received a J7.4 Track Identifier message for a particular TN, however, the operator may initiate transmission of this message to request the remote unit to transmit its TN-to-DLRN-to-SRN associations. With version E-18A, AWACS transmits the J7.4 message only when in single Link 16 operations and not when operating as a concurrent interface unit (CIU).

♦ IFF/SIF Management

AWACS transmits and receives the J7.5 Identification Friend or Foe/Selective Identification Feature (IFF/SIF) Management message to resolve IFF data differences between those sensed (or manually assigned) to a local track and those received for this track over Link 16. With the Action Code set to 0, this message transmits the operator-initiated Clear IFF Data order.

The operator is alerted to, and should resolve, IFF conflicts.

When an unresolved IFF Conflict is detected, the operator will see a flashing attention against the local track on the situation display. The actual IFF codes may be viewed on the TD.

♦ Filter Management

To reduce the volume of information communicated over the network, the AWACS operator may create Link 16 filters. Those that he subsequently enables, however, will not be transmitted to other units for review. The filter parameters may be viewed on a TD.

AWACS neither orders nor accepts other units' filters.

AWACS does not have the capability to enable filters that are defined by another unit, or request that another unit implement an AWACS-defined filter. Therefore, it discards all Filter Implementation requests (J7.6 with Action Code 0) received from the Link 16 network.

♦ Pointers

Any AWACS mission operator may initiate a geographical pointer on the situation display, which causes it to be transmitted to either a C2 platform or F-15 or F-22 fighter in a J7.3 Pointer message on NPG 7. AWACS may also specify the type of operator (for example, Surveillance or Weapons) to which the pointer is displayed aboard the addressed unit. AWACS does not implement the text option in the J7.3 Pointer message.

The operator may direct a pointer to a specific section aboard another platform.

All received J7.3 Pointer messages cause the operator concerned to be given a text alert, supplemented by a large arrow on the situation display at the location of the pointer.

The AWACS operator may also initiate a J12.6 Target Sorting pointer for transmission to fighter aircraft on NPG 9. Only one specific fighter aircraft may be addressed at a time. Alternatively, the J12.6 pointer can be transmitted to the Collective Address, enabling display for all implementing fighters on the E-3's control channel

■ Weapons Coordination and Management

To successfully manage a complex battle situation, the coordination of assets and tasking between C2 platforms is of paramount importance.

♦ Commands

The AWACS implementation of the J9.0 Command message does not extend much beyond the Addressee, Objective TN, Command, and Friendly Weapon TN, and receipt/compliance indicators. To describe fully the individual command values that may be used in the message is beyond the scope of this guidebook. We do describe, however, the operator interface associated with Command communication between C2 platforms. The AWACS operator may view the details of all commands—both transmitted and received, as well as their responses—on the TDL J Commands TD.

■ Transmitting a Command

The J9.0 Command message is transmitted only as a result of operator action at a senior director, weapons, or battle staff console. The operator may specify many parameters, such as Command Type, Target TN, and Reference TN. The system uses these parameters to build the message for transmission on the Link 16 network. With E-18A software, AWACS no longer processes J9.0 Weapons Free, Weapons Tight, or formal alert states.

■ Receiving a Command

When the AWACS system receives a J9.0 Command message, it alerts the battle staff and weapons operators, who may then view a TD for the message's specific details.

♦ Engagement Status

AWACS transmits the J10.2 Engagement Status message for a controlled asset in the situations described in the following paragraphs.

The Battle Staff and Weapons section are automatically alerted on receipt of a command.

Mission Assignment

The weapons operator can assign a mission to a controlled asset, whether it is controlled by voice or over Link 16. AWACS will transmit the J10.2 Engagement Status message after the Commit action is taken.[1]

Self-assigned Mission

When a fighter is under AWACS' Link 16 control, receiving a J12.6 Target Sorting message containing the fighter's Engagement Status value initiates his engagement record in the AWACS database. AWACS subsequently reports his engagement status to the C2 community with J10.2 Engagement Status messages.

Battle Damage Assessment

AWACS can receive, process, and display battle damage assessments (BDAs) from fighters received in the J12.6 message. AWACS will also transmit the BDA in the J10.2 message to the Combined Air and Space Operations Center (CAOC) and other C2 units. AWACS operators can manually transmit BDAs in the J10.2 message for fighter results reported by voice. AWACS also receives and displays J10.2 BDA messages from other C2 units, such as from JSTARS.

Handover

Digital handover is performed by transmitting the J10.3 Handover message. Handovers from the AWACS are operator-initiated for a locally controlled asset, but AWACS cannot request transfer of control utilizing the J10.3 message for a remotely controlled asset. The operator's response to the J10.3 Handover request generates the appropriate Receipt/Compliance message.

Fighter engagement status is tracked in the AWACS database.

1 *The Commit action is discussed below, under Air Control.*

♦ Controlling Unit Reports

AWACS periodically transmits a J10.5 Controlling Unit Report (CUR) for each fighter that is under its control, either a Radar Controlled Track (RCT) or Radar Controlled Track No Guidance (RCN). AWACS also transmits the J10.5 Terminate Control message to indicate that it has relinquished control, either by operator action or during Handover.

The operator may either initiate or reply to a digital handover.

Received CURs may be viewed on a TD, thus allowing the operator to monitor the controlling agency for other weapons assets.

AWACS transmits a CUR for every unit under its control.

♦ Pairing Status Messages

AWACS allows the operator to pair a controlled asset to any other point or track in the system. It reports all pairings to the C2 community by periodically transmitting them in J10.6 pairing messages. AWACS processes the J10.6 pairing messages it receives to allow the weapons operator to monitor a remotely initiated pairing on his local situation display.

The operator may pair his fighter to any TN.

■ Air Control

With the release of E-18, AWACS now exploits many of Link 16's air control capabilities, which are described in the paragraphs below.

♦ Mission Assignments

If a controlled platform is identified in the AWACS system as an RCT weapons track, the operator may initiate a mission assignment for this fighter. By switch action, the operator specifies fighter type. If the fighter is Link 16-equipped, Link 16 control is assumed, and AWACS transmits a J12.0 Mission Assignment message. As part of the switch action, the operator also specifies the mission type, and this dictates which MAD value is transmitted in the message.

Operators initiate Mission Assignments for RCT fighters.

AWACS can transmit the Attack MAD when committed against a Hostile Land/Ground Point or Track. The operator may commit against a remote Air, Surface, or Land/Ground track only if a local or Monitor track association is in effect. A commit can be performed against a local or remote Land/Ground point, however, without a Monitor track association.

The AWACS system then monitors for the fighter's response. Initially, the fighter transmits a Machine Receipt (MR) followed by its operator's R/C, which contains either a WILCO, HAVCO, or CANTCO. If one of these responses is not received within a certain period of time, AWACS alerts the weapons operator with a flashing attention against the fighter's track on his situation display. The weapons operator is informed of the response received from the fighter operator on a TD and by an attention against the track on the situation display.

The system automatically monitors for MRs and R/C.

♦ Digital "Alpha Check"

One technique for the J12.0 Combat Air Patrol (CAP) message is to perform a digital Alpha Check confirming the bull's-eye location. AWACS sends a J12.0 CAP for the flight lead to the bull's-eye (normally a J3.0). The Flight Lead should reply with a J12.0 response of WILCO if the location matches his displays, or CANTCO if it does not. A CANTCO requires voice coordination to resolve the correct bull's-eye location. If the controller receives a WILCO, he will then send a J12.0 Cease Mission message.

♦ Vectors

AWACS is capable of transmitting J12.1 Vector messages to a fighter to indicate various non-target-specific instructions from the operator. Current tactics, techniques, and procedures (TTPs), however, limit the operational use of vectors. The AWACS system monitors for the fighter's response, which must be either WILCO, HAVCO, or CANTCO, to the operator's instructions.

♦ Flight Path Instructions

AWACS does not implement the J12.3 Flight Path message.

AWACS does not support Flight Path instructions.

♦ Controlling Unit Change Order

Controlling Unit Change Orders are transmitted in the J12.4 message. AWACS can assume Link 16 control of USAF, USN, and Coalition fighters by any of the methods described in the following paragraphs. In addition, the AWACS operator can utilize the TN Flight Lead message (J2.2C5) to automate the assumption or release of control of flights of aircraft.

AWACS can also control Navy, Allied, and Coalition fighters.

■ As the result of a Handover

The AWACS system automatically initiates Link 16 control of a fighter after an operator accepts it during a Handover. The final stage of this process is exchanging J12.4 Control Change Orders with the fighter.

■ Controller-Initiated J12.4 (Digital Check-In)

AWACS controllers can transmit the J12.4 to fighters (aka "Grab Control"), specifying the UHF voice frequency and control channel on which to contact the E-3. Upon receipt of the fighter's WILCO, AWACS automatically begins transmitting J10.5 Controlling Unit Reports.

Fighter-Initiated J12.4

AWACS receives and displays fighter J12.4 requests both to the Collective Address and to the E-3's TN. Controllers can respond with a J12.4 WILCO, after which the AWACS begins transmitting the J10.5 Controlling Unit Report. The B-2 and many USN and Coalition aircraft can initiate the J12.4, but F-15s and F-16s cannot.

"Steal Control"

The operator may take a Commit switch action to take any Link 16-capable fighter under control, without transmitting a J12.4 Control Change message.

Extracting Engagement Status Data from J12.6 Messages

The AWACS mission system also processes engagement status data from J12.6 Target Sorting messages that it receives from Link 16 fighters under its control. The operator may view new engagements, and may monitor the status of all active engagements on a TD. AWACS reports any self assigned missions it receives to the wider data link community other C2 platforms by transmitting the J10.2 Engagement Status message.

All active engagements are available to the operator.

Mission Assignment Messages—High Interest Tracks

AWACS can transmit the J12.0 High Interest Track message to a fighter under Link 16 control via a locally controlled RCT. This is used chiefly to identify High Interest Tracks, for which the system creates an attention display in the track block for any track designated as high interest.

AWACS can now indicate High Interest TNs.

Battle Damage Assessment

AWACS can receive, process, and display BDAs from fighters from the J12.6 message. AWACS will also send the BDA in the J10.2 message to the CAOC and other C2 units. AWACS can also receive and display J10.2 BDA messages from other C2 units, such as JSTARS.

Link 16 Voice

NPGs 12 and 13 provide either 2.4-kbps or 16-kbps secure voice, antijam (AJ) communications in a JTIDS network. Their use is usually accommodated by stacked net operations. The E-3 implements J0.1 and free-text digital voice in these NPGs. The two voice channels can be operated either separately or simultaneously. Use of both voice channels on the AWACS will result in loss of access to one UHF radio.

AWACS implements Link 16 voice.

Text Messages

Any AWACS operator may compose a Text message of up to 263 lines, 52 characters per line, by updating a blank message skeleton in its TD. The message is then transmitted in a J28.2(0) US National Text message.

AWACS supports the transmission of J28.2 text messages.

Threat Warning Messages

The operator may generate for transmission a J15.0 Threat Warning message against any specific TN. When AWACS receives these messages, it places an operator alert and a flashing attention on the situation display against the threatened entity.

The AWACS operator may initiate and observe Threat Warnings.

Message		Tx	Rx
System Information Exchange and Network Management			
J0.0	Initial Entry	T	R
J0.1	Test Message	T	R
J0.2	Network Time Update	T	R
J0.3	Time Slot Assignment	T	R
J0.4	Radio Relay Control	T	R
J0.5	Repromulgation Relay	T	R
J0.6	Communications Control	T	R
J0.7	Time Slot Reallocation	T	R
J1.0	Connectivity Interrogation	NT	NI
J1.1	Connectivity Status	NT	NI
J1.2	Route Establishment	NT	NI
J1.3	Acknowledgement	NT	NI
J1.4	Communication Status	NT	NI
J1.5	Net Control Initialization	NT	NI
J1.6	Needline PG Assignment	NT	NI
PPLI			
J2.0	Indirect Interface Unit PPLI	NT	R
J2.2	Air PPLI	T	R
J2.3	Surface (Maritime) PPLI	NT	R
J2.4	Subsurface (Maritime) PPLI	NT	NI
J2.5	Land (Ground) PPLI	NT	R
J2.6	Land (Ground) Track PPLI	NT	NI
Surveillance			
J3.0	Reference Point	T	R
J3.1	Emergency Point	T	R
J3.2	Air Track	T	R
J3.3	Surface (Maritime) Track	T	R
J3.4	Subsurface (Maritime) Track	NT	NI
J3.5	Land (Ground) Point/Track	T*	R
J3.6	Space Track		R
J3.7	EW Product Information	T	R
ASW			
J5.4	Acoustic Bearing and Range		
AMP			
J6.0	Amplification Information	T	R
Information Management			
J7.0	Track Management	T	R

Figure 6-6. AWACS Link 16 messages (continued on next page)

Message		Tx	Rx
J7.1	Data Update Request	T	R
J7.2	Correlation	T	R
J7.3	Pointer	T	R
J7.4	Track Identifier	T	R
J7.5	IFF/SIF Management	T	R
J7.6	Filter Management	NT	NI
J7.7	Association	NT	R
J8.0	Unit Designator	NT	NI
J8.1	Mission Correlator Change	NT	NI
Weapons Coordination and Management			
J9.0	Command	T	R
J9.1	Engagement Coordination	NT	NI
J9.2	ECCM Coordination	NT	NI
J10.2	Engagement Status	T	R
J10.3	Handover	T	R
J10.5	Controlling Unit Report	T	R
J10.6	Pairing	T	R
Control			
J12.0	Mission Assignment	T	NIRC
J12.1	Vector	T	NIRC
J12.2	Precision Aircraft Direction	NT	NI
J12.3	Flight Path	NT	NI
J12.4	Controlling Unit Change	T	R
J12.5	Target/Track Correlation	T	NI
J12.6	Target Sorting	T	R
J12.7	Target Bearing	NT	NI
Platform and System Status			
J13.0	Airfield Status	NT	NI
J13.2	Air and Platform System Status	T	R
J13.3	Surface (Maritime) Platform and System Status	NT	R
J13.4	Sub Surface (Maritime) Platform and System Status	NT	NI
J13.5	Land (Ground) Platform and System Status	NT	R
EW			
J14.0	Parametric Information	T	R
J14.1	Database Transfer	NT	NI
J14.2	EW Control / Coordination	T	R

Figure 6-6. AWACS Link 16 messages (continued on next page)

Message		Tx	Rx
TW			
J15.0	Threat Warning	T	R
Image Transfer			
J16.0	Image Transfer	NT	NI
National Use			
J28.0	National Messages (J28.2(0) Only)	T	R
J28.2	Text Message	T	R
J28.7	UK National 1	T	R
J29.0	Spoke Report	NT	NI
Miscellaneous			
J31.0	OTAR Management	NTRC	R
J31.1	OTAR	NTRC	R
J31.7	No Statement	T	R
RTT-A	Round Trip Timing Interrogation Addressed	T	R
RTT-B	Interrogation Broadcast	T	R
RTT-R	Round-Trip Timing Replay	T	R

Notes:

1. Abbreviations: Anti-submarine Warfare (ASW), Amplification (AMP), Electronic Warfare (EW), Threat Warning (TW)
2. Annotations used:
   - T Transmit at least minimum message requirements
   - NT Does not transmit the message
   - NTRC Message transmitted only for Receipt/Compliance purposes
   - R Receive and interpret some parts of the message
   - NI Message not interpreted
   - NIRC Message interpreted only for Receipt/Compliance purposes
   - Rx Receive
   - Tx Transmit
   - * Points Only

Figure 6-6. Examining AWACS' transmit and receive message capabilities provides understanding of how this C2 aircraft performs on Link 16—as well as what to expect from AWACS if you are an operator aboard another Link 16 platform.

Section C

JSTARS

The Joint Surveillance Target Attack Radar System (JSTARS) is a Joint Air Force/Army system. JSTARS is the premier C2, battle management, surveillance, and targeting system designed to provide air and land component commanders with near-real-time, wide-area surveillance, ground moving target indicators, and synthetic aperture radar products of surface targets, as well as limited detection of low, slow airborne movers.

Mission

While flying in friendly airspace, JSTARS can look deep behind hostile borders to detect and track ground movements in both forward and rear areas. It has a radar range of more than 120 miles (200 kilometers). Wide-Area Surveillance and Moving Target Indicator are the radar's fundamental operating modes. They are designed to detect, locate, and identify slow-moving targets. Through advanced signal processing, JSTARS can differentiate between wheeled and tracked vehicles. By focusing on smaller areas of terrain, the radar image can be enhanced for increased resolution display. This high resolution is used to define moving targets and provide combat units with accurate information for attack planning. JSTARS develops this information and uses it to support offensive and defensive air and ground fire support to delay, disrupt, and destroy enemy forces.

JSTARS can focus on small ground targets and terrain areas.

JSTARS operates in virtually any weather, on-line, in real time and around the clock. The augmented Army-Air Force mission crew can be deployed to a potential trouble spot within hours to provide valuable data on ground force movements.

Location

Robins AFB, Georgia, is home to the E-8 JSTARS. In the past, JSTARS platforms have supported Pacific Air Forces (PACAF) through planned theater rotations from Kadena AB, Japan, and contingency responses in Southwest Asia from various air bases in the US Central Command Area of Responsibility (AOR). JSTARS has also been deployed for, and directly contributed to the ultimate success of, Operations Desert Storm, Joint Endeavor I and II, Allied Force, Iraqi Freedom, and Enduring Freedom.

JSTARS supports operations and contingencies worldwide.

Description

JSTARS consists of an airborne platform—an E-8C aircraft with a multimode radar system—and US Army mobile common ground stations (CGSs). The E-8C, a modified Boeing 707, carries a phased-array radar antenna in a 26-foot, canoe-shaped radome under the forward part of the fuselage. The radar can provide targeting and battle management data to all JSTARS operators, both in the aircraft and in the CGSs. These operators, in turn, can call on aircraft, missiles, or artillery for fire support. Within the airframe are 18 multipurpose workstations; AJ secure UHF/VHF and secure HF voice; secure digital data link communications to Army via a specialized data link, called the Surveillance and Control Data Link (SCDL) for communicating with the CGS, and two Class 2 terminals for communicating with Link 16 participants.

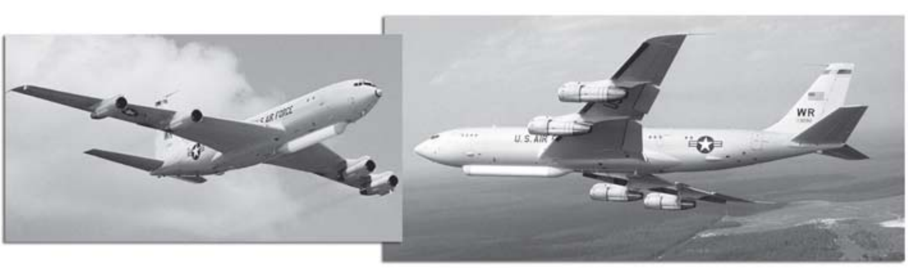


Figure 6-7. The JSTARS aircraft provides near-real time, wide-area surveillance, ground moving target indicators and synthetic aperture radar products of surface targets, as well as low, slow airborne movers.

Equipment Configuration

The synthetic aperture radar (SAR) and fixed target indicator (FTI) produce a photograph-like image or map of selected geographic regions. SAR data maps contain precise locations of critical nonmoving targets, such as bridges, harbors, airports, buildings, or stopped vehicles. The FTI display is available while operating in the SAR mode to identify and locate fixed targets within the SAR area. The SAR and FTI capability used with the moving target indicator and its history display allow post-attack assessments to be made by onboard or ground operators following an attack on hostile targets. As indicated earlier, the JSTARS has two Class 2 terminals secured by KGV-8 secure data units (SDUs). Each terminal has dedicated access to a lower fuselage antenna and shared access to a single upper fuselage antenna.

Operational Considerations

JSTARS aircraft and GCSs are widely in demand by competing interests. For this reason, the Commander, Joint Task Force (CJTF) determines the most effective use of JSTARS, based on particular situations and concept of operations.

CJTF prioritizes the deployment of JSTARS.

Link 16 Implementation

System Information Exchange and Network Management

The JSTARS concept was designed so that dynamic network management would normally be performed by the ground environment. As a result, the capability to generate and transmit Network Management messages is currently not implemented.

JSTARS does not implement the Network Management function.

♦ Initial Entry and Time Synchronization

JSTARS is capable of functioning as NTR, and may be so designated in the OPTASK LINK. When the operator initializes the terminal with this network role, it accordingly transmits the J0.0 Initial Entry message on NPG 1, in every frame, time slot A-0-6, to allow other platforms to join the network.

JSTARS can function as NTR.

♦ Dynamic Network Amendment

JSTARS will participate in Network Management functions, including the reception of the Time Slot Assignment (J0.3) message, as well as the transmission of the Radio Relay Control (J0.4) and Time Slot Reallocation (J0.7) messages, beginning in FY08, when IR5 is delivered.

■ PPLI and Platform Status Messages

JSTARS automatically reports its network participation status, identification, and positional information in the J2.2 Air PPLI message, once per frame, on NPG 6 (PPLI and Status B). Its JTIDS terminal automatically composes and transmits the J2.2 PPLI message based on information provided by its host computer.

JSTARS' PPLI is contained in the J2.2 message.

JSTARS receives and processes the J2.0 Indirect Interface Unit, J2.2 Air, J2.3 Surface (Maritime), and J2.5 Land Point PPLI messages. The J2.6 Land Track PPLI message is received by JSTARS, but it is processed as a J2.5 Land Point message to provide SA.

JSTARS processes direct and indirect PPLIs from many unit types.

■ Bailout Indicator

When JSTARS receives a Bailout indicator from a J2.2 Air PPLI, it flashes the Bailout (BO) attention indicator on its graphics display. In addition to this indicator, Bailout is displayed in the information TD. On receiving a Bailout location, JSTARS automatically produces J3.l Emergency Point messages at the last known location of J2.2 with related TN of PPLI.

■ Surveillance Track on PPLI

JSTARS recognizes that a Land Point or Land Track is inactive whenever it has not received a J2.5 or J2.6 PPLI from that JU for 60 seconds. When this happens, the PPLI information from that JU is dropped, and the JSTARS operator can manually enter a Land Track or Point with the entity's TN and the PPLI Indicator set. JSTARS will then continue to report this entity as a Land Track or Point (with PPLI Indicator set) until the unit again becomes active on the link. As soon as the system receives a new PPLI from the unit that contains a nonzero Position Quality (Q_p), JSTARS will relinquish reporting responsibility for the entity and will cease reporting it on the Link 16 network.

♦ Platform Status Information

JSTARS processes the JU Platform Status information received in the J13.2, J13.3, and J13.5 Platform Status messages. JSTARS transmits its own platform status in an Air Platform and System Status message (J13.2) every 3.2 minutes. In addition, it will also transmit this message in response to a DUR message (J7.1 with Action Code 1) when the TN in the message is set to the TN of the JSTARS platform.

JSTARS reports its own status, but does not process status from other JUs.

♦ Airfield Status Data

JSTARS transmits and receives the J13.0 Airfield Status Data message.

■ Surveillance, Amplification, and EW Messages

For the JSTARS system, surveillance consists of receiving Air, Surface (Maritime), Land Point, and Land Track information, as well as transmitting Land Point, Land Track, Reference Point, and Reference Area information. JSTARS can also augment these transmissions with amplification information.

♦ Tracks

JSTARS both transmits and receives Land Tracks and Land Points in J3.5 messages, for the purpose of exchanging tactical surveillance information on ground tracks, as well as on physical points (sites, as opposed to the intangible points exchanged in J3.0 messages). The system automatically composes and transmits these messages for any Land Tracks and Land Points designated by the operator, and will retransmit them at appropriate intervals.

JSTARS automatically transmits operator-initiated tracks.

The JSTARS system updates its Land Tracks and Land Points databases with the data it receives from the Link 16 network in J3.5 messages. These database entries are built with the following data items:

- Position
- Heading and Speed (for tracks based on moving target indications)
- Identification (initially, this is defined specific to the theater)
- Elevation
- Platform, Platform Activity, and Specific Type (when available)
- Strength, Total Number of Vehicles, and Percent Tracked (when available)

The Land Tracks and Land Points databases support both remote and local entities. Local tracks are those defined as either Automated (A) or Extrapolated (E), with respect to the onboard sensor. Remote tracks may be defined as either A, E, or None of the Above. A None of the Above remote track is a track generated by a non-JSTARS JU. When the JSTARS system holds both local and remote data for a track—that is, when both entries have the same TN—the data for both the local and remote tracks is retained separately, and standard R2 rules apply. The limit on local tracks is enforced by the track creation process.

The Land Point database entries may contain, in addition to system-assigned time tags, up to three coded time function data items, along with the time function code. The three sets of times and codes retained are the three most recently received, different codes from the Link 16 network or the onboard system. For each database entry, there may be three different codes, with one time entry per code. All Land Point time functions defined by MIL-STD-6016 are supported: Establishment Time, Activation Time, and Deactivation Time.

When JSTARS receives a remote Land Track or Land Point that exceeds its database capacity, an existing remote track is deleted to make room for the new entry. The deletion is based on staleness, Force Tell status, volatility, and whether the existing remote track is involved in a data item conflict or an internal pairing or correlation.

JSTARS also sets staleness timeout criteria for deleting entities received in J3.5 Land Point or Track messages. If these entities are not updated, JSTARS will delete them from its database. The timeout criterion for Land Tracks is 192 seconds. The timeout criterion for Land Points, on the other hand, is 384 seconds.

JSTARS' transmission of J3.5 messages depends on certain actions or conditions. Transmission occurs when the system is reporting a new Land Track or Land Point, when assuming R2 for one, when the entity's alert indicator is initiated while holding R2, and periodically—at a nominal interval of 48 seconds for tracks and 96 seconds for points. It also transmits a J3.5 message whenever data on one of these entities changes, as well as in response to a DUR in a J7.1 DUR message.

JSTARS transmits and receives Air track messages (J3.2) and displays them to the operator. When Air tracks are selected, the system generates their symbols based on values for their Platform, Platform Activity, and Specific Type. An Air track symbol contains a vector stick that indicates the track's direction and velocity. The operator may deselect the display of Air track symbols by filtering them out.

JSTARS can also transmit and receive Surface (Maritime) track messages (J3.3) and display them to the operator. There is no system-level receive filter for this message.

When Surface (Maritime) tracks are selected, the system generates their symbols based on values for their Platform and Platform Activity. The Surface (Maritime) track types, therefore, will not necessarily have their own unique symbols. Like Air track symbols, the symbols for Surface (Maritime) tracks contain vector sticks that indicate direction and velocity of the tracks. The JSTARS operator may deselect Air and Surface (Maritime) tracks for display.

Air and Surface (Maritime) track amplification data, such as track blocks, attention and status indicators, and IFF codes, is shown on symbol modifiers and TDs.

On receipt of an Air or Surface (Maritime) track message from the Link 16 network, the JSTARS system determines whether the received entity already exists in its databases. If it does, JSTARS updates the existing information; if it does not, it assigns an internal system reference number (ISRN) and creates a new a database entry with the received data. The system stores the track entity with both its generated ISRN and the received Link 16 TN.

♦ Fighter Sensor Data

JSTARS processes J12.6 Air Sensor reports from Link 16-equipped fighters under JSTARS control and can create a pseudolocal J3.2 Air Track based on a received Air Sensor Target report. JSTARS does not process Land or Surface J12.6 Sensor Target Reports.

♦ Points

JSTARS both transmits and receives the Reference Point (J3.0) message. JSTARS implements Points and single-point Areas, multipoint Areas, and Lines. It automatically updates its database with the nonphysical (intangible) Points received from the Link 16 network in J3.0 messages. The system also automatically composes and transmits the J3.0 message for Points designated for transmission by the operator, and retransmits them at appropriate intervals. There is no system-level receive filter for this message.

JSTARS implements only the Points and single-point Area capabilities.

The Point database entries may contain, in addition to system-assigned time tags, up to three coded time function data items, along with the time function code. The three sets of times and codes retained are the three most recently received, different codes from the Link 16 network or the onboard system. For each database entry, there may be three different codes, with one time entry per code. All Point time functions defined by MIL-STD-6016C Table D.5.1-1 are supported based on time function by Point Type and Point Amplification, Establishment Time, Activation Time, Arrival Time, Departure Time, Operational Time, Nonoperational Time, and Deactivation Time.

JSTARS transmits the J3.0 message by one of two methods, depending on whether the message defines a Reference Point or an Area. Transmission depends on the value of the Periodic Report Indicator and on certain actions or conditions. Transmission occurs when the system is reporting a new Reference Point or Area, and this will update periodically at a nominal interval of 96 seconds. Lines and multipoint Areas will be updated periodically at a nominal interval of 12.8 minutes. When JSTARS holds R2, it will also transmit the J3.0 message whenever data items change, upon receipt of a J7.1 DUR, and upon receipt or transmission of a Force Tell status change in a J7.0 message with Action Code 4.

JSTARS can transmit orbit values for Orbit, Race Track and Orbit, Figure Eight based on operator-entered geometries. Because Orbit, Closed Random requires multiple points, however, this function is not supported.

On receipt of a J3.0 message from the Link 16 network, the JSTARS system determines whether the point entity already exists in its databases. If it does, JSTARS updates the existing information; if it does not, it assigns an ISRN and creates a new database entry with the received data. The system stores the point entity with the generated ISRN and the Link 16 TN.

JSTARS also discards and does not process the J3.0 Points message under certain conditions:

- All messages other than non-ASW Points or single-point Areas are discarded.
- Slaved points are not processed. The system databases are checked, however, and any J3.0 Reference Point with the same TN is deleted.
- The Course and Speed data items are retained and stored, but they are processed only for display as amplifying data.
- Data item TN, Related is ignored.
- JSTARS discards Continuation words concerning Latitude and Longitude deltas and ASW data.

JSTARS does not perform Point slaving.

Lines and Areas

The JSTARS system does not process Reference Lines or Multiple Point Areas from J3.0 messages.

JSTARS does not understand Reference Lines and multipoint Areas!

Electronic Support Processing

JSTARS does not support the transmission or reception of EW Product Information. JSTARS receives J3.7 EW Fix and AOP values.

EW Product Association Message

JSTARS does not process the EW Product Association message.

EW Control and Coordination (J14.2)

This function does not apply to the JSTARS system.

♦ EA Strobes

JSTARS does not support the transmission or reception of EA Strobe product information.

♦ Amplification Data

JSTARS transmits the following J6.0 Amplification message on established Air, Surface (Maritime), and Land tracks: Nationality/Alliance, Platform Type, Platform Activity, Specific Type, Activity Amplification Index, Operational Status, Type Modification, Track Number Objective, Track Number Controlling Agency, Local Discrete Identifier, Threat Type, Threat Weapon, Threat Fuel, and those surface-to-air and surface-to-missile types that are applicable to the Surface environment only.

JSTARS reports certain EW/I data in J6.0 messages.

JSTARS transmits and receives the J6.0 Amplification message for both tracks and points. The system automatically updates its air track, ground track, surface track, and physical points databases with data received in these messages. The system automatically composes and transmits the J6.0 message for both tracks and points designated for transmission by its operators.

■ Information Management

Managing track data is essential on Link 16 to ensure that the network as a whole presents a consolidated surveillance picture.

♦ Track Management

JSTARS uses the Track Management message (J7.0) for several functions, depending on the message's Action Code. In general, actions triggered by J7.0 messages are presented to onboard operators in the form of standard alerts and/or graphical indications in the Attention Indicator block of the designated track or point symbol. Specific attention indicators include the Difference, Emergency, and Force Tell status, and the status is displayed as long as the conditions exist. Drop is shown as an Attention Indicator from the time the condition is identified until the system drops the entity. The functions implemented are described in the following paragraphs.

■ Drop Track Report (J7.0, Act. 0)

JSTARS automatically generates a J7.0 Drop Track Report message whenever a track or point for which it holds R2 is deleted from its databases, and whenever the operator inhibits its transmission. When JSTARS receives this message, the action it takes depends on whether it is able to assume R2 for the track. When it is able—that is, when the dropped entity is a Land, Air, or Surface (Maritime) track for which JSTARS has local, correlated, tracks and transmission is not inhibited—the system automatically transmits the appropriate J3.x message and assumes R2. If it receives a Drop Track message when it has no correlated track, it will follow drop procedures and, on operator direction, will create a local track to retain the track data and allow itself to assume R2. On receipt of a Drop Track message that contains the TN of a point held in its databases, the system will simply follow drop procedures.

When a remote JU drops an entity that JSTARS is tracking, JSTARS assumes R2.

■ Difference Reports and Change Data Orders (J7.0 Act. 1/2)

JSTARS automatically generates an appropriate J7.0 Difference Report message (Action Code 1) when it does not hold R2 for a track, and either the operator manually rejects the conflict or the system automatically rejects the remote data. The operator generates a J7.0 Change Data Order message (Action Code 2) only upon a specific command and confirmation. When JSTARS receives a J7.0 Difference Report message, it takes appropriate action automatically as specified by the MIL-STD-6016 decision tables: it will either discard the message, update its database entries, or request operator resolution. When it receives a J7.0 Change Data Order message, the system will automatically update the specified system database entries and “lock out” further changes from the operator, and from any JU except a C2 JU, for at least 30 seconds. The sole exception to the lockout is change resulting from an Exercise Status Order.

The JSTARS operator can issue a CDO.

Emergency and Force Tell Reports (J7.0, Act. 3/4)

A J7.0 Emergency (Action Code 3) or Force Tell (Action Code 4) message is generated automatically whenever an operator changes the value of the corresponding data item for a remote track in the local database. When JSTARS receives one of these messages, it automatically sets the appropriate assigned value in its local databases.

The JSTARS operator may modify Emergency and Force Tell status.

Strength Change Report (J7.0, Act. 5)

JSTARS automatically generates the J7.0 Strength Change message whenever the operator manually sets a local value for data items Strength, Total Number of Vehicles or Strength, Percent of Tracked Vehicles of a Land Track that causes a conflict with the remote data being reported. When JSTARS receives a J7.0 Strength Change message, it automatically sets the appropriate values in its local databases. If the change is in either the Strength, Total Number of Vehicles or Strength field for a Land entity, the system will automatically update both fields. If the change is to the Strength, Percent of Tracked Vehicles for a Land entity, then only this field will be changed.

The JSTARS operator can challenge a remote track's strength.

Exercise Status Change Order (J7.0, Act. 6)

An onboard JSTARS operator generates the J7.0 Exercise Status Order message only upon specific command with confirmation. When JSTARS receives a J7.0 Exercise Status Order message, it reverts the IDs of all Exercise tracks and points it currently retains in its databases to Friend, and the Exercise Indicators for these entities will be cleared. Change Data Order “lockouts” do not affect the Revert Status action.

The Exercise Status Order reverts all Exercise tracks and points to Friends.

♦ Data Update Requests

The J7.1 message allows JUs to request transmission of data held by other JUs either for an entity identified by TN, or for all entities of a particular type. The JSTARS operator can transmit and receive the J7.1 DUR message, the Data Update Request, by Track Number only. When JSTARS receives a J7.1 DUR message that is not addressed to the Collective Address and is not specifically addressed to itself, it discards the message with no further processing. When it receives a J7.1 message by Track Number Reference (TNR), JSTARS will perform the following actions:

- If the TN is its own Surface Track Number (STN), it transmits an Air Platform and System Status message (J13.2) in response.
- If JSTARS has R2 on the TN, it transmits the appropriate message (a J3.0 Reference Point, J3.5 Land Point or Track, or J6.0 Amplification message) in response.
- If JSTARS does not have R2 on the TN, it discards the DUR.
- If JSTARS is the controlling unit of a nonC2 JU, it transmits the J10.5, J10.2, or J10.6 message, as appropriate.

JSTARS sets the Response Indicator in all its responses to a DUR by TN.

JSTARS responds to DURs only for itself and entities for which it has R2.

♦ Correlation

JSTARS does not process track-to-track correlations, which are reported on Link 16 in the J7.2 Correlation message.

JSTARS does not support automatic correlation.

♦ Track Identifier

JSTARS receives the J7.4 Track Identifier message.

♦ IFF/SIF Management

JSTARS receives the J7.5 IFF/SIF Management message.

♦ Filter Management

JSTARS does not process the J7.6 Filter Management message.

♦ Pointers

JSTARS transmits and receives the J7.3 Pointer message.

♦ Association

JSTARS transmits and receives the J7.7 Association message. JSTARS also implements Designated Mean Point of Impact (DMPI) associations.

■ Weapons Coordination and Management

JSTARS implements the J9.0 Command message, all required values in accordance with MIL-STD-6016, Appendix A. JSTARS also transmits J12.0 Mission Assignments, the J10.2 Engagement Status message, the J10.6 Pairing message, the J12.4 Controlling Unit Change Order, the J12.5 Target Track Correlation (for Air TNs only), and the J12.6 Target Sorting message (only the J12.6 Pointer). On reception, JSTARS processes only Air TNs for sensor target reports.

JSTARS does not perform weapons coordination.

■ Text Messages

The US National Text message (J28.2(0)) allows link participants to exchange alphanumeric text information. Multiple pages of information, contained in multiple messages, may be transmitted and received as a Text Report. A complete Text Report may consist of up to 240 messages, each containing up to 57 characters, for a total maximum report size of 13,680 characters. No provision is made, however, for retransmission of errored data or the nonreceipt of individual messages in a report.

No support is provided for any individual platform to transmit more than one Text Report simultaneously.

JSTARS supports the transmission of J28.2(0) Text messages.

Any JSTARS operator may compose a Text message by updating a blank message skeleton TD. The transmit process begins when the operator composes or retrieves a Text Report. If the operator wishes to transmit a stored report, he first selects it from a list of stored reports, and the selected report is then retrieved and transmitted. If the operator wishes to compose a Text Report, he enters text into an editing screen. In either circumstance, only an operator action will cause the message to be transmitted.

When a Text Report is received by the system, and the addressee's TN is neither the JSTARS platform, nor the Collective Address (177, aka the "Broadcast" address), the system will discard the message. The received Text Report components are separated by their STN. All like Source Track Numbered report components are then placed in the database. The Message Count field, located in the Initial word, identifies the number of Initial words contained in the received Text Report.

The JSTARS system alerts the operator that a message is in the queue and available to be read when either of two conditions occurs:

- It has received the number of report data elements identified by the Message Count field, or
- 96 seconds have elapsed since it has last received a specifically Source Track Numbered report component from that TN.

♦ Radar Service Requests and Responses

Link 16 participants transmit the Radar Service Request/Response (RSR) message (J28.2.3) to request radar services from JSTARS and to report service request status. The JSTARS system generates a J28.2.3 Radar Service Response message for all changes in status. Upon initial receipt, JSTARS generates a response that contains the service request ID with the status Pending. When the Sensor Management Officer (SMO) approves, disapproves, or terminates the request, the system generates the J28.2.3 message with the appropriate Request/Response Indicator field set.

JSTARS responds to Radar Service Requests from other JUs.

When JSTARS receives a J28.2.3 message, it determines whether the RSR already exists in the system. Existence is based on the Request Type and Service Request Number fields. If the Request Type field is set to Initial, then a new entry is created, assigned a Service Request ID, and placed in the RSR Pending queue. If the Request Type field is set to either Modified or Termination but the Service Request is still Pending, the existing entry is modified or deleted in accordance with the Request Type field. If the Service Request has been approved, an entry is added to the Pending queue with the action code set to Modify or Delete in accordance with the Request Type field.

There is no system-level receive filter for this message. The J28.2.3 messages received by JSTARS are processed only if the Request/Response Indicator is set to Request. JSTARS discards the message for all other values of this field.

♦ Activity Level Indicator Message

JSTARS transmits, but does not receive, the Activity Level Indicator message (J28.2.4) to disseminate moving target Activity Level indications. This data is generated from JSTARS Wide Area Surveillance (WAS) Moving Target Indicator (MTI) data. The system subdivides the area of interest into a grid of blocks and assigns each block an Activity Level value of None, Low, Medium, or High. The entire grid is compressed for transmission, skipping large areas of blocks with no reported activity.

JSTARS transmits Activity Level indications on moving targets.

The system generates a variable number of J28.2.4 messages to report the MTI Activity Level grid. An Activity Indicator Initial word and Continuation words are transmitted first to define the corners of the area of interest and the threshold values for the Activity Levels (that is, Low, Medium, or High). The entire grid is compressed into the minimum number of Initial and Extension words necessary to define the grid cells with MTI activity.

■ Threat Warning Messages

JSTARS does not process the J15.0 Threat Warning message.

■ Image Transfer

JSTARS transmits and receives the J16.0 Image Transfer message. JSTARS can send and receive J16.0 images and may annotate the image, crop the image, and specify up to seven Regions of Interest (ROIs) to apply different compression levels within the operator-specified ROIs. The images can be sent and received as grayscale or color. They can be addressed to an individual TN or broadcast, using either JPEG or Eagle Eye compression. Images can be sent using either one-way or two-way image transmission protocol.

Message		JSTARS IR5 Implementation	
		Term	Host
J0.0	Initial Entry Message	T / R	- / -
J0.1	Test Message	T / R	- / -
J0.2	Update Network Time	T / R	- / -
J0.3	Time Slot Assignment Message	-/-	- / -
J0.4	Radio Relay Control Message	T(1) / R	- / -
J0.5	Repromulgation Message	T / R	- / -
J0.6	Communications Control Message	T(1) / R	- / -
J0.7	Time Slot Reallocation		T(2) / R(2)
J1.0	Connectivity Interrogation	- / -	- / -
J1.1	Connectivity Status	- / -	- / -
J1.2	Route Establishment	- / -	- / -
J1.3	Acknowledgment	- / -	- / -
J1.4	Communicant Status	- / -	- / -
J1.5	Net Control Initialization	- / -	- / -
J1.6	Needline Participation Group Assignment	- / -	- / -
J2.0	Indirect Interface Unit (IIU) PPLI	- / -	- / R
J2.2	Air Platform PPLI	T / R	T / R
J2.3	Surface Platform PPLI	- / R	- / R
J2.4	Subsurface Platform PPLI	- / R	- / R
J2.5	Land Point PPLI	- / R	- / R

Figure 6-8. JSTARS message capabilities (continued on next page)

Message		JSTARS IR5 Implementation	
		Term	Host
J2.6	Land Track PPLI	- / R	- / R
J3.0	Reference Point Message	- / -	T / R
J3.1	Emergency Point	- / -	T / R
J3.2	Air Track	- / -	T / R
J3.3	Surface Track	- / -	T / R
J3.4	Subsurface Track	- / -	- / -
J3.5	Land Point Track	- / -	T / R
J3.6	Space Track	- / -	- / -
J3.7	EW Product Information	- / -	- / R(3)
J5.4	Acoustic Bearing/Range	- / -	- / -
J6.0	Amplification Data	- / -	T / R
J7.0	Track Management	- / -	T / R
J7.1	Data Update Request	- / -	T(4) / R(4)
J7.2	Correlation Request	- / -	- / -
J7.3	Pointer Message	- / -	T / R
J7.4	Track Identifier Message	- / -	- / -
J7.5	IFF/SIF Management	- / -	- / R
J7.7	Association	- / -	T / R
J9.0	Command	- / -	T / R
J9.1	Engagement Coordination	- / -	- / -
J10.2	Engagement Status	- / -	T / R
J10.3	Handover Status	- / -	T / R
J10.5	Controlling Unit Report	- / -	T / R
J10.6	Pairing	- / -	T / R
J12.0	Mission Assignment	- / -	T / R
J12.1	Vector	- / -	- / -
J12.3	Flight Path	- / -	- / -
J12.4	Controlling Unit Change Order	- / -	T / R
J12.5	Target/track Correlation	- / -	T(5) / -
J12.6	Target Sorting	- / -	T(6) / R
J12.7	Target Bearing	- / -	- / -
J13.0	Airfield Status	- / -	T / R
J13.2	Air Platform And System Status Report	- / -	T / R
J13.3	Surface Platform And System Status Report	- / -	- / R
J13.4	Subsurface Platform And System Status Report	- / -	- / -

Figure 6-8. JSTARS message capabilities (continued on next page)

Message		JSTARS IR5 Implementation	
		Term	Host
J13.5	Land Platform And System Status Report	- / -	- / R
J14.0	Parametric Information	- / -	- / -
J14.2	EW Control/Coordination	- / -	- / -
J15.0	Threat Warning	- / -	- / R
J16.0	Image Transfer	- / -	T / R
J17.0	Weather Over Target Report	- / -	T / R
J28.2(0)	Text	- / -	T / R
J28.2(3)	Radar Service Request	- / -	T / R
J28.2(4)	Activity Level Indicator	- / -	T / R
J31.0	Over-the-air Rekeying Management	- / R	- / -
J31.1	Over-the-air Rekeying	- / R	- / -
J31.7	No Statement	(7) / (7)	- / -
RTT-A	Round-trip Timing – A	T / R	- / -
RTT-B	Round-Trip Timing – B	T / R	- / -
RTT-REP	Round-Trip Timing – REP	T / R	- / -
Digital Voice	2.4 kbps UNCODED LPC-10	- / -	T(8) / R(8)
Digital Voice	2.4 kbps CODED LPC-10	- / -	T(8) / R(8)
Digital Voice	16 kbps CVSD	- / -	T(8) / R(8)

NOTES:
JSTARS HOST, where "–" is listed, HOST does not process.
(1) Transmitted for receipt compliance purposes only.
(2) J0.7 Time Slot Reallocation is only implemented on NPGs 7 (Surveillance), 11 (Imagery), and 29 (Free Text) and only two NPGs at any given time.
(3) JSTARS only receives EW FIX and AOP.
(4) JSTARS only transmits and receives Track Specific Data Update Requests.
(5) Only transmit J12.5 on environment/category AIR when J12.6 Air Sensor Target Report is correlated with a J3.2 Air Track.
(6) JSTARS only transmits J12.6 Pointer.
(7) The J31.7 No Statement message is automatically exchanged between terminals. Transmit and receive tables are not provided for this message.
(8) IR5 added software capability to control J-Voice. JSTARS also needs a hardware upgrade to take advantage of J-Voice (awaiting funding).

Figure 6-8. This summary of the JSTARS transmit and receive message capabilities provides understanding of how this C2 aircraft performs on Link 16—as well as what to expect from JSTARS if you are an operator aboard another Link 16 platform.

Section D

Rivet Joint, Cobra Ball, and Combat Sent

The USAF RC-135V/W Rivet Joint (RJ), Cobra Ball (CB), and Combat Sent (CS) surveillance aircraft are equipped with an extensive array of sophisticated intelligence-gathering equipment that allows military specialists to monitor the electronic activity of adversaries. Using automated and manual equipment, electronic and intelligence specialists can precisely locate, record, and analyze much of what is being transmitted in the electromagnetic spectrum. There are 17 RJ, CB, and CS aircraft, with 11 or 12 available for training and operational use at any given time. The remainder are in various stages of maintenance and modernization.

☐ Mission

The RJ, CB, and CS aircraft provide direct, near-real-time reconnaissance information and EW support to theater commanders and combat forces. Their basic roles include providing indications about the location and intentions of enemy forces and warnings of threatening activity broadcasting a variety of direct voice communications. Of highest priority are combat advisory broadcasts and imminent threat warnings that can be sent directly to aircraft in danger, employing both data and voice links to provide target information to US ground-based air defenses.

The mission of highest priority for RJ, CB, and CS is combat advisories and threat warnings.

☐ Location

The RJ, CB, and CS aircraft are operated by the 55th Wing, Offutt AFB, Nebraska. The 97th Intelligence Squadron (IS), 390th IS, and 488th IS provide the intelligence personnel, who work in the back of the plane. In support of the 55th, the 82nd Reconnaissance Squadron (RS), 343rd RS, 38th RS, and 95th RS provide pilots and navigators to fly the aircraft. Since the beginning of Operation Joint Endeavor in December 1995 through May 1996, the 95th and 488th flew 625 hours and 72 sorties together in support of the peacekeeping operation in Bosnia-Herzegovina. RJ has also been deployed in support of the occupation of Haiti and Desert Storm. RJ has maintained a continuous presence in Southwest Asia since late 1990.

RJ missions are performed by specialists from seven organizations.

Description

The RJ, CB, and CS aircraft are air-refuelable theater assets. These aircraft have secure UHF, VHF, HF, and SATCOM communications. Refined intelligence data can be transferred from RJ to Ballistic Missile Command and Control (BMC2) on Link 16, Link 11, or onto intelligence channels via satellite and the Information Broadcast Service (IBS), which is a near-real-time theater information broadcast.

Figure 6-9. The RJ aircraft are capable of conducting Electronic Intelligence (ELINT) and Communications Intelligence (COMINT) intercept operations against targets at ranges of up to 240 kilometers.

Equipment Configuration

The RJ Operator Workstation Upgrade procures and installs high-resolution operator displays to improve target detection and signal recognition, provide wideband fiber-optic base audio distribution network to all operators, and provide wideband, high-capacity, commercial off-the-shelf (COTS) audio recorders, as well as high-capacity, digital, reprogrammable, wideband demodulators and processors.

Link 16 Implementation

The most recent RJ configuration is Baseline 8, which began to be fielded in late 2006, alongside the remaining Baseline 7 aircraft. This summary of RJ's Link 16 implementation is based on Baseline 7. A table summarizing the Link 16 messages transmitted and received by the Baseline 7 RJ may be found at the end of this section.

Baseline 8 is RJ's latest Link 16 baseline.

Network Management Messages

The RJ implementation of the network management function was designed to allow for querying and response to Network Time Update and for R/C to Radio Relay Control messages only.

RJ's participation in network management is limited.

Initial Entry and Time Synchronization Messages

Initial network entry is at the discretion of the data link operator (DLO), and is performed through a manually initiated sequence. The RJ Link 16 system uses Zulu time received from the GPS as default network time, although the operator has recently been provided with the capability to enter time manually, which enables RJ's participation in non-Zulu-time-based networks. RJ has not implemented the External Time Reference (ETR) capability.

♦ Dynamic Network Amendment Messages

RJ implementation is described below.

■ Network Time Update

RJ both transmits and receives the J0.2 Network Time Update message.

■ Relay Functions

RJ receives and responds to the J0.4 Radio Relay Control message.

■ Communications Control

RJ receives and processes the J0.6 Communications Control message and responds for proper R/C. This message is used to initiate or terminate transmissions, to control communications, and to request network management actions.

■ Over-the-Air Rekeying

RJ can receive the J31.0 OTAR Management and J31.1 OTAR messages, and will respond accordingly.

RJ can perform the OTAR function.

■ Other Dynamic Network Amendment Messages

RJ neither receives nor transmits the J0.3 TSA, the J0.5 Repromulgation Relay, or the J0.7 TSR messages.

■ PPLI and Platform Status Messages

RJ transmits its own PPLI in the J2.2 message. RJ can receive and display the J2.0 Indirect Interface Unit, the J2.2 Air, the J2.3 Surface (Maritime), the J2.4 Subsurface (Maritime), the J2.5 Land Point, and the J2.6 Land Track PPLI messages.

RJ’s PPLI is contained in the J2.2 message.

♦ Miscellaneous PPLI Processing

- When the Bailout Indicator is set in a received PPLI, it alerts the operator to a valid JU bailout situation. The operator will immediately begin searching for and providing direction-finding and location services on the emergency locator beacon in support of combined search and rescue (CSAR) activities.
- Time Quality is not displayed to RJ operators, and therefore they cannot use this important indicator to judge the health of the network.

♦ Platform Status Information

RJ transmits its own platform status using the J13.2 Air Platform and System Status message approximately every 3.2 minutes. It reports only the minimum information required under MIL-STD-6016, Appendix A, Minimum Implementation (Able to Perform Mission, No Statement for Burnable Fuel, Time of Report in Hours and Minutes).

RJ interprets status messages only from air platforms.

RJ can receive and display most data items, except for sensor and system status, from Air Platform and System Status information, which it receives from airborne JUs in J13.2 messages. However, it cannot interpret platform status data from the J13.3 Surface (Maritime), the J13.4 Subsurface (Maritime), or the J13.5 Land (Ground) Platform messages.

■ Airfield Status Data

RJ neither receives nor processes the J13.0 Airfield Status message.

■ Surveillance, Amplification, and Electronic Support Measures

RJ's surveillance function is implemented primarily to support the reporting of air tracks, ground points representing threats and items of interest on the battlefield, and intelligence amplification of local and remote tracks and points.

♦ Track Transmission and Reception

RJ is required by US National directive to set the Special Processing Indicator (SPI) to the value 1 in all of its surveillance and amplification messages. This setting indicates that information within the message requires special handling. The intent of this directive is that this SPI value will prevent RJ's surveillance data from being forwarded onto uncovered data links (links not cryptographically protected to the proper level), such as NATO Link 1. But RJ's setting the SPI value to 1 should not be misconstrued as intending to limit the information's transmission, forwarding, database population, or display by any network participants within properly covered data links, such as Link 11 and Link 16.

All RJ surveillance messages have the SPI bit set.

RJ may report Air tracks, and in some instances Surface (Maritime) surveillance tracks, as either nonreal-time, which have a TQ of zero (0), or real-time, which may have a TQ value between 1 and 15. Since all tracks reported by RJ are created from passive sensor data, standard track quality algorithms may not apply. For air tracks, RJ uses empirical source accuracy information to assign the TQ value.

For most track sources, the historically observed accuracy was equated to a Link 16 TQ, and was then reduced by one TQ value to err on the side of conservatism. (For example, an empirically suggested TQ value of 8 would actually be reported on the data link as TQ 7.) The RJ's unique TQ determination nevertheless meets the spirit and intent of TQ, since it provides a 95 percent probability that the track in question is physically located within the area defined by the TQ value at the time of transmission.

The maximum TQ of RJ's air tracks is 7.

RJ is capable of producing air tracks with TQ values of 0 – 7. Passive sensor upgrades in the near future may enhance that capability. A track entry in RJ's database is built with the following information:

- The TN and STN
- All available track kinematics information, including history, and
- All available track Identity and Activity information.

The RJ system provides the basic symbology, as well as an operator-definable track history trail (for example, showing the last 10 minutes of track history) for analytical purposes. The operator may define various elements of kinematics data and/or identification for tabular display next to the track symbology.

RJ processes and displays to the operator all Environment and ID values for received tracks, and processes all TQ values, in accordance with filter settings.

♦ Amplification

RJ operators will attempt to provide amplifying information on received tracks in accordance with previously established priorities, as well as with dynamic requests from on-scene C2 assets. The RJ transmits and receives this amplifying information in the J6.0 Amplification message.

RJ prioritizes Intel requests.

♦ Processing of Fighter Sensor Data

RJ cannot process sensor data from Link 16-equipped fighters.

♦ Points

RJ operators are able to create and transmit Reference Points, Land (Ground) Points, and Emergency Points. The operators will populate the messages with as much information as possible, such as Platform, Platform Activity, and Specific Type.

RJ transmits points for TBM impact, SAMs, and AAAs.

Reference Points, which are transmitted in J3.0 messages, may indicate ballistic missile launch and impact points.[2] Land (Ground) Points, which are transmitted in J3.5 messages, primarily indicate threats, such as surface-to-air missiles (SAMs) and anti-aircraft artillery (AAA), as well as other physical points of interest to C2 and combatant platforms. Emergency Points, which are transmitted in J3.1 messages, are limited to friendly forces in need of immediate assistance—for example, Bailout and Mayday messages.

♦ Lines and Areas

RJ has the capability to transmit and receive some Reference Lines and Areas.

♦ Electronic Support Processing

RJ's implementation of EW Product Information supports both the exchange of raw EW Parametric data and the resulting EW Products.

RJ handles EW parametrics on NPG 10 and EW products on NPG 7.

The primary purpose of RJ's Electronic Support Measures (ESM) implementation is to provide

- Indications of threats on the battlefield
- Detailed parametric information supporting combat identification, and
- Heads-up among similarly equipped platforms for the cooperative location of fleeting signals of interest and high-value tasking.

RJ uses the ESM data it receives from offboard sources primarily for activity tip-off and confirmation of its own, onboard analysis.

2 *The C5 Continuation Word is transmitted with the J3.0 Initial Word to convey the axes of the Impact Point.*

♦ EW Product Information

The J3.7 EW Product Information message is used to exchange locational and identification information on entities discovered through ES. Operational rules of engagement dictate whether RJ transmits a J3.7 EW Product Information or a J3.5 Land (Ground) Point—especially to indicate land-based threat systems—to ensure receipt by JUs that do not implement the J3.7 message.

The exchanges in the following paragraphs support the creation of Electronic Surveillance products.

■ EW Parametric Information

RJ exchanges EW parametric information for the purposes of activity tip-off and cooperative EW. The lack of a well-defined EW concept of employment, however, significantly diminishes cooperative efforts. The RJ system automatically sends a J14.0 EW Parametric Information message on NPG 10 (EW) when transmitting an EW Product in a J3.7 message on NPG 7 (Surveillance) that relates to the same entity.

■ EW Control and Coordination

RJ does not implement the J14.2 EW Control and Coordination message capability. However, when the Joint EW community establishes a workable EW concept of employment, RJ is expected to implement this capability in accordance with the Joint concept.

♦ EA Strobes

RJ's Link 16 implementation supports the reporting of ECM Strobes.

♦ EW Fixes

EW Fixes are transmitted by operator action both on NPG 7 (Surveillance) as J3.7 EW Products, and simultaneously on NPG 10 (EW) as J14.0 EW Parametric messages.

♦ EW and Amplification Data

To assist in identifying Nationality/Alliance, Platform, Activity, and Specific Type of air, space, land, and surface maritime tracks, RJ produces the J6.0 Amplification messages to provide intelligence amplification on these entities. RJ's identification and intentional information is used in the formal combat identification (CID) process to support targeting decisions. Among other command, control, intelligence, surveillance, and reconnaissance (C2ISR) assets, this amplification is referred to as EW/I information.

RJ transmits amplifying data in J6.0 messages.

■ Information Management

The management of track data is essential to ensure that the network as a whole presents a consolidated surveillance picture.

♦ Track Management

RJ uses the J7.0 Track Management message for several different functions, which depend on the Action Code value transmitted in the message. The Action Code values implemented by RJ for its J7.0 Track Management message are:

■ Drop Track Report (J7.0, Act. 0)

In accordance with standard R2 rules, RJ issues a Drop Track Report (Action Code = 0) when it ceases reporting a track or point on Link 16.

■ Information Difference Report (J7.0, Act. 1)

RJ informs the Link 16 network that it has conflicting information on a track by transmitting an Information Difference Report on that track. RJ can also receive and process Information Difference Reports.

■ Change Data Order (J7.0, Act. 2)

RJ can receive and properly process CDOs from other units. RJ does not, however, currently transmit the CDO. Although this capability is resident in the RJ system, it is not accessible by the operator. If RJ ever acquires change data authority in future, access by the operator can be restored by a software update.

Currently, RJ does not hold CDO authority.

■ Emergency and Force Tell Reports (J7.0, Act. 3/4)

RJ both transmits and receives Emergency and Force Tell status changes.

■ Strength Change Report (J7.0, Act. 5)

RJ processes this message on receipt, but it does not transmit it.

■ Exercise Status Change Order (J7.0, Act. 6)

RJ receives this message, which changes Exercise identities back to Friend.

♦ Data Update Requests

The RJ operator can generate DURs in J7.1 messages on a variety of data link entities. RJ also will respond with requested data when queried by another JU.

RJ both transmits and responds to DURs.

♦ Correlation

RJ can correlate local and remote tracks by either of two methods:

- **Manual Correlation**, which is strictly an operator-originated manual effort. The RJ system will accept operator inputs to correlate two entities into a single entity.
- **Automatic Correlation**, for which RJ uses two algorithms to support this function.

RJ has manual and automatic correlation capabilities.

RJ does not implement the Restricted Automatic Correlation mode, nor does it receive and process J7.2 Correlation messages.

♦ Track Identifier

RJ neither transmits nor processes the J7.4 Track Identifier message.

♦ IFF/SIF Management

The RJ implementation of the IFF/SIF Management message (J7.5) supports the full exchange, for both transmit and receive functions, of:

- The Clear IFF message (J7.5, Act. 0)
- The IFF Difference Report (J7.5, Act. 1)
- The IFF Update Request (J7.5, Act. 2), and
- The IFF Special Codes message (J7.5, Act. 3).

♦ Filter Management

The RJ operator can create and enable filters to reduce the volume of information it receives over the Link 16 network. RJ cannot, however, transmit a Filter Description Report (J7.6, Act. 1) to other units for review.

RJ discards Filter Implementation Requests (J7.6, Act. 0), so it cannot enable filters that are defined by other units. Moreover, it cannot transmit Filter Implementation Requests to other units containing RJ-defined filters.

♦ Pointers

RJ allows the operator to create a J7.3 Pointer message and transmit it to a specified JU. The operator cannot enter more than a single addressee, which may be either a single JU or the All Stations address. RJ cannot append text to the Pointer message.

RJ does not interpret the nonC2 pointer exchanged within the J12.6 Target Sorting message. Other received Pointer messages are displayed to the aircrew as large arrows, with their tips over the coordinates specified in their messages. Any text appended to these messages, however, will not be processed by RJ.

■ Weapons Coordination and Management

RJ does not actively participate in the exchange of Weapons Coordination and Management information. It does, however, interpret certain exchanges for operator situational awareness.

RJ does not directly participate in weapons coordination.

♦ Commands

RJ does not participate in the exchange of intra-C2 Command information conveyed in the J9.0 Command messages.

♦ Engagement Status

RJ does not transmit J10.2 Engagement Status messages, but it does interpret them for operator situational awareness.

♦ Handover

RJ does not actively participate in Link 16 air control exchanges, nor does it interpret the J10.3 Handover message.

♦ Controlling Unit Reports

RJ does not transmit Controlling Unit Reports (J10.5), but it will receive and interpret them for operator situational awareness.

♦ Pairing Status Messages

RJ does not transmit tactical Pairing messages (J10.6), but it will receive and interpret them for operator situational awareness.

■ Air Control

The use of Link 16 to control and direct weapon systems is not implemented in the RJ system. Therefore, do not expect RJ to actively participate in Link 16 control exchanges, such as Mission Assignments, Vectors, Flight Path Instructions, or Controlling Unit Change Orders. RJ cannot, moreover, extract Engagement Status data transmitted by Link 16-equipped fighters in J12.6 Target Sorting messages.

RJ does not participate in air control functions.

■ Link 16 Voice

RJ can transmit and receive Link 16 voice on NPGs 12 and 13. Both 2.4 kbps and 16 kbps voice can be transmitted and received.

■ Text Messages

The RJ operator may compose an alphanumeric text message by updating a blank message skeleton in a TD. The message is then transmitted in a J28.2(0) US National Text message. This capability allows the operator to transmit and receive messages of up to 263 lines, and having up to 52 characters per line.

RJ supports the transmission of J28.2 text messages.

■ Threat Warning Messages

As an expected primary provider of threat warning information, RJ allows for the transmission, reception, and processing of J15.0 Threat Warning messages.

RJ both transmits and receives Threat Warning messages.

The operator first creates a subject-object pair relationship between a shooter and a target, and then selects the appropriate reason code—in this case Threat—for the pairing to be transmitted.

Message		Tx	Rx
System Information Exchange and Network Management			
J0.0	Initial Entry	T	R
J0.1	Test Message	T	R
J0.2	Network Time Update	T	R
J0.3	Time Slot Assignment	NTRC	NI
J0.4	Radio Relay Control	NTRC	R
J0.5	Repromulgation Relay	NT	NI
J0.6	Communications Control	NTRC	R
J0.7	Time Slot Reallocation	NT	NI
J1.0	Connectivity Interrogation	NT	NI
J1.1	Connectivity Status	NT	NI
J1.2	Route Establishment	NT	NI
J1.3	Acknowledgement	NT	NI
J1.4	Communication Status	NT	NI
J1.5	Net Control Initialization	NT	NI
J1.6	Needline PG Assignment	NT	NI
PPLI			
J2.0	Indirect Interface Unit PPLI	NT	R
J2.2	Air PPLI	T	R
J2.3	Surface (Maritime) PPLI	NT	R
J2.4	Subsurface (Maritime) PPLI	NT	R

Figure 6-10. RJ Baseline 7 message implementation (continued on next page)

Message		Tx	Rx
J2.5	Land (Ground) PPLI	NT	R
J2.6	Land (Ground) Track PPLI	NT	R
Surveillance			
J3.0	Reference Point	T	R
J3.1	Emergency Point	T	R
J3.2	Air Track	T	R
J3.3	Surface (Maritime) Track	T	R
J3.4	Subsurface (Maritime) Track	T	R
J3.5	Land (Ground) Point/Track	T*	R
J3.6	Space Track		R
J3.7	EW Product Information	T	R
ASW			
J5.4	Acoustic Bearing and Range	NT	NI
AMP			
J6.0	Amplification Information	T	R
Information Management			
J7.0	Track Management	T	R
J7.1	Data Update Request	T	R
J7.2	Correlation	NT	NI
J7.3	Pointer	T	R
J7.4	Track Identifier	NT	NI
J7.5	IFF/SIF Management	T	R
J7.6	Filter Management	NT	NI
J7.7	Association	T	R
J8.0	Unit Designator	NT	NI
J8.1	Mission Correlator Change	NT	NI
Weapons Coordination and Management			
J9.0	Command	NT	NI
J9.1	Engagement Coordination	NT	NI
J9.2	ECCM Coordination	NT	NI
J10.2	Engagement Status	NT	NI
J10.3	Handover	NT	NI
J10.5	Controlling Unit Report	NT	NI
J10.6	Pairing	NT	NI

Figure 6-10. RJ Baseline 7 message implementation (continued on next page)

Message		Tx	Rx
Control			
J12.0	Mission Assignment	NT	NI
J12.1	Vector	NT	NI
J12.2	Precision Aircraft Direction	NT	NI
J12.3	Flight Path	NT	NI
J12.4	Controlling Unit Change	NT	NI
J12.5	Target/Track Correlation	NT	NI
J12.6	Target Sorting	NT	NI
J12.7	Target Bearing	NT	NI
Platform and System Status			
J13.0	Airfield Status	NT	NI
J13.2	Air and Platform System Status	T	R
J13.3	Surface (Maritime) Platform and System Status	NT	R
J13.4	Subsurface (Maritime) Platform and System Status	NT	NI
J13.5	Land (Ground) Platform and System Status	NT	R
EW			
J14.0	Parametric Information	T	R
J14.2	EW Control / Coordination	NT	NI
TW			
J15.0	Threat Warning	T	R
Image Transfer			
J16.0	Image Transfer	NT	NI
Weather			
J17.0	Weather Over Target	NT	NI
National Use			
J28.0 J29.0	National Messages (J28.2(0) Only)	T	R
J29.0	Spoke Report	NT	NI
Miscellaneous			
J31.0	OTAR Management	NTRC	R
J31.1	OTAR	NT	R
J31.7	No Statement	T	R
RTT-A	Round Trip Timing Interrogation Addressed	T	R

Figure 6-10. RJ Baseline 7 message implementation (continued on next page)

Message		Tx	Rx
RTT-B	Interrogation Broadcast	T	R
RTT-I	Reply	T	T
RTT-R	Round Trip Timing Reply	T	R
Free Text	Digital Voice 2.4 kbps coded LPC-10	T	T
Free Text	Digital Voice 16 kbps CVSD	T	R

Notes:

1. Abbreviations: Anti-submarine Warfare (ASW), Amplification (AMP), Electronic Warfare (EW), Threat Warning (TW)
2. Annotations used:

T	Transmit at least minimum message requirements
NT	Does not transmit the message
NTRC	Message transmitted only for Receipt/Compliance purposes
R	Receive and interpret some parts of the message
NI	Message not interpreted
NIRC	Message interpreted only for Receipt/Compliance purposes
Rx	Receive
Tx	Transmit

Figure 6-10. The RJ Baseline 7 Link 16 message implementation is shown in this table. Due to its mission, RJ is a primary provider of combat ID amplification data, but it does not perform air control.

Section E

Control and Reporting Center

The CRC is a worldwide-deployable battlespace management platform employed at the tactical level to support the planning and execution of air operations across the entire range of operations, from military operations other than war (MOOTW), to major combat operations. As a tactical C2 element, the CRC can operate independently or in combination with other tactical C2 elements, such as AWACS and JSTARS. It supports missions by horizontally integrating with other tactical C2 nodes, as well as vertically integrating with the AOC. Because of its modular equipment capability, the terms Modular Control Equipment (MCE) and Modular Control System (MCS) pertain to the CRC. For our purposes, CRC, MCE, and MCS are interchangeable terms.

As an integral element of the Theater Air Control System (TACS) and C2 architecture, the CRC provides a deployable, adaptable, and independent C2 system capable of conducting a wide array of battle management functions at the tactical level, including:

- Theater Air Defense (TAD)
- Data Link Management
- Surveillance
- Identification, and
- Air Battle Execution (ABE).

Mission

The CRC's five principal missions are:

- Data link management
- Surveillance
- Identification
- ABE, and
- Theater Missile Defense.

The CRC can integrate the tactical picture from various data links and sensor sources.

Although each mission is an important aspect of the CRC operations, the discussion in this guidebook covers only the CRC's data link management mission. The CRC has an inherent capability to manage, consolidate, and disseminate an integrated picture. It consolidates radar data, data link inputs, and other sensor inputs into an integrated picture for distribution over data links. The CRC interfaces on and forwards data to and from Link 11, Link 11B, Link 4A, Link 16, Army Tactical Data Link 1 (ATDL-1), and NATO Link 1. When communications and data link connectivity have been established at the CRC, the air picture is received and transmitted to many adjacent facilities in a Joint environment.

Data link operations are the backbone of the CRC mission, and they become of paramount importance during large-scale operations. CRC integration in link architecture, which is determined by the command authorities directing air operations, is published in Operations Orders (OPORDs). Specific CRC link execution is addressed in the OPTASK LINK message. The CRC integrates incoming data and presents it in a format that can be tailored to the SA needs of the Joint Forces Air Component Commander (JFACC).

Location

The CRCs operated by Air Combat Command (ACC) are based at

- Mountain Home AFB, Idaho (726th ACS)
- Eglin AFB, Florida (728th ACS), and
- Hill AFB, Utah (729th ACS).

In support of NATO, the USAF has two CRCs, based at Spangdahlem AB, Germany (606th ACS) and Aviano AB, Italy (603rd ACS).

The Air National Guard (ANG) operates ten ACS units, at

- Orange, Connecticut (103rd ACS)
- Savannah, Georgia (117th ACS)
- Gulfport, Mississippi (255th ACS)
- Salt Lake City, Utah (109th ACS)
- Camp Rilea, Oregon (116th ACS)
- Blue Ash, Ohio (123rd ACS)
- Volk Field, Wisconsin (128th ACS)
- McConnell AFB, Kansas (134th ACS)
- Punta Borinquen, Puerto Rico (141st ACS), and
- Barking Sands, Hawaii (154th ACS).

Currently, there are two Expeditionary CRCs: the 727th Expeditionary ACS (EACS), based at Balad Air Base, Iraq, and the 71st EACS at Al Udeid Air Base, Qatar. Additionally, CRCs (both ACC and ANG) have been deployed to a number of other overseas locations, including Saudi Arabia, and throughout the Mediterranean sphere of influence.

CRCs have been deployed throughout CONUS, Europe, and the Middle East.

ACC and ANG have Formal Training Units (FTUs) at Luke AFB, Arizona (607th ACS and 107th ACS (ANG)) and a Test Squadron at Fort Dodge, Iowa (133rd TS (ANG)).

Description

The CRC's most prominent feature is its AN/TPS-75 radar set. In a full CRC configuration, it has two radar sets at its disposal. The CRC directs the remoting and deployment of the radars to provide:

- Optimal sensor coverage of the Area of Interest (AOI), and
- Ground-air-ground radio communications within the AOI.

Up to five OMs can be configured together using the Fiber-Optic Interface Panel (FOIP). Battle Management and C2 operations are conducted in the CRC's AN/TYQ-23 Operations Modules (OMs). The CRC's OMs are nearly identical to the USMC's Tactical Air Operations Modules (TAOMs). Each OM contains four Operations Console Units (OCUs) and four UHF, three VHF, and two HF radios per OM to manage tactical air surveillance, data link, and aircraft control operations. Up to five OMs can be deployed in a progressive combination of configurations to perform air surveillance and early warning, tactical data link interfacing, aircraft identification, and air battle management. When OMs are "FOIPed" together, all radios from all OMs are available to any operator position. In addition to this operational equipment, the CRC also has support equipment and a large number of military vehicles, all contributing to the CRC's mobile capability.

Figure 6-11. The CRC is a high-capacity ground radar station and C2 center that can operate from garrison or a deployed location.

Equipment Configuration

The CRC's Link 16 equipment is contained in two deployable shelters, the OM and the JTIDS Module (JM), both of which require support from other deployable shelters and equipment. For example, power is provided by external generators, communication capabilities are provided by communication vans and deployed antennas, and the live radar is provided by the AN/TPS-75 radar set. The CRC is equipped with two types of JTIDS antennas: one omnidirectional and one directional.

The JM can operate Link 16 by itself, or tied with the OM.

The JM communications shelter is designed to interface with the OM. It is a modified S-711 shelter containing an AN/URC-107(V)10 or (V)9 JTIDS terminal (Class 2 or 2H, respectively) and associated cryptographic and support equipment. The JM interfaces with an OM using Tri-Service Tactical Communications (TRI-TAC)-compatible communications equipment and fiber-optic cable. It is within the JM that the Class 2 terminal and the tactical control display are located.

Figure 6-12. The CRC Link16 capability is sheltered in two pieces of prime equipment, the OM and JM, and consists of a JTIDS Class 2 terminal, a tactical control device, and two antennas.

Operational Considerations

Factors to consider when operating Link 16 with a CRC include the following:

- After a unit deployment into a theater AOR, a CRC may initially require 12 hours to become operational.
- The CRC must have the current release of the OPTASK LINK, the comm plan, the EMCON plan, the requisite current crypto, and a uniquely assigned track block.
- Location of Link 16 antennas and geographic features may limit the Link 16 line of sight (LOS).
- The CRC has an inherent capability of acting as a TDL data forwarder.
- Depending on the CRC configuration, certain data link capabilities may be reduced or nonexistent.
- The CRC is capable of running 24-hour operations for a minimum of 30 days without resupply or additional manning.

The terrain and the CRC's location may limit its Link 16 LOS!

Link 16 Implementation

Network Management Messages

The CRC has the capability to generate and transmit Network Management messages. The CRC can act as a primary dynamic network management facility. Note that the CRC can perform the NTR role (generating the J0.0 Initial Entry message), as well as the relay function. It can also perform the transmit time slot assignment function (J0.3 message), and transmit the J31.0 and J31.1 OTAR messages for receipt compliance purposes only.

For the Network Management function, the CRC can be a primary.

PPLI and Platform Status Messages

The CRC automatically generates the J2.5 Land PPLI message, once per frame, on NPG 6 (PPLI and Status B). It transmits, receives, processes, and forwards the J2.0 Indirect Interface Unit. It receives J2.2 Air, J2.3 Surface (Maritime), and transmits and receives J2.5 Land/Ground PPLI messages, and uses this received positional information to support remote tracks in its database.

The CRC's PPLI is contained in the J2.5 message.

PPLI Information

Bailout Indicator

If the CRC receives a J2.2 Air PPLI message with its Bailout indicator set, the system automatically initiates an Emergency point at the aircraft's last received position and reports it to the network in a J3.1 Emergency Point message on the Surveillance NPG.

Surveillance Track on PPLI

The CRC automatically assumes R2 for a radio silent JU by transmitting the appropriate Surveillance Track message (J3.x) containing its JU address as its track number. The CRC automatically relinquishes R2 when it again receives a PPLI message from the JU.

Platform Status Information

The CRC transmits its J13.5 Land Platform and System Status message every 3.5 minutes, in its PPLI time slot. It can receive, process, and forward Platform and System Status information for J13.2 Air Platforms, J13.3 Surface (Maritime) Platforms, and other J13.5 Land Platforms. It will also forward J13.3 data for indirect players on the NPG 7 (Surveillance). The CRC can transmit and receive the J13.0 Airfield Status message.

CRC retains own local positions for remote tracks correlated to local tracks.

■ Surveillance, Amplification, and EW Messages

With its AN/TPS-75 radar set, the surveillance function is one of the CRC's five principal roles, and it employs the Link 16 Surveillance messages extensively.

♦ Tracks

Tracks initiated by a CRC operator on sensor data from the AN/TPS-75 radar, IFF, or ES subsystems are automatically transmitted on Link 16, subject to active filters. The operator may also nominate radar jamstrobes for transmission. The association of tracks with ES and jamming data is a manual function, however, and these associations are transmitted only as a result of operator action.

At the CRC, associating tracks with ES and jamming depends on operator action!

The CRC reports its air and surface tracks in the J3.2 Air Track and J3.3 Surface (Maritime) Track messages, and forwards J3.3 Surface (Maritime) tracks, on NPG 7 (Surveillance). Its tactical computer calculates Track Quality (TQ) based on the volume of a sphere whose radius is a value for the confidence level of the track's position. A track entry in the CRC database is built from the following information:

- The operator initiates the track from synthetic sensor data that provides track position, course, and speed. For air tracks, it also provides altitude.
- The operator may then further develop the track data by entering other parameters—when they are known—such as ID, Platform Type, Size (count), EW Identity Amplification, Platform Activity, Exercise Status, and Special Processing Status.
- The track's IFF codes can be added to its database entry, either automatically by the software from interrogation responses, or manually by the operator.

CRC receives and processes most status messages from most platform types.

Received information about a track is presented to the operator as a symbol on the operational display. The operator may view further information on the track TD. If the CRC internally correlates a local track with a remote track, it then consolidates the display, giving preference to the local track's positional information.

♦ Fighter Sensor Data

The CRC receives and processes the J12.6 Target Sorting message from Link 16-equipped fighters. It can also receive and display designated ground targets from the F-15E Strike Eagle, although this particular data is not currently correlated with local or remote surveillance tracks. The operator may use it, however, to initiate or update local track information.

The CRC receives and processes fighter sensor data.

♦ Points

The CRC operator can define and transmit J3.1 Emergency Point messages, as well as a wide range of J3.0 Reference Point messages, all of which are transmitted on NPG 7 and are displayed as symbols on the operational display. The operator may view additional information associated with local and remote points on a TD. CRC also transmits and receives J3.5 Land Point and Track messages on NPG 7.

The operator can initiate Emergency and Reference Points.

♦ Lines and Areas

The CRC both receives and transmits the J3.0 Reference Point message and has the graphics capability to display lines and areas.

The CRC can display lines and areas.

♦ Electronic Support Processing

The CRC does not support the reporting of raw parametric J14.0 EW data messages and J14.2 EW Control and Coordination messages.

♦ EW Product Information

The CRC supports reporting of EW Tracks with the J3.7 EW Product Information message to transmit EW information of tactical interest to the wider surveillance community.

The CRC transmits EW products on NPG 7.

♦ EA Strobes

When the operator forms a passive track using the raw strobe data on his operational display, the J3.7 EW Product Information message reports an EA strobe.

The operator initiates EA strobes as passive tracks on NPG 7.

♦ EW Fixes

When the operator initiates self-triangulation of an EA strobe source or an ES line of bearing, the J3.7 EW Product Information message also reports EW Fixes. An exception to this reporting method is when the source is judged to be a ground jammer; the operator must first validate this before it can be reported on the network. In this case, the transmitted J3.5 Land Point or Track message contains the ground jammer fixes.

Ground jammers are considered to be Land Points or Tracks.

♦ EW Amplification Data

The CRC can receive and forward amplification data, which is transmitted and received in J6.0 Amplification messages.

Information Management

The management of track data is essential within the Link 16 network to ensure that a consolidated surveillance picture is maintained.

Track Management

The CRC transmits the Track Management message (J7.0) on NPG 7 for several different functions, each of which is indicated by a value of the Action Code setting within the message, as described below. The CRC's tactical system will generate the appropriate Action Code for this message based on the operator's request. The J7.0 Track Management messages are transmitted on NPG 7 (Surveillance).

Drop Track Report (J7.0, Act. 0)

Any operator may, by switch action, manually drop any local track when it can no longer be supported or is no longer of interest. If a track is locally dropped, a flashing attention is placed on the track on the operational display to inform other operators that the track is in the process of being dropped.

Difference Report (J7.0, Act. 1)

When both local and remote data exist for a particular TN, and the remote unit holds R2, the CRC operator can change the ID or the Environment of the local track. Doing so triggers the transmission of a J7.0 Difference Report.

The CRC operator can change track Category and/or ID.

Change Data Order (J7.0, Act. 2)

If the CRC holds CDO authority, the operator may initiate the transmission of a J7.0 CDO. This message forces the remote unit to change his track's ID or Environment/Category. When a track is the subject of a received ID conflict, a flashing track attention on the operational display will inform the operator.

With proper authority, the CRC can issue CDOs.

■ Emergency or Force Tell Reports (J7.0, Act. 3/4)

If the operator modifies the Emergency or Force Tell status of an entity in the CRC's database, this new status is transmitted in the J7.0 Track Management message with Action Code 3 or 4, respectively. When the CRC receives Emergency or Force Tell Reports, a flashing attention is placed next to this entity on the operational display.

The CRC operator may modify Emergency and Force Tell status.

■ Strength Change Report (J7.0, Act. 5)

The CRC operator may modify the strength of a track—for example, its count or flight size—by a manual switch action. This update is then transmitted over the data links. The operator may also request a computer-estimated raid size for a track. This count, however, is held internally; it is not transmitted over the links unless manually updated as stated above.

■ Exercise Status Order (J7.0, Act. 6)

When the CRC holds the authority, the operator may initiate a global J7.0 Exercise Status Order, which is then transmitted to the Link 16 network. Whether the CRC has transmitted or received this message, it performs the following actions: all exercise tracks have their IDs reset to Friend, exercise weapons engagements are terminated, exercise Emergency Points are deleted, and wherever applicable, exercise data is reset to No Statement.

The Exercise Status Order reverts all Exercise tracks to Friends.

♦ Data Update Requests (J7.1)

The CRC operator may manually generate a J7.1 DUR, containing Action Code 1 and a TN, to be transmitted to request another JU for information concerning its points, amplification, or engagement status.

♦ Correlation (J7.2)

The CRC supports both Automatic Correlation and Restricted Correlation, but not at the same time. The CRC transmits the J7.2 Correlation message.

The CRC supports automatic correlation.

♦ Track Identifier (J7.4)

When it operates in multilink mode, the CRC maintains a Link 11/11B DLRN and a Link 16 TN (and, when needed, its NATO Track Number, or NTN) for each entity in its database. It identifies the association between these numbers on Link 16 by transmitting a J7.4 Track Identifier message for each new entity in its database.

CRC's database keeps several identifiers for each TN.

When the CRC receives a J7.4 Track Identifier message, it uses it to maintain a cross-reference between the TNs, DLRNs, and SRNs for the remote entities in its database. When it has not received a J7.4 Track Identifier message for a particular TN, however, the operator may initiate transmission of this message to request the remote unit to transmit its TN-to-DLRN-to-SRN associations.

♦ IFF/SIF Management (J7.5)

The CRC transmits the J7.5 IFF/SIF Management message to resolve IFF data differences between those sensed (or manually assigned) to a local track and those received for the subject track over Link 16. With the Action Code set to 0, this message transmits the operator-initiated Clear IFF Data order.

The operator is alerted to, and should resolve, IFF conflicts.

When an unresolved IFF Conflict is detected, the operator will see a flashing attention against the local track on the operational display. The actual IFF codes may be viewed on the TD.

♦ Filter Management (J7.6)

CRC operators may create their own Link 16 filters to reduce the volume of information communicated over the network. However, it neither transmits nor receives the J7.6 Filter Management message.

The CRC neither orders nor accepts other units' filters.

♦ Pointers (J7.3)

A CRC operator may initiate a geographical pointer on the operational display, which causes it to be transmitted to either a C2 platform or F-15 fighter in a J7.3 Pointer message. All received J7.3 Pointer messages cause the operator to be given an alert, supplemented by a large arrow on the operational display at the location of the pointer.

■ Weapons Coordination and Management

♦ Commands (J9.0)

The J9.0 Command message is transmitted only as a result of operator action. The operator may specify many parameters, such as Command Type, Target TN, Reference TN, and formal alert states. When the CRC system receives a J9.0 Command message, it alerts the weapons operator.

CRC commands require operator action.

♦ Engagement Status (J10.2)

The CRC transmits the J10.2 Engagement Status message for a controlled asset when the weapons operator assigns a mission to that asset. The CRC system will transmit the J10.2 Engagement Status message after the commit action is taken.

CRC transmits Engagement Status for controlled assets.

♦ Handover (J10.3)

The CRC issues the J10.3 Handover message to perform digital handovers. These may be either operator-initiated for a locally controlled asset, or they may be requested for a remotely controlled asset. The CRC system will also provide an alert when a handover request is received from another platform.

The operator may either initiate or request a digital handover.

♦ Controlling Unit Reports (J10.5)

The CRC periodically transmits a J10.5 Controlling Unit Report for each fighter that is under its control. It also transmits the J10.5 Terminate Control message to indicate that it has relinquished control, either by operator action or during Handover.

The CRC transmits a CUR for every fighter under its control.

♦ Pairing Status Messages (J10.6)

The CRC allows the operator to pair a controlled asset to any other point or track in its system. It reports all pairings to the C2 community by periodically transmitting them in J10.6 Pairing messages. The CRC processes the J10.6 Pairing messages it receives to allow the weapons operator to monitor a remotely initiated pairing on his local operational display.

■ Air Control

The CRC is a ground air controller, and as such, it implements the following air control functions.

♦ Mission Assignments (J12.0)

If a controlled platform is identified in the CRC system as an interceptor, the operator may initiate a mission assignment for this fighter. If the fighter is Link 16-equipped, Link 16 control is assumed, and the CRC transmits a J12.0 Mission Assignment message. The operator may commit against a remote Air, Surface, or Land/Ground track or point. The CRC system then monitors for the fighter's response. Initially, the fighter transmits an MR followed by its operator's WILCO, HAVCO, or CANTCO.

The CRC operator may initiate Mission Assignments for a fighter.

♦ Vectors (J12.1)

The CRC can transmit J12.1 Vector messages to a fighter to indicate various non-target-specific instructions from the operator. Current Tactics, Techniques, and Procedures (TTPs), however, mandate that vectors be turned off—which means that these messages do not contain actual vectoring information.

Vectors are not currently utilized.

♦ Flight Path Instructions (J12.3)

The CRC does not transmit the J12.3 Flight Path message.

♦ Controlling Unit Change Orders (J12.4)

Controlling Unit Change Orders are transmitted in the J12.4 message. The CRC can assume Link 16 control of a fighter by either of these methods:

■ As the Result of a Handover

The CRC system automatically initiates Link 16 control of a fighter after an operator accepts it during a Handover. The final stage of this process is exchanging J12.4 Control Change Orders with the fighter.

■ Commit

The operator may take a Commit switch action to take a USAF F-15 fighter under control.

♦ Extraction of Engagement Status Data from J12.6 Messages

The CRC's system also processes engagement status data from J12.6 Target Sorting messages that it has received from Link 16 fighters under its control. The operator may view new engagements, and may monitor the status of all active engagements on the operational display. The CRC reports any self-assigned missions it receives by transmitting the J10.2 Engagement Status message.

All active engagements are available to the operator.

■ Link 16 Voice

The CRC both transmits and receives Link 16 voice on NPGs 12 and 13.

■ Text Messages

The CRC operator may compose a Text message of up to 263 lines (52 characters per line) by updating a blank message skeleton in its operational display. The message is then transmitted in a J28.2(0) US National Text message.

CRC supports Free Text transmissions.

■ Threat Warning Messages

The operator may generate for transmission a J15.0 Threat Warning message against any specific TN. When the CRC receives these messages, it places an operator alert and a flashing attention on the operational display against the threatened entity.

Message		Tx	Rx
System Information Exchange and Network Management			
J0.0	Initial Entry	T	R
J0.1	Test Message	T	R
J0.2	Network Time Update	T	R
J0.3	Time Slot Assignment	T	R
J0.4	Radio Relay Control	T	R
J0.5	Repromulgation Relay	T	R
J0.6	Communications Control	T	R
J0.7	Time Slot Reallocation	T	R
J1.0	Connectivity Interrogation		
J1.1	Connectivity Status		
J1.2	Route Establishment		
J1.3	Acknowledgement		
J1.4	Communication Status		
J1.5	Net Control Initialization		
J1.6	Needline PG Assignment		
PPLI			
J2.0	Indirect Interface Unit PPLI	T	RF
J2.2	Air PPLI		R
J2.3	Surface (Maritime) PPLI		R
J2.4	Subsurface (Maritime) PPLI		R
J2.5	Land (Ground) PPLI	T	RF
J2.6	Land (Ground) Track PPLI		R
Surveillance			
J3.0	Reference Point	T	RF
J3.1	Emergency Point	T	RF
J3.2	Air Track	T	RF
J3.3	Surface (Maritime) Track	T	RF
J3.4	Subsurface (Maritime) Track	F	
J3.5	Land (Ground) Point/Track	T	RF
J3.6	Space Track		R
J3.7	EW Product Information	T	RF
ASW			
J5.4	Acoustic Bearing and Range	F	

Figure 6-13. Summary of J-series messages (continued on next page)

Message		Tx	Rx
INT			
J6.0	Intelligence Information		RF
Information Management			
J7.0	Track Management	T	RF
J7.0.0	Drop Track Report	T	R
J7.0.1	Difference Report	T	R
J7.0.2	Change Data Order	T	R
J7.0.3	Emergency Status Change	T	R
J7.0.4	Force Tell Status Change	T	R
J7.0.5	Strength Change	T	R
J7.0.6	Exercise Status Order	T	R
J7.1	Data Update Request	T	RF
J7.2	Correlation	T	RF
J7.3	Pointer	T	RF
J7.4	Track Identifier	T	RF
J7.5	IFF/SIF Management	T	RF
J7.6	Filter Management		
J7.7	Association (TBM Only)	T	RF
J8.0	Unit Designator		
J8.1	Mission Correlator Change		
Weapons Coordination and Management			
J9.0	Command	T	RF
J9.2	ECCM Coordination		
J10.2	Engagement Status	T	RF
J10.3	Handover	T	RF
J10.5	Controlling Unit Report	T	RF
J10.6	Pairing	T	RF
J10.6.1	General Pairing	T	R
J10.6.2	Strike Pairing	T	R
J10.6.3	Rendezvous	T	R
J10.6.4	Combat Air Patrol	T	R
J10.6.5	Close Air Support Pairing	T	R
J10.6.6	Return To Base Pairing	T	R
J10.6.7	Tanker Pairing	T	R

Figure 6-13. Summary of J-series messages (continued on next page)

Message		Tx	Rx
J10.6.15	Terminate Pairing	T	R
Control			
J12.0	Mission Assignment	T	R
J12.1	Vector	T	R
J12.2	Precision Aircraft Direction		
J12.3	Flight Path		
J12.4	Controlling Unit Change	T	R
J12.5	Target/Track Correlation	T	
J12.6	Target Sorting	T	R
J12.7	Target Bearing		
Platform and System Status			
J13.0	Airfield Status	T	R
J13.2	Air and Platform System Status	T	RF
J13.3	Surface (Maritime) Platform and System Status		RF
J13.4	Subsurface (Maritime) Platform and System Status		R
J13.5	Land (Ground) Platform and System Status	T	RF
EW			
J14.0	Parametric Information		
J14.2	EW Control / Coordination		
TW			
J15.0	Threat Warning	T	R
Image Transfer			
J16.0	Image Transfer	T	R
National Use			
J28.0	U.S. National 1 (USA)		
J28.1	U.S. National 2 (USN)		
J28.2	U.S. National 3 (USAF)	T	R
J28.2(0)	Text Message	T	R
J28.3	U.S. National 4 (USMC)		
J30.0	National Use (Reserved)		
Miscellaneous			
J31.0	OTAR Management		R
J31.1	OTAR	R	R
J31.7	No Statement	T	R

Figure 6-13. Summary of J-series messages (continued on next page)

Message		Tx	Rx
RTT-A	Round Trip Timing Interrogation Addressed	T	R
RTT-B	Interrogation Broadcast	T	R
RTT	Reply	T	R

Notes:

1. Abbreviations: Anti-submarine Warfare (ASW), Intelligence (INT), Amplification (AMP), Electronic Warfare (EW), Threat Warning (TW)
2. Annotations used:
   - T Transmit at least minimum message requirements
   - NT Does not transmit the message
   - NTRC Message transmitted only for Receipt/Compliance purposes
   - R Receive and interpret some parts of the message
   - NI Message not interpreted
   - NIRC Message interpreted only for Receipt/Compliance purposes
   - Rx Receive
   - Tx Transmit
   - RF Receive/Forward
   - FO Forward Only

Figure 6-13. This summary of the CRC's J-series message capabilities provides understanding of how it performs on Link 16—as well as what to expect from the CRC if you are an operator aboard another Link 16 platform.

Section F

Air and Space Operations Center

The AN/USQ 163 Falconer AOC weapon system is the senior C2 element of a TACS and the operational-level focal point for C2 of air and space forces during Air Force, Joint, and Coalition operations. The Falconer AOC weapon system includes personnel, equipment, and interfaces to other AF C2 centers to ensure the effective conduct of air and space operations. The Falconer AOC weapon system is provided by the Air Force Forces (AFFOR) and employed by the Commander, Air Force Forces (COMAFFOR) when designated as a Joint or Combined Force Air Component Commander (JFACC or CFACC), or when executing air and space operations and no JFACC or CFACC is designated. The Falconer AOC may be tailored in size to meet the COMAFFOR's requirements. The five divisions within the AOC are:

- **Strategy Division (SD)**, which provides long-range planning and guidance
- **Combat Plans Division (CPD)**, which provides current operational planning
- **Combat Operations Division (COD)**, which executes air and space operations
- **Intelligence, Surveillance, and Reconnaissance Division (ISRD)**, which provides Intelligence, Surveillance, and Reconnaissance (ISR) support to entire AOC, and
- **Air Mobility Division (AMD)**, which provides inter- and intratheater airlift and Air Refueling (AR) planning, execution, and support.

The AOC is the USAF's senior C2 element.

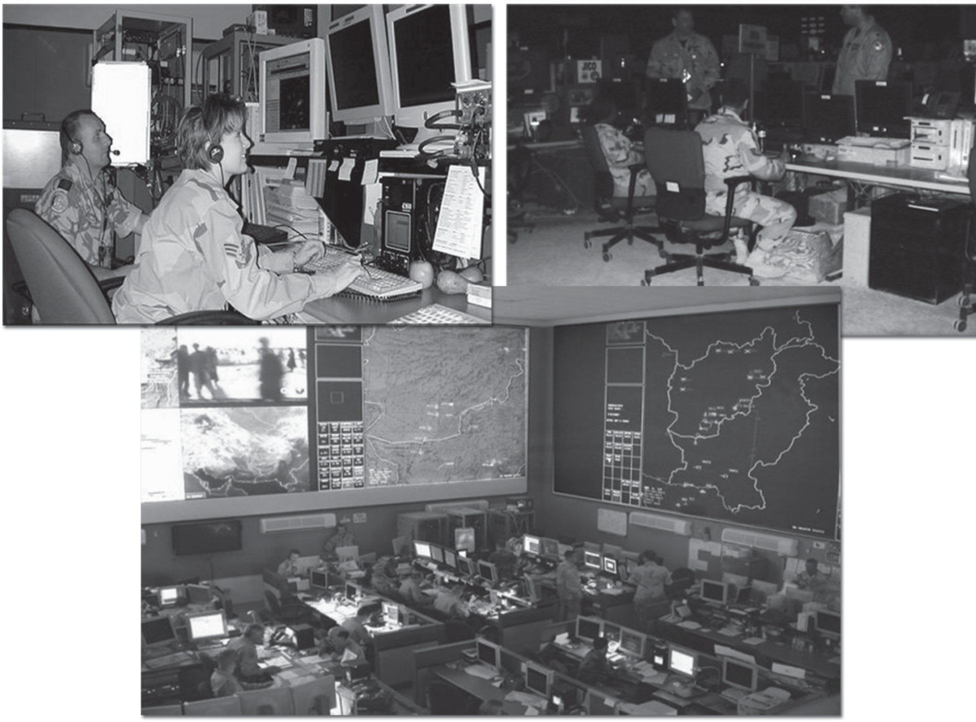


Figure 6-14. The Air and Space Operations Center (AOC) is the USAF's primary ground-based theater air control element. It is equipped to provide the planning, coordinating, deconflicting, and directing functions for theater air operations.

Mission

The AOC provides operational-level C2 of air and space forces as the focal point for planning, directing, and assessing air and space operations. Although the Air Force provides the core manpower for the AOC, other Service components provide personnel in support of exercises and contingency operations. To integrate the numerous aspects of air and space operations and accomplish its mission, the AOC coordinates closely with superior and subordinate C2 nodes, as well as with the headquarters of other functional and Service component commands.

The AOC is also the senior element of a TACS, which is composed of both airborne and ground-based C2 elements. Its airborne elements (AETACS) are AWACS and JSTARS. Its ground elements (GTACS) are the AOC, CRC, Air Support Operations Center (ASOC), and the Tactical Air Control Party (TACP). To effectively integrate the TACS elements, the AOC develops and establishes theater-wide guidance through the following documents and messages:

- The Joint Air Operations Plan (JAOP)
- The Air Operations Directive (AOD)
- The Air Defense Plan (ADP)
- The Airspace Control Plan (ACP)
- The Airspace Control Order (ACO)
- The Air Tasking Order Special Instructions (SPINS)
- The Tactical Operations Data (TACOPDAT), and
- The Operational Tasking Data Links (OPTASK LINK).

These documents provide overarching direction to the TACS elements by defining roles, responsibilities, and authorities for decentralized execution. Each of the TACS elements serves the C2 and Battle Management (BM) needs of the Joint Warfighter with unique capabilities and flexibility. Each system has been developed and refined for particular and complementary functions.

The primary functions of the AOC are to

- Develop air and space operations strategy and planning documents integrating air, space and information operations (IO) to meet JFACC operational objectives and guidance
- Task, execute, and assess day-to-day air and space operations
- Provide rapid reaction, positive control, and coordinate and deconflict kinetic and nonkinetic weapons (WPNs) employment, as well as integrate total air, space, and information effort
- Receive, assemble, analyze, filter, and disseminate all-source intelligence and weather (WX) information to support air and space operations planning, execution and assessment
- Issue airspace control procedures and coordinate airspace control activities for the airspace control authority (ACA) when the JFACC is designated the ACA
- Provide overall direction of air defense, including theater missile defense (TMD), for the area air defense commander (AADC) when the JFACC is designated the AADC
- Plan, task, execute, and assess the theater ISR mission
- Conduct operational-level assessment to determine mission and overall air, space, and IO effectiveness as required by the JFC to support the theater assessment effort
- Produce and disseminate an Air Tasking Order (ATO) and changes, and
- Integrate intertheater air mobility support into the theater air mobility operation.

Location

AOCs are located worldwide in support of exercises and contingency operations. AOCs can be Falconer AOCs, tailored AOCs, or other types and configurations that support various AOC duties and responsibilities.

The AOCs located throughout the world fulfill a variety of missions.

Falconer AOCs (Combat Air Operations)

The Falconer AOCs, which support combat air operations, are located at

- Air Force Central (AFCENT) at Al Udeid, Qatar
- Air Force Europe (AFEUR) at Ramstein Air Base (AB), Germany
- Air Force Republic of Korea (AFROK) at Osan AB, ROK
- Air Force Pacific (AFPAC) at Hickam AFB, Hawaii, and
- Air Force South (AFSOUTH) at Davis-Monthan AFB, Tucson, Arizona.

Tailored AOCs (Specialized Missions)

The tailored AOCs support specialized missions. These are located with the following commands:

- Air Force North (AFNORTH) at Tyndall AFB, Florida, in support of Homeland Defense
- Air Force Special Operations Forces (AFSOF) at Hurlburt Field, Florida, in support of Special Operations
- Air Force Strategic Command (AFSTRAT) at Barksdale AFB, Louisiana, in support of Global Strike, and
- The Alaska AOC at Elmendorf AFB, Alaska, in support of Homeland Defense.

Functional AOCs

The functional AOCs provide command and control for certain operations:

- Air Force Space Command (AFSPC) at Vandenberg AFB, California, providing command and control of Space operations
- Tanker Airlift Control Center (TACC) at Scott AFB, Illinois, providing command and control of Air Mobility.

AOC Air Mobility Division Augmentation

The following AMC units provide personnel trained in AOC operations that will deploy to augment a Falconer or tailored AOC:

- 15th Air Mobility Operations Center (AMOS) at Travis AFB, California
- 21st AMOS at McGuire AFB, New Jersey.

AOC Manpower Augmentation

The following Air and Combat Operations units provide personnel trained in AOC operations that will deploy to augment a Falconer or tailored AOC:

- 112th Air Operations Squadron (AOS) at State College, Pennsylvania
- 152nd Air Operations Group (AOG) at Syracuse, New York
- 157th AOG at St Louis, Missouri
- 701st Combat Operations Squadron (COS) at March, California
- 710th COS at Langley, Virginia.

AOC Support

Finally, certain AOCs exist to support other AOCs worldwide. These units are:

- CAOC-X at Langley AFB, Virginia, which performs integration, testing and assessment
- The AOC Help Desk at Langley AFB, Virginia, which provides technical support
- The AOC Formal Training Unit at Hurlburt Field, Florida, which provides training
- CAOC-N at Nellis AFB, Nevada, which provides advanced training
- Warfighting Headquarters (WFHQ) Operations Support Center, at a location to be determined.

Description

The AOC is staffed by the **Interface Control Team** (ICT). This team, through the **Interface Control Officer** (ICO), is responsible to the Combat Control Officer (CCO), or Senior Air Defense Officer (SADO) designated by the CCO, for TDL interface management functions. The ICO directs the team, based on guidance from the AADC and the OPLAN, to determine the specific data link participants, their equipment capabilities and limitations, and their respective needs. When these have been compiled, the ICO assists C2 in planning the design of the data link architecture and the production of the OPTASK LINK.

During employment, the ICO, through the ICT, ensures optimum data link connectivity by monitoring the data link and directing changes as necessary. The ICT

- Manages the data link network
- Provides the CFACC or JFACC with a consolidated and accurate air picture
- Provides direction to attached units relative to alert status
- Produces and maintains the Recognized Air Picture (RAP) by managing the pictures produced by subordinate C2 units
- Coordinates the Operations Common Operational Picture (COP) with the Manager for the air component input to the COP
- Builds and disseminates the multi-TDL air picture used to support situational awareness for combat operations and for exchange of digital messages
- Provides multi-TDL connectivity for machine-to-machine interoperability, in support of J-series message exchange for dynamic targeting and prosecution of dynamic target and TST operations
- Develops and executes the TDL architecture
- Develops the Global Command and Control System (GCCS) COP, and
- Manages surveillance operations.

The AOC baseline data link capabilities include Link 16, Satellite Link 16 (SAT-J), Serial J, Socket J, and JREAP A/B/C, as well as Link 11. The AOC is also the primary integrator of the air Common Tactical Picture into the Combatant Commander's General Service Secret COP on Global Command and Control System with Link 16 (GCCS-J). The AOC can participate in both Link 11 and Link 16 networks, either separately or concurrently.

Equipment Configuration

AOCs are equipped with the Air Defense Systems Integrator (ADSI®), the Joint Range Extension Transparent Multiple Platform Gateway (the "JRE Gateway"), PRC-117/PSC-5 UHF radios, and the MIDS LVT-11 Link 16 terminal.

The interconnection to the Link 16 network for both these applications is provided by the AN/TSQ-214, which is also known as the ADSI®. The ADSI® acts as the front-end communications processor for transmitting, receiving, translating, and forwarding Link 11, Link 11B, Link 16, and intelligence data. The ADSI® ex-changes data in Link 16 format, and does not forward data received on the intelligence links. It also monitors and controls the Link 16 terminal.

The AOC's RF Link 16 front end is the JRE.

The AOC Baseline design includes a direct connection from a JTIDS Class 2 terminal to the JRE as part of the Communications Enhacement Package. Additionally, some AOCs may have radio frequency (RF) Link 16 capability from the AOC itself utilizing MIDS LVT-2 or LVT-11 terminals connected to a JRE.

Link 16 Implementation

Network Management Messages

Initial Entry and Time Synchronization Messages

The AOC transmits J0.0 Initial Entry message on NPG 1, once in every frame, in time slot A-0-6, to allow other platforms to join the network when initialized as the NTR. When it is initialized as an Initial Entry JU (IEJU), it transmits the J0.0 message every other frame.

♦ Time Slot Assignment

TSA, or the ability to amend the transmit and receive time slot assignments for another unit, is provided by a TD that allows an operator to formulate J0.3 TSA messages. These messages contain the new transmit/receive TSBs for other units.

AOC can assign and reassign time slots.

♦ Relay Functions

The AOC can transmit and receive the J0.4 Radio Relay Control and the J0.5 Repromulgation Relay messages.

♦ Over-the-Air Rekeying

The AOC can receive the J31.0 OTAR Management and the J31.1 OTAR messages.

■ PPLI and Platform Status Messages

♦ PPLI Information

The AOC transmits its own PPLI as a J2.5 Ground PPLI message. It receives the J2.0 Indirect IU, the J2.2 Air, the J2.3 Surface (Maritime), and J2.5 Land/Ground PPLI messages.

The AOC PPLI is contained in the J2.5 message.

♦ Platform Status Information

The AOC can receive and display Link 16 JU Platform Status information for Air Platforms (J13.2), Surface (Maritime) Platforms (J13.3), and Land Platforms (J13.5).

AOC can process Platform Status for many unit types.

The AOC transmits its own unit platform status in the J13.5 Air Platform and System Status message, in its PPLI time slot on NPG 6. When it does, it replaces the AOC PPLI for that frame. Note that none of the information contained in the AOC Platform Status message is from an automated source; instead, all its data derives from operator inputs or from terminal initialization.

Look for the AOC's own unit Platform Status messages in its PPLI time slot, about every 3.2 minutes!

♦ Airfield Status Information

The AOC does not implement the J13.0 Airfield Status message.

■ Surveillance, Amplification, and Electronic Warfare Messages

♦ Tracks

AOC reports its Air and Surface tracks in the J3.2 Air Track and J3.3 Surface (Maritime) Track messages on NPG 7 (Surveillance).

AOC automatically transmits operator-initiated tracks.

♦ Points

The AOC operator can define and transmit J3.1 Emergency Point messages, as well as a wide range of J3.0 Reference Point messages. These points are transmitted on NPG 7 and are displayed as symbols on the situation display. The operator may view additional information associated with local and remote points on a TD.

The operator can initiate Emergency and Reference Points.

AOC also transmits J3.5 Land and Ground Point messages on NPG 7.

♦ Lines and Areas

AOC does not receive or process Reference Lines and Areas from J3.0 messages.

AOC does not understand Reference Lines and Areas.

■ Information Management

The management of track data is essential within the Link 16 network to ensure that a consolidated surveillance picture is maintained.

♦ Track Management

AOC transmits the J7.0 Track Management message on NPG 7 for several different functions, each of which is indicated by a value of the Action Code setting within the message. The J7.0 Track Management messages are transmitted on NPG 7 (Surveillance).

Track Management messages are transmitted in NPG 7, Surveillance.

■ Drop Track Report (J7.0, Act. 0)

The operator can drop local and remote tracks.

■ Difference Report (J7.0, Act. 1)

The operator can initiate Difference reports on tracks.

The operator can challenge a remote track's Category or ID.

■ Change Data Order (J7.0, Act. 2)

With the proper authority, AOC can issue the CDO.

Emergency and Force Tell Reports (J7.0, Act. 3/4)

The AOC operator may modify Emergency and Force Tell status.

Strength Change Report (J7.0, Act. 5)

The AOC operator may modify the Strength of a track—for example, its count or flight size—by a manual switch action. This update is then transmitted over the data links.

The AOC operator can challenge a remote track's strength.

Exercise Status Order (J7.0, Act. 6)

The Exercise Status Order, which reverts all Exercise tracks to Friends, can be initiated by the AOC operator.

Data Update Requests

The operator can transmit and receive DURs.

Correlation (J7.2)

AOC supports neither Automatic Correlation nor Restricted Correlation. The only way AOC can correlate a local and remote track is by operator action. The operator may specify which TN is to be retained and whether the correlation is reversible. If the two tracks then pass a series of parameter checks, the correlation is transmitted onto the link in the J7.2 Correlation message. If no rejection is received within a certain time, the correlation proceeds, and the tracks are merged.

AOC does not support automatic correlation.

♦ Track Identifier

The AOC can transmit and receive the J7.4 Track Identifier message for each entity in its database.

The AOC database keeps several identifiers for each TN.

♦ IFF/SIF Management

AOC transmits and receives the J7.5 IFF/SIF Management message to resolve IFF data differences between those sensed (or manually assigned) to a local track and those received for this track over Link 16. With the Action Code set to 0, this message transmits the operator-initiated Clear IFF Data order.

The operator is alerted to, and should resolve, IFF conflicts.

When an unresolved IFF conflict is detected, the operator will see a flashing attention against the local track on the situation display. The actual IFF codes may be viewed on the TD.

♦ Filter Management

To reduce the volume of information communicated over the network, the AOC operator may create Link 16 filters. Those that he subsequently enables, however, will not be transmitted to other units for review.

AOC neither orders nor accepts other units' filters.

AOC does not have the capability to enable filters that are defined by another unit, or request that another unit implement an AOC-defined filter. Therefore, it discards all Filter Implementation requests (J7.6 with Action Code 0) received from the Link 16 network.

♦ Pointers

Any AOC mission operator may initiate a geographical pointer on the situation display, which causes it to be transmitted to either a C2 platform or an F-15 fighter in a J7.3 Pointer message. AOC may also specify the type of operator (for example, Surveillance or Weapons) to which the pointer is displayed aboard the addressed unit.

The operator may direct a pointer to a specific operator aboard another platform.

All received J7.3 Pointer messages cause the operator concerned to be given a text alert, supplemented by a large arrow on the situation display at the location of the pointer.

AOC may now send a Target Sorting pointer to a Navy fighter.

The AOC operator may now initiate a J12.6 Target Sorting pointer for transmission to USN fighter aircraft. Only one fighter aircraft may be addressed at a time. The AOC operator receives no feedback on the location or past recipient of the pointer.

■ Weapons Coordination and Management

To successfully manage a complex battle situation, the coordination of assets and tasking between C2 platforms is of paramount importance.

♦ Commands

The AOC implementation of the J9.0 Command message is fairly extensive, and to describe fully the individual command values that may be used in the message is beyond the scope of this guidebook. We do describe, however, the operator interface associated with Command communication between C2 platforms. The AOC operator may view the details of all commands—both transmitted and received, as well as their responses—on the TDL J Commands TD.

■ Transmitting a Command

The J9.0 Command message is transmitted only as a result of operator action at a senior director, weapons, or battle staff console. The operator may specify many parameters, such as Command Type, Target TN, Reference TN, and formal alert states. The system uses these parameters to build the message for transmission on the Link 16 network.

■ Receiving a Command

When the AOC system receives a J9.0 Command message, it alerts the battle staff and weapons operators, who may then view a TD for the message's specific details.

The Battle Staff and Weapons section are automatically alerted on receipt of a command.

♦ Engagement Status

AOC transmits the J10.2 Engagement Status message for a controlled asset in either of the two following situations discussed in the subparagraphs below.

■ Mission Assignment

The weapons operator can assign a mission to a controlled asset, whether it is controlled by voice or over Link 16. AOC will transmit the J10.2 Engagement Status message after the commit action is taken.[3]

■ Self-assigned Mission

When a fighter is under the AOC's Link 16 control, receiving a J12.6 Target Sorting message containing the fighter's Engagement Status value initiates his engagement record in the AOC's database. AOC subsequently reports his engagement status to the C2 community with J10.2 Engagement Status messages.

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3 *The Commit action is discussed below, under Air Control.*

♦ Handover

Digital handover is performed by transmitting the J10.3 Handover message. Handovers may be either operator-initiated for a locally controlled asset, or they may be requested for a remotely controlled asset. The AOC system will also provide an alert when a handover request is received from another platform. The operator's response to the J10.3 Handover request generates the appropriate Receipt/Compliance message.

Fighter engagement status is tracked in the AOC database.

♦ Controlling Unit Reports

AOC periodically transmits and receives a J10.5 CUR for each fighter that is under its control, either an RCT or an RCN. AOC also transmits the J10.5 Terminate Control message to indicate that it has relinquished control, either by operator action or during Handover.

The operator may either initiate or request a digital handover.

Received CURs may be viewed on a TD, thus allowing the operator to monitor the controlling agency for other weapons assets.

AOC transmits a CUR for every unit under its control.

♦ Pairing Status Messages

AOC allows the operator to pair a controlled asset to any other point or track in the system. It reports all pairings to the C2 community by periodically transmitting them in J10.6 Pairing messages. AOC processes the J10.6 Pairing messages it receives to allow the weapons operator to monitor a remotely initiated pairing on his local situation display.

The operator may pair his fighter to any TN.

■ Air Control

♦ Mission Assignments

If a controlled platform is identified in the AOC system as an RCT weapons track, the operator may initiate a mission assignment for this fighter. By switch action, the operator specifies fighter type. If the fighter is Link 16-equipped, Link 16 control is assumed, and AOC transmits a J12.0 Mission Assignment message. As part of the switch action, the operator also specifies the mission type, and this dictates which MAD value is transmitted in the message.

Operators initiate Mission Assignments for RCT fighters.

AOC can transmit the Attack MAD when committed against a Hostile Land/Ground Point or Track. The operator may commit against a remote Air, Surface, or Land/Ground track only if a local or Monitor track association is in effect. A Commit can be performed against a local or remote Land/Ground point, however, without a Monitor track association.

AOC does not fully exploit Link 16's air control capabilities.

The AOC system then monitors for the fighter's response. Initially, the fighter transmits an MR, followed by its operator's R/C, which contains either a WILCO, HAVCO, or CANTCO. If one of these responses is not received within a certain period of time, AOC alerts the weapons operator with a flashing attention against the fighter's track on his situation display. The weapons operator is informed of the response received from the fighter operator on a TD and by an attention against the track on the situation display.

The system automatically monitors for MRs and receipt compliance.

♦ Vectors

AOC is capable of transmitting J12.1 Vector messages to a fighter to indicate various non-target-specific instructions from the operator. Current tactics, techniques, and procedures (TTPs), however, limit the operational use of vectors. The AOC system monitors for the fighter's response, which must be either WILCO, HAVCO, or CANTCO, to the operator's instructions.

AOC vector transmission is limited.

♦ Flight Path Instructions

AOC does not transmit the J12.3 Flight Path message.

AOC does not support Flight Path instructions.

♦ Controlling Unit Change Order

Controlling Unit Change Orders are transmitted in the J12.4 message. AOC can assume Link 16 control of a fighter by either of the methods discussed below.

■ As the result of a Handover

The AOC system automatically initiates Link 16 control of a fighter after an operator accepts it during a Handover. The final stage of this process is exchanging J12.4 Control Change Orders with the fighter.

■ Commit

The operator may take a Commit switch action to take a USAF F-15 fighter under control, without transmitting a J12.4 Control Change message.

AOC can also control Navy and RAF fighters.

♦ Extracting Engagement Status Data from J12.6 Messages

The AOC mission system also processes engagement status data from J12.6 Target Sorting messages that it receives from Link 16 fighters under its control. The operator may view new engagements, and may monitor the status of all active engagements on a TD. AOC reports any self-assigned missions it receives to other C2 platforms by transmitting the J10.2 Engagement Status message.

All active engagements are available to the operator.

♦ Mission Assignment Messages—High Interest Tracks

AOC can transmit the J12.0 Mission Assignment message to a fighter under Link 16 control via a locally controlled RCT. This is used chiefly to identify High Interest Tracks, for which the system creates an attention display in the track block for any track designated as high interest.

AOC can now indicate High Interest TNs.

■ Link 16 Voice

The AOC currently does not have Link 16 Voice capability.

■ Text Messages

J28.2(0) Text messages will be transmitted and received from the AOC Combat Operations Division Interface Control Cell via the JRE or the ADSI®. Care must be taken during network planning, so that whatever platform or gateway the AOC links to via MIL-STD-3011 has RF transmit and receive capability to ensure that J28.2(0) messages are forwarded to and from the AOC onto Link 16.

AOC supports Free Text transmissions.

■ Image Transfer

AOC transmits and receives the J16.0 Image Transfer message. AOC can send and receive J16.0 images and may annotate the image, crop the image, and specify up to seven ROIs to apply different compression levels within the operator-specified ROIs. The images can be sent and received as grayscale or color. They can be addressed to an individual TN or broadcast, using either JPEG or Eagle Eye compression. Images can be sent using either one-way or two-way image transmission protocol.

■ Threat Warning Messages

The operator may generate for transmission a J15.0 Threat Warning message against any specific TN. When AOC receives these messages, it places an operator alert and a flashing attention on the situation display against the threatened entity.

The operator may initiate and observe Threat Warnings.

Message		Tx	Rx
System Information Exchange and Network Management			
J0.0	Initial Entry	T	R
J0.1	Test Message	T	R
J0.2	Network Time Update	T	R
J0.3	Time Slot Assignment	T	R
J0.4	Radio Relay Control	T	R
J0.5	Repromulgation Relay	T	R
J0.6	Communications Control	T	R
J0.7	Time Slot Reallocation	NT	NI
J1.0	Connectivity Interrogation	NT	NI
J1.1	Connectivity Status	NT	NI
J1.2	Route Establishment	NT	NI
J1.3	Acknowledgement	NT	NI
J1.4	Communication Status	NT	NI
J1.5	Net Control Initialization	NT	NI
J1.6	Needline PG Assignment	NT	NI
PPLI			
J2.0	Indirect Interface Unit PPLI	NT	R
J2.2	Air PPLI	NT	R
J2.3	Surface (Maritime) PPLI	NT	R
J2.4	Subsurface (Maritime) PPLI	NT	NI
J2.5	Land (Ground) PPLI	T	R
J2.6	Land (Ground) Track PPLI	NT	NI
Surveillance			
J3.0	Reference Point	T	R
J3.1	Emergency Point	T	R
J3.2	Air Track	T	R
J3.3	Surface (Maritime) Track	T	R
J3.4	Subsurface (Maritime) Track	NT	NI
J3.5	Land (Ground) Point/Track	T(1)	R
J3.6	Space Track		R
J3.7	EW Product Information	T	R
ASW			
J5.4	Acoustic Bearing and Range	NT	NI
AMP			
J6.0	Amplification Information	T	R
Information Management			
J7.0	Track Management	T	R

Figure 6-15. AOC transmit and receive messages (continued on next page)

Message		Tx	Rx
J7.1	Data Update Request	T	R
J7.2	Correlation	T	R
J7.3	Pointer	T	R
J7.4	Track Identifier	T	R
J7.5	IFF/SIF Management	T	R
J7.6	Filter Management	NI	NI
J7.7	Association	NT	R
J8.0	Unit Designator	NT	NI
J8.1	Mission Correlator Change	NT	NI
Weapons Coordination and Management			
J9.0	Command	T	R
J9.1	Engagement Coordination	NT	NI
J9.2	ECCM Coordination	NT	NI
J10.2	Engagement Status	T	R
J10.3	Handover	T	R
J10.5	Controlling Unit Report	T	R
J10.6	Pairing	T	R
Control			
J12.0	Mission Assignment	T	NIRC
J12.1	Vector	T	NIRC
J12.2	Precision Aircraft Direction	NT	NI
J12.3	Flight Path	NT	NI
J12.4	Controlling Unit Change	T	NIRC
J12.5	Target/Track Correlation	NT	NI
J12.6	Target Sorting	T	R
J12.7	Target Bearing	NT	NI
Platform and System Status			
J13.0	Airfield Status	NT	NI
J13.2	Air and Platform System Status	NT	R
J13.3	Surface (Maritime) Platform and System Status	NT	R
J13.4	Subsurface (Maritime) Platform and System Status	NT	NI
J13.5	Land (Ground) Platform and System Status	T	R
EW			
J14.0	Parametric Information	NT	NI
J14.1	Database Transfer	NT	NI
J14.2	EW Control / Coordination	NT	NI

Figure 6-15. AOC transmit and receive messages *(continued on next page)*

Message		Tx	Rx
TW			
J15.0	Threat Warning	T	R
Image Transfer			
J16.0	Image Transfer	T	R
National Use			
J28.0	National Messages (J28.2(0) Only)	T	R
J28.2	Text Message	T	R
J28.7	UK National 1	T	R
J29.0	Spoke Report	NT	NT
Miscellaneous			
J31.0	OTAR Management	NTRC	R
J31.1	OTAR	NTRC	R
J31.7	No Statement	T	R
RTT-A	Round Trip Timing Interrogation Addressed	T	R
RTT-B	Interrogation Broadcast	T	R
RTT-R	Round Trip Timing Replay	T	R

Notes:

1. Abbreviations: Anti-submarine Warfare (ASW), Amplification (AMP), Electronic Warfare (EW), Threat Warning (TW)
2. Annotations used:
   - T Transmit at least minimum message requirements
   - NT Does not transmit the message
   - NTRC Message transmitted only for Receipt/Compliance purposes
   - R Receive and interpret some parts of the message
   - NI Message not interpreted
   - NIRC Message interpreted only for Receipt/Compliance purposes
   - Rx Receive
   - Tx Transmit
   - (1) Points Only

Figure 6-15. Examining AOC' transmit and receive message capabilities provides understanding of how the AOC performs on Link 16—as well as what to expect from AOC if you are an operator aboard another Link 16 platform.

Section G

F-15 Eagle and F-15E Strike Eagle

The first F-15A flight was made in July 1972, followed by the first flight of the two-seat F-15B trainer, formerly the TF-15A, in July 1973. Delivery of the F-15B to the USAF was made in November 1974, with the first Eagle destined for a combat squadron to be delivered in January 1976.

The single-seat F-15C and the two-seat F-15D models entered the Air Force inventory beginning in 1979. The F-15 Multi-Stage Improvement Program (MSIP) was initiated in February 1983, with the first production of the MSIP F-15C produced in 1985. Improvements included an upgraded central computer; a programmable armament control set that allowed for advanced versions of the AIM-7, AIM-9, and AIM-120A missiles; an expanded tactical EW system that provides improvements to the ALR-56C radar warning receiver and ALQ-135 countermeasure set; and cabling for future integration of Link 16 capability.

The F-15 has been deployed in theaters of war since 1991.

F-15C, D, and E models were deployed to the Persian Gulf in 1991, in support of Operation Desert Storm, where they proved their superior combat capability. F-15C fighters accounted for 34 of the Air Force's 37 air-to-air victories. The ground attack variants, F-15E Strike Eagles, were operated mainly at night, hunting SCUD missile launchers and artillery sites using their Low-Altitude Navigation and Targeting Infrared, Night (LANTIRN) systems.

The JTIDS Class 2 was originally installed aboard one squadron of F-15Cs.

In the 1980s, the USAF identified a requirement for the JTIDS Class 2 terminal aboard F-15Cs. This requirement was deleted in 1989, due in part to poor reliability during testing, and in part to cost. In 1992, the ACC initiated a fresh look at data link in fighters with a project at Mountain Home AFB, Idaho. Known as the JTIDS

Operational Special Project (OSP), it involved integrating JTIDS Class 2 terminals into F-15C aircraft. The Class 2 terminal was chosen because it was just coming off the production line; the F-15C was chosen because the host software to support JTIDS was already completed and ready for release. This OSP, conducted from September 1993 until April 1997, involved day-to-day operational missions flown by the 390th Fighter Squadron at Mountain Home AFB, Idaho, and the 422nd Test and Evaluation Squadron (TES) at Nellis AFB, Nevada.

The current F-15 versions are the F-15A-D and the F-15E Strike Eagle.

In 1994, an early interoperability demonstration was conducted at Mountain Home AFB as part of the OSP. The three-week demonstration involved the Mountain Home F-15s, the USAF E-3, as well as UK F-3s, UK E-3D, USN E-2C, and USN F-14s. The 422nd TES used JTIDS in several major tests, and these test results also contributed to the project. The OSP was a resounding success, and it formed the basis for an Air Force decision to put Link 16 in most of its aircraft by 2005.

Mission

The F-15 Eagle is an all-weather, extremely maneuverable, tactical fighter designed to permit the Air Force to gain and maintain air superiority in aerial combat. The Eagle's air superiority is achieved through a mixture of unprecedented maneuverability and acceleration, range, weapons, and avionics. The F-15's superior maneuverability and acceleration are achieved through high engine thrust-to-weight ratio and low wing loading, which allow it to turn tightly without losing airspeed.

The F-15 can penetrate enemy defense and can outperform and outfight any current enemy aircraft. It carries electronic systems and weaponry to detect, acquire, track, and attack enemy aircraft while operating in friendly or enemy-controlled airspace. The weapons and flight control systems are designed so that one person can safely and effectively perform air-to-air combat.

Figure 6-16. The F-15 Eagle is the USAF's premier air superiority fighter that can perform multiple roles. The E model, called the Strike Eagle, is especially suited to ground attack missions.

Location

Because they are the most capable aircraft in the world, it is understandable for F-15s to be stationed worldwide. ACC-owned F-15s are located at Langley AFB, Virginia (1st FW), Eglin AFB, Florida (33rd FW), and Mountain Home AFB, Idaho (366th WG). In addition to these air-to-air variants, ACC stations Strike Eagles at Mountain Home AFB and Seymour-Johnson AFB, North Carolina (4th FW). In support of NATO, F-15s and Strike Eagles are stationed at Royal Air Force (RAF) Lakenheath, England (48th FW). The Pacific Rim is supported by F-15s at Elmendorf AFB, Alaska (3rd FW) and Kadena AB, Japan (18th WG). Finally, various ANG F-15 units are spread throughout the United States, tasked principally with the mission of CONUS Air Defense. All variants of the F-15 have fulfilled ongoing requirements in support of Operation Enduring Freedom (OEF), Operation Iraqi Freedom (OIF), and Operation Noble Eagle.

Description

A multimission avionics system sets the F-15 apart from other fighter aircraft. It includes a heads-up display, advanced radar, inertial navigation system, flight instruments, UHF and VHF communications, tactical navigation system, and instrument landing system. It also carries an internally mounted, tactical EW system, IFF system, electronic countermeasures set, and a central digital computer. The F-15's EW system provides both threat warning and automatic countermeasures against selected threats.

The heads-up display and Joint Helmet Mounted Cueing System (JHMCS) project the essential flight and tactical information gathered by the integrated avionics system. These displays, which are visible in any light condition, provide the pilot with the data necessary for tracking and destroying an enemy aircraft without having to look down at cockpit instruments.

The F-15's versatile pulse-Doppler radar system can look up at high-flying targets and down at low-flying targets without being confused by ground clutter. It can detect and track aircraft and small, high-speed targets at distances from beyond visual range down to close range, and at altitudes down to treetop level. The radar feeds target information into the central computer for effective weapons delivery. For close-in dogfights, the radar automatically acquires enemy aircraft, and this information is projected on the heads-up display.

A variety of air-to-air weaponry can be carried by the F-15. An automated weapon system enables the pilot to perform aerial combat safely and effectively, using the heads-up display and the avionics and weapons controls located on the engine throttles or control stick. When the pilot changes from one weapon system to another, visual guidance for the required weapon automatically appears on the heads-up display.

The Eagle can be armed with combinations of four different air-to-air weapons: AIM-120 advanced medium-range air-to-air missiles on its lower fuselage corners, AIM-9L/X Sidewinder or AIM-120 missiles on two pylons under the wings, and an internal 20-mm Gatling gun in the starboard wing root.

The F-15E Strike Eagle is a two-seat, dual-role, totally integrated fighter for all-weather, air-to-air, and deep interdiction missions. The rear cockpit is upgraded to include four multipurpose displays for managing aircraft systems and weapons. The digital, triple-redundant Lear Siegler flight control system permits coupled automatic terrain following, enhanced by a ring-laser gyro inertial navigation system (INS). For low-altitude, high-speed penetration and precision attack on tactical targets at night or in adverse weather, the F-15E carries a high-resolution APG-70 radar and low-altitude navigation and targeting infrared for night pods.

Low-drag, conformal fuel tanks were specially developed for the F-15E model. These tanks, which are attached to the sides of the engine air intake trunks under each wing, are designed to the same load factors and airspeed limits as the basic aircraft. Each fuel tank contains over 600 gallons of fuel, reducing the need for in-flight refueling on global missions and increasing loiter time in the combat area. The tanks also provide multiple stations for air-to-ground munitions in addition to the full array of air-to-air weapons.

Equipment Configuration

The FDL terminal, aka MIDS LVT-3, is now installed aboard F-15Cs and F-15Es. FDL provides the same operational capabilities as the previously used JTIDS Class 2, but at reduced cost. The cost reduction is achieved by using many commercial parts, reducing the power requirement, and removing the JTIDS secure voice and TACAN functions. These F-15s instead retain their original F-15 TACAN, but they have no Link 16 secure voice capability.

The FDL terminal, without secure voice, is installed aboard F-15C and F-15E.

The exchange of friendly position and status information with radar targets on Link 16 contributes to mission effectiveness in several ways. The display of flight members and other friendlies aids mutual support, and assists in the execution of tactics, a benefit that is enhanced during night and adverse weather operations. The exchanges of radar targets and lock lines, and the onboard correlation of air targets by each F-15, provide a common radar picture among the flight as well as a picture of the flight members' targeting, both of which lead to more efficient targeting and weapons employment. The display of Friend IDs and primary designated targets (PDTs) can also reveal the inadvertent targeting of friendlies, thus reducing the potential for fratricide. Ground object information and engagement instructions may be passed digitally and loaded directly into other aircraft sensors and weapon systems, an especially useful capability for finding mobile time-critical targets.

Link 16 is a great benefit to the F-15!

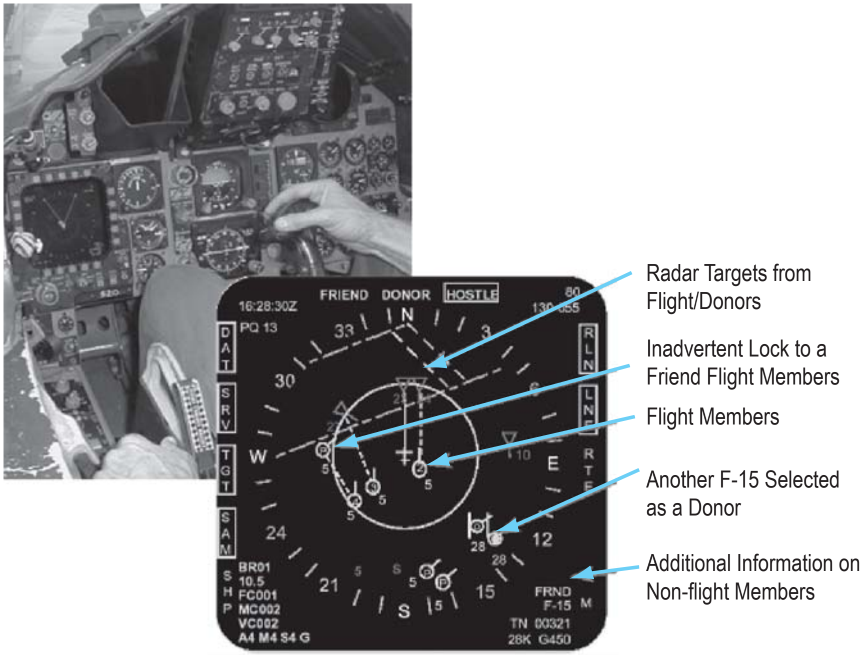

Figure 6-17. The F-15's multipurpose cockpit display (MPCD) allows the pilot to reference target and flight data. The upper photograph shows its location in the cockpit. The lower photograph displays flight members and radar targets, with circles representing flight members and friends, and triangles representing potential targets.

■ Features of the F-15C Display

Ownship position in Figure 6-15 is shown in blue in the center of the multipurpose cockpit display (MPCD). In this figure's upper right-hand corner, the current range selection of 80 nm denotes the range from ownship to the compass rose. Bearing and range from Ownship to the ACQ symbol is just below this. Zulu time is shown in the upper left-hand corner, with navigation Q_p just below it. Pilot display options are shown in boxes on the left and right of the display.

The two types of information that are automatically exchanged among F-15s can be shown on this display:

- **Flightmember position and status reports** are represented on the display with round blue symbols with flight position inside, and other link-equipped friendlies shown as round green symbols with a "P" (for participant) or a dot inside. These symbols have vector sticks indicating their direction of flight. Additional information from the position and status reports, including call sign, fuel, armament, and net numbers, can be viewed in the lower left-hand and right-hand corners by placing the ACQ symbol over the aircraft symbol.
- **Radar target reports** are automatically transmitted by each F-15. Each can also display targets from up to three other flight members and four selected "donors" chosen by the pilot. The central computer prioritizes and correlates for display all received position and status and target reports. Additional information—such as ID, PDT, and Missile in Flight—is transmitted with the target reports. A radar target is Unknown if no pilot action was taken by the originator, or Friend or Hostile if an ID was selected.

The F-15 pilot can select target "donors."

Aboard the F-15, pilot action is required for positive ID.

The MPCD can also display missile shots. A lock line appears from each flight member to its PDT that flashes when a missile is fired. If multiple missiles are fired at multiple targets, flashing lock lines will appear to the targets, and a steady lock line will appear to the next PDT.

☐ Operational Considerations

F-15s normally operate as flights, as opposed to operating autonomously. The flight lead normally controls flight operations and execution.

☐ Link 16 Implementation

■ PPLI and Platform Status Messages

Recall that PPLIs enable beyond line-of-sight (BLOS) mutual support and instant ID among friendlies. This is especially true for F-15 flight members. Their transmitted PPLIs convey location, altitude, heading, and flight position on the MPCD. Flight members are shown as blue circles, and friendly airborne Link 16-equipped aircraft as green circles with a "P" inside their symbols. Large surface ships, such as aircraft carriers, cruisers, and destroyers, are displayed as solid green ship symbols. Own unit location's Q_p or Q_{pr} is displayed in the upper left-hand corner. Q_t, however, is *not* displayed.

The F-15 displays its own Link 16 position qualities.

The F-15 normally displays only airborne PPLIs received in J2.2 Air messages, but certain types of ships, flight members, and other friendly aircraft can also be displayed, using the Update List command. Note that, regardless of Link 16 net number, the F-15 displays only the PPLIs of fighters that are operating in a compatible navigation mode.

While using Rel Grid Nav, the F-15 cannot "see" PPLIs from aircraft using Geo Nav.

The PPLI update rate is normally two seconds for fighters, and 12 seconds for C2 platforms.

The use of contention access for F-15 PPLIs may decrease reception probability due to message collision and rejection. However, PPLI reception probability is still very good, and it fully supports operational needs.

♦ Platform Status Information

F-15 platform and system status is updated every 48 seconds in its J13.2 Air Platform and System Status message, or as weapons are expended.

■ Surveillance, Amplification, and EW Messages

♦ Tracks

Off-board surveillance provides broad area situational awareness and tracks from multiple sources, many outside the fighter radar's field of view (FOV). The F-15 can receive surveillance tracks (J3-series messages) from all C2 units contributing to the surveillance net on NPG 7. When received, these are displayed to the pilot as dashed line symbols that conform to the standard symbology and color conventions. Note that the F-15 purges stale surveillance tracks after 25 seconds.

The F-15 purges Surveillance tracks after 25 seconds.

The F-15 processes all real-time tracks (those with TQ greater than zero). In general, track TQ is not displayed to the pilot, and there is no indication that TQ is low or degrading. As a result, the pilot is not aware of the positional accuracy of surveillance tracks. A future F-15 upgrade, however, may display the TQ value to the pilot.

The F-15 typically cannot see the TQ of surveillance tracks.

The F-15E can display TQ for air-to-ground tracks. Land (Ground) Points and Tracks from J3.5 messages appear with solid-lined symbols. The F-15 also processes nonreal-time ground tracks. When interrogated with the “ACQ” symbol, their TQ is displayed in feet in the lower corner of the display.

The F-15 processing and display assumes a correlated surveillance air picture. Note that when local sensor data is not available, the F-15 will not perform correlation of tracks it has only received on the surveillance NPG. However, the F-15 does correlate surveillance tracks with own radar targets.

♦ Fighter Sensor Data and Fighter-to-Fighter Exchange

F-15 flight members exchange fighter radar targets to provide a common radar picture. They can share multiple targets per fighter. The cockpit display represents targets as solid-line symbols, which are shape- and color-coded by combat ID. Radar lock lines are displayed from flight members to PDTs, and launching a missile causes the lock line to flash as a missile-in-flight indicator J3.x series (Tracks and Points), J12.6 (Targeting Sorting), and J13.2 (Platform Status).

F-15s can share multiple targets with flight members.

The F-15 automatically correlates radar targets to the targets, tracks, and PPLIs it receives on Link 16. Stale fighter radar targets are removed from the display after approximately 13 seconds. The F-15 extrapolates target position every half-second.

F-15 radar targets “stale out” after 13 seconds.

The FDL terminal accepts targets from all fighters communicating on the same fighter-to-fighter net number. Only targets from flight members and selected donors are processed for display. Target reports are transmitted automatically as a result of all radar work. Initial target display and transmission ID is reported as Unknown until the pilot changes the ID of the PDT to Hostile or Friend. This pilot-selected ID will remain with the target.

Fighter targets are typically very accurate and short in duration, as pilots prefer. USAF fighter targets usually have a three-second or six-second update rate. The backlink of fighter targets, which is required by MIL-STD-6016, is transmitted on

NPG 19 in the F-15. (Note that other fighters normally transmit fighter sensor targets on NPG 9.)

♦ Points

The F-15E exchanges points to support air-to-ground employment among fighters, sharing its targets in the form of Mark Points and Designated Ground Targets (DGTs). Mark Points, which appear on the cockpit display as small amber triangles, and DGTs, which appear as small red triangles, allow flight members and donors to share the location of points of tactical significance, and can also aid in target sorting. A DGT indicates that the aircraft has "locked on," and its position represents the location where the munitions will be delivered when the weapon is released.

Mark Points aid in target sorting.

The F-15E also processes the Missile Launch Point (J3.0 C5). It will, in addition, process Emergency Points from J3.1 messages if it has received a mission assignment of Search and Rescue, and the TN or the Emergency Point matches the Emergency Point's TN. Mark Points are normally exchanged on NPG 19, but they can also be directed to NPG 9 for use by intelligence platforms.

♦ Special Points and Threats

Currently, the F-15C displays only Suspect and Hostile SAM symbology. With its more robust Special Point capability, however, the F-15E can process and display vehicles, tanks and trains with Unknown, Suspect and Hostile IDs. In general, these entities all appear on the display as tank symbols, color-coded by ID. The F-15E also processes Hostile and Suspect AAA and SAM sites. The AAA site appears on the display as "A," color-coded by ID, and a SAM site appears with an alphanumeric character indicating its Specific Type, color-coded by Platform Activity.

The F-15E has enhanced display capabilities for Special Points and Threats.

The F-15E processes a number of Specific Type values to further identify the surveillance entity. Platform Activity is used to specify SAM operational status, such as Launch Ready, Site Down, or Engaging. The F-15E also processes the high-precision position information that allows point location to be expressed with very exact resolution.

♦ Lines and Areas

The F-15 has the capability to display reference lines on the MPCD. With the current implementation, reference lines are loaded at the Joint Mission Planning System (JMPS) and are carried to the aircraft as part of the initialization data available on the Data Transfer Module (DTM). Each reference line load stored on JMPS consists of up to 63 lines or areas, and up to two such loads can be placed on a DTM for a given mission.

These reference lines can also be updated in flight. The F-15 can employ this capability, even though current USAF C2 platforms cannot yet transmit reference lines. (Several are in the process of implementing this capability.) Each reference line load can be set up at the JMPS to include up to three categories of lines or areas:

- Lines and areas that cannot be changed in flight (for example, AOR or Training Area)
- Lines and areas that can be changed by the airspace control authority (for example, Low-Level Transit Corridors)
- Lines and areas that can be newly created and added by the Airspace Control Authority during the mission (for example, Kill Zones).

♦ EW Product Information

The F-15 does not participate in EW information exchange. Any EW-related data it receives arrives in J3.2 Air Track or J3.5 Land Track or Point messages. The F-15 does not receive, process, or transmit the J3.7 EW Product Information message.

♦ Track Management

Of the Link 16 track management messages, the F-15 implements only Pointers.

■ Pointers

The F-15 can receive the J7.3 Pointer message and display it as a triangle containing the character “P.” Additional information is then needed to describe the significance of the point. If the message is addressed to own unit’s JU address, a flight member’s JU address, or to all parties, the F-15E will receive the J7.3 Pointer message. The F-15E does not process the text portion of the pointer message.

As described above, the F-15E also processes the Mark Point message when sent from a flight member or donor. The Mark Point appears on the display as a small amber triangle, with nothing inscribed.

■ Weapons Coordination and Management

Link 16 provides numerous capabilities to perform digital weapons coordination and management, which minimizes the need for voice coordination between C2 units and F-15s. Here we describe how the F-15 implements these capabilities.

♦ Air-to-Air Mission Control

Digital control provides mission assignments to a flight. An assignment is for a single track being reported on the Surveillance NPG. If the flight is intended to kill a group of hostile fighters, and if the group is represented by several tracks, then only one track is selected for the assignment. That single track will be used as a “marker” for the group of hostiles at the time of the assignment, which will be supplemented by voice. The assignment of individual targets from the group to individual members of the flight is the responsibility of the flight leader. USAF sends mission assignments only to the flight lead, and it is the flight lead’s responsibility to accept (WILCO) or reject (NO GO) all assignments for the flight.

Mission assignments are sent to the flight leader.

A fighter checks in with its controlling unit (CU) on voice (*not* Link 16 Voice) and sets the appropriate control net number, which in the F-15 is called the **mission channel**. Check-in allows the flight to accept assignments from the CU.

The flight can receive both air and point missions. The F-15E can also receive assignments against air-to-ground tracks. If a subsequent assignment is sent to the flight, and the flight lead WILCOs the assignment, the previous assignment is replaced.

If a CU initiates the control link-up—a process known as “grab control”—the flight will receive the Control prompt at the top of the MPCD, and new CU data will be displayed in the lower right-hand corner. The CU data is easily recalled by placing the ACQ symbol over own unit. To start receiving mission assignments and to check in by voice with the new CU, flight members must first dial in the new mission and voice net numbers.

♦ Air-to-Ground Mission Control

For F-15E air-to-ground missions, mission assignments are handled in a similar manner. Only one active mission assignment is given per flight; the F-15E can, however, accept multiple DMPIs per target. The DMPIs are expressed in the J7.7 Association message, in which the mission assignment objective is associated with the surveillance tracks that will become DMPIs.

♦ Engagement Status

The F-15 receives J10.2 Engagement Status messages with C2 units on NPG 8. This enhances SA by showing which tracks are being engaged by other weapons systems.

The F-15’s SA comes from Engagement Statuses on NPG 8.

The mission assignment for own flight is displayed as a blue engagement box around the assigned track, as described a previous section. A magenta engagement diamond around a track means that a weapons system either has been committed to the track or has accepted the assignment—for example, an F-15 assigned by a controller, with the pilot’s WILCO.

When a flight lead receives the J9.0 Command with Action Code 2 (Engage), a white Engage message appears in the upper center of the MPCD, with WILCO and NO GO on either side. A white line appears between Ownship symbol and the target, and information about the target—combat ID, flight size or strength, TN, altitude, and ground speed—appears in the lower right tabular display. All flight members see the assignment; only the flight lead, however, sees the WILCO and NO GO options. If the flight lead selects the WILCO option to accept the mission assignment, a blue assignment box appears around the target, and the white Engage message is replaced with the Commit box for all flight members.

F-15s can engage air tracks ordered by a C2 or the flight lead.

In addition to receiving assignments from C2, the flight lead has the option to self-assign against unknown and hostile surveillance tracks.

The F-15E can engage ground tracks.

The F-15E can also receive assignments against ground tracks. The process is similar to the air track process just described—but recommended ingress and egress headings, suggested munitions, the five closest friendly positions, and the option to provide damage assessment are also displayed.

♦ Vectors

The F-15 can receive J12.1 Vector messages that indicate various non-target-specific instructions from C2 platforms.

Currently, the F-15 does not process vector messages.

♦ Control Handover—F-15

The F-15 has the capability to support digital handovers. On initial check-in with its first CU, it processes his Grab Control request, in which the CU sends the flight leader a J12.4 Controlling Unit Change message requesting the flight to place itself under its own control. The pilot sees the message Control at the top of the MPCD, with the CU's voice frequency and control net data displayed in the lower right-hand corner. The flight leader's WILCO causes the CU's data to be saved. It can be recalled later by interrogating Ownship symbol.

The F-15 supports digital handovers.

When the CU decides to hand over a flight of F-15Cs to another CU, it sends the flight lead a J12.4 Controlling Unit Change message providing him the control net number and voice frequency or net number of the new CU. This command appears as "Hand Off" at the top of the MPCD. All flight members will see it, but only the flight lead can respond. His WILCO causes the information to be saved. The flight members then select the new voice frequency and control net (which F-15 crew call a mission channel) and check in with the new CU by voice.

Another category of control handover uses full digital functions among CUs and the F-15s. For this type of handover, best termed "Assume Control," the old CU relinquishes control to a new CU. The sequence begins when the old CU transmits the J10.3 Handover request to the new CU. The new CU WILCOs the request and provides its own control net number, voice frequency, or Link 16 Voice channel. The old CU then transmits a J12.4 Controlling Unit Change order to the flight leader, whose MPCD displays "Hand Off." All flight members see this command. The flight lead then selects his response, WILCO or NO GO. The J12.4 Controlling Unit Change order contains the new CU's control net number and voice frequency or Link 16 Voice channel number. Flight members then complete the handover by dialing in the new control information.

♦ Handover Procedure for F-15C/D and AWACS

In the following example, an F-15C/D checks in with his first CU, an AWACS, receives mission assignments, and is then digitally handed over to a second AWACS before receiving mission assignments from this second CU. Note that although the scenario is abbreviated for this example, the procedural steps are accurate:

- The F-15C flight lead checks in by voice with AWACS 1, and the flight receives its current control net number.
- Each member of the flight dials in the appropriate control net number.
- AWACS 1 transmits J12.0 Mission Assignment messages to the F-15C flight.
- AWACS 1 initiates handover of the F-15C flight with AWACS 2 by transmitting to him the J10.3 Handover request.
- AWACS 2 WILCOs the J10.3 Handover request, providing its own control net number frequency.
- AWACS 1 transmits the J12.4 Controlling Unit Change Order (CCO) to the F-15C flight leader with AWACS 2's control net number frequency. The F-15C flight members hear and receive the "Message, Message" cue, and "Hand Off" is displayed across top of their MPCDs, with the new controller's information displayed in the lower right-hand corner.
- The F-15C flight leader WILCOs the CCO, and flight members dial in AWACS 2's control net number.
- The F-15C flight leader coordinates the flight's changing net numbers and frequencies, and then checks in by voice with AWACS 2.
- AWACS 2 transmits control and mission assignments to the F-15C flight as described above.

■ Link 16 Voice

F-15s, because they are equipped with the MIDS LVT-3 (FDL) terminal, do not have the Link 16 voice capability.

■ Text Messages

F-15Es will receive Text messages beginning with Suite 6, which will be fielded in 2009. F-15Cs do not receive Text messages.

■ Image Transfer

The F-15E Suite 5 receives the J16.0 Image Transfer message and transmits acknowledgements for each packet received. The F-15E Suite 6 transmits and receives the J16.0 Image Transfer message.

Message		Tx	Rx
System Information Exchange and Network Management			
J0.0	Initial Entry	T	R
J0.1	Test Message	T	R
J0.2	Network Time Update	NT	R
J0.3	Time Slot Assignment	NTRC	R
J0.4	Radio Relay Control	NTRC	R
J0.5	Repromulgation Relay	NT	R
J0.6	Communications Control	NTRC	R
J0.7	Time Slot Reallocation	NT	NI
J1.0	Connectivity Interrogation	NT	NI
J1.1	Connectivity Status	NT	NI
J1.2	Route Establishment	NT	NI
J1.3	Acknowledgement	NT	NI
J1.4	Communication Status	NT	NI
J1.5	Net Control Initialization	NT	NI
J1.6	Needline PG Assignment	NT	NI
PPLI			
J2.0	Indirect Interface Unit PPLI	NT	R
J2.2	Air PPLI	T	R
J2.3	Surface (Maritime) PPLI	NT	R
J2.4	Subsurface (Maritime) PPLI	NT	R
J2.5	Land (Ground) PPLI	NT	R
J2.6	Land (Ground) Track PPLI	NT	R
Surveillance			
J3.0	Reference Point	NT	R
J3.1	Emergency Point	NT	R
J3.2	Air Track	NT	R
J3.3	Surface (Maritime) Track	NT	R
J3.4	Subsurface (Maritime) Track	NT	NI
J3.5	Land (Ground) Point/Track	NT	R
J3.7	EW Product Information	NT	NI
ASW			
J5.4	Acoustic Bearing and Range	NT	NI
AMP			
J6.0	Amplification Information	NT	NI
Information Management			
J7.0	Track Management	NT	R
J7.1	Data Update Request	NT	NI

Figure 6-18. Processed F-15A-D and F-15E messages (continued on next page)

Message		Tx	Rx
J7.2	Correlation	NT	NI
J7.3	Pointer	NT	R
J7.4	Track Identifier	NT	NI
J7.5	IFF/SIF Management	NT	NI
J7.6	Filter Management	NT	NI
J7.7	Association	NT	NI/R*
J8.0	Unit Designator	NT	NI
J8.1	Mission Correlator Change	NT	NI
Weapons Coordination and Management			
J9.0	Command	NT	R
J9.1	Engagement Coordination	NT	NI
J9.2	Engagement Status	NT	R
J10.3	Handover	NT	R
J10.5	Controlling Unit Report	NT	R
J10.6	Pairing	NT	R
Control			
J12.0	Mission Assignment	NTRC	R
J12.1	Vector	NTRC	R
J12.2	Precision Aircraft Direction	NT	NI
J12.3	Flight Path	NT	NI
J12.4	Controlling Unit Change	NTRC	R
J12.5	Target/Track Correlation	NT	NI
J12.6	Target Sorting	T	R
J12.7	Target Bearing	NT	NI
Platform and System Status			
J13.0	Airfield Status	NT	Ni
J13.2	Air and Platform System Status	T	R
J13.3	Surface (Maritime) Platform and System Status	NT	NI
J13.4	Subsurface (Maritime) Platform and System Status	NT	NI
J13.5	Land (Ground) Platform and System Status	NT	NI
EW			
J14.0	Parametric Information	NT	R
J14.2	EW Control / Coordination	NT	R
TW			
J15.0	Threat Warning	NT	NI/R*

Figure 6-18. Processed F-15A-D and F-15E messages (continued on next page)

135-02-004

Message		Tx	Rx
Image Transfer			
J16.0	Image Transfer	T	R
National Use			
J28.0	National Messages (J28.2(0) Only)	NT	R
J29.0	Spoke Report	NT	NI
Miscellaneous			
J31.0	OTAR Management	T	R
J31.1	OTAR	NTRC	R
J31.7	No Statement	T	R
RTTA	Round Trip Timing Interrogation Addressed	T	R
RTTB	Interrogation Broadcast	T	R
RTTR	Reply	T	R
RTTB	Alpha Numeric Free Text	NT	NI

Notes:

1. Abbreviations: Anti-submarine Warfare (ASW), Amplification (AMP), Electronic Warfare (EW), Threat Warning (TW)
2. Annotations used:

T	Transmit at least minimum message requirements
NT	Does not transmit the message
NTRC	Message transmitted only for Receipt/Compliance purposes
R	Receive and interpret some parts of the message
NI	Message not interpreted
NIRC	Message interpreted only for Receipt/Compliance purposes
Rx	Receive
Tx	Transmit
NI/R	NI refers to F-15A/D only
NI/R*	R* refers to F-15, F-15E only

Figure 6-18. The processed F-15A-D and F-15E Link 16 messages are illustrated here. Knowledge of the F-15's message processing capabilities provides understanding of how these fighters operate on Link 16. Note that while F-15s can process all received real-time tracks, only the F-15E can display track quality to the pilot, and only for air-to-ground tracks. The capability to display track quality may be included in a future upgrade.

Section H

F-16 Fighting Falcon

The F-16 Fighting Falcon is a versatile and highly maneuverable fighter aircraft that is employed for air intercept, strike, and close air support missions. Traditionally, the F-16's only data link has been its Situation Awareness Data Link (SADL) implementation.

Link 16 has been introduced aboard the aircraft, and Link 16-capable F-16s began their operational fielding during the summer of 2004. The MIDS LVT-1 terminal was added to the F-16 fleet during its Common Configuration Implementation Program (CCIP), which introduced similar modifications to the F-16 Block 40 and Block 50 aircraft. The entire CCIP upgrade of the F-16 Block 40 and 50 fleets will continue until FY09.

Link 16 was introduced to Blocks 40 and 50 F-16s in 2004.

The F-16 Block 30 program, on the other hand, is currently employing the use of a data link "gateway" that enables a limited Link 16 capability to be utilized through its SADL terminal.

A single-seat model of the F-16A first flew in December 1976. The first operational F-16A was delivered in January 1979 to the 388th Tactical Fighter Wing at Hill AFB, Utah. The F-16B, a two-seat model, has tandem cockpits that are about the same size as the one in the A model. Its bubble canopy extends to cover the second cockpit. To make room for the second cockpit, the forward fuselage fuel tank and avionics growth space were reduced. During training, the forward cockpit is used by a student pilot, with an instructor pilot in the rear cockpit. All F-16s delivered since November 1981 have built-in structural and wiring provisions and systems architecture that permit expansion of the multirole flexibility to perform precision strike, night attack, and BLOS interception missions. This improvement program led to the F-16C and F-16D aircraft, which are the single- and two-seat counterparts to the F-16A/B.

These variants incorporate the latest cockpit control and display technology. All active units and many ANG and Air Force Reserve units have converted to the F-16C/D.

Figure 6-19. The F-16 Fighting Falcon is a versatile and highly maneuverable aircraft that performs air intercepts, strikes, and close air support.

□ Mission

In an air combat role, the F-16's maneuverability and combat radius (the distance it can fly to enter air combat, stay, fight, and return) exceed that of all potential threat fighter aircraft. It can locate targets in all weather conditions and can detect low-flying aircraft in radar ground clutter. In an air-to-surface role, the F-16 can fly more than 500 miles (860 kilometers), deliver its weapons with superior accuracy, defend itself against enemy aircraft, and return to its starting point. An all-weather capability allows it to deliver ordnance accurately during nonvisual bombing conditions.

Location

ACC-owned "Vipers" are located at Hill AFB, Utah (388th FW), Mountain Home AFB, Idaho (366th WG), and Shaw AFB, South Carolina (20th FW). In support of NATO, the F-16s are prepositioned at Spangdahlem AB, Germany (52nd FW) and Aviano AB, Italy (31st FW). In the Pacific theater, three locations are home to the Vipers: Eielson AFB, Alaska (354th FW), Kunsan AB, Republic of Korea (8th FW), and Misawa AB, Japan (35th FW). In addition to these permanent locations, the USAF F-16 multimission fighters are deployed in support of contingency operations, flying a variety of missions, including suppression of enemy air defense, offensive counter-air, defensive counter-air, close air support, and forward air controller missions. USAF Coalition fighters are deployed worldwide in support of contingency operations.

Link 16 Implementation

This information on the F-16's message implementation applies only to those aircraft equipped with MIDS LVT-1. Specific details about the processing are included here to let you know what to expect when you work with Link 16 flights in a Link 16 network. Note that the F-16 does not have the Link 16 voice capability.

System Information Exchange and Network Management

Network management functions for the F-16 are designed for front line, end-user participation. The F-16 does not perform management control of the network; it performs only own unit controls.

Initial Entry and Time Synchronization

The F-16 transmits and receives the J0.0 Initial Entry message. The aircraft is currently set up to automatically use GPS time and date inputs, and it will have ETR capability. Manual entry backup will be present in case GPS is not available. The F-16 can function as NTR. Note that when it is not NTR, the aircraft uses a one-minute time uncertainty window for net entry.

The F-16 can function as NTR.

♦ Network Time Update (J0.2)

The F-16 transmits and receives the J0.2 Network Time Update message.

♦ Time Slot Assignment (J0.3)

The F-16 receives, but does not transmit, the J0.3 Time Slot Assignment message.

♦ Radio Relay Control (J0.4)

The F-16 receives, but does not transmit,the J0.4 Radio Relay Control message.

■ PPLI and Platform Status Messages

♦ PPLI Information

As a Link 16 participant, the F-16 transmits its available data in a J2.2 Air PPLI message. Its PPLI receive processing, however, has certain limitations. In general, the F-16 entirely drops any PPLI message it receives with the Simulation Indicator set, or with No Statement set for latitude, longitude, altitude, Q_t, course, or speed. Other characteristics of its received PPLI processing are described below.

The F-16's PPLIs are contained in the J2.2 message.

■ Indirect Interface Unit PPLI (J2.0)

The F-16 accepts the J2.0 message only from indirect Air units, and all other J2.0 messages will be discarded.

The F-16 receives indirect PPLIs only from Air units.

Air PPLI (J2.2)

If no update is received within 20 seconds, the track will be dropped. The F-16 must also receive valid values for Q_{pg}, Strength, and Altitude and Altitude Quality. If it receives No Statement for Strength, the F-16 assumes Strength to be 1. The F-16 receives and processes only Air Platforms (except types 0 - 36); any others will cause it to discard the entire J2.2 message. It receives and processes only Interpret Voice Call Sign for the Voice Call Sign Indicator, and the Voice Call Sign must be valid. If the indicator is incorrectly set, the F-16 does not process the Voice Call Sign.

The F-16 receives direct PPLIs from most unit types.

Surface (Maritime) PPLI (J2.3)

The F-16 receives PPLIs from Surface (Maritime) units, but it assumes that the unit's Altitude/Elevation is zero if it receives No Statement in this field.

Land (Ground) Point PPLI (J2.5)

The F 16 receives the J2.5 Land Point PPLIs messages, but it does not receive the J2.6 Land Track PPLIs messages.

Miscellaneous PPLI Processing

The F-16 is able to transmit Bailout in its J2.2 PPLI message. However, it is not able to receive Bailout indicators from other units.

Platform and System Status Information

F-16s transmit their own platform status in a J13.2 Air Platform and System Status message approximately every 3.2 minutes, reporting fuel, sensor and radio status, weapons availability for up to four weapon types, and many other data elements. Most of the message words and fields are utilized; exceptions are ASW Status, air EW Status, Equipment Status, Air Control Status, and Additional Stores Status.

The F-16's status is contained in the J13.2 message.

Air Platform and System Status (J13.2)

The F-16 is receives and processes all Air Platform and System Status messages. However, it will process only Air Specific Types. It does not recognize other Specific Type values.

F-16s receive status messages only from other aircraft.

Airfield Status Data (J13.0)

The F-16 does not receive the J13.0 Airfield Status message.

Surveillance, Amplification, and ESM

For the F-16, surveillance messages are limited to Air tracks, Surface (Maritime) tracks, and Land Tracks and Points. On receiving one of these track messages with either the Simulation or Exercise Indicator set, it will entirely discard the message.

F-16s does not receive Simulation and Exercise tracks.

Information Management

The F-16 supports the J7.0 Track Management messages with a limited, receive-only capability. It receives the J7.0 Track Management message only with Action Code 1 (Drop Track). From this message, it processes and responds to the Drop Track request if the TN is valid. It also receives the J7.3 Pointer message.

F-16s only receive Track Management messages.

Its methods for processing the J7.1 Data Update Request, the J7.2 Correlation message, the J7.3 Pointer message, the J7.4 Track Identifier message, the J7.5 IFF/SIF Management messages, and the J7.6 Filter Management messages, if these will be implemented, have not yet been specified.

Weapons Coordination

If the F-16 plans to implement Weapons Coordination messages—Commands (J9.0), Engagement Status (J10.2), Handover (J10.3), and Controlling Unit Reports (J10.5)—they have not yet been specified.

Air Control

The F-16 program implements only the J12.x Air Control messages discussed below.

Mission Assignments (J12.0)

The F-16 transmits, receives, and processes the J12.0 Mission Assignment message. An existing mission assignment is terminated when the pilot selects Disengage, or if any of the following is received: Break Engagement, Cancel High Interest Track, Cease Attack, Cease Mission. The F-16 also receives Air Specific Types in this message.

Controlling Unit Change Order (J12.4)

The only F-16 flight member that can respond to a J12.4 message is the addressee. Therefore, the message should be sent directly to the flight leader, using his primary TN (JU address). The F-16 processes this message only when the Control Change Indicator is set to Control Change Order. The F-16 expects the Voice Frequency/Channel Indicator to be set to Alternate Voice Frequency/Channel, and it does not process Primary Voice Frequency/Channel.

Only the addressee can respond to a CU Change Order!

Target/Track Correlation (J12.5)

The F-16 receives this message when the Originator is set to a primary TN.

♦ Target Sorting (J12.6)

The F-16 transmits, receives, and processes the J12.6 Target Sorting message only if its Environment/Category is Air and its Exercise Indicator is set to Non-Exercise. If either of these conditions is not met on receive, the F-16 will discard the message.

The F-16 receives Target Sorting only for non-Exercise Air tracks.

■ Other Processing

As of this writing, the F-16 does not implement Amplification data, EW Product Association, J28.2(0) Text messages, Threat Warnings, or Fighter Spoke messages. Reception of the J28.2(0) Text message will be included in Operational Flight Program (OFP) Version 5.1.

F-16s currently do not implement Link 16 Voice or J28.2(0) Text messages.

Message		Tx	Rx
System Information Exchange and Network Management			
J0.0	Initial Entry	T	R
J0.1	Test Message	NT	NI
J0.2	Network Time Update	T	R
J0.3	Time Slot Assignment	NT	R
J0.4	Radio Relay Control	NT	R
J0.5	Repromulgation Relay	T	R
J0.6	Communications Control	NT	NI
J0.7	Time Slot Re-allocation	NT	NI
J1.0	Connectivity Interrogation	NT	NI
J1.1	Connectivity Status	NT	NI
J1.2	Route Establishment	NT	NI
J1.3	Acknowledgement	NT	NI
J1.4	Communication Status	NT	NI
J1.5	Net Control Initialization	NT	NI
J1.6	Needline PG Assignment	NT	NI
PPLI			
J2.0	Indirect Interface Unit PPLI	NT	R
J2.2	Air PPLI	T	R
J2.3	Surface (Maritime) PPLI	NT	R
J2.4	Subsurface (Maritime) PPLI	NT	NI
J2.5	Land (Ground) PPLI	NT	R
J2.6	Land (Ground) Track PPLI	NT	NI
Surveillance			
J3.0	Reference Point	NT	NI
J3.1	Emergency Point	NT	NI
J3.2	Air Track	NT	R
J3.3	Surface (Maritime) Track	NT	R
J3.4	Subsurface (Maritime) Track	NT	NI
J3.5	Land (Ground) Point/Track	NT	R
J3.7	EW Product Information	NT	NI
ASW			
J5.4	Acoustic Bearing and Range	NT	NI
AMP			
J6.0	Amplification Information	NT	NI
Information Management			
J7.0	Track Management	NTRC	R
J7.1	Data Update Request	NT	NI

Figure 6-20. F-16 transmit and receive summary (continued on next page)

Message		Tx	Rx
J7.2	Correlation	NT	NI
J7.3	Pointer	NT	R
J7.4	Track Identifier	NT	NI
J7.5	IFF/SIF Management	NT	NI
J7.6	Filter Management	NT	NI
J7.7	Association	NT	NI
J8.0	Unit Designator	NT	NI
J8.1	Mission Correlator Change	NT	NI
Weapons Coordination and Management			
J9.0	Command	NT	NI
J9.1	Engagement Coordination	NT	NI
J9.2	Engagement Status	NT	NI
J10.3	Handover	NT	NI
J10.5	Controlling Unit Report	NT	NI
J10.6	Pairing	NT	NI
Control			
J12.0	Mission Assignment	T	R
J12.1	Vector	NT	NI
J12.2	Precision Aircraft Direction	NT	NI
J12.3	Flight Path	NT	NI
J12.4	Controlling Unit Change	NTRC	R
J12.5	Target/Track Correlation	NT	R
J12.6	Target Sorting	T	R
J12.7	Target Bearing	NT	NI
Platform and System Status			
J13.0	Airfield Status	NT	NI
J13.2	Air and Platform System Status	T	R
J13.3	Surface (Maritime) Platform and System Status	NT	NI
J13.4	Subsurface (Maritime) Platform and System Status	NT	NI
J13.5	Land (Ground) Platform and System Status	NT	NI
EW			
J14.0	Parametric Information	NT	NI
J14.2	EW Control / Coordination	NT	NI
TW			
J15.0	Threat Warning	NT	NI
Image Transfer			
J16.0	Image Transfer	NT	NI

Figure 6-20. F-16 transmit and receive summary (continued on next page)

Message		Tx	Rx
National Use			
J28.0	National Messages (J28.2(0) Only)	NT(1)	NI
J29.0	Spoke Report	NT	NI
Miscellaneous			
J31.0	OTAR Management	NT	NI
J31.1	OTAR	NT	NI
J31.7	No Statement	NT	NI
RTT-A	Round Trip Timing Interrogation Addressed	T	R
RTT-B	Interrogation Broadcast	T	R
RTT-B	Reply	T	T
RTT-B	Alpha Numeric Free Text	NT	NI

Notes:

1. Abbreviations: Anti-submarine Warfare (ASW), Amplification (AMP), Electronic Warfare (EW), Threat Warning (TW)
2. Annotations used:

T Transmit at least minimum message requirements

NT Does not transmit the message

NTRC Message transmitted only for Receipt/Compliance purposes

R Receive and interpret some parts of the message

NI Message not interpreted

NIRC Message interpreted only for Receipt/Compliance purposes

Rx Receive

Tx Transmit

(1) J28.2(0) to be implemented in OFP Version 5.1 release.

Figure 6-20. This summary of the F-16's transmit and receive message capabilities provides understanding of how these fighters operate on Link 16—as well as what to expect from them if you are an operator aboard another Link 16 platform.

Section I

F-22A Raptor

The F-22A Raptor is a twin-engine, single-seat, air superiority fighter aircraft that will maintain air dominance into the future. The F-22A gained initial operating capability (IOC) in late 2005, and it is continuing to undergo phased advancements. All 183 F-22A aircraft planned for delivery will be equipped with the Link 16 receive capability.

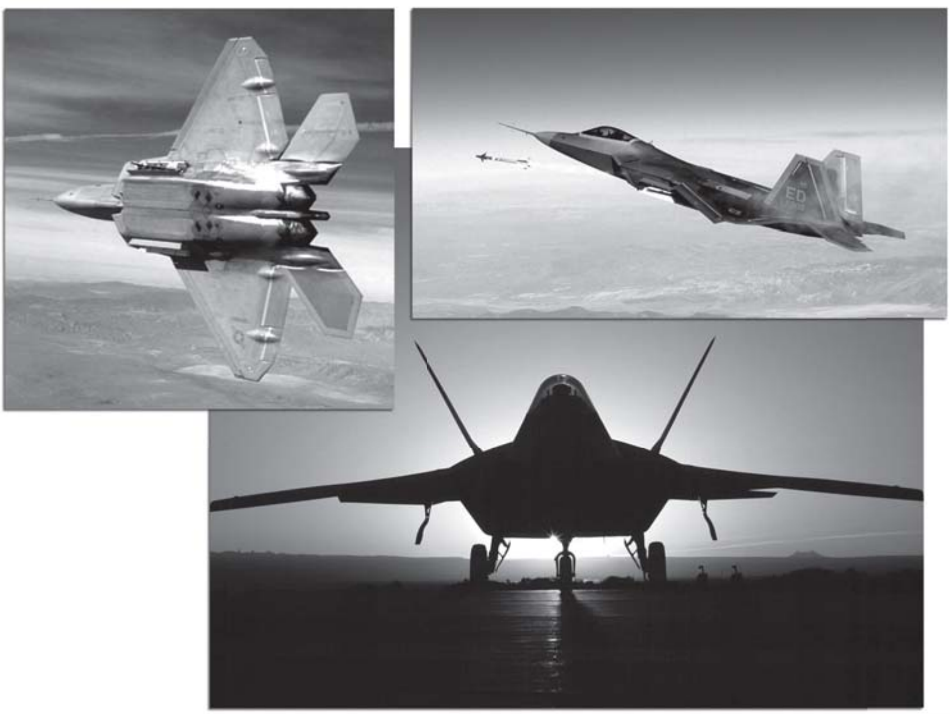

Figure 6-21. The F-22A Raptor is a twin-engine, single-seat fighter aircraft that will maintain air dominance into the future. All F-22As planned for delivery will be equipped with the Link 16 receive capability. The transmit capability is being considered for future implementation.

Mission

The F-22A's Link 16 system will process both J3.x Surveillance messages and Fighter-to-Fighter messages (NPG 19), in addition to J12.x Air Control messages and J28.2(0) Text messages. The pilots will also be able to display and save up to eight received text messages with a maximum size of approximately 500 characters each. PPLI data will be available for fusion with existing avionics system tracks. Link 16 SA and control information will be available to the pilot on a color situation display. The pilot will be able to control both the quantity and type of Link 16 entities for display. In addition to air, land, and maritime tracks, the F-22A will be able to display up to 20 multisegmented lines and areas. An independent color display, centered on any selectable object, will also be available. Both displays will provide pilot-selectable quantities from 10 to 100 prioritized tracks.

The F-22A will receive PPLIs, surveillance, air control, fighter-to-fighter, and text messages.

Up to ten Link 16 network designs may be loaded onto a data transfer cartridge (DTC) and transferred to the F-22A. Since the F-22A will initially be a receive-only Link 16 platform, it is planned that its controlling unit will use voice to confirm mission assignments.

In an air combat role, the F-22A's maneuverability and combat radius (the distance it can fly to enter air combat, stay, fight, and return) exceed that of all potential threat fighter aircraft. It can locate targets in all weather conditions and can detect low-flying aircraft. In an air-to-surface role, the F-22A can fly more than 500 miles (860 kilometers), deliver its weapons with superior accuracy, defend itself against enemy aircraft, and return to its starting point. An all-weather capability allows it to deliver ordnance accurately during nonvisual bombing conditions.

Location

ACC-owned F-22A Raptors are located at Tyndall AFB, Florida; at Langley AFB, Virginia; at Elmendorf AFB, Alaska; and at Holloman AFB, New Mexico.

Link 16 Implementation

System Information Exchange and Network Management

Initial Entry and Time Synchronization

The F-22A will receive the J0.0 Initial Entry message.

Network Time Update (J0.2)

The F-22A will receive the J0.2 Network Time Update message.

Time Slot Assignment (J0.3)

The F-22A will receive the J0.3 Time Slot Assignment message.

Radio Relay Control (J0.4)

The F-22A will receive the J0.4 Radio Relay Control message.

PPLI and Platform Status Messages

As a Link 16 participant, the F-22A will receive J2.2 Air PPLI messages. Its PPLI receive processing will have certain limitations. In general, it will entirely drop any PPLI message it receives with the Simulation Indicator set, or with No Statement set for Latitude, Longitude, Altitude, Q_t, Course, or Speed. Other expected characteristics of its received PPLI processing are described below.

♦ PPLI Information

■ Indirect Interface Unit PPLI (J2.0)

The F-22A will accept the J2.0 message only from indirect Air units, and all other J2.0 messages will be discarded.

The F-22A will receive only Air indirect PPLIs.

■ Air PPLI (J2.2)

The F-22A receives the J2.2 Air PPLI messages. If no update is received within 20 seconds, the track will be dropped. The F-22A must also receive valid values for Q_{pg}, Strength, and Altitude and Altitude Quality. If it receives No Statement for Strength, the F-22A will assume Strength to be 1. The F-22A will receive and process only Air Platforms (except types 0 − 36); any others will cause it to discard the entire J2.2 message. It will receive and process only Interpret Voice Call Sign for the Voice Call Sign Indicator, and the Voice Call Sign must be valid. If the indicator is incorrectly set, the F-22A will not process the Voice Call Sign.

■ Surface (Maritime) PPLI (J2.3)

The F-22A will receive PPLIs from maritime units, but it will assume that the unit's Altitude/Elevation is 0 if it receives No Statement in this field.

■ Land (Ground) Point (J2.5) and Land (Ground) Track (J2.6) PPLIs

The F-22A will receive both the J2.5 Land Point and the J2.6 Land Track PPLI messages.

The F-22A will receive direct PPLIs from most unit types.

♦ Platform Status Information

■ Air Platform and System Status (J13.2)

The F-22A receives and processes all Air Platform and System Status messages. However, it will process only Air Specific Types. No other Specific Type values will be recognized.

F-22As will receive status messages only from other aircraft.

■ Airfield Status Data (J13.0)

The F-22A does not receive the J13.0 Airfield Status message.

■ Surveillance, Amplification, and ESM

For the F-22A, surveillance will be limited to Air tracks, Surface (Maritime) tracks, and Land Tracks and Points. On receiving one of these track messages with either the Simulation or Exercise Indicator set, it will entirely discard the message.

F-22As will not receive Simulation and Exercise tracks.

Its methods for processing Link 16 fighter sensor data, Special Points, ESM, EW Product Information, ECM strobes, and EW fixes, if these will be implemented, have not yet been specified.

■ Information Management

The F-22A will support the J7.0 Track Management messages with a limited, receive-only capability. It will receive the J7.0 Track Management message only with Action Code 1 (Drop Track). From this message, it will process and respond to the Drop Track request if the TN is valid.

F-22As will only receive Track Management messages.

Its methods for processing the J7.1 Data Update Request, the J7.2 Correlation message, the J7.3 Pointer message, the J7.4 Track Identifier message, the J7.5 IFF/SIF Management messages, and the J7.6 Filter Management messages, if these will be implemented, have not yet been specified.

■ Weapons Coordination

The F-22A receives the J9.0 Commands, the J10.2 Engagement Status, the J10.3 Handover, and the J10.5 Controlling Unit Reports messages.

■ Air Control

Thus far, the F-22A program plans to implement only those J12.x Air Control messages discussed below.

♦ Mission Assignments (J12.0)

The F-22A will receive and process the J12.0 Mission Assignment message. An existing mission assignment will be terminated when the pilot selects Disengage, or any of the following is received: Break Engagement, Cancel High Interest Track, Cease Attack, and Cease Mission. The F-22A also receives Air Specific Types in this message.

Only the addressee can respond to a CU Change Order!

♦ Controlling Unit Change Order (J12.4)

The F-22A will receive and process the J12.4 message if it is the addressee. The message should be sent to the flight leader, using his primary TN. The F-22A will process this message only when the Control Change Indicator is set to Control Change Order. The F-22A will expect the Voice Frequency/Channel Indicator to be set to Alternate Voice Frequency/Channel, and will not process Primary Voice Frequency/Channel.

♦ Target/Track Correlation (J12.5)

The F-22A will receive this message when the Originator is set to a primary TN.

♦ Target Sorting (J12.6)

The F-22A will receive and process the J12.6 Target Sorting message only if the Environment/Category is Air and its Exercise Indicator is set to Non-Exercise. If either of these conditions is not met, the F-22A will discard the message.

The F-22A will receive Target Sorting only for Non-Exercise Air tracks.

■ Other Processing

Thus far, the F-22A has not specified its implementations of Amplification data, EW Product Association, Text messages, Threat Warnings, or Fighter Spoke messages.

Message		Tx	Rx
System Information Exchange and Network Management			
J0.0	Initial Entry	NT	R
J0.1	Test Message	NT	NI
J0.2	Network Time Update	NT	R
J0.3	Time Slot Assignment	NT	R
J0.4	Radio Relay Control	NT	R
J0.5	Repromulgation Relay	NT	R
J0.6	Communications Control	NT	NI
J0.7	Time Slot Re-allocation	NT	NI
J1.0	Connectivity Interrogation	NT	NI
J1.1	Connectivity Status	NT	NI
J1.2	Route Establishment	NT	NI
J1.3	Acknowledgement	NT	NI
J1.4	Communication Status	NT	NI
J1.5	Net Control Initialization	NT	NI
J1.6	Needline PG Assignment	NT	NI
PPLI			
J2.0	Indirect Interface Unit PPLI	NT	R
J2.2	Air PPLI	NT	R
J2.3	Surface (Maritime) PPLI	NT	R
J2.4	Subsurface (Maritime) PPLI	NT	NI
J2.5	Land (Ground) PPLI	NT	R
J2.6	Land (Ground) Track PPLI	NT	NI
Surveillance			
J3.0	Reference Point	NT	NI
J3.1	Emergency Point	NT	NI
J3.2	Air Track	NT	R
J3.3	Surface (Maritime) Track	NT	R
J3.4	Subsurface (Maritime) Track	NT	NI
J3.5	Land (Ground) Point/Track	NT	R
J3.7	EW Product Information	NT	NI
ASW			
J5.4	Acoustic Bearing and Range	NT	NI
AMP			
J6.0	Amplification Information	NT	NI
Information Management			
J7.0	Track Management	NTRC	R
J7.1	Data Update Request	NT	NI

Figure 6-22. F-22A transmit (future) and receive messages (continued on next page)

Message		Tx	Rx
J7.2	Correlation	NT	NI
J7.3	Pointer	NT	R
J7.4	Track Identifier	NT	NI
J7.5	IFF/SIF Management	NT	NI
J7.6	Filter Management	NT	NI
J7.7	Association	NT	NI
J8.0	Unit Designator	NT	NI
J8.1	Mission Correlator Change	NT	NI
Weapons Coordination and Management			
J9.0	Command	NT	NI
J9.1	Engagement Coordination	NT	NI
J9.2	Engagement Status	NT	NI
J10.3	Handover	NT	NI
J10.5	Controlling Unit Report	NT	NI
J10.6	Pairing	NT	NI
Control			
J12.0	Mission Assignment	NT	R
J12.1	Vector	NT	NI
J12.2	Precision Aircraft Direction	NT	NI
J12.3	Flight Path	NT	NI
J12.4	Controlling Unit Change	NTRC	R
J12.5	Target/Track Correlation	NT	R
J12.6	Target Sorting	NT	R
J12.7	Target Bearing	NT	NI
Platform and System Status			
J13.0	Airfield Status	NT	NI
J13.2	Air and Platform System Status	NT	R
J13.3	Surface (Maritime) Platform and System Status	NT	NI
J13.4	Subsurface (Maritime) Platform and System Status	NT	NI
J13.5	Land (Ground) Platform and System Status	NT	NI
EW			
J14.0	Parametric Information	NT	NI
J14.2	EW Control / Coordination	NT	NI
TW			
J15.0	Threat Warning	NT	NI
Image Transfer			
J16.0	Image Transfer	NT	NI

Figure 6-22. F-22A transmit (future) and receive messages (continued on next page)

Message		Tx	Rx
National Use			
J28.0-J28.5	National Messages (J28.2(0) Only)	NT	NI
J29.0	Spoke Report	NT	NI
Miscellaneous			
J31.0	OTAR Management	NT	NI
J31.1	OTAR	NT	NI
J31.7	No Statement	NT	NI
RTTA	Round Trip Timing Interrogation Addressed	NT	R
RTTB	Interrogation Broadcast	NT	R
RTTB	Reply	NT	R
RTTB	Alpha Numeric Free Text	NT	NI

Notes:
1. Abbreviations: Anti-submarine Warfare (ASW), Amplification (AMP), Electronic Warfare (EW), Threat Warning (TW)
2. Annotations used:
   - T Transmit at least minimum message requirements
   - NT Does not transmit the message
   - NTRC Message transmitted only for Receipt/Compliance purposes
   - R Receive and interpret some parts of the message
   - NI Message not interpreted
   - NIRC Message interpreted only for Receipt/Compliance purposes
   - Rx Receive
   - Tx Transmit

Figure 6-22. This summary of the F-22A's transmit (future) and receive message capabilities provides understanding of how this fighter operates on Link 16—as well as what to expect from it if you are an operator aboard another Link 16 platform.

Section J

B-1B Lancer

Mission

In 1998, a limited Link 16 capability, using JTIDS Class 2 terminals in conjunction with a two-way, multiple-channel BLOS satellite link, was installed in two B-1B aircraft. The Link 16 LOS and satellite BLOS capabilities for these two systems were not integrated into the avionics system, but simply demonstrated Link 16 and BLOS data link integration on the aircraft, which participated in a September, 1998 Expeditionary Force Experiment (EFX-98). After the exercise, one retained the hardware to develop B-1 data link operational concepts during the following year. As a result of FY02 consolidation, all 60 platforms will be equipped with Link 16.

In FY93, the B-1B began the Conventional Mission Upgrade Program (CMUP) to incorporate an improved conventional weapons capability. It has completed Block D and Sustainment Block 12 of this multiphased program, which adds the capability to deliver cluster bomb units. Development for CMUP was completed in FY02, and production and installation is slated to be finished in FY12.

The Fully Integrated Data Link (FIDL) capability will be flight-tested in FY08 and fielded in FY10. The B-1 will have a BLOS capability for Link 16, however, before FIDL is fielded, as part of the Digital Communications Initiative (DCI) program. The aircraft will have a nonintegrated, laptop-based display of Link 16 information. The communications will occur over UHF SATCOM via an ARC-210 Warrior radio. The DCI system is currently in flight test and will begin operational fielding before the end of FY08, with an estimated completion date for the entire fleet in August, 2009. The aircraft will transmit its position as an indirect PPLI and will process a limited set of Link 16 messages. These will include the J12.0 Mission Assignment, the J10.2 Engagement Status, the J15.0 Threat Warning, and the J28.2(0) Text messages.

FIDL will be integrated into the aircraft host software and will have essentially the same message capability, but it will have both the LOS and the BLOS capabilities. It will also have a machine-to-machine interface for sending coordinates directly to the onboard weapons. The initial FIDL development will put the data link capability only into the aft cockpit. The Vertical Situation Display (VSD) modification to follow will upgrade the displays in the front cockpit.

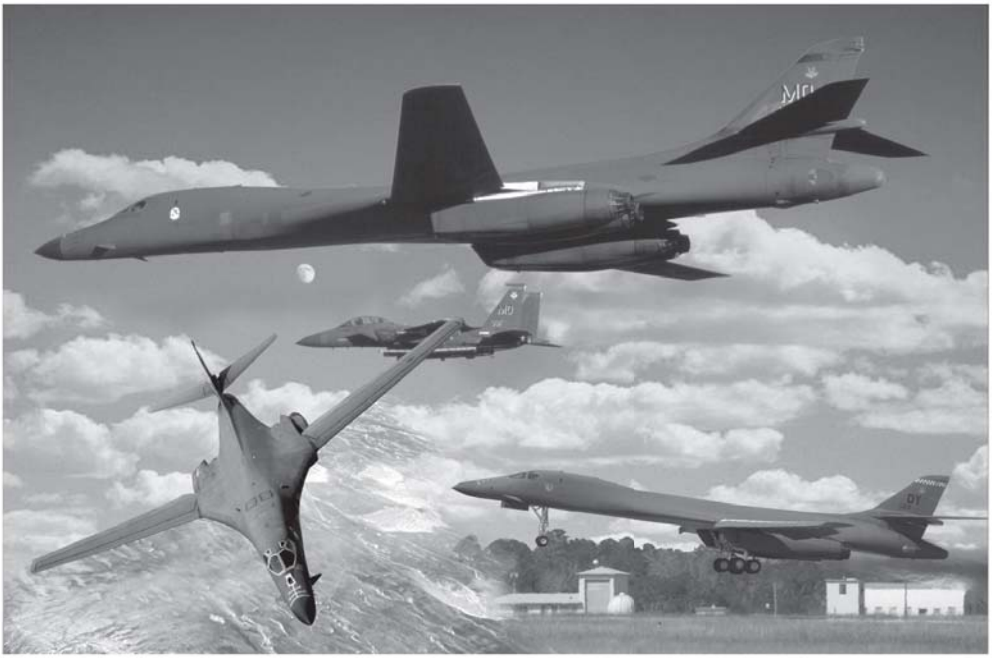

Figure 6-23. For the B-1B, Link 16 is now part of its ongoing upgrade program with FIDL equipment. However, the SPO is working toward implementing Link 16 with the MIDS JTRS radio, with initial flight testing in October, 2008.

The System Program Office (SPO) for B-1B is currently planning for the next block upgrade program, which will emphasize, among other systems, self-targeting and digital information. While Link 16 is not part of the CMUP, the computer upgrade to be performed in Block E will provide the capability to implement Link 16. The B-1B is working toward using the MIDS LVT-1 for initial flight tests.

Location

ACC-owned "Lancers" are located at Dyess AFB, Texas and Ellsworth AFB, South Dakota, as well as at forward-deployed locations in the Middle East.

Link 16 Implementation

System Information Exchange and Network Management

Initial Entry and Time Synchronization

The B-1B will transmit and receive the J0.0 Initial Entry message.

Network Time Update (J0.2)

The B-1B will transmit and receive the J0.2 Network Time Update message.

Time Slot Assignment (J0.3)

The B-1B will receive the J0.3 Time Slot Assignment message.

Radio Relay Control (J0.4)

The B-1B will receive the J0.4 Radio Relay Control message

PPLI and Platform Status Messages

As a Link 16 participant, the B-1B will transmit its available data in a J2.2 Air PPLI message. Its PPLI receive processing will have certain limitations. In general, it will entirely drop any PPLI message it receives with the Simulation Indicator set, or with No Statement set for Latitude, Longitude, Altitude, Q_t, Course, or Speed. Other expected characteristics of its received PPLI processing are described below.

The B-1B's PPLI will be contained in the J2.2 message.

♦ PPLI Information

■ Indirect Interface Unit PPLI (J2.0)

B-1B airframes equipped with FIDL will accept the J2.0 message originating only from indirect Air units and will discard all other J2.0 messages. B-1B airframes equipped with the DCI system, however, will accept all J2.0 messages on receipt.

■ Air PPLI (J2.2)

If no update is received within 20 seconds, the track will be dropped. The B-1B must also receive valid values for Q_{pg}, Strength, and Altitude and Altitude Quality. If it receives No Statement for Strength, the B-1B will assume Strength to be 1. The B-1B will receive and process only Air Platforms (except types 0 – 36); any others will cause it to discard the entire J2.2 message. It will receive and process only Interpret Voice Call Sign for the Voice Call Sign Indicator, and the Voice Call Sign must be valid. If the indicator is incorrectly set, the B-1B will not process the Voice Call Sign.

■ Surface (Maritime) PPLI (J2.3)

The B-1B will be able to receive PPLIs from maritime units, but it will assume that the unit's Altitude/Elevation is 0 if it receives No Statement in this field.

■ Land (Ground) Point (J2.5) and Land (Ground) Track (J2.6) PPLIs

The B-1B will be able to receive both Land Point and Land Track PPLIs.

The B-1B will receive direct PPLIs from most unit types.

■ Miscellaneous PPLI Processing

The B-1B will be able to transmit Bailout in its J2.2 PPLI message. However, it will not be able to receive Bailout indicators from other units.

♦ Platform and System Status Information

B-1Bs will transmit their own platform status in an J13.2 Air Platform and System Status message approximately every 3.2 minutes, reporting fuel, sensor and radio status, weapons availability for up to four weapon types, and many other data elements. Most of the message words and fields will be utilized; exceptions are ASW Status, Air EW Status, Equipment Status, Air Control Status, and Additional Stores Status.

The B-1B's status will be contained in the J13.2 message.

■ Air Platform and System Status (J13.2)

The B-1B is expected to be able to receive and process all Air Platform and System Status messages. However, it will process only Air Specific Types. No other Specific Type values will be recognized.

B-1Bs will receive Status messages only from other aircraft.

■ Airfield Status Data (J13.0)

The B-1B is not expected to receive the (J13.0) Airfield Status message.

■ Surveillance, Amplification, and ESM

For the B-1B, surveillance will be limited to Air tracks, Surface (Maritime) tracks, and Land Tracks and Points. On receiving one of these track messages with either the Simulation or Exercise Indicator set, it will entirely discard the message.

B-1Bs will not receive Simulation and Exercise tracks.

Its methods for processing Link 16 fighter sensor data, Special Points, ESM, EW Product Information, ECM strobes, and EW Fixes, if these will be implemented, have not yet been specified.

Information Management

The B-1B will support the J7.0 Track Management messages with a limited, receive-only, capability. It will receive only the Drop Track Report, J7.0 with Action Code 1. From this message, it will process and respond to the Drop Track request if the TN is valid.

B-1Bs will only receive Track Management messages.

Its methods for processing the Data Update Request (J7.1), the Correlation message (J7.2), the Pointer message (J7.3), the Track Identifier message (J7.4), the IFF/SIF Management messages (J7.5), and Filter Management messages (J7.6), if these will be implemented, have not yet been specified.

Weapons Coordination

If the B-1B plans to implement Weapons Coordination messages—Commands (J9.0), Engagement Status (J10.2), Handover (J10.3), and Controlling Unit Reports (J10.5)—they have not yet been specified. It is currently planned, however, only to process the Engagement Status (J10.2) message. When this is implemented, the B-1B will display a diamond around the targeted track and will have textual information about the aircraft doing the targeting.

Air Control

Thus far, the B-1B program plans to implement only the J12.x Air Control messages discussed below. It is important to note that all B-1Bs must be treated as single ships for assignments. They will have no capability to see mission assignments sent to their wingmen.

Mission Assignments (J12.0)

The B-1B will receive and transmit responses to the J12.0 Mission Assignment message. An existing mission assignment will be terminated when the pilot selects Disengage, or any of the following is received: Break Engagement, Cancel High

Interest Track, Cease Attack, Cease Mission. The B-1B also receives Air Specific Types in this message.

♦ Controlling Unit Change Order (J12.4)

The only B-1B flight member that will be able to receive and respond to a J12.4 message is the addressee. Therefore, the message should be sent directly to each aircraft individually, using its primary TN. The B-1B will process this message only when the Control Change Indicator is set to Control Change Order. The B-1B will expect the Voice Frequency/Channel Indicator to be set to Alternate Voice Frequency/Channel, and will not process Primary Voice Frequency/Channel.

Only the addressee can respond to a CU Change Order!

♦ Target/Track Correlation (J12.5)

The B-1B will receive this message when the Originator is set to a primary TN.

♦ Target Sorting (J12.6)

The B-1B will receive and process the J12.6 Target Sorting message only if its Environment/Category is Air and its Exercise Indicator is set to Non-Exercise. If either of these conditions is not met, the B-1B will discard the message.

The B-1B will receive Target Sorting only for non-Exercise Air tracks.

■ Other Processing

Thus far, the B-1B has not specified its implementations of Amplification data, EW Product Association, Text messages, Threat Warnings, or Fighter Spoke messages. Note, however, that it is planned for both FIDL and DCI airframes to implement the J15.0 Threat Warning and the J28.2(0) Text messages.

Message		Tx	Rx
System Information Exchange and Network Management			
J0.0	Initial Entry	T	R
J0.1	Test Message	NT	R
J0.2	Network Time Update	NT	R
J0.3	Time Slot Assignment	NT	R
J0.4	Radio Relay Control	NT	R
J0.5	Repromulgation Relay	NT	R
J0.6	Communications Control	NT	R
J0.7	Time Slot Reallocation	NT	R
J1.0	Connectivity Interrogation	NT	NI
J1.1	Connectivity Status	NT	NI
J1.2	Route Establishment	NT	NI
J1.3	Acknowledgement	NT	NI
J1.4	Communication Status	NT	NI
J1.5	Net Control Initialization	NT	NI
J1.6	Needline PG Assignment	NT	NI
PPLI			
J2.0	Indirect Interface Unit PPLI	NT	R
J2.2	Air PPLI	T	R
J2.3	Surface (Maritime) PPLI	NT	R
J2.4	Subsurface (Maritime) PPLI	NT	R
J2.5	Land (Ground) PPLI	NT	R
J2.6	Land (Ground) Track PPLI	NT	R
Surveillance			
J3.0	Reference Point	NT	R
J3.1	Emergency Point	NT	R
J3.2	Air Track	NT	R
J3.3	Surface (Maritime) Track	NT	R
J3.4	Subsurface (Maritime) Track	NT	R
J3.5	Land (Ground) Point/Track	NT	R
J3.7	EW Product Information	NT	R
ASW			
J5.4	Acoustic Bearing and Range	NT	NI
AMP			
J6.0	Amplification Information	NT	R
Information Management			
J7.0	Track Management	NTRC	R
J7.1	Data Update Request	NT	NI

Figure 6-24. B-1B message capabilities summary (continued on next page)

Message		Tx	Rx
J7.2	Correlation	NT	NI
J7.3	Pointer	NT	R
J7.4	Track Identifier	NT	NI
J7.5	IFF/SIF Management	NT	NI
J7.6	Filter Management	NT	NI
J7.7	Association	NT	R(1)
J8.0	Unit Designator	NT	NI
J8.1	Mission Correlator Change	NT	NI
Weapons Coordination and Management			
J9.0	Command	NT	NI
J9.1	Engagement Coordination	NT	NI
J10.2	Engagement Status	NT	R
J10.3	Handover	NT	NI
J10.5	Controlling Unit Report	NT	NI
J10.6	Pairing	NT	NI
Control			
J12.0	Mission Assignment	T(2)	R
J12.1	Vector	NT	R
J12.2	Precision Aircraft Direction	NT	NI
J12.3	Flight Path	NT	NI
J12.4	Controlling Unit Change	NTRC	R
J12.5	Target/Track Correlation	NT	R
J12.6	Target Sorting	NT(3)	R(4)
J12.7	Target Bearing	NT	NI
Platform and System Status			
J13.0	Airfield Status	NT	NI
J13.2	Air and Platform System Status	T	R
J13.3	Surface (Maritime) Platform and System Status	NT	NI
J13.4	Subsurface (Maritime) Platform and System Status	NT	R
J13.5	Land (Ground) Platform and System Status	NT	R
EW			
J14.0	Parametric Information	T	R
J14.2	EW Control / Coordination	T	R
TW			
J15.0	Threat Warning	T	R
Image Transfer			
J16.0	Image Transfer	T	R

Figure 6-24. B-1B message capabilities summary (continued on next page)

Message		Tx	Rx
National Use			
J28.0	National Messages (J28.2(0) Only)	T	R
J29.0	Spoke Report	NT	NI
Miscellaneous			
J31.0	OTAR Management	NT	NI
J31.1	OTAR	NT	NI
J31.7	No Statement	NT	NI
RTT-A	Round Trip Timing Interrogation Addressed	T	R
RTT-B	Interrogation Broadcast	T	R
RTT-R	Reply	T	T
RTT-B	Alpha Numeric Free Text	NT	NI

Notes:

1. Abbreviations: Anti-submarine Warfare (ASW), Amplification (AMP), Electronic Warfare (EW), Threat Warning (TW)
2. Annotations used:

   T Transmit at least minimum message requirements
   NT Does not transmit the message
   NTRC Message transmitted only for Receipt/Compliance purposes
   R Receive and interpret some parts of the message
   NI Message not interpreted
   NIRC Message interpreted only for Receipt/Compliance purposes
   Rx Receive
   Tx Transmit
   (1) The J7.7 will be received only when used for DMPI association.
   (2) Will not be able to generate a mission assignment. Will be able only to WILCO/NO GO a message.
   (3) The transmit capability has been removed from the initial FIDL release.
   (4) The receive capability has been removed from the initial FIDL release.

Figure 6-24. This summary of the B-1B's transmit and receive message capabilities provides understanding of how this bomber operates on Link 16—as well as what to expect from it if you are an operator aboard another Link 16 platform.

Section K

B-2 Spirit

The B-2 has an integrated Link 16 suite that provides battlespace situational awareness as well as the digital transfer of target coordinates through the J12.0 message. It uses a MIDS LVT-7 without TACAN and Link 16 voice capability, and it operates in a receive-only mode whenever the tactical situation dictates. Future plans will incorporate transmission of received threat locations in a nontraditional intelligence, surveillance, and reconnaissance (NTISR) role.

The B-2's Link 16 usage is receive-only in certain tactical situations.

The B-2 also employs nonintegrated BLOS connectivity using SAT-J/JREAP-A over a Demand Assigned Multiple Access (DAMA) UHF SATCOM network.

Figure 6-25. The B-2 is a long-range stealth bomber with an integrated LOS Link 16 capability and a nonintegrated BLOS Link 16 capability.

Mission

The B-2 is an all-weather, multirole stealth bomber with intercontinental range and a wide array of both conventional guided and nuclear weapons. See Air Force Tactics, Techniques, and Procedures (AFTTP) 3-1 or 3-3, Volume 23, for further details.

Location

B-2s are permanently stationed only at Whiteman AFB, outside Kansas City, Missouri. Deployable B-2 shelters have been constructed at Fairford, UK, at Andersen AFB, Guam, and Diego Garcia, in the Indian Ocean, for deployed operations.

Integrated Link 16 Implementation

The B-2 is compliant with MIL-STD-6016A and incorporates the MAD-48 Attack Target Complex feature of MIL-STD-6016C. Interface Change Proposals (ICPs) are regularly fielded.

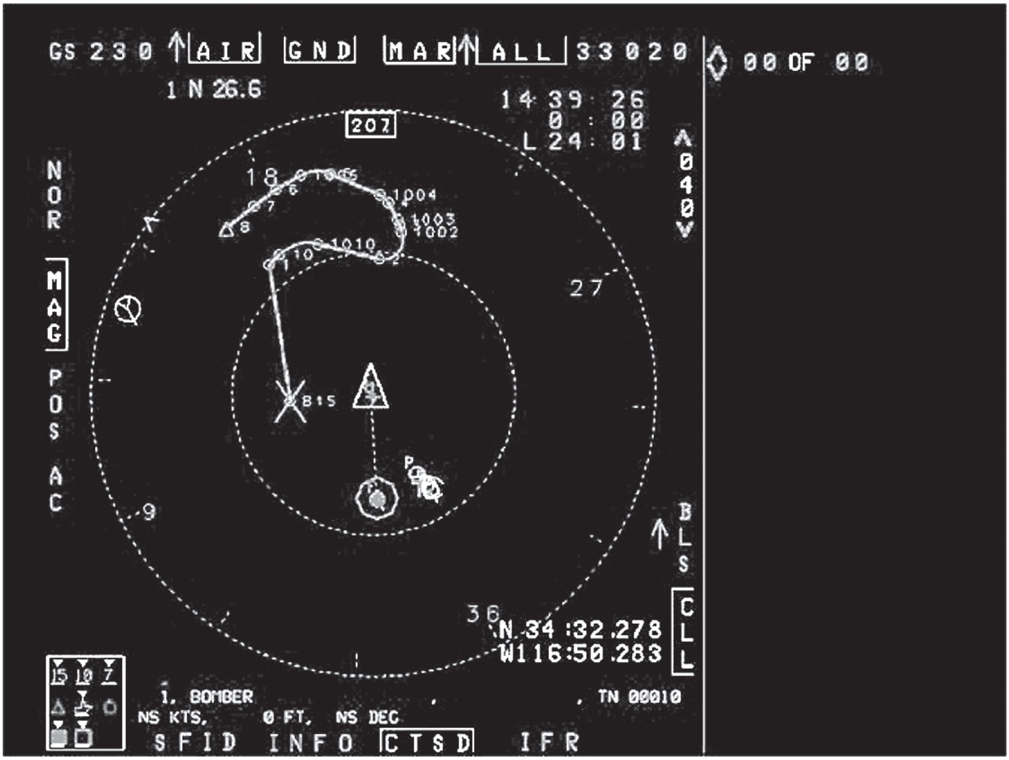

Figure 6-26. The B-2 cockpit display's Situation Awareness page is shown.

System Information Exchange and Network Management

Network management functions for the B-2 are designed for frontline, end-user participation. The B-2 Mission Planning software can provide up to eight networks and four crypto pairs at once to the aircrew, as shown in the following figure.

B-2 "NDL SEL" #:	1	2	3	4	5	6	7	8
Network Name:	USFU2A	USFU2A	USFU2A	USFU2A	USFO0004A	USFO0004A	USFU1A	USFU1A
SDU and SKL Locations	R0, R1	R2, R3	R4, R5	R6, R7	R0, R1	R2, R3	R4, R5	R6, R7
Crypto Keymat Short Title	5339	3174	3173	5340	5339	3174	3173	5340

Figure 6-27. A typical B-2 Mission Planning set of eight networks and four crypto pairs is shown. In the example above, there are actually only three separate network design files, but their association with different crypto pairs yields eight different usage possibilities.

Initial Entry and Time Synchronization

The B-2 transmits and receives the J0.0 Initial Entry message. The aircraft automatically uses GPS time and date inputs and has ETR capability. Manual entry backup is present in case GPS is not available. The B-2 can function as NTR. When it is not NTR, the aircraft uses a 12-second uncertainty window for net entry.

PPLI and Platform Status Messages

PPLI Information

The B-2 transmits its available data in a J2.2 Air PPLI message. It can receive PPLIs from Air (J2.2), Surface (Maritime) (J2.3), Land/Ground Point (J2.5), and Land/Ground Track (J2.6) platforms.

Miscellaneous PPLI Processing

The B-2 cannot transmit Bailout in its J2.2 PPLI message.

♦ Platform and System Status Information

B-2s transmit their own platform status in a J13.2 Air Platform and System Status message, reporting fuel, radio status, weapons availability, and many other data elements.

The B-2's system status is reported in the J13.2 message.

■ Air Platform and System Status (J13.2)

The B-2 is able to transmit and receive J13.2 Air Platform and System Status messages.

The B-2 receives Status messages only from other air platforms.

■ Surveillance, Amplification, and ESM

Surveillance is limited to Air tracks (J3.2), Surface (Maritime) tracks (J3.3), and Land Track and Point (J3.5 and J3.6) messages.

■ Weapons Coordination

The B-2 receives the Engagement Status (J10.2) message.

■ Air Control

♦ Mission Assignments (J12.0)

The B-2 receives and processes the J12.0 Mission Assignment message, but not all Mission Assignment Discretes (MADs), although it does process the Attack Target Complex MAD-48. The B-2 is not affected by multiple J12.0s at one time. If it is sent a subsequent J12.0 against a previously sent TN with identical coordinates, the B-2 will not create an additional target. If the coordinates are different for the same TN, however, it will ask the pilot for permission to modify them with the Modify Desired Mean Point of Impact (DMPI Modify) discrete.

The B-2 processes only certain discretes in the J12.0 message.

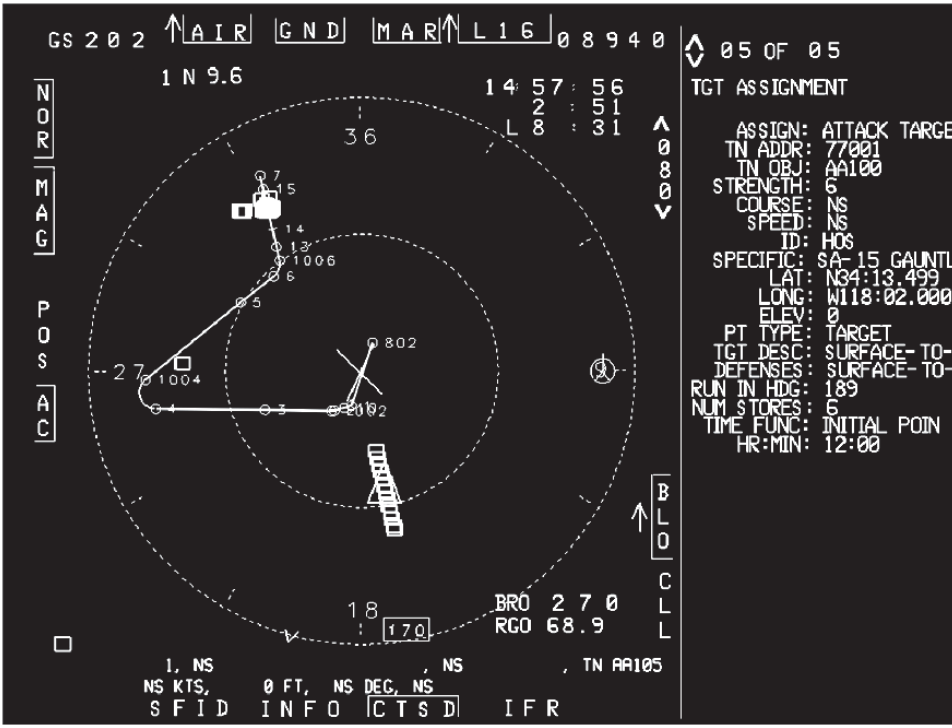

Figure 6-28. Two B-2 J12.0 Mission Assignment messages (continued on next page)

Figure 6-28. Two B-2 J12.0 Mission Assignment message pages are shown above.

The B-2 cannot create a target directly from a J3.x Track or a J12.6 Target Sorting message. It must rely on receiving a J12.0 Mission Assignment message from a C2 unit in order to digitally create a target. The pilot can, however, enter target coordinates manually.

■ Controlling Unit Change Order (J12.4)

The B-2 receives and processes the J12.4 Controlling Unit Change message and does not need the J12.4 to be able to receive a J12.0.

■ Target Sorting (J12.6)

The B-2 sends Attack Status, Results, Mark Point (Coordinates of Interest), and Pointer to Call Attention to TN. Mark Points are limited to the radar FOV (the forward 3-9 line).

Figure 6-29. This B-2 Results page shows some of the Battle Damage Assessments (BDAs) transmitted in its J12.6 messages.

■ *Threat Warning Messages*

♦ Threat Warning (J6.0, J15.0)

The B-2 receives J6.0 Amplification and J15.0 Threat Warning messages, but only those with the B-2 as the target.

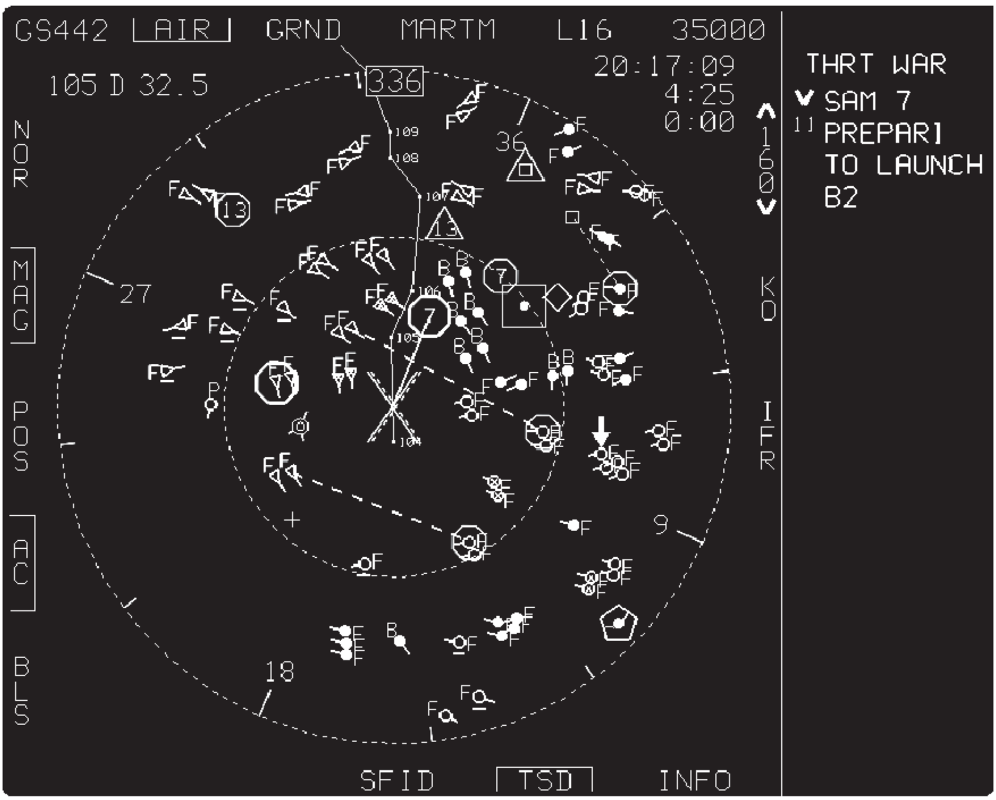

Figure 6-30.The B-2 cockpit display's Threat Warning configuration is shown. Threat Warnings are transmitted in J15.0 messages.

■ Text Messages

The B-2 can receive J28.2(0) Text Messages but cannot transmit them. Future plans will incorporate this capability.

■ Future NTISR Capabilities

The B-2 has plans to transmit J12.6 Sensor Point of Interest messages on NPGs 9, 19, and 20 as needed, to provide NTISR threat information to enabled participants.

■ Security

The B-2 may be directed to operate on US-only networks, limiting its visibility to some participants.

□ Nonintegrated BLOS Link 16 Implementation

The B-2 has a BLOS Link 16 system that does not connect to the B-2's OFP, requiring a manual transfer of any information between systems. This system uses either JRE 5.1 or Gateway Manager software on a laptop or rack-mounted PC, which is connected to a PRC-117 radio and a DAMA network. This provides the B-2 aircrew with intelligence feeds en route to the target area, Link 16 SA when outside the LOS network, and a backup for their integrated Link 16 if this should fail. It also provides them with a FalconView/GPS moving map, which is not available in the aircraft's OFP.

An AOC must provide the SAT -J or JREAP-A feed from the LOS network and send it over a UHF SATCOM DAMA channel to the aircrew. UHF SATCOM is a scarce and sometimes unreliable resource, so BLOS Link 16 is not considered a primary C2 link for the B-2.

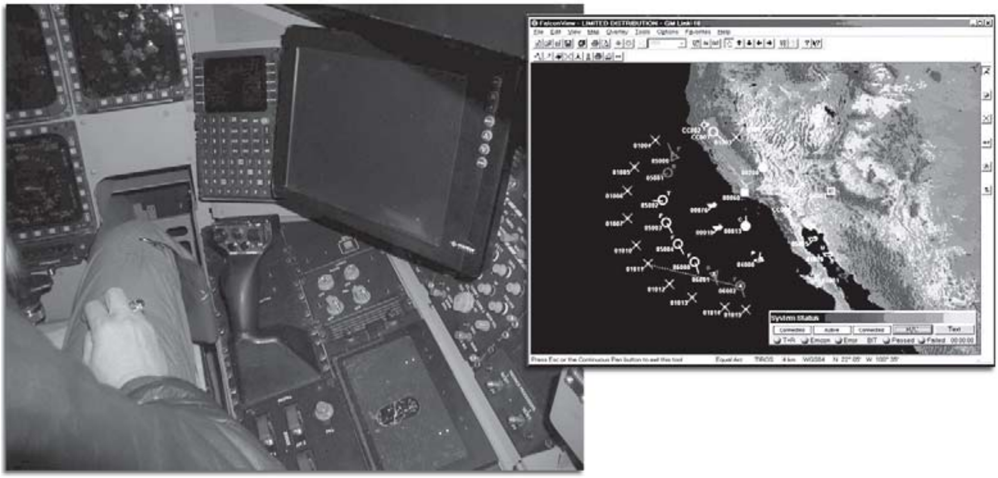

Figure 6-31.The nonintegrated B-2 BLOS equipment in the cockpit and its FalconView display are shown.

Msg	Message Description	Tx	Rx
System Information Exchange and Network Management			
J0.0	Initial Entry	T	R
J0.1	Test	NT	NI
J0.2	Network Time Update	T	R
J0.3	Time Slot Assignment	NT	R
J0.4	Radio Relay Control	NT	R
J0.5	Repromulgation Relay	T	R
J0.6	Communications Control	NT	NI
J0.7	Time Slot Reallocation	NT	NI
J1.0	Connectivity Interrogation	NT	NI
J1.1	Connectivity Status	NT	NI
J1.2	Route Establishment	NT	NI
J1.3	Acknowledgement	NT	NI
J1.4	Communicant Status	NT	NI
J1.5	Net Control Initialization	NT	NI
J1.6	Needline Participation Group Assignment	NT	NI
PPLI			
J2.0	Indirect Interface Unit PPLI	NT	R
J2.2	Air PPLI	T	NR
J2.3	Surface (Maritime) PPLI	NT	R
J2.4	Subsurface (Maritime) PPLI	NT	NI
J2.5	Land (Ground) Point PPLI	NT	R
J2.6	Land (Ground) Track PPLI	NT	R
Surveillance			
J3.0	Reference Point	NT	R
J3.1	Emergency Point	NT	NI
J3.2	Air Track	NT	R
J3.3	Surface (Maritime) Track	NT	R
J3.4	Subsurface Maritime Track	NT	NI
J3.5	Land (Ground) Point/Track	NT	R
J3.7	EW Product Information	NT	NI
ASW			
J5.4	Acoustic Bearing/Range	NT	NI
AMP			
J6.0	Amplification Information	NT	R
Information Management			
J7.0	Track Management	NTRC	R
J7.1	Data Update Request	NT	NI

Figure 6-32. B-2 message capabilities summary (continued on next page)

Msg	Message Description	Tx	Rx
J7.2	Correlation	NT	NI
J7.3	Pointer	NT	NI
J7.4	Track Identifier	NT	NI
J7.5	IFF/SIF Management	NT	NI
J7.7	Association	NT	NI
J8.0	Unit Designator	NT	NI
J8.1	Mission Correlator Change	NT	NI
Weapons Coordination and Management			
J9.0	Command	NT	NI
J9.1	Engagement Coordination	NT	NI
J10.2	Engagement Status	NT	R
J10.3	Handover	NT	NI
J10.5	Controlling Unit Report	NT	NI
J10.6	Pairing	NT	NI
Control			
J12.0	Mission Assignment	NT	R
J12.1	Vector	NT	NI
J12.2	Precise Aircraft Direction	NT	NI
J12.3	Flight Path	NT	NI
J12.4	Controlling Unit Change	NT	R
J12.5	Target/Track Correlation	NT	NI
J12.6	Target Sorting	T	R
J12.7	Target Bearing	NT	NI
Platform and System Status			
J13.0	Airfield Status	NT	NI
J13.2	Air Platform and System Status	NT	R
J13.3	Surface (Maritime) Platform and System Status	NT	NI
J13.4	Subsurface (Maritime) Platform and System Status	NT	NI
J13.5	Land (Ground) Platform and System Status	NT	NI
EW			
J14.0	Parametric Information	NT	NI
J14.2	EW Control /Coordination	NT	NI
TW			
J15.0	Threat Warning	NT	R
Image Transfer			
J16.0	Image Transfer	NT	NI
National Use			
J28.0	US National 1 (Army)	NT	NI

Figure 6-32. B-2 message capabilities summary (continued on next page)

Msg	Message Description	Tx	Rx
J28.1	US National 2 (Navy)	NT	NI
J28.2(0)	US National 3 (Air Force) Alphanumeric Text	NT	R
J28.2(1)	US (AF)-AWACS Suppress SIM Tape	NT	NI
J28.2(3)	US (AF)-Radar Service Request/Response	NT	NI
J28.2(4)	US (AF) Activity Indicator	NT	NI
J28.2(12)	US (AF) Differential Global Positioning System Correction	NT	NI
J28.3	US National 4 (Marines)	NT	NI
J28.4	French National 1	NT	NI
J28.5	French National 2	NT	NI
J28.6	US Nat'l 5 (NSA)(TIBS)	NT	NI
J28.7	UK National	NT	NI
J29	National Use (Reserved)	NT	NI
J29.1	UK Nation Use	NT	NI
Miscellaneous			
J31.0	OTAR Management Message	NT	NI
J31.1	OTAR	NT	NI
J31.7	No Statement	NT	NI
RTT-A	Round Trip Timing-Addressed	T	R
RTT-B	Round Trip Timing-Broadcast	T	R
RTT-R	Round Trip Timing-Reply	T	R

Notes:

1. Abbreviations: Anti-submarine Warfare (ASW), Amplification (AMP), Electronic Warfare (EW), Threat Warning (TW)
2. Annotations used:
   - T Transmit at least minimum message requirements
   - NT Does not transmit the message
   - NTRC Message transmitted only for Receipt/Compliance purposes
   - R Receive and interpret some parts of the message
   - NI Message not interpreted
   - NIRC Message interpreted only for Receipt/Compliance purposes
   - Rx Receive
   - Tx Transmit

Figure 6-32. This summary of the B-2's transmit and receive message capabilities provides understanding of how this bomber operates on Link 16—as well as what to expect from it if you are an operator aboard another Link 16 platform.

Section L

Airborne Laser

The Airborne Laser (ABL) weapon system is being developed as one element of the Missile Defense Agency's (MDA's) Ballistic Missile Defense System (BMDS). The current ABL aircraft is a Boeing 747-F; follow-on aircraft are expected to use the B747-8 airframe. The initial ABL program is currently defining this system with the goal of developing a prototype ABL, maturing the engineering design, and using it successfully to shoot down a ballistic missile in the boost phase in late FY09. One ABL system, designated YAL-1, is undergoing integration testing as part of the initial program. A second ABL test aircraft purchase decision will be made after the shoot-down demonstration in 2009.

The anticipated ABL fleet will consist of seven new production aircraft, plus one refurbished test aircraft. The engineering and manufacturing phase is scheduled to begin in FY 2015, with IOC for three ABL aircraft in FY 2022. Current plans are for a MIDS LVT-1 to be used in the ABL to support the weapon system software development and Link 16 integration.

Figure 6-33. The Airborne Laser (ABL) will be able to detect and destroy ballistic missiles while they are still in the boost phase over their launch territory. ABL will incorporate the MIDS LVT-1 to be able to transmit its highly accurate launch and impact point assessments.

Because the ABL will be part of the Joint theater battle architecture and MDA's Command and Control/Battle Management/Communications (C2BMC) system, interoperability is a key performance parameter. Link 16 will provide the primary means of mission communications with other BMDS elements, C2 nodes, and Joint participants. The ABL will coordinate its efforts with the entire ballistic missile defense architecture, providing highly accurate ballistic missile (BM) Launch Point estimates, J3.0C5 Impact Point predictions messages, and J3.6 State Vector data messages to the theater over Link 16.

Mission

The primary mission of the ABL is ballistic missile defense in support of Homeland Defense, Defense of Friends and Allies, and Defense of Deployed Forces. ABL achieves this mission by negating enemy BMs during the boost phase of flight. As a system designed to disable an enemy's offensive missile capabilities, it is expected to provide an autonomous, long-range, wide-area surveillance sensor and laser weapon capable of detecting, acquiring, identifying, tracking, and negating multiple BMs during the boost phase from standoff ranges. The ABL battle management system will enable selective engagement of ballistic missiles based on pre-established criteria and rules of engagement.

Location

The first and expected second MDA aircraft will be based out of Edwards AFB, CA. If the program undergoes transition and is transferred to the USAF, a basing decision will be forthcoming. All basing options are being considered.

Link 16 Implementation

This information on the ABL's Link 16 message implementation is to be considered tentative, and applying only to those aircraft soon to be equipped with MIDS LVT-1. The minimum implementation message specification is complete, and testing is underway. Specific details about the expected processing are included here to provide a preview of what to expect when working with ABL in Link 16 flights in a future Link 16 network.

System Information Exchange and Network Management

Network management functions for the ABL are designed for frontline, end-user participation. The ABL will not perform management control of the network; it will perform only own unit controls.

Initial Entry and Time Synchronization

The ABL will transmit and receive the J0.0 Initial Entry message. The aircraft is currently set up to use GPS time and date inputs automatically, and it will have ETR capability. Manual entry backup will be present in case GPS is not available. The ABL will be able to function as NTR. Note that when it is not NTR, the aircraft is planning to use a one-minute uncertainty window for net entry.

The ABL will be able to function as NTR.

The ABL will not transmit or receive the J1.x Network Management messages.

PPLI Information

Although not a C2 asset in the traditional sense (as is the E-3, for example), as a Link 16 participant, the ABL will transmit its available data in the J2.2 Air PPLI message with the Command and Control Indicator bit always set to 1, indicating that ABL is a C2 Unit.

Its PPLI receive processing will have certain limitations. In general, it does not process the Exercise Indicator bit. It will reject changes where the Simulation Indicator bit has changed from Simulated to Live. ABL will not process Relative Navigation data from non-Air platforms.

■ Platform and System Status Information

The ABL will not receive any J13.x Platform and System Status messages. The ABL will transmit its Air Platform and System Status message with only the Command and Control Status Continuation word.

■ Surveillance

The ABL will receive and process the Reference Point (J3.0), Air Track (J3.2), Surface (Maritime) Track (J3.3), Land Point/Track (J3.5), and Space Track (J3.6) messages, with some limitations. In general, it will not process the Exercise Indicator bit in the J3.0 message, and it will reject all changes where the Simulation Indicator bit has changed from Simulated to Live for all messages. Depending upon the Point Type of the J3.0 message certain continuation words will not be processed if they are received. The ABL will not process Strength, axis, and positional data for Land Points/Tracks.

The ABL will transmit J3.0 messages with Continuation words for Impact Points axes only, where required, and it will transmit the Space Track (J3.6) message. The Exercise Indicator and Simulation Indicator bits are set to 0.

■ Amplification

The ABL will receive, but will not transmit, the J6.0 Amplification message. Additional Amplification and EW message implementations are currently under consideration.

Information Management

The ABL will transmit and receive the J7.0 Track Management message, but it will not process the Strength and Specific Type Continuation words if these are received. The only exception is the J7.0C1 word for the Change Data Order message, which will be processed. The ABL will transmit only the J7.0 Drop Track message, with the Initial word only.

The ABL will receive and respond to the J7.1 Data Update Request message, but it will not transmit this message.

The ABL will transmit and receive the Pointer (J7.3) message.

Weapons Coordination

The ABL will receive the J9.0 Command message, but it may not process the Extension and Continuation words, depending on the setting of the Command field. The ABL will not transmit the J9.0 Command message.

The ABL will transmit and receive the J10.2 Engagement Status message, but it will not process the Friendly Weapons Continuation word if this is received. It will not transmit the J10.2C2 Friendly Weapons Continuation word.

Air Control

The ABL will neither transmit nor receive J12.x Air Control messages.

Text Messages

The ABL will transmit and receive the J28.2(0) Text message.

■ Link 16 Voice

The ABL will not have the Link 16 voice capability in the minimum implementation, but this will be considered for future development.

■ ABL Link-16 Implementation Summary

The initial implementation for ABL Block 04 will be in three sets. Sets 1 and 2 have been implemented, and Set 3 will be added in future. Additional message sets will considered during development of the second ABL aircraft. The following table identifies the first three sets of Link-16 messages that ABL will transmit and receive.

Message		Tx	Rx
System Information Exchange and Network Management			
J0.0	Initial Entry	T	R
J0.1	Test Message	T	R
J0.2	Network Time Update	T	R
J0.3	Time Slot Assignment		R
J0.4	Radio Relay Control		
J0.5	Repromulgation Relay	T	R
J0.6	Communications Control		R
J0.7	Time Slot Re-allocation	T (1)	R (1)
J1.0	Connectivity Interrogation		
J1.1	Connectivity Status		
J1.2	Route Establishment		
J1.3	Acknowledgement		
J1.4	Communication Status		
J1.5	Net Control Initialization		
J1.6	Needline PG Assignment		
PPLI			
J2.0	Indirect Interface Unit PPLI		R
J2.2	Air PPLI	T	R
J2.3	Surface (Maritime) PPLI		R
J2.4	Sub-surface (Maritime) PPLI		R
J2.5	Land (Ground) PPLI		R
J2.6	Land (Ground) Track PPLI		R
Surveillance			
J3.0	Reference Point	T	R
J3.1	Emergency Point		
J3.2	Air Track		R
J3.3	Surface (Maritime) Track		R
J3.4	Sub surface (Maritime) Track		R
J3.5	Land (Ground) Point/Track		R
J3.6	Space Track	T	R
J3.7	EW Product Information		
ASW			
J5.4	Acoustic Bearing and Range		
AMP			
J6.0	Amplification Information		R
Information Management			
J7.0	Track Management	T	R

Figure 6-34. ABL message capabilities (continued on next page)

Message		Tx	Rx
J7.1	Data Update Request		R
J7.2	Correlation		
J7.3	Pointer	T	R
J7.4	Track Identifier		
J7.5	IFF/SIF Management		
J7.6	Filter Management		
J7.7	Association		
J8.0	Unit Designator		
J8.1	Mission Correlator Change		
Weapons Coordination and Management			
J9.0	Command		R
J9.1	Engagement Coordination		
J10.2	Engagement Status	T	R
J10.3	Handover		
J10.5	Controlling Unit Report		
J10.6	Pairing		
Control			
J12.0	Mission Assignment		
J12.1	Vector		
J12.2	Precision Aircraft Direction		
J12.3	Flight Path		
J12.4	Controlling Unit Change		
J12.5	Target/Track Correlation		
J12.6	Target Sorting		
J12.7	Target Bearing		
Platform and System Status			
J13.0	Airfield Status		
J13.2	Air and Platform System Status	T	
J13.3	Surface (Maritime) Platform and System Status		
J13.4	Sub Surface (Maritime) Platform and System Status		
J13.5	Land (Ground) Platform and System Status		
EW			
J14.0	Parametric Information		
J14.2	EW Control / Coordination		
TW			
J15.0	Threat Warning		
Image Transfer			
J16.0	Image Transfer		

Figure 6-34. ABL message capabilities (continued on next page)

Message		Tx	Rx
National Use			
J28.0	National Messages		
J28.1	National Messages		
J28.2	National Messages	T	R
J28.3	National Messages		
J28.4	National Messages		
J28.5	National Messages		
J29.0	Spoke Report		
Miscellaneous			
J31.0	OTAR Management		R (1)
J31.1	OTAR		R (1)
J31.7	No Statement	T (1)	R (1)
RTT-A	Round Trip Timing Interrogation Addressed	T (1)	R (1)
RTT-B	Interrogation Broadcast	T (1)	R (1)
RTT-B	Reply	T (1)	R (1)
RTT-B	Alpha Numeric Free Text		

Notes:

1. Abbreviations: Anti-submarine Warfare (ASW), Amplification (AMP), Electronic Warfare (EW), Threat Warning (TW)
2. Annotations used:
   - T Transmit at least minimum message requirements
   - R Receive and interpret some parts of the message
   - (1) Set 3 Implementation

Figure 6-34. This summary of the ABL's transmit and receive message capabilities provides understanding of how it operates on Link 16—as well as what to expect from ABL if you are an operator aboard another Link 16 platform.

Section M

ROBE

The Roll-on Beyond-Line-of-Sight Enhancement (ROBE) system is a rapidly installable, nonintegrated airborne tactical data link node that can be rolled or floor-loaded onto a ROBE-modified KC-135 tanker aircraft before participating in an operation, to forward command decision-making information anywhere in the world as well as participate in the Link 16 RF network as a relay platform and for aircrew situational awareness.

ROBE Spiral 1.0 provides Link 16 and BLOS SATCOM to the KC-135 tanker.

The Chief of Staff, AF directed the modification of 40 KC-135 aircraft and the procurement of 20 ROBE communication suites. Initial fielding of 40 KC-135 ROBE aircraft (Group A) and 20 ROBE tactical information gateway (TIG) sets (Group B) was completed in May 2004. ROBE achieved initial operational capability in April 2006. ROBE Spiral 2.0 added SADL to Spiral 1.0's Link 16 LOS and satellite communications (SATCOM) BLOS networks. The Spiral 2.0 Group A and Group B upgrades were completed in July 2008.

ROBE Spiral 2.0 adds the SADL capability.

Figure 6-35. The permanent ROBE equipment (Group A) is installed aboard 40 KC-135 tanker aircraft. The Group B equipment, called the Tactical Information Gateway (TIG) set, may be rapidly installed aboard the tanker to perform a new mission: forwarding Link 16 data via satellite in accordance with MIL-STD-3011.

Mission

ROBE connects multiple dissimilar and incompatible tactical data networks and their participants with each other and to their battle directors in Joint C2 nodes, such as the AOC.

ROBE is designed to function as a hub for remote Link 16 networks.

Theater participants require the capability to establish and maintain secure battlespace SA to locate, identify, track, observe, and monitor friendly, enemy, hostile, and nonaligned forces and actors anywhere, anytime in near-real time to form a COP for executing combat operations. ROBE is a LOS/BLOS gateway that will enable decision-makers to use C2 nodes' ability to create and utilize decision-quality information for increasing predictive battlespace awareness (PBA), shortening the decision cycle for combat operations (such as the Find, Fix, Track, Target, Engage, Assess [F2T2EA] process), facilitating precision attack, and compressing the sensor-to-shooter kill chain.

ROBE is designed to function as a hub for remote Link 16 networks.

Tactical Data Link Hardware

The TDL capability in the TIG on the ROBE Group B Kit includes the MIDS LVT-3 (FDL) terminal, the Gateway Manager, which provides the BLOS support, and SADL.

Figure 6-36. A ROBE crewmember loads crypto into the TIG set's MIDS LVT-3 (FDL) terminal. The TIG set consists of the MIDS LVT-3 for Link 16 communications, the ARC-210 radio for forwarding Link 16 BLOS, a GPS system, a SADL radio, and the Gateway Manager for forwarding and hands-off communications management.

Location

Forty ROBE-capable aircraft are located primarily at McConnell AFB, Kansas, at Fairchild AFB, Washington, and at Grand Forks AFB, North Dakota. Some of these aircraft have been further dispersed throughout the active duty tanker fleet, including overseas bases such as Kadena, Japan and Mildenhall, UK.

Forwarding

The ROBE package of equipment allows for the forwarding of data to and from SAT-J. The forwarding standards use MIL-STD-3011.

In ROBE Spiral 2, the additional functionality of the SADL Transparent Multi-Platform Gateway (TMPG) allows for the forwarding of SADL J2.2 messages transmitted onto NPG 7 (Surveillance) and the J13.2 Systems Status message transmitted onto NPG 8 (Weapons Coodination and Mission Management).

Link 16 Implementation

This information on ROBE's message implementation applies only to those KC-135 aircraft that are Group A-modified with a Group B kit on board equipped with SADL and MIDS LVT-3. Message specification is complete. The specific details of ROBE message implementation are separated into messages transmitted when the KC-135 is tasked as the ROBE network participant. The onboard displays provide SA to the aircrew and details of the message processing for this purpose are described below. SA is provided to the flight deck using an onboard computer hub from Group A to a Mission Commander Display (MCD) computer from Group B connected at the pilot, copilot, or navigator position. Note that ROBE does not have the Link 16 voice capability.

ROBE as a Link 16 Network Participant

System Information Exchange and Network Management

Network management functions for ROBE are designed for frontline, end-user participation. ROBE will not perform management control of the network; it will perform only own unit controls. There are no dedicated TDL operators in the AMC who are tasked with supporting ROBE missions. The Boom Operator has been designated to preflight, power up, and power down the TIG system, which is configured as a "turn-it-on-and-forget-it" system with very little anticipated operator interaction. Coordination with the ROBE tanker crew would be limited to voice communications over existing KC-135 aircraft radios until the TIG is linked into the DAMA SATCOM or Link 16 network. Once Link 16 is established, communication with the tanker crew can be exchanged via J28.2(0) Text messages. The crew will be able to monitor this link only on a not-to-interfere basis during their primary air refueling mission.

ROBE has two primary functions: forwarding and and Link 16 relay.
ROBE is not a track generator; therefore, ROBE does not require track block assignments.

Initial Entry and Time Synchronization

Although ROBE can function as NTR, normally it will be planned to enter an established link already in progress. Certain exceptions, however, could require the ROBE tanker to fulfill the NTR function: fighter drags, initial response to a new, immature theater, participating in an invasion package, and the like.

Technically, ROBE can function as NTR, but normally it will not perform this role.

ROBE will transmit and receive the J0.0 Initial Entry message. The aircraft is currently set up to automatically use GPS time and date inputs, and has GPS ETR capability. Manual entry backup will be present in case GPS is not available. When ROBE is not NTR, the aircraft will use the standard, six-second time uncertainty window for network entry. The time uncertainty value is an operator-selectable setting. To minimize operator interaction, this value should be worked out in mission planning for incorporation into the Quick Start software for the Boom Operator's power-up.

Network Time Update (J0.2)

ROBE will transmit and receive the J0.2 Network Time Update message if operating as NTR.

■ Time Slot Assignment (J0.3)

ROBE will transmit and receive the J0.3 Time Slot Assignment message. ROBE will not initiate the time slot assignment message but only reply to the receipt of the message affecting the ROBE transmit time slot assignments.

■ Radio Relay Control (J0.4)

ROBE will receive and reply to the J0.4 Radio Relay Control message. ROBE will not initiate the Radio Relay Control message but will only reply to the receipt of the message affecting the ROBE relay function.

■ Repromulgation Relay (J0.5)

ROBE will receive and reply to the J0.5 Repromulgation Relay message. ROBE will not initiate the repromulgation relay message but only reply to the receipt of the message affecting the ROBE time slot assignments.

ROBE does not carry an "operator" to initiate transmit of ROBE Network Management messages or Surveillance track injections.

♦ PPLI and Platform Status Messages

As a Link 16 participant, ROBE will transmit its available data in a J2.2 Air PPLI message.

ROBE's PPLI will be contained in the J2.2 message.

■ Platform and System Status Information

ROBE-equipped tankers will transmit their own platform status in an Air Platform and System Status message (J13.2) approximately every 3.2 minutes, reporting fuel, sensor and radio status, weapons availability for up to four weapon types, and many other data elements. Most of the message words and fields will be utilized; exceptions are ASW Status, air EW Status, Equipment Status, Air Control Status, and Additional Stores Status.

ROBE's Status will be contained in the J13.2 message.

■ Miscellaneous PPLI Processing

ROBE will be able to transmit Bailout in its J2.2 PPLI message. However, it will not be able to receive Bailout indicators from other units.

♦ Relay

The LVT-3 terminal on ROBE will provide the capability to relay messages between RF Link 16 network participants.

Message Processing for Onboard Display

These operational considerations are at the display-only level aboard the ROBE tanker and do not affect RF Link 16 relay functionality or forwarding of the data to and from SAT-J or SADL.

PPLI Information

Its PPLI receive processing will have certain limitations. In general, it will entirely drop any PPLI message it receives with the Simulation Indicator set, or with No Statement set for Latitude, Longitude, Altitude, Q_t, Course, or Speed. Other expected characteristics of its received PPLI processing are described below.

Indirect Interface Unit PPLI (J2.0)

ROBE will accept the J2.0 message only from indirect Air units, and all other J2.0 messages will be discarded.

ROBE will receive only Air indirect PPLIs.

Air PPLI (J2.2)

If no update is received within 20 seconds, the track will be dropped. ROBE must also receive valid values for Q_{pg}, Strength, and Altitude and Altitude Quality. If it receives No Statement for Strength, ROBE will assume Strength to be 1. ROBE will receive and process only Air Platforms (except types 0–36); any others will cause it to discard the entire J2.2 message. It will receive and process only Interpret Voice Call Sign for the Voice Call Sign Indicator, and the Voice Call Sign must be valid. If the indicator is incorrectly set, ROBE will not process the Voice Call Sign.

Surface (Maritime) PPLI (J2.3)

ROBE will be able to receive PPLIs from maritime units, but it will assume that the unit's Altitude/Elevation is zero if it receives No Statement in this field.

■ Land (Ground) Point (J2.5) and Land (Ground) Track (J2.6) PPLIs

ROBE will be able to receive both Land Point and Land Track PPLIs.

ROBE will receive direct PPLIs from most unit types.

■ Air Platform and System Status (J13.2)

ROBE is expected to be able to receive and process all Air Platform and System Status messages. However, it will process only Air Specific Types. No other Specific Type values will be recognized.

ROBE aircraft will receive status messages only from other aircraft.

■ Airfield Status Data (J13.0)

ROBE is does not receive the J13.0 Airfield Status message.

♦ Surveillance, Amplification, and ESM

For ROBE, surveillance will be limited to Air tracks (J3.2), Surface (Maritime) tracks (J3.3), and Land Track and Land Point (J3.5 and J3.6) messages. On receiving one of these track messages with either the Simulation or Exercise Indicator set, it will entirely discard the message.

ROBE aircraft will not receive Simulation and Exercise tracks.

♦ Information Management

ROBE will support the J7.0 Track Management messages with a limited, receive-only capability. It will receive only the Drop Track Report, J7.0 with Action Code 1. From this message, it will process and respond to the Drop Track request if the TN is valid.

ROBE aircraft will only receive, not transmit,
Track Management messages.

Its methods for processing the Data Update Request (J7.1), the Correlation message (J7.2), the Pointer message (J7.3), the Track Identifier message (J7.4), the IFF/SIF Management messages (J7.5), and Filter Management messages (J7.6), if these will be implemented, have not yet been specified.

♦ Weapons Coordination

ROBE does not plan to implement Weapons Coordination messages. These include Commands (J9.0), Engagement Status (J10.2), Handover (J10.3), and Controlling Unit Reports (J10.5).

ROBE will not implement Weapons Coordination messages.

■ Mission Assignments (J12.0)

ROBE will receive and process the J12.0 Mission Assignment message. An existing mission assignment will be terminated when the pilot selects Disengage, or any of the following is received: Break Engagement, Cancel High Interest Track, Cease Attack, and Cease Mission. ROBE also receives Air Specific Types in this message.

■ Controlling Unit Change Order (J12.4)

The only ROBE flight member that will be able to respond to a J12.4 message is the addressee. Therefore, the message should be sent directly to the flight leader, using his primary TN. The ROBE equipment will process this message only when the Control Change Indicator is set to Control Change Order. ROBE will expect the Voice Frequency/Channel Indicator to be set to Alternate Voice Frequency/Channel, and will not process Primary Voice Frequency/Channel.

Only the addressee can respond to a CU Change Order!

Target/Track Correlation (J12.5)

ROBE will receive this message when the Originator is set to a primary TN.

Target Sorting (J12.6)

ROBE will receive and process the J12.6 Target Sorting message only if its Environment/Category is Air and its Exercise Indicator is set to Non-Exercise. If either of these conditions is not met, ROBE will discard the message.

ROBE will receive Target Sorting only for Non-Exercise Air tracks.

Other Processing

Thus far, ROBE has not specified its implementations of amplification data, EW Product Association, Text messages, Threat Warnings, or Fighter Spoke messages.

Message		Tx	Rx
System Information Exchange and Network Management			
J0.0	Initial Entry	T	R
J0.1	Test Message	NT	NI
J0.2	Network Time Update	T	R
J0.3	Time Slot Assignment	T	R
J0.4	Radio Relay Control	T	R
J0.5	Repromulgation Relay	T	R
J0.6	Communications Control	NT	NI
J0.7	Time Slot Reallocation	T	R
J1.0	Connectivity Interrogation	NT	NI
J1.1	Connectivity Status	NT	NI
J1.2	Route Establishment	NT	NI
J1.3	Acknowledgement	NT	NI
J1.4	Communication Status	NT	NI
J1.5	Net Control Initialization	NT	NI
J1.6	Needline PG Assignment	NT	NI
PPLI			
J2.0	Indirect Interface Unit PPLI	NT	R
J2.2	Air PPLI	T	R
J2.3	Surface (Maritime) PPLI	NT	NI
J2.4	Subsurface (Maritime) PPLI	NT	NI
J2.5	Land (Ground) PPLI	NT	R
J2.6	Land (Ground) Track PPLI	NT	R
Surveillance			
J3.0	Reference Point	NT	R
J3.1	Emergency Point	NT	R
J3.2	Air Track	NT	R
J3.3	Surface (Maritime) Track	NT	R
J3.4	Subsurface (Maritime) Track	NT	NI
J3.5	Land (Ground) Point/Track	NT	R
J3.7	EW Product Information	NT	R
ASW			
J5.4	Acoustic Bearing and Range	NT	NI
AMP			
J6.0	Amplification Information	NT	R
Information Management			
J7.0	Track Management	NTRC	R
J7.1	Data Update Request	NT	NI

Figure 6-37. ROBE message capabilities (continued on next page)

Message		Tx	Rx
J7.2	Correlation	NT	NI
J7.3	Pointer	NT	R
J7.4	Track Identifier	NT	NI
J7.5	IFF/SIF Management	NT	NI
J7.6	Filter Management	NT	NI
J7.7	Association	NT	NI
J8.0	Unit Designator	NT	NI
J8.1	Mission Correlator Change	NT	NI
Weapons Coordination and Management			
J9.0	Command	NT	NI
J9.1	Engagement Coordination	NT	NI
J9.2	Engagement Status	NT	NI
J10.3	Handover	NT	NI
J10.5	Controlling Unit Report	NT	NI
J10.6	Pairing	NT	NI
Control			
J12.0	Mission Assignment	T	R
J12.1	Vector	NT	NI
J12.2	Precision Aircraft Direction	NT	NI
J12.3	Flight Path	NT	NI
J12.4	Controlling Unit Change	NTRC	R
J12.5	Target/Track Correlation	NT	R
J12.6	Target Sorting	T	R
J12.7	Target Bearing	NT	NI
Platform and System Status			
J13.0	Airfield Status	NT	NI
J13.2	Air and Platform System Status	T	R
J13.3	Surface (Maritime) Platform and System Status	NT	NI
J13.4	Subsurface (Maritime) Platform and System Status	NT	NI
J13.5	Land (Ground) Platform and System Status	NT	NI
EW			
J14.0	Parametric Information	NT	NI
J14.2	EW Control / Coordination	NT	NI
TW			
J15.0	Threat Warning	NT	NI
Image Transfer			
J16.0	Image Transfer	NT	NI
National Use			

Figure 6-37. ROBE message capabilities (continued on next page)

Message		Tx	Rx
J28.0	National Messages (J28.2(0) Only)	NT	NI
J29.0	Spoke Report	NT	NI
Miscellaneous			
J31.0	OTAR Management	NT	NI
J31.1	OTAR	NT	NI
J31.7	No Statement	NT	NI
RTT-A	Round Trip Timing Interrogation Addressed	T	R
RTT-B	Interrogation Broadcast	T	R
RTT-R	Reply	T	T
RTT-B	Alpha Numeric Free Text	NT	NI

Notes:

1. Abbreviations: Amplification (AMP), Anti-Submarine Warfare (ASW), Threat Warning (TW)
2. Annotations used:

    T Transmit at least minimum message requirements
    NT Does not transmit the message
    NTRC Message transmitted only for Receipt/Compliance purposes
    R Receive and interpret some parts of the message
    NI Message not interpreted
    NIRC Message interpreted only for Receipt/Compliance purposes
    Rx Receive
    Tx Transmit

Figure 6-37. This summary of ROBE's transmit and receive message capabilities provides understanding of how the KC-135's TIG equipment processes Link 16 messages as a ROBE network participant—as well as which messages are processed for display to the aircrew on the MCD.

Section N

Unmanned Aerial Vehicles

The MQ-1 Predator and the RQ-4 Global Hawk are the USAF's primary unmanned aerial vehicle (UAV) systems designed to provide ISR products to the Joint Forces Commander (JFC). Both systems provide electro-optical/infrared (EO/IR) and synthetic aperture radar imagery through LOS or BLOS data links. The MQ-9 Reaper is the USAF's primary UAV system, designed for strike interdiction, hunter-killer, and Close Air Support (CAS) to support the JFC. These three UAVs are equipped with a myriad of data links and communications systems to enable vehicle control and product offload.

A ground-based Link 16 capability has been integrated with the existing communication systems of these UAVs. Access to Link 16 enables them to provide PPLI and targeting data (such as Sensor Point of Interest) and receive targeting requests from various users in the net. This Link 16 capability provides the COP to their GCSs and MCEs.

☐ MQ-1 Predator

The MQ-1 Predator system consists of four aircraft (UAVs), a GCS, a communications suite, and 55 ground personnel. The Predator system was designed to provide constant ISR data to US strategic and tactical forces. This system is operated by the 11^{th}, 15^{th} and 17^{th} Reconnaissance Squadrons at Creech AFB, Nevada, as well as three (soon to be four) ANG squadrons in remote split operations (RSO) configurations. RSO requires ground personnel and pilots at a forward operating base as a launch and recovery element, with pilots and sensor operators conducting the mission in the MCE-configured GCSs within CONUS.

The Predator is currently outfitted to carry and deploy AGM-114 Hellfire missiles. Because of its small size, the Predator is currently size-, weight-, and power-constrained from hosting any currently produced organic airborne Link 16 capability. But the Link 16 capability is being studied and evaluated for a future block implementation.

The Predator's current ground-based Link 16 capability consists of a Joint Air Defense System Integrator (JADSI), Cursor-on-Target (CoT) XML translator, and FalconView mission planning system and overlays. During flight operations, the UAV provides pilots and sensor operators sitting in the GCS "cockpit" with critical telemetry data—which includes airspeed, altitude, GPS coordinates, sensor coordinates, and the like—for proper operation of the UAV and related sensors.

A portion of this telemetry data is converted into Exploitation Support Data (ESD). This ESD is attached as metadata with the full-motion video stream that is sent to various customers for analysis and SA. In addition, the ESD is converted to usable J-series message formats (PPLI, SPI, and targets) by CoT for transmission by the JADSI via Socket J over the secure network to the CAOC. The mission GCSs receive the theater-level Link 16 COP in reverse, except that the received data is displayed via FalconView overlays for pilot and sensor SA. There is a JADSI operating for each AOR—OEF, OIF—supporting all Predator operations.

Figure 6-38. The MQ-1 Predator system provides constant ISR to US strategic and tactical forces. Predator's airborne Link 16 capabilities could be implemented in the future.

☐ *MQ-9 Reaper*

The MQ-9 Reaper system consists of several UAVs, a GCS, a communications suite, spares, and ground personnel. The Reaper system was designed to provide persistent hunter-killer against emerging targets, as well as CAS for US tactical forces. The Reaper is currently outfitted to carry and employ AGM-114 Hellfire missiles and GBU-12 Paveway II munitions. The Reaper system is operated by the 42^{nd} Attack Squadron at Creech AFB, Nevada, and is projected for AF Special Operations Command (AFSOC) and one ANG squadron.

Reapers are operated in RSO mode similar to Predators. The Reaper is considerably larger in size than Predator, and in future it should not have the size, weight, and power constraints for hosting organic airborne Link 16 capability. Currently, initial combat capability is being fielded without organic airborne Link 16. The Link 16 capability is being studied and evaluated for a future block implementation.

The Reaper's current ground-based Link 16 capability consists of a JADSI, a CoT XML translator, and FalconView mission planning system and overlays. As with the Predator, during flight operations the Reaper UAV provides critical telemetry data to pilots and sensor operators sitting in the GCS so they can operate the UAV and related sensors. A portion of the Reaper's telemetry data is converted into ESD and is attached as metadata with the full-motion video stream that is sent to various customers for analysis and SA. This ESD is also converted to usable J-series message formats (PPLIs, SPI data, and targets) by CoT for transmission by the JADSI via Socket J to the CAOC over the secure network. The mission GCSs receive the theater-level Link 16 COP in reverse, except that the received data is displayed via FalconView overlays for pilot and sensor operator SA. Just as it does for Predator, a JADSI operating for each AOR in OEF and OIF supports all Reaper operations.

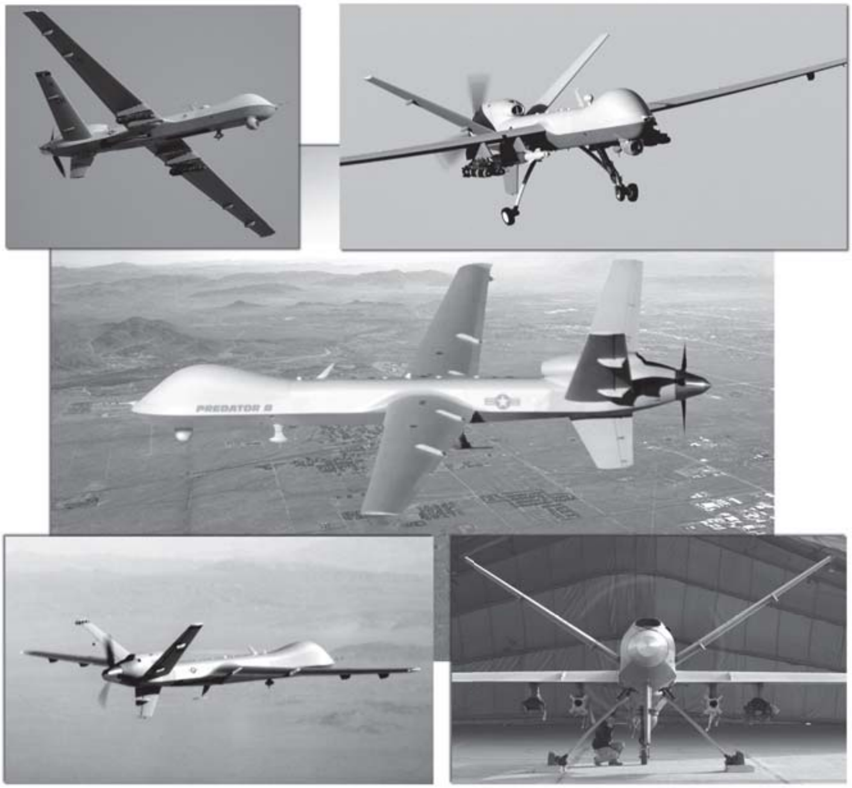

Figure 6-39. The MQ-9 Reaper system provides persistent hunter-killer against emerging targets and CAS for US tactical forces. Reaper's airborne Link 16 capabilities will be implemented in the future.

RQ-4 Global Hawk

The RQ-4 Global Hawk system can operate up to three UAVs from a single MCE. Each UAV requires a launch-and-recovery element at its operating base. Current plans call for four different variations, or blocks, of aircraft to provide EO/IR SAR image intelligence (IMINT), signals intelligence (SIGINT), multiple IMINT/SIGINT, and multipurpose Radar Technology Insertion Program capabilities with associated ground stations. This system is currently operated by the 9th Reconnaissance Wing at Beale AFB, California, and at various forward operating locations. Global Hawks are operated in RSO mode similar to Predators and Reapers. A ground-based Link 16 capability similar to Predator and Reaper is being utilized at the Global Hawk's MCEs. The exception is that Global Hawk's JADSI systems have been integrated into the associated MCE without the use of CoT. Global Hawk does not have an operational requirement for an organic airborne Link 16 capability.

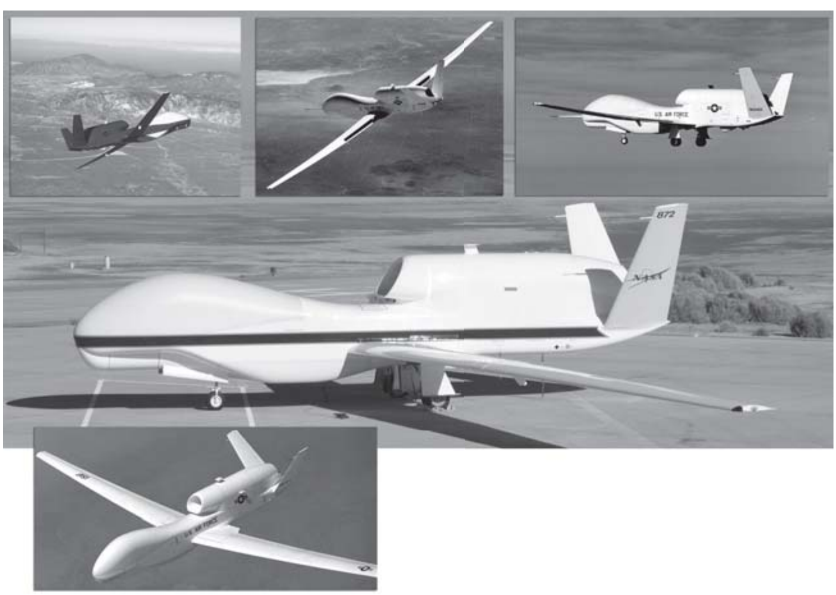

Figure 6-40. The RQ-4 Global Hawk system can operate up to three UAVs from a single GCS. The UAV component is shown here. Each UAV requires a launch and recovery element at its operating base.

Section O

Planned Implementations

Overview

The USAF's Tactical Data Link Roadmap[4] provides the plan of action that the Air Force uses to implement tactical data links, including Link 16, aboard its platforms. This plan does not mandate when any specific platform should implement Link 16; rather, each platform funds and schedules its own specific data link requirements. The various platforms have their own, varying development and update cycles. The overall goal of the USAF, however, is to have implemented the Link 16 capability in the platforms discussed here by 2020.

Joint Strike Fighter

The Joint Strike Fighter (JSF), lately designated the F-35 Lightning II, is the USAF's next-generation, multirole, single-engine, single-seat fighter that is envisioned to replace the F-16 and A-10 and complement the F-22A. The JSF currently is under development and will begin testing in late 2008 or early 2009. The intent is to maintain F-16-like performance in terms of speed, maneuverability, and range, while correcting known deficiencies in survivability, lethality, and supportability. Because it will be operating in large-scale C2ISR networks, it is essential that the JSF have an enhanced interoperability with all elements—air and land—of US forces. Interoperability with the Allied services is also desired.

4 *AF Tactical Data Link Roadmap, ESC/DIVJ, 29 October 2001.*

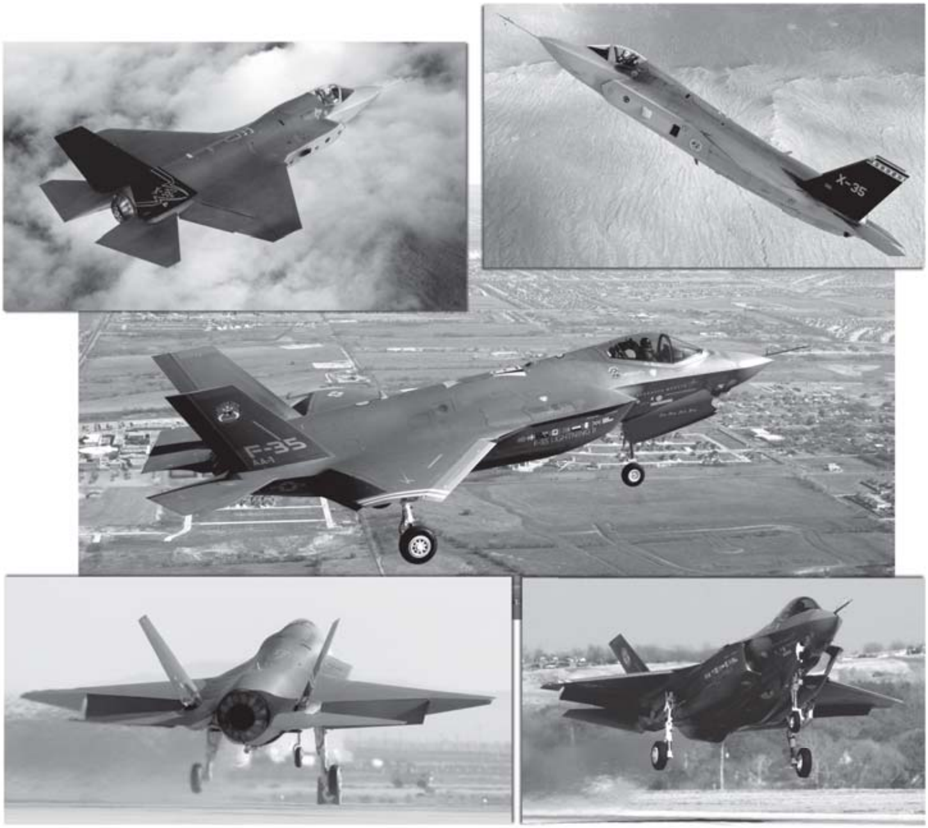

Figure 6-41. The Joint Strike Fighter is a next-generation, multirole fighter aircraft whose Link 16 capabilities are still being defined. These need to include in-flight retasking and retargeting, as well as overall SA and the locations of friendly forces.

■ Use of Link 16

JSF's data link capabilities are still in the planning stage. The fighter will have to be compatible with the evolving C4ISR architecture for 2010, which includes Link 16 and Variable Message Format (VMF). The JSF will need secure voice communications and data transmissions. It will also need the capability to transmit and receive essential and timely information in a hostile environment with low probability of intercept, such as that provided by Link 16. Its incoming information should improve SA, provide targeting information, and allow for in-flight retasking and retargeting.

The JSF will need timely and reliable offboard communication about air-to-air and surface-to-air threats so it can tactically limit its use of onboard sensors. The fighter will also need location information on friendly forces. It will need to correlate information from multiple sources to improve its SA and mission effectiveness, and it will also need to be able to share sensor and targeting data among flight members.

B-52 Stratofortress

Data link planning for the B-52 will follow a three-spiral acquisition program. Each spiral delivers a data link capability, with interface “hooks” to the other two. Each is severable, and can be delivered to operate without the other two. The principal milestones of Spirals 1 and 2 are color displays, BLOS conventional, air-launched, cruise missile retasking, improved SA, advanced extremely high-frequency antenna, modem, processor, operator interface, and weapons retasking for its precision-guided munitions (PGM). Spiral 3 integrates Link 16.

Seventy-six B-52 platforms are currently scheduled to be equipped with the MIDS LVT-1 terminal for Link 16 communications. At the time of this writing, the B-52 Link 16 plan is under revision for update, and its final decision is pending the completed Operations Requirement Document.

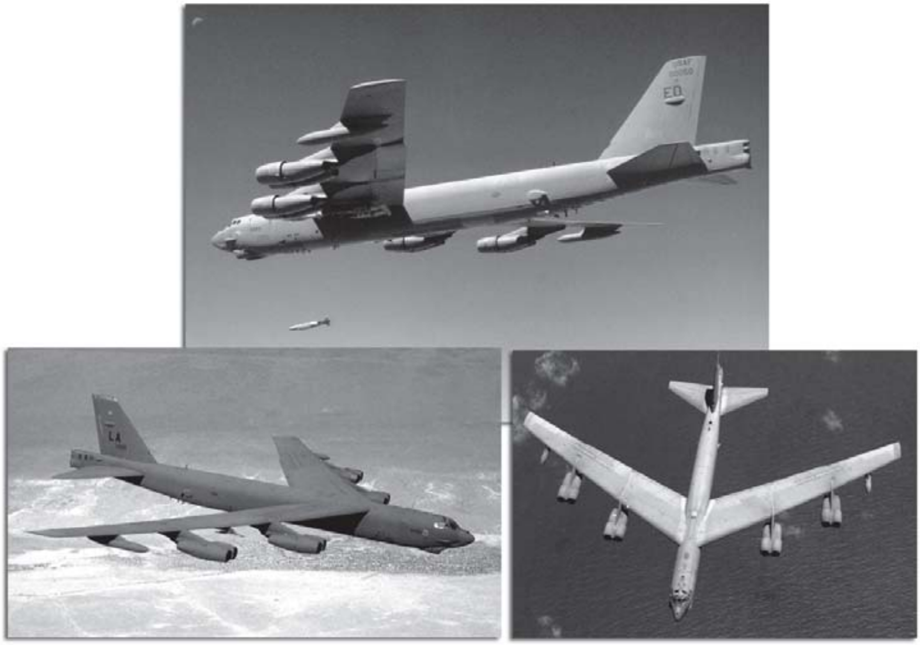

Figure 6-42. B-52 bomber aircraft, or "Mighty Buffs," have been in use since 1954. Data link capability will be introduced during a three-spiral acquisition program, which will integrate Link 16 as part of Spiral 3.

Air Support Operations Center Gateway

The Air Support Operations Center (ASOC) Gateway will provide the capability to tie all Joint Terminal Attack Controllers (JTACs) on the battlefield with digital network aircraft that employ Link 16 and SADL. The Close Air Support System (CASS) software itself, without the use of the Gateway, has direct LOS digital communications with F/A-18s, AV-8Bs, and F-16s. The ASOC Gateway employs the Rosetta/FalconView messaging engine and database.

The ASOC Gateway will be capable of communicating on the following data links:

- Link 16
- Air Force Applications Program Development (AFAPD) – Improved Data Modem (IDM), used by F-16 Block 40
- VMF, supporting F/A-18, A-10, and JSF
- Marine Tactical System (MTS), supporting AV-8B
- JRE, supporting SAT-J and JREAP B
- Force XXI Battle Command, Brigade-and-Below (FBCB2), supporting the Army and Marine Corps, and
- Air Force Airborne Tactical Data System (AFATDS), supporting the Army and Marine Corps.

The ASOC Gateway will process National Geospatial-Intelligence Agency (NGA) maps and imagery.

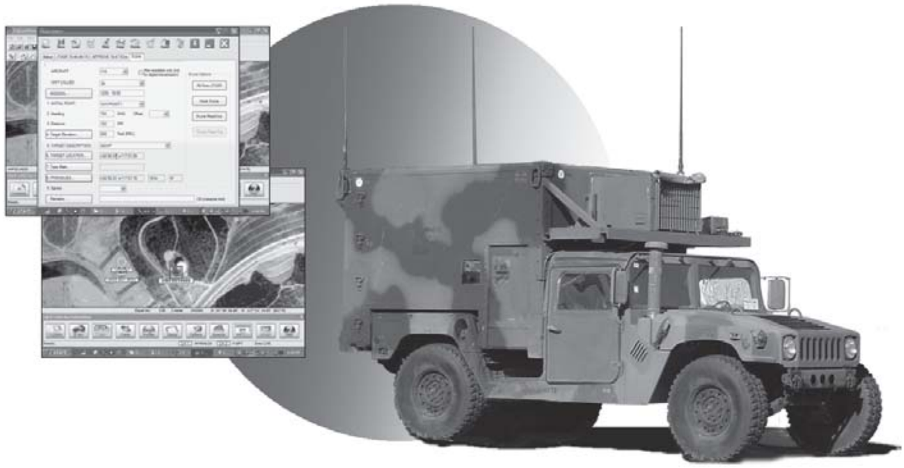

Figure 6-43. The Air Support Operations Center (ASOC) Gateway is hosted aboard a High Mobility Multipurpose Wheeled Vehicle (HUMMWV). Its Rosetta/FalconView messaging engine and database are also shown here.

■ Link 16 Message Implementation

♦ Current Capabilities

The ASOC's Link 16 message implementation currently includes only transmitting and receiving the J2.0 Indirect PPLI, the J3.5 Land/Ground Track, and the J7.0 Drop Track messages.

♦ Future Capabilities

The ASOC's future implementation will include transmit and receive capabilities for the J9.0 Command, J12.0 Mission Assignment, J12.6 Target Sorting, and J16.0 Image Transfer messages.

Increment 1 Capabilities

The ASOC Increment 1 hardware will include

- JRE and TMPG software
- PRC-117F radios, for UHF, VHF, and SATCOM connectivity
- MIDS LVT-2, for Link 16 network participation
- The SADL radio, and
- The PRC-150 radio, for HF BLOS connectivity.

Increment 2 Capabilities

To provide the path forward to new-technology network systems, the ASOC Increment 2 will

- Upgrade the Objective Gateway software
- Upgrade the MIDS JTRS or other new TDL-capable radios
- Replace the PRC-117F radios with IP-capable, Software Communications Architecture (SCA)-certified radios
- Add Common Data Link (CDL), if adequately automated, with no increase in personnel, and
- Provide TACP and JTAC access to Link 16 and SADL networks.

Battle Command and Control Center

The Battle Command and Control Center (BC3) AFCENT replaces MCE AN/TYQ-23 assets now being employed in support of OIF and OEF. BC3 is a fixed, nonmobile system.

BC3 provides a tactical-level C2 execution capability for the CFACC. It is responsible for providing positive and procedural control to assigned air assets. BC3 shares responsibility for this mission with the airborne C2 elements—for example, E-3, E-2, and JSTARS. It also supports the ASOC and TACP, which are the TACS elements responsible for planning, requesting, and controlling the CAS assets that support ground forces.

BC3 supports AFCENT execution of

- Air defense
- TDL management
- Airspace surveillance
- Aircraft identification
- Airspace management, and
- ATO execution.

BC3 provides flexibility to meet next generation warfare through scalability and exploitation of new technologies. The primary attributes of BC3 are:

- Increased surveillance volume through integrating organic and nonorganic radars
- C2 capabilities for supporting current and evolving OIF/OEF operational requirements
- Improved interoperability with higher headquarters, as well as with lateral and subordinate C2 elements
- Improved mission planning and execution capabilities
- Improved operator and Battle Staff situational awareness, and
- Operator interface with Theater Battle Management Core Systems (ATO, ACO, WX) and secure chat capability via stand-alone Secure Internet Protocol Router Network (SIPRNET) workstations.

Figure 6-44. The Battle Command and Control Center (BC3) replaces the MCE AN/TYQ-23. The BC3 Test site at Charleston, South Carolina, is shown here along with an internal view of the Operations floor at Balad Air Base, Iraq.

■ Link 16 Message Implementation

The BC3 uses Link 16 as a primary means of passing data link messages. Figure 6-44 depicts Link 16 messages resident in the JRE that are mapped to the Multiple Source Correlator Tracker. Because all translation and forwarding to Link 11 and Link 11B takes place in the ADSI®, the required Link 16 protocol includes only the transmit and receive capabilities.

Msg	Message Description	BC3		F-35 JSF		B-52 (with JRE)		ASOC Gateway	
System Information Exchange and Network Management									
J0.0	Initial Entry	T	R	T	R				
J0.1	Test	T	R	T	R				
J0.2	Network Time Update	T	R	T	R				
J0.3	Time Slot Assignment	T	R	NTRC	R				
J0.4	Radio Relay Control			NTRC	R				
J0.5	Repromulgation Relay			T	R				
J0.6	Communications Control			NTRC	R				
J0.7	Time Slot Reallocation	T	R						
PPLI									
J2.0	Indirect Interface Unit PPLI	T	R	NT	R	T	R	NT	R
J2.2	Air PPLI	NT	R	T	R			NT	R
J2.3	Surface (Maritime) PPLI	NT	R	NT	R			NT	R
J2.5	Land (Ground) Point PPLI	T	R	NT	R			NT	R
J2.6	Land (Ground) Track PPLI	NT	R	NT	R			NT	R
Surveillance									
J3.0	Reference Point	T	R	NT	R	NT	R	NT	R
J3.1	Emergency Point	T	R	NT	R			NT	R
J3.2	Air Track	T	R	NT	R	NT	R	NT	R
J3.3	Surface (Maritime) Track	NT	R	NT	R	NT	R	NT	R
J3.5	Land (Ground) Point/Track	T	R	NT	R	NT	R	NT	R
J3.6	Space Track	NT	R						
J3.7	EW Product Information	NT	R	NT	R				
AMP									
J6.0	Amplification	NT	R	NT	R	NT	R		
Information Management									
J7.0	Track Management	T	R	NT	R	NT	R	NT	R
J7.1	Data Update Request	T	R						
J7.2	Correlation	T	R						
J7.3	Pointer	T	R						
J7.4	Track Identifier	T	R						
J7.5	IFF/SIF Management	T	R						
J7.7	Association	T	R	NT	R	NT	R		
Weapons Coordination and Management									
J9.0	Command	T	R					NT	R
J9.1	Engagement Coordination	T	R						
J10.2	Engagement Status	T	R	NT	R	NT	R	NT	R

Figure 6-45. BC3 message capabilitiies (continued on next page)

Msg	Message Description	BC3		F-35 JSF		B-52 (with JRE)		ASOC Gateway	
J10.3	Handover	T	R						
J10.5	Controlling Unit Report	T	R						
J10.6	Pairing	T	R						
Control									
J12.0	Mission Assignment	T	R	T	R	NT	R		
J12.1	Vector	T	R						
J12.4	Controlling Unit Change	T	R	T	R	T	R		
J12.5	Target/Track Correlation	T	NR	NT	R				
J12.6	Target Sorting	NT	R	T	R	T	R		
J12.7	Target Bearing								
Platform and System Status									
J13.0	Airfield Status	T	R						
J13.2	Air Platform and System Status	NT	R	T	R	T	R	NT	R
J13.3	Surface (Maritime) Platform and System Status	NT	R	NT	R				
J13.4	Subsurface (Maritime) Platform and System Status								
J13.5	Land (Ground) Platform and System Status	T	R	NT	R			NT	R
EW									
J14.0	Parametric Information			T	NR				
J14.2	EW Control /Coordination								
TW									
J15.0	Threat Warning	T	R	NT	R	NT	R		
Image Transfer									
J16.0	Image Transfer			T	R				
Weather									
J17.0	Weather Over Target	T	R						
National Use									
J28.2(0)	US National 3 (Air Force) Alphanumeric Text			T	R	T	R	NT	R
Miscellaneous									
J31.0	OTAR Management			NTRC	R				
J31.1	OTAR			NTRC	R				
J31.7	No Statement			T	R				
RTT-A	Round Trip Timing-Addressed			T	R				

Figure 6-45. BC3 message capabilitiies (continued on next page)

Msg	Message Description	BC3		F-35 JSF		B-52 (with JRE)		ASOC Gateway	
RTT-B	Round Trip Timing-Broadcast			T	R				
RTT-R	Round Trip Timing-Reply			T	R				
Free Text	Digital Voice, 2.4 kbps uncoded LPC-10			T	R				
Free Text	Digital Voice, 2.4 kbps coded LPC-10			T	R				
Free Text	Digital Voice, 16 kbps CVSD			T	R				

Notes:

1. Abbreviations: Anti-submarine Warfare (ASW), Amplification (AMP), Electronic Warfare (EW), Threat Warning (TW)
2. Annotations used:

   T Transmit at least minimum message requirements
   NT Does not transmit the message
   NTRC Message transmitted only for Receipt/Compliance purposes
   R Receive and interpret some parts of the message
   NI Message not interpreted
   NIRC Message interpreted only for Receipt/Compliance purposes
   Rx Receive
   Tx Transmit

Figure 6-45. This summary of the BC3, the JSF, the B-52, and the ASOC Gateway transmit and receive message capabilities provides an understanding of how they will operate in future on Link 16.

Introduction

This chapter reviews the operational goals of the Link 16 system and summarizes the fundamental steps relevant to its employment: Operational Goals, Link 16 Planning, Link 16 Management, and Infrastructure Support. As capabilities and employment concepts evolve, Link 16 operational applications will change to meet the warfighter's needs. For detailed data link Standard Operating Procedures, refer to the Joint Multi-Tactical Data Link (TDL) Operating Procedures (JMTOP), CJCSM 6120.01D.

Section A

Operational Capability

The Link 16 message standard is designed to support the full range of tactical information exchange requirements (IERs) necessary in the great majority of operational scenarios. Ideally, a force should be able to operate sufficiently using Link 16 as the sole means of external real-time tactical communications, without relying on voice or other types of external communications. This is the reason for the greatly expanded volume of information that can be exchanged over Link 16. The key operational areas supported by Link 16 are:

- Battle space awareness
- Command and Control (C2) connectivity and integration
- Interoperability with Joint, Allied, and multinational forces.

Battle Space Awareness

The basic ability to provide the positions of friendly forces with Precise Participant Location and Identification (PPLI) data greatly enhances our situational awareness. Providing force disposition to all levels of operations gives commanders a valuable tool for monitoring all operational phases and greatly reduces the possibility of fratricide. Even a minimal Link 16 capability can result in an extreme advantage for our forces.

C2 Connectivity and Integration

Link 16 is designed to support maximum automation of tactical functions, such as engagement tactics and combat decisions. Its near-real-time data exchange provides the means to support effective mission execution. Doctrinally, our forces operate under the concept of Centralized Control and Decentralized Execution. The following example describes how Link 16 supports this doctrine.

Link 16 supports the goals of centralized control and decentralized execution.

The Air and Space Operations Center (AOC) identifies an emerging target for immediate action. A J9.0 Command message is transmitted on NPG 8 (Mission Management) to a controlling platform (AWACS or a CRC), identifying the target. The AWACS machine-receipts the J9.0 Command message, then sends a J12.0 Mission Assignment message on the NPG 9 uplink to the asset best suited to attack the target. This asset responds with WILCO to the AWACS on the NPG 9 backlink. The J10.2 Engagement Status message is then transmitted by the AWACS for wide area distribution on NPG 8. Upon termination of the engagement, the attacking asset will transmit a J12.6 Target Sorting message for wide-area distribution. This allows the "centralized" AOC to control the battle, while allowing the forward units to execute the mission as effectively as possible.

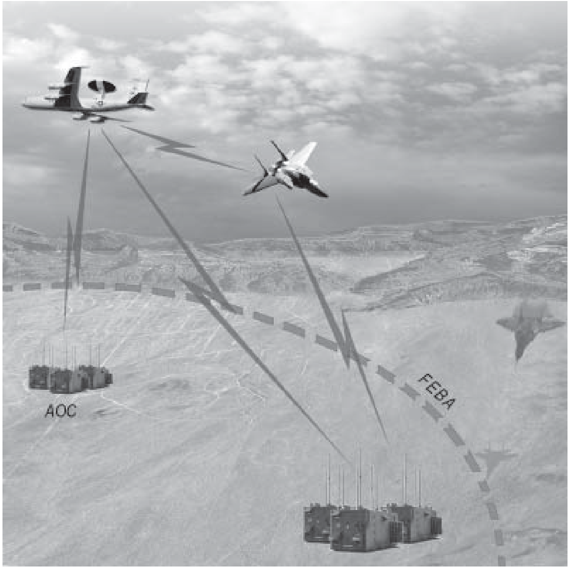

Figure 7-1. In this figure, a "centralized" Air and Space Operations Center (AOC), on the far left, controls a battle, while allowing its forward units to execute particular missions. The AOC has selected an enemy target for immediate action. On NPG 8, the AOC transmits a command to an AWACS identifying this target, the fighter asset to attack it with, and the identity of the controlling unit (CU) for this engagement (here, a ground installation). The AWACS, in turn, sends a mission assignment on the NPG 9 uplink to the fighter chosen for the attack. The fighter WILCOs the assignment on the NPG 9 backlink. His engagement status will be then transmitted for wide area distribution on NPG 8. The forward edge of the battle area is labeled FEBA.

This example also depicts Link 16's role in the kill chain. Link 16 supports all phases of the Find, Fix, Track, Target, Engage, and Assess (F2T2EA) process. This process maximizes the application of forces and supports operational execution of Time Sensitive Targeting (TST) and Time Critical Targeting (TCT).

Link 16 efficiently supports the kill chain.

As stated earlier, Link 16 employment concepts and operational applications will grow and change as mission priorities and platform capabilities demand. Because the nature of war is dynamic, it is important for all users of Link 16 to focus on the overall goal of the system, and then develop employment concepts that maximize Link 16 capabilities.

☐ Interoperability with Joint, Allied, and Multinational Forces

The general policy of maximum standardization is reflected in the Link 16 J-series messages in two important ways. First, data element definition and employment needs are standardized to the maximum feasible extent to support mission execution. Second, USAF implementation of all data items is standardized to the maximum appropriate extent among its platforms.

Link 16 promotes standardization among platforms.

These data elements and message implementations are described in MIL-STD-6016. Such standardized implementation is intended to:

- Promote interoperability among the platforms, Services, Allies, and multinational users of Link 16
- Greatly reduce the need for operators to learn and accommodate differences between platforms operating together, and
- Promote efficiency in the overall USAF Link 16 platform implementation process.

Section B

Link 16 Planning

This section outlines the steps required to plan Link 16 operations:

- Requesting a network
- Designing a network
- Naming the network design
- Generating the Operational Tasking Data Links (OPTASK LINK) message.

Requesting a Network

Before beginning daily operations, an exercise, or a contingency, mission planners must select a Link 16 network from the network library that will support their operational requirements. Their **network selection criteria** include:

- The number and types of participants
- Line-of-sight (LOS) constraints
- Relay requirements, and
- Electromagnetic compatibility (EMC) requirements.

Depending on the network and the number and types of other tactical data links to be fielded for the exercise or operation, the planners specify additional initialization parameters to tailor the network to their specific implementation. These additional parameters, called **planning parameters**, include:

- The terminal addresses or system reference numbers
- Required participating platforms
- Required cryptographic keys, and
- Required track blocks for each participant for track reporting on each TDL.

Requesting a network may be as simple as identifying an existing network that meets employment needs. If an entirely new network is required, however, a network request form can be submitted to the USAF Network Design Facility (AF NDF) for its creation.

Designing a Network

Each network in the library of networks is designed to meet the requirements of daily operations, a specific exercise, or a contingency scenario, including the expected data throughput requirements. The network design process is normally performed well in advance of its associated operation. During the network design phase, network participants are identified by their general type—such as CRC, AWACS, AOC, F-15, JSTARS, RJ, and so on. The correlation of actual units to general network participant types is performed during the network-planning phase.

The primary tool for creating a network design is the Joint Network Design Aid (JNDA). This tool is used by the NDFs of all US Services and is managed jointly to maintain interoperability. Each Service employs it to generate platform initialization files for their respective Link 16 users. Although the resulting load files may be different, and are created by different NDFs, they are all created from a common database called a "connectivity matrix." This matrix is where the transaction analysis is defined for each specific platform's transmit, receive, and relay assignments. An example portion of a connectivity matrix is given in Figure 7-2.

Slot Group			1	2	3	4	5	6	7	8	9	10	11	12	13
			RTT-B	NMGT	NMGT	NMGT	NMGT	PPLI_B	PPLI_B	PPLI_B	PPLI_B	PPLI_B	PPLI_B	PPLI_B	PPLI_B
NPGs			3	4	TY	4	TY	6	6	TY	6	TY	6	6	6
Net Number			0	0	0	10	10	0	0	0	10	10	0	0	10
TSEC Variable			1	1	1	1	1	1	1	1	1	1	1	1	1
MSEC Variable															
Access Mode			4	D		D		D	D		D		8	3	8
Overlay ID															
Packing Limit			RTT	P4		P4		P2SP	P2SP		P2SP		P2SP	P2SP	P2SP
Per Unit Slot/Frame								1	1		1				
Total Slots/Frame			8	4	4	4	4	18	24	24	14	14	64	64	64
Participant ID	Net Entry Transmit Enable	Default Net													
E3(1)	Y	0	T	R	Y			T/R	R	Y	R	Y	R		
E3(2)	Y	0	T	R	Y			T/R	R	Y	R	Y	R		
E3(3)	Y	0	T	R	Y			T/R	R	Y	R	Y	R		
E3(4)	Y	0	T	R	Y			T/R	R	Y	R	Y	R		
GTS_LVT_1(1)	Y	0	T	R	R			R	T/R	R	T/R	R	R		R
ADSI_LVT_7(1)	Y	0	T	R	R			R	T/R	R	T/R	R	R		R
ADSI_PJ(1)	Y	0	T	R	R			R	T/R	R	T/R	R	R		R
SJS(1)	Y	0	T	R	R			R	T/R	R	T/R	R	R		R

Figure 7-2. A connectivity matrix defines the transmit (T), receive (R), and relay (Y) assignments for every participant of the network. It also specifies the time slot groups, message security (MSEC) and transmission security (TSEC) cryptovariables, NPGs, access mode, packing limit, and number of time slots for each unit.

For large-scale, Joint operations, the network design process may involve the Joint Network Design Team (JNDT). The JNDT is composed of network design specialists from the USAF, USA, USN, and USMC NDFs. The team's primary responsibility is to ensure adequate network design support is available to the supported combatant commander. All Joint networks, however, are coordinated between the Service NDFs regardless of whether or not the formal JNDT was organized to create a particular network.

Network Naming Convention

General

Each network design is allocated a name in accordance with the International Link 16 Network Naming Convention, which is defined in JMTOP D, Annex B to Appendix D to Enclosure A, and ADatP-33 (Series), Volume 2, Annex A. The network name, which conveys a certain amount of information to the user, consists of six elements:

- Country of Origin
- Originating NDF
- Network Use/Environment
- National Use
- Series Identifier, and
- Version Identifier.

The International Link 16 Network Naming Convention complies with the nine alphanumeric-character limit of the OPTASK LINK message and is composed of the six elements presented in Figure 7-3, below.

Country of Origin	Originating NDF	Network Use/ Environment	National Use	Series Identifier	Version Identifier
2 characters	1 character	1 character	2 characters	2 characters	1 character

Figure 7-3. The International Link 16 Network Naming Convention is given above. Note that this naming convention became effective on 1 October 2005.

Country of Origin

The originating country of a network design is indicated with two alphabetic characters assigned by STANAG 1059. A list of designators for countries with existing or planned NDFs is shown in Figure 7-4. As other countries develop NDFs, a country's Country of Origin designator will be the STANAG 1059 alphabetic two-character code for that country, unless that country requests another unique two-letter designator.

Ownership	Originating Country
AU	AUSTRALIA
BE	BELGIUM
CA	CANADA
DK	DENMARK
ES	SPAIN
FR	FRANCE
DE	GERMANY
GR	GREECE
IT	ITALY
JP	JAPAN
KR	KOREA, REPUBLIC OF
NL	NETHERLANDS
NO	NORWAY
PT	PORTUGAL
PL	POLAND
NT	NATO
SE	SWEDEN
CH	SWITZERLAND
TW	TAIWAN
TR	TURKEY
UK	UNITED KINGDOM
US	UNITED STATES
All Other Codes to be assigned from STANAG 1059 as required, unless an exception is requested.	

Figure 7-4. The STANAG 1059 two-character, alphabetic designators for a network design's Country of Origin are given above. If an additional country develops an NDF, its Country of Origin code will be derived from the same source, unless it requests another unique alphabetic two-character code.

♦ Originating Network Design Facility

Design responsibility is vested in the originating NDF, which is indicated with a single alphabetic character. A list of designators for Originating NDF is shown in Figure 7-5.

NDF Name	Originating Service
A	ARMY
C	COMBINED
F	AIR FORCE
J	JOINT
M	MARINE CORPS
N	NAVY/MARITIME
S	SHAPE
All Other Codes available for international use.	

Figure 7-5. The single-character alphabetic designators for the originating Network Design Facility are given above. Note that the final designator on this list is for the NATO NDF.

♦ Network Use/Environment

Network Use/Environment is indicated by a single alphabetic character. A list of designators for Network Use/Environment is given in Figure 7-6.

Network Use	Environment
D	WARTIME/CRISIS MANAGEMENT
E	EXERCISE
O	OPERATIONAL
P	PEACETIME
T	TEST
U	TRAINING
X	EXPERIMENTAL
Z	OTHER
All Other Codes unspecified	

Figure 7-6. The single-character alphabetic designators for Network Use and Environment are given above.

♦ National Use

The numeric characters in the National Use field are reserved for national use; refer to the Network Description Document for further details. The default setting is double zero (00).

♦ Series Identifier

The Series Identifier is a two-character numeric designator used by network designers as a unique identifier for a network design. When considered along with the originating NDF designator, it forms a unique network design identifier.

♦ Version Identifier

The version identifier is a single alphabetic character. It is assigned by network designers to identify updates to an existing network design.

♦ Naming Process

A network design with the name USFU0002A indicates that it was originated by the United States (characters 1 and 2), by their Air Force NDF (character 3), and was designed for training (character 4). The fifth and sixth characters are for national use (by default, these characters are 00), and characters 7 and 8 indicate that this is the second training network designed by the USAF NDF. If the allocation of a network is changed, meaning that the network with the new allocation is no longer compatible with the previous network, then the Series Identifier must be changed from 02 to 03 and, as this would be the first version of this network, the ninth character would then revert to A. The resulting new network name would be USFU0003A. If this network were subsequently modified, but it remained compatible with the original network design, then a new version identifier would be required, resulting in a new network name of USFU0002B.

Generating the OPTASK LINK

After the planning parameters have been specified and the network has been designed, the network initialization information is then disseminated to participants through the OPTASK LINK or equivalent message, which will also include the network implementation schedule.

The **OPTASK LINK** is a member of the **US Message Text Format (USMTF)** series. Its format is given in MIL-STD-6040, which is available on the Defense Information Systems Agency (DISA) Center for Standards Website located on the Army Knowledge Online (AKO) portal. There is a good deal of latitude in the standard for composing this message. The standard should be referenced when reading and, in particular, writing an OPTASK LINK.

Reference the latest MIL-STD-6040 when preparing the OPTASK LINK!

The OPTASK LINK provides detailed instructions and information concerning data link establishment and operations. It is promulgated by the Area Air Defense Commander (AADC) and may be supplemented by a Regional AADC. It is used to report changes or to expand on an Operations Order. The changes promulgated in an OPTASK LINK are considered permanent, and all remaining unchanged data should be considered valid.

The changes in an OPTASK LINK are permanent. Unchanged items remain valid.

The JNETWORK SET

The Link 16 segment of the OPTASK LINK is designed for maximum flexibility. For this reason, some sets and fields may not be used whenever the JNETWORK SET is used. The JNETWORK SET references the Joint Tactical Information Distribution System (JTIDS) Network Library (JNL) network descriptions and platform initialization data loads (IDLs), which contain the same information as the unused sets and fields. This information, therefore, will not normally be distributed in the OPTASK LINK unless:

- The planner determines that a modified parameter is required and needs one or more platforms to make a manual change to its initialization data load, or
- For whatever reason, a platform has no initialization data load (IDL) and requires the data.

Message Scope

The OPTASK LINK message covers all tactical data links to be employed in an operation or exercise. For this guidebook, however, only the Link 16 portion is discussed, and then only the portion directly involved in setting up and operating the network—that is, everything except Link 16 filters.

OPTASK LINK Example

An example OPTASK LINK message is given in Figure 7-7. On the first line is BT, for Begin Transmission. As the second line states, this example is unclassified (UNCLAS). Note that operational OPTASK LINK messages are classified; however, units may decide that training networks may be supported by unclassified OPTASK LINK messages so that they may be distributed by email.

After the classification statement, the message in the figure continues with a sequence of data sets, each of which starts with a general **set identifier (SETID)**. The SETIDs from the example in the figure are described in the following paragraphs. You will notice that one or more fields may follow a SETID, separated by single forward slash mark (“/”). A double slash mark (“//”) denotes the end of each SETID statement.

```
BT
UNCLAS
TRAINING&TESTING/GULF COMMON NETWORK//
MSGID/OPTASKLINK/46TS/001/SEP//
LINKXVI/16//
PERIOD/18092006/UFN//
LNKXVI/LINK 16 SEGMENT//
JNETWORK/USFU0002A/-/10 JULY 2006/-/PRI/
CRYPDAT/BLUE GCN/USKAT 3173/-/-//
CRYPDAT/RED GCN/USKAT 3173/-/-//
```

Figure 7-7. Link 16 operational planning parameters are shown in this unclassified example of a USMTF OPTASK LINK message, which states the period of applicability during which Link 16 will be active.

♦ Message Identifier SETID

The first SETID is the **message identifier (MSGID)**, and in this case the message is an OPTASK LINK:

```
MSGID/OPTASKLINK/46TS/001/SEP//
```

The third field on this line reveals that it was prepared by the 46th Test Squadron (originator); the fourth and fifth fields indicate that this is the first (/001/) such message prepared by this unit during the month of September (/SEP/).

♦ Period of Operation SETID

The second SETID indicates the **period of operation (PERIOD)**, in this case for the OPTASK LINK, since it follows the OPTASK LINK message identifier:

```
PERIOD/09182006/UFN//
```

The second field in this line specifies that the period begins on 18 September and the OPTASK LINK is effective until further notice (/UFN/).

The third SETID indicates that the following section of the OPTASK LINK pertains to Link 16:

```
LNKXVI
```

Notice that this **link** SETID is in Roman numerals (XVI).

♦ JNETWORK SETID

The fourth SETID is the **JNETWORK** set. This set summarizes network initialization for combined Link 16 networks.

```
JNETWORK/USFU0002A/-/10 JULY 2006/-/PRI/
```

In this example, the Link 16 network is identified as network USFU0002A. The network was originated on 10 July 2006. Since no time is specified in this example, the network time is assumed to be Zulu.

♦ CRYPDAT SETID

The **crypto data (CRYPDAT)** SETID is used to associate a cryptovariable logic label (CVLL) with a key short title:

```
CRYPDAT/BLUE GCN/USKAT 3173/-/-//
CRYPDAT/TSEC 1 IS SET TO CRYPTO VARIABLE LOCATION 0/1FOR ALL
PARTICIPANTS
```

In this example, USKAT 3173 is associated with CVLL 0/1.

Section C

Link 16 Management

☐ Roles and Responsibilities

The basic roles involved with network management are shown in Figure 7-8. In theory, the NDF refers to the standing Operational Plans (OPLANs) and, for each OPLAN, it designs one or more Link 16 networks that will be suitable for use when a particular operation or exercise is put into effect.

■ The Network Design Phase

Normally, a Link 16 network is part of a larger multi-TDL network. Link 16 networks are designed in terms of generic participants; for example, E-3(1), RJ(1), CRC(1), CRC(2), JSTARS(1), F-15C(1.1.1),[1] F-15C(1.1.2).... When the network has been properly named, the network descriptions and initialization data sets for the generic network participant identifiers are then sent to all potential network managers and participants, where they are held in local network libraries ready for use. Networks are also cited by name in their associated OPLANs. This part of network management is considered part of the **Network Design Phase**.

1 *F-15s use a noded identifier to represent individual fighters and different Operational Flight Program (OFP) suites, and to identify particular groups of fighters.*

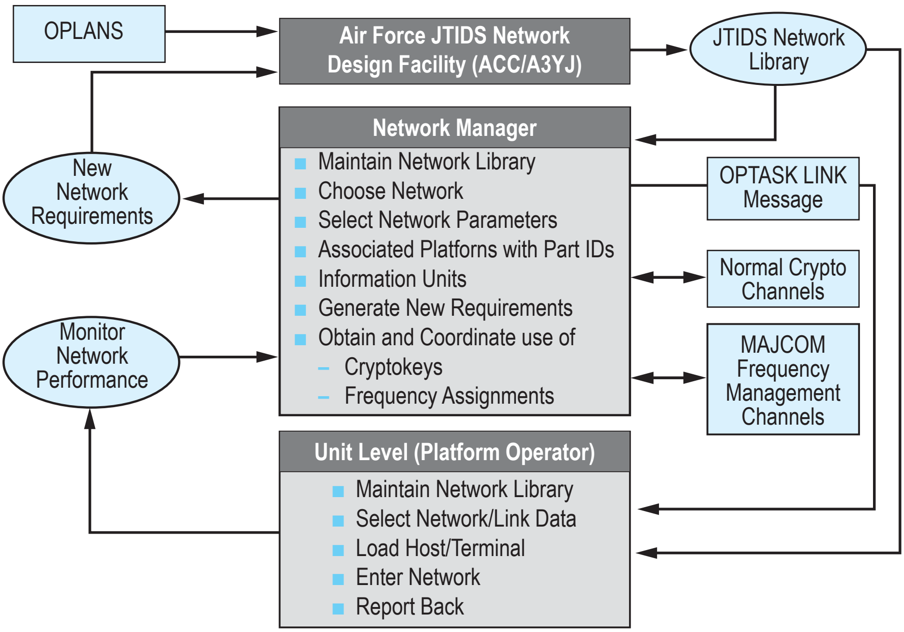

Figure 7-8. An NDF's job is to translate requirements and OPLANs into usable network designs. ACC/A3YJ builds network designs based on these requirements. To get the network up and running, platform operators initialize their terminals with the network design specified in the OPTASK LINK and enter the network individually—under the J1CO's control and following JMTOP guidance.

After a network is designed, it can be used for any operation!

■ The Network Planning Phase

After it becomes part of the library, a network can be selected for use. The network manager in theater is normally the JICO. The JICO refers to the OPLANs and the Link 16 network library and selects a network for use. The JICO also associates each actual participant by unit and voice call sign with a generic network participant identifier: for example, he may associate the 964 AWACS, call sign Bandsaw, with E-3(1), or the 728 ACS, call sign Demon, with CRC(1). He must also select a few initialization parameters unique to theater operation, and must designate certain participants to play special roles in the network, also unique to the operation.

Now, all of this information must be distributed to the network participants. As discussed earlier, this is done through disseminating an OPTASK LINK message. This part of network management is considered the **Network Planning Phase**.

■ The Network Initiation Phase

At the unit, the platform operator selects the appropriate initialization data set from his local library. The USAF calls this initialization data set the **initialization data load (IDL)**. The IDL actually contains all parameters that must be entered, but those that will be determined in theater are given default values (normally zero) in the IDL. So the platform operator must actually modify these defaults. The operator adds the parameters received from the OPTASK LINK and adds a small set of locally determined parameters, such as the net numbers used for voice and air control. Only then is he ready to begin network operations. This phase of network management is considered the **Network Initiation Phase**.

When the operator has loaded his platform's host processor and his Link 16 terminal, he then begins to enter the network—that is, he starts the process of becoming time synchronized with the network. If he has trouble entering the network, he reports back to the network manager. But if he succeeds in entering the network, he should monitor network operations from his perspective and that of his platform's operators, and report this back to the network manager. This can be done by voice radio in real time, as well as during debriefs at the end of the mission.

■ The Network and the OPLANs

This is all well and good for the first days of an operation, assuming the OPLAN was close. But network requirements often change quickly. In response to this, the network manager must request from the network design facility a new network or modifications to current networks. The design facility creates the new networks and distributes their descriptions and IDLs to the appropriate units and platforms. The USAF has developed the capability to distribute their networks and IDLs electronically, through the Internet.

■ Additional Responsibilities of the Network Manager

The network manager has two additional duties:

- Link 16 is a secure radio system, so it utilizes cryptokeys. Although the cryptokey to be used by all participants in a network is identified in the OPTASK LINK, the network manager must also ensure that this cryptokey is coordinated with all participants.
- In addition, Link 16 operates in the same radio frequency band as radio navigation aids, and the FAA imposes requirements on its operation. Meeting these requirements is also the network manager's responsibility.

■ Wing and Unit Managers

The USAF has designated points of contact (POCs) at wing and unit level to act as Link 16 experts, and to interface between their wings or units and other elements of the Link 16 operational infrastructure. This is done for other platform systems and is critical for Link 16. Some bases, such as Tinker AFB and the 522 ACW, have only wing managers. Others, such as Mountain Home AFB, have individual unit managers, such as the 390 FS and 726 ACS, as well as an overall coordinating wing manager.

The wing/unit manager is the interface between the wing/unit and the AF NDF.

All networks must have a network manager, even if this is simply a flight leader for a simple four-ship flight of fighters operating autonomously. Ad hoc Link 16 networks are not encouraged!

IDL Configuration Management

In general, the wing and unit managers should access the AF NDF Website weekly, and should download any new or modified networks. A network consists of the network description and its IDLs. The manager should have a notebook for the descriptions. How he handles the IDLs, however, depends on his platform type. Each platform type has its own means for obtaining, storing, and using the IDLs. As an independent consideration, the manager should also carefully manage the configuration of networks in his local JNL. The following are examples of how certain platforms manage IDLs.

AWACS Network Load

AWACS may receive its IDLs in either of two ways:

- It can receive a form that is set up to support manual entry from its ground support system. Up to 1000 IDLs can be placed on the Removable Media Assembly (RMA) (a removable hard disk), which holds supporting data for the AWACS computer. Each IDL is simply given a sequence number (000 through 999) for reference. The sequence number must be associated on a separate list with a network name and participant identifier. During flight, the Computer Display Maintenance Technician will install the RMA into the AWACS computer and select the correct IDL sequence number for use. The JTIDS terminal can then be directed to read the IDL through the computer, which happens nearly instantaneously.
- Alternatively, AWACS can receive a form that is set up to support manual entry aboard the aircraft through the Control Monitor Set (CMS). The Communications Technician will print the proper IDL prior to the flight and enter all settings and slot assignments by hand. This process, which is more error-prone, takes approximately 30 minutes. This technique is most often used for recent updates and test networks.

JSTARS Network Load

JSTARS receives its IDLs by email or by downloading them from the ACC/A3YJ Website. The IDLs are received in electronic format, beginning with Operational Flight Program (OFP) Interim Release 5 (IR5), Microsoft Word, or PDF format. On receipt, each network's participating JSTARS information is electronically (IR5) or manually entered into a Communications Plan-of-the-Day (CPOD). The naming convention for each CPOD is an eight-character entry (for example; USFU0021) that indicates the IDL USFU0002A JSTARS(1) load.

The JSTARS aircraft has undergone several configuration upgrades to date. These configuration upgrades are referred to as "Blocks." The Block 10 configuration consists of a combination of General Purpose Computers (GPCs) and System Management and Control (SM&C) computers. The Block 10 aircraft are being upgraded with new Central Computers (CCs), along with other configuration changes to form the Block 20 configuration. The Block 20 configuration, in turn, is being upgraded to incorporate the changes resulting from the SATCOM Engineering and Manufacturing Development (EMD) program to form the Block 30 configuration.

The CPODs for each Block are entered in identical fashion; they are maintained separately, however, due to software restrictions. The CPODs are built by the Wing Data Link Manager using software in the Computer Support Squadron (CSS) Media Library. CSS then stores all CPODs on Master Disks; the Master Disks, in turn, are used to fill the requested software requirements for each mission. Aboard the aircraft, the Communication Systems Technician (CST) obtains the requested CPODs from the Airborne Mission System Specialist (AMSS). The specific CPOD to be employed must then be downloaded to the JTIDS terminal for use during the mission. Hard copies of the network connectivity matrices are carried in the CST's comm folder to allow for modifications, corrections, or total rebuilds during flight to meet mission requirements.

■ Rivet Joint Network Load

RJ receives its IDL from the NDF's website, by downloading the file to a floppy disk. The diskette is read by its ground support system, and the IDL is placed on a portable hard disk, which is taken to the aircraft. The support system operator should name each load with its proper network name concatenated with the correct participant identifier. The number of IDLs that can be stored on the hard disk is, for all practical purposes, unlimited. If necessary, the diskette can be carried to the aircraft and loaded onto the hard disk there. The Rivet Joint wing manager should perform careful configuration management for the network diskettes in the local network library.

■ CRC Network Load

The CRC must copy its IDLs from floppy diskette to their SunSPARC workstation. The CRC-specific data from the IDL can also be typed directly into the OM, saved to the Removable Interchangeable Media Module (RIMM), and can be accessed at any time in the future. Its JTIDS Class 2 terminal can accept its IDL from either the Operations Module (OM) or the JTIDS Module (JM).

■ F-15 Network Load

The F-15 community receives its IDLs on network floppy disks. A diskette is read by the Joint Mission Planning System (JMPS) and is stored in a library of up to 50 networks. The pilot can load up to two IDLs on his data transfer module (DTM), which is then taken to the aircraft and used to load the terminal. The IDL name on the DTM is the proper network name concatenated with the correct participant identifier (for example, USFU0002AF15C1.1.1). The F-15 wing or unit manager should carefully perform configuration management for the network diskettes in his local Link 16 network library. These should include the IDLs stored on JMPS, since that device could fail, as well as those that may not fit on it.

■ F-16 Network Load

The F-16 community receives its IDLs on network floppy disks. A diskette is read by the Cartridge Support System (CSS) and is stored in a library of up to 50 networks. The pilot can load up to two IDLs on his data transfer cartridge (DTC), which is then taken to the aircraft and used to load the terminal. The IDL name on the DTC is the proper network name concatenated with the correct participant identifier. The F-16 wing or unit manager should carefully perform configuration management for the network diskettes in his local Link 16 network library. These should include the IDLs stored on CSS, since that device could fail, as well as those that may not fit on it.

The Operational Phase

After the operation commences and the Link 16 network is initiated, the operational users, planners—and in some cases, designers—will monitor the network's performance to assess its operational effectiveness. They will also monitor the operation's progress to anticipate changes in requirements.

The Joint Interface Control Cell

Within the AOC, the **Area Air Defense Commander** (AADC) delegates the responsibility for administering the minute-by-minute operation of the data link architecture, including Link 16, to the **Joint Interface Control Cell** (JICC). Within the JICC, the role of the **Joint Interface Control Officer** (JICO) is a responsibility, rather than a terminal function. The JICO function may be assigned to any surface C2 Link 16 unit (JU). Moreover, the JICO may designate a specific **Link 16 Manager** to manage Link 16 for him in complex multilink architectures.

> ***In a USAF-only environment, an ICO performs the network management duties.***

JICO Operational Responsibilities

The JICO's duties in managing the operation of a Link 16 network consist of actions needed to dynamically establish, maintain, and terminate Link 16 communications among net participants, while also being ready to take action to accommodate a changing operational environment. In addition to performing general link administration and conducting network control and coordination, the JICO must also monitor:

- Force composition and geometry
- Proper network configuration, and
- Multilink requirements.

When required, the JICO also has the authority to:

- Assign network roles to specific units
- Activate and deactivate relays
- Direct activation of data filters, and
- Change the active or data silent status of JUs.

The JICO's job is to optimize the links and keep the data flowing!

The JICO must also ensure that a sufficient number of JUs transmit the J0.0 Initial Entry message to support network-wide net entry. This is more a function of network design than requiring a JICO to direct a button action. The JICO only directs a unit to assume a function—NTR, Initial Entry JTIDS Unit (IEJU), or Relay—that enables transmission of the J0.0 Initial Entry message.

But the actual number of units transmitting the Initial Entry message is only one consideration: in other words, ten Initial Entry transmitters are not necessarily better than one. The JICO must also consider the geography, topography, and LOS conditions of the OP Area, and the spatial relationships and ranges of the participants with respect to one another.

Without LOS to the NTR or an IEJU,
you can't see the show!

Other positions may support the JICO in the conduct of network management. These include:

- The Link 11/11B Manager
- The Link 16 Manager, and
- The Track Data Coordinator (TDC).

Yet another important consideration, especially while a platform is attempting to enter a Link 16 network, is the ability to synchronize with the network's time of day (TOD). This requires a precise time hack down to the second, preferably from the NTR.

Without an accurate time hack—preferably from the NTR—you can't see the show!

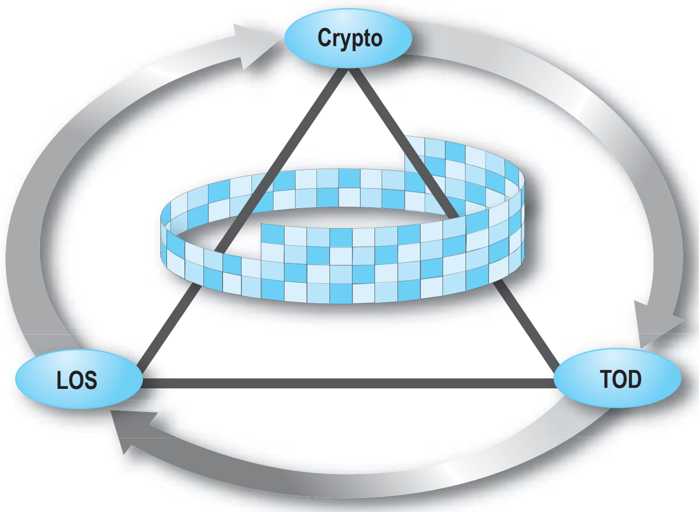

Figure 7-9. Many considerations come into play when initializing a platform for operating in a Link 16 network. But if certain basic parameters are inaccurate, you will not be able to participate in network operations, even if your platform is otherwise correctly initialized. Proper cryptokeys, accurate time of day (TOD), and adequate line of sight (LOS) are the "Big Three" basic necessities for entering a Link 16 network.

■ Data Filtering

One of the most confusing yet beneficial aspects of network management is the capability to filter data. Fortunately, most platforms have the ability to filter their received or transmitted data, but they do not have access to the "Big Picture" to implement their various filters effectively. The JICO manages a multilink network; therefore, it is his responsibility to ensure that this capability is implemented effectively.

The JICO may order data filters for the "Big Picture."

Data filters may be employed to inhibit selected tracks from transmission, to exclude them from track stores upon reception, and to inhibit them from being forwarded. Filters may be required to prevent the disclosure of protected data, or to prevent the overload of an individual unit's database, of the data link itself, or even of the operator. Normally, filters are assigned either by Operation Order (OPORD) or OPTASK LINK. In view of both the high track density anticipated for modern and future warfare and of the greater numbers of JUs, PUs, and RUs expected to participate, a versatile filtering capability is an important prerequisite for participating in all data link operations—including Link 16.

Filters help the JICO and operators manage track R2 and data volume.

This data filtering capability allows R2 to be partitioned according to various combinations of geographic areas, track environment/category, and track identity. The ordering and reporting of filter insertion, moreover, may be reported over the link. According to the JMTOP, preplanned filters should be assigned in the OPTASK LINK, while others may be designed, ordered, and reported during the course of operations, as situations dictate. Filters are normally ordered by, and reported to, the JICO, or may be designated to the TDC.

Filters ordered and reported on Link 16 may also apply to Link 11 and to data forwarding!

Section D

Infrastructure Support

This section briefly touches on the support agencies within the Air Force, including their missions and responsibilities. It also introduces some of the tools that are available to ICOs, JICOs, and Wing and Unit Data Link Managers.

□ Air Force Network Design Facility

The Air Force Link 16 Network Design Facility (AF NDF) is located at Headquarters (HQ) ACC/A3YJ (C2ISR Operations Division), Langley AFB, Virginia. This agency is the AF's service provider and POC for network engineering and design products for Link 16 operations.

■ Mission

The AF NDF supports existing and future combat air forces (CAF) Link 16 network design requirements, Link 16 management, and training. They support operational commanders directing contingency operations, exercises, testing, and training activities.

■ Responsibilities

The AF NDF is the sole provider of operational Link 16 network design products and services within the AF. For AF-only Link 16 requirements, the AF NDF coordinates directly with the requesting unit or platform POCs to help define their Link 16 requirements. The AF NDF will then design and develop a new Link 16 network and platform loads, or will modify an existing network to satisfy the customer's tasking. Completed Link 16 networks and IDLs are disseminated by email and/or are posted on the AF NDF Website located on the AF Portal, whose address is given in Appendix A. The AF NDF coordinates with other Service NDFs and the Joint Forces Command (JFCOM), including the Joint Interoperability Division (JID), on Joint network design requests and issues. The AF NDF also:

- Maintains the master Air Force JNL of all networks, which include all Link 16-capable platforms. The Air Force JNL provides a centralized source of predefined Link 16 networks for selection and implementation by Link 16-equipped units, forces, and theaters. These networks meet or exceed the operational requirements for Link 16 military operations outlined in the Multiple Required Operational Capability for Link 16 by the Joint Chiefs of Staff. This collection of AF networks is available on the AF NDF Website, whose address is given in Appendix A.
- Manages AF allocation of seats in the Link 16 training classes. These Joint training programs have been established at the Joint Multi-TDL Training School (JMTS) at JFCOM-JID, which is located at Fort McPherson, Georgia, to ensure that a cadre of knowledgeable persons is maintained with a comparable level of expertise in each Service. The AF NDF is therefore the focal point for USAF attendance and training.[2] Working with Numbered Air Force and agency POCs for class nominations and the JMTS for scheduling, the AF NDF fills the AF Service quota for these courses and provides class attendees with school and course information and fund site data for travel orders. The AF NDF also manages the monthly class quota for Air National Guard (ANG) and Air Force Reserve participation at the JMTS.
- Serves as POC and releasing authority for the distribution of AF Link 16 cryptokeys.

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2 *Training opportunities are detailed in Appendix D.*

- Serves as POC for the Air Force NDF Website, which supports up/down channel communications and feedback and information-sharing between the HQ staff at AF NDF and operational units; conveys network design requests to the AF NDF from AF field units and operators; disseminates completed network designs and platform loads to customers (for example, fighter, AWACS, CRC); and provides access to Link 16-related documents and information links. The AF NDF Website is accessible through any military network domain.
- Represents the Air Force on Link 16 operational and technical in-Service, Joint, combined, NATO, and bilateral forums where Link 16 planning and training, system interoperability, and related issues are addressed. The AF NDF also provides assistance in developing the JMTOP document, CJCSM 6120.01, the Air Force data link message standards, and the configuration management process. The AF NDF also provides assistance with JICO working groups.
- Chairs the Air Force Link 16 Network Management Working Group (AFNMWG), with participation from various platform and system managers and operators. The AFNMWG addresses all operational support area concerning Link 16 networks, spectrum support, cryptokey management, and training opportunities.

■ AF NDF Contact Information

As stated above, the AF NDF maintains the master AF JNL of all networks, which include all AF Link 16-capable platforms. The master AF JNL is available on the Air Force Portal at:

https://www.my.af.mil/gcss-af/afp40/USAF/ep/globalTab.do?command=org&channelPageId=-1717014&pageId=681742

You can also contact HQ ACC/A3YJ by email at

af.jtids@langley.af.mil (NIPRNET)

or

acc.a3yj@langley.af.smil.mil (SIPRNET)

Figure 7-10. The Air Force Link 16 Network Design Team supports AF Link 16 operational network design requirements.

Electronic Systems Center

ESC Overview

The Air Force Materiel Command's Electronic Systems Center (ESC) is headquartered at Hanscom AFB, Massachusetts. Teams of professionals specializing in engineering, business management, acquisition, and information technology direct the design, development, testing, production, and deployment of net-centric command and control (C2), intelligence, surveillance and reconnaissance (ISR) systems as well as combat support (CS) information systems. C2ISR systems gather and analyze information on potentially hostile forces, providing warfighting commanders with battlefield situational awareness and enabling them to make quick decisions and rapidly pass directions on to their forces. They help to provide accurate, relevant, decision-quality information on a global information grid.

With the annual budget of approximately $5 billion, ESC is the Air Force's leader in command and control programs. It manages more than 200 programs, ranging from secure communication systems to mission planning systems and from airborne networking systems connecting the AF to the global information grid to major C2 platforms such as AWACS and JSTARS. In addition to providing C4I systems to the U.S. military, ESC personnel are developing C2, air defense, and other systems for allied forces—such as the Royal Thai and Royal Saudi Air forces—and NATO partners through over 100 Foreign Military Sales cases.

The Air Force Program Executive Officer for Command and Control and Combat Support (AF PEO/C2&CS) is dual-hatted as the ESC commander, and he leads the workforce of approximately 9,000 military, civilian, and contractor personnel. The contractor workforce is made up of a combination of contracted support from small and large businesses as well as The MITRE Corporation, a federally funded research and development center. ESC consists of an Air Base Wing to run the Hanscom AFB installation, four acquisition wings, and two direct report groups. Each acquisition wing contains a number of system program offices organized into groups, divisions, and squadrons. Almost half of the workforce is located at one of seven major geographically separated units at Wright Patterson AFB, Ohio; Maxwell AFB, Alabama; Tinker AFB, Oklahoma; Lackland AFB, Texas; Randolph AFB, Texas; Peterson AFB, Colorado; and Offutt AFB, Nevada.

Due to their complexity and funding levels, sixty-one of ESC's programs are designated as an acquisition category (ACAT) program requiring PEO or higher oversight. Of these, 26 require the AF Acquisition Executive or the DoD Acquisition Executive to make the final determination on acquisition strategy and milestone decisions. These programs are directly filling a need for the Combatant Commanders, such as Strategic Command, Space Command, Central Command, and Southern Command, DoD Agencies such as Missile Defense Agency, and AF Major Commands, such as Air Combat Command and Air Mobility Command.

■ Mission

The 653d Electronic Systems Wing executes a $21 billion fiscal year defense plan budget with 1,300 personnel. The 653 ELSW acquires, delivers, and sustains Air Force and Joint systems, including communications, intelligence, and airspace management capabilities supporting AF Global Continuous Operations. Additionally, the wing provides engineering and integration to optimize the delivery of net-centric capabilities to warfighters for effects-based combat operations and support. The wing serves nine major commands, four Services, seven Combatant Commanders (COCOMs), 14 national agencies, and NATO.

■ 653 ELSG

The 653d Electronic Systems Group (ELSG) acquires, fields, and sustains networks, integrated information systems, enterprise services, and applications for the global information grid, facilitating communication between land, naval, air, and space warfare forces. This group develops capabilities for voice, video, and data networks focused on joint and coalition warfighter needs to enable worldwide net-centric operations.

Air Force Global Cyberspace Integration Center

The Air Force Global Cyberspace Integration Center (GCIC) is the lead organization for integrating and influencing command and control and intelligence, surveillance and reconnaissance for the Air Force. The AF GCIC is located in Hampton, Virginia.

Essentially, the GCIC improves USAF information flow by bringing together stove-piped systems into an integrated C2 “system of systems.” The Center is the Air Force’s C2 and ISR integrating force that receives inputs from the Air Staff, the major commands, and Air Force agencies, and coordinates them into a single battle information system that both meets the warfighters’ needs and reduces duplication of effort.

Mission

The principal tasks of the GCIC are:

- Integrating air and space C2 and ISR operational and delegated systems architectures, roadmaps, requirements, and standards in a continuing drive toward commonality, for maximizing efficiency and reducing duplication of effort
- Building aerospace C2 and ISR modernization strategies, integrated mission area plans (MAPS), investment plans, divestment strategies, appropriate Command, Control, Communications, Computers, and Intelligence (C4I) support plans, and associated programming documents that ensure Air Force C2 and ISR will meet the challenges of Global Engagement and Joint Vision 2010 and beyond
- Ensuring roadmaps, requirements, and the operational and delegated systems architectures are linked to the current Air Force Modernization Planning Process, the Air Force Strategic Plan, and Thrust Area Transformation Plans and their future evolutions
- Serving as the Air Force interface for establishing all C2- and ISR-related Joint Tactics, Techniques, and Procedures (JTTPs), and
- Acting as the implementing agent for Air Force experimentation for the Commander, Air Combat Command, and the designated lead.

For the purposes of this guidebook, the organizational element that most influences tactical data links is GCIC's Global Communications and Information Division, and specifically the Warfighting Networks, Integration and Standards Branch (GCIC/RINIS).

GCIC Contact Information

The GCIC website is located on the AF Portal:

https://www.my.af.mil/gcss-af/afp40/USAF/ep/globalTab.do?command=org&channelPageId=-336218&pageId=681742.

Link 16 Network Support and Test Tools

Gateway Manager

The Gateway Manager (GM) is a fourth-generation tactical connectivity platform that extends and distributes data link communications. Its predecessors were the Data Terminal Set Simulators (DTSSs) and Link Data Distribution Systems (LDDSs) for Link 16 and Link 11, and most recently, the Common Connectivity Device (CCD). The GM can act as a host, a terminal, a monitor, a data forwarder, and a data recording and playback device.

The GM runs on a Windows-based operating system, enabling the management and routing of tactical communications through a familiar human/machine interface. Its user-friendly display windows provide critical information regarding the configuration and effectiveness of tactical communications, while enabling control of the communications processes.

The GM provides adaptable connectivity for a wide array of data communications. It is an indispensable component for connecting local operations to the global information grid employed by today's Joint and International Forces operations. The GM's tactical router contributes to net-centric warfare by providing warfighters with timely tactical communications among units participating in local and global operations. The GM is unique in its Joint use among all Services, because it reliably and adaptably provides situational awareness to operational participants at all levels of the command structure.

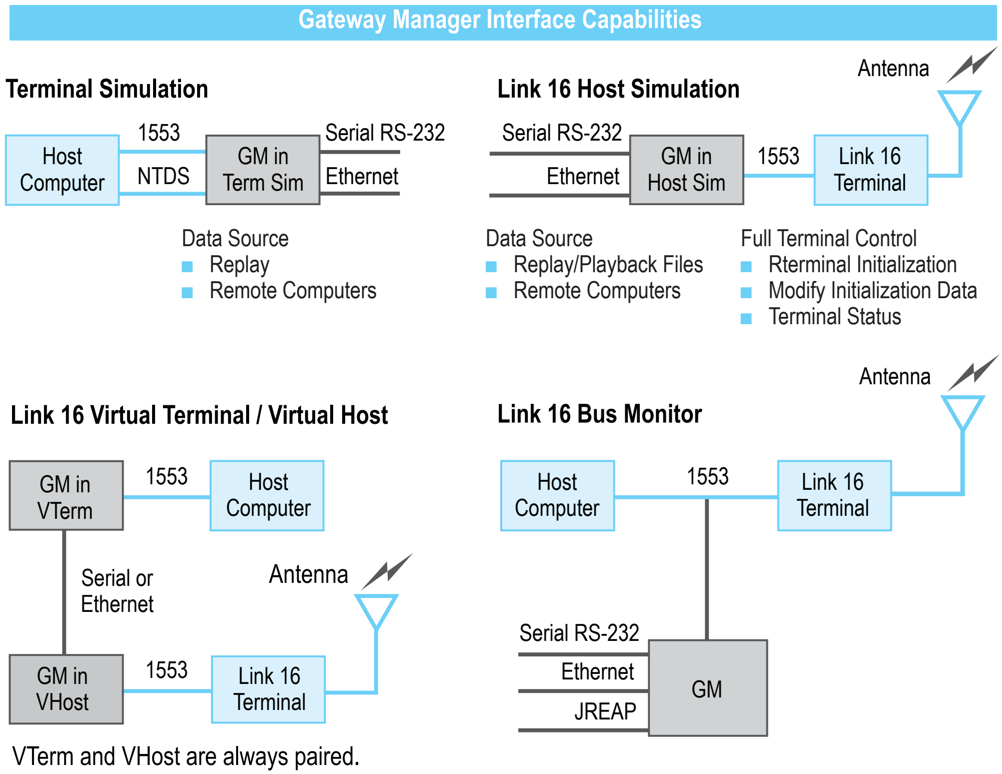


Figure 7-11. The Gateway Manager (GM) may be employed in various useful configurations: for example, as a terminal simulator, a host simulator, or a bus monitor, shown above. It can function as a data forwarder and router, and it enables a unit to connect over serial and telephone lines with remote locations whose units are participating in different networks. It provides the operator with flexible message filter capabilities, as well as enhanced recording and replay functions. With its satellite interface, it is employed aboard the ROBE KC-135 tanker to provide its tactical data link interface.

The GM implements all Link 16 terminal ICDs—F-15, MCE, Army Class 2M, and USN—as well as SIMPLE and Serial J. As well as ensuring connectivity with Link 16 and Link 11 devices, GM also provides editable, configurable interfaces in accordance with Distributed Information Systems (DIS), Satellite Link 16 (SAT-J), MIL-STD-3011 (JREAP A, B, and C), and global positioning system (GPS) protocols. It also provides an operator interface to the FalconView application.

GM is employed by the US Services as a data collection tool, to provide remote connectivity between hosts and/or terminals in operational Link 16 networks, and to support remote certification. It is also employed by developers to support host and terminal software development. Its satellite interface is employed aboard the ROBE KC-135 tanker to provide its tactical interface.

Proven in operations and exercises, the GM has also been used on the B-1, B-2, and B-52 bombers, Paul Revere, and by all Services and many agencies in CONUS and overseas. The GM continues to evolve, adding new capabilities that can be applied to existing systems.

■ Link Management System

The planning, management, and analysis of data link communications are highly complex processes. Joint and Coalition operations require rapid planning, dynamic management, and accurate analysis of theater communications. JICOs and other network managers must detect in real time any problems that can interfere with generating a coherent tactical picture.

The Link Management System (LMS™) was developed to help JICOs succeed in their mission during real-world operations. The LMS™ has proven its worth and reliability during operations in Kosovo, Afghanistan, the Persian Gulf, and Operation Iraqi Freedom.

The LMS™ enables JICOs to manage TDL networks in real time, detect problems that interfere with the generation of a coherent tactical picture, and solve these problems on the spot. The LMS™ automatically alerts operators to existing and potential problems, and records data for later analysis. The LMS™ provides a current tactical situation display, as well as a JICO Whiteboard that projects the real-time, color-coded connectivity status of each network participant.

The LMS™ provides information the JICO needs to manage the Link 16 network.

The LMS™ enables the operator to customize the display of information. Technicians and net managers can set up the system so they can see at a glance how the networks are performing and which units are experiencing problems. The status information at the top of the display is also configurable to provide relevant network operational data. Information categories alert operators to potential trouble areas by displaying color-coded, quantitative information.

With information provided by LMS™, the JICO can proactively manage the multi-TDL network to ensure reliable and complete connectivity among all participants. Supported by hard copies and the LMS™ replay capability, the JICO can readily present network events and performance characteristics at hot wash-ups and debriefs.

♦ Transmit/Receive Capabilities

The LMS™ acquires Link 16 data via its Ethernet connection to a specially instrumented MIDS LVT-11. Like its predecessor, the LMS™-16 and its AN/GRR-43(C) receive-only JTIDS terminal, it provides both signal and tactical information about the performance of the multi-TDL network, is controlled with enhanced information, and supports up to eight JREAP C interfaces. This terminal is transmit-capable for its own PPLI, nonreal-time (J3.x) tracks, Text messages (J28.2), and Link 16 Voice.

On receive, the MIDS LVT-11 processes the Link 16 signal to acquire information regarding the quality and characteristics of the signal and sends that information to the LMS processor. The LMS processes this information for presentation on its dual-monitor display.

Like its predecessor, the AN/GRR-43(C) receive-only JTIDS terminal, the MIDS LVT-11 has the unique ability to synchronize on transmissions other than the first one in the time slot. This enables the JICO to detect unintentional contention access resulting from incorrect platform initialization and to verify IEJU transmissions of the J0.0 Initial Entry message. The system also calculates Time Slot Duty Factor (TSDF) for each JU and for the network as a whole, taking into account the contention transmissions of multiple, authorized relayers.

The LMS™ can look "behind" the first transmission received in a time slot.

♦ Displays

The Tactical Situation display provides both situational awareness (SA) and historical trends. Tracks may be color-coded by age, by ID, or by reporting unit with or without their history. Color-coding by reporting unit makes R2 battles and dual designations immediately and clearly visible. The JICO may scroll through received messages, filtering them by NPG, by JU, by Track Number, and/or by message label. Received messages are automatically Data Extraction and Reduction Guide (DERG)-formatted and logged for post-mission data analysis. Four track data readout windows are provided for hooking and comparing track information. Expert system software automatically detects anomalies and logs alerts for the JICO. The operator may also assess LOS limitations on this display.

The Network Summary display maintains information on the distribution of the current track load, both by ID and by Category. It identifies which units are transmitting PPLIs and how many, which are being forwarded from Link 11 and Link 11B and by whom, which units have active sensors and the number of tracks they are reporting, and which units are actively relaying data and how much.

The Signal Quality displays provide the JICO with information about packing structure, noise and interference, and range based on actual RF propagation time. Both direct and relayed transmissions are processed, which allows the JICO to assess relay performance.

The NPG Utilization displays verify that units have the correct network load and have sufficient capacity for their transmission requirements. The network design may be graphically displayed on the screen and compared with actual usage. Time slot usage is updated in real time and may be referenced back to the actual platform loads to determine which unit actually transmitted, which unit is assigned to transmit, which units are assigned to receive, and which units are assigned to relay.

The Trend displays provide historical information on PPLI connectivity, range, surveillance utilization, time slot duty factor measurements, signal erasure levels, JU quality measurements, and distribution of Track IDs and Categories. The operator can focus on one IU or compare performances among all IUs. Loss of surveillance data, for example, can indicate that a tactical system has been reset. Loss of PPLIs can indicate that a JTIDS terminal has been reset or has moved out of range.

Figure 7-12. The Link 16 Management System (LMS™) allows JIC0 staff to manage Link 16 in real time. Its specially instrumented receiver, the MIDS LVT-11, allows the operator to look into time slots, assess network NPG capacity and utilization, and follow TSDF, erasures, and other trends. It also provides a tailorable situation display and an operator-configurable status area.

♦ LMS™ Standard Configuration

The standard version of the LMS™, shown in Figure 7-13, can control the MIDS LVT-11 terminal with enhanced information. It also supports multiple JREAP C interfaces. It is transmit-capable for nonreal-time (J3.x) tracks and text messages (J28.2) and supports up to eight JREAP C interfaces. It receives the Link 16 signal, processes it to acquire information regarding its quality and characteristics, and sends that information to the LMS™ processor. The LMS™ processes this information for presentation on its dual-monitor display.

Performance of Link 11 and Link 11B units, which is reflected by the Link 16 messages transmitted by their forwarder, can also be observed. For monitoring their performance directly, however, the LMS™ NTDS Upgrade, described below, enables the user to receive and manage the Link 11 interface.

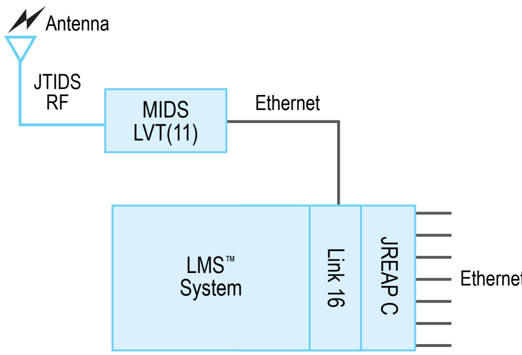


Figure 7-13. The LMS™ standard configuration provides both signal and tactical information about the Link 16 network. Its MIDS LVT-11 terminal supports up to eight JREAP C interfaces and can transmit its own PPLI, nonreal-time (J3.x) tracks, Free Text messages (J28.2), and Link 16 Voice.

♦ LMS™ NTDS Upgrade Configuration

The available LMS™ NTDS Upgrade configuration enables the user to receive and manage the Link 11 interface. Displays support measuring the overall connectivity of the PUs in the Link 11 network in addition to assessing track data on individual and multiple tracks. The operator can also view the status of individual PUs' responses to polling. The LMS™ NTDS Upgrade Configuration is shown in Figure 7-14. The LMS™ Standard and LMS™ NTDS Upgrade configurations are compared in Figure 7-15.

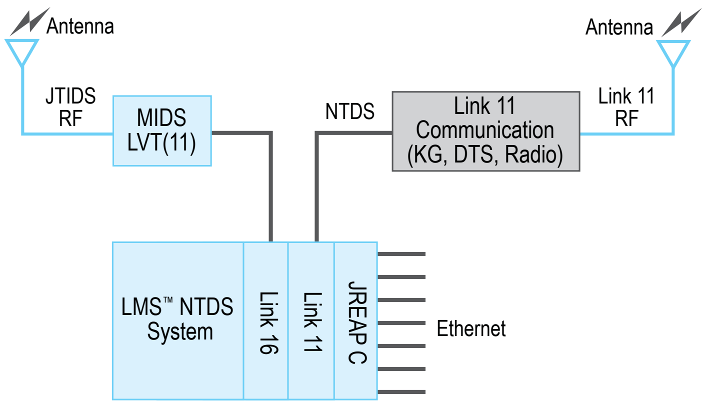


Figure 7-14. The LMS™ NTDS Upgrade enables users to select the most appropriate configuration for their specific application. In addition to the standard configuration's capabilities, this configuration enables the user to receive and manage the Link 11 interface, measure the overall connectivity of the PUs in the Link 11 network, assess track data on individual and multiple tracks, and view the status of PU polling responses. This is the most capable LMS™ system.

Capability	LMS™ Standard Configuration	LMS™ NTDS Upgrade
Host to LVT-11 Interface	✓	✓
Monitor LVT-11 Interface	✓	✓
Dual-monitor Display	✓	✓
Software Support	✓	✓
Link 11 Performance Evaluation		✓
OPTASK LINK Capability	✓	✓
JTIDS Network Capability	✓	✓
TSDF Monitoring	✓	✓
Erasures / Signal Quality Monitoring	✓	✓
NPG Bandwidth Usage Monitoring	✓	✓
Time Slot Usage Adherence to Plan	✓	✓
JREAP C Capability	✓	✓

Figure 7-15. LMS™ capabilities are presented in this figure. In response to specific customer requirements, the LMS™ can be produced for users who require management only of Link 16 networks. Adding the Link 11 monitoring capability is done by incorporating the LMS™ NTDS Upgrade kit to add Link 11 functionality to the basic LMS™.

■ Interim JICO Support System

USAF's Interim JICO Support System (I-JSS) allows JICO staff to perform operational planning, execution, and analysis all with a single system. The I-JSS is a suite of tools that provides the capability to manage Link 16, Link 11, and Link 11B in large-scale, multi-TDL architectures, from the planning stage through dissemination, operation, and debrief. Its Windows-based graphical interface presents data in operator-tailorable formats, including graphs, tabular displays, and situation displays. These afford the JICO a wide-angle snapshot of overall network operation, as well as the capability to zoom in with greater and greater detail to identify and solve specific problems. Twenty-two full systems have been fielded at US AFBs, at two Army installations, aboard three USN carriers, one USMC installation, and in four countries outside the US.

The I-JSS enables JICOs to plan, manage, and analyze multi-TDL networks.

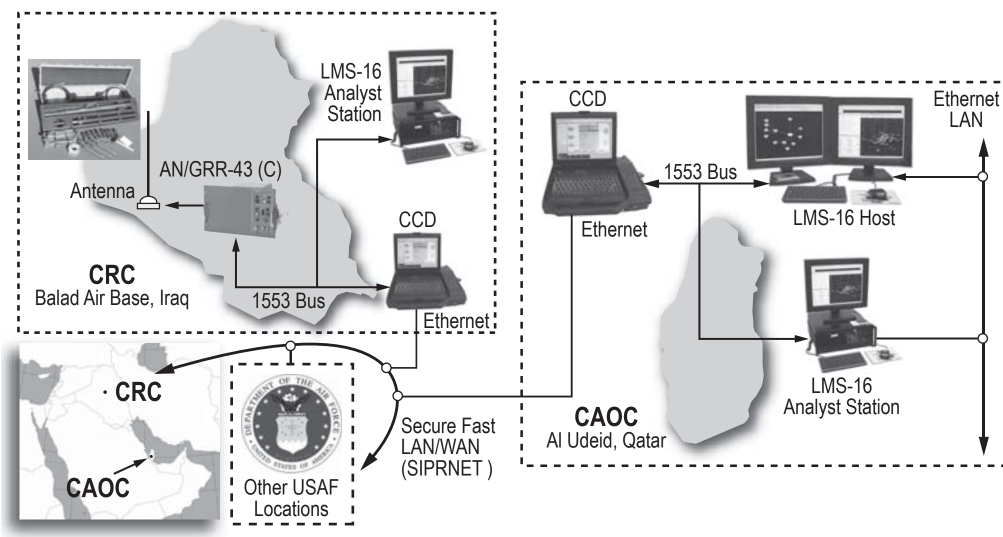


Figure 7-16. The Interim JICO Support System (I-JSS) provides the capability to remote the JICO cell anywhere in theater.

Modern multi-TDL networks are complex architectures. A multiplicity of participants has become the norm, and each participant must acquire data from other participants and transmit its own data on the link its equipment supports. Combining data from all these links adds greatly to the detail of the picture the commander sees. A great variety of hardware and software systems are involved, and networks must be designed to accept the inputs of all participants without interference among them. Paramount among the challenges of multi-TDL management are:

- **Connectivity**: Participants' radios have limited range, and often, as in the case of Link 16, require unobstructed LOS conditions, careful deployment of relays, and even the capability to find optimal, alternate paths for data flow when a data forwarding platform goes down.
- **Signal quality**: Many factors can degrade TDL signals, causing dual or multiple TN designations, dual or multiple R2 units, data looping, and data failures.
- **Equipment failures**: If a participant's equipment is not working properly, it can provide errored information or degrade the quality of network communications. Antenna failure, for example, can cause the network to lose a unit's contribution to the tactical picture, and the affected unit to lose the picture altogether.
- **Network utilization**: If network utilization by individual participants deviates from intended usage, it may interfere with the entire network's performance. For example, if one unit's tracks are "aging out" of its system because the unit has not been allocated enough time slots for surveillance, the JICO should be able to diagnose the problem and take proactive measures.
- **Adherence to network design**: Network designs are complex, and if they are not strictly adhered to by all participants, communications can be degraded. Units inadvertently "sharing" the same time slots, for example, introduce contention access that will interfere with all units' receiving the same tactical picture.

The I-JSS provides an independent eye on network details.

The core tool of the I-JSS is the LMS™-MT, a multi-TDL-enhanced LMS™-16. Its displays allow JICOs, TDCs, and commanders to manage Link 16, Link 11, and Link 11B by monitoring tactical situations, TDL messages, and connectivity among units, both in real time, and as trends built from data collected over many hours. The I-JSS also monitors how each JU is utilizing the network design, as well as its capacity for each NPG. Its AN/GRR-43(C) receiver, a specially instrumented receive-only JTIDS Class 2 terminal, provides the I-JSS displays with independent information about signal quality, data reconstruction, and data failures, as well as all the tactical data that appears on the displays. If design parameters are not strictly adhered to by all participants, communications can be degraded. Units inadvertently "sharing" the same time slots, for example, introduce contention access that will interfere with all units' receiving the same tactical picture.

The JICO Whiteboard tells everyone who's up, who's down, who's about to go down, who's talking to whom, and who's radio silent!

The JICO Whiteboard tool, which is part of the I-JSS suite, enables projecting a connectivity diagram of participants color-coded by status, so that JICO staff and commanders can tell at a glance which units are having communications problems.

Figure 7-17. The Interim JICO Support System (I-JSS) allows JICO staff to perform operational planning, execution, and analysis all with a single system, and also provides the capability to manage Link 16, Link 11, and Link 11B in large-scale, multi-TDL architectures.

■ JICO Support System

The Joint Interface Control Officer (JICO) Support System (JSS) consists of a baseline of common modular hardware, software, computer operating systems, documentation, training, and local JICO Data Repository (JDR). This suite is also known as the JSS Common Core Capability (CCC). The JSS will be located in the operational facility (OPFAC) in which the responsible Service believes will most likely be called upon to execute the JICO, Regional Interface Control Officer (RICO), and Sector Interface Control Officer (SICO) roles. The system will be operated and maintained by trained JICC personnel. The individual Services will provide the common required communications equipment, such as a Link 16 terminal, deemed necessary to interface with the JSS to enable the system to support JICO functions.

All JSSs will be capable of the same functions, so that any formally trained JICO could be deployed to any OPFAC with a resident JSS and perform their assigned duties. Moreover, the JSS enables the JICO organization to remotely retrieve and affect data from the JDR to aid in the planning and management of the Multi-TDL Architecture (MTA). This functionality includes the ability to access existing MTA plans and Link 16 network designs and descriptions. If no existing Link 16 network design or description meets the requirement, the JSS will aid the JICO in developing parameters for a new MTA by accessing the local or remote JDR.

The JSS is capable of concurrently operating 25 TDLs with up to 4000 tracks, plus forwarding data among the configured TDLs. In addition to participating on all of the data links, the JSS performs network monitoring and management, as well as recording all TDL message traffic. The JSS-supported TDLs include two local and two remote Link 16 terminals, eight beyond-line-of-sight (BLOS) Link 16 networks, one satellite Link 16 network, two Link 11 networks, eight Link 11B networks, one Link 22 network, and one NATO Link 1 network.

The JSS client-server design supports up to 50 independent workstations. This permits a group of operators to focus on live operations while others are engaged in nonreal-time tasks such as Multi-TDL Architecture (MTA) planning, training, and simulation.

The JSS also provides an embedded training capability in three formats. Self-paced training is delivered using a computer-based training (CBT) program. Classroom training can also be conducted at JSS workstations, using either simulated data or information recorded during live operations. The JSS also provides an exercise training capability in which the live tactical data feed comes from a distributed simulation network. All training functions can be conducted without interfering with live operational or planning activities that are concurrently being conducted at other workstations.

The JSS Full Expeditionary Capability (FEC) supports a Combatant Command or Service requirement for a rapidly deployable JICO Cell capability, capable of being set up and operated in immature or austere environments. The JSS FEC is defined as the JSS CCC in a ruggedized and transportable configuration, with all the associated communications equipment supporting JICO operations. The FEC Wrapper is the set of communications and auxiliary equipment that augments the CCC to make up the FEC.

Figure 7-18. The Joint Interface Control Officer (JICO) Support System (JSS) Common Core Capability (CCC) consists of a baseline of common modular hardware, software, computer operating systems, documentation, training, and local JICO Data Repository (JDR).

The key JSS functions include:

- Planning
- IER definition
- Validation and production of the OPTASK LINK message
- Data repository
- TDL configuration
- Internal/external communications
- TDL management
- Data forwarding
- Automated alert capability
- Quality-of-service indicators
- Dynamic network management
- Time slot reallocation
- Data analysis
- Automated troubleshooting of JSS hardware
- Simulation-based training
- Scenario development
- Computer-based training.

■ Air Defense Systems Integrator

The Air Defense Systems Integrator (ADSI®) is a routing and data forwarding system that interfaces to all major TDLs. Its displays allow the operator to view both TDL message streams and the tactical situation. It can also be used to provide connectivity over serial and telephone lines between units in the field and remote C2 stations.

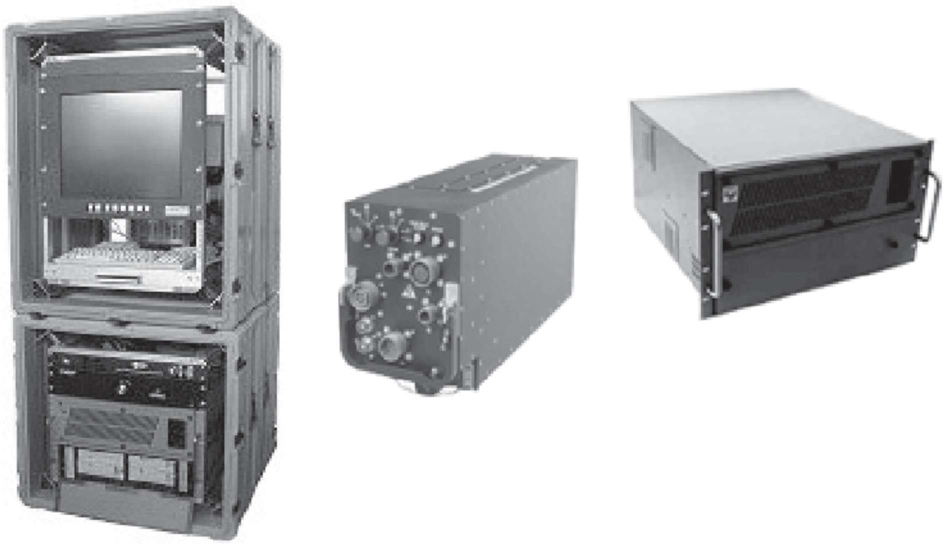


Figure 7-19. The Air Defense Systems Integrator, or ADSI®, is a routing and data forwarding system in use by various platforms of all Services. It can provide the functionality of a tactical host, initializing and interacting with a JTIDS or MIDS terminal.

The ADSI® supports many warfighter requirements, providing interoperability not only between US Forces but also between international forces. It can fulfill the requirement for a standalone tactical data link, radar, and/or EW/I functions. It has been fielded at command centers, aboard ships, with mobile military units, and at other military and homeland security units without organic weapons. ADSI® has been operated by Joint Task Force users in support of various operations including Operations Enduring Freedom, Southern and Northern Watch (OSW/ONW), Joint Task Force Korea, and Operation Allied Force.

Improved Multi-TADIL Distribution System

The Improved Multi-TADIL Distribution System (IMTDS) acts as a networking device and data forwarder, permitting multiple units to share a single JTIDS terminal. The connection from these units to the IMTDS connection is serial, and the system implements the Serial J landline protocol. The IMTDS also can operate as a Link 11B forwarder. Its display shows the tactical situation and provides throughput information on the active connections. Operationally, the IMTDS has been deployed for OEF and has been in use at the Combined Air Operations Center (CAOC) at Nellis AFB. The IMTDS has also been employed at Exercises Roving Sands, All Services/Joint Combat Identification Evaluation Team (ASCIET/JCIET), Optic Windmill, Foal Eagle, numerous Red Flags, and many others.

Battlefield Operations Support System

The Battlefield Operations Support System (BOSS™) is a Windows-based, multi-TDL system that is currently employed by a wide array of users. The system is fielded in desktop, laptop, and rack-mounted configurations. Test agencies, platform integrators, and operational units use BOSS™ to support their respective TDL requirements. It provides the capability to script scenarios consisting of simulated tactical elements and generate the TDL messages associated with the simulated elements. When it is configured with a data link terminal and participating in a live network, the BOSS™ provides a complete C2 host processor. When configured with a Link 16 terminal and supporting live operations, the system is commonly referred to as the Ground Tactical Data Link System (GTS). The BOSS™ message processing capability encompasses the entire range of the J-series catalog, including all current Data Field Identifier and Data Use Identifier (DFI/DUI) values in MIL-STD-61016C. Specific functions and configurations are tailored to units' requirements for supporting live, virtual, constructive, test, and development applications.

The BOSS™ core capabilities include:

- Multilink Link 11 and Link 16 processing in accordance with MIL-STD-6016C and MIL-STD-6011C
- Link 16 Network Time Reference (NTR) functionality
- Link 11 Network Control Station (NCS) functionality
- Full support R2 and IFF processing
- Command and control, with all air control mission assignment discretes (MADs)
- Mission management functions
- Common track store
- Data forwarding between Link 16 and Link 11 in accordance with MIL-STD-6020
- Remote gateway capability
- MIL-STD-2525 symbology
- DERG recording, display, and playback functions
- Host for JTIDS Class 2 (Navy Ship, F-15, E-8C, E-3 Class 2H, and MCE) terminals
- Host for all MIDS LVT platform type variants 1 through 11
- Remote terminal host via MIL-STD-1553 and client/server Transmission Control Protocol/Internet Protocol (TCP/IP) connection
- Link 16 terminal emulation
- Link 11 data terminal set (DTS) emulation.

To support these capabilities, BOSS™ enables the following interfaces:

- MIL-STD-1553B terminals, including JTIDS Class 2 for MCE, AWACS 2H, and Navy ship, as well as MIDS Platform Types A and I and Fighter Data Class Link (FDL, also known as MIDS LVT-3) Platforms A, B, C, D, and E
- MIDS Platform Type J terminals
- MIDS Platform Type D terminals
- Socket J (Multi-TDL Capability, Version 2)
- Serial J
- Link 11 Airborne Tactical Data System (ATDS) or Naval Tactical Data System (NTDS)

- Joint Range Extension Application Protocols (MIL-STD-3011), Appendix C (JREAP C)
- Distributed Interactive Simulation (DIS)
- Standard Interface for Multiple Platform Link Evaluation (SIMPLE).

The BOSS™ also includes the following special features and functions:

- External Time Reference (ETR)
- Link 16 imagery (J16.0)
- J3.6 Space Track message
- Weapons Data Link (J11.0, J11.1, and J11.2)
- Global Area Reference System (GARS) (J16.2)
- Range Training Officer (RTO) display
- F-15 Situation display emulation
- US National (Classified and Unclassified) message sets
- Support for Australian Link 16 and Link 11 Messages.

Figure 7-20. The Battlefield Operations Support System (BOSS™) is shown above, configured as a Ground Tactical Data Link System (GTS). BOSS™ can be fielded in desktop, laptop, and rack-mounted configurations so that test agencies, platform integrators, and operational units can support their respective TDL requirements.

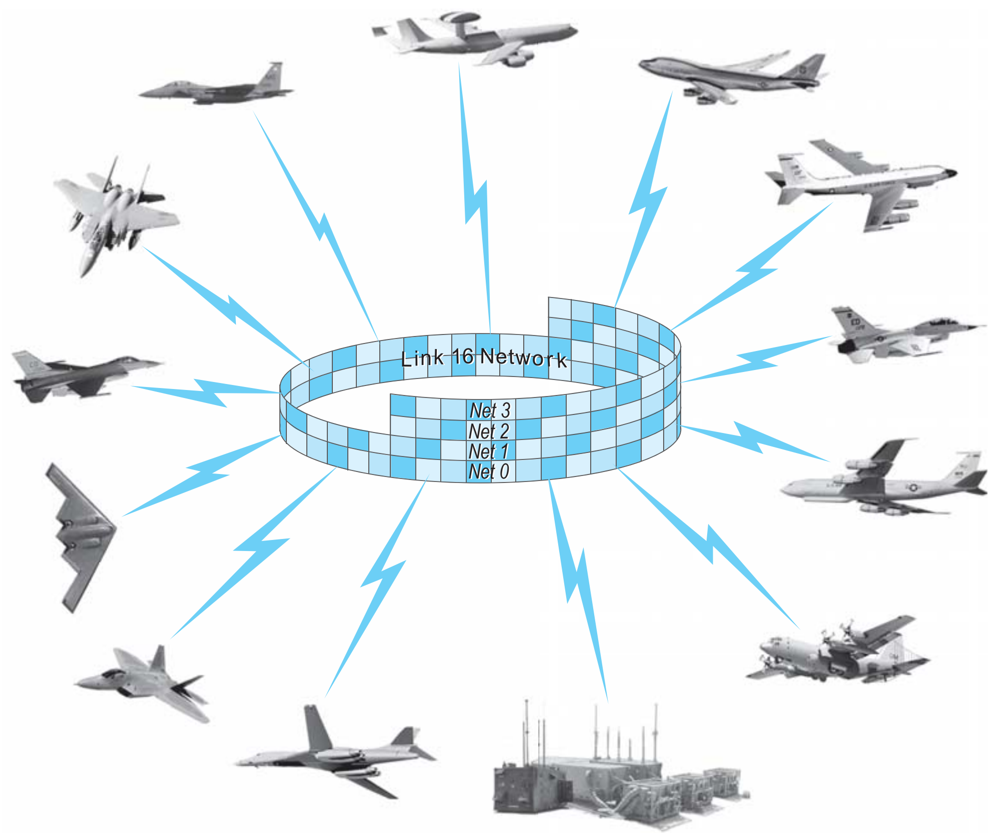
■ Joint Range Extension Transparent Multiple Platform Gateway

The Joint Range Extension Transparent Multiple Platform Gateway (JTEP), commonly called the "JRE Gateway," provides multipoint interoperability for BLOS data link connectivity. The JRE Gateway allows tactical data to be transmitted over digital media and networks that were not originally designed for tactical data exchange. J-series messages are embedded in MIL-STD-3011 JREAP messages as data fields in available commercial and government protocols, such as those used over satellites and terrestrial links. JRE Gateway protocols currently include Serial J, UHF DAMA, MIL-STD-3011 (JREAP), JRE SHF SATCOM, and various Internet protocols. JRE Gateway systems were used during OEF and OIF. As of this writing, about two dozen USAF, USMC, and Missile Defense Agency (MDA) JRE Gateway systems support these theaters of operation.

Figure 7-21. The Joint Range Extension Transparent Multiple Platform Gateway (JTEP) is commonly called the "JRE Gateway." This system embeds J-series messages in JREAP messages that may be exchanged over satellite and terrestrial links. In addition to the configuration shown here, the JRE is available in laptop and ruggedized configurations.

Appendix A

USAF Platform Capabilities Summary



This appendix points readers of this guidebook to the message set implementations for all USAF platforms that are Link 16 capable. Assessing actual interoperability, however, must include platform comparison below the message level, comparing words, data items, and bits. The information in this appendix was accurate as of this printing.

US Air Force Platforms' Link 16 Implementations

Link 16 platform implementation data is provided by the Air Force Global Cyberspace Integration Center (AF GCIC/RINIC). For the most current USAF platforms' Link 16 message implementations, link to the following location from a Secret Internet Protocol Router Network (SIPRNET) computer:

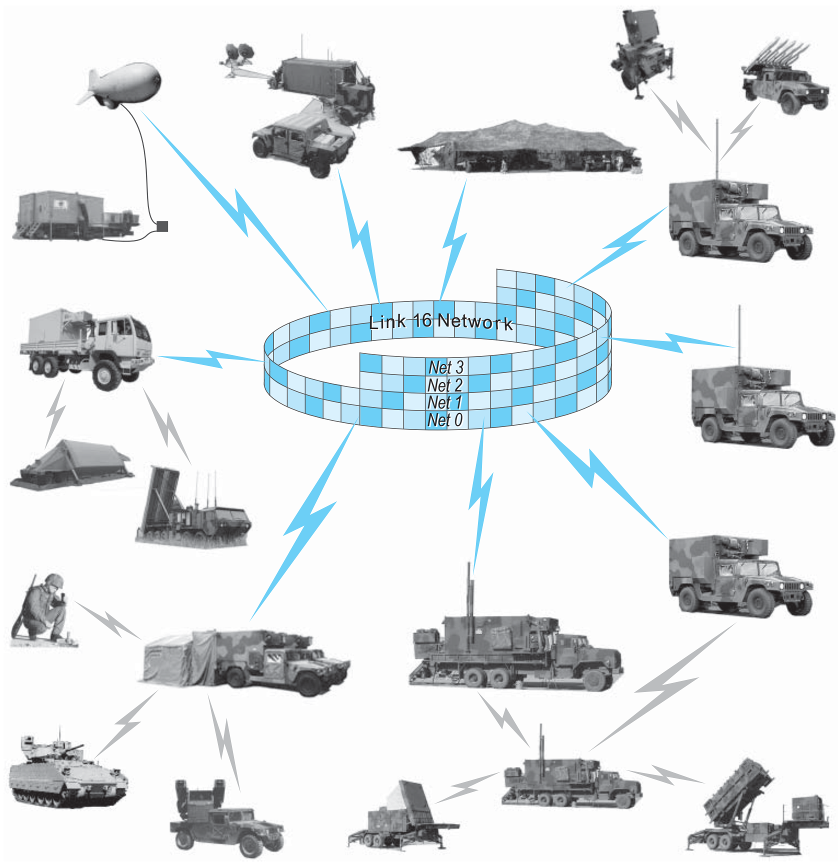
https://gcic.af.mil/warfighter/divisions/A6G/ismart/index.html

If this link changes, the following point of contact can provide an updated link:

AF GCIC/RINIC
Interoperability and TDL Standards Branch
300 Exploration Way
Hampton, VA 23666
DSN: 575-5500
Commercial: (757) 225-5500
Facsimile: (757) 225-3720
DSN FAX: 575-3720
Email: *afc2isrc.ismart@langley.af.mil*

Appendix B

US Army Platform Capabilities Summary



This appendix points readers of this guidebook to the message set implementations for all US Army platforms that are Link 16 capable. Assessing actual interoperability, however, must include platform comparison below the message level, comparing words, data items, and bits. The information in this appendix was accurate as of this printing.

US Army Platforms' Link 16 Implementations

The Army plans to implement the iSmart process in the future, Currently, however, Link 16 platform implementation data is provided by the US Army Network Design Facility (ANDF), Software Engineering Directorate (SED), at Redstone Arsenal, Alabama. For the most current Army Link 16 networks and general information, link to the following location using Common Access Card (CAC)-enabled login, from a Nonclassified Internet Protocol Router Network (NIPRNET) computer:

https://army.link16.amrdec.army.mil

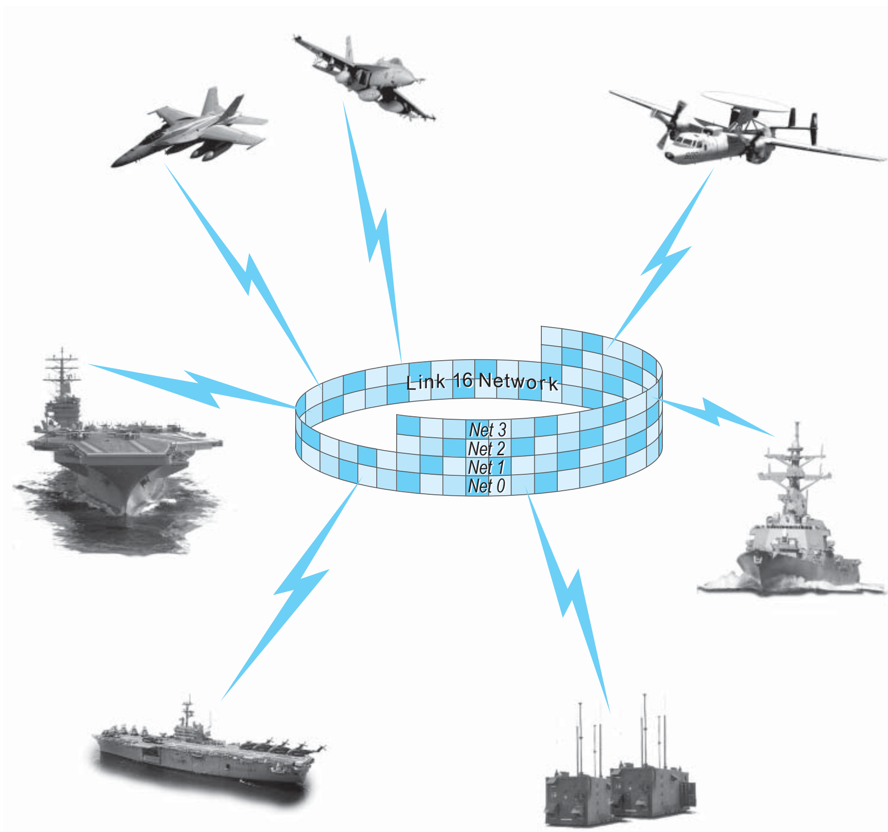
Or contact the Army Network Design Facility at:

CDR US Army Research, Development and Engineering Command (RDECOM)
Software Engineering Directorate (SED)
AMSRD-AMR-BA-C3I
Bldg 6260 (ATTN: ANDF)
Redstone Arsenal, AL 35898-5260

DSN:	746-4928
Commercial:	(256) 876-4928
Email:	*army.link16@us.army.mil*
Secure:	*army.link16@us.army.smil.mil*

Appendix C

USN/USMC Platform Capabilities Summary



This appendix points readers of this guidebook to the message set implementations for all US Navy and US Marine Corps platforms that are Link 16 capable. Assessing actual interoperability, however, must include platform comparison below the message level, comparing words, data items, and bits. The information in this appendix was accurate as of this printing.

US Navy Platforms' Link 16 Implementations

The Navy's Link 16 platform implementation data is provided by the Navy Center for Tactical Systems Interoperability (NCTSI), at San Diego, California. For the most current Navy platforms' Link 16 message implementations, link to the following location from a Secret Internet Protocol Router Network (SIPRNET) computer:

https://www.nctsi.navy.smil.mil/

Click on the iSMART button, and then on the eSMART Account Request Form button to access the form. Print the form, fill in the required data, sign it, and fax the form to Mr. Rodney Lee (NCTSI N331). The completed form may also be sent via email in an Adobe Acrobat PDF file.

Rodney Lee
NCTSI N331

DSN:	553-7316
Commercial:	(619) 553-7316
Facsimile:	(619) 553-9366
Email:	*rodney.l.lee@navy.mil*
Secure:	*rodney.lee@nctsi.navy.smil.mil*

USMC Platforms' Link 16 Implementations

The Marine Corps' iSMART process is under development. Currently, USMC platform tactical data link implementation is available by contacting either of the following personnel at the Marine Corps Tactical Systems Support Activity (MCTSSA). Note that all correspondence via Secret Internet Protocol Router Network (SIPRNET) should be preceded by a telephone call or a Nonclassified Internet Protocol Router Network (NIPRNET) email directing the contact's attention to the appropriate SIPRNET account:

Commanding Officer
Marine Corps Tactical Systems Support Activity
SE&ISD / IOB
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Appendix D

Tactical Data Link Training Opportunities

Link 16 and multi-TDL training classes of value to USAF operators, AOC staff, and unit/wing managers are described in this appendix, along with their relevant points of contact. Note that certain training courses, such as US Joint Forces Command - Joint Interoperability Division's (USJFCOM-JID) JICO course, have prerequisites for enrollment.

☐ US Joint Forces Command – Joint Interoperability Division, Fort McPherson, Georgia

The Joint Multi-TADIL School (JMTS) provides formal classroom data link instruction covering planning and employment of Joint Battlespace Interoperability and Multi-Tactical Data Link (TDL) operation. Training is multisystem oriented, with courses taught at the campus location on Fort McPherson, as well as distance learning for JT-101 and mobile training teams using instructors from all branches of the US Armed Services. The courses offered are oriented towards planners, operators, managers, and communicators supporting critical Command and Control (C2), communications systems, and Intelligence, Surveillance and Reconnaissance (ISR) engagement systems. The first four courses are primarily concerned with TDLs; the remaining two concentrate on United States Message Text Format (USMTF) training. Air Force quotas for the TDL courses (JT-101, JT-102, JT-201, JT-301, and JT-220) are managed by HQ ACC/A3YJ. For further information, contact A3YJ at DSN 574-8328, or email *af.jtids@langley.af.mil*.

■ JT-101: Link 16 Joint Interoperability Course

The course provides training in all aspects of Link 16, from technical theory to operational employment. Topics covered during the course include Link 16 terminology, features and functions, employment, and network design documentation. The course is geared toward operators of Link 16-equipped systems. The course duration is 4 training days.

■ JT-102: Multi-TDL Advanced Joint Interoperability Course

The Multi-TDL Advanced Joint Interoperability Course (MAJIC) provides instruction on Joint Command and Control (C2) organizational structures, Joint and Coalition planning considerations, and interface management fundamentals. The data links included in the course are Link 16, Link 11/11B, SADL, and other Joint data links. Students also receive instruction in OPTASK LINK message interpretation and preparation. The course duration is 10 training days.

■ JT-201: Link 16 Planner Course

The Link 16 Planner Course provides instruction in advanced Link 16 concepts and Link 16 terminal capabilities, as they relate to planning. The course is geared toward personnel with experience in Link 16 employment, who will be tasked to perform Link 16 planning for training, testing, exercises, and contingency operations. Prerequisites for attending the Planner course are JT-101 and JT-102. The course duration is 10 training days.

■ JT-220: Link 16 Unit Manager Course

The Link 16 Unit Manager (LUM) course provides instruction in Joint planning and operating procedures associated with Link 16 network employment. The course is designed to provide the student with the tools needed to effectively plan, manage, and employ Link 16. There are no prerequisites for this course; however, the target audience is the Link 16 wing and unit manager. The course duration is 5 days.

■ JT-301: Joint Interface Control Officer Course

The Joint Interface Control Officer (JICO) course provides training to personnel who will be responsible for the Joint Multi-TDL architecture as JICOs, Joint Track Data Coordinators (TDCs), and/or TDL Managers. The JICO course also focuses on planning guidance and management procedures for Joint Multi-TDL architectures. The target audience is personnel serving in senior TDL-related positions in their respective Services or a Joint billet. The duration of the academic portion of the class is 80 hours (10 days); the duration of the practical application portion, which follows, will vary, depending on the exercise supported by the class. Prerequisites for attending the JICO course are JT-101, JT-102, and JT-201.

■ United States Message Text Format Training Program

Two instructional USMTF Courses are offered to user organizations. Instruction is provided on the currently implemented USMTF standard using the Defense Information Infrastructure/Common Operating Environment (DII/COE) Message Processor. The available courses are:

♦ JT-105: USMTF Automation Course

The USMTF Automated Message Preparation Course is designed to train Joint Staff, Joint Force Component staff, and Joint Force and Defense Agency administrative support personnel who compose USMTF reports or messages using microcomputers. This course is procedures-oriented and includes practical applications and hands-on software training. Instructional period: 8 hours (1 day).

♦ JT-205: USMTF Managers Course

The USMTF Managers Course is designed to train personnel at Joint commands who have been designated to implement a new USMTF program or direct a program already underway. This course presents procedural guidance to establish resource requirements for implementing a recurring training capability. The USMTF Managers Course is a “train-the-trainer” program. Instructional period: 24 hours (3 days).

Air and Space Operations Center Formal Training Unit, 505th Training Squadron, Hurlburt Field, Florida

The following classes offered at Hurlburt Field are designed for personnel who are assigned, attached, or who have an assignment to an ACC Air and Space Operations Center (AOC) and are ACC-funded. For PACAF and USAFE personnel assigned to an AOC, however, this training would be unit-funded. Quotas for the following courses are controlled by ACC/A3C. For further information on these classes, contact DSN 575-2840.

Interface Control Officer Course

The Interface Control Officer (ICO) Course trains personnel, O5 and below, who are assigned to an AN/USQ-163 AOC weapon system or manpower forces unit, how to perform ICO duties in a Joint Air and Space Operations Center (JAOC). Personnel receive education and training on fundamental JAOC organization, Air Tasking Order processes and Theater Battle Management Core Systems (TBMCS), and other associated AOC C2 systems. Personnel receive specific education and training on multi-Service TDL systems and capabilities, as well as how to design a Joint multi-TDL architecture. Students will then design a limited OPTASK LINK. Training consists of academic lectures, computer application labs, practical exercises, and a comprehensive end-of-course exercise that simulates a JAOC environment.

Tactical Data Link Managers Course

The TDL Managers course trains personnel assigned to an AN/USQ-163 AOC weapon system or manpower forces unit how to perform Interface Control Technician (ICT) duties in a JAOC. Personnel receive education and training on fundamental JAOC organization, air tasking order processes and TBMCS, and other associated AOC C2 systems. Personnel receive specific education and training on JAOC interface control organization, duties, and responsibilities; TDL theory, equipment, and processes for planning a Joint multi-TDL architecture, and building an OPTASK LINK. Training consists of academic lectures, computer application labs, practical exercises, and a comprehensive end-of-course exercise that simulates a JAOC environment.

Northrop Grumman Space & Mission Systems Corp., San Diego, California

Northrop Grumman offers several types of courses, both in basic Link 16 theory and operator-oriented, hands-on Link 16 systems training. For information on prices, scheduling, and classification, contact the Customer Service Help Center at (877) 784-4357, email *cis.productsupport@ngc.com*, or go to *http://www.tacticalnetworks-ngc.com* and click on the On-line HELP link to submit a ticket requesting the desired information.

Focus on Link 16

Northrop Grumman offers a two-day, 16-hour "Focus on Link 16" lecture course for operators, field support personnel, programmers, and engineers, at either a customer site or at Northrop Grumman's San Diego facility, as required. The first day of the course focuses on the Link 16 waveform and messages. The second day, which is based on the Joint Multi-TDL Operating Procedures and is limited to US nationals, focuses on the planning and use of Link 16 for surveillance and other operational functions. For classes attended by foreign nationals, a one-day, 8-hour version of this course can be provided.

Data Link Management Systems Training

Operator courses for Northrop Grumman's data link management systems—the Link Management System (LMS™), the Gateway Manager (GM), the JICO Support System (JSS), and the Interim JICO Support System (I-JSS)—are also available. Typically, these courses are conducted at a customer installation site, but they may be conducted at Northrop Grumman's San Diego facility, as required.

Data Link Simulator Training

Northrop Grumman also produces data link simulators, which are used for scenario generation, simulation exercises, testing, and TDL message certification. Operator training for the Multiple Link Simulation Test and Training Tool (MLST3) is two weeks (80 hours) in duration. Operator training for the Single Link Monitor for Link 16 (SLM-16) or the Tactical Data Link Integration Exerciser (TIGER) is one week in duration (40 hours). All courses are typically conducted at customer sites.

☐ Ultra Electronics, Incorporated, Austin, Texas

Ultra Electronics, Incorporated offers training for operators and maintenance personnel for the Air Defense System Integrator (ADSI®). Basic courses are one week (40 hours) in duration, but they can be tailored to meet customer needs. Training is conducted at either the customer's or Ultra's facility, as required. For information concerning these courses or to enroll, contact Ultra at (512) 327-6795, extension 235.

Appendix E

References

The documents included in this Appendix, among many others, are available on the USAF Community of Practice (CoP) website referenced at the beginning of Chapter 5. Some were referenced in the preparation of this guidebook. Others will be useful for pursuing your interest in Link 16 and multi-TDL standards, platforms, and operations. The annotations following each title provide an overview of the document's contents.

CJCSM 6120.01D

Joint Multi-Tactical Data Link (TDL) Operating Procedures (JMTOP), 22 November 2005

Provides procedures for operators who employ tactical data links for planning, initializing, controlling, and terminating the exchange of real-time and near-real-time tactical data between tactical data systems, and defines responsibilities for these functions. Provides authority, delineates responsibility, establishes procedures, provides guidance, and defines terms for employing Command and Control (C2), intelligence, and weapons systems. Addresses tactical data link (TDL) information exchange on the basic Interface (consisting of Link 11, Link 11B, and Link 16) and extended Interface (consisting of Link 4A, IJMS, Army Tactical Data Link 1 [ATDL-1], and NATO Link 1. Describes the Joint Interface in terms of interface units (IUs) and configuration, associated data links, voice coordination nets, responsibilities for planning, initiating, conducting and terminating operations, procedures for establishing, initializing, net entry, modifying the multi-TDL Interface, and procedures for control of aircraft. Appendixes include:

- Tactical Data Systems (TDSs) and Their Interface-related Characteristics
- OPTASK LINK Message Summary
- Link 11 Establishment and Maintenance
- Link 16 Establishment and Maintenance
- Link 11B Establishment and Maintenance
- IJMS Establishment and Maintenance
- Link 4A Establishment and Maintenance
- ATDL-1 Establishment and Maintenance
- NATO Link-1 Establishment and Maintenance
- Data Link Interface Operator Fidelity Drills, and
- Link Management Codes.

For multi-TDL procedures, reference the JMTOP!

Interdepartment Radio Advisory Committee (IRAC), Document 33583/1, 25 March 2004

The certification released by the National Telecommunication and Information Administration (NTIA) establishes the Link 16 operating limits, including TSDF and geographic area restrictions, and applies to the operation of any JTIDS/MIDS terminal system using Time Division Multiple Access (TDMA) within 200 nautical miles (nm) of the coastal United States and its Possessions (US&P). The restrictions also apply to any military unit from a foreign nation and/or Coalition force operating with US forces within 200 nm of the coastal US&P.

Additional information on the certification guidance can be found in the Link 16 Spectrum Deconfliction instruction (CJCSI 6232.01D) and the JTIDS/MIDS Spectrum Users Guide (JSUG), which are described in this appendix.

CJCSI 6232.01D

Link 16 Spectrum Deconfliction, 15 December 2006

Implements policy to ensure that the use of Link 16 systems, including Joint Tactical Information Distribution System (JTIDS) and Multifunctional Information Distribution System (MIDS), does not exceed pulse density limitations specified in National Telecommunications and Information Administration (NTIA) and US Military Communications Electronics Board (MCEB) guidance. Applies to all units operating JTIDS or MIDS in the proximity of United States and Possessions (US&P). Provides the policy, definition, procedures, and organizational responsibilities to manage and deconflict JTIDS/MIDS use through control, monitoring, supervision, and management of pulse densities, referred to as pulse deconfliction.

JTIDS/MIDS Spectrum Users Guide, *June 2004*

Provides the warfighter, Joint Task Force (JTF) planners, unit, and staff organizations a familiarization and quick reference guide. Covers general information on various JTIDS/MIDS spectrum topics that influence operations and must be considered as part of the operational planning process. Includes a reference section and point of contact list for further research. JTIDS/MIDS terminals operate within the frequency band 960 to 1215 MHz, which is designated on a worldwide basis for aeronautical radio navigation. For DoD to operate JTIDS/MIDS equipment within the US&P requires adherence to the operational restrictions and coordination procedures summarized in this guide. Also details current procedures for planning and conducting operations. Provides guidance to JTIDS/MIDS operators, leading them through the procedures involved when obtaining permission to operate. Understanding these procedures ensures that users are aware of applicable JTIDS/MIDS restrictions and coordination requirements before beginning operations.

For the latest separation requirements, consult the JSUG!

CJCSM 6520.01

Link 16 Joint Key Management Plan, *28 January 2008*

Outlines procedures for production, distribution, and use of Link 16 communications security (COMSEC) keying material (KEYMAT) under the current system and Electronic Key Management System (EKMS).

Joint Tactical Air Operations (JTAO) Interface Training Reference Notebook ("The Purple Book"), *1 October 2004*

Provides system operators with the technical parameters and tactical procedures to operate in a multi-Service JTAO Interface environment. Addresses the following:

- Interface Management and Coordination
- Interface Systems and Capabilities
- Data Link Operating Procedures
- Data Link Interface Operator Fidelity Drills
- Data Link Digital Messages
- Joint Tactical Information Distribution System, and
- Joint Theater Missile Defense.

MIL-STD-6016C, Change 1

Tactical Data Link (TDL) 16 Message Standard, *31 March 2004*

Describes the approved standards to achieve compatibility and interoperability between C2 and communications systems and equipment of US military forces, employed or intended to be employed, in Joint tactical operations. Complemented by CJCSM 6120.01, the JMTOP, described above. Contents include:

The applicable documents required to operate on Link 16

- A glossary of terms and definitions
- A summary description of Link 16
- Certain terms concerning interoperability, compatibility, and commonality
- General requirements, conventions, and protocols for information exchange and data forwarding on Link 16
- Detailed requirements for the Link 16 Fixed-Format message construction and the J-series data word descriptions, and
- Detailed descriptions for Link 16 words J0 through J12 and the RTT words.

Also identifies the minimum implementation requirements, data forwarding rules, protocols, and translations required between the J-series and M-series messages, and is a repository for Interface Change Proposals (ICPs) written against this standard.

For data item descriptions and message sequencing rules, refer to MIL-STD-6016C!

Joint Tactical Information Distribution System (JTIDS), System Segment Specification for Class 2 Terminal, 8 July 2005

Establishes the software interface for the JTIDS Class 2 terminal. This software Interface Control Document (ICD) defines completely for all platforms that host JTIDS terminals:

- Terminal initialization data and associated protocols to load, modify, or request these data
- Terminal status data and associated protocols to request these data
- Terminal input messages (TIMs) and Terminal output messages (TOMs) exchanged between the terminal and the platforms, and
- Bus messages exchanged between the terminal and the platforms, associated bus protocols, and data exchange rates.

Multifunctional Information Distribution System (MIDS), System Segment Interface Control Document, 16 September 2005

Establishes the software interface for the MIDS Low-Volume Terminal (MIDS-LVT). This software ICD defines completely for all platforms that host MIDS LVTs:

- Terminal initialization data and associated protocols to load, modify, or request these data,
- Terminal status data and associated protocols to request these data,
- Functional input messages (FIMs) and functional output messages (FOMs) exchanged between the terminal and the platforms, and
- Bus messages exchanged between the terminal and the platforms, associated bus protocols, and data exchange rates.

Air Force Instruction XX-XXX, Planning and Operations [Draft]

Prescribes and explains how US Air Force units plan, design, implement, and manage Link 16 networks both within the US&P and in theaters of operations outside US&P. Covers the responsibilities of agencies and groups tasked with designing and managing Link 16 operations. Carries out the tenets of Chairman of the Joint Chiefs of Staff Instruction (CJCSI) 6232.01D, which applies to all Air Force (AF) personnel who engage in planning, design, implementation, or management of Link 16 operations.

Air Force Concept of Link Employment (COLE), Version 2, *18 April 2001*

Describes how Link 16 equipped platforms work together to support the counter-air, interdiction, Suppression of Enemy Air Defense (SEAD), and Close Air Support (CAS) missions in sufficient detail to:

- Guide individual platform implementation definitions and mechanization designs so that they work together in the overall Link 16 system
- Support coordination of concepts with other Services and our Allies, and
- Support analyses to ensure that network capacity demanded of the proposed implementations can reasonably be met.

Also describes the new requirements on related systems, such as the Link 16 Joint Network Design Aid (JNDA) and the Air Force Mission Support System (AFMSS), which are dictated by the planned Link 16 implementations. Supports estimation of implementation costs and the definition of phased implementations coordinated among the platforms to provide the most beneficial overall capabilities first, while remaining affordable. By describing the interrelationships among USAF platforms, the COLE serves as an implementation-planning tool for assessing impact of programmatic or implementation changes to all USAF Link 16 platforms.

Concept of Network Employment

The Concept of Network Employment (CONE), which consists of a series of volumes addressing various mission profiles, documents existing and potential tactical data network (TDN) capabilities of the US Air Force. CONE volumes may address existing and future TDN capabilities of the combatant commands (COCOMs), Services, and Agencies (C/S/A), including Allies and Coalition forces as applicable. In addition, the CONE supports Joint operational plans and Service-specific Tactics, Techniques, and Procedures (TTPs). The current volumes include CAS, CSAR, and airlift.

Air Force Link 16 Operational Support Plan, October 2000

Describes the Link 16 operational support infrastructure required to operate, maintain, and employ the data link capability, identifies the associated training and fielding support that is required as Link 16 is fielded on AF platforms. Identifies offices of primary responsibility (OPRs) for the tasks composing the required infrastructure, training, and fielding support. Also provides guidance regarding the distributed nature of the data link system and how it affects the fielding of Link 16 in individual platforms, and on the associated training for those platforms. Individual platform-specific Link 16 Fielding Plans are not a part of this document; however, they should be prepared to be consistent with the overall approach to Link 16 operational support outlined in this plan and Appendix A. Describes the infrastructure required to operate Link 16 networks and employ the data link system, discusses the fielding of Link 16, including an introduction to Link 16 training, and presents special considerations resulting from the distributed nature of the system and differences between its fielding in nonC2 (fighters and bombers) and C2 platforms. Also discusses special requirements for exercises resulting from the distributed nature of the data link system.

Air Force Tactical Data Link Roadmap, 29 October 2001

Defines strategy for acquiring, fielding, and sustaining tactical data link capabilities within the United States Air Force. Consolidates tactical data link priorities, at mission area level, into a comprehensive plan that horizontally integrates C2, Intelligence, Surveillance, and Reconnaissance (ISR) platforms with fighter, bombers, and support assets to achieve effects-based implementation. Provides the path for migration to common, standardized systems and compliance with DoD policies for tactical data link implementation, as described in the Joint Tactical Data Link Management Plan. Facilitates the establishment of tactical data links as a major AF system acquisition program and provides the foundation for development of Program Objective Memorandum (POM) requirements and priorities.

F-15C JTIDS/Link 16 Guide, MITRE Corporation, June 2000

Provides a pilot-oriented perspective of Link 16 and its use in the F-15C. Prepared to support the fielding of Fighter Data Link (FDL) terminals in F-15C/D operational and test squadrons. Provides background on the system and briefly introduces the color Link 16 display to show the types of information available to the F-15C pilot with this tactical data link system. Some benefits of the system are presented, but the potential applications only hint at the many uses the tactical community will find for this system. Also presents a broad overview of the data link system, followed by discussion of the primary information exchanges between key operational platforms using Link 16 in the Air Force (F-15C, E-3, and Rivet Joint) at the time it was written. Addresses special topics as well, discussing in greater depth certain features of the data link system that are considered important for pilot's successful use of the system. Briefly outlines the network management process. Describes operation of the system using Southwest Asia (SWA) as a scenario.

Appendix F

Acronyms and Abbreviations

The following acronyms and abbreviations may be found in this document, as well as in certain supporting references.

Acronym	Definition
µs	microsecond
	A
AAA	Anti-Aircraft Artillery
AADC	Area Air Defense Commander
AEELS	Automatic Electronic Emitter Location System
AB	Air Base
ABE	Air Battle Execution
ABL	Airborne Laser
AC/TMD	Air Control/Theater Missile Defense
ACA	Airspace Control Authority
ACAT	Acquisition Category
ACC	Air Combat Command
ACC/A3YJ	Air Combat Command/C2ISR Operations Division - Link 16 Network Design Facility
ACCS	Air Command and Control System (NATO)
ACDS	Advanced Combat Direction System
ACM	Airspace Control Means
ACO	Airspace Control Order
ACP	Airspace Control Plan
ACQ	Acquire
ACR	Air Control Revision
ACS	Air Control Squadron
Act.	Action Code
ACUS	Army Common User System
ACW	Air Control Wing
ADA	Air Defense Artillery (US Army)

Acronym	Definition
ADAM	Air Defense Airspace Management (US Army cell)
ADCP	Air Defense Communications Platform (USMC)
ADDS	Army Data Distribution System
ADDSI	Army Data Distribution System Interface
ADP	Air Defense Plan
ADSI®	Air Defense Systems Integrator
AEELS	Automatic Electronic Emitter Location System
AEHF	Advanced EHF
AETACS	Airborne Elements of the Tactical Air Control System
AF	Air Force
AF DCGS	Air Force Distributed Common Ground Station
AF GCIC	Air Force Global Cyberspace Integration Center
AF NDF	USAF Link 16 Network Design Facility
AF PEO/C2&CS	Air Force Program Executive Officer for Command and Control and Combat Support
AFAPD	Air Force Applications Program Development
AFATDS	Air Force Airborne Tactical Data System; Advanced Field Artillery Tactical Data System
AFB	Air Force Base
AFCENT	Air Force Central
AFEUR	Air Force Europe
AFFOR	Air Force Forces
AFMSS	Air Force Mission Support System
AF NDF	Air Force Network Design Facility
AFNMWG	Air Force Link 16 Network Management Working Group
AFNORTH	Air Force North
AFOIRG	Air Force Operational Interoperability Requirements Group

Acronym	Definition
AFPAC	Air Force Pacific
AFPD	Air Force Policy Directive
AFROK	Air Force Republic of Korea
AFSOC	Air Force Special Operations Command
AFSOF	Air Force Special Operations Forces
AFSOUTH	Air Force South
AFSPC	Air Force Space Command
AFSTRAT	Air Force Strategic Command
AFTRG	Air Force Tactical Data Network Requirements Group
AFTTP	Air Force Tactics, Techniques, and Procedures
AIMS	ATCRBS IFF Mark XII System
AIU	Antenna Interface Unit
AJ	Antijam
aka	Also known as
AKO	Army Knowledge Online
AMC	Air Mobility Command
AMD	Air Mobility Division
AMDPCS	Air and Missile Defense Planning and Control System (US Army)
AMOS	Air Mobility Operations Center
AMP	Amplification
AMSS	Airborne Mission System Specialist
ANDF	Army Network Design Facility
ANG	Air National Guard
AOC	Air and Space Operations Center
AOCE	Alpha-Omega Change Engineering
AOCFTU	Air Operations Center Formal Training Unit

Acronym	Definition
AOCP	Airborne Operational Computer Program
AOD	Air Operations Directive
AOG	Air Operations Group
AOI	Area of Interest
AOP	Areas of Probability
AOR	Area of Responsibility
AOS	Air Operations Squadron
AR	Air Refueling
ASCIET/JCIET	All Services/Joint Combat Identification Evaluation Team
ASIT	Adaptable Surface Interface Terminal
ASO	Air Surveillance Officer
ASOC	Air Support Operations Center
ASU	Anti-surface Warfare; Aircraft Sector Understanding; Antenna Switching Unit
ASW	Anti-submarine Warfare
ATACC	Advanced Tactical Air Control Center
ATCRBS	Air Traffic Control Radar Beacon System
ATDL-1	Army Tactical Data Link 1
ATDS	Airborne Tactical Data System
ATO	Air Tasking Order
ATTN	Attention
AU	Australia
AWACS	Airborne Warning and Control System
AWACS ADS	AWACS Airspace Deconfliction System
AWACS AIU	AWACS Avionics Interface Unit

Acronym	Definition
AWACS CC-2E	AWACS Central Computer Version 2E
AWACS CDU	AWACS Control Display Unit
AWACS CPS	AWACS Communications Processing Subsystem
AWACS DDP	AWACS Distributed Data Processing
AWACS ECSP	AWACS Electronic Command Signal Processor; Electronic Control Signal Processor
AWACS EGI	AWACS Embedded Global Positioning System/Inertial Navigation Unit
AWACS ETK	AWACS Embedded Toolkit
AWACS HDS	AWACS Hard Disk Subassembly
AWACS HPA	AWACS High Power Amplifier
AWACS HPAG	AWACS High Power Amplifier Group
AWACS IU	AWACS image understanding
AWACS LPF	AWACS Low Pass Filter
AWACS PDU	AWACS power distribution unit
AWACS RFA	Radio Frequency Amplifier
AWACS SDC	AWACS Signal Data Converter
AWACS SDU	AWACS Secure Data Unit
	B
BC3	Battle Command and Control Center
BCP	Battery Command Post (US Army)
BCS-F	Battle Control System-Fixed
BCS-M	Battle Control System-Mobile
BDA	Battle Damage Assessment
BDHI	Bearing Distance Heading Indicator
BE	Belgium
BHI	Bomb Hit Indication

Acronym	Definition
BIM	Bus Input Message
BIT	Built-in Test
Bldg	Building
BLK	Block
BLOS	Beyond Line of Sight
BM	Battle Management
BMC2	Ballistic Missile Command and Control
BMC4I	Battle Management Command, Control, Communications, Computers, and Intelligence
BMD	Ballistic Missile Defense (US Army)
BMDS	Ballistic Missile Defense System
BO	Bailout
BOM	Bus Output Message
BOSS™	Battlefield Operations Support System
bps	Bits per Second
	C
C&D	Command & Decision [system] (USN)
C/S/A	Combatant Commands, Services, and Agencies
C2	Command and Control
C2 JU	
C2BMC	Command and Control/Battle Management/Communications
C2I	Command, Control, and Intelligence
C2ISR	Command, Control, Intelligence, Surveillance, and Reconnaissance
C2P	Command and Control Processor (USN)
C2WAC	Command and Control Warrior Advanced Course
C2WS	C2 Warrior School

Acronym	Definition
C3I	Command, Control, Communications, and Intelligence
C4I	Command, Control, Communications, Computers, and Intelligence
CA	Canada
CAC	Common Access Card
CAC2S	Common Aviation Command and Control System (USMC)
CAF	Combat Air Forces
CANTCO	Cannot Comply
CANTPRO	Cannot Process
CAOC	Combined Air and Space Operations Center
CAOC-N	Combined Air Operations Center, Nellis AFB
CAOC-X	Combined Air Operations Center, Experimental
CAP	Combat Air Patrol
CAS	Close Air Support
CASS	Close Air Support System
CB	Cobra Ball
CBT	Computer-Based Training
CC	Compass Call; Central Computer
CCC	Common Core Capability
CCD	Common Connectivity Device
CCIP	Common Configuration Implementation Program
CCITT	Consultative Committee International Telegraph and Telephone
CCO	Combat Control Officer
CCPD	Current Cryptoperiod Designator
CCSK	Cyclic Code Shift Keying
CDL	Common Data Link

Acronym	Definition
CDLI	Common Data Link Interface (US Army)
CDLIM	Common Data Link Interface Module
CDLMS	Common Data Link Management System (USN)
CDLS	Communications Data Link System (USMC)
CDO	Change Data Order
CDP	Conditioned Diphase
CFACC	Combined Forces Air Component Commander
CG	Guided Missile Cruiser (USN)
CGN	Guided Missile Cruiser, Nuclear (USN)
CGS	Common Ground Station
CH	Switzerland
CID	Combat Identification
CIO	Concurrent Interface Operations
CIU	Concurrent Interface Unit
CJCSI	Chairman, Joint Chiefs of Staff Instruction
CJCSM	Chairman, Joint Chiefs of Staff Manual
CJTF	Commander, Joint Task Force
CMS	Control Monitor Set
CMUP	Conventional Mission Upgrade Program
COCOM	Combatant Command; Combatant Commander
COD	Combat Operations Division
COLE	Concept of Link Employment
COMAFFOR	Commander, Air Force Forces
COMINT	Communications Intelligence
COMSEC	Communications Security

Acronym	Definition
CONCOPS	Concurrent Operations
CONE	Concept of Network Employment
CONUS	Continental United States
CoP	Community of Practice
COP	Common Operational Picture
COS	Combat Operations Squadron
CoT	Cursor-on-Target
COTS	Commercial Off-the-Shelf
CPD	Crypto Period Designator; Combat Plans Division
CPOD	Communications Plan-of-the-Day
CPSM	Continuous Phase Shift Modulation
CPU	Central Processing Unit
CRC	Control and Reporting Center
CRYPDAT	Crypto Data (USMTF SETID)
CS	Combat Sent; Combat Support
CSAR	Combat Search and Rescue; Combined Search and Rescue
CSAR-X	Combat Search and Research-X
CSIA	Core − Subscriber Interface Assembly, Army
CSM	Common Software Module
CSO	Communications System Operator
CSP	Common Signal Processor
CSS	Cartridge Support System
CST	Communication Systems Technician; Communication Support Technician
CT	Communications Technician

Acronym	Definition
CTN	Common Track Number
CTP	Cypher Text Processor
CU	Control Unit; Controlling Unit
CUI	Common User Interface
CUR	Controlling Unit Report
CV	Cryptovariable; Aircraft Carrier (USN)
CVLL	Cryptovariable Logical Label
CVM	Common Variable Mode
CVN	Aircraft Carrier, Nuclear (USN)
CVSD	Continuously Variable Slope Delta
	D
DAMA	Demand Assigned Multiple Access
dB	Decibels
dBm	Decibels Referenced to One Milliwatt
DCGS	Distributed Common Ground Station
DCI	Digital Communications Initiative
DDG	Guided Missile Destroyer (USN)
DDP	Digital Data Processor
DE	Germany
DERG	Data Extraction and Reduction Guide
DFI	Data Field Identifier
DFI/DUI	Data Field Identifier and Data Use Identifier
DGT	Designated Ground Target
DII/COE	Defense Information Infrastructure/Common Operating Environment
DIS	Distributed Information Systems

Acronym	Definition
DIS IP	Digital Imaging Surveillance Interchange Protocol
DISA	Defense Information Systems Agency
DIVJ	Training Division J
DK	Denmark
DLMC	Data Link Management Cell
DLO	Data Link Operator
DLRN	Data Link Reference Number
DLRP	Data Link Reference Point
DME	Distance Measuring Equipment
DMPI	Designated Mean Point of Impact
DMPI Modify	Modify Desired Mean Point of Impact
DOD	Department of Defense
DPCP	Data Processor Computer Program
DPG	Data Processor Group
DSCS	Defense Satellite Communications System
DTB	Data Transfer Block
DTC	Data Transfer Cartridge
DTDMA	Distributed Time Division Multiple Access
DTI	Data Transfer Interrupt
DTM	Data Transfer Module
DTS	Data Terminal Set
DTSS	Data Terminal Set Simulator
DUI	Data Use Identifier
DUR	Data Update Request
	E
EA	Electronic Attack

Acronym	Definition
EACS	Expeditionary Air Control Squadron
ECCM	Electronic Counter-Countermeasures
ECM	Electronic Countermeasures
ECO	Electronic Combat Officer
ECW	Electronic Combat Wing
EDAC	Error Detection and Correction
EFX	Expeditionary Force Experiment
EHF	Extremely High Frequency
EKMS	Electronic Key Management System
ELINT	Electronic Intelligence
ELSG	Electronic Systems Group
ELSW	Electronic Systems Wing
EMC	Electromagnetic Compatibility
EMCON	Emission Control
EMD	Engineering and Manufacturing Development
EO/IR	Electro-Optical/Infrared
EOS	End-of-Slot
EPLRS	Enhanced Position Location and Reporting System
ES	Electronic Support; Electronic Surveillance; Spain
ESC	Electronic Systems Center
ESD	Exploitation Support Data
ESM	Electronic Support Measures
ETA	Estimated Time of Arrival
ETD	Estimated Time of Departure
ETR	External Time Reference

Acronym	Definition
EW	Electronic Warfare
EW/I	Electronic Warfare (EW) Intelligence
EW/ISR	EW Intelligence, Surveillance, and Reconnaissance
EWC	Electronic Warfare Coordinator
	F
F2T2EA	Find, Fix, Track, Target, Engage, and Assess
FAA	Federal Aviation Administration
FAAD	Forward Area Air Defense
Faker	Exercise Hostile
FBCB2	Force XXI Battle Command, Brigade-and-Below
FCA	Frequency Clearance Agreement
FDL	Fighter Data Link
FEBA	Forward Edge of Battle Area
FEC	Full Expeditionary Capability
FFF	Form, Fit, and Function
FIDL	Fully Integrated Data Link
FIM	Functional Input Message
FIO	FDL Input/Output
FJU	Forwarding JTIDS Unit
FJUA	Forwarding JU on Link 11
FJUAB	Forwarding JU on Link 11 and Link 11B
FJUB	Forwarding JU on Link 11B
FLOT	Forward Line of Own Troops
FLTSAT	Fleet Satellite
FMP	Fleet Modernization Program
FOB	Forward Operating Base

Acronym	Definition
FOIP	Fiber-Optic Interface Panel
FOM	Functional Output Message
FORSCOM	US Army Forces Command
FOV	Field of View
FR	France
FS	Fighter Squadron
FSatU	Forwarding Satellite Unit (UK)
FSK	Frequency Shift Keying
FT	Free Text
FTI	Fixed Target Indicator
FTU	Formal Training Unit; Field Training Unit
FW	Fighter Wing
FWF	Fixed Word Format
	G
GAAC	Geographic Area Assignment Controller
GARS	Global Area Reference System
GCCS-J	Global Command and Control System with Link 16
GCIC	Global Cyberspace Integration Center
GCIC/RINIS	Global Communications and Information Division/Warfighting Networks, Integration and Standards Branch
GCS	Ground Control Station
GDOP	Geometric Dilution of Precision
GE	Germany, German
GHz	Gigahertz
GLONASS	Global Orbiting Navigation Satellite System
GM	Gateway Manager

Acronym	Definition
GNSS	Global Navigation Satellite System
GPC	General Purpose Computer
GPS	Global Positioning System
GR	Greece
GSM	Ground Station Module
GTACS	Ground Element of the Tactical Air Control System
GTS	Ground Tactical Data Link System
	H
HAVCO	Have Complied
HF	High Frequency
HPA	High Power Amplifier
HPAG	High Power Amplifier Group
HQ	Headquarters
HUR	High Update Rate
Hz	Hertz
	I
I-JSS	Interim JICO Support System
I/O	Input/Output
IBCS	Integrated Battlefield Control System
IBS	Information Broadcast Service
ICC	Information and Coordination Central (US Army)
ICD	Interface Control Document
ICO	Interface Control Officer
ICP	Interface Change Proposal
ICT	Interface Control Team; Interface Control Technician

Acronym	Definition
ID	Identification, Identity
IDL	Initialization Data Load
IDM	Improved Data Modem
IE	Initial Entry
IEJU	Initial Entry JTIDS Unit
IER	Information Exchange Requirement
IEUJ	Initial Entry JTIDS Unit
IFF	Identification Friend or Foe
IFF/SIF	Identification Friend or Foe/Selective Identification Feature
IFTU	In-Flight Target Update
IIU	Indirect Interface Unit
IJMS	Interim JTIDS Message Specification
IMINT	Image Intelligence
IMTDS	Improved Multi-TDL Distribution System
INS	Inertial Navigation System
INT	Intelligence
IO	Information Operations
IOC	Initial Operating Capability
IP	Internet Protocol
IPF	Interference Protection Feature
IR	Infrared
IR5	Interim Release 5
IRAC	Interdepartment Radio Advisory Committee
IS	Intelligence Squadron
ISO	International Standards Organization
ISR	Intelligence, Surveillance, and Reconnaissance

Acronym	Definition
ISRD	Intelligence, Surveillance, and Reconnaissance Division
ISRN	Internal System Reference Number
IT	Italy
ITS	Initialization Time Slots
IU	Interface Unit
	J
JAC2C	Joint Aerospace Command and Control Course
JACAC	Joint Aerospace Computer Applications Course
JADSI	Joint Air Defense System Integrator
JAOC	Joint Air and Space Operations Center
JAOP	Joint Air Operations Plan
JASAC	Joint Aerospace Systems Administrator Course
JASSM	Joint Air-to-Surface Standoff Missile
JCS	Joint Chiefs of Staff
JDAM	Joint Direct Attack Munition
JDR	JICO Data Repository
JDS	JTIDS/MIDS Deconfliction Server
JFACC	Joint Forces Air Component Commander
JFC	Joint Forces Commander
JFCOM	Joint Forces Command
JFCOM-JID	Joint Forces Command - Joint Interoperability Division
JHMCS	Joint Helmet Mounted Cueing System
JICC	Joint Interface Control Cell
JICO	Joint Interface Control Officer
JID	Joint Interoperability Division
JIEO	Joint Information Engineering Organization

Acronym	Definition
JITC	Joint Interoperability Test Command
JLENS	Joint Land Attack Cruise Missile Defense Elevated Netted Sensor (US Army)
JM	JTIDS Module (USMC)
JMPS	Joint Mission Planning System
JMTOP	Joint Multi-Tactical Data Link (TDL) Operating Procedures
JMTS	Joint Multi-TDL School
JNDA	Joint Network Design Aid
JNDL	Joint Tactical Information Distribution System (JTIDS/MIDS) Design Library
JNDT	Joint Network Design Team
JNETWORK	JNL Network Descriptions and Platform IDLs (USMTF SETID)
JNL	Joint Tactical Information Distribution System (JTIDS/MIDS) Network Library
JNPT	JICO Network Planning Tool
Joint STARS	Joint Surveillance Target Attack Radar System
JP	Japan
JPEG	Joint Photographic Experts Group
JPT	Joint Planning Tool
JRE	Joint Range Extension
JREAP	Joint Range Extension Application Protocol
JSF	Joint Strike Force; Joint Strike Fighter
JSOW	Joint Standoff Weapon
JSS	JICO Support System
JSSC	Joint Aerospace Operations Senior Staff Course
JSTARS	Joint Surveillance Target Attack Radar System
JSTNETS	Stacked Nets Set Identifier (USMTF SETID)
JSUG	JTIDS/MIDS Spectrum Users Guide

Acronym	*Definition*
JTAC	Joint Terminal Attack Controller
JTAGS	Joint Tactical Ground Station (US Army)
JTAO	Joint Tactical Air Operations
JTEP	Joint Range Extension Transparent Multi-Platform Gateway Equipment Package
JTF	Joint Task Force
JTIDS	Joint Tactical Information Distribution System
JTIDS TIDP-TE	JTIDS Technical Interface Design Plan (Test Edition)
JTRS	Joint Tactical Radio System
JTTP	Joint Tactics, Techniques, and Procedures
JU	JTIDS Unit
JUDATA	JU Data (USMTF SETID)
	K
K	Effective Earth Radius
kb	kilobit
kbps	kilobits per Second
KEYMAT	Keying Material
kHz	kilohertz
KR	Republic of Korea
	L
LAK	Link 16 Alaska
LANTIRN	Low-Altitude Navigation and Targeting Infrared, Night
LCC	Amphibious Command Ship (USN)
LCN	Logical Channel Number
LDDS	Link Data Distribution System
LFE	Large Force Exercise
LHA	Amphibious Assault Ship (USN)

Acronym	*Definition*
LHD	Amphibious Landing Ship (USN)
LMS™	Link Management System
LMS™-16	Link 16 Management System
LMS™-MT	Multi-TDL Link 16 Management System
LNKXVI	Link 16
LOB	Line of Bearing
LOS	Line of Sight
LPD	Landing Platform Dock (USN)
LPI	Low Probability of Intercept
LTPO	Lower Tier Project Office
LTTI	Long Term Transmit Inhibit
LUM	Link 16 Unit Manager
LVT	Low Volume Terminal (MIDS)
LVT-1	MIDS Low Volume Terminal Type 1
LVT-2	MIDS Low Volume Terminal Type 2
LVT-3	MIDS Low Volume Terminal Type 3
LVT-4	Low Volume Terminal Type 4
LVT-6	Low Volume Terminal Type 6
LVT-7	MIDS Low Volume Terminal Type 7
LVT-11	MIDS Low Volume Terminal Type 11
	M
m	millisecond
MAD	Mission Assignment Discrete
MAJIC	Multi-TDL Advanced Joint Interoperability Course
MAPS	Mission Area Plans
MCD	Mission Commander Display

Acronym	Definition
MCE	Modular Control Equipment
MCEB	US Military Communications Electronics Board
MCO	Major Combat Operations
MCS	Modular Control System
MCTSSA	Marine Corps Tactical Systems Support Activity
MDA	Missile Defense Agency
MDR	Medium Data Rate
MDTCI	Multiplex Data Transfer Complete Interrupt
MF	Medium Frequency
MHz	Megahertz
MIDS	Multifunctional Information Distribution System
MIDS LVT	MIDS Low-Volume Terminal
MIDSCO	MIDS consortium
MILSTAR	Military Strategic and Tactical Relay Satellite
MIL-STD	Military Standard
MLST3	Multiple Link Simulation Test and Training Tool
Mode S	Mode Select Beacon System
MOOTW	Military Operations Other Than War
MOS	MIDS-on-Ship (USN and USMC)
MPCD	Multipurpose Cockpit Display
MR	Machine Receipt
ms	Milliseconds
MSCT	Multiple Source Correlator Tracker
MSD	Maintenance Support Device
MSEC	Message Security
Msg	Message

Acronym	Definition
MSGID	Message Identifier (USMTF SETID)
MSIP	Multi-Stage Improvement Program
MT	Main Terminal
MTA	Multi-TDL Architecture
MTI	Moving Target Indicator
MTS	Marine Tactical System
MUX	Multiplex
	N
NATO	North Atlantic Treaty Organization
NATO NDF	NATO Network Design Facility
NAV	Navigation
NAVAID	Navigation Aid
NC	Navigation Controller
NCTSI	Navy Center for Tactical Systems Interoperability
NDA	Network Design Aid
NDF	Network Design Facility
NDL	Network Data Load
NECT	Net Entry Control Terminal
NETE	Net Entry Transmit Enable
NEW	Network Enabled Weapons
NFA	Notch Filter Assembly
NGA	National Geospatial-Intelligence Agency
NI	Received but Not Interpreted
NICP	Network Interface Computer Program
NILE	NATO Improved Link Eleven

Acronym	Definition
NIPG	Network Interface Program Group
NIPRNET	Nonclassified Internet Protocol Router Network
NITFS	National Imagery Transmission Format Standard
NL	Netherlands
nm	Nautical Miles
NMSC	Navy Marine Corps Spectrum Center
NO	Norway
NonC2	Non-Command and Control
NonC2 JU	Non-Command and Control JTIDS Unit
NPG	Network Participation Group
NS	No Statement
ns	Nanosecond
NSA	National Security Agency
NSS	National Security Systems
NT	NATO; Not Transmitted
NT/NI	Not Transmitted/Not Interpreted
NTDS	Naval Tactical Data System
NTIA	National Telecommunications and Information Administration
NTISR	Nontraditional Intelligence, Surveillance, and Reconnaissance
NTN	NATO Track Number
NTR	Network Time Reference
NTR^{E}	Network Time Reference, ETR-enabled
	O
OCU	Operations Console Unit
OEF	Operation Enduring Freedom

Acronym	Definition
OFP	Operational Flight Program
OIF	Operation Iraqi Freedom
OM	Operations Module
OPEVAL	Operational Evaluation
OPF	Operational Flight Program
OPFAC	Operational Facility
OPLAN	Operational Plan
OPORD	Operation Order
OPR	Office of Primary Responsibility
OPTASK LINK	Operational Tasking, Data Links (USMTF)
ORD	Operations Requirement Document
ORN	Other Reference Number
OSP	Operational Special Project
OSW	Operation Southern Watch
OTAR	Over-the-Air Rekeying
	P
P	IJMS Position and Status
P2	Packed-2
P2DP	Packed-2 Double Pulse
P2SP	Packed-2 Single Pulse
P4	Packed-4
P4SP	Packed-4 Single Pulse
PACAF	U.S. Air Force, Pacific
Patriot BCP	Patriot Battery Command Post (US Army)
Patriot ICC	Patriot Information and Coordination Central (US Army)
PBA	Predictive Battlespace Awareness

Acronym	Definition
PDS	Passive Detection System
PDT	Primary Designated Target
PERIOD	Period of Operation (USMTF SETID)
PGM	Precision-Guided Munitions
PJHI	Position Location Reporting System/JTIDS Hybrid Interface
PL	Poland
PN	Pseudorandom Noise
POC	Point Of Contact
POM	Program Objective Memorandum
PPLI	Precise Participant Location and Identification
PR	Position Reference
PRU	Primary User
PT	Portugal
PTB	Plain Text Bus
PTP	Plain Text Processor
PTT	Push-to-Talk
PU	Participating Unit (Link 11)
PVM	Partitioned Variable Mode
	Q
Q_p	Position Quality
Q_{pg}	Geodetic Position Quality
Q_{pr}	Relative Position Quality
Q_t	Time Quality
	R
R	Receive
R-S	Reed-Solomon

Acronym	Definition
R/C	Receipt/Compliance
R/T	Receiver/Transmitter
R2	Reporting Responsibility
RAF	Royal Air Force (UK)
RAOC	Regional Air Operations Center
RAP	Recognized Air Picture
RCN	Radar Controlled Track No Guidance
RCP	Radio Control Parameter
RCT	Radar Controlled Track
RDECOM	Research, Development, and Engineering Command (US Army)
RDF	Radio Direction Finding
REFPOINT	Reference Point
RELNAV	Relative Navigation
Reprom	Repromulgation
RF	Radio Frequency
RFA	Request for Frequency Assignment
RICO	Regional Interface Control Officer
RIMM	Removable Interchangeable Media Module
RINIS	Warfighting Networks, Integration and Standards Branch
RJ	Rivet Joint
RMA	Removable Media Assembly
ROBE	Roll-on Beyond Line of Sight Enhancement
ROI	Regions of Interest
ROK	Republic of Korea
rpm	Revolutions per Minute
RPS	Remote Power Supply

Acronym	*Definition*
RRN	Recurrence Rate Number
RS	Reconnaissance Squadron
RSO	Remote Split Operations
RSR	Radar Service Request/Response
RTO	Range Training Officer
RTT	Round-Trip Timing
RTT-A	Round-Trip Timing Message - Addressed
RTT-B	Round-Trip Timing Message - Broadcast
RTT-I	Round-Trip Timing Message - Interrogation
RTT-R	Round-Trip Timing Message - Reply
RU	Reporting Unit (Link 11)
RW	Reconnaissance Wing
	S
SA	Situational Awareness
SACP	Stand-Alone Control Panel
SADL	Situation Awareness Data Link
SADO	Senior Air Defense Officer
SAM	Surface-to-Air Missile
SAMOC	Surface-to-Air Missile Operations Center
SAR	Synthetic Aperture Radar; Search and Rescue
SAT J	Satellite TADIL-J
SATCOM	Satellite Communications
SAT-J	Satellite Link 16
SatU	Satellite Unit (UK)
SCA	Software Communications Architecture

Acronym	Definition
SCDL	Surveillance and Control Data Link
SD	Strategy Division
SDU	Secure Data Unit
SE	Sweden
SEAD	Suppression of Enemy Air Defense
SED	Software Engineering Directorate (US Army)
SETID	Set Identifier (USMTF)
SFSTRAT	Air Force Strategic Command
SHF	Super High Frequency
SHORAD	Short Range Air Defense
SICO	Sector Interface Control Officer
SICP	Subscriber Interface Computer Program
SIF	Selective Identification Feature
SIGINT	Signals Intelligence
SIMPLE	Standard Interface for Multiple Platform Link Evaluation
SINCGARS	Single Channel Ground-to-Air Radio System
SIPG	Subscriber Interface Program Group
SIPRNET	Secret Internet Protocol Router Network
SJU	Satellite JTIDS Unit
SKL	Simple Key Loader
SLAMRAAM	Surface Launched Advanced Medium Range Air-to-Air Missile (US Army)
SLM-16	Single Link Monitor for Link 16
SM&C	System Management and Control
SMO	Sensor Management Officer
SMP	Signal/Message Processor
SNC	Secondary Navigation Controller

Acronym	Definition
SOCAL	Southern California
SOF	Special Operations Forces
SP	Spain
SPI	Special Processing Indicator
SPINS	Air Tasking Order Special Instructions
SPO	System Program Office
SRN	System Reference Number
SS	Senior Scout
SSDS	Ship Self-Defense System (USN)
SST	Senior Surveillance Technician
STANAG	Standardization Agreement (NATO)
STD	Standard
STD-DP	Standard Double Pulse
STDL	Satellite Tactical Data Link (UK)
S-TDL J	Satellite Link 16 (USN)
STE	Secure Telephone Equipment
STGU	Satellite TDL Gateway Unit
STN	Source Track Number
STRN	System Time Reference Network
STU	Secure Telephone Unit
SU	Secondary User
SWA	Southwest Asia
	T
T	Transmit; IJMS Limited Track
T&E	Test and Evaluation

Acronym	Definition
T/R	Transmit/Receive
TACAN	Tactical Air Navigation
TACC	Tactical Air Command Center (USMC); Tanker Airlift Control Center
TACOPDAT	Tactical Operations Data
TACP	Tactical Air Control Party
TACS	Tactical Air Control System
TAD	Theater Air Defense
TAOC	Tactical Air Operations Center
TAOM	Tactical Air Operations Module
TBD	To Be Determined
TBM	Theater Ballistic Missile
TBMCS	Theater Battle Management Core Systems
TCAS	Traffic Collision Avoidance System
TCG	Tactical Communications Group
TCP	Transmission Control Protocol
TCP/IP	Transmission Control Protocol/Internet Protocol
TCS	Tactical Command System
TCT	Time Critical Targeting
TD	Tabular Display
TDC	Track Data Coordinator
TDL	Tactical Data Link
TDL SPO	Tactical Data Links System Program Office
TDMA	Time Division Multiple Access
TDN	Tactical Data Network
TDS	Tactical Data System

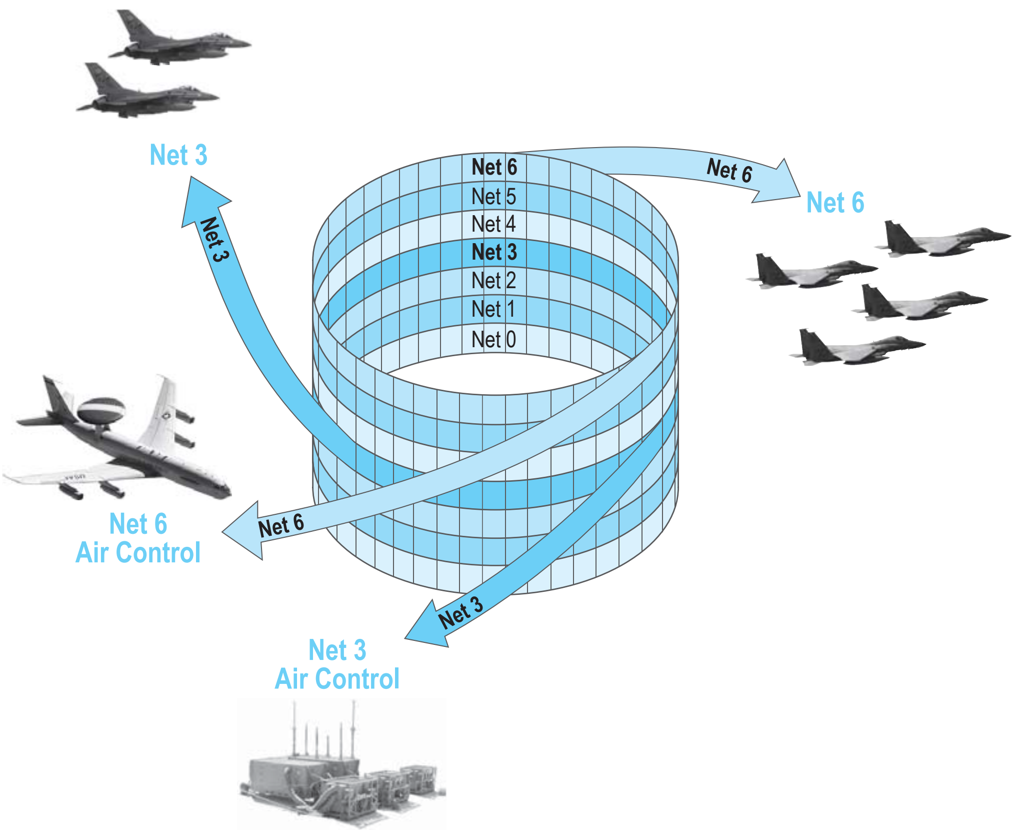
Acronym	Definition
TECHEVAL	Technical Evaluation
TES	Test and Evaluation Squadron
THAAD	Terminal High Altitude Area Defense
TIDP-TE	Technical Interface Design Plan (Test Edition)
TIG	Tactical Information Gateway
TIGER	Tactical Data Link Integration Exerciser
TIM	Terminal Input Message
TIO	Tailored Input/Output
TJRS	TDL J Requirements Specification
TJU	TDL J Upgrade (JSTARS)
TMD	Theatre Missile Defense
TMPG	Transparent Multi-Platform Gateway
TN	Track Number
TNR	Track Number Reference
TOA	Time of Arrival
TOAi	TOA of the Interrogation
TOAr	TOA of the Reply
TOD	Time of Day
TOM	Terminal Output Message
tp	Propagation Time
TPA	Track Production Area
TQ	Track Quality
TR	Turkey
TRI-TAC	Tri-Service Tactical Communications
TS	Test Squadron
TSA	Time Slot Assignment

Acronym	Definition
TSB	Time Slot Block
TSDF	Time Slot Duty Factor
TSEC	Transmission Security
TSR	Time Slot Reallocation
TST	Time-Sensitive Target; Time-Sensitive Targeting
TTP	Tactics, Techniques, and Procedures
TW	Threat Warning
	U
UAV	Unmanned Aerial Vehicle
UDP	User Datagram Protocol
UFN	Until Further Notice
UFO	Ultrahigh Frequency Follow-On
UHF	Ultrahigh Frequency
UK	United Kingdom
UNCLAS	Unclassified
US	United States
US&P	United States and Possessions
USA	United States of America; United States Army
USAF	United States Air Force
USAFE	U.S. Air Force, Europe
USJFCOM	US Joint Forces Command
USMC	United States Marine Corps
USMTF	United States Message Text Format
USN	United States Navy
USW	Undersea Warfare

Acronym	Definition
UT	Universal Time
UTC	Coordinated Universal Time
	V
VACAPES	Virginia Capes
VHF	Very High Frequency
VMF	Variable Message Format
Vocoder	Voice Encoder/Decoder
VOR	VHF Omnidirectional Range
VORTAC	VHF Omnidirectional Range - Tactical Air Navigation
VSD	Vertical Situation Display
	W
WAS	Wide Area Surveillance
WFHQ	Warfighting Headquarters
WG	Wing
WGS-84	World Geodetic Survey 1984
WIFT	Weapon In-flight Track
WILCO	Will Comply
WNW	Wideband Networking Waveform
WPN	Weapon
WSC	Weapons System Coordinator
WSO	Weapon System Officer
WX	Weather
	X, Y, Z
XML	Extensible Markup Language
XOR	Exclusive Or
XOR'd	Exclusively-Or'd

Appendix G

Glossary



The following terms have been used or defined in this guidebook. Terms in *italics* are cross-references to other terms in this Glossary.

Access rate — The assigned rate that determines the frequency of a Link 16 terminal's *contention access* to an assigned time-slot block.

Active synchronization — The Link 16 terminal's procedure for transmitting *round-trip timing* messages to refine and maintain its estimate of system time.

Address — A number applied to an *Interface Unit* to associate information and directives with other Interface Units interface units for digital and voice communication on Link 16 and on Link 11.

Air Control — The *Network Participation Group* (NPG 9) that provides the means for *command and control* (C2) Link 16 units (JUs) to control *nonC2* JUs.

Antijam margin — The degree of protection against jamming provided by several characteristics inherent in a communications architecture. Factors contributing to the antijam margin of the Link 16 signal include error-correction encoding, pseudorandom noise, transmission redundancy, *jitter*, and *frequency hopping*.

Automatic acknowledgement — A machine verification function whereby a terminal that receives a message addressed to it retransmits a copy of that message back to the source during a later *time slot*, verifying the receipt of the original message.

Backlink — An adjective describing the *time slots* that are dedicated to the transmitted responses of controlled aircraft. It also applies to aircraft equipped with Link 16 that are capable of transmitting them.

Bailout Indicator — A field in an AIR PPLI indicating a J3.1 Emergency Point message.

Bilingual — The ability of certain JTIDS terminals to process both *IJMS* and JTIDS messages.

Bit — A binary digit. A bit has only two possible values: zero and one.

Blind relay — A *relay* in which a Link 16 relaying unit is initialized with the correct *transmission security* (TSEC) cryptovariable for receiving and retransmitting messages, but is initialized with a different *message security* (MSEC) cryptovariable, which prevents it from being able to decrypt the messages it relays.

Buffer — An area in computer memory that is reserved for the temporary storage of data. Tactical data systems reserve buffers for input and output.

Carrier
An electromagnetic wave or alternating current whose modulations are used as signals in radio transmissions.

Chipping sequence
A transformation, produced by *cyclic code-shift keying*, of the interleaved symbols of message codewords for transmission. This transformation produces for each 5-bit symbol a sequence of 32 bits, or chips.

Change Data Order (CDO)
A Track Management order (J7.0) from a designated authority that changes the environment and identification.

Coarse synchronization
The initial procedure of Link 16 net entry, during which a Link 16 unit attempts to receive an Initial Entry message without adjusting its internal clock for the propagation time of the message. During this synchronization state, the Link 16 terminal can receive and process messages and achieve fine synchronization.

Codeword
A sequence consisting of 31 5-bit symbols that correspond to a sequence of 155 *Reed-Solomon*-encoded bits, which in turn correspond to a 75-bit data word to which 80 bits have been added for error detection and correction.

Combat Override
All *interference protection features* are overridden. This should be used only when continued operation is imperative - in spite of a known IPF failure, and realizing that navigation systems will probably be jammed.

Command and Control (C2) Unit
A platform equipped to direct the activities of other Link 16 units (JUs) over Link 16.

Common Track Number (CTN)
The track number held by all *Interface Units* for a contact and used in voice and other communications to identify it.

Common variable mode
A Link 16 communications security (COMSEC) mode in which identical cryptovariable logical labels are assigned to *message security* (MSEC) and *transmission security* (TSEC).

Communication mode
A setting on the Link 16 terminal that controls the degree of *message security* (MSEC) and *transmission security* (TSEC) employed. This can include slot usage and whether *frequency hopping* is employed. Three communication modes are recognized by NATO and the United States Armed Services.

Concurrent Interface Unit (CIU)
A unit participating concurrently, but not as a *forwarding unit*, on both Link 11 and Link 16.

Concurrent Operations (CONCOPS) Operations by a single unit on both Link 16 and Link 11 at the same time. The unit so operating does not forward data.

Conditional relay A *relay* mode in which Link 16 units (JUs) selectively activate or deactivate their relay function based on which JU can provide most efficient coverage.

Contention access The assignment of *time slots* to a group of units for transmission purposes, such that any or all of the units may be transmitting simultaneously during the assigned time slots. However, each JU will transmit at a specified rate in the time slot block by selecting time slots for transmission pseudorandomly. Receipt is determined based on proximity of the transmitting unit.

Continuation word The final portion of a *fixed format* message. It contains 70 data bits, 4 parity bits, and 1 spare bit.

Continuous phase-shift modulation (CPSM) The process of modulating the frequency of a carrier in such a way that the phase remains continuous.

Controlled (nonC2) unit A platform equipped to accept the direction of its activities over Link 16 by a *command and control* (C2) JU.

Cryptonet (Crypto Isolated) A communications net whose participants are isolated from other participants by the use of a separate encryption key.

Cryptoperiod designator (CPD) A number, either 0 or 1, which designates to a Link 16 terminal which *cryptovariable* of a today/tomorrow pair to use when encrypting and decrypting Link 16 transmissions.

Cryptovariable (CV) A binary key used by the Link 16 terminal to encrypt and decrypt data or transmissions. *Cryptovariables* are assigned during network design and are loaded into the *Secure Data Unit* during terminal initialization.

Cryptovariable logic label (CVLL) A label that applies to a *cryptovariable* in a Link 16 network. The CVLL is a number between 0 and 127.

Current CPD Current cryptoperiod designation for any day is either 0 or 1. It is established on the date in which the terminal is initialized.

Cyclic code shift keying (CCSK) A method of encoding and decoding data using a class of codes that is particularly effective in detecting and correcting multiple errors. For Link 16, cyclic code shift keying is applied to a five-bit symbol to produce a 32-bit *chipping sequence* by shifting leftward the bits of a 32-bit starting sequence number by a number of places that corresponds to the numerical value of the symbol.

Data Field identifier (DFI) A category of data whose specification includes one or more *Data Use Identifier* (DUI) specifications. Each DUI's class of data must fall within the bounds of the DFI category.

Data filter A technique for including or excluding data of certain types for transmission and/or reception.

Data forwarding The process of receiving data on one digital data link and outputting the data, using the proper format and link protocols, to another type of digital data link. In the process, a message received on one link is translated to an appropriate message on another link. Data forwarding is accomplished by the selected forwarding units simultaneously participating on more than one type of data link. The data that is forwarded is based on the data received and is not dependent upon the local system data of the data forwarding unit or its implementation of the received message or the forwarded message. CRCs and Navy ships can be utilized as data forwarders.

Data Link Reference Point (DLRP) A fixed geographic reference point, specified by appropriate authority, from which Link 11 participating units calculate the relative positions of own unit and local tracks, and from which all tracks are reported over this link. The DLRP is the origin of the force X/Y-grid.

Data Mile A unit of distance used in tactical data link messages that is equal to 6000 feet.

Data silence A setting on the Link 16 terminal that inhibits the transmission of data. Voice and TACAN transmissions, however, remain enabled. A Link 16 unit (JU) functioning in data silence becomes a Secondary User on the Link 16 network.

Data transfer blocks A message structure defined for the exchange of information between the Link 16 terminal'sterminal's *Subscriber Interface Computer Program* (SICP) and its *Network Interface Computer Program* (NICP).

Data Use Identifieruse identifier (DUI) — A JTIDS data element (class of data). The DUI specification determines the name and permitted contents of each message field to which the DUI is assigned. (See DFI, above.)

Dedicated access — The assignment of *time slots* to a uniquely identified unit for transmission purposes, such that only that unit transmits during the assigned time slots.

Distance measuring equipment (DME) — A civilian system of navigation, used for measuring distance, which consists of an airborne interrogator and a ground transponder.

Donated time slot — A *time slot*, assigned to a particular Link 16 unit (JU), which the unit temporarily donates to the receiver of a message that requires an automatic acknowledgement, and during which the receiving JU transmits its required response.

Double buffering — Alternately switching back and forth between two buffers.

Double-pulse — A Link 16 transmission format for redundantly conveying message data, employing two *pulse symbol packets* that are transmitted on two different carrier frequencies.

Drop Track Report — Manually dropping any local track (J7.0) when it can be no longer be supported or is no longer of interest.

Effective earth radius — A modification to the radius of the earth that allows the propagation path of radio waves uniformly bent by the atmosphere to be treated as though it were straight-line propagation. The ratio of the effective earth radius to the true earth radius, which is denoted by K, can range between 0.6 and 5.0. In temperate climates, its average value is approximately 1.33.

Electronic Warfare (EW) — (1) Generally, the use of radiated electromagnetic energy to passively establish the location, course, and speed of another platform. (2) The Link 16 Network Participation Group (NPG 10) that supports these functions by conveying orders and parametric data.

Engagement Coordination — NPG that is used solely by the U.S. Army for inter-Army coordination of engagements by Patriot and THAAD units.

Emergency Report — Alert that indicates the existence of a life-threatening condition that requires immediate action or assistance.

Epoch
The period of longest duration in the *time division multiple access* (TDMA) structure of the Link 16 architecture. A single day consists of 112.5 epochs. One epoch occupies 12.8 minutes. Epochs are subdivided into 64 *frames* and three *sets* of *time slots*. An epoch contains 98,304 time slots, which are its smallest division of time.

Error correction encoding
The JTIDS forward error correction encoding function that utilizes *Reed-Solomon encoding* of data.

Error detection encoding
An encoding process that allows the detection of a residual message error condition after the error correction function *(Reed-Solomon)* is executed.

Exercise Status Order
Directs all IUs to cease reporting tracks as Exercise tracks.

Extended range
The longer of two range options for a Link 16 Terminal, providing a line-of-sight range capability of 0-500 nautical miles with respect to the allocated propagation for message transmission.

Extension word
The second portion of a *fixed format* message. It contains 70 data bits, 4 parity bits, and 1 spare bit.

Fighter-to-Fighter Target Sorting
A *Network Participation Group* (NPG 19) used by *nonC2* units, such as fighter aircraft, to exchange radar, sensor, and target data.

Fighter Data Link (FDL)
Term used when referring to the Link 16 terminals employed by F15s. It is a member of the Multifunctional Information Distribution System (MIDS) family of Low Volume Terminals (LVTs), specifically LVT-3.

Fine synchronization
Part of a procedure for entering a Link 16 network, during which a Link 16 unit (JU) adjusts its internal clock to correct for propagation time. Fine synchronization must be achieved in order to participate on the network. A Link 16 terminal may employ either *active synchronization* or *passive synchronization* to achieve this state.

Fixed format
A Link 16 *message format* consisting of multiple words, each containing 70 data bits, 4 parity bits, and 1 spare bit. Fixed format messages consist of an initial word, and may be followed by one or more extension words, and one or more continuation words.

Flood relay
A network design strategy in which every Link 16 unit (JU), including the originator, acts as a *relay* by retransmitting messages that it receives.

Force Tell Reports
Alert that indicates that a condition exists which, although it does not meet the criteria for an Emergency Alert, is sufficiently important to ensure that all C2 IUs are aware of the track's presence.

Forwarding JTIDS Unit (FJU)
A network role assigned to a Link 16 unit (JU) that will forward data between tactical data links during a multilink operation. An FJU that translates and forwards data between *Interface Units* (IUs) using J-series and M-series messages. An FJU is either an FJUA (TDL A), FJUB (TDL B), or FJUAB.

Frame
A period of time in the Link 16 *time division multiple access* (TDMA) architecture equal to one sixty-fourth of one epoch. A frame is 12 seconds in duration and contains 1,536 time slots.

Free Text
A type of Link 16 message structure that uses all bits for data. A bit-oriented message whose information bits may be used to represent digitized voice, teletype, and other forms of Free Text information.

Frequency
The number of cycles a wave completes during one second.

Frequency hopping
A transmission technique in which the carrier frequency is changed for each pulse of a pulsed signal. For Link 16, 51 different frequencies are used, and the duration of each pulse is 6.4-microseconds. The pseudorandom assignment of frequency establishes a hopping pattern and is part of the transmission encryption process.

Frequency modulation (FM)
The transmission technique that modulates or shifts the carrier frequency of the signal to convey information.

Frequency shift keying
A method of encoding data by shifting a carrier frequency between two predetermined values.

Functional input messages (FIMs)
Messages that transfer data from a host computer to the MIDS terminal over a specified multiplex data bus to the host computer.

Functional output messages (FOMs)
Messages that transfer data over a specified multiplex data bus from the MIDS terminal to a host computer.

Geodetic grid
An earth-based coordinate system used by Link 16 units (JUs) to report positions by specifying latitude, longitude, and altitude. The geodetic grid is always active.

Geodetic Position Quality (Q_{pg})
A measure of the quality of a Link 16 terminals' geodetic position reported in the terminal's Position and Status Reports. Geodetic Position Quality is reported as an integer from 0-15, where the higher numbers correspond to the higher qualities.

Gigahertz (GHz)
A measure of frequency equal to a billion hertz.

Global memory
An area in the Link 16 terminal's memory that is reserved for the sharing and exchange of information among the multiple processors within the terminal.

Handover
A procedure for passing the control of an aircraft from one controller to another.

Header
The leading bits of each message are coded as a (16, 7) *Reed-Solomon codeword* that provides 35 bits of information and 45 bits of associated forward error correction code.

Hertz
A unit used to measure frequency. One hertz equals one vibration, or cycle, per second.

High TN block
A block of contiguous, assignable Link 16 track numbers, including the octal track numbers 10000 through 77777 and the alphanumeric track numbers 0A000 through ZZ777. No track numbers in this block correspond to Link 11 track numbers.

Housekeeping words
Blocks of information that are exchanged, in either direction, between the JTIDS terminal's Subscriber Interface Computer Program (SICP) and its Network Interface Computer Program (NICP). Their primary purpose is to convey information required for the encryption and decryption of the signal.

Identification Friend or Foe (IFF)
An interrogator, which can be either ground-based (with the Air Traffic Control Radar Beacon System) or airborne, that transmits pulses and receives replies containing the responding aircraft's identity, altitude, and other essential information.

Imagery
Network Participation Group 11, for image files.

Indirect Precise Participant Location and Identification (Indirect PPLI)
The *Network Participation Group* (NPG 14) on which USN Forwarding Link 16 units (FJUs) transmit to other Link 16 units (JUs) the Precise Participant Location and Identification messages of units not participating on the Link 16 network.

Initial Entry The procedure by which a subscriber terminal becomes a system participant initially and may achieve *coarse synchronization* with system time. Initial Entry is also one of the *Network Participation Groups* (NPG 1).

Initial Entry JTIDS Unit (IEJU) A Link 16 unit (JU) that transmits *Initial Entry messages* for the purpose of assisting other units in achieving synchronization with, and entry into, a Link 16 network.

Initial Entry message A Link 16 message transmitted by a Link 16 unit (JU) to facilitate the entry of other units into the Link 16 network.

Initial word The first portion of a *fixed format* message. It contains 70 data bits, 4 parity bits, and 1 spare bit.

Interface Unit (IU) A JU on Link 16, Participating Unit (PU) on — Link 11, or Reporting Unit (RU) on — Link 11B, which is communicating directly or indirectly on the interface.

Intelligence The product resulting from the collection, processing, integration, analysis, evaluation, and interpretation of available information concerning foreign countries or areas, or forces of tactical interest, gained by means other than radar, sonar, or electronic support measures (ESM).

Interference Protection Feature (IPF) An automatic function of the Link 16 terminal that monitors its own transmissions and disables the terminal whenever it detects that they are in any way improper. Three settings of IPF are available on the terminal: normal, exercise, and *combat override*.

Interim JTIDS Message Specification (IJMS) messages An early implementation of messages exchanged between the Class-1 JTIDS terminals. The Air Force Class 2 terminals retain both an IJMS and JTIDS message capability, and can translate between them. NPGs 30 and 31 are provided for the exchange of IJMS messages.

Interleave To arrange in an alternating sequence or order. Time slots of the three sets (— A, B, and C) — are interleaved, as are the transmission symbols of the message and data codewords.

Jamming The process of obstructing, or rendering unintelligible, a transmitted message by sending out interfering signals or messages.

Jitter The first portion of the *time slot*, during which the transmitter is silent. Jitter may be either applied or not applied within a time slot and when applied, it may be of varying duration. Its purpose is to render the actual start time of the data transmission impossible to predict.

Joint Precise Participant Location and Identification
A *Network Participation Group* (NPG 27) in which identification and location information is exchanged during Joint operations.

Joint Tactical Information Distribution System (JTIDS)
(1) The method, hardware, and software by which tactical information is disseminated over Link 16. (2) Commonly, the JTIDS terminal, which modulates, transmits, receives, and demodulates messages for a participant in a Link 16 network.

JTIDS net
One of 127 time division structures comprising a Link 16 network. Each net consists of a continuous stream of time intervals *(time slots)* with 98,304 times slots per 12.8-minute epoch, during which digital data whose signal characteristics are determined by a cryptographic variable in conjunction with a unique net number are distributed.

JTIDS Unit (JU)
A platform equipped to participate in Link 16 communications. A JU is either a *Command and Control* (C2) unit or a controlled *(nonC2)* unit. JTIDS Unit (JU) is synonymous with Link 16 unit.

J-series message
The fixed format messages, containing tactical data and commands, which are used to exchange information over Link 16. These messages adhere to the standards defined in MIL-STD-6016C, Change 1.6016B.

Kilohertz (kHz)
A measure of frequency equal to 1,000 hertz.

Lx Band
A portion of the RF UHF band stretching from 390 MHz to 1.550 GHz. Link 16 operates within this band on frequencies between 960 and 1216 MHz.

Line of sight (LOS)
The direct line in which radio waves travel, without bending over mountains or the curvature of the earth.

Link 11
The tactical digital data link protocol, formerly known as TADIL A, specified by MIL-STD-6011, for communications among a multiple number of units. Its netted communications are characterized by a round-robin, designated Roll Call, in which every participant reports in turn when requested to do so by one unit, designated the Net Control Station. The messages exchanged over Link 11, known as M-series messages, adhere to the Link 11 message standard.

Link 11B
The tactical digital data link protocol, formerly known as TADIL B, specified by MIL-STD-6011, for point-to-point communication over landline between two units. The messages over Link 11B, known as M-series messages, adhere to the Link 11 message standard.

Link 16
The secure, jam-resistant, high-capacity, nodeless tactical digital data link, formerly known as TADIL J, which utilizes the JTIDS/MIDS terminal and its *time division multiple access* (TDMA) architecture for multinetted communications. The information exchanged on this link is conveyed in the J-series messages, which conform to the operational specifications contained in MIL-STD-6016 Series.

Link 16 network
The Link 16 structure (usable only with Mode 1 communications) having a total usable capacity of 98,304 *time slots* per *epoch*, per *net*, with a maximum number of nets being 127. All nets are synchronized so that each time slot of each net is time-coincident with the corresponding time slot (same net and number) of every other net.

Link 22
The tactical digital data link protocol specified for netted communications among multiple nets, each consisting of multiple numbers of units. Its TDL-J-series messages use the Link 16 data dictionary. Commonly referred to as NATO Improved Link Eleven, or NILE.

Long-Term Transmit Inhibit (LTTI)
A setting on the Link 16 terminal that inhibits all radio transmissions, including voice and TACAN as well as data.

Low probability of intercept (LPI)
A characteristic of the *frequency-hopping* technique that makes the Link-16 signal extremely difficult to locate.

Low TN block
The block of assignable Link 16 track numbers that range from 0 to 07776. The track numbers in this block correspond to all Link 11 assignable track numbers.

M-series messages
Messages transmitted over Link 11 and Link 11B between participating units.

Machine receipt (MR)
A Link 16 message, automatically transmitted by a Link 16 terminal, which acknowledges the receipt of certain types of other messages.

Main net
The default net in a network design on which housekeeping and overhead functions are preformed.

Megahertz (MHz)
A measure of frequency equal to 1 million hertz.

Message formats
For a given tactical data link, the set of sequences of fields, composed of prescribed numbers of bits, that may be encoded into prescribed sets of values to convey specific information. The values of their prescribed data items are supplied in the message specification for the given tactical data link.

Message header
That portion of a Link 16 message, consisting of a single codeword, that specifies the format of the message data, whether the data is encoded, which *packing structure* has been used for its transmission, the *Secure Data Unit* serial number, and the track number of the Link 16 terminal that originated the message.

Message security (MSEC)
A cryptovariable that is used by a Link 16 unit (JU) to encrypt message data for transmission on Link 16.

Message standard
A set of protocols consisting of rules, procedures, formats, data element definitions, or other conventions for information exchange and related interactions agreed upon between cooperating systems to ensure interoperability.

Microsecond (μs)
One one-millionth of a second.

Millisecond (ms)
One one-thousandth of a second.

Mission Management
The *Network Participation Group* (NPG 8) that provides a means for coordinating weapons and engagements for the Battle Group.

Mode 1 communication
Mode 1 Link 16 transmissions consist of a sequence of wide-band transmission symbol packets (*single-pulse*, 13-microsecond packets and *double-pulse*, 26-microsecond packets), the pulses of which are formed by *continuous phase shift modulation* (CPSM) of the carrier frequency. The signal processing required to transform baseband data to the JTIDS waveforms for transmission includes baseband data encryption, forward error correction encoding, error detection encoding, *cyclic code shift keying* (CCSK) encoding, data symbol *interleaving*, and the selection of a variable start time.

Mode 2 communication
Mode 2 Link 16 transmissions are identical to Mode 1, except that Mode 2 operates in the narrow-band mode.

Mode 4 communication
Mode 4 Link 16 transmissions have waveform characteristics identical to Mode 2, except that Mode 4 does not employ baseband data encryption signal processing.

Multifunctional Information Distribution System (MIDS)
A terminal that modulates, transmits, receives, and demodulates messages for a participation in a Link 16 network. Its predecessor is the Joint Tactical Information Distribution System (JTIDS) terminal.

Multiplex (MUX) cycle
Exchange of input and output messages that takes place cyclically.

MUX data transfer complete interrupt (MDTCI)
An interrupt triggered by the host, notifying the terminal that it has finished reading data from the terminal.

Nautical mile (nm)
A unit of distance used in air and sea navigation based on the length of a minute of arc of a great circle of the earth. The unit used by the U.S. is equal to 6076.115 feet, or approximately 1.15 statute miles.

Navigation Controller (NC)
A *network role*, assigned to a mobile unit that acts as the reference unit for the grid. The NC establishes the origin and north orientation of the U, V relative grid for the *Relative Navigation* function. By definition, the NC's Position Quality is 15 and its Azimuth Quality is 7, the maximum values.

Net
A group of participants exchanging messages among themselves. For Link-16, this is one of the 127 possible net numbers. (0-126).

Needline Participation Group
A functional grouping of Link 16 message formats that supports a particular type of messages used by the United States Army. Needline participation groups constitute a subclass of *Network Participation Groups*. Netted subscribers compiled without regard to the specific messages they exchange with each other.

Net Entry Control Terminal (NECT)
A *network role* that propagates the system time to units beyond line of sight of the *Network Time Reference* by transmitting the *Initial Entry message* in *time slot* A-0-6. By definition, an NECT is not a Network Time Reference (NTR). Also called *Initial Entry JTIDS Unit* (IEJU).

Network Interface Computer Program (NICP)
A software program, residing within the Link 16 terminal, which has overall responsibility for communications with the RF network.

Network Management
The *Network Participation Group* (NPG 4) during which commands are transmitted for managing the operation of a particular Link 16 network.

Network Management messages
The messages transmitted in *Network Participation Group* (NPG 4), consisting of commands that are transmitted for managing the operation of a particular Link-16 network.

Network Participation Group (NPG)
A unique list of applicable messages used to support an agreed-upon technical function without regard to subscriber identities. This list is a means of transmitting a common set of messages to all interested users.

Network role
A function assigned, on the basis of platform capabilities and expected platform position, to a *command and control* (C2) Link 16 unit (JU), either by initialization or by operator entry. Network roles support network synchronization, navigation, and interlink operations.

Network Time Reference (NTR)
A *network role* assigned uniquely to a single *command and control* (C2) unit. The NTR's clock establishes the timing for the network and is the reference with which all other units must achieve and maintain fine synchronization to remain in the network. By definition, the NTR's Time Quality is 15, the maximum value.

Normal mode
The standard mode of terminal operations with respect to receipt and transmission of messages.

Normal range
The shorter of two range options for a Link 16 terminal, providing a line-of-sight coverage capability of 0-300 nautical miles with respect to the allocated propagation for message transmission.

No Statement word
A data word (J31.7I) supplied by the Link 16 terminal when there is an insufficient number of words that are required to complete a message packing format for transmission.

OPTASK LINK
That portion of the Operation Tasking Order that applies to tactical data link communications involving participating platforms.

Over-the-Air Rekeying (OTAR)
Allows a function controlled by a C2 unit that manages terminal rekeying over the air J-Messages.

Passive synchronization
A secondary method of net entry, employed by Link 16 units (JUs) in radio silence, during which fine synchronization is achieved and maintained by passively monitoring the messages on the Precise Participant Location and Identification Network Participation Groups.

Packing structure
The grouping of Link 16 message words, of any format, into a Link 16 transmission. These groups can contain 3 words, 6 words, or 12 words.

Packed-2 format
A message consisting of six words that may be transmitted redundantly within a single *time slot*. Nonredundant transmission is referred to as Packed-2 *Single-Pulse* (P2SP) format, and redundant transmission is referred to as Packed-2 *Double-Pulse* (P2DP) format.

Packed-4 format A message consisting of 12 words that are transmitted within a single *time slot*. Its nonredundant transmission is also referred to as Packed-4 *Single-Pulse* (P4SP) format.

Paired slot relay A type of *relay* in which the time slot of the original transmission is paired with a second time slot after a specified delay for the retransmission of the message by the relaying unit.

Parallel interface A computer interface in which multiple bits are transferred in parallel, at the same time, along separate lines.

Parametric data For electronic warfare (EW), the unprocessed data that is collected by sensors, which includes lines of bearing, pulse width, pulse repetition frequency, antenna scan period, etc. A *Network Participation Group* (NPG 10) is reserved for the transmission of this parametric data before it is evaluated by a tactical data system.

Partitioned variable mode A Link 16 communications security (COMSEC) mode in which different *cryptovariable logic labels* are assigned to *message security* (MSEC) and *transmission security* (TSEC).

Phase-coherent binary frequency shift keying The application of two frequencies whose periods differ by precisely one-half wavelength during a specified interval to a carrier, such that the higher frequency represents one value or condition and the lower frequency represents its opposite. For Link 16, the difference in frequencies represents a change in the value of contiguous constituents of chipping sequences, rather than the absolute value of any constituent. The higher frequency is applied whenever a constituent differs from the previous constituent, and the lower value is applied whenever they are identical. For Link 16, the period over which the requisite frequencies are maintained is precisely 200 nanoseconds.

P-messages A designation for *Interim JTIDS Message Specification* (IJMS) Position and Status messages transmitted on the *Network Participation Group* (NPG 30) reserved for this purpose.

Platform Status Messages The J13.x messages, which provide additional unit information. These are periodically transmitted in the unit's PPLI time slot.

Pool One or more time slot blocks that can be used to satisfy a particular functional requirement, or the total JTIDS capacity that can be divided into pools to satisfy all functional requirements.

Position Quality (Q_p) A value between 0 and 15 that indicates the accuracy with which a Link 16 unit (JU) fixes its own position. Two Position Qualities are maintained: the *Geodetic Position Quality* (Q_{pg}) and the Relative Position Quality (Q_{pr}). When the geodetic grid is operational, the maximum value is assigned to JUs acting as *Position References*. When the relative grid is operational, the maximum value is assigned to the JU acting as *Navigation Controller*. The maximum value, 15, indicates a positional accuracy of within 50 feet.

Position Reference (PR) A network role that is always assigned to a well-surveyed, stationary site whose *Position Quality* is 15, the maximum value. This role is not required and may not be assigned in every network.

Positive identification The means of identifying a Link 16 unit (JU), during *Network Participation Groups* dedicated to *Precise Position Location and Identification* information, which consists of a unique JU number, Identification Friend or Foe (IFF) codes, platform type, and information on the platform's movement and link activity.

Precise Participant Location and Identification (PPLI) Two *Network Participation Groups* (NPG 5 and 6) during which Link 16 units (JUs) transmit their precise location, identification, fuel and weapons status, and communications data. Controlling units use NPG 6, PPLI and Status, Pool B; controlled units such as fighter aircraft use NPG 5, PPLI and Status, Pool A, to transmit more rapid position updates.

Primary User (PRU) A network role assigned to every Link 16 unit (JU) that is actively maintaining synchronization with its Link 16 network. The *Network Time Reference*, as the unit that establishes the timing of the network, does not need to maintain synchronization and is therefore not considered a primary user.

Propagation The fifth and final portion of the *time slot*, during which no pulses are transmitted and the signal is allowed to propagate.

Pseudorandom noise A 32-bit sequence which, when exclusively OR'd bitwise with a 32-bit *chipping sequence*, produces another 32-chip sequence, the *transmission symbol*. The 32-chip pseudorandom noise sequence, which is determined by the *transmission security* (TSEC) cryptovariable, changes continuously.

Pulse symbol packet A 13-microsecond transmission period within the time slot. A single -pulse symbol packet consists of a 6.4-microsecond pulse of modulated carrier frequency followed by 6.6 microseconds of dead time. A double-pulse symbol packet, which consists of two single-pulse symbol packets, is 26 microseconds in duration.

Radio horizon — The distance to the horizon, as defined by the slightly curved path followed by a radio wave. This distance can be determined from the *effective earth radius*.

Receipt/Compliance (R/C) — The protocol by which certain messages are acknowledged and responded to by the machine and, in some cases, by the operator. For Link 16, the machine receipt function is performed automatically by the Link 16 terminal.

Recurrence rate — The total number of *time slots* per *epoch* assigned or deleted in a single time block assignment, specified as an integer, R, whose values range from = 0 to 15.

Reed-Solomon (R-S) encoding — The scheme employed for encoding Link 16 message data that consists of the addition of error detection and correction bits to 75-bit words to form 155-bit sequences, which are then taken, in groups of five, to create 31 symbols.

R-S codeword — An R-S encoded data word consist of 31, 5-bit *transmission symbols*.

Relative grid — A three-coordinate flat-plane system used by Link 16 units (JUs) to report their position from the relative grid origin. The relative grid is active when there is a grid origin provided by the *Navigation Controller* (NC).

Relative grid origin — The origin, calculated by the network's *Navigation Controller* (NC), which inherently includes the NC's own geodetic navigation errors.

Relative navigation (RELNAV) — An automatic and constant function of the Link 16 terminal, used for synchronizing all platforms in the network and for determining the distance between platforms.

Relay — A *network role* assigned to a Link 16 unit. Messages received within designated *time slots* are retransmitted after a specified delay. The retransmission of messages by airborne relay platforms allows information to be propagated to other units that are not within *line of sight* of the original transmitters.

Relay delay — A fixed offset, from 6 to 31 time slots, between the time slot during which a Link 16 message is originally transmitted and the time slot during which it is retransmitted by a relaying unit.

Relay function — A JTIDS/MIDS terminal capability.

Relay pair — The first and *relay*-repeated transmissions of a single message.

Relay hops — The retransmissions required to extend Link 16 connectivity beyond *line of sight*.

Reporting responsibility (R2) — The requirement for the IU with the best positional data on a track to transmit track data on the interface. Automatic procedures exist to limit the number of units reporting a particular radar contact, or track, to a single unit. This determination is based on track qualities, and the unit designated as having responsibility for reporting the track is said to have R2.

Repromulgated relay — A *relay* technique, used by the U. S. Army, in which any suitably initialized receiver will relay a transmitted message during the next *time slot*.

Residual Message NPG — A *Network Participation Group* (NPG 29) in which messages not specifically assigned to other NPGs may be exchanged.

Round-trip timing (RTT) — The process used by a Link 16 terminal to directly determine the offset between its clock and that of another Link 16 terminal. This is used to achieve and maintain fine synchronization and to improve the terminal's time quality. This process involves the exchange of RTT Interrogation and Reply messages.

Round-trip Timing (RTT) message — One of a set of messages that support fine synchronization between the units of a Link 16 network. They are both sent and received during a single *time slot* by an individual Link 16 unit (JU): the interrogation is sent, and the reply is received.

RTT-A (NPG 2) — By definition, the *Network Participation Group* during which specifically addressed *Round-Trip Timing messages* are transmitted during *time slots* that are dedicated to particular Link 16 units (JUs).

RTT-B (NPG 3) — By definition, the *Network Participation Group* during which *Round-Trip Timing messages* are transmitted during *time slots* that are shared among units and which are accessed by contention.

Secondary Navigation Controller (SNC) — A *network role*, assigned when a relative grid is to be used by units of a Link 16 network, to a single unit that can be either stationary or mobile, but which must be in relative motion with respect to the *Navigation Controller*, and must be in synchronization and *line of sight* of it.

Secondary User (SU) — A *network role* taken by any Link 16 unit (JU) that enters a Link 16 network under restricted conditions, during which they remain either radio silent or *data silent*.

Serial interface A computer interface in which single bits are transferred serially, one after the other, along one line.

Serial J Legacy point-to-point (as opposed to netted) communications protocols that use J-series messages.

Set In Link 16 *time division multiple access* (TDMA) architecture, one-third the total number of *time slots* in one *epoch*. The three sets of time slots are designated Set A, Set B, and Set C. The epoch consists of the interleaved time slots of these three sets.

Selective Identification Feature (SIF) A capability that, when added to the basic *Identification Friend or Foe* (IFF) system, provides the means to transmit, receive, and display selected coded replies which uniquely identify a platform.

SIMPLE Standard Interface for Multiple Platform Link Evaluation, a data link exchange protocol.

Single pulse A Link 16 transmission format employing one pulse symbol packet to convey messages.

Socket J An unofficial term used to characterize the moving of compatible data over a TCP/IP network.

Spread spectrum A modulation/demodulation technique in which the transmission bandwidth is much greater than the minimum bandwidth that would be required to transmit the digital information, and which results in a performance improvement. In Link 16, five bits of digital information are transmitted with each pulse by associating each 5-bit message with a different phase of the 32-bit direct-sequence spreading code.

Stacked nets The principle of Link 16 TDMA architecture by which the time slots of a single NPG may be simultaneously allocated to 127 different nets, transmitting on different frequency-hopping patterns. The Voice and the Air Control NPGs are the most common examples of stacked nets..

Standard (STD) format A transmission format consisting of three words that are transmitted A message consisting of three words that are transmitted redundantly within a single time slot. Because messages of this format are always transmitted with the double-pulse structure, it is sometimes referred to as Standard Double-Pulse (STD-DP) format.

Strength Change Report The J7.0 Act. (5) message. Note that Strength Changes are not performed by the CDO.

Statute mile — A unit of distance that is equal to 5,280 feet.

Subscriber Interface Computer Program (SICP) — A computer program, residing within the JTIDS terminal, which has overall responsibility for communicating with the host platform.

Surveillance — The process of searching for, detecting, locating, identifying, and tracking objects of interest to the force. Surveillance information is exchanged on *Network Participation Group* (NPG 7).

Suspended relay — A *relay* function of a terminal in suspend mode.

System time — The time maintained by a designated terminal, the *Network Time Reference* (NTR).

Symbol — A single element of a codeword that corresponds to five Reed-Solomon encoded bits of a 155-bit sequence. This sequence represents a 75-bit data word, to which 80 bits have been added for error detection and correction.

Symbol interleaving — The intermixing of the *symbols* that constitute the header and data of the message. Its purpose is to render the positions of elements of the message header unpredictable, thus greatly decreasing the possibility that the message transmission can be intercepted, exploited, or jammed.

Synchronization — (1) The acquisition and maintenance of system time by any member of a Link 16 network. (2) The second portion of the time slot, during which a specific sequence of symbols is transmitted.

Tactical Air Navigation (TACAN) — A military navigation system that combines distance and direction measurement to military aircraft, which are specially equipped to reference them.

Terminal input messages (TIMs) — Messages that transfer data from a host computer to the JTIDS terminal over the MIL-STD-1553B multiplex data bus

Terminal output messages (TOMs) — Messages that transfer data over the MIL-STD-1553B multiplex data bus from the JTIDS terminal to a host computer.

Time Division Multiple Access (TDMA) — The architectural principle by which Link 16 networks are structured and periods of transmission are assigned to every unit.

Time Quality (Q_t) The measure, kept by every Link 16 unit (JU), of its accuracy with respect to a designated *Network Time Reference*. Time Quality (Q_t) is expressed as an integer from 0 to 15 that represents the number of nanoseconds' deviation about the standard reference. The maximum Q_t value is 15, which represents a deviation less than or equal to 50 nanoseconds.

Time refinement The third portion of the time slot, during which four double-pulse starting sequence number (S0) symbols are transmitted over 104 microseconds.

Time slice For the Link 16 *time division multiple access* (TDMA) architecture, the designation for a single *time slot* that occurs during the identical period of time for all 127 stacked nets.

Time slot The allocated period of time during which a netted unit contributes its information over a tactical data link. Also, the period of shortest duration of which the Link 16 TDMA architecture is structured. The time slot is the basic window of access to the network and is the period during which a Link 16 unit (JU) is either transmitting or receiving. The duration of the Link 16 time slot is 7.8125 milliseconds.

Time slot block (TSB) A collection of time slots spaced uniformly in time over each *epoch* and belonging to a single time slot *set*. A block is defined by indexing time slot number (0 - 32,767), set (A, B, or C), and a *recurrence rate* number (0-15).

Time slot duty factor (TSDF) A restriction that limits the usage of time slots to a number of pulses per unit of time.

Time slot reallocation An access method that establishes a pool of *time slots*, which are periodically reassigned among the participants of a *Network Participation Group* (NPG), based on their transmission needs.

Time slot reuse The practice of assigning two or more Link 16 units (JUs) to transmit on the same net during the same time slot.

Time synchronization messages The J0.0 (Initial Entry) and J0.2 (Network Time Update) messages.).

Time Uncertainty setting An Link 16 operator setting that tells the terminal how many seconds of uncertainty to use in listening for the *Network Time Reference* unit's *Initial Entry message* to achieve *coarse synchronization*.

T-messages — A designation for *Interim JTIDS Message Specification* (IJMS) messages, except for IJMS Position and Status messages, that are transmitted on the *Network Participation Group* (NPG 31) reserved for this purpose.

Today/tomorrow pair — A schedule for the use of *cryptovariable* pairs loaded into the *Secure Data Unit* that allows the network to roll over *cryptovariables* from one day to the next without disruption to the link.

Track number (TN) — A number, applied to a located object, which is used to associate information and directives for digital communication over Link 16.

Track number association — The process of assigning, and consistently using, a low track number for tracks that were originated on Link 16 with a high track number and are being forwarded to Link 11.

Transmission security (TSEC) — A *cryptovariable* that is used by a Link 16 unit (JU) to determine the duration of jitter within the time slot, as well as the *pseudorandom noise* with which the received transmission was masked by the transmitter.

Transmission symbol — A 32-bit sequence that results from the bitwise exclusive-or operation of a 32-bit sequence of *pseudorandom noise* and a 32-bit *chipping sequence* of data.

Unconditional relay — A *relay* mode in which a Link 16 unit (JU) in *fine synchronization* with the network and not in Long-Term Transmit Inhibit (radio silence) always relays messages in accordance with its *time slot* assignments.

Upper packing limit — An initialization parameter of the Link 16 terminal that constrains its transmissions to a subset of the full range of possible *packing structures*. Its purpose is to establish the minimum amount of *antijam margin* always retained.

Variable format — A Link 16 message format that supports the U. S. Army's Link 16 communications requirements, and which consists of a variable number of 75-bit words.

VHF omnidirectional range (VOR) — A transmitter that is used by aircraft for measuring range. It can be co-located with *Distance Measuring Equipment* for providing aircraft with both range and distance.

Voice A, Voice B — The two channels, *Network Participation Groups* 12 and 13, respectively, that are used by Link 16 units (JUs) for secure digitized voice transmissions.

VORTAC (1) A transmitter that combines the functions of a military *TACAN* system and a civilian *VOR* to provide VOR azimuth, TACAN azimuth, and TACAN distance to an airborne interrogator.

Weapons Coordination The *Network Participation Group* (NPG 18) during which commands are transmitted for employing tactical weapons.

Word For Link 16, a sequence of 75 bits, 70 of which are tactical data and 5 of which are for parity. Data words are Reed-Solomon encoded with the (31, 15) algorithm, in which 15 bits are transformed into coded 31 bits.

Zoom relay A *relay* type in which selected portions of the *main net* are designated for relay on another net.

U.S. AIR FORCE

Don’t let Link 16 pass you by!

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552nd Air Control Wing (ACW) 6-7

653rd Electronic Systems Group 7-32

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ADSI®. *See* Air Defense Systems Integrator

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