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TACTICAL DATA LINK – FROM LINK 1 TO LINK 22

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Abstract: *Tactical data links (TDL) are elements of C4ISR system, which provide a continuous data exchange in (nearly) real time about space, ground, air, surface and subsurface platforms including allied, neutral and foe units data. The main scope of TDL is to provide the operation monitoring capability (for commander) and to send particular commands and data (for subordinates), being one of the basic components of network centric warfare concept implementation. A TDL uses data link standards in order to provide communication via radio waves or cable to transmit, relay and receive tactical encrypted data. This paper aims to outline a comparison between the main TDL standards and their capabilities.*

Key words*: tactical data link, Link 1, Link 11, Link 16, Link 22*

1. Introduction

There is an unprecedented rise in the data and information volume needed for planning, decision-making and commanding military actions. The information about targets, troops' movement and their condition, supply levels and availability of resources – for all belligerent parties (our own, the allied and the opponent's) – must be supplied to the joint commandment and its forces, considering that it is obtained from geographically dispersed equipments. Thus, it is necessary that information to be delivered to commanders in time, at the right location and in the required form, in order for them to make decisions (in command and control processes) in near-real time, during military action deployment by the joint forces.

The "data link" term refers to all technologies, applications and messages package used in the communication system. The military "tactical data link" term represents the data links used as support in military actions. Known data links were designed according to specific standards such as Link 1, Link 4, Link 11, Link 14, Link 16 or Link 22. Each of them has been developed for specific military communication requirements. Some of them are obsolete, but still in use (e.g. Link 1). On the other hand, Link 16 and Link 22 are the newest and most advanced tactical data link networks. With respect to the above discussion, we will present a short description of these standards.

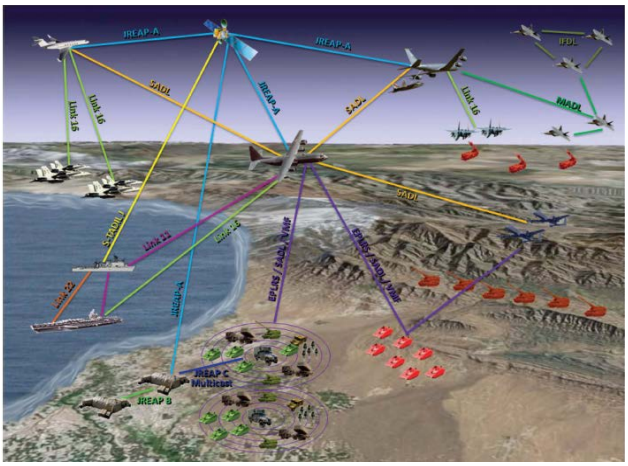

Figure.1. Example of Tactical Data Link (TDL) Usage [1]
Table 1. TDL systems which NATO uses

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Link type	User community	Application
Link 1	Aerial situation	Interfaces with other networks (aerial control/ aerial defense), with mobile systems and with the primary users group.
Link 11	Marine control Aerial control	Provides tracking data exchange for image compilation and transmission of orders in the C2 domain.
Link 11B	Aerial defense	Tactical information exchange between soil-based weapon systems, C2 and surveillance systems and Link 11 network participating units.
Link 16	Joint	High-throughput digital data link, without a nodal point (hub), which includes EPM for engaging a multiple combat environment (terrestrial, naval and aerial combat)
Link 22	Joint	Designed for ensuring connectivity outside the direct line-of-sight (BLOS), using DTDMA architecture.

2. Tactical Data Link (TDL)

The joint operations command must have TDL equipments in order to benefit from MIDS (Multifunctional Information Distribution Systems) networks input data, introduced by terrestrial forces, aerial forces, marine forces and military information organizations, according to the commandment's needs (as per its tasks and abilities), as well as to introduce specific data into these networks (figure 1). Table 1 presents general characteristics of TDLs.

TDL systems are potential solutions for implementing the concept of Joint Intelligence, Surveillance and Reconnaisance (JISR). The main JISR missions are: early warning, information support for operations planning, information about the enemy and the environment for situational assessment , data and information about targets, informational operations support, information for risk assessment and troops protection, The accomplishment of these missions depends on the TDLs specifications which will comply the following requirements: regularity, clarity, conciseness, standardization, verification, selective distribution and classification of information.

Depending on what messages are used to convey tactical data, the main TDL functions are:

a. TDL parameters information exchange;
b. Network management;
c. Precise Participant Location and Identification (PPLI)
d. Air surveillance;
e. Land surveillance;
f. Terrestrial surveillance;
g. Space surveillance;
h. Electronic surveillance;
i. Electronic warfare (EW);
j. Intelligence;
k. Mission management;
l. Weapons coordination and management;
m. Air control;
n. Managementul informatic;
o. Free text exchange;
p. Voice communication exchange.

TDL usage depends on the military area of operation or drill area, as seen in Table 2.

Table 2. TDL functional areas

Functional areas	Link 11	Link 16	Link 22
Status monitoring platform	x	x	x
Air surveillance	x	x	x
Land surveillance	-	x	x
Surface surveillance	x	x	x
Subsurface surveillance	x	x	x
Space surveillance	-	x	x
Electronic warfare	x	x	x
Weapons coordination	x	x	x
Command	x	x	x
Aircraft control	-	x	x
Network management	-	x	x
Imagistics	-	x	-

Data exchange capability imposes that the transmission medium is available prior to initiating and starting any TDL system for landline communications and radio frequencies allocation.The main characteristics of the equipments connection scheme in tactical data links are presented in Table 3.

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Table 3. Characteristics of TDL networking scheme

Characteristics	Link 1	Link 11	Link 16	Link 22
Frequency	Point-to-point land line	HF/ UHF	UHF/ Spread	HF/UHF Spread
Speed (bit/sec)	1,200	1,800	> 57,600	-
ECM resistance	-	-	x	x
Crypto-secure	-	x	x	x
Nodeless	-	-	x	x
Extended LOS	-	-	x	x
Antijam	-	-	x	-
Data rate (kbps)	1.2	1.3 ÷ 2.25	2.8 ÷ 115.2	2.4
Standard message	S-series	M series	J series	J series
Participants		4 ÷ 8	> 128	40
Voice circuits	-	-	2	-
Architecture	Duplex digital	Radio Broadcast	TDMA	DTDMA

3. From Link 1 to Link 22

In the Data Links evolution, there are two main generations. The first generation Data Links (Link1, Link4, Link11, Link11B, Link14) was developed on 8-bit computers, in 1950's and 1960's, with limited functionality and slow data rates (600 - 2400 bps). The second generation Data Links (Link16, Link22) was developed on 16-bit computers, in the 1970's and 1980's, is multifunctional and works at faster data rates (2400bps-1Mbps).

3.1 Link 1

Link 1 is a point-to-point tactical link based on a fixed digital message set, which interconnects European NATO terrestrial counterair fixed locations in order to exchange data and information regarding the air situational awareness in the main network group.

3.2 Link 11

Link 11 is a secure half-duplex tactical data radio link used by NATO for digital information transmission among airborne, land-based, and ship-board tactical data systems. Link 11 works in HF or UHF band. Currently Link 11 is intended to be replaced by Link 22. The standard that defines its specification is MIL-STD-6011.

3.3 Link 16

Link 16 is a high-capacity datalink, with frequency hopping features and jam resistance capabilities. Links 16 uses Joint Tactical Information Distribution System (JTIDS) terminals and Multifunctional Information Distribution System (MIDS). Link 16 has implemented the Time Division Multiple Access (TDMA) technique, that provides 128 time slots/second for the JU (JTIDS Units) participants. The time slots are organized in several functional groups of network users.

Unlike Link1 and Link 11, Link 16 uses encryptied high-capacity datalink, with no single point of failure (NCS), and provides electronic protection measures for fully-operational communications in combat situations (air, terestrial, sea). In table no. 2 there are ilustrated main characteristics of the TDL developed by NATO over the past decades, including the oldest and the newest technologies available.

The main purpose of Link 16 is to provide the support for real-time tactical information exchange between joint units. Link 16 is allowing the tactical usage of the involved platforms (equiped with Link 16) and provides enhanced communication capabilities , which include::

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

Main applications where Link16 Tactical Data Link is used are:

- Surveillance
- Electronic War (EW)
- Mission Management (MM) / Weapons Coordination (WC)
- Air control
- Fighter-to-fighter net
- Secure voice channels
- Navigation

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- Network management.

Link 16 is represented by several tactical data links which provide the information exchange using the Line of Sight radio medium. The available Link 16 terminals are:

- JTIDS – first generation terminals, including Class1 and Class2 terminals (software, hardware, RF equipment, and high-capacity, secure, anti-jam waveforms)
- MIDS-LVT - LVT1-LVT11 is the second generation class of Link 16 equipments
- JTRS şi MIDS JTRS – the future generation of Link 16 terminals.

3.4 Link 22

Same as Link 11, Link 22 is a secure digital radio link that works in the HF and UHF bands that provide the support for data exchange between air, ground, and navy of all the allied forces.

The one important thing about Link 22 is the fact that enables BLOS (Beyond Line of Sight) communication capabilities, so in the HF band Link 22 is able to provide communications up to 300 nautical miles distance. Unlike the HF communications which can provide both LOS and BLOS communications, the UHF band is designated only for LOS transmissions.

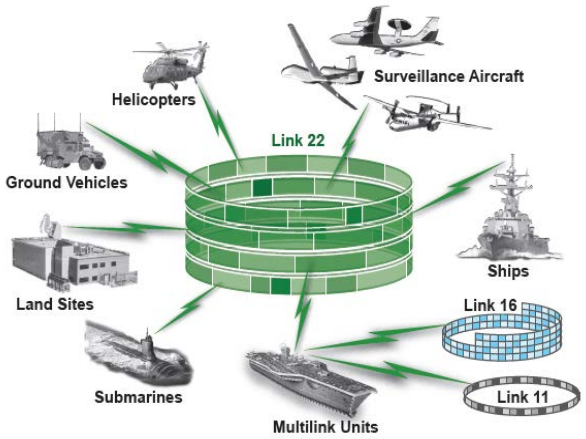


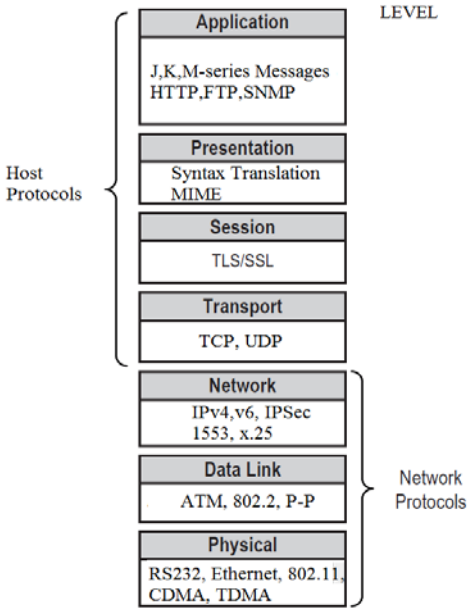
Figure 2. Link 22 Network Overview [1]

As we mentioned before, the Link 11 capabilities were limited, so the Link 22 initial program (NILE – NATO Improvement Link Eleven) objectives are:

- Link 11 upgrading and improvement;
- Allied Forces interoperability increasing;
- Link 16 complementary;
- C4ISR capabilities enhancement.

A visible improvement of Link 11 is the fact that Link 22 is able to be operational even in bad transmission conditions; it provides communication although at a lower data rate. In case of a specific unit failure, the whole network will not be affected because of the distributed protocols usage.

The design of Link 22 was similar to the standard ISO communications stack concept, which consists of several layers with individual and specific functions (Figure 3).



.**Figure 3. The equivalent ISO OSI reference model [1]**

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A synthetic comparison between Link11 and Link 22 is presented in Table 4

Table 4. A synthetic comparison between Link11 and Link 22

Function/ Specification	Parameters/Advantages/Limitations	
	Link 11	Link 22
Network Access	- Increased net cycle times - Large access delay	- TDMA access - Prioritization of messages feature
Emergency calls	- No options	- Priority Injection feature
Capacity	- Limited number of participants (62)	- More units (125)
Area of Operation (Network Coverage)	- Limited area - Dependence of the platforms and their positions - Units must be all connected with the NCS	- No limitation (it uses the WGS-84 System); - Increased area of operation; - Flexibile network; - LOS and BLOS capabilities; - Routing&relay protocols.
Communication Security	- Low encryption level - Weak security.	- Strong encryption system. - Strong security.
Transmission Security	- Fixed HF or UHF frequencies; - Jam vulnerabilities.	- Frequency hoping solutions provide reliable communications; - Fixed frequency communications are not so affected as Link 11 because of the multiple networks
NCS failure	- If NCS is down the entire network will be affected	- No NCS required - No single point of failure
Reliability	- Bad conditions could affect the transmission - Limited waveforms availability	- Special mechanism for bad transmission conditions - More robust waveforms
Bandwidth	- Limited Bandwidth - Transmission rates from 1,090 bit/s to 1,800 bit/s	- Wider Bandwidth - Transmission rates from 1,493 bit/s to 12,666 bit/s

CONCLUSIONS

Tactical Data Links provide near-real time combat information to U.S. and NATO allies about the integrated air picture with both friendly and hostile aircraft locations, and general situational awareness data, including defence threats. This contributes to an integrated control of fighters by either ground-based or airborne controllers, which will increase the fighters' situational awareness and the ability to engage targets or to avoid threats, thereby increasing mission effectiveness.

TDL capabilities offer a near-term solution for exchanging information over a common network that is continuously and automatically updated.

TDL ensure the hardware and software support for communication capabilities in C4ISR applications during peacetime, as well as fight exercises and war. They are meant to serve NATO as well as the allied forces, which contribute to its continuous improvement according to threats and vulnerabilities dynamic. Currently, even Link16 and Link22 undergo a continuous adaptation process to new IT&C technologies developed and implemented in NATO deployable networks.

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