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IMAGERY INTEROPERABILITY ARCHITECTURE TACTICAL RECONNAISSANCE SYSTEMS

Synectics Corporation

Arnold H. Lanckton and Cheryl Haritatos

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Air Force Systems Command
Griffiss Air Force Base, NY 13441-5700

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This report presents the concept of imagery interoperability, reviews the background leading to the establishment of the Imagery Interoperability Architecture (IIA), describes in detail this architecture, and discusses the military advantages to be gained by applying the architecture to a reconnaissance program. The primary benefit of the IIA is the value that is added with its incorporation into any imaging reconnaissance system (using still and/or dynamic imagery), permitting any ground system to receive any image at any time regardless of the source.

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ACRONYMS AND ABBREVIATIONS

AFSC	Air Force Systems Command
ATARS	Advanced Tactical Air Reconnaissance System
C^3	Command, Control, Communications
C^3I	Command, Control, Communications & Intelligence
CARS	Common Architecture for Reconnaissance Systems
CDL	Common Data Link
CGS	Common Ground Station
COMINT	Communications Intelligence
DBMS	Data Base Management System
DoD	Department of Defense
EEI	Essential Elements of Information
ELINT	Electronic Intelligence
EO	Electro-optical
FSED	Full Scale Engineering Development
HOL	Higher Order Language
ICD	Interface Control Document
IDL	Interoperable Data Link
IIA	Imagery Interoperability Architecture
IIDL	Imagery Interoperable Data Link
IIR	Image Information Reformatter
IISS	Interoperable Image Surface Station
IMINT	Imagery Intelligence
IPIX	Interface Processor for Imagery Exchange
IR	Infrared
ISG	Industrial Support Group
ISO	International Standards Organization
JSIPS	Joint Services Imagery Processing System
LAN	Local Area Network
MASINT	Measurement and Signal Intelligence
NAFAG	NATO Air Force Armament Group
NATO	North Atlantic Treaty Organization
NIDS	NATO Interoperability Design Study
NIIDL	NATO Imagery Interoperability Data Link
NIIDLS	NATO Imagery Interoperability Data Link Study
NIIRS	National Imagery Interpretability Rating Scale
OSI	Open Systems Interconnection
RADC	Rome Air Development Center
RDES	Reconnaissance Data Exchange Standard
RL	Rome Laboratory (formerly RADC)
SAR	Synthetic Aperture Radar
SIGINT	Signal Intelligence
STANAG	Standard Agreement
UARV	Unmanned Aerial Reconnaissance Vehicle
UAV	Unmanned Aerial Vehicle

1.0 INTRODUCTION

This report presents the concept of imagery interoperability, reviews the background leading to the establishment of the Imagery Interoperability Architecture (IIA), describes in detail this architecture, and discusses the military advantages to be gained by applying the architecture to a reconnaissance program. The primary benefit of the IIA is the value that is added with its incorporation into any imaging reconnaissance system (using still and/or dynamic imagery), permitting any ground system to receive any image at any time regardless of the source.

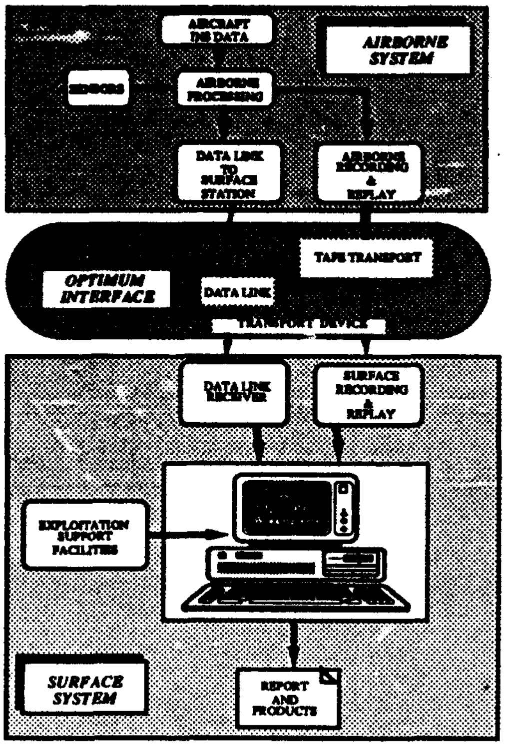
Imagery, one of the highest quality sources of remotely collected intelligence, is the "eyes" of the commander. As a result imagery is used to support a wide range of military applications. Hence, it is both resource and mission effective to be able to share an image with any military function that can use it. In the traditional environment, where reconnaissance systems rely upon hard copy film, sharing imagery requires film duplication and dissemination by means of physical shipping and/or handcarrying. This process is both resource intensive and time consuming. With the advent of electro-optical sensors and the use of digital systems it is now feasible to handle imagery in electronic form. The image is duplicated, when needed, through the use of a softcopy system and disseminated in near-real-time via transmission over communication lines. The availability of high quality imagery in near-real-time tremendously increases its value to the military commander.

Digital electronics technology is the key for improving the responsiveness and timeliness of the reconnaissance intelligence cycle. Unfortunately, the number and diversity of reconnaissance platforms and exploitation systems being deployed has grown, the cost of training and logistics support has increased, and there is no guarantee that the analyst will be able to access the best imagery available. The current philosophy of system development and deployment tightly couples reconnaissance platforms to specific and unique ground exploitation facilities. To overcome this shortfall and ensure that the military commander has timely access to all appropriate imagery, the establishment of a common surface system and interoperability among all digital imagery systems is essential.

In simplest terms image interoperability is the facility for *"providing the right image to the right user at the right time."* Interoperability provides the user the capability to receive, transport, display, review, and exploit imagery from virtually any electronic imagery sensor to any ground system.

The Air Force's Rome Laboratory, recognizing the critical need for imagery intelligence interoperability among multiple programs and systems, established the Imagery Interoperability Architecture (IIA) Program. The objective of the IIA Program is to provide technical solutions for establishing interoperability across electronic imagery intelligence systems. The Imagery Interoperability Architecture, the foundation of the IIA Program, addresses specific technical areas for achieving interoperability via standards, specifications, and limited hardware and software development. The IIA provides standards and specifications for imagery tape recorders and cassettes, data links, and imagery data format architectures. The Imagery Interoperability Architecture is designed such that interoperability can cost-effectively be accomplished not only in future reconnaissance systems but in existing systems as well. In establishing the means for achieving electronic imagery interoperability, the focus of the IIA Program has been on the interface between the collection systems (airborne systems) and the exploitation systems (surface systems). Exhibit 1 illustrates the components of a digital reconnaissance system and the basic elements of the Imagery Interoperability Architecture. Section 3.0 of this report details the elements of the Imagery Interoperability Architecture.

Exhibit 1
Image Interoperability Architecture



DATA STRUCTURES/FORMATS - STANDARDS
- RECONNAISSANCE DATA EXCHANGE STANDARD
- STANAG 7023

TAPE RECORDERS/CASSETTES - STANDARDS
- MIL-STD-2179B
- STANAG 7024

DATA LINKS - STANDARDS
- COMMON DATA LINK STANDARD
- NATO IMAGE INTEROPERABLE DATA LINK STUDY

REFORMATTER - HARDWARE/SOFTWARE

The availability of a data link connecting the airborne and surface systems eliminates the need for them to be collocated. Hence, the viewing/exploitation stations can be deployed wherever the military situation dictates and still receive timely data directly from the remote collection systems. If the data link is implemented using the IIA, deployment options become more flexible and make feasible the development of an interoperable ground system. An interoperable ground system is a family of common components that meet the specific requirements of all imagery user organizations and agencies, thus allowing the receipt, exploitation, and dissemination of all collected imagery, regardless of the source, at any single system.

The concept for an interoperable ground system was developed by the Rome Laboratory in the late 1970s. Then in 1986 this concept was evaluated when Air Force Systems Command (AFSC) conducted an F-16 Reconnaissance Ground Exploitation Concept Validation. This activity is commonly referred to as the Advanced Tactical Air Reconnaissance System (ATARS) Validation. The ATARS validation identified the need to establish an interoperability architecture for electro-optical imagery. From an operational perspective this activity demonstrated that the data link greatly expands the commander's options for flexible deployment and employment of image exploitation systems. In particular, it verified that the traditional deployment of collocating airborne collection systems and exploitation/reporting systems is no longer necessary.

From a military perspective, the diversity of reconnaissance assets that are now available to the commander must be integrated into a force structure similar to that of weapons systems in order to achieve the maximum benefit and efficiency of these powerful systems. It is becoming too costly and inefficient to operate and manage reconnaissance systems on a system by system basis, where each system consists of a single-type collector and a unique ground processing facility (termed a "stove pipe"). The deployment, integration, and application of reconnaissance collection assets must be managed as a single force and not managed in such a “stove pipe manner.”

Now that digital technology allows for the development of a ground station(s) capable of supporting any and all collection systems, the Imagery Interoperability Architecture (IIA) is required to achieve the interoperability that will allow the military to evolve toward an optimized reconnaissance force structure. The IIA offers the system developer and user the flexibility to meet unique requirements while maintaining compatibility with all available reconnaissance systems allowing timely access to their imagery products.

2.0 BACKGROUND

Rome Laboratory initiated the first system architecture for digital imagery system interoperability for the Air Force through an effort called the Common Architecture for Reconnaissance Systems (CARS). This architecture was developed in close coordination with the Advanced Tactical Air Reconnaissance System (ATARS) and the Joint Services Imagery Processing System (JSIPS) program offices, and the U.S. Navy, using the International Standard Organization's Open Systems Interconnection Model (OSI). The OSI model provides the basis for standards definitions for network and point to point communication protocols, data transfer formats, and computer systems environments. The OSI model has been adopted by the Government, industry, and the intelligence community because it promotes interoperability between systems and provides a more integrated approach to evolving operational capabilities.

Under the CARS effort a military standard was developed for magnetic tape recording and playback of high bandwidth data. This standard was formally approved as a MIL-STD-2179A - "Helical Digital Recording Format for 19mm Magnetic Tape Cassette Recorder/Reproducer." This standard followed industry's technology trends to develop a *high performance*, high bandwidth tape recorder playback device using a helical scan concept. This recorder was adopted by both the JSIPS and ATARS programs.

Also under the CARS effort the Rome Laboratory developed a data structure standard for digital imagery and imagery related data. This proposed standard is referred to as the Reconnaissance Data Exchange Standard (RDES). This standard follows the OSI model and defines the order and structure of data using headers for delineating various data types. Both the standard for data structures and the high performance high bandwidth tape recorder playback are incorporated into the Joint Services Imagery Processing System (JSIPS).

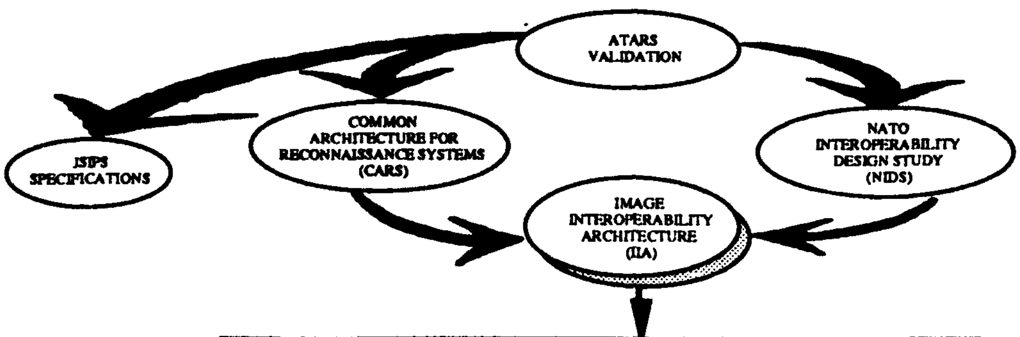
In 1987, NATO conducted an electro-optical image interoperability study for NATO Air Force Armaments Group (NAFAG) Air Group IV A/C 224 (Tactical Aerial Reconnaissance in Intelligence). Rome Laboratory agreed to chair a NATO Interoperability Design Study (NIDS) Working Group. NIDS identified the best layer or point of interface for an imaging reconnaissance system is between a collector and a surface or ground station. Exhibit 1 represents the top level functions of an aerial imaging system. There are only two ways or methods of transporting electronic imagery from the collector to a surface station: electrical transmission and electrical recording of the data on magnetic tape. Thus the Working Group recommended that the following transport standard be developed: STANAG 7024 – "Imagery Air Reconnaissance Tape Recorder Standard."

This Working Group also recommended that a data structure standard be developed so that imagery and imagery related data could be transported across the above standard. STANAG 7023 – "Digital Air Reconnaissance Imagery Data Architecture" is the resultant standard.

The NIDS also recommended that an Image Information Reformatter (IIR) be developed for reformatting electronic imagery from one format to another format. This development would be a cost effective interim solution for providing interoperability of electronic imagery formats that have not adopted the data structures and data transport standards.

The Imagery Interoperability Architecture (IIA) represents a merging of the CARS and NIDS activities into a single electronic architecture that is applicable to all reconnaissance systems regardless of country or platform. Exhibit 2 illustrates the general flow of activities that have led to the creation of the IIA.

Exhibit 2
Image Interoperability Architecture Legacy



U.S. EFFORTS	IIA TECHNICAL AREA	NATO EFFORTS
Reconnaissance Data Exchange Standard	Data Structures	STANAG 7023 - Air Reconnaissance Imagery Data Architecture
STANAG 7024 - Imagery Air Reconnaissance Tape Recorder Standard	Recorder/Cassette	STANAG 7024 - Imagery Air Reconnaissance Tape Recorder Standard
Common Data Link	Data Link	NIIDL Study
Cooperative IIR Effort	Image Information Reformatter	Cooperative IIR Effort

3.0 IMAGERY INTEROPERABILITY ARCHITECTURE

The IIA consists of five major technical areas which have been divided into two categories. The first category contains those technical areas which require the establishment of standards and/or specifications. The second category includes those areas which require some hardware and/or software development.

The technical areas requiring the establishment of standards and/or specifications are:

√ Data Structures/Formats

√ Tape Recorders/Cassettes

√ Data Link

The technical areas requiring some hardware/software development are:

√ Imagery Information Reformatter for non-standard systems

√ Processor adaptable to multiple SAR systems.

The following sections address each of the technical areas which comprise the IIA and discuss the advantages gained by applying them to a reconnaissance program.

3.1 DATA STRUCTURES/FORMATS STANDARDS

Within the IIA, the Reconnaissance Data Exchange Standard (RDES) is the standard for handling electronic imagery and imagery related data for both still and dynamic imagery. This standard has been submitted to NATO as a draft standard, referred to as STANAG 7023 – "Air Reconnaissance Imagery Data Architecture." The RDES is being prepared for submission to the Defense Information Systems Agency, the executive agent for DoD information standards, for consideration and approval as a DoD standard.

The aim of RDES/STANAG 7023 is to provide a standard data structure to be utilized in the design specification of the transport system used for the exchange of digital sensor and auxiliary data from airborne reconnaissance collection platforms (source) to surface receive stations and/or exploitation terminals (destination). Appropriate application of RDES also facilitates the transport of imagery and imagery related data between users, to and from a user and a storage device, and many other imagery transport systems. This common architecture eases the interoperability of reconnaissance systems in DoD and among the allied countries. The combination of the data format produced from this architecture with compatible data transfer devices is the minimum requirement to achieve interoperability. An example of this basic data structure defined in RDES/STANAG 7023 is illustrated in Exhibit 3.

The standard incorporates parameters which are the same in structure and definition for each system and can be used interchangeably. Not all systems require exactly the same parameters. Depending on system specifications, the utilization of parameters such as sensor calibration, data sensor, compression data, etc. may vary for each system. In other words, one system may use a specific parameter while another does not. This architecture has been designed to include such parameters, permitting the systems that need them to access them.

An important aspect of RDES/STANAG 7023 is the use of a header block to define two basic categories of data, sensor data and auxiliary data. Sensor data is a free format and is handled on a bit by bit basis. This standard allows any sensor to sample its environment in any number of dimensions. Auxiliary data provides information about the imagery both to the surface processing equipment and to personnel using the imagery. Auxiliary data contains information about the mission, platform, and sensor operation of that image which can be used when it is received by a processing system. Exhibit 3 illustrates the basic data structure of the header block. Exhibit 4 provides an example of the types of information included in the sensor data and auxiliary data categories.

Exhibit 3
Basic Data Structure of RDES/STANAG 7023

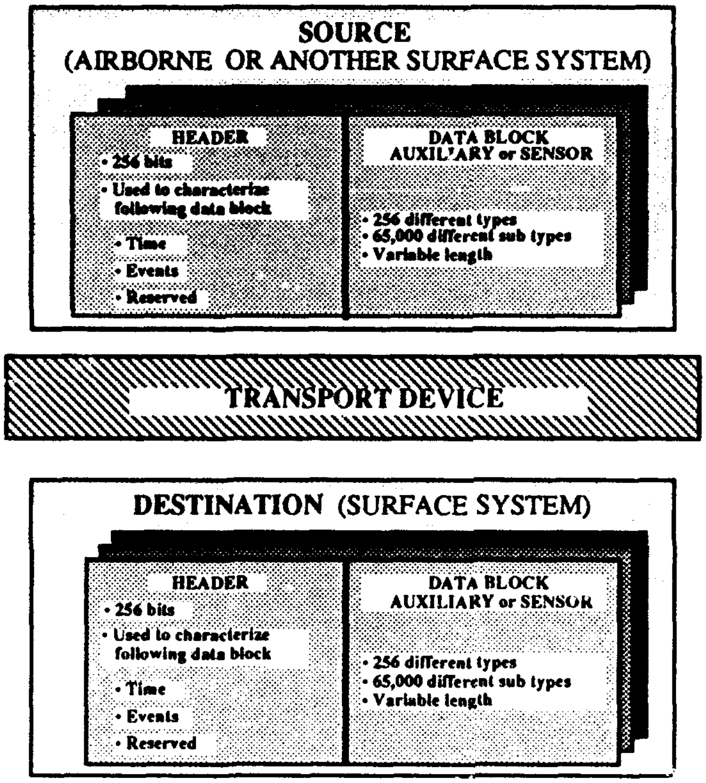
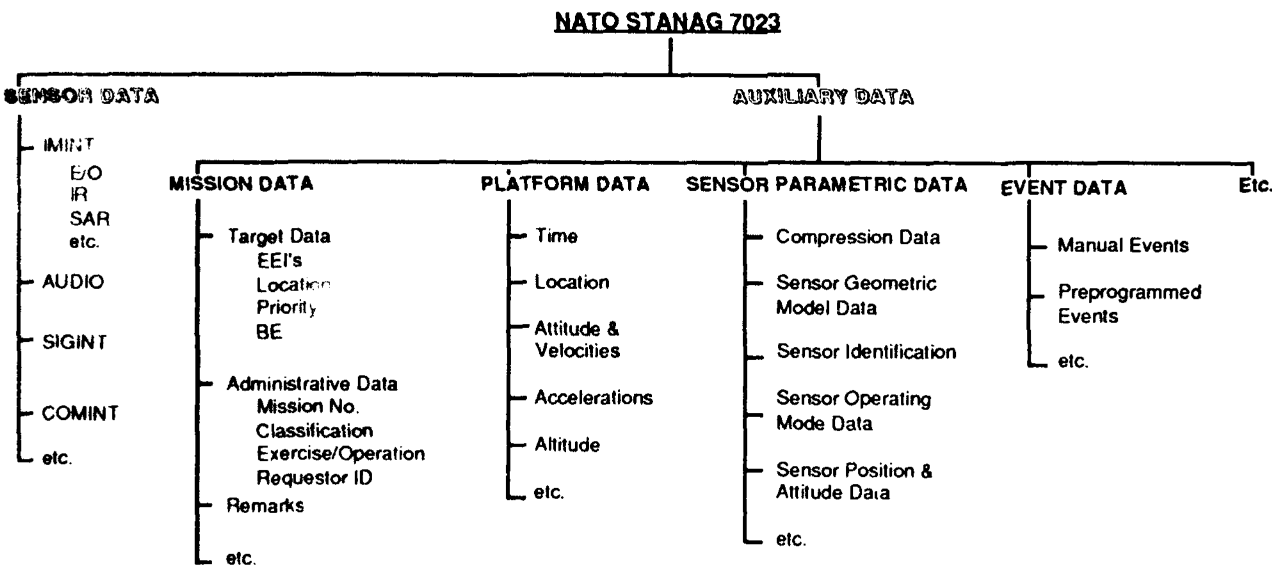


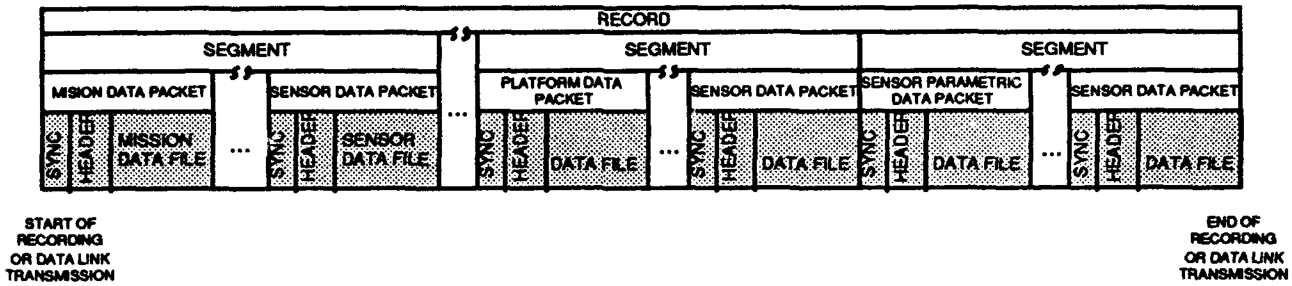
Exhibit 4
An Example of Data Types in RDES/STANAG 7023



The architecture is designed to be compatible with the OSI model for transporting digital data over communication systems and magnetic tape media. To simplify the management or handling of reconnaissance events (as an example multiple missions on a single platform), source resident sensor and auxiliary data have been divided into manageable parts called blocks. Each block is further divided into files and the standard allows for the proper order of files within a block to be defined.

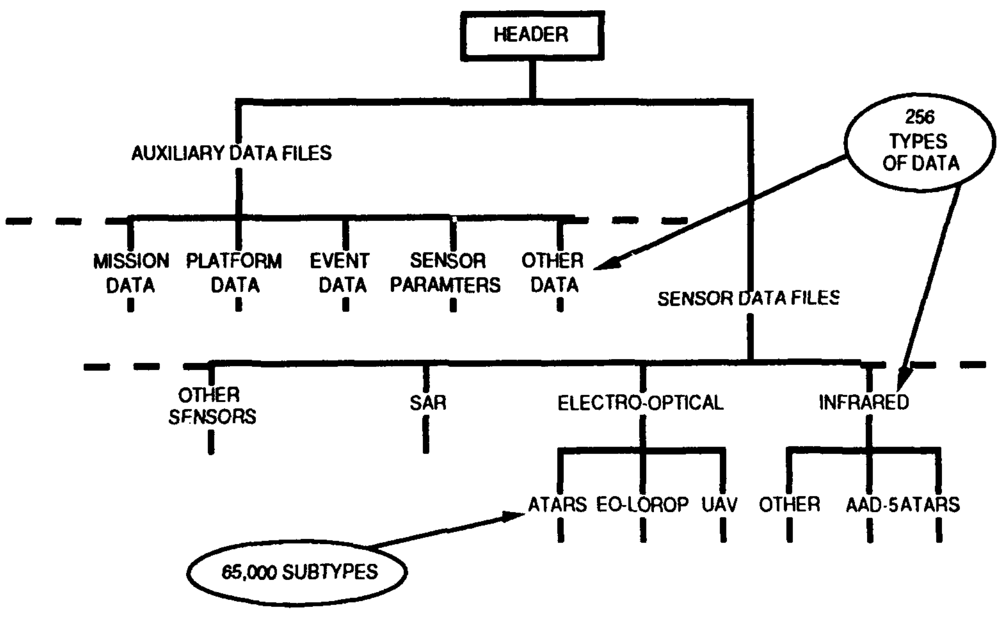
To provide for transport flexibility, files are divided into records; records are composed of segments; and segments contain packets. Each Packet consists of a synchronization field, a header field and a related data field. Exhibit 5 is an illustration of a record.

Exhibit 5
An Example of RDES/STANAG 7023 Record



The architecture has specifically been designed with the capability to incorporate future systems as they are developed. Data areas have been reserved for parameters which are yet to be defined. The architecture also provides the ability to describe multiple missions as they are being recorded. The mission data block can be repeated throughout the mission and the rate of repetition is flexible, depending upon the collection tasking. In this respect, the standard has been characterized as a "living standard" which can adjust and continually grow with the addition of new systems. Exhibit 6 illustrates the growth potential of the standard.

Exhibit 6
RDES/STANAG 7023 Growth Potential



3.1.1 HEADER BLOCK

An in-depth view of the header block demonstrates the flexibility that is inherent in RDES/STANAG 7023. The sync word is 10 bytes with the remaining 22 bytes distributed as illustrated in Exhibit 7.

Exhibit 7
Header Data Format

Field	Data Type	Number of Bytes
1	Synchronization Type	1
2	Data Source	1
3	Data File Address	2
4	Flags	1
5	Length of Block	2
6	Block File Number	2
7	Event Number	1
8	Event Type	1
9	Data File Size	2
10	Image Number Segment	1
11	Time Tag	4
12	Reserved	2
13	Checksum	2

√ **Synchronization Type** — The first field in the header, the synchronization (sync) type, is used to identify each type of sync which may be required when transmitting sensor data. The sync type field precludes having different sync codes to identify the various types of sync. The different types of sync used in this standard, and their order of precedence are: block, frame, field, swath and line. An order of precedence is necessary since different types of sync will be required to occur at a particular boundary in the RDES data. If a block sync occurs, it implies that all the syncs following will occur as well, and so on through the order.

√ **Data Source** — This field describes the source from which a data file originates. For example, sensor 1, sensor 2, platform, mission, etc. are specific data sources.

√ **Data File Address** — This field further breaks down the address of the individual fields associated with each data source.

√ **Flags** — Eight separate two state flags are included in the header. The first flag indicates which auxiliary data blocks have been updated. The second flag indicates whether or not the data has been compressed. The last six flags are currently reserved for future use.

√ **Length of block** — This field contains the length of the block from which the associated data field originated. The length is defined as an integer number of data files per block. This allows the data files to be variable length and thereby a more efficient data record.

- √ **Block file number** — This field indicates the order of the associated data file within the block from which it originated. It is used for source block replication at the destination system. This allows more efficient use of the data collected.

- √ **Event number** — The event number is sequentially assigned to each marked event throughout any record. Throughout the course of a reconnaissance mission several significant events can be identified to permit queuing or sorting of sensor data.

- √ **Event type** — The event type field identifies the type of the marked event.

- √ **Data file size** — This field contains an integer number representing the number of words contained in the associated auxiliary data file, or the number of samples contained in the associated sensor file. This allows the data files to be variable length and thereby a more efficient data record.

- √ **Image Segment Number** — This field identifies the image segment. Initially set at one, it increases by increments of 1 for each new acquisition.

- √ **Time tag** — This field permits relative time correlation of different events. The time indicates the point at which the contents of the associated data file were recorded. The time tag is a 32 bit increment periodic count which commences at the start of a record with a value of 0. This field becomes very important when it is necessary to sort out different reconnaissance images of the same area. This will allow developing a time sequence of images of the same geographical area, but were collected by different reconnaissance systems.

- √ **Reserved** — This field is reserved for future growth. This reserved field is very large and can be used for different applications that have not been considered in the development of this data structure.

- √ **Checksum** — The checksum is the complement of modulo 256 sum used to verify the validity or integrity of data in the header.

3.1.2 DATA FILES

RDES/STANAG 7023 has two general categories of data files: sensor data and auxiliary data.

3.1.2.1 Sensor Data Files

Sensor data is the imagery collected from the reconnaissance sensors. Sensor data is classified by the type of data generated by the sensor system such as IR, EO, and SAR. Sensor data files may be variable in length. The length of the sensor data file is identified in the header block preceding the file. The specific data structure of sensor data file is sensor dependent and the structure is identified in the sensor parametric auxiliary data file. There can be up to 65,000 different sensor data files. These can be either different sensors or different collection systems. Thus there can be slightly more than 65,000 different reconnaissance systems accommodated by this data structure. The sensor data can be of any pixel depth and can be any number of pixels per frame or per mission of line scan system. The format can accommodate the handling of unprocessed (phase history) Synthetic Aperture Radar (SAR) and can even be used to record nonimaging sensor data such as SIGINT sensor data.

3.1.2.2 Auxiliary Data Files

Auxiliary data provides the information necessary for the imagery analyst to derive intelligence information from the imagery. It also provides the information required by the surface exploitation system to process raw imagery data into a form which is usable by the imagery analyst. Auxiliary data is divided into categories associated with the source of the information. Auxiliary data files may be variable in length. The length of the auxiliary data file is identified in the header block preceding the file. Auxiliary data can be used by a reconnaissance system in handling different reconnaissance sensor configurations and through acceptance of the standard can process non-reconnaissance imagery. The RDES/STANAG 7023 has defined the following categories of auxiliary data which comprise the auxiliary data files:

3.1.2.2.1 Format description data files. The format description data files provide descriptive information about the format, such as time tag parameters. The data format is also assigned a version number which is used for identification purposes.

3.1.2.2.2 Fill data files. The fill data files consist of predefined byte sequences inserted into the imagery and its auxiliary data so that data rates are equalized.

3.1.2.2.3 Mission data files. The mission data files describe the mission correlating to the sensor data. The mission data files contain three categories of information: administrative data (i.e. mission number, requester identification air tasking order data, security classification, etc.), target search data (i.e. target type, location, basic encyclopedia numbers, etc.), and remarks. Only those mission data files required to describe the mission need be used.

Mission data is one of the unique features of RDES/STANAG 7023, in that the information contained in this file provides any image exploitation system with the information to fully exploit any image. This image exploitation interoperability allows a collector to data link imagery to any exploitation system at any time. In times of hostilities it is not always possible to complete a reconnaissance mission as planned, the incorporation of the mission data files assures that collected imagery can be transmitted to a ground system even if the mission is aborted.

3.1.2.2.4 Platform data files. Platform data files provide parametric information describing the platform on which the sensors are mounted. This file was derived from NATO STANAG 3837AA.

This file can easily accommodate navigation and air data computer systems that are not compatible with this particular format. To handle these unique systems, another type of platform data file can be built and incorporated into the RDES/STANAG 7023. Incorporation of this data file structure provides the reconnaissance program automatic compatibility with all of the other DoD and NATO standards for this data.

3.1.2.2.5 Event/index data files. The event/index data files function as a directory used to cue significant events that occurred during a mission on the transport media. These data files contain a chronological record of the events. Events are categorized as either programmed or manual.

This is a very useful data file for a reconnaissance ground station and provides an easy method to rapidly sort through large volumes of mission data and sort between missions to locate specific events.

3.1.2.2.6 Sensor parametric data files. The sensor parametric data files describe the sensor data format directly through the provision of parameters, or indirectly through a table of tabular parameters. Currently, there are eight types of sensor parametric data: 1) sensor identification, 2) sensor calibration, 3) sensor data compression, 4) sensor sample description, 5) sensor sample element description, 6) sensor operating mode, 7) sensor processing, and 8) sensor mapping. The sensor transfer order data, sampling order data, sample timing data, and sensor sample coordinate data files are tables used to geometrically model any one-to-one sensors. This data file identifies the unique characteristics of each sensor.

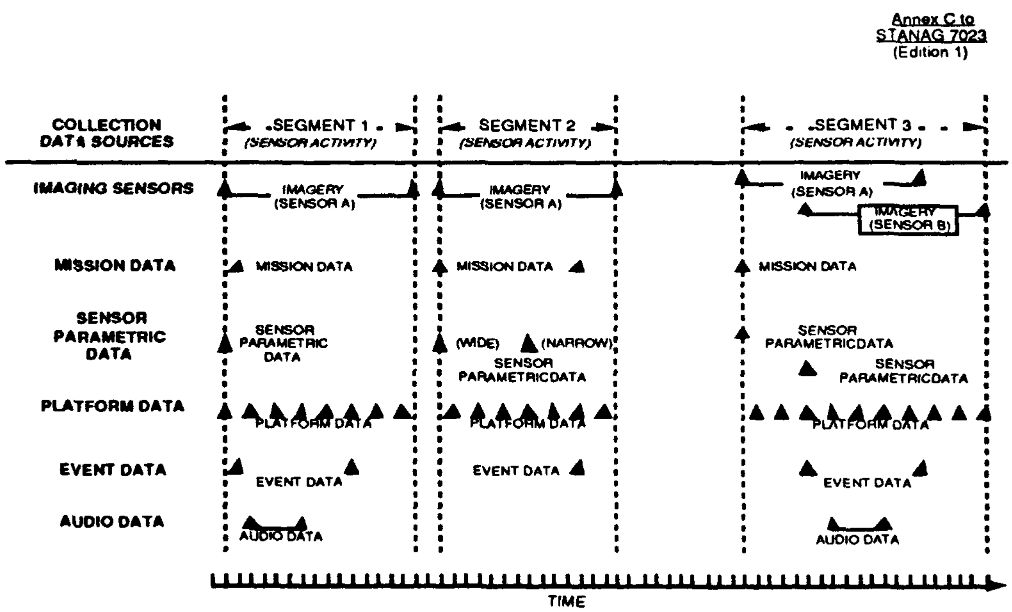
Selected sensor parametric files have already been defined and these can be used by the reconnaissance program as a guide to developing specific files for unique reconnaissance sensors.

3.1.2.2.7 Audio data files. Audio data enables the reconnaissance aircrew on the collection platform to provide an audio narrative of mission events to the imagery analyst located in the ground station. To accommodate the various and diverse formats, audio data is formatted as one-dimensional sensor data and is described in the sensor parametric data files.

3.1.3 ADVANTAGES OF APPLYING THE STANDARD DATA STRUCTURES/FORMATS TO A RECONNAISSANCE PROGRAM

An example of how RDES/STANAG 7023 might be used in a reconnaissance mission is illustrated in Exhibit 8. This architecture allows multiple data types to be recorded simultaneously during a mission. The data structures and the organization of the data structures allows for the multiple, simultaneously recorded data (sensor, platform, inflight pilot reports, etc.) to be transported to multiple ground stations where the entire mission can be reconstructed with respect to time for viewing and or exploitation. The information contained in the mission data file allow receipt, exploitation, and dissemination of imagery by a non-tasked system(s). This exploitation *interoperability* (any system being able to satisfy the mission requirements of any collected data) is a unique feature of the IIA and for the first time ensures that data collected can be exploited despite any disruptions to the originally planned mission. This benefit of interoperability provides a functionality that is critical in times of hostility where the expected availability of scheduled or dedicated exploitation resources may change significantly from prior plans.

Exhibit 8
Example of a Reconnaissance Mission with Multiple Recordings



Both RDES and STANAG 7023 have more than sufficient capacity for accommodating the unique needs of any reconnaissance system. The flexibility of the header structure and its contents allows it to accommodate any specific reconnaissance needs. One of the Sensor Data File formats has already been specifically designed to address magnetic tape recording formats for conventional TV signals conforming to common industry TV video transmission standards ESD 170 and ESD 343. The Auxiliary Data Files currently meet all of the reconnaissance information needs with the implementation of the Sensor Parametric Data, Mission Data, and Platform Data Files. The Event/Index Data File can be used to facilitate the ground system's ability to search and retrieve from recorded imagery.

The reconnaissance program accrues many advantages by incorporating the IIA data structures/formats standards.

- √ Common data structures and formats for all reconnaissance systems are ensured.
- √ Interoperability and commonality across all reconnaissance systems is allowed.
- √ Interoperability and commonality with future NATO reconnaissance systems is permitted.
- √ All the benefits and advancements achieved by the IIA Program are inherited.

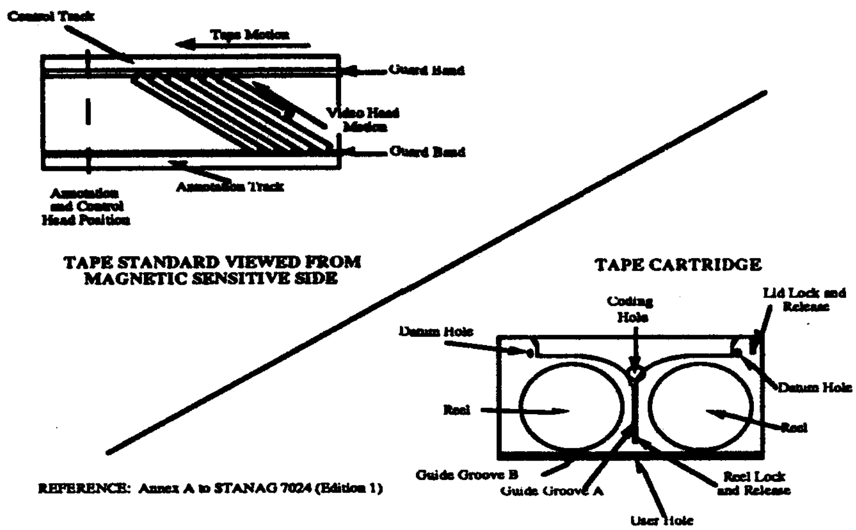
3.2 HELICAL RECORDER/CASSETTE STANDARDS

The magnetic tape recorder and cassette can be used for on-board recording of imagery and imagery related data and subsequent ground based playback, as well as being used to transport imagery and imagery related data between users. The IIA Helical Recorder/Cassette Standard specifies physical cassette dimensions, tape size, materials and principal properties, tape record locations, dimensions and orientation, a helical recording method and specifications, and the physical and electronic recorder-cassette interface tape cassettes. The IIA Helical Recorder/Cassette Standard provides the physical means to exchange digital data among reconnaissance systems and components. This standard also specifies analog formats and prescribes a single (serial) digital bit stream recorded and/or reproduced proportional to the input clock rate. It accommodates data rates from 10 to 480 megabits per second. It allows changes within data rates while maintaining a specific packing density and format at any speed. Tape speeds are variable and independent to input data rates. This standard specifies that data be recorded in a helical-scan format, with tracks of supporting data recorded in a longitudinal format. The longitudinal tracks are used for annotation data, servo control, and time code or voice respectively. Exhibit 9 illustrates the format characteristics of this standard.

3.2.1 MIL-STD-2179B-"HELICAL DIGITAL RECORDING FORMAT FOR 19MM MAGNETIC TAPE CASSETTE RECORDER/REPRODUCER"

This helical digital recorder standard was developed by the Navy for the anti-submarine warfare systems and uses the TV production industry's standard D-1 recording tape. MIL-STD-2179B is an updated revision of MIL-STD-2179A reflecting current technology.

Exhibit 9
Helical Recorder/Cassette Standard



3.2.2 STANAG 7024 - "IMAGERY AIR RECONNAISSANCE TAPE RECORDER STANDARD"

This helical digital recorder standard addresses the digital and analog recording of reconnaissance imagery on the following media:

√ 8 mm width tape for recording both analog and digital data.

√ 12.65 mm width tape for recording analog data.

The incorporation of the MIL-STD-2179 for the 19 mm cassette tape for recording digital data has been included in STANAG 7024 as a "to be added" option based upon further test and evaluation.

3.2.3 ADVANTAGES OF APPLYING THE RECORDER/CASSETTE STANDARD TO A RECONNAISSANCE PROGRAM

The IIA Recorder/Cassette standards, MIL-STD-2179B and STANAG 7024, have a full range of recording and playback capabilities that are directly applicable to the reconnaissance program. This relevance is demonstrated by the tape/cassette sizes and signal recording types addressed by these standards:

√ 8 mm width tape for recording both analog and digital data.

√ 12.65 mm width tape for recording analog data.

√ 19 mm cassette tape for recording digital data

All of the above IIA Recorder/Cassette standards can meet a large majority of the needs of a reconnaissance program. The advantages the reconnaissance program accrues by incorporating the IIA Recorder/Cassette standards are:

√ The use of common recorders/cassettes for all reconnaissance systems is ensured.

√ Interoperability of imagery across all reconnaissance systems is allowed.

√ Interoperability of imagery with future NATO reconnaissance systems is permitted.

√ All the benefits and advancements achieved by the IIA Program are inherited.

3.3 DATA LINK STANDARD

Duane P. Andrews, the Assistant Secretary of Defense for C^3I stated, in a December 13, 1991 memorandum to the Secretaries of the Military Departments, the Directors of the Defense Agencies, and the Director of the Joint Staff:

> *"The Department of Defense has an increasing number of imagery and signals intelligence collection systems which use or require a high-capacity, secure jam-resistant data link to connect the airborne sensor payloads to the land or shipboard control and processing segments. Common interfaces between these systems within the respective discipline is essential for interoperability, and they provide the opportunity for significant cost-savings in development, procurement and support of airborne and ground systems."*

There are two separate efforts under the Imagery Interoperability Architecture Program to develop a data link standard for electronic imagery as directed by Mr. Andrews:

√ USAF effort for a Common Data Link, which is the DoD directed standard program

√ NATO Imagery Interoperable Data Link Study (NIIDLS)

The goal of both of these efforts is to create data link interoperability through a family of equipments that provide full service Command, Control, and Communications (C^3) for all intelligence/reconnaissance assets. The concept of an interoperable data link is illustrated in Exhibit 10.

Currently, digital or electronic imagery can be transmitted via data link to surface facilities accelerating the delivery and exploitation of priority imagery. As a first step in achieving data link interoperability, a model was developed based upon the philosophy and standards of the Open Systems Interconnection (OSI) which is addressing the issue of interoperability between computer systems. The Interoperable Data Link Model (IDL) is a layered model where:

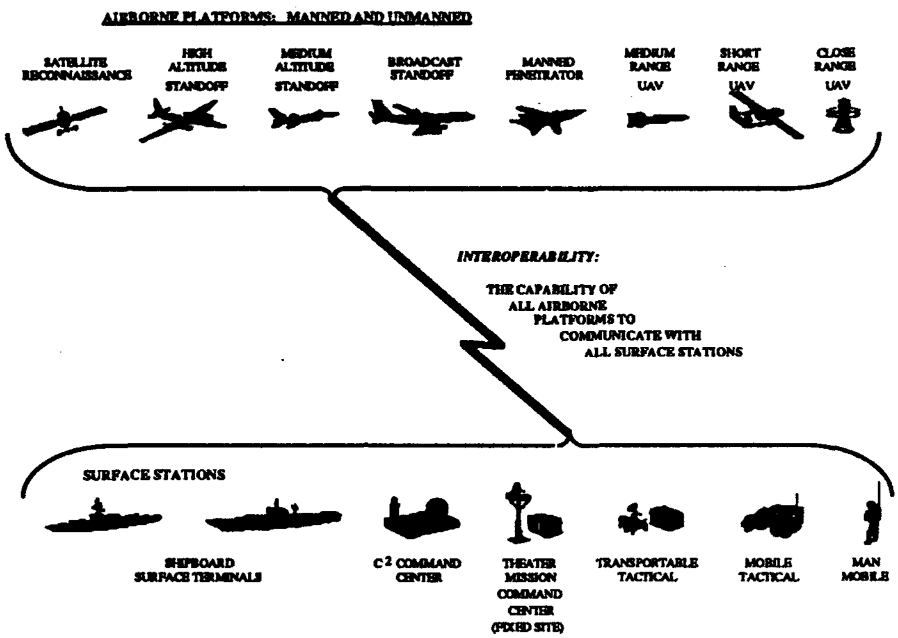
√ The highest level interacts with the outside world

√ Equivalent layers must correspond

√ Each layer in a single system communicates only with those layers directly above or below it

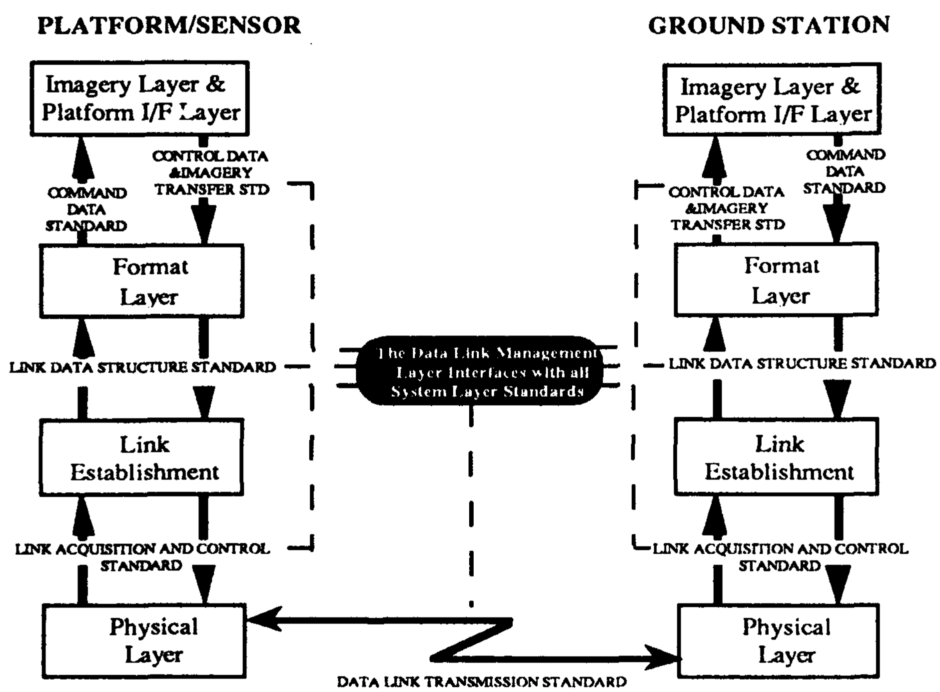
√ The lowest layer, the physical layer, contains the data link and data link medium or channel.

Exhibit 10
Interoperable Data Link



The Interoperable Data Link Model, illustrated in Exhibit 11, is the functional design being used by both the US Control Data Link Program and the NATO Imagery Interoperable Data Link Study (NIIDLS).

Exhibit 11
Interoperable Data Link Model



(Source: NIIDLS Final Report Volume II p. 21)

From a technical perspective, data link interoperability can be achieved through the following steps:

- √ Specify and direct interoperability through a series of A-level segment documents, program funding assessments, and the creation of a high level government program.
- √ Create a family of common modules that would adequately implement the specified standard. These common modules will be sufficiently flexible, in terms of fit and functionality, to be usable on a variety of platforms and operation environments.
- √ Create user documentation so that a true non-vendor specific implementation is achievable.

The following sections describe the US and the NATO data link programs and discuss how each is addressing the issue of interoperability.

3.3.1 U.S. COMMON DATA LINK (CDL)

In the mid 1970s it became apparent to top DoD managers in the Office of the Secretary of Defense/Assistant Secretary of Defense for C^3I that mission requirements and objectives established by the Joint Chiefs of Staff (JCS) and theater Commanders in Chiefs (CINCs) could only be fulfilled if interoperability among intelligence sources could be achieved. Studies performed by OSD/C^3I concluded that data link interoperability was the key. Additional activity concluded that a development of data link standards with implementing common modules was the favored approach.

In 1988, Congress mandated in the Defense Authorization to the Department of Defense (DoD), that the data link developments should be consolidated under the guidance of a Common Data Link program office. The CDL program office has the authority to establish standards and interfaces; control the configuration of common modules; and develop additional technology as required.

The ultimate goal of the CDL program is to define a data link capability to support C^3 by providing the following:

- √ Specifications for sensor control interfaces.
- √ Specifications for platform interfaces.
- √ Ensuring that the above interfaces are non -platform and non-sensor specific.
- √ Ensuring that the C^3 interfaces are compatible with any defined user.
- √ C^3 interfaces that are adaptable from both a technology and threat perspective.

This C^3 interoperability is achieved by providing specifications for electrical, mechanical and performance requirements through an end-to-end system which could be implemented using defined hardware and software specific functionality. The hardware is known as the CDL Common Modules. The subsystem specifies communication paths, path characteristics, wave forms, and baseband information. A similar set of specifications is also provided for the data link control links. A draft specification (Type A Specification for the Common Data Link Segment - Class 1, Specification Number 7681990, dated August 1989) has been prepared and a revision will soon be released.

The CDL will have completed Full Scale Engineering Development (FSED) in late 1991. The CDL has developed all the standards required to implement the IDL Model (see Exhibit 11). The CDL has also produced a family of digital, analog, radio frequency, and antenna modules that can implement the basic Interoperable Data Link (IDL) waveform and provide an expansion capability to implement additional waveforms as projected by the technology insertion plans. The CDL has been determined to meet the existing and planned needs for both interoperability and commonality.

The application of the CDL common modules and assets provides the military commander the capability to establish both a Global and Theater communications capability to control and disseminate real time products from Tactical and National reconnaissance platform products which yield multi-spectral and multi-signal information anywhere in the world.

3.3.2 NATO IMAGERY INTEROPERABLE DATA LINK STUDY (NIIDLS)

A NIIDLS Ad Hoc Working Group was established in April 1990 by the NATO Air Force Armament Group (NAFAG) Air Group IV "Tactical Air Reconnaissance Intelligence" (AC/244). The origin of the NIIDL Ad Hoc Working Group has its roots in a previous study, the NATO Interoperability Design Study (NIDS). NIDS was completed in 1988 and provided the foundation for the implementation of a NATO Imagery Interoperability Architecture.

The NATO Interoperability Imagery Data Link Study (NIIDLS) Ad Hoc Working Group served as an excellent forum for the international exchange of diverse viewpoints and created an acceptable methodology for technical resolution of issues. This Working Group was supported by an Industrial Support Group (ISG) whose responsibilities were to provide technical guidance and perform the analysis of the data base and assess the results in an advisory capacity to the NIIDL Ad Hoc Working Group. The following suggestions are the consensus of the participating members in the NIIDL Study Ad Hoc Working Group and were presented to NAFAG Air Group IV with recommendations for their consideration and action.

√ NATO data link interoperability is achievable but no existing data link currently available or being planned supports all NATO interoperability system(s)/data link(s) requirements.

√ Three classes of data links are sufficient to span the NATO functional, performance, and operational requirements. They are:

- Class 1 - Analog Links
- Class 2 - Point to Point Digital Links
- Class 3 - Broadcast Digital Links

√ Interoperability is achievable through the development of specific interface standards for future systems. The standards should adopt the proposed interoperable data link model which is presented in Exhibit 11.

√ In the short term the burden of interoperability implementation should be placed on the ground data link segments rather than the airborne data link segments. The study proposes several joint NATO R&D programs that would allow the ground segments to handle the problems.

- √ Any interoperable data link must incorporate the NATO Image Interoperability Architecture standards:
  - STANAG 7023 - "Air Reconnaissance Imagery Data Architecture"
  - STANAG 7024 - "Imagery Air Reconnaissance Tape Recorder Standard"
- √ The establishment of a NATO cooperative development program for a flexible data receive/transmit data link subsystem and a common sensor signal processor subsystem would increase the ability to achieve operational interoperability in the near term. An image information reformatter is still necessary to achieve near term interoperability.

3.3.3 ADVANTAGES OF APPLYING THE IIA DATA LINK STANDARDS TO A RECONNAISSANCE PROGRAM

The IIA Data Link efforts are focused on minimizing the expenditure of resources for data links within both the U.S and NATO forces. It is anticipated that the IIA effort will follow the United States Common Data Link philosophy. Data link interoperability is established through a family of equipments that provide full service Command, Control, and Communications (C^3) for intelligence/reconnaissance assets controlled by the DoD. The CDL program has three objectives that are directly compatible with a reconnaissance program, they are:

- √ Establish a family of standards and specifications that follow the International Systems Organization (ISO) Open Systems Interconnection (OSI) model philosophy tailored for data link C^3 applications.
- √ Develop a family of common modules that can be used by the various services and their program offices to implement mission specific hardware/software functions and will assure compliance with the interoperability standards and specifications. These modules are to be available from multi-vendor sources.
- √ Devise a technology insertion plan for C^3 data links that will enhance the integrated C^3 connectivity and follow the mission needs and objectives of DoD and NATO.

The advantages accrued by a reconnaissance program through the incorporation of the IIA Data Link standards are:

- √ Availability of a Common Data Link for the reconnaissance program that is also common to other reconnaissance surveillance systems both U.S. and NATO.
- √ Data link interoperability and commonality across all reconnaissance programs is facilitated.
- √ The benefits of the IIA program are shared.

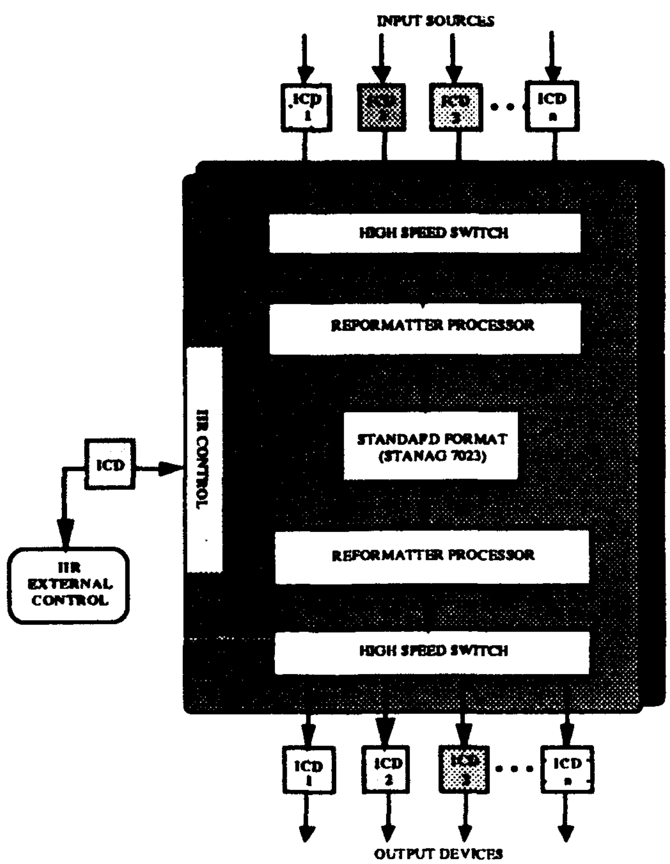
3.4 IMAGERY INFORMATION REFORMATTER (IIR)

Interoperability cannot be achieved through format standards and specifications alone. Existing systems are not standard, and to modify them is simply not cost effective. Recognizing that there is a need to address non-standard systems, now and possibly in the future, the IIA includes the development of a reformatter to provide interoperability of existing electro-optical imagery and auxiliary data from one format to another in near-real-time. A top level schematic of this system is illustrated in Exhibit 12. The IIR performs three basic reformatting functions:

- √ Reformats any unique sensor image format into a single standard (IIA) format.
- √ Reformats a single standard (IIA) format into any unique sensor format.
- √ Allows the interchange of sensor imagery information and auxiliary data between two different unique imagery information systems.

These two reformatting capabilities will reduce subsequent image processing system development costs since reformatting diverse sensor formats to a single standard reduces image hardware costs, and eliminates the cost of modifying each algorithm for every image format. STANAG 7023 has been selected as the single standard format, because it can accommodate any sensor format and preserves the integrity of any sensor.

Exhibit 12
Image Information Reformatter Schematic



3.4.1 IMAGERY INFORMATION REFORMATTER (IIR) FUNCTIONALITY

A reformatting scenario would begin with acceptance of the uniquely formatted imagery and auxiliary information from the source transport device by the I/O interface module. The data is then converted into formats compatible with the I/O busses Interface Control Document (ICD). This conversion requires numerous functions including analog-to-digital conversion (or vice versa), multiplexing/demultiplexing, data rate matching, compression/decompression, filtering, etc. The I/O bus transports the source data to the core where software format configuration files are programmed to recognize the information source. Once the source data is identified, the core further reformats the data into a standard format (STANAG 7023 has been selected based upon its robustness). At this point, any additional auxiliary data required by the destination format/system is automatically inserted. (Manual insertion is also available.) Data is then reformatted from the internal STANAG 7023 to an ICD compatible format via a bus to the I/O interface module. The I/O interface module, which is connected to the destination transport device (or directly to a host system imagery processor), then performs the necessary functions to convert the data to the specified destination format.

3.4.2 IMAGERY INFORMATION REFORMATTER FUNCTIONS

The Image Information Reformatter has several valuable functions in addition to the advantages discussed above. Some of these reformatter functions are:

- √ **Media Conversion.** The reformatter can be used to reformat sensor data from one media to another. Such as placing imagery on optical disc, or on magnetic disc, or converting 8 mm magnetic tape to 12.65 mm magnetic tape, etc.

- √ **Duplication.** This is similar to media conversion, however, the reformatter has the capacity to make multiple copies simultaneously. The number of simultaneous copies is directly dependent upon the speed of the slowest input /output device being used.

- √ **Front End Processor.** The reformatter can serve as a front end processor for any image processing system needing to reformat all input data into an internal processing format. The front end processing function also supports converting any sensor data format into any secondary dissemination format. This functionality assures that any sensor product can be disseminated to any user employing existing formats and communication systems.

- √ **Sensor Data Filter.** The reformatter can be used to filter out selected data as it is being input into the reformatter system. This can serve as a data reduction or speed reduction process. This function can also be used to downgrade selected imagery.

3.4.3 ADVANTAGES OF THE IMAGERY INFORMATION REFORMATTER (IIR) TO A RECONNAISSANCE PROGRAM

The Image Information Reformatter reduces the cost and time to accommodate a new source or destination format. With the integration of the IIR in any reconnaissance system, the addition of a new source or destination would require only the one time development of protocols to and from STANAG 7023 - "Air Reconnaissance Imagery Data Architecture" in order to transmit the data. There is no need to develop multiple direct conversion methods from every source format to every destination format. All that is needed is a method to convert the source format to the

STANAG 7023, and/or from STANAG 7023 to a new destination format. Thus, once in STANAG 7023, data from any unique sensor can be reformatted to any specific destination system/device. Without the reformatter an additional unique interface must be developed for each destination every time a new source or a new destination is added to the configuration.

The IIA Image Information Reformatter is directly and immediately applicable to a reconnaissance program by allowing the reconnaissance program to be interoperable with any other reconnaissance/exploitation/viewing system.

The following benefits are attained by a reconnaissance program when the IIA Image Information Reformatter is incorporated:

- √ Reconnaissance systems are able to receive and process reconnaissance/surveillance data collected by other systems with a minimum of system modifications.
- √ Imagery interoperability and commonality is achieved across all reconnaissance systems.
- √ The benefits of the IIA program are shared with all the systems using the IIR.

3.5 THE OPERATIONAL ADVANTAGES OF THE IMAGERY INTEROPERABILITY ARCHITECTURE

3.5.1 INTEROPERABLE IMAGE SURFACE STATION (IISS) OVERVIEW

When interoperability is achieved among all reconnaissance/surveillance and exploitation systems, the development of the Common Ground Station (CGS) becomes not just feasible but practical. A key component of the CGS is the exploitation or image system. A modular image processing system, which permits technology insertion and has the adaptability necessary for addressing unique user requirements, is an essential element for achieving an interoperable ground system. For the first time, with the acceptance of the IIA, it is now technically and operationally feasible to evolve an Interoperable Image Surface Station (IISS) which is capable of receiving, processing, and disseminating any imagery from any source. The IISS is a viewing/exploitation system that:

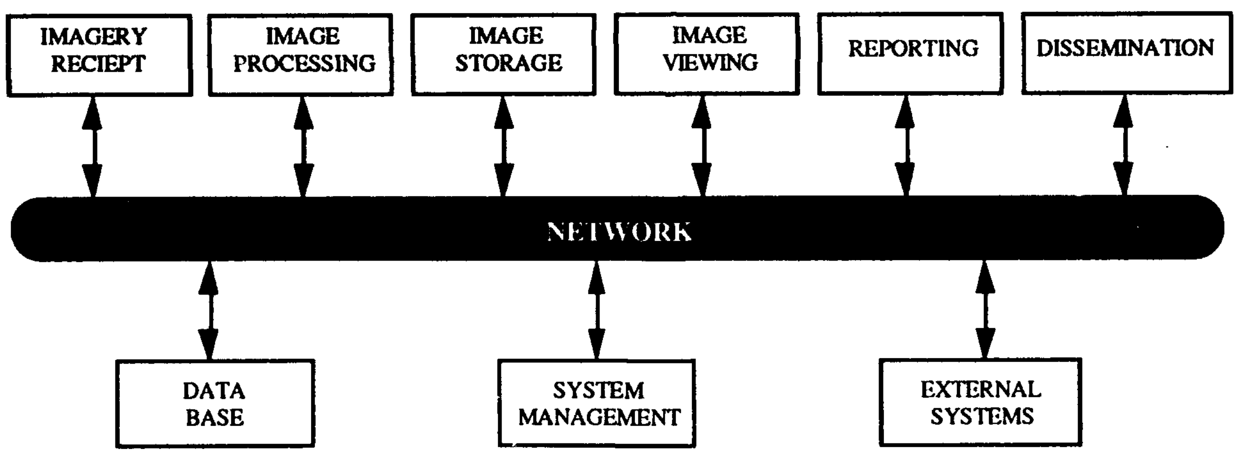
- √ Follows the Open System Architecture.
- √ Can receive and process any image.
- √ Is reconfigurable to meet all imagery viewing and exploitation needs.

Because the IISS follows the open system architecture it consists of common and non-common components. The IISS can be reconfigured to meet any image viewing or exploitation requirement. The IISS is an evolutionary system that can be expanded or changed to meet different imaging requirements and different levels of image verification. In order to meet these evolutionary requirements, the IISS must be developed using the International Standards Organization's Open Systems Interconnection (OSI) model. The OSI model establishes a set of standards for network protocols, point-to-point communication protocols, systems environments, and data transfer formats. This high level of standardization is also a de facto standard used in international, national, DoD, and commercial systems. These standards allow greater extensibility of the communications resources and application software, and scalability of system hardware and software. They also result in reduced maintenance support and training for both hardware and software, and establish a more consistent user interface across internal and external systems. The IISS will be developed using C, Ada, and other HOLs necessary to easily construct the software modules.

3.5.2 THE IISS OPEN SYSTEM ARCHITECTURE

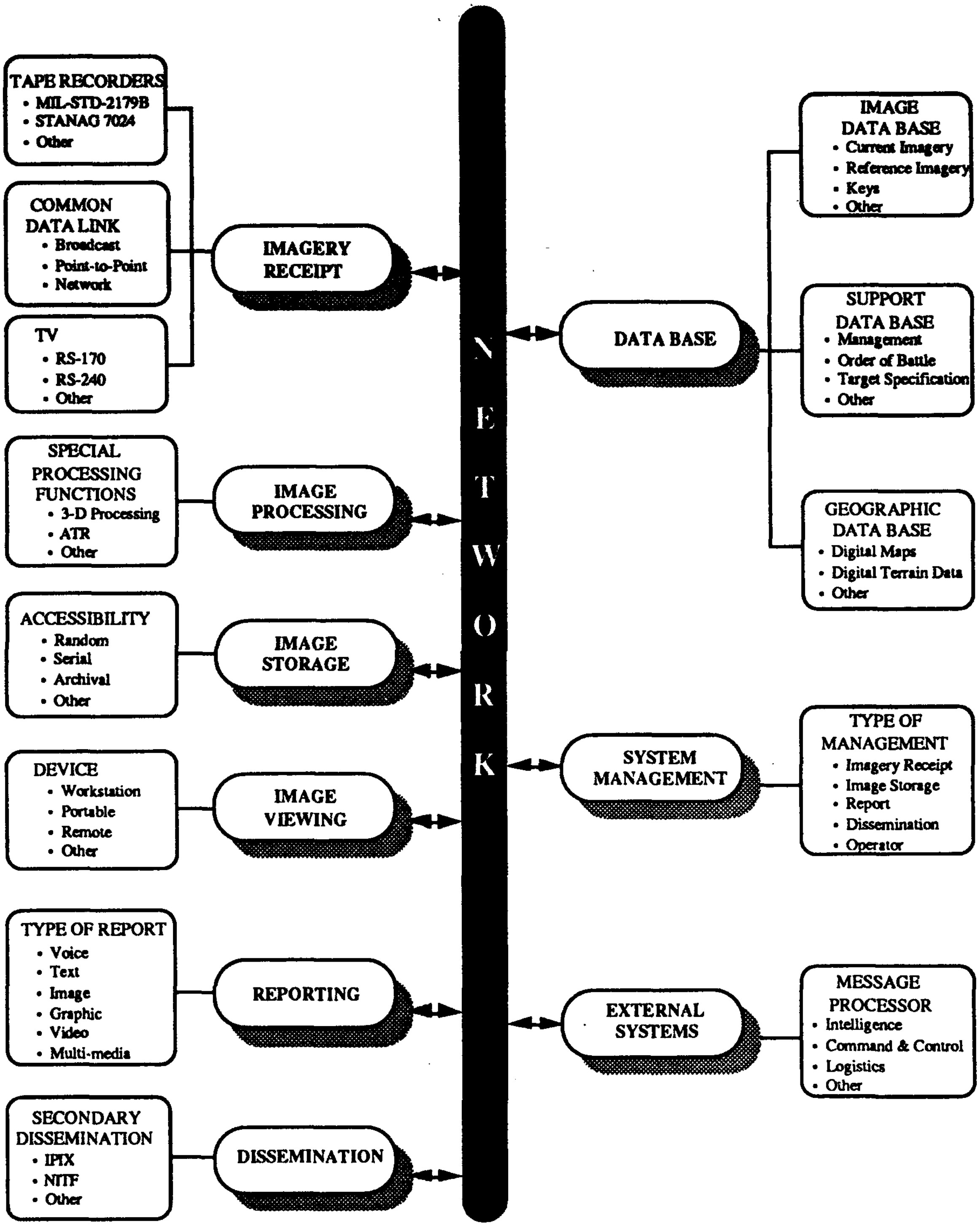
IISS will be developed in accordance with the standards established under the OSI model which provides guidelines for standard file transfer protocols and file formats for most data types. These standards enable vendors to read the data contained in another vendor's file. This allows multiple independent systems to be easily integrated into an interoperable system. The IISS environment includes: windowing, data base queries, graphics processing, imagery processing, interoperating system communication, Local Area Network(s) (LANs), and operating systems. The IISS transfer formats for all data types will include text, graphic, and imagery files. Throughout the IISS system environment, data integrity will be maintained and provisions will be included to ensure that no information is lost or that the quality of data is not compromised. Exhibit 13 illustrates the basic architecture of the IISS.

Exhibit 13
Basic Architecture of the IISS



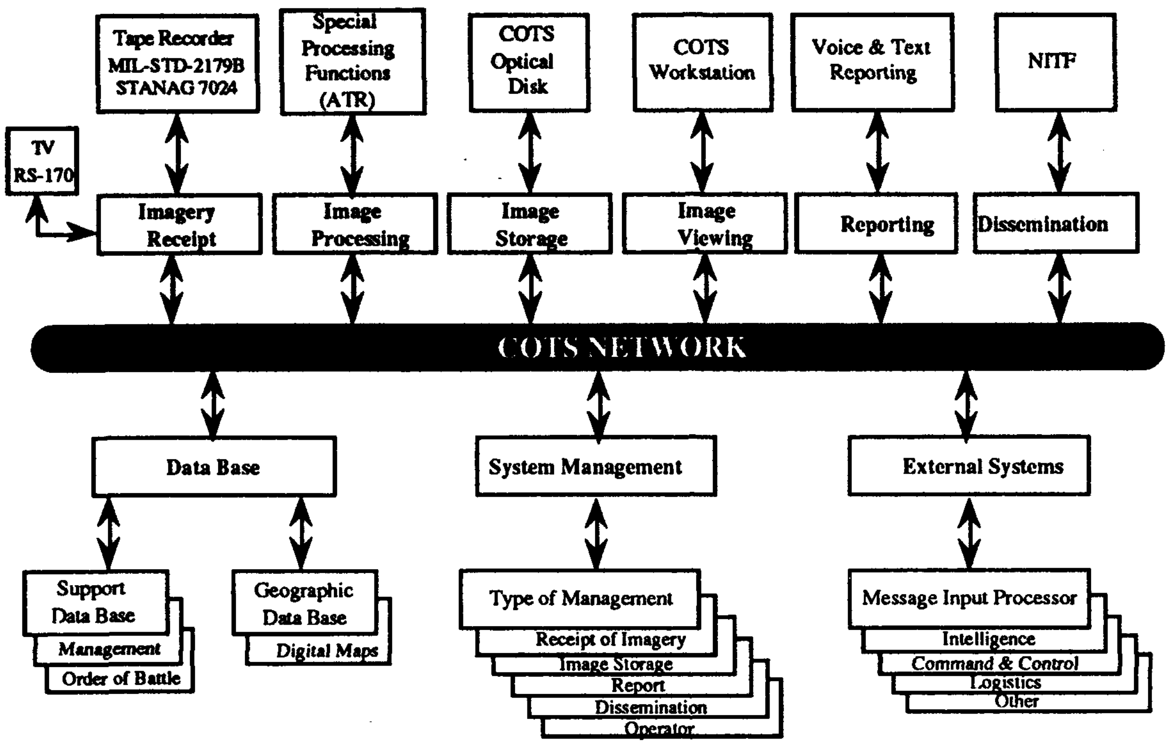
The IISS will be designed as an evolutionary system which can meet new functional requirements and incorporate new technology and advanced imagery processing systems as they are developed. In order to meet this system challenge, the IISS will be designed to provide interoperating systems support. This support consists of establishing the appropriate protocols, file formats, and system environment standards in a manner that will promote interoperability and extensibility without impacting the unique, internal needs of each specific system. The evolutionary potential of the IISS is illustrated in Exhibit 14.

Exhibit 14
An Example of the Modular IISS



The IISS open system architecture allows multiple systems to be integrated into a single functional component. The user workstation, which is the device used for viewing, exploiting, and reporting, along with the local area network (LAN) are the basic components of the IISS from which other configurations can evolve. Both of these systems have significant growth potential to increase the functional capabilities of the IISS. Other systems or components can also be integrated into the IISS. An example of an IISS configured to meet a specific operational need is illustrated in Exhibit 15.

Exhibit 15
An Example of an IISS Operational Configuration



3.5.3 WORKSTATION

The IISS workstation is the primary functional system that interfaces the operator with existing and evolutionary IISS capabilities. Critical in the design of the IISS is the system allocation of functions on either the workstation or onto another interoperating system. A workstation is generally divided into the following functional components: a display device, a man/machine interface control, and an input device.

4.0 SUMMARY

With the rising demand for timely high quality imagery and the steady decline in military budgets, interoperability, achieved through maximum use of technically sound, cost effective methods is critical for meeting operational requirements. Interoperability allows any ground system to receive, process and disseminate all imagery. When imagery interoperability is achieved any ground system can receive the necessary and appropriate information on:

√ What imagery has been collected and when it was collected.

- √ What imagery is planned to be collected and when it will be collected.
- √ Where and when a collector will be in range or view to data link the required imagery directly to the ground station.
- √ How imagery that has been collected can be transmitted to the ground station other than by directly down linking the imagery.

4.1 BENEFITS OF THE IMAGERY INTEROPERABILITY ARCHITECTURE

The Imagery Interoperability Architecture (IIA) is a cost effective, flexible means for achieving imagery interoperability among the digital electronic imagery assets of the United States and its allies. The reconnaissance program will gain numerous benefits by appropriately applying the IIA on new systems as well as existing systems. The IIA:

4.1.1 PROVIDES INTEROPERABILITY ACROSS THE RECONNAISSANCE FORCE STRUCTURE

First and foremost the IIA provides the capability to allow an image collected by one reconnaissance system to support the needs of a user of another collection system. By using the IIA, the user need not be aware of how his specific imagery needs are met.

4.1.2 LIMITS THE PROLIFERATION OF UNIQUE/DEDICATED SYSTEMS

Through the implementation of the IIA standards the need for unique and/or dedicated systems tends to disappear. If future reconnaissance systems follow the architecture then interoperability is assured.

4.1.3 ENHANCES COMBINED OPERATIONAL FLEXIBILITY

The IIA allows various reconnaissance systems and users' systems to be integrated into different configurations to meet any specific operational need. This attribute of the IIA is critical for meeting today's and tomorrow's military demands. Changes in military doctrine will occur and the military must be ready to respond.

4.1.4 REDUCES DEVELOPMENT COSTS

The basic reason for the establishment by the International Standard Organization of the OSI model was to reduce overall system development costs and to provide a more competitive development environment. By following this model for system development the IIA shares the same attributes as the OSI model. Standards allow competitive developers to propose different system and technology solutions to meet the same need.

4.1.5 PROVIDES COMMONALITY IN LOGISTICS AND TRAINING

As a variety of systems are developed that address similar functions, a greater degree of commonality in both logistic support and training is ensured when each system is implemented to meet the appropriate system standards.

4.1.6 MAXIMIZES THE BENEFIT OF OVERALL IMAGERY RECONNAISSANCE SYSTEMS INVESTMENT

When an imagery reconnaissance system incorporates the IIA it inherits a flexibility that allows it to fulfill the requirements for which it was developed, while also achieving the capability to expand its functionality to support a commander's changing operational requirements. The IIA provides the interoperability necessary for any system to interface with and disseminate information to any surface system requiring the collected imagery.

4.2 CONCLUSION

The Imagery Interoperability Architecture (IIA) is the key for achieving interoperability among all reconnaissance assets both U.S. and with those of our allies. Once imagery interoperability is established the development of an Interoperable Image Surface Station is attainable. The IIA provides the information and standards for a total reconnaissance force to get "*the right image to the right user at the right time.*" The IISS provides the system architecture to integrate both common and non-common components into a surface system that can receive any image at any time, thus meeting the military imagery needs for today and tomorrow.

The Image Exploitation Branch of Rome Laboratory's Intelligence and Reconnaissance Directorate is responsible for the the Imagery Interoperability Architecture. The point of contact is: Mr. Ronald B. Haynes, RL/IRRE, Griffiss AFB, New York, 13441-5700.

Appendix A

List of Documents Related to Imagery Interoperability Architecture

APPENDIX A

LIST OF DOCUMENTS RELATED TO IMAGERY INTEROPERABILITY ARCHITECTURE

DOCUMENT TITLE	AUTHOR	DATE	DOCUMENT CLASSIFICATION	TYPE OF DOCUMENT
Unmanned Vehicles	Defense News	18 February 1991	Unclassified	Article
Air Force Seeks Imaging Specs	Charlotte Adams Military & Aerospace Electronics	October 1991	Unclassified	Article
UAV Prospects Rising as Military Resistance Fades	Charlotte Adams Military & Aerospace Electronics	October 1991	Unclassified	Article
Combat Operations Garner Unmanned Aerial Support	Robert J. Roy Signal Magazine	April 1991	Unclassified	Article
Technical Glitches Stall Short-Range UAV Effort	Caleb Baker Defense News	6 May 1991	Unclassified	Article
Unmanned Vehicles	Defense News	17 June 1991	Unclassified	Articles
Unmanned Aerial Vehicle Interoperability	Arnold H. Lanckton Synectics Corporation	No Date	Unclassified	Briefing
UAV Interoperability Design Study (UNIDS)	Rome Laboratory Image Exploitation Branch	15 April 1991	Unclassified	Briefing
Electronic Imagery Interoperability	Ronald B. Haynes RADC/IRRE Mary B. DeMatteo Autometric, Inc. Thomas A. Galayda Autometric, Inc.	No Date	Unclassified	Briefing
DSPO Briefing to NATO on Datalinks Interoperability	Defense Support Project Office (DSPO)	No Date	Unclassified	Briefing
Future Unmanned Aerial Vehicle Reconnaissance Force Structure	Ronald B. Haynes USAF Rome Laboratory Arnold H. Lanckton Synectics Corporation	No Date	Unclassified	Briefing
NATO Interoperability for Multi-Service UAV's	Ronald Haynes USAF Rome Laboratory	20-21 February 1989	Unclassified	Briefing
Joint Services Imagery Processing System	E-Systems Garland Division	No Date	Unclassified	Briefing

DOCUMENT TITLE	AUTHOR	DATE	DOCUMENT CLASSIFICATION	TYPE OF DOCUMENT
Common Data Link Architecture Task Force	AFSC, AFLC, AFCC, SAC, TAC, AFSPACECOM, Air Staff Final AF Working Level Review	6 December 1988	Unclassified	Briefing
NATO Interoperable Data Link Study - Task #8 Presentation Materials for the NIIDLS Ad Hoc Working Group Meeting	Harris Corporation	31 January 1991	Unclassified	Briefing
NATO Tactical Reconnaissance Data Link	William D. Lindsay UNISYS Corporation Communication Systems Division	25 October 1988	Unclassified	Briefing to NATO Air Group IV London, England
Basic Mission Planning Considerations for the Joint Non-Lethal UAV Family Volume I Executive Summary	The Directorate for C^3I Technology Applications Electronic Systems Division (AFSC)	December 1990	Unclassified	Executive Summary
NATO Interoperable Imagery Data Link Study (NIIDLS)	NATO Interoperable Imagery Data Link Study Ad Hoc Working Group Mr. Ron Haynes Chairman	January 1991	Unclassified	Final Report
Unmanned Aerial Reconnaissance Vehicle Imagery Interpretation - Task 21	Katherine A. R. Jones Lee Helser Boeing Defense and Space Group	9 April 1991	Unclassified	Final Report
Unmanned Aerial Vehicle - Short Range Battlefield Communications Demonstration Report No.: H-91-02	Joe D. Smith System Dynamics International, Inc.	January 1991	Unclassified	Final Report for U.S. Army Missile Command
RPV Feasibility for Small NATO Ships	Gary L. LaMonica Chairman, Mission Essential Equipments Committee Loral Defense Systems-Arizona	December 1988	Unclassified	Final Report to Special Working Group/11
Architecture for Electronic Imagery Interoperability (RADC-TR-90-257)	Autometric, Inc.	August 1990	Unclassified	Final Technical Report

DOCUMENT TITLE	AUTHOR	DATE	DOCUMENT CLASSIFICATION	TYPE OF DOCUMENT
Imagery Interpretation Requirements for Reconnaissance Systems (RADC-TR-90-370)	RADC/IRRE Knowl[illegible]ge Systems Conce[illegible]	1990	Unclassified	Final Technical Report
Concept Feasibility Analysis: UAV Data Link Commonality/Modularity Final Technical Report	Thomas J. Gleason Gleason Research Associates, Inc.	September 1989	Unclassified	Final Technical Report for US Army Missile Command, Research, Development, and Engineering Center
Interface Requirements Specification for the TAF Unit-Level Open System Architecture (ULOSA) Common User Interface (Draft - Revision 1)	Electronic Systems Division	14 February 1990	Unclassified	Interface Requirements Specification (IRS)
Implementing the Imagery Interoperability Architecture	Autometric, Inc.	August 1991	Unclassified	Interim Report
Unmanned Aerial Vehicle Master Plan 1991	Department of Defense	1 March 1991	Unclassified	Master Plan
Unmanned Aerial Vehicle Master Plan	Department of Defense	16 February 1990	Unclassified	Master Plan
Minutes of the Reconnaissance and Intelligence Panel for the Common Data Link	Robert Bishop, Capt ATARS Data Link Mgr ATARS Program Officer	October 1988	Unclassified	Meeting Minutes
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Travel Duty Report: AFSC/XTKP Data Link Working Group	Ronald Haynes	15 December 1988	Unclassified	Travel Duty Report

Appendix B

Points of Contact

APPENDIX B

POINTS OF CONTACT

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STANAG 7024	Mr. Ronald Haynes	Rome Lab/IRRE Griffiss AFB, NY 13441	315-330-4592
Reconnaissance Data Exchange Standard (RDES)	Mr. Ronald Haynes	Rome Lab/IRRE Griffiss AFB, NY 13441	315-330-4592

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