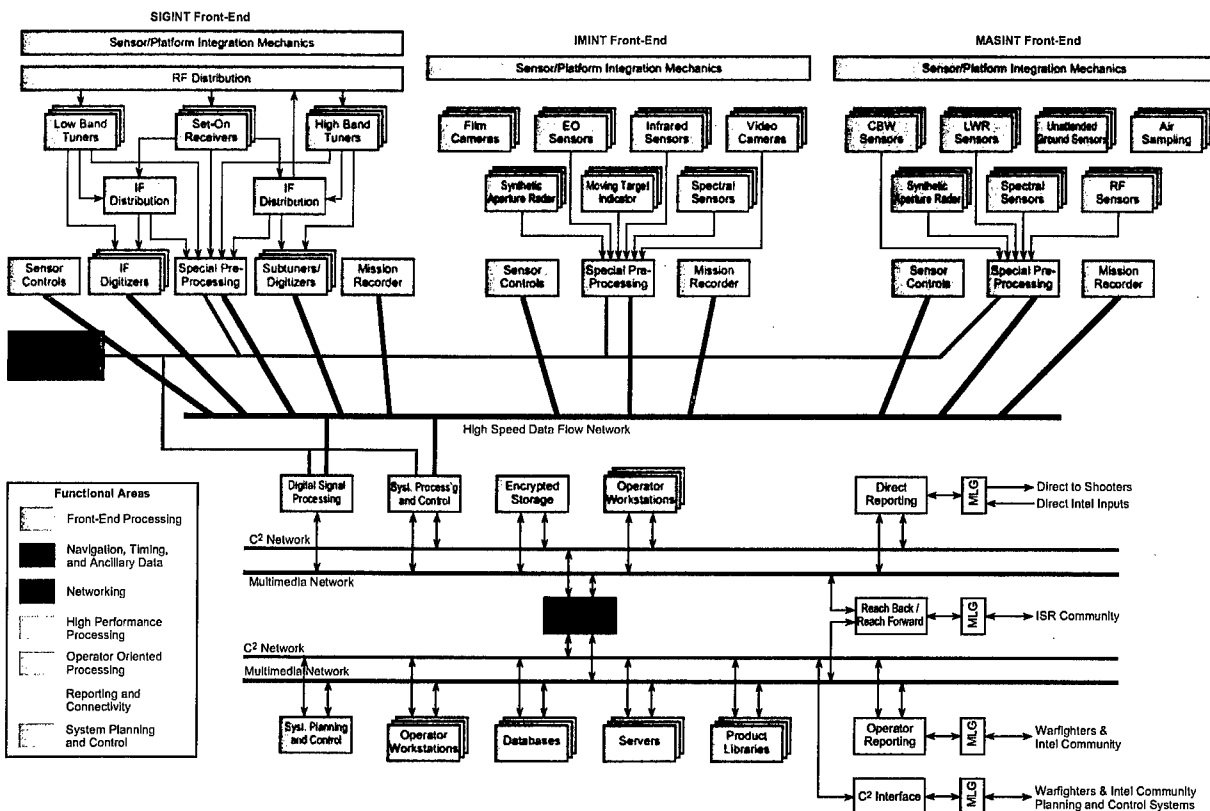




Airborne Reconnaissance Information Technical Architecture

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13. ABSTRACT (Maximum 200 words) The Airborne Reconnaissance Information Technical Architecture (ARITA) in conjunction with the <i>DoD Joint Technical Architecture</i> (JTA) provides the technical foundation for migrating airborne reconnaissance systems towards the objective architecture identified in the DARO <i>Integrated Airborne Reconnaissance Strategy</i> (IARS) and in the various program plan documents published by the DARO. Migrating from today's stove-piped systems to the objective airborne reconnaissance architecture by the year 2010 is highly dependent upon achieving the concepts promulgated by <i>C4I for the Warrior</i> , other DoD technical architectures, and Service/Agency operational architectures. The ARITA supports four (4) objectives that provide the framework for meeting warfighter requirements: (1) it provides the foundation for the seamless flow of information and interoperability among all airborne reconnaissance systems and associated ground/surface systems that produce, use, or exchange information electronically; (2) it establishes a minimum set of standards and technical guidelines for the development and acquisition of new, improved, and demonstration systems to achieve interoperability, with reductions in costs and fielding time; (3) it ensures interoperability with warfighter C4I systems and enables development of new or alternative connectivities and operational plans for specific mission scenarios for airborne reconnaissance systems; and (4) it provides the framework of attaining interoperability with space-based and other intelligence, surveillance and reconnaissance systems. The ARITA has recently been accepted as the <i>Airborne Reconnaissance Annex</i> to the DoD JTA.				
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AIRBORNE RECONNAISSANCE INFORMATION TECHNICAL ARCHITECTURE



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1. Introduction

This *Airborne Reconnaissance Information Technical Architecture* (ARITA) document, in conjunction with the *DoD Joint Technical Architecture* (JTA) document, provides the technical foundation for migrating airborne reconnaissance systems towards the objective architecture identified in the *Integrated Airborne Reconnaissance Strategy* and in the various program plan documents of the Defense Airborne Reconnaissance Office (DARO). That objective architecture (depicted in Figure 1-1) is a high-level vision of the migration plans and major thrusts to achieve the capabilities, connectivities, and interoperability required of airborne reconnaissance systems. In concert with space-based systems, this objective architecture will support the warfighter with responsive and sustained intelligence data from anywhere, day or night, regardless of weather. The objective architecture is best described as a responsive, full spectrum information architecture centered on satisfying the commander's reconnaissance information requirements across the operational continuum.

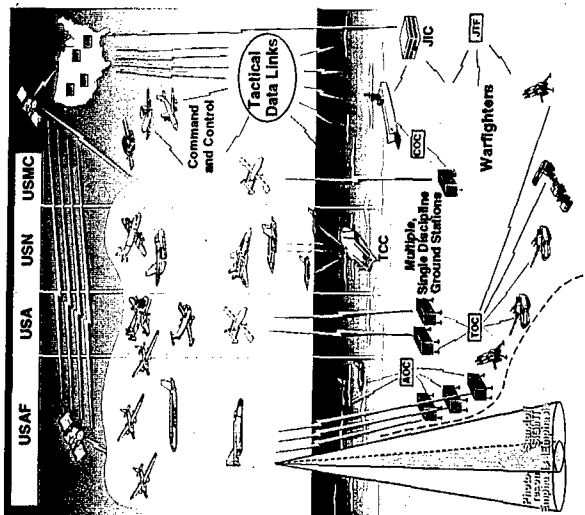
Migrating from today's stove-piped systems to the objective architecture by 2010 is highly dependent upon achieving the concepts promulgated by *C⁴I For The Warrior*, other DoD technical architectures, and Service/Agency operational architectures. These architectures, including the ARITA, result in system architectures and migration plans which include performance capabilities, development and modification schedules, and projected costs. The system architectures and migration plans are in turn impacted by Service/Agency program priorities, OSD and JCS guidance/decisions, and Congressional budget decisions and program direction resulting in overall DARO investment strategies. These strategies ensure that airborne reconnaissance systems will become interoperable, integrated with the warfighter and intelligence community systems, and capable of "delivering the right data, to the right user, at the right time."

This section describes the purpose, background, and scope of the ARITA document; describes the relationship between three levels of architectures and two reference models; gives the criteria for selecting standards, and summarizes what's in this document.

From today's vertically integrated systems...

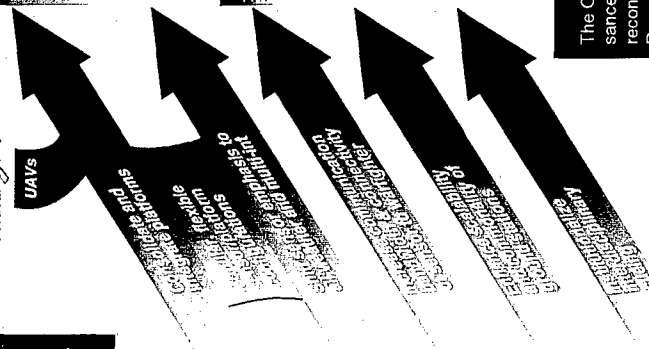
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Capable but relatively inflexible systems developed by a given Service in support of a specific intelligence discipline work well with one type of airborne platform and may be interoperable to a limited degree with others. But the lack of joint integration across disciplines and the lack of reconfigurability of the airborne and ground elements limits operational flexibility for the warfighter and unnecessarily complicates operations, maintenance, and logistics support.

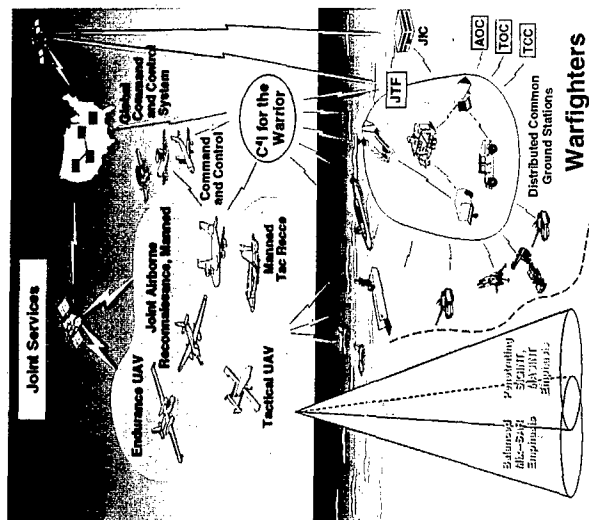


ARCHITECTURE MIGRATION PLAN

Endurance
Tactical
UAVs



OBJECTIVE 2010



The Objective Architecture effectively addresses extended reconnaissance. Significant changes in process, priorities, and direction of the reconnaissance force mix will include Advanced Concept and Technology Demonstrations to deliver capabilities to the warfighter quickly and cost-effectively. Inter- and intra-theater communications using C4I for the Warfighter will balance airborne and national contributions. The architecture will flexibly meet the ultimate goal—SERVICE TO THE WARFIGHTER.

Figure 1-1: Migration to the Objective Architecture

1.1 Purpose

The ARITA supports four mutually supporting objectives that provide the framework for meeting warfighter requirements. First and foremost, the ARITA provides the foundation for seamless flow of information and interoperability among all airborne reconnaissance systems and associated ground/surface systems that produce, use, or exchange information electronically. Second, it establishes the minimum set of standards and technical guidelines for development and acquisition of new, improved, and demonstration systems to achieve interoperability, with reductions in costs and fielding times that would be unachievable without a technical architecture. Third, it ensures interoperability with warfighter C⁴I systems and enables development of new or alternative connectivities and operational plans for specific mission scenarios for airborne reconnaissance systems. And fourth, it provides the framework for attaining interoperability with space-based and other intelligence, surveillance, and reconnaissance (ISR) systems.

Specific goals for the ARITA are:

- Maximize interoperability;
- Minimize duplication of development;
- Be adaptable to new requirements, preferably through software reconfiguration;
- Be extensible by enabling modular increases in system capabilities;
- Leverage commercial technology and standards;
- Allow functionality to be optimized for mission and platform;
- Make provisions for retaining required legacy systems;
- Provide mechanisms for cross-sensor cueing to improve ISR capability; and
- Support multiple platform operations using like or dissimilar platforms and sensors improve precise geolocation.

The ARITA applies to all airborne reconnaissance and associated ground/surface systems. Senior Officers/Officials, Service Acquisition Executives (SAE), Program Executive Officers (PEO), System Program Office (SPO) Directors,

Program/Product Managers (PMs), Advanced Technology Demonstration (ATD) Managers, and Advanced Concept and Technology Demonstration (ACTD) Managers are responsible for incorporating ARITA standards into their respective programs. Developers will use the ARITA to ensure that products meet interoperability, performance, and sustainment criteria. Operations and Intelligence organizations will use the ARITA in developing requirements, operational plans and functional descriptions. Technology demonstrators will use the ARITA to ensure that the fielding of "good ideas" and "new technologies" are not unduly delayed by the cost and time required for wholesale reengineering to meet interoperability requirements and integrate with other airborne reconnaissance and warfighter systems.

1.2 Background

The evolution of national military strategy in response to post cold war era events combined with the economic reality of a shrinking budget has resulted in a new vision for the Department of Defense (DoD). This vision is most commonly known as *C⁴I For The Warrior* concept as documented in *Joint Pub 6-0*. Under this concept, there is increased reliance on information systems to provide the decisive edge in combat and to improve the military worth of DoD systems.

The Services have developed corresponding visions in the following documents:

- The Army Enterprise Strategy: The Vision
- The Air Force Strategy: Horizon FY95
- The Navy Strategy: Copernicus Forward
- The Marine Corps Strategy: MAGTF/C4I

The Chairman, Joint Chiefs of Staff is developing the "*Joint Vision 2010*" which envisions seamless integration of all ISR systems to achieve precision engagement, dominant maneuver, focused logistics, and full dimensional protection. To attain that vision, airborne reconnaissance systems must achieve and maintain interoperability across a continuum of six dimensions at once:

- Reconnaissance (and surveillance) Systems: Space, airborne, ground, and surface

- Command, Control, Communications, Computers and Intelligence (C⁴I) & Support: Command and control, intelligence, logistics, and Warfighter support
- Forces: National Command Authority, commanders, and warfighters
- Joint/Coalition: Coalition, Joint, CINC, Joint Task Force, and Services
- Power Projection: Sustaining base, split base, and forward based
- Time/Technology: Backward and forward compatibility

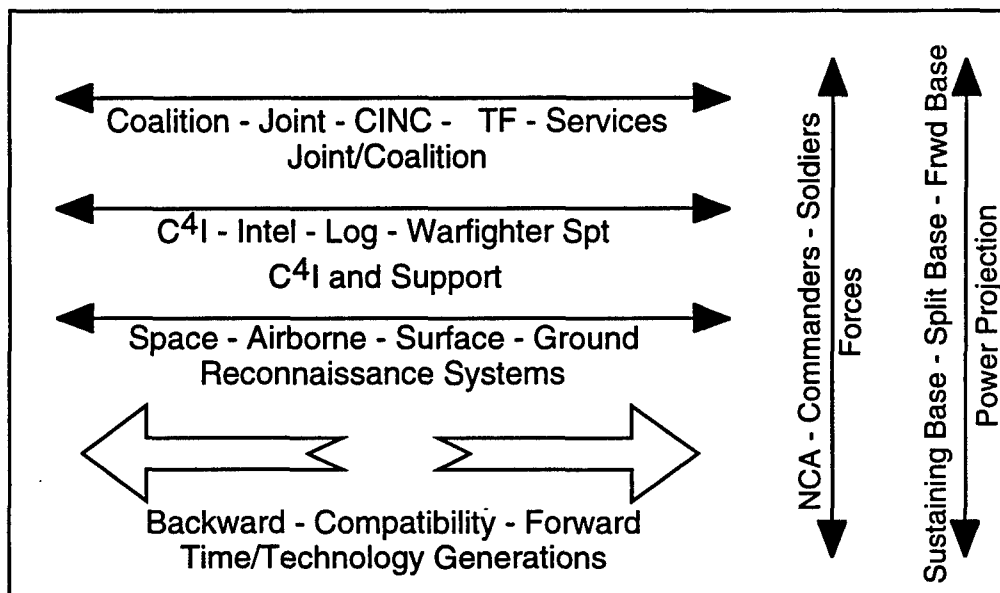


Figure 1-2: The Dimensions of Interoperability

To achieve interoperability, it is imperative that standards are uniform across all DoD information systems. The DoD has accelerated implementation of standards within DoD information systems through new and revised policy initiatives. These initiatives include the DoD Joint Technical Architecture for achieving DoD-wide inter-system interoperability and increased integration of commercial technology in DoD systems. For the warfighters, these initiatives will provide seamless, transparent operation of airborne reconnaissance systems and other DoD systems, enabling them to work together to provide higher quality support at lower cost.

1.3 Scope

Guiding and controlling the acquisition of interoperable C⁴I systems requires the use of architectures, reference models, and standards. The use of these tools to understand and analyze complex systems is well understood and used throughout the DoD. The CINCs, Services, and Agencies use architectural constructs to support a variety of objectives, such as visualizing and defining operational and technical concepts, identifying requirements, guiding systems development and implementation, and improving interoperability. This section introduces the reference models used to define the technical architecture for airborne reconnaissance, explains the relationship of the ARITA with other standards documents, and cites the criteria for selecting standards.

1.3.1 Architectures Defined

The proliferation of “architectures” within the DoD C⁴I and information systems communities prompted the Office of the Secretary of Defense (OSD) to task a Defense Science Board study in 1994, which resulted in the Joint Chiefs of Staff approving formal architectural definitions. These definitions have been adopted for the ARITA and are described below. Figure 1-3 shows the relationship among the three defined architectures and how the ARITA fits into the overall scheme.

1.3.1.1 Operational Architecture

An Operational Architecture is “a description (often graphical) of the operational elements, assigned tasks, and information flows required to support the warfighter. It defines the type of information, the frequency of exchange, and what tasks are supported by these information exchanges.” (C4ISR)

1.3.1.2 Systems Architecture

“The systems architecture defines the physical connection, location and identification of the key nodes, circuits, networks, warfighting platforms, etc., associated with information exchange and specifies systems performance parameters. The systems architecture is constructed to satisfy operational architecture requirements per the standards defined in the technical architecture.” (C4ISR)

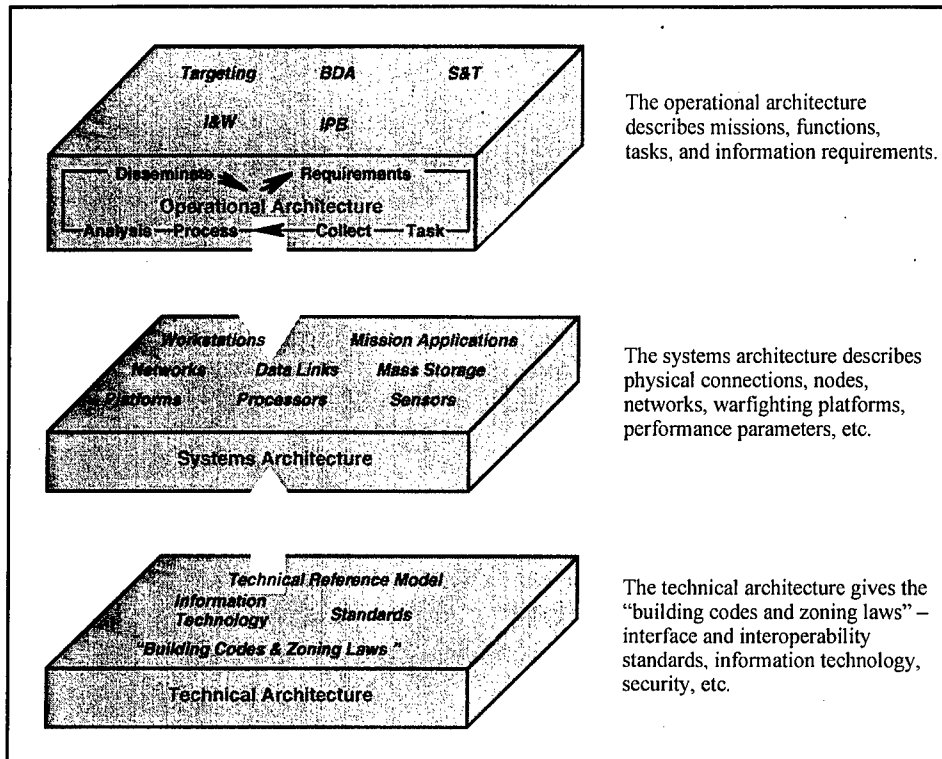


Figure 1-3: Architectures Defined

1.3.1.3 Technical Architecture

A Technical Architecture is a “minimal set of rules governing the arrangement, interaction, and interdependence of the parts or elements whose purpose is to ensure that a conformant system satisfies a specific set of requirements. It identifies system services, interfaces, standards, and their relationships. It provides the framework, upon which engineering specifications can be derived, guiding the implementation of systems.” (C4ISR)

1.3.2 Dual Reference Models

“Architectures” address multiple aspects crossing the boundaries of operational, technical, and system level architectures (as defined above). The ARITA focuses on the technical architecture level, and it specifically identifies only those standards that have a direct bearing on airborne reconnaissance systems.

In order to achieve the desired focus, the ARITA uses two reference models: a functional reference model (FRM) and a technical reference model (TRM). These complementary frameworks (or perspectives) are used to present and discuss the technology and information standards selected for airborne reconnaissance systems.

The FRM, described in Section 3, depicts the generic, functional makeup of airborne reconnaissance systems and shows how the various functions are interrelated. It is particularly well suited for showing which specific technology standards apply to each functional area.

The TRM, described in Section 4, reflects the Technical Architecture Framework for Information Management (TAFIM) Volume 2, Version 3 which focuses on information technology (IT) standards that apply to specific parts of the FRM (e.g., the operator-oriented processing functions). It is well suited for showing which IT standards have been selected for airborne reconnaissance systems and depicting how the standards relate to each other.

1.3.3 Basis for the ARITA

The ultimate objective for any technical architecture is to influence the design and implementation of actual systems to improve their interoperability and enable incremental migration through technology insertion. No developer can completely predict future requirements for interoperability among multiple, complex systems given the rapid advancement of technology and changing/unpredictable military operations. The standards-based framework defined by a technical architecture facilitates construction of new system-to-system interfaces when needed (or envisioned) with lower costs, faster implementation, and lower technical risk than would otherwise be incurred. Equally important, the standards-based framework also enables insertion of advanced technology into legacy systems with lower costs, faster implementation, and lower technical risk than would otherwise be incurred. By enabling this flexibility – changing interconnections and inserting advanced technology when needed – a technical architecture serves to facilitate “incremental migration” whereby actual systems can provide increasing military worth while adapting to keep pace with evolving warfighter operational requirements.

The basis for the ARITA is depicted in Figure 1-4. It focuses on the specific needs of an airborne reconnaissance architecture, but it also ties-in to the various DoD,

CINC, Service, and Agency architectures to ensure the best possible ISR support for the warfighters.

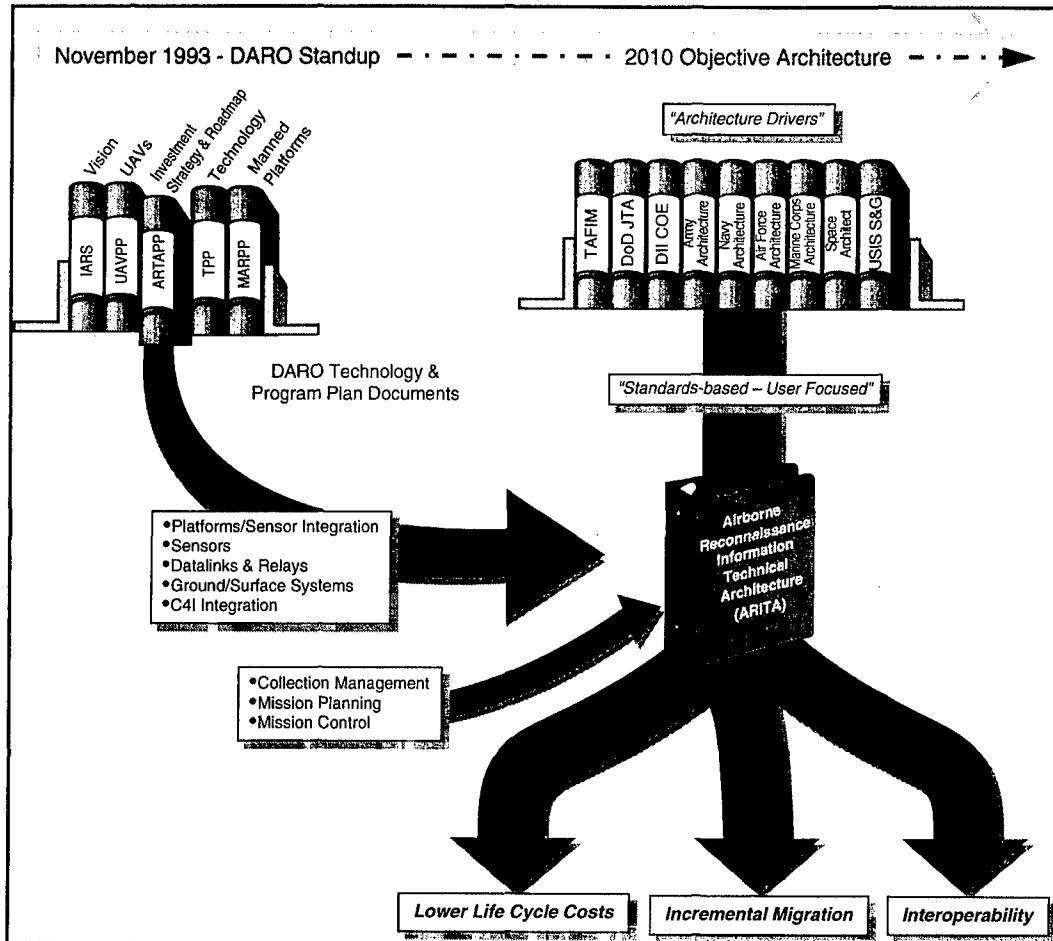


Figure 1-4: Basis for the ARITA

1.3.4 Relationships of ARITA and Other Standards Documents

As depicted in Figure 1-5, the ARITA is a DoD-level standards document. It complements the Defense Information Infrastructure Common Operating Environment (DII COE) and DoD Joint Technical Architecture (JTA) which define overall standards for DoD C4I systems. That is, the ARITA adds standards required for an airborne reconnaissance "domain." The DII COE, JTA, and ARITA all follow the DoD Technical Architecture Framework for Information

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Management (TAFIM) and other guidance provided by the Open Systems Joint Task Force (OS-JTF).

Discipline-specific standards handbooks provide detailed, implementation level, standards guidance for specific interrelated systems. In essence, these handbooks combine the DoD level technical architecture standards with: (1) program-specific acquisition guidance such as master migration plans and common development responsibilities; and (2) other DoD-level standards and guidelines developed specifically for SIGINT, IMINT, and MASINT communities. There are currently two standards handbooks governing airborne reconnaissance systems: the Joint Airborne SIGINT Architecture (JASA) Standards Handbook and the Common Imagery Ground/Surface System (CIGSS) Acquisition Standards Handbook. These standards handbooks were written by the developers and provide the most specific guidance for implementing interrelated systems (e.g., the joint SIGINT and common imagery umbrella programs shown in the diagram).

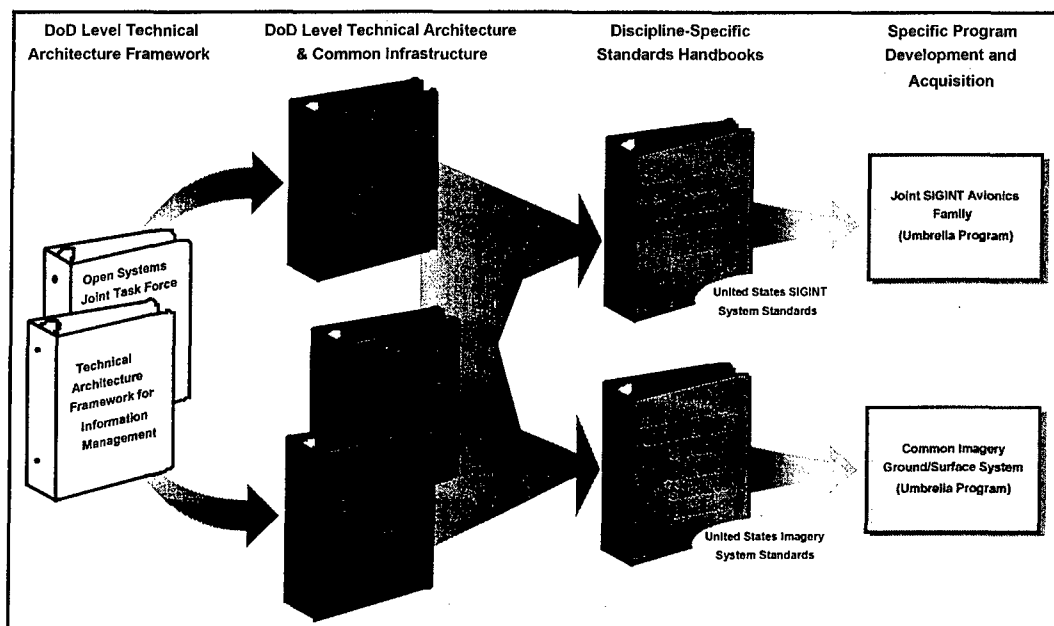


Figure 1-5: Relationships of ARITA and Other Standards Documents

1.3.5 Criteria for Selecting Standards

The selection criteria used in developing the ARITA generally focused on identifying standards and guidelines determined to be critical for interoperability, implementable, and used commercially or widely used throughout the DoD (in cases where commercial standards are not available). As with the DoD's recent initiative to define the Joint Technical Architecture (see Section 2.1.4), the standards selected for the ARITA should meet all of the following criteria:

- **Interoperability and/or Business Case** — They ensure joint Service/Agency information exchange and support joint (and potentially combined) C4I operations, and/or there is strong economic justifications that the absence of a mandated standard will result in duplicative and increased life-cycle costs.
- **Maturity** — They are technically mature and stable.
- **Implementability** — They are technically implementable.
- **Public** — They are publicly available (e.g., open systems standards).
- **Consistent with Authoritative Sources** — They are consistent with law, regulation, policy, and guidance documents.

Standards that are commercially supported in the marketplace with validated implementations available in multiple vendors mainstream commercial products take precedence. Publicly held standards are generally preferred. International, national, and industry standards are preferred over military or other government standards.

The ARITA includes document and selected technology standards. Document standards include commercial, international, national, federal, military, NATO, and other government standards. Selected technology standards identify critical elements of the ARITA deemed essential to achieve the goals described in Section 1.1. Together, the selected standards provide descriptions of the engineering and design criteria and specific technical requirements that must be satisfied by airborne reconnaissance systems.

1.4 Document Organization

The ARITA consists of five sections. This section is the introduction and overview. The next four sections are:

Section 2 Associated Technical Architectures – Identifies the principal sources from which standards were selected and tailored for the ARITA.

Section 3 Airborne Reconnaissance Functional Reference Model and Selected Technology Standards – Describes the FRM and identifies technology selected for specific functional areas in the ARITA.

Section 4 Airborne Reconnaissance Technical Reference Model and Information Technology Standards – Describes the TRM and identifies information technology (IT) standards selected for specific IT areas in the ARITA.

Section 5 Follow-On ARITA Activities – Identifies the key follow-on activities required for further development of the ARITA.

1.5 What's New in this Version

This is the first release of the ARITA document. This section will summarize the changes made in subsequent revisions.

1.6 Configuration Management

This document is under configuration control of the ARITA Working Group, which meets periodically (currently monthly) to review proposed changes to the ARITA. Please send all comments to the ARITA secretariat, C/O MITRE Corporation, Mail Stop Z030, 1820 Dolley Madison Blvd., McLean, VA 22102-3481.

2. Associated Technical Architectures

This section provides an overview of the principal sources from which standards were selected and tailored for the ARITA. The ARITA synthesizes across those architectures, identified in the following figure, and tailors them to reflect the needs of airborne reconnaissance systems. In general, the ARITA adopts standards already mandated by the DoD, Services, and intelligence community organizations (e.g., CIO, NSA) to serve the needs of the airborne reconnaissance acquisition community. In addition, future versions of the ARITA will identify follow-on standards initiatives to address standardization areas that are critical for airborne reconnaissance but are not being addressed in other forums.

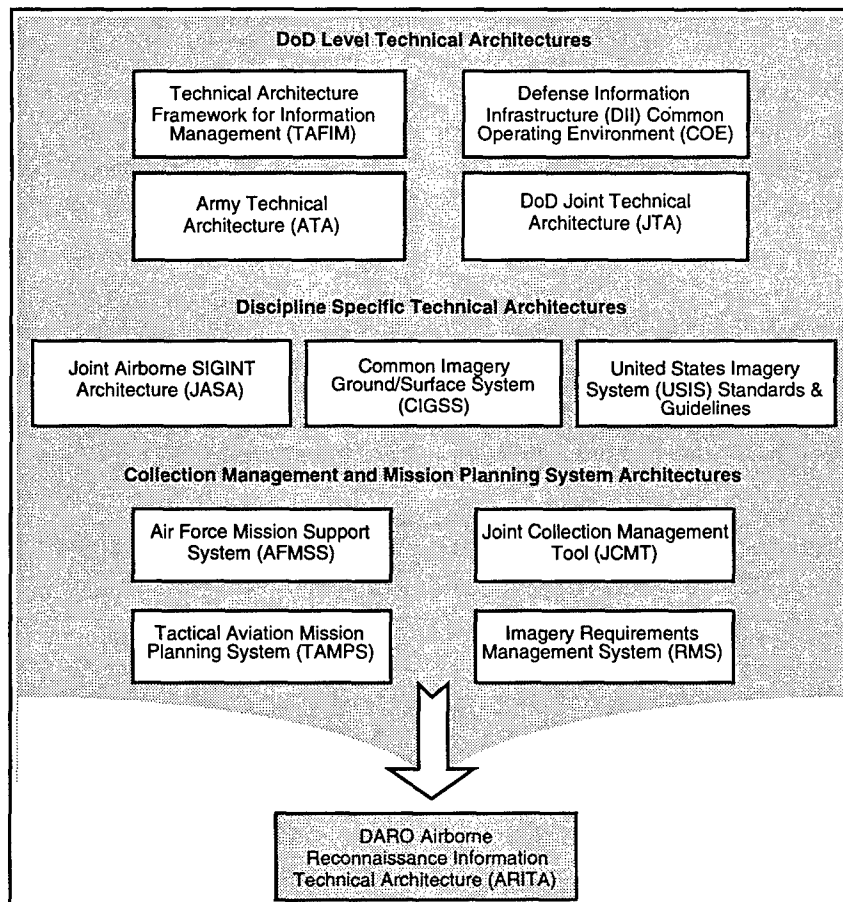


Figure 2-1: Associated Architectures

2.1 DoD Level Technical Architectures

2.1.1 Technical Architecture Framework for Information Management

The Technical Architecture Framework for Information Management (TAFIM) provides a technical architecture definition that documents the services, standards, design concepts, components, and configurations used to guide the development of other technical architectures. The underlying premise of the TAFIM is implementation of an open systems environment for information systems. This environment allows information systems to be developed, operated, and maintained independent of applications or proprietary vendor products. Open systems are characterized by their use of standards to define services, interfaces, and formats. The TAFIM uses international, national and federal standards, which are adopted by industry, and standards agreed to by the U.S. and its allies, as well as selected DoD standards. By implementing well-defined, widely-known and consensus-based standards, the DARO can leverage the industry investments in the commercial market and assure a migration path into the future.

2.1.2 Defense Information Infrastructure Common Operating Environment

The Defense Information Infrastructure (DII) Common Operating Environment (COE) describes the requirements for building and integrating C⁴I systems for the warfighters. It represents the basis for end-user warfighter systems that reconnaissance assets support. This makes the DII COE a very important technical source for developing the ARITA.

The DII COE is a “plug and play” open software architecture designed around a client/server model. It provides implementation details that describe, from a software development perspective, the following:

- The COE approach to software reuse,
- The COE runtime execution environment,
- The definition and requirements for achieving COE compliance,
- The process for automated software integration, and
- The process for electronically submitting/retrieving software components to/from the COE software repository.

The DII COE concept is best described as an architecture that is fully compliant with the TAFIM, an approach for building interoperable systems, a collection of reusable software components, a software infrastructure for supporting mission area applications, and a set of guidelines and standards. The guidelines and standards specify how to reuse existing software, and how to properly build new software so that integration is seamless and automated.

Two systems presently use the DII COE: the Global Command and Control System (GCCS), and the Global Combat Support System (GCSS). Both use the same infrastructure and integration approach, and the same COE components for functions that are common between the two systems. GCCS is a C⁴I system with two main objectives: the near-term replacement of the World-Wide Military Command and Control System (WWMCCS) and the implementation of the *C⁴I For the Warrior* concept. GCCS is already fielded at a number of operational CINCs. GCSS is presently under development and is targeted for the warfighting support functions (logistics, transportation, etc.) to provide a system that is fully interoperable with the warfighter C⁴I system.

2.1.3 Army Technical Architecture

The Army Technical Architecture (ATA) was developed by the Army Staff, Army Systems Engineering Office, Army Science Board, MACOMs, and PEOs/PMs to support the Army Enterprise Strategy. The ATA is based on the TAFIM, DoD Directive 8320 series governing data standardization, and the Army's initiatives for streamlining the acquisition process. It mandates the use of the DII COE for software development, the use of specific network protocols and message formats for data transport, the use of the Defense Data Dictionary System for data management, and the use of IDEF for information modeling. It also establishes human-computer interface standards and delineates standards for information security. The ATA capitalizes on the substantial investment commercial industry has made in information technologies.

2.1.4 DoD Joint Technical Architecture

DISA is leading the creation of the Joint Technical Architecture (JTA) with strong participation from the Services, Agencies, and (recently) the DARO. The JTA mandates certain "rules" to be used across DoD to provide specific services and interfaces in systems being procured today. All standards mandated are required

for interoperability (unless there is a strong business case against it); must be mature, technically implementable, and publicly available; and must be consistent with authoritative sources. Commercial product availability is a very high priority. The scope is focused on C⁴I interoperability for the warfighter, and later versions will address other domains (including the sustaining base, airborne reconnaissance, and weapon systems).

2.2 Discipline Specific Technical Architectures

There are currently three on-going efforts for developing discipline-specific technical architectures: (1) Joint Airborne SIGINT Architecture, (2) Common Imagery Ground/Surface System Architecture, and (3) United States Imagery System Standards and Guidelines. These are discussed in the following subsections.

2.2.1 Joint Airborne SIGINT Architecture

The Joint Airborne SIGINT Architecture (JASA) is the DoD's plan for meeting the warfighter's 2010 airborne SIGINT requirements and beyond. The fundamental philosophy behind JASA is to leverage the digital signal processor (DSP) technology investment of commercial industry to counter the ever growing population of varied radio frequency (RF) signals, reflecting a variety of modulation schemes and signal multiplexing structures. By digitizing the signal early in the sensor system, common hardware processing can be used that is independent of signal type, reducing the need for signal specific specialized hardware. This approach to signal processing increases the flexibility and overall capacity of the SIGINT system, which must rapidly respond to the explosion of digital signals in the environment. Key characteristics of JASA are that it will:

- Be an open architecture
- Facilitate digitization close to the RF front-end with a few standardized intermediate frequencies
- Incorporate a high bandwidth digital local area network onto which both general and specific processors can be connected
- Have interface standards to allow for connectivity between various hardware implementations
- Maximize the use of commercial-off-the-shelf (COTS) technology

The initial version of the JASA functional architecture was approved by the DARSC and published in June 1995. The airborne reconnaissance functional reference model described in Section 3 of this document is the JASA model with adaptations needed for the overall multi-discipline ARITA.

Version 1.0 of the *JASA Standards Handbook* developed by the JASA Standards Working Group was published in July 1996. Standards identified in that document have been incorporated in the ARITA.

2.2.2 Common Imagery Ground/Surface System Architecture

The first version of the *Common Imagery Ground/Surface System (CIGSS) Acquisition Standards Handbook* was published in June 1995. Standards from that document have been incorporated in ARITA. The CIGSS architecture is depicted in Figure 2-2.

The CIGSS concept has been approved by the JROC and is fully supported by the Services. It is not a system in the traditional sense; instead, CIGSS is an umbrella program which defines interoperability, performance, and commonality requirements and standards for DoD ground/surface based imagery processing and exploitation systems. It consolidates the following systems into a single DARP project:

- The Joint Service Image Processing System (JSIPS) program – including Navy, Air Force, and Marine Corps
- The Army's Enhanced Tactical Radar Correlator (ETRAC)
- The Army's Modernized Imagery Exploitation System (MIES)
- The imagery parts of the Air Force's Contingency Airborne Reconnaissance System (CARS)
- The Marine Corps' Tactical Exploitation Group (TEG) programs
- The Korean Combined Operational Intelligence Center (KCOIC) imagery systems

Some of the on-going CIGSS projects include revising the CIGSS Acquisition Standards Handbook, development of a Common Imagery Processor, and interfacing CIGSS compliant systems with the following imagery community systems:

- The Image Exploitation Support System (IESS)
- The Image Product Library and (IPL)
- The Requirements Management System (RMS)
- The Joint Collection Management Tool (JCMT)
- The Defense Dissemination System (DDS)

Future efforts will include interfacing with the Medium Altitude Endurance (MAE) and High Altitude Endurance (HAE) UAVs and developing common mission planning and mission control functions.

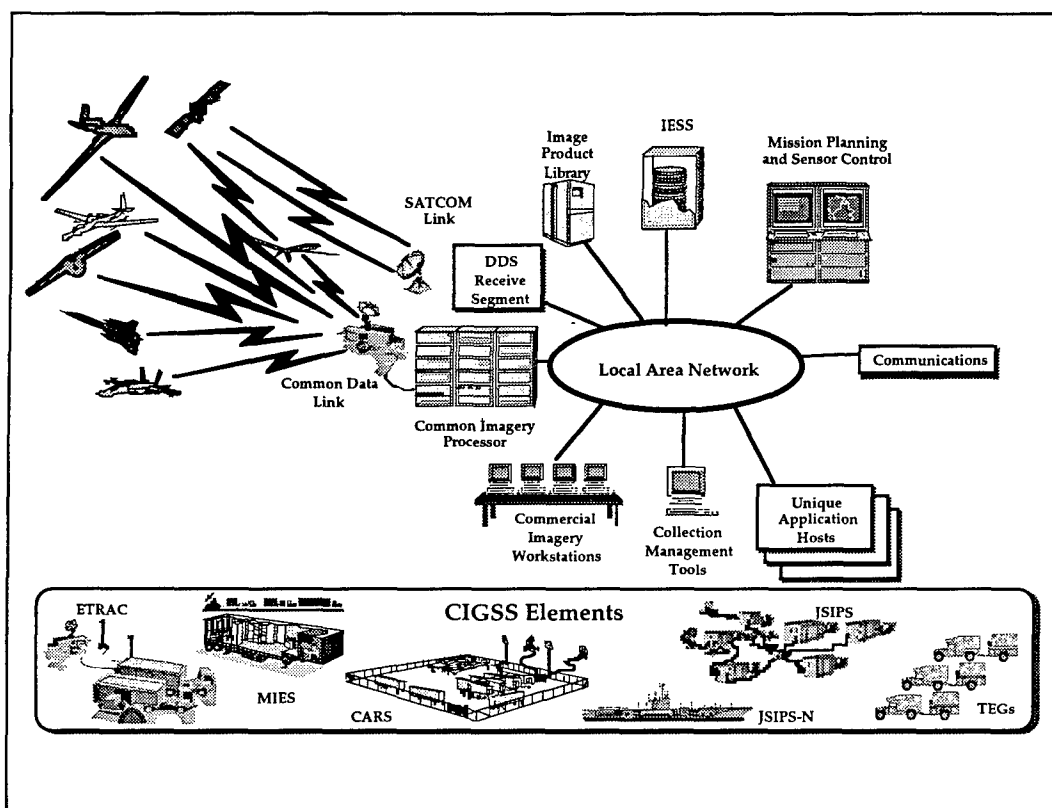


Figure 2-2: Common Imagery Ground/Surface System

2.2.3 United States Imagery System Standards and Guidelines

The *United States Imagery System (USIS) Standards and Guidelines* focus on information technology standards specifically pertaining to imagery related application programs (i.e., software) integrated in open systems computing environments. The standards identified in the *USIS Standards and Guidelines* document are closely tied to the imagery-specific services identified in the *USIS Objective Architecture Definition and Evolution* document and the *USIS Technical Architecture Requirements*. The USIS imagery standards are controlled by the Imagery Standards Management Committee (ISMC).

The scope of the *USIS Standards and Guidelines* document is limited to imagery-specific standards that ensure interoperability among elements of the USIS. Other standards that would apply are identified in higher level standards documents, such as the TAFIM, or peer level profiles.

Standards cited in Version 1 of the *USIS Standards and Guidelines* document, dated 13 October 1995, are incorporated in this ARITA. Other sources include the CIGSS (see Section 2.2.2) and information obtained from various Central Imagery Office CIO-sponsored imagery standards working groups (e.g., video, common interoperable imagery facilities, etc.).

2.3 Collection Management and Mission Planning System Architectures

The ARITA would be unacceptably incomplete if it did not tie-in with an effective architecture for collection management and mission planning. However, such an architecture has not been defined by the DoD or Services. Therefore, functions and standards were derived for the ARITA from an assessment of four key systems and their planned migrations:

- The Joint Collection Management Tool (JCMT);
- The imagery community's Requirements Management System (RMS);
- The Air Force Mission Support System (AFMSS); and
- The Navy's Tactical Aviation Mission Planning System (TAMPS).

More detail on these systems is provided in Section 3.8, System Planning and Control Functions.

2.3.1 Collection Management Systems

Routine tasking to an operational collection asset (either airborne or national) normally flows via an up-echelon Collection Management Authority (CMA). The process can include provisions to allow ad hoc tasking to be generated directly by a supported task force or task force component. The collection management systems provide functions that support the CMA in prioritizing collection requests (which could be received from numerous users), generating specific tasking for the designated collection asset(s), and tracking the status of that collection tasking and subsequent ISR reporting.

There are two specific collection management systems that will interact with airborne reconnaissance systems in the future (either directly or indirectly).

The Joint Collection Management Tool (JCMT) is the migration system designated by the DoD to be used for all DoD all-source collection management functions (i.e., legacy systems will be phased out as JCMT supersedes them). As such, it will combine IMINT, SIGINT, MASINT, and HUMINT tasking. However, MASINT requirements for collection management tasking are not defined at this time.

The Requirements Management System (RMS) is the migration system designated by the DoD to be used for all DoD imagery collection management functions. An RMS aircraft tasking study has been recently completed which defines a conceptual CONOPS and technical requirements for interfacing with imagery ground stations, AFMSS, and TAMPS. However, this has not been completely reflected in the ARITA since the results have not yet been fully coordinated/approved nor has an implementation plan been developed. Mission Planning Systems

2.3.2 Mission Planning Systems

A multitude of mission planning systems exist today. Many of these are special applications that were designed for specific aircraft and operate on specific hardware suites. There are formal, programmatic efforts underway to consolidate these into several generic systems, two of which were picked as representative systems for purposes of developing the ARITA: The Navy's TAMPS and the Air Force's AFMSS. Note that other specific mission planning systems have been consolidated into these two programs. TAMPS consists of a core and a number of

mission planning modules for specific Navy, Marine Corps, and Coast Guard aircraft and weapons. AFMSS contains a core and a number of avionics/weapons/electronics (AWE) modules for specific Air Force, Army, and US Special Operations Command aircraft and weapons. Long-term plans call for combining these into one DoD-wide mission planning system.

Both TAMPS and AFMSS have adopted the same general architectural design and acquisition approach: (1) common, centrally procured hardware; (2) common, centrally procured and managed software; and (3) aircraft-specific software modules and data transfer devices that are (generally) procured and managed by aircraft program managers. For example, both the AFMSS system and the TAMPS system consist of common, core software sets and specific AWE (avionics/weapons/electronics) modules for supported aircraft.

Basic, core functions provided by both mission planning systems include:

- Integrate and manage critical information including operations, weather, intelligence, threat analysis, maps and charts, digital terrain elevation data (DTED), imagery, and command/control information;
- Produce maps and/or strip charts, flight plans and knee-board cards, radar predictions, imagery, and post-mission reports; and
- Program the data transfer device which automatically initializes the aircraft avionics for the specific mission planned on the system.

While both the TAMPS and AFMSS programs show plans to provide mission planning capabilities for reconnaissance platforms (such as the U-2, UAVs, RC-135, EP-3, F/A-18 and others), the plans are generally for platform and navigation planning only (e.g., flight path, threat avoidance, take-off and landing calculations, fuel consumption, etc.). Mission planning modules for the reconnaissance sensor system payloads and communications system planning are currently not in the baseline.

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3. Airborne Reconnaissance Functional Reference Model and Selected Technology Standards

The airborne reconnaissance functional reference model (FRM) provides a common framework for defining the scope and functional makeup of airborne reconnaissance systems. The FRM is critical for selecting standards and effectively depicting where they must be applied in the overall framework. The FRM is based on the functional model developed by the Joint Airborne SIGINT Architecture (JASA) Working Group and approved by the Defense Airborne Reconnaissance Steering Committee (DARSC). The FRM incorporates additional functions found in IMINT and MASINT systems required to satisfy warfighter requirements, more explicit mission planning and control functions, and expanded functions for integrating airborne reconnaissance with warfighter and other C⁴I systems (e.g., command and control systems, air tasking, and collection management).

3.1 FRM Overview

The airborne reconnaissance FRM shown in Figure 3-1 breaks out the overall functional components into seven distinct areas:

- Front-end processing functions;
- Navigation, timing, and ancillary data;
- Networking functions;
- High performance processing functions;
- Operator-oriented processing functions;
- Reporting and connectivity functions; and
- System planning and control functions.

There is a high degree of commonality in the Operator-oriented and Reporting & connectivity functions which suggests these areas are the most important for applying standards.

Four key adaptations were added to the JASA functional model to accurately reflect and integrate functions for the other “INTs.” The overall airborne reconnaissance functional reference model consists of:

- Different front-ends for SIGINT, IMINT, and MASINT;
- Product libraries for audio, imagery, MASINT, and SIGINT data;
- Multimedia network sized for data, digital audio, digital video, imagery, MASINT, and SIGINT data rates; and
- Integrated system planning and control functions.

The airborne reconnaissance FRM is a generic model intended to show only functional flow; it does not depict actual implementations of airborne reconnaissance systems. The generic model is intended to encompass all aspects of an airborne reconnaissance architecture that will meet the needs of manned aircraft and Unmanned Aerial Vehicles (UAVs) as well as their sensors and associated ground/surface systems. The FRM provides the functional framework for achieving the goals and objectives of the ARITA cited in Section 1.1, Purpose.

A description of each functional block in the FRM is given in the following subsections together with discussions of applicable technology standards. This includes identification of those standards selected for airborne reconnaissance systems (i.e., mandated), and references to technologies which are not yet mature enough to select as standards but show promise for resolving key technical architecture issues.

Based on the technology standards identified in this section an overall roll-up of the selected and emerging information technology standards is provided in Section 3.9, Summary of Technology Standards.

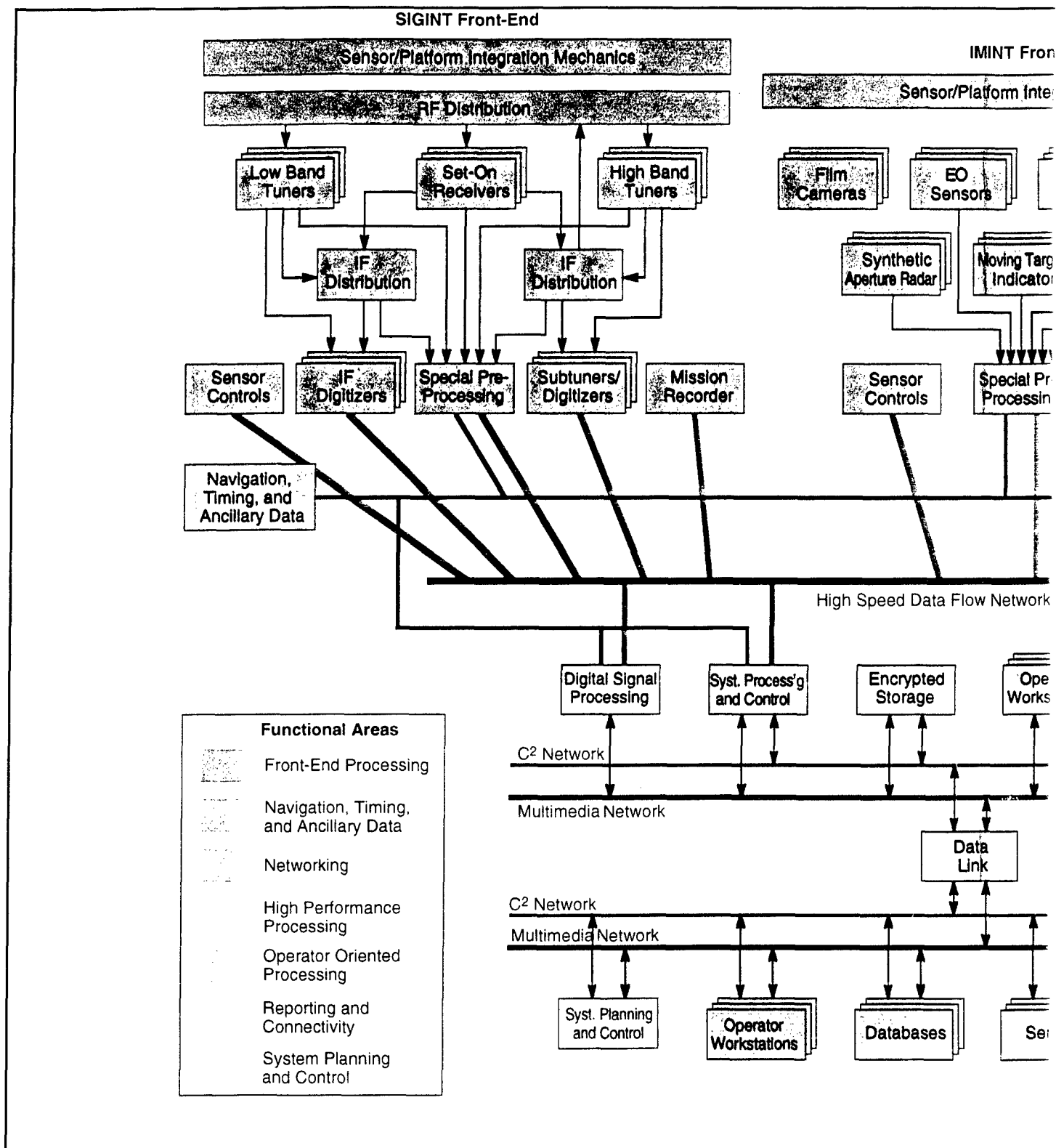
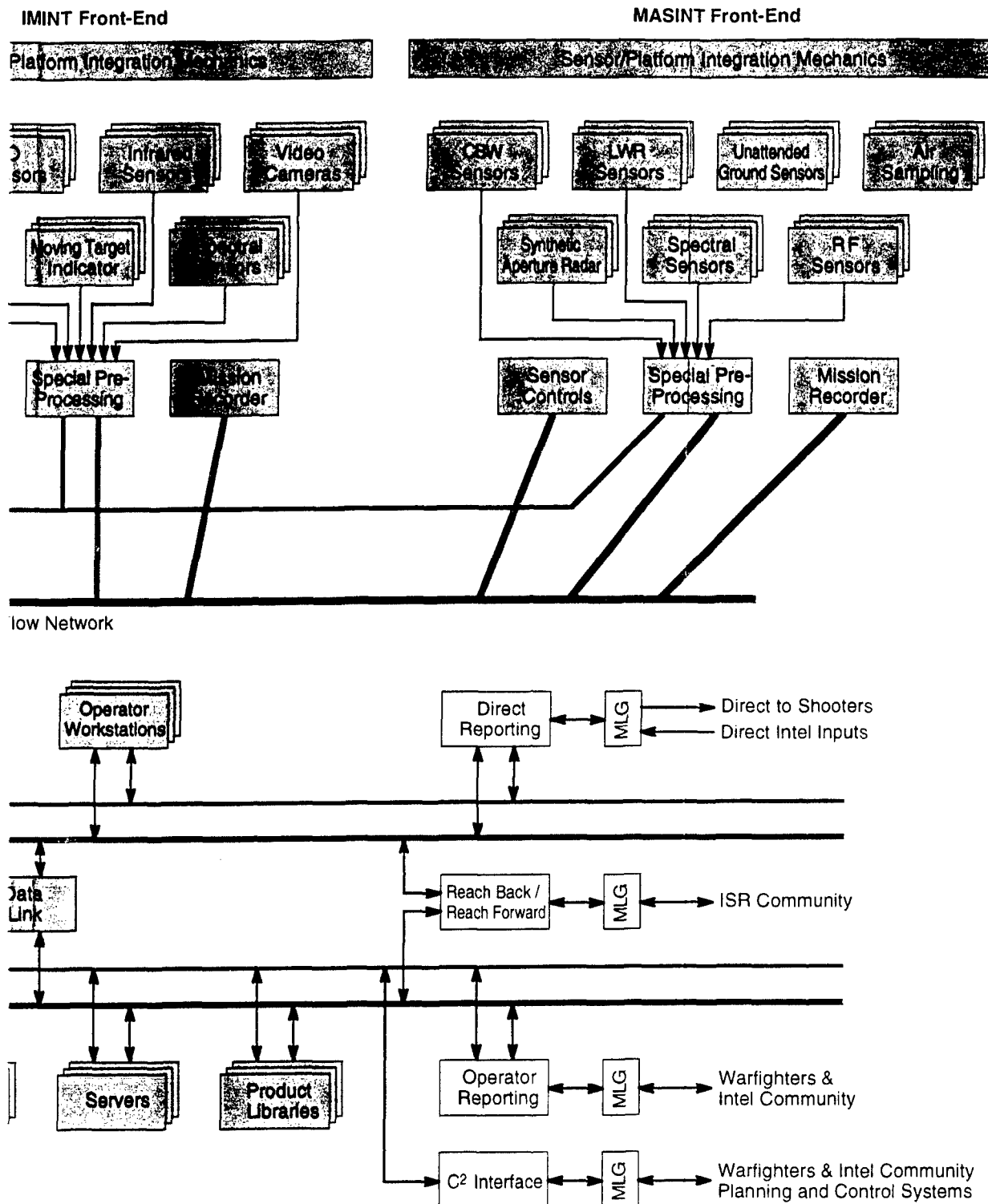


Figure 3-1: Airborne Reconnaissance

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ie Reconnaissance FRM

3.2 Front-End Processing Functions

In general, the front-end processing functions encompass all of the mechanics associated with integration of SIGINT, IMINT, and MASINT sensors into the various platforms, sensor data capture and recording, special pre-processing, and interfacing the front-end functions with the rest of the FRM. Due to the nature of the physical phenomenon being exploited, the specific functions of the front-end sensors are different. The common front-end functions are discussed in the next subsection followed by discipline-specific functions for SIGINT, IMINT, and MASINT.

3.2.1 Common Front-End Functions

The following functional elements are common across the three front-end functional areas (color coded green): Sensor/Platform Integration Mechanics, Sensor Control Functions, Special Pre-Processing Functions, and Mission Recorders.

3.2.1.1 Sensor/Platform Integration Mechanics

Standards for this functional area are:

- *Prime Power: MIL-STD-704E*

The integration of the sensor into an airframe is a complex task. In addition to the classic interface specifications of size, weight, and power; airframe integration must include balance, pressurization, cooling, and unique mounting configurations. Dynamic operational conditions that must be addressed are vibration, shock, torque, pressure and atmospheric changes. Integration of any sensor into an airborne platform covers several areas and requires a total system analysis.

In the case of a SIGINT system, the platform antenna (or antenna arrays) frequency range, sensitivity, directional patterns, and calibration must match the SIGINT sensor capability. Although this matching is done through engineering design processes it is not sufficient to ensure achievement of performance specifications when installed on a physical airframe and connected with prime (Group B) SIGINT receiving equipment. Additional modeling may be needed in

such cases. Thus anechoic chamber work on platform scale models is standard practice to accommodate anomalies in performance that occur in interferometric DF. These anomalies are typically caused by the antenna elements interacting with the airframe causing resonance at some frequencies. The resonant frequencies effectively cause signal nulls or signal drop-outs, and ambiguous DF answers can be adjusted by slightly readjusting antenna locations in the anechoic chamber modeling before installing them on the airframe. This avoids problems before expensive airframe modifications are made. The addition of antenna (or antenna arrays) requires modification of existing RF distribution to match RF feeds from new antenna elements and proper RF outputs to receivers, tuners, or converters.

Imagery sensors are typically mounted in the nose of the airframe, the underside of the fuselage, or in a pod. The enclosure covering the sensor may be either part of the airframe, part of the pod, or part of the sensor system. The sensors are typically enclosed in an unpressurized compartment and image through a window. The imaging window must maintain optical quality and sustain a pressure differential from buffeting winds. If the sensor is in a pressurized compartment, the window strength becomes even more important. High quality sapphire windows are typically used, but there are also substitutes. Sapphire windows are just now being produced in sizes large enough (12 inch) to be used for high quality electro-optical sensors with large apertures. Infrared and multi-spectral sensors have the most severe specifications for the optical window. The sensor enclosure may move to keep the window centered on the optical axis. Although this increases sensor to airframe mounting complexity, it is not practical to make the windows large enough to cover the complete sensor field of view. The windows may require heating or cooling to eliminate condensation and maintain performance. Radar systems used for collecting IMINT are enclosed in radomes that typically can be produced as uniformly transparent, and they do not have to rotate or move in unison with antenna movements.

There are no special requirements to integrate MASINT sensors which are the same as SIGINT or IMINT sensors. Other MASINT sensors require appropriate integration, for example, MASINT sensors exposed to the atmosphere for air sampling purposes. Future MASINT sensors – including tunable or programmable sensors – may be pod mounted or be enclosed as part of the airframe.

The only standard identified for sensor/platform integration is for Prime Power: MIL-STD-704E.

3.2.1.2 Sensor Control Functions

Standards for this functional area are:

- *None*

Commands to various SIGINT, IMINT, and MASINT front-end equipment flow through the sensor control component of the FRM. In actual implementations, command and control messages may flow directly to equipment through either the C² network or the high speed data flow network.

There are no standards currently identified for sensor control functions. However, this may be an area worthy of further analysis. A standard command set may be an effective means to stimulate design and marketing of competitive equipment. A simple example of the benefit of a standard command set is seen in the common modem used in virtually every personal computer and office workstation – they all use the basic Hayes command set.

3.2.1.3 Special Pre-Processing Functions

Standards for this functional area are:

- *None*

The FRM allows for variations of special pre-processors to coexist in the system. The variations will be optimized to provide specific mission functions, but will have common interfaces for timing, to include both coherency and absolute time, and for command and control.

The FRM provides for special pre-processing functions that either (a) cannot be implemented in the digital domain, or (b) are optimized by analog pre-processing. The output of the pre-processors will interface to the high-speed data flow network and, if applicable, to the multimedia network.

Pre-processing functions are performed to the sensor data for the purposes of enhancing data utilization. Functions may include analog-to-digital conversion, data compression, and data formatting.

Although there are no standards for special pre-processing functions, standards should be developed for assuring end-to-end quality.

3.2.1.4 Mission Recorders

Standards for this functional area are:

IMINT payloads:

- *High data rate digital imagery:*
 - *DCRSi for the U-2 (ASARS-II recorder)*
 - *ANSI X3B5/94-024, 19 mm helical scan digital tape (F/A-18 ATARS)*
 - *ANSI X3.175-1990, ID-1 digital tape (F/A-18 ATARS)*
- *Legacy analog video:*
 - *VHS and Super-VHS for recording video*
 - *Hi 8 mm (e.g., for ARL and gun cameras)*
- *Video migration to digital:*
 - *Preferred implementation is Y/C (component analog) video recorders with Society of Motion Picture and Television Engineers (SMPTE) vertical interval time code VITC generators/readers and two audio tracks (one for mission audio, one for ancillary data)*
 - *Dual-capable analog/SMPTE 259M video recorders (to support the migration from analog to digital video)*
- *Digital video:*
 - *SMPTE 259M-compliant recorders capable of 259M input and output*

SIGINT payloads:

- *Hi 8 mm (ARL ESM data)*
- *AN/USH-28, 28 track tape recorder (RC-135)*
- *Optical drive for archive data (RC-12)*
- *Magnetic drive for temporary data (RC-12)*

- *Digital temporary storage recorder (DTSR), based on Winchester hard disk (Army and Air Force programs)*

Timing:

- *IRIG-106-93, Telemetry Standards, Analog Digital Adaptable Input Output Data Format Specification Annex*

Mission recorders are used to capture the raw, pre-processed sensor data together with associated navigation, timing, and ancillary data. Additionally a computer controlled interface for basic recorder functions such as start, stop, shuttle, fast forward, and rewind is included.

In conjunction with recording the raw sensor data, timing data will be recorded (on a separate track) in accordance with the "IRIG-B" (Inter-Range Implementation Group) standard: IRIG-106-93, Telemetry Standards, Analog Digital Adaptable Input Output Data Format Specification Annex. The IRIG-B standard was written specifically for magnetic tape storage, but it is applicable to disk storage media as well.

The standards cited above include legacy systems. In conjunction with migrating to all digital systems, mission recorder standards will be reevaluated to emphasize digital and de-emphasize analog.

3.2.2 SIGINT Front-End Functions

SIGINT front-end standards are concerned primarily with functional elements that receive and process radio frequency (RF): from low frequency (LF), 30 KHz to 300 KHz, through extra high frequency (EHF), 30 GHz to 300 GHz, received by the platform antenna/antenna arrays. These RF antenna/antenna array types may be omni-directional, directional, beam-steered, steered dish, interferometric, or spinning dish. In addition to the common front-end functions, the SIGINT front-end functional elements include the RF distribution, low and high band tuners, set-on receivers, IF distributing IF digitizer and sub-band tuners, digitizers and channelizers. Figure 3-2 displays the functional elements of the SIGINT front-end. Hardware implementation may not match Figure 3-2: SIGINT Front-End FRM (e.g., low/high band tuners, IF switching, and IF digitization functions can be combined into a single receiver unit).

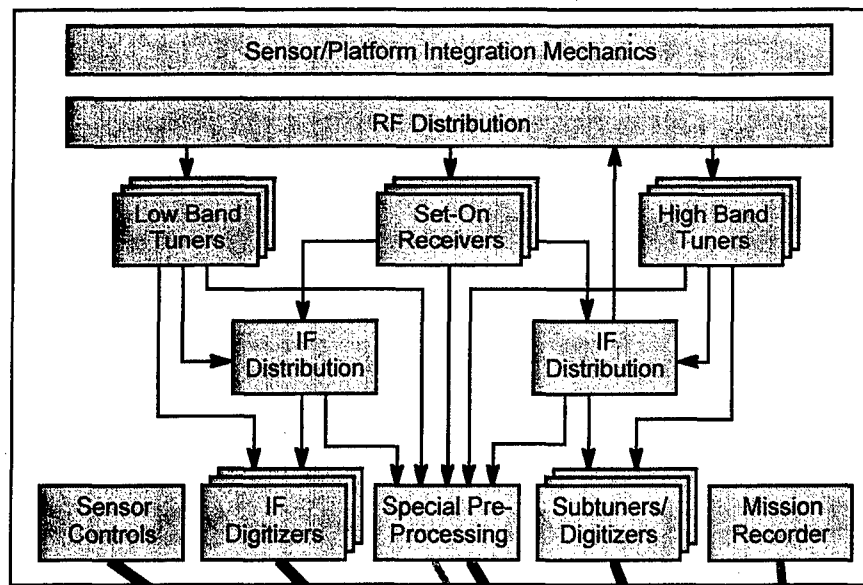


Figure 3-2: SIGINT Front-End FRM

3.2.2.1 RF Distribution

Standards for this functional area are:

- 50 Ohm fixed impedance coaxial cable in agreement with EIA RS-225, dated 1959

RF from antenna normally flows through an RF distribution function. The RF distribution function allows for appropriate signal flow from the multitude of platform antenna of varying types and frequency coverage and provides for the conditioning and distribution to the functional receiver/tuner elements.

The conditioning component of the RF distribution provides for the requisite preselection or band filtering to frequency band-limit incoming antenna paths from potentially interfering signals (both off-board and on-board) and preamplification to optimize the system-level noise while providing an acceptable signal saturation level (i.e., intercept point). Phase/gain matching of multiple discrete antenna paths for interferometric direction finding (DF) is also a function of the RF distribution conditioning.

The distribution function provides appropriate RF switches, RF power dividers or coupler, attenuators, and blanking interface to facilitate the necessary quantity and

type of signal paths to the various platform SIGINT receiver/tuners. This allows multiple signal paths to be routed or selected to one or more receiver paths for maximum flexibility and to reduce the number of dedicated antennas that otherwise would be required on the platform.

Traditionally, RF from antenna has been distributed to tuners, band converters, and receivers through 50 Ohm fixed impedance coaxial cable in agreement with Electronic Industries Association (EIA) RS-225, dated 1959. Replacement of coax with fiber optics is being researched for ELINT antenna to RF distribution. Early digitization (analog to digital (A/D) conversion) and precise time tagging of this digital data are essential elements of this architecture. Properly bandwidth-limited RF is passed on to ELINT and COMINT tuners, receivers, or band converters.

3.2.2.2 Low and High Band Tuners

Standards for this functional area are:

- *IF center frequencies of 21.4 MHz, 70 MHz, 160 MHz, 1000 MHz, and 5000 MHz*

Highband RF covers the UHF through EHF (300 MHz to 300 GHz). Low band RF covers LF through UHF (30 KHz to 3 GHz). The LF, UHF, and EHF designations follow the Institute for Electrical and Electronic Engineers (IEEE) definitions. However, signal densities and properties, propagation factors, and semiconductor physics necessitate different basic implementations. Actual implementation must provide seamless processing of all specified signals of interest. The frequency coverage and number of channels will be a function of the individual platform and mission requirements.

The tuners (several types are required) will provide preselection of a portion of the RF spectrum and convert it to one of the standard intermediate frequency (IF) center frequencies of 21.4 MHz, 70 MHz, 160 MHz, 1000 MHz, and 5000 MHz. The tuner's technical specifications should reflect the requirements to allow direction finding, time difference of arrival, differential Doppler, co-channel interference reduction, pulse code modulation, etc. The IF from the high band tuners may feed through a coaxial based (50 Ohm) IF distribution into the RF distribution function to allow further selection and processing by the low band tuners and assets for narrowband signals. The IF from the low band tuners may

feed into the high band IF distribution function to allow further selection and processing for wideband signals.

3.2.2.3 Set-On Receivers

Standards for this functional area are:

- *None*

The FRM incorporates provision for a pool of set-on receivers to enhance collection based on a platform's operational mission. These receivers would be included when system constraints prohibit contiguous coverage, when additional throughput is required, or when additional coverage of specific high priority signals is to be provided. The set-on receiver outputs may be digital audio, digital IF (filtered), or analog (pre- or post- detected). The numbers, types, frequency range, modulations, and outputs of these receivers will be determined by the individual platform's requirements. There are currently no formalized standards for set-on receivers and conventional practice is to use commercially available equipment.

3.2.2.4 IF Distribution

Standards for this functional area are:

- *None*

The FRM allows for multiple IFs to exist in the system. The IF distribution function accepts the various inputs from the tuners and receivers and routes them to the outputs via the C²I network. The IF switches and distribution elements must support the dynamic range, phase noise, linearity, bandwidth, isolation and other functional specifications required of their collective applications. As with the RF, IF signals are also distributed through 50 Ohm coaxial cable.

3.2.2.5 IF Digitizer

Standards for this functional area are:

- *None*

The IF digitizer accepts the output of the tuners and IF distribution, and performs the analog to digital (A/D) conversion. It may include such functions as down-conversion and signal conditioning. This digital output is connected to the high-speed data flow network. The digitizers may be comprised of multiple-speed bandwidth and dynamic range converters (reflecting the different processing bandwidth / dynamic range tradeoffs required for different signals). The data will include a precision time stamp and system clock. Precise time-tagging of data will take place at the point of digitization.

3.2.2.6 Sub-Band Tuners/Digitizers/Channelizers

Standards for this functional area are:

- *None*

The sub-band tuners/digitizers/channelizers accept the output of the high band tuners and IF distribution functions. This module will support: automatic and manual search of signals with direction finding (antenna/array dependent); signal characterization; sample incoming IF energy; and measurement of phase shift of IF energy. These functions must provide high performance (e.g., sensitivity, dynamic range, interference cancellation) and allow for reprogramming (scan plans, signal parameters, etc.). Signal data will be provided to the high-speed data flow network. This functional block must accept time synchronization and system clock and also time-tag the digitized data as required.

3.2.3 IMINT Front-End Functions

As shown in Figure 3-3, IMINT front-end functions are divided into ten major areas: seven types of image acquisition sensors, sensor control functions, special pre-processing functions, and mission recorders. The following subsections describe the seven types of image acquisition sensors and the specific technology standards that apply. The other areas are discussed in Section 3.2.1.

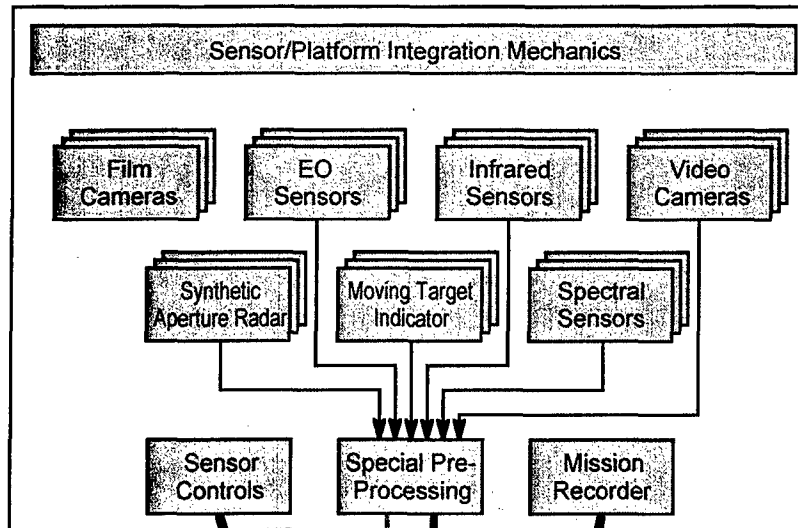


Figure 3-3: IMINT Front-End FRM

3.2.3.1 Film Cameras

Standards for this functional area are:

- None

Film cameras typically used in airborne reconnaissance systems employ advanced optics (lenses and/or mirrors) and focusing subsystems to capture high quality imagery on large-format film. Film width is not standardized, but ranges from four-to-nine inches wide depending on the design of the camera. Lens focal lengths vary from 25 inches for wide area coverage to almost 150 inches for high resolution imaging from greater distances.

Film cameras are being phased out as IMINT systems migrate to electronic/digital imaging sensors which offer superior performance and image processing capabilities.

3.2.3.2 Electro-Optical Sensors

Standards for this functional area are:

- None

Electro-optical (EO) sensors are essentially the same as traditional film cameras except that electronic imaging is used in place of film. EO sensors offer higher quality and faster response to warfighters by enabling the use of digital image processing technology, direct data link communications, and more sophisticated storage and dissemination capabilities.

EO sensors typically cover the panchromatic (or Pan) part of the spectrum and use digital techniques to collect image data (i.e., staring arrays and linear scanning arrays). In a strict sense the term "panchromatic" means the light spectrum that is visible to the human eye. In practice this usually applies to a modified spectrum in which the EO sensor operates. Typically, Pan EO sensor sensitivity may exclude some of the blue region of the spectrum and may include some near infrared (IR) wavelengths of the spectrum. The blue may be excluded to reduce the effects of haze in long range viewing, whereas near IR penetrates the haze better than visible wavelengths and provides better contrast between vegetation and camouflage. More detail on IR is in Section 3.2.3.3.

Staring array sensors use a two-dimensional array that acquires the entire frame at a single instant, just like a handheld film camera. These sensors are capable of taking between a few frames a second to a frame every few seconds. Typical focal plane arrays vary from between 500 to 2,000 detectors on each side, and they are usually square. The images formed generally have the same number of pixels as the array has detectors. These sensors need to be physically stabilized to keep each detector focused on the same target for the duration of the exposure – a platform/sensor integration consideration. The resulting images are a series of still frames.

Linear scanning array sensors use a string of electronic detectors to record only one line of the image at a time. The linear array is typically 2,000 to 20,000 detectors wide. This determines how many pixels are in each line of the processed image. An image is formed as the aircraft and sensor motion continuously scans new parts of the scene. The resulting image formed by a scanning array sensor is a continuously moving, or waterfall image. Nothing on the image moves as in a video or movie; rather the scene itself is continuously moving as the sensor scans the ground given the motion of the aircraft.

Currently there are no formalized standards governing the design of EO sensors, but the following two technical attributes tend to be common among various sensor designs:

- Most monochromatic (greyscale) sensors produce imagery at 8 to 11 bits per pixel. Color sensors most often output 24 bits per pixel (e.g., eight bits each for red, blue, and green.)
- As a practical limit derived from the Common Data Link, most EO sensors output data at rates less than 274 megabits per second. This affects design trades between detector/spacing (spatial resolution), field of view, and image data compression.

3.2.3.3 Infrared Sensors

Standards for this functional area are:

- *None*

Infrared (IR) sensors detect radiation (reflected and emitted) at wavelengths longer than visible light. The IR part of the spectrum is broader than the visible part and the types of IR sensors can be subdivided into near wavelength infrared (near IR or NIR), short wavelength infrared (SWIR), middle wavelength infrared (MWIR), long wavelength infrared (LWIR), and any number of subsets of these major categories. Each broad category of wavelengths has unique reflection and emittance characteristics, analogous to visible colors. NIR has most of the characteristics as Pan, but has better haze penetration and higher reflection by water bearing cells in plants that facilitates healthy vegetation characterization and camouflage detection. SWIR has even better haze penetration than NIR and some reflective properties for camouflage detection. MWIR is sensitive to thermal imaging as well as reflective infrared and works well in low light-level applications. LWIR provides true thermal imaging that can be used in total darkness.

As the operating wavelength of an infrared sensor increases, the technology required to design and construct the sensor becomes complex and more expensive. The transmittance of optical glass stops at SWIR and greater wavelengths, so the sensors need special lens material or more likely will use reflective optics (mirrors). The longer the wavelength of operation, the more thermal noise will have to be reduced. This requires cooling of the detector array, to cryogenic levels for LWIR operation, and possibly the optics and other parts of the sensor. The composition of the detector array is different for IR than it is for Pan, and sometimes multiple arrays need to be employed for different IR wavelength categories. These characteristics can put demands on platform

integration for cooling and on digital signal processing functions for calibration and noise reduction. There are no standards for IR sensors.

3.2.3.4 Video Cameras

Standards for this functional area are:

- *NTSC and RS-170 for analog video*
- *HDTV and MPEG-2 for digital video*

Motion video adds a time dimension to imagery, where motion of objects and other time-dependent activities can be directly observed. Video is really a series of still images that overlap the same coverage and repeat the scene nominally 30 times per second which is the commercial broadcast standard frame rate. Video cameras usually employ zoom lenses or multiple optics for adjusting viewing area and detail. In addition, dynamic flight control permits close range imaging for high resolution, and far range imaging for increasing area coverage with lower resolution.

Video cameras are most often used on UAVs where they originally served to support the remote pilot during takeoff and landing. Now they have become recognized as a highly valuable reconnaissance asset. The cameras are very similar, if not identical, to commercial models available for commercial broadcast and/or home use. Real-time video can be broadcast directly to the warfighters and other receivers through various communications systems using the same technology that the commercial television broadcast industry uses.

For current legacy systems, the base analog video standard is the National Television Standards Committee (NTSC) signal provided in RS-170 format. This standard defines the broadcast industry standard image with 525 lines of analog luminance (density) trace signals. It has 30 unique frames per second. The video trace is interlaced so that there are actually 60 fields or traces per second of 262 lines each. The increased frame rate is used to reduce scene flicker on the cathode ray tube or TV screen used for display.

Commercial industry is currently migrating away from analog video components to all-digital systems. It is anticipated that within five years, professional-quality analog video products will no longer be manufactured. Airborne reconnaissance systems will leverage advances in commercial television technology which

provides the standards base for interoperability among commercial broadcast and military video systems. Additional benefits include improved video quality; inter-service and NATO/allied forces interoperability; improved protection from obsolescence; and lower life cycle costs. In fact, COTS solutions are currently available for a complete end-to-end digital video system implementation, adhering to the following standards:

- Uncompressed digital video: CCIR 601 4:2:2 component
- Video time base: SMPTE VITC Drop Frame Recommended Practices (SMPTE RP173: 1993 and SMPTE RP179: 1994)
- Digital video compression: MPEG-2 4:2:2 Profile@Main Level (ISO/IEC 13818-1 Systems, 13818-2 Video, and 13818-3 Audio)
- Digital video physical layer: SMPTE 259M

The key outstanding standards problem for video, from an airborne reconnaissance point of view, is metadata – data about data. Developing a standard for video metadata is one of the highest priority tasks being worked in the CIO's Video Working Group. (See Section 5.1.1 for more details.)

3.2.3.5 Synthetic Aperture Radars

Standards for this functional area are:

- *None*

Radar systems transmit radio signals and measure the reflected energy from the target. Power, frequency, and modulation of the transmitted signal can be altered to achieve different effects of range, resolution, and penetration. Radar sensors have the ability to operate day and night and penetrate clouds, offering true all-weather operation.

Synthetic aperture radar (SAR) is the most commonly used type of radar for imagery reconnaissance applications. The systems are called synthetic aperture because the combination of the individual radar returns effectively creates one large antenna with an effective aperture size equivalent to the flight path-length traversed during the signal integration. The formation of this large synthetic aperture is what enables these radars to produce images with fine in-track (for azimuthal) resolution; the high bandwidth and pulse repetition interval enables the SAR's fine cross track (or range) resolution. The image can be produced with

ground resolutions less than one foot, when operating in “spot” mode, and approach photographic appearance and interpretability. In search modes, ground sampled distances (more correctly radar impulse response) is often ten feet or more.

The classic SAR (above) is ill suited for imaging targets which have rotational motion. They tend to defocus and blur the image unless the rotational motion is accurately predicted and compensated for in the processing algorithms. Inverse SAR (ISAR) systems use different algorithms that exploit the object’s rotational motion, rather than the radar’s relative velocity, which results in sharper images.

Interferometric Synthetic Aperture Radar (IFSAR) systems produce three dimensional images (i.e., they also produce elevation data). The IFSAR system operates by using two separate antennas spaced a meter to several meters apart. The systems employ two receivers and measure the phase difference of the received signal at the second antenna, using the received signal at the first antenna as a reference. The phase difference measurement is made by an interferometric technique. This phase difference is then processed to provide the third dimension of information. IFSAR systems are predominately experimental (e.g., R&D prototypes).

Currently there are no standards for SAR sensors or for their interfaces with associated pre-processors. The need for such interface standards will be addressed in a future version of the ARITA.

3.2.3.6 Moving Target Indicator Radar

Standards for this functional area are:

- *None*

Moving Target Indicator (MTI) Radar systems detect the movement of objects within the radar’s field of view. The range of speed detectable is different for each system and is limited by many design considerations. Fields of view are typically very large and can extend up to 200 miles distance from the radar. The processed MTI data is normally displayed on a map background and used for area surveillance and command and control of force deployments. If the MTI radar also has a SAR capability, then images of specific targets can be acquired, or low resolution search imagery can be taken of limited areas for use in place of the map background when displaying the MTI data.

Currently there are no standards for MTI sensors or for their interfaces with associated pre-processors. The need for such interface standards will be addressed in a future version of the ARITA.

3.2.3.7 Spectral Sensors

Standards for this functional area are:

- *None*

Spectral sensors provide unique targeting and intelligence data based on collection from multiple bands of reflected radiance, and from combinations of bands. The primary reconnaissance application for spectral data is to detect, locate, and identify exigent targets. Some of the spectral sensor data will be used to form images; other uses involve MASINT exploitation techniques as described in 3.2.4.6.

Spectral sensors are defined and categorized in the scientific community according to the number of non-redundant spectral bands within the sensor. The following nomenclature is generally accepted:

- Multispectral Imagery (MSI) Sensor: A sensor capable of receiving between 2 and 19 separate spectral bands.
- Hyperspectral Imagery (HSI) Sensor: A sensor capable of receiving between 20 and 299 separate spectral bands.
- Ultraspectral Imagery (USI) Sensor: A sensor capable of receiving 300 or more spectral bands.

Spectral sensors have individual detector arrays with various spectral responses (i.e., one detector array for each spectral band). Each detector array produces an image (or image layer) corresponding to the spectral response in the given band. Multiple image layers are captured nearly simultaneously and registered to each other. Spectral bandpass filters may be used to change the spectral response of one or more of the detector arrays.

Spectral imagery is only beginning to be developed for operational use. It is possible to use the different scene reflectance in each band to detect and distinguish specific targets. Details that are not observable with panchromatic (visible) sensors may be detected from the image variations between multispectral

layers. Spectral data may also be used in automatic target recognition (ATR) and/or cueing (ATC) software to provide more dependable performance than panchromatic imagery.

Spectral sensors typically produce very large quantities of data due to the fact that there are several layers (corresponding to the different bands), where each layer contains the same quantity of data as a panchromatic or IR image. This increase in generated imagery data and the technical challenges it presents are often a limiting factor in the design and use of spectral sensors. Recording and storing the data, as well as processing and exploiting it are more difficult than for single spectral imagery. Transmitting the larger quantity of information over a data link, especially in real time, is a formidable challenge.

Currently there are no standards for spectral sensors.

3.2.3.8 Image Quality Standards

Standards for this functional area are:

- *National Imagery Interpretability Rating Scale (NIIRS)*

There are different National Imagery Interpretability Rating Scales (NIIRS) for visible, IR, and SAR imagery. There are no corresponding scales for video or spectral imagery. However, a video scale is being developed under CIO direction.

Measuring image quality with the NIIRS requires the subjective judgments of experienced imagery analysts. One potential airborne reconnaissance operational use of image quality measures is monitoring image quality in a ground station. Images could be prioritized so analysts could decide to exploit the images with lowest quality last. Another use could be to detect problems in processing. One candidate standard metric for this use is based on an objective metric – digital power spectrum analysis.

However, the Video Working Group (VWG)-sponsored Video Image Quality Control Board (VIQCB) is currently working on a video quality metric to accommodate the unique temporal aspect of video.

3.2.4 MASINT Front-End Functions

The following sections apply to the MASINT front-end components of the airborne reconnaissance functional reference model (Figure 3-4). Two important distinctions between MASINT and other intelligence systems are the maturity and diversity of the component systems. The MASINT discipline encompasses seven technological areas of remote sensing. Within each of the seven areas there are numerous implementations, many of which are still in the R&D phase, which makes the creation of standards a much more difficult task. Where possible, standards for MASINT systems are specified in this document; however, much work is ongoing to complete a set of standards. Instead, references to specific systems are given in this section to indicate the broad scope and relative immaturity of the MASINT discipline.

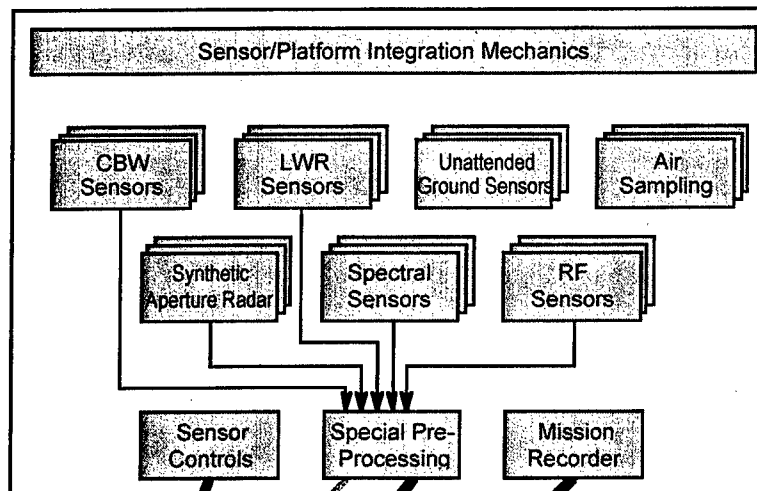


Figure 3-4: MASINT Front-End FRM

3.2.4.1 Chemical/Biological Weapons Sensors

Standards for this functional area are:

- *Interface Specification, Radio Frequency Transmission Interfaces for DoD Physical Security Systems, SEIWG-005, 15 December 1981*

Within the Chemical and Biological Weapons (CBW) area, there is currently a broad cross section of emerging technologies with few common elements. The DARO's *Technology Program Plan* and *Airborne Reconnaissance Technical*

Architecture Program Plan have shown, for example, that there are at least ten different sensor technologies that can be applied to the mission area of chemical and biological weapons detection. No operational sensor systems for airborne MASINT missions exist as yet. However, two prototype chemical sensor systems have been field tested on DARO UAV systems. The tested systems include a passive sensor system called the Lightweight Standoff Chemical Agent Detector and a point detector system called the Surface Acoustic Wave Chemical Agent Detector. No airborne biological systems have been fielded or tested.

CBW sensors can be logically categorized into four groups as follows:

Passive, optical-based standoff detectors

- Fourier Transform Infrared (FTIR)
- Spectral Sensors (see section 3.2.4.6)

Active, optical based standoff detectors

- Laser Imaging Detection and Ranging (LIDAR)
- Differential Absorption LIDAR (DIAL)

Point detectors

- Surface Acoustic Wave (SAW)
- Ion Mobility Spectrometer (IMS)
- Fiber-Optic Wave Guide (FOWG)
- Optical Planar Wave Guide (OPWG)
- Optical Antibody-Based Biosensor
- Nerve Cell
- DNA Analyzer

Collateral sensors

- Meteorological (MET)

The platforms used to carry CBW sensors include tactical UAVs, manned aircraft, hand launched UAVs, and cassondes (canisters with sensor payloads ejected from aircraft or UAVs). Tactical UAVs would be the ideal candidates for passive

optical based standoff detectors but probably not point detectors because of post mission decontamination problems. LIDARS, with sufficient detection ranges must reside on a manned platform because of power considerations. Since chemical agent clouds are rapidly dissipated by wind and rain, toxic agents must be deployed in close proximity to the targeted forces and consequently, point detectors must also be close in. Point sensors would be hosted by cassondes, small UAVs, or other attritable platforms that sample toxic clouds and relay information back to analysis nodes. This alleviates the decontamination problem for more expensive reconnaissance assets, and in many cases could obviate the need for manned platforms, with all their inherent risks.

Accurate knowledge of weather conditions is crucial to predict the boundaries of CBW agents. Miniature meteorological sensors that measure and transmit data will be ejected from platforms (dropsondes) to detail atmospheric conditions (wind, temperature, humidity, position, and barometric pressure) while descending through the air. Sensor types can be configured to send meteorological data after ground impact as well. The CBW architecture must accommodate these sensors and input this data to meteorological models along with all other CBW sensor data.

The standard used for unattended ground sensors (SEIWG-005), cited in Section 3.2.4.3, is also applicable to CBW sensors.

3.2.4.2 Laser Warning Receivers

Standards for this functional area are:

- None

Laser intelligence (LASINT) encompasses collection sensors for signature development and laser threat characterization. This function provides near-real-time battlefield laser warning and counter-measures. Essentially, laser warning receivers (LWR) provide an inexpensive, quick capability to detect, identify, and characterize foreign laser weapons and designators.

The following sensors are considered part of a comprehensive set of airborne LWR/LASINT systems:

- Cluster Halt
- LOFT

- LASINT LWR Sensor (USN R&D effort)

Laser warning receivers must have interfaces to on-board alarm systems and connect to warning dissemination systems for alerting other aircraft and/or ground systems. This dissemination could be implemented through the direct reporting functions described in Section 3.7.1, but there are no alarm interface standards available. Raw LASINT data for signature analysis and Order of Battle (OB) requires a different communications or recording path than the alarms. As with most MASINT functionality, a dual path is required with LASINT/LWR, one that gives immediate reconnaissance information/identification and another that transfers huge data files to ground exploitation centers.

3.2.4.3 Unattended Ground Sensors

Standards for this functional area are:

- *Interface Specification, Radio Frequency Transmission Interfaces for DoD Physical Security Systems, SEIWG-005, 15 December 1981*

Unattended ground sensors (UGS) are MASINT sensors that can be emplaced by airborne platforms, hand emplaced by special forces, and use platforms as relay communications back to a common exploitation station. Typically, UGS systems are fairly small, have autonomous power and communications, and transmit alarm messages when seismic, acoustic, magnetic, infrared (day-night imaging), and other sensors are activated.

Advanced UGS systems contain embedded automatic target recognition algorithms to recognize specific targets such as SCUD launchers and mobile command centers. This is accomplished by extracting key attributes from target signatures such as engine type, transmission type, exhaust location, number of axles, weight and weight distribution.

Available sensors include:

- Tactical Reconnaissance Sensor System
- Improved Remotely Monitored Battlefield Sensor System
- Miniature Intrusion Detection System
- Selected commercial sensors

Sensors in development include:

- Steel Rattler (formerly called Unattended MASINT System)
- Internettetted Unattended Ground Sensor (IUGS)
- REMOTE SENTRY (P/O Rapid Force Projection Initiative)
- Air Mobile Ground Security and Surveillance System
- DNA Unattended Sensor Program
- Wide Area Munitions (WAM)

The following is an “all-encompassing” military standard that governs the design of unattended ground sensors (e.g., it covers RF, data formats, transmission protocols, connectors, etc.): Interface Specification, Radio Frequency Transmission Interfaces for DoD Physical Security Systems, SEIWG-005, 15 December 1981

3.2.4.4 Air Sampling

Standards for this functional area are:

- *None*

Of all the MASINT functions, air sampling is the oldest and most unique technique. Air sampling captures physical samples of atmospheric gases and particles. Additionally, beta and gamma radiation detectors are used on WC-135s to guide the flight path through the plumes. This MASINT function is not real time: no on-board processing is required, only power, space, and inlet ports within the airframe. The high degree of precision needed to analyze the samples can only be achieved in the laboratory.

3.2.4.5 Synthetic Aperture Radars

Standards for this functional area are:

- *None*

Functionally, SAR sensors are common to both IMINT and MASINT disciplines. MASINT does not require additional SAR instruments but uses the raw data from the IMINT collection systems (Section 3.2.3.5) for specialized MASINT

processing and exploitation. Although MASINT processors will normally process the data post mission, future systems will include on-board SAR phase history (PH) processing with products, along with raw in-phase and quadrature-phase (I&Q) data, available to ground systems. Therefore, standards affecting interoperability with MASINT SAR phase history processing systems must be considered.

Currently there are no standards for SAR sensors or for their interfaces with associated pre-processors. The need for such interface standards will be addressed in a future version of the ARITA.

3.2.4.6 Spectral Sensors

Standards for this functional area are:

- *None*

MASINT functions exploit spectral data acquired with the same spectral sensors as those used for imagery applications (see Section 3.2.3.7). One key difference is that rather than using imagery analysis techniques, MASINT applications process the spectral data directly (i.e., spectral signature analysis) to detect, classify, characterize, and identify various chemicals, biological compounds, and other affluents.

3.2.4.7 RF Sensors

The technologies discussed in the following subsections make up the RF portion of the MASINT technical architecture.

3.2.4.7.1 Passive Bistatic Radar

Standards for this functional area are:

- *None*

Passive bistatic radar technology is based on non-cooperative coherent exploitation of random background ambient signals. Signal exploitation is for purposes of airborne and ground based target detection, tracking, and identification. The non-cooperative exploited signal can be narrowband or

wideband at, any carrier frequency from HF through X-band. The technology employs several processing modes that utilize cooperative and non cooperative emitters from commercial broadcast services through surveillance radars.

3.2.4.7.2 Foliage Penetration

Standards for this functional area are:

- *None*

Exploitation of foliage penetration (FOPEN) signatures will detect and potentially classify targets that are underground or concealed by dense foliage. Systems ideally would be used to gather information on communications, oil, gas, and power lines; toxic waste dump sites; underground tunnels; command bunkers; antipersonnel mines; and all concealed man-made objects using RF and acoustic technology. RF based systems generally employ broadband (nominally 200-400 MHz) low power emitters (1 watt). FOPEN processing algorithms require multiple polarization antennas (normally one vertical antenna, one horizontal polarized receive antenna, one transmit antenna) to optimize signatures from man made objects and eliminate return clutter from large natural objects such as large tree trunks. Acoustic FOPEN combines acoustic signatures analysis, for example, artillery fire sound, with phased microphone direction finding arrays to locate and identify hidden targets. Microphone arrays would be integrated on a UAV or other platform as part of an exigent target detection suite, feeding sensor information into advanced MASINT automatic target recognition functions with direct sensor-to-shooter product dissemination.

3.2.4.7.3 Ultra-Wideband

Standards for this functional area are:

- *None*

Ultra-wideband sensors exploit non-intentional RF, detect wideband communications and tracking systems, or provide all-weather missile launch (plume) detection by characterizing rocket motor propellants and consequently the launch vehicle. An ultra-wideband receiver requires nominal operation over a band extending from 100 MHz to 10 GHz with greater than 2 GHz instantaneous bandwidth (10 GHz for strong signals with post processing). This is achieved

through the use of antennas and receivers specifically developed for ultra-wideband (wideband blade antenna) use with fiber optic feeds and fiber optic distribution of intercepted RF signals.

3.2.4.7.4 Non-Cooperative Target Identification

Standards for this functional area are:

- *None*

This is a broad category of MASINT RF techniques including analysis of radar cross section (RCS) signatures, feature modulation spectrum, and in general, it characterizes targets using the totality of all unintentional RF emissions. Ultra-wideband RF sensors collect against a wide variety of RF emissions from military equipment including directed energy weapons.

3.3 Navigation, Timing, and Ancillary Data

Standards for this functional area are:

- *Timing data synchronized to the United States Naval Observatory Coordinated Universal Time (USNO-UTC)*
- *A one-pulse per second (PPS) time tick provided over a MIL-STD-1553B bus*
- *IRIG-B timing standard*
- *SMPTE VITC Drop Frame Recommended Practices (SMPTE RP173: 1993 and SMPTE RP179: 1994) (video time base)*

The navigation, timing, and ancillary data functions, color coded blue in the airborne reconnaissance FRM (Figure 3-1), are very important common support functions that directly affect the overall quality of the finished airborne reconnaissance product. All processing and exploitation functions use navigation, timing, and ancillary data in some way when processing the sensor data. In general, navigation data is information about the position and attitude (roll, pitch, and yaw) of the collection platform, timing data is an exact reference to absolute real-time, and ancillary data is information about the sensors and payload (e.g., sensor mode, settings, commands invoked, etc.).

Functionally, navigation, timing, and ancillary data are “captured” in the front-end subsystems and disseminated to all other functions. Navigation data is captured from the platform’s inertial navigation subsystem and/or GPS; timing data is captured from the GPS and an on-board atomic clock frequency reference; and ancillary data is captured from the sensors themselves and the sensor control functions. The key term “data capture” includes data recorded either periodically (e.g., record the sensor mode every 15 seconds) or upon detection of specified triggering events (e.g., record the sensor mode whenever it is changed). “Recording” refers to real-time functions (on-board the platform) which logically attach time-tag data, navigation data, and ancillary data to the collected sensor data. The critical aspect is maintaining strict correlation of sensor data with the associated navigation, timing, and ancillary data.

Timing data synchronized to the United States Naval Observatory Coordinated Universal Time (USNO-UTC) is mandated. It will include a common precision frequency reference based on a rubidium or cesium atomic clock reference standard. Accuracy, precision, and latency will be set to meet the worst-case real-time processing requirements for SIGINT, IMINT, and MASINT payloads.

From the airborne platform inertial navigation system (INS) and Global Positioning System (GPS), navigational data and a one-pulse per second (PPS) time tick are provided over a MIL-STD-1553B bus. A fiber optic version of 1553B (i.e., MIL-STD-1773) is under investigation.

For video, the SMPTE VITC Drop Frame time base will be used for synchronization and timing. For all other data sources, the IRIG-B standard will be used in the case where a general purpose time reference is provided with a sensor data stream (e.g., on the audio track of a mission tape recorder or a time reference channel on the data link). IRIG-B calls for a 1 KHz signal with timing information encoded using pulse-width modulation. The IRIG-B message uses binary coded decimal (BCD) to encode the Julian date (three digits) and time of day (six digits) as follows: DDDHHMMSS. In some cases a high-precision time-tag will also be recorded with the data. Navigation data includes the following data elements (examples):

- Altitude (AGL and MSL)
- Latitude and longitude (or UTM)
- GPS delta

- Heading
- Ground speed and acceleration
- Drift angle
- Cross track
- Roll, pitch, and yaw

Ancillary data is particularly important for IMINT missions and payloads.

Example data elements include:

- Sensor identification (model, type, serial number)
- Sensor configuration (installed options, lens type & identification)
- Film type (if applicable)
- Calibration data (such as identification of dead CCD elements and lens aberrations)
- Camera location
- Forward and side look angles
- Camera mode
- Frame number
- Focal length, field of view, and exposure

Currently, the specific data elements, format, and details for transmission of the data are usually specified in Interface Control Documents (or equivalent system-specific specifications) that are unique for given system-to-system interfaces. An “across-the-board” standard would greatly enhance interoperability among airborne reconnaissance systems; for example, it would provide a basis for allowing alternative ground/surface systems to receive and process information from platforms other than the one(s) they were specifically designed for. A common metadata standard for airborne imagery is being developed by CIO and DARO and will be incorporated in a future version of the ARITA. The requirement for precise geopositioning (e.g., for TDOA/FDOA calculations and IFSAR/SAR PHD processing) demands highly accurate and precise timing and navigation data. Detailed standards are under development and will be adopted across the INTs in a future version of the ARITA.

3.4 Networking Functions

The networking functions (color coded red in the FRM, Figure 3-1) provide four key attributes as described in the following subsections.

3.4.1 Command and Control Network

Standards for this functional area are:

- *Ethernet (10 Mb/s)*
- *Fast Ethernet (100 Mb/s)*
- *FDDI (100 Mb/s dual counter rotating ring)*
- *ATM/SONET (155 Mb/s) (JTA Section 3.2.2.2.5 and 3.2.3.3)*
- *Fibre Channel (800 Mb/s)*

The primary function of the command and control (C²) network is to transport and distribute near-real-time commands to control on-board sensors and other functional components in the FRM. C² network functions are very similar to the multimedia network, the key difference being data throughput. In fact, the C² network functions can be implemented on the same physical LAN as the multimedia network. For many applications, the FDDI network referenced below is more than adequate to accommodate the C² information flow.

3.4.2 High-Speed Data Flow Network

Standards for this functional area are:

- *Fibre Channel*

The high-speed data flow network provides the transport and distribution functions for real-time exchange of raw/pre-processed digital sensor data between processing components. In order to preserve real-time synchronization of vital sensor data, the high-speed (500 to 1000 megabits per second) data flow network must have a low, deterministic end-to-end latency.

The SIGINT community has selected ANSI X3.230, Fibre Channel Physical and Signaling Interface (FC-PH), as the lowest risk technology for the high-speed data flow network. It offers the following technical characteristics which should be

adequate to meet the functional needs of IMINT and MASINT sensors as well the SIGINT applications for which it was selected as a technology standard.

- Layered high speed serial transport standard
- Scalable to support data rates of 12.5, 25, 50, and 100 megabytes per second (100 Mbytes per second equates to 1.0625 Giga-baud fiber rates)
- Support point-to-point links and non-blocking switching matrix
- Designed to replace physical interfaces for IPI-3 (Intelligent Peripheral Interface), SCSI II and Ultra SCSI (Small Computer System Interface), and HIPPI (High Performance Parallel Interface)
- Being applied to high speed LANs
 - TCP/IP (Transport Control Protocol / Internet Protocol)
 - Real-time and arbitrated rings/loops
 - UDP (User Datagram Protocol) over IP

3.4.3 Multimedia Network

Standards for this functional area are:

- *Ethernet (10 Mb/s)*
- *Fast Ethernet (100 Mb/s)*
- *FDDI (100 Mb/s dual counter rotating ring)*
- *ATM/SONET (155 Mb/s) (JTA Section 3.2.2.2.5 and 3.2.3.3)*
- *Fibre Channel (800 Mb/s)*

The multimedia network provides the transport and distribution functions for near-real-time distribution of processed sensor data and metadata tagged to the sensor data (e.g., information about the sensors and platform). It is similar to the high-speed data flow network, but the multimedia network can introduce small non-deterministic delays (latency) since it does not have to support true real-time communications requirements. However, it must be designed (data rate, number of nodes, media access protocol) such that the maximum latency through the

network meets the near-real-time requirements for networking multimedia data – spectral data, digital audio, video, graphics, imagery, and MASINT sensor data.

The ARITA recommends FDDI or Fast Ethernet for the multimedia network. Although ATM data rates may be preferable over FDDI and Fast Ethernet, especially for IMINT and multispectral applications, the lack of maturity of ATM LAN technology precludes its selection at this time.

The following are key FDDI technical characteristics.

- Token ring fiber optic network (62.5/125 micron multi-mode fiber)
- Dual counter-rotating fiber optic rings for redundancy
- 100 megabit per second data rate (125 mega-baud fiber rate)
- Maximum of 500 connections (stations)
- Maximum of 2 kilometers distance between stations
- Maximum frame size of 4500 octets
- Bit error rate of less than 2.5×10^{-12}
- 1300 nanometer LED transmitter
- Laser transmitter can be used on single mode fiber

Fast Ethernet is similar to FDDI in performance. Two key differences are that Ethernet doesn't use dual counter-rotating ring topology, and uses carrier-sense multiple access with collision detection access protocol (CSMA/CD) rather than the token ring protocol used in FDDI.

3.4.4 Data Link

Standards for this functional area are:

- *System Description Document for CDL, Specification #7681996, 5 May 1993*
- *System Specification for the CDL Segment, Class 1, Specification #7681990, draft-C, 11 April 1996*

The data link provides for near-real-time communications between the airborne platform and ground/surface functions. Note that the FRM (Figure 3-1) is

notional, and different airborne reconnaissance system implementations may place specific functions on different sides of the data link interface. For example, the SAR image formation function is allocated to the digital signal processing (DSP) block in the FRM, but actual equipment performing this function could be implemented in ground/surface system in some instances. Similarly, operator oriented database functions, reach back, and other functions shown to be ground/surface based in the FRM can actually be implemented on-board manned aircraft.

An OASD (C3I) Policy Letter, dated 18 October 1994, requires the Common Data Link (CDL) be used for all primary data links in airborne reconnaissance systems. CDL is a full duplex, jam resistant, point-to-point, microwave communications system developed by the Government for use in imagery and signals intelligence systems. It provides an interoperable, high bandwidth, digital data link for air-to-ground, air-to-surface, and air-to-satellite (relay) communications in airborne reconnaissance systems. The term "CDL" actually refers to a family of interoperable data links offering alternative levels of capabilities for different specific applications. In other words, the "generic" CDL can be scaled and configured in various ways to provide data link capabilities required for specific airborne reconnaissance mission requirements. For example, configuration options include choices of operating RF band (X or Ku), data rate (up to 274 megabits per second on the return link), and transmission power (offering design trades for size, weight, power, and range). Interoperability among the CDL family of datalinks is achieved by specifying the data link waveform (RF and digital), controlling and coordinating hardware configuration options, and managing pre-planned product improvement and technology insertion efforts to maintain backwards compatibility with fielded systems. For detailed technical information on CDL refer to the System Description Document for CDL, Specification #7681996, 5 May 1993, and the System Specification for the CDL Segment, Class 1, Specification #7681990, draft-C, 11 April 1996.

CDL provides "standardized" command link and return link services. The command link operates at a 200 kilobits per second (spread spectrum) data rate and provides services for transmitting data to the airborne platform (e.g., commands to the platform and/or sensor equipment, secure voice, ranging and navigation corrections, and commander's tactical terminal (CTT) link data). The return link operates at either 10.7, 137, or 274 megabits per second data rates and provides services for transmitting data from the airborne platform (e.g., sensor data, platform navigation data, secure voice, etc.).

CDL communications links through satellite utilize different data rates than the other line-of-sight CDLs. The return link operates at 2xT-1 (3.088 megabits per second), T-1 (1.544 megabits per second), T/2 (772 kilobits per second), and T/4 (386 kilobits per second) data rates and provides services for transmitting data from the remoted airborne platform (e.g., sensor data, platform navigation data, secure voice, etc.). The command link operates from 200 bits per second up to 6 kilobits per second over X band DSCS satellites and up to 64 kilobits per second data rate over commercial Ku band satellites and provides services for transmitting data to the remoted airborne platform (e.g., command and control of sensors, platform (UAVs), secure voice, CTT data link).

The standardized channel assignments for data multiplexing on the command link and return link are shown in Figure 3-5 and Figure 3-6 respectively. These assignments reflect current design practice, but a more flexible scheme is needed to accommodate future requirements (such as variable data rates from sensor outputs). In this regard, the CDL will migrate to a LAN interface standard (such as ATM or Fast Ethernet) which will provide a more robust, flexible, and transparent interface between airborne and ground/surface networks.

Legacy video systems currently use analog components; however, digital video is preferred and is the desired goal. To provide a clear migration path toward an all-digital system, any upgrades to existing systems should, at a minimum, support dual-capable analog/259M equipment. CDL will be used for the primary data link and real-time dissemination to warfighters can be supported by either the industry-standard DSS-based JBS/GBS or NTSC analog broadcast methods.

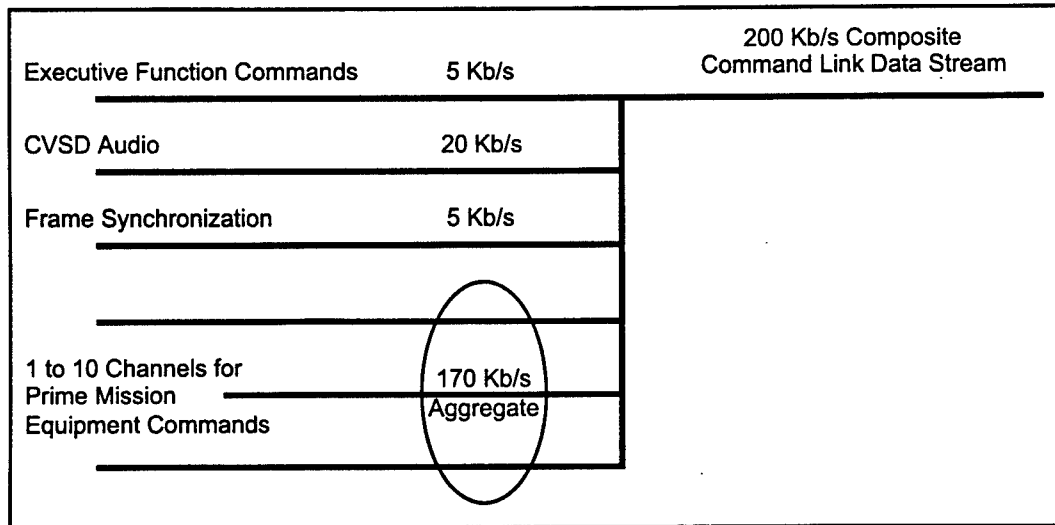


Figure 3-5: CDL Channelization Standard – Command Link

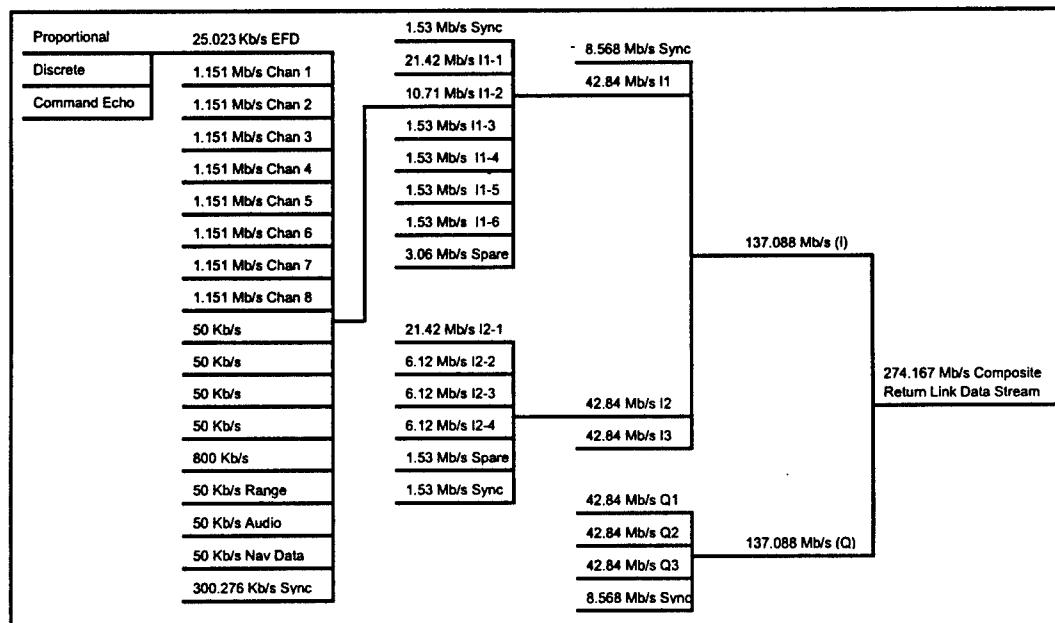


Figure 3-6: CDL Channelization Standard – Return Link

3.5 High Performance Processing Functions

High performance processing functions (color coded orange in the FRM, Figure 3-1: Airborne Reconnaissance FRM) generally refer to real-time processing operations performed on raw (or pre-processed) sensor data and real-time system control functions typically performed in airborne reconnaissance subsystems.

The term “real-time processing” refers to the ability to process data at computing speeds fast enough to keep up with continuous, sustained sensor data-rates with no data buffering. The term also refers to the ability to time-tag sensor data with great accuracy and precision, which may be measured in nanoseconds (e.g., accuracy of marking an event to an absolute time reference might be ± 50 nanoseconds, and precision might be to the nearest nanosecond). Similarly, the term “real-time system control” refers to the ability to invoke sensor (and other subsystem) commands at an exact instant in time, typically with accuracy measured in microseconds.

Functional descriptions for the digital signal processing, system processing and control, and encrypted storage functional areas are given in the following subsections.

3.5.1 Digital Signal Processing Functions

Standards for this functional area are:

- *Digital video: MPEG-2 4:2:2 Profile@Main Level (ISO/IEC 13818-1 Systems, 13818-2 Video, and 13818-3 Audio)*
- *Digital imagery: Joint Photographic Experts Group (JPEG) image compression*
- *Common Image Processor (emerging)*

The digital signal processing (DSP) functions are generally “number crunching” mathematical operations performed on the sensor data in real-time. Sensor data is input from the SIGINT, IMINT, and/or MASINT front-ends via the high-speed data flow network. Processed data is output to subsequent functions (e.g., processing, storage, or direct reporting) via the multimedia network. Currently, no standards exist for all DSP functions although some are under development.

Example DSP functions in the SIGINT domain include the following:

- Digital filtering (sub-band tuning, channelization, notch filtering)
- Transformations (fast fourier transforms (FFTs), spectrum analysis)
- Signal analysis and demodulation (modulation type, parameterization, decoding)
- Time difference of arrival (TDOA), differential doppler, and precise geopositioning
- Direction finding
- Pulse processing
- Search

Example DSP functions in the IMINT domain include the following:

- Image formation (SAR phase history processing)
- Transformations (FFTs, discrete cosine transforms (DCTs))
- Image compression algorithms
- Automatic target detection and automatic target recognition algorithms
- Digital filtering (haze removal, edge enhancement)
- Radiometric corrections

Example DSP functions in the MASINT domain include the following:

- Similar functions as for SIGINT and IMINT
- SAR phase history processing
- Spectral analysis
- Signature characterization and analysis

The Common Imagery Processor (CIP) program is directed at standardizing some of the DSP functions for imagery. Originating from the CIGSS initiative, the DARO funded the initial CIP program to develop a proof-of-concept capability for imagery ground/surface systems to demonstrate the feasibility of processing data from multiple IMINT sensor subsystems in a single, common processor. The functions would be similar to those cited above for the IMINT DSP functions. The CIP will interface with sensors of various types (SAR, electro-optical, and IR), and from various manufacturers. If the proof-of-concept is successful, the

DARO will assess whether a CIP follow-on program will be pursued as a standard technology for IMINT ground/surface systems.

The services also have been migrating to common SIGINT processors to conserve R&D dollars and lower recurring costs through multi-service purchases. In addition, the SIGINT community's JASA initiatives include standardizing some of the real-time SIGINT processors (e.g., SEI processors, PROFORMA, ELINT, multichannel, etc.). Recent R&D shows promise for a shoe-box size CRAY super-computer that will enhance the capability to process multiple types of signals simultaneously through state-of-the-art technology (e.g., Marquise, S90E). Massively parallel super-computers enable multiple signal processing algorithms to execute concurrently which widens the instantaneous spectral coverage. This type of technology will become more prevalent in airborne reconnaissance systems, especially where mission requirements call for high performance processing in airborne components of the system.

For digital video, MPEG-2 4:2:2 Profile@Main Level (ISO/IEC 13818-1 Systems, 13818-2 Video, and 13818-3 Audio) is the designated standard.

The only other applicable technology standards identified to date are for image compression algorithms. Airborne reconnaissance systems should use image compression algorithms specified in the National Imagery Transmission Format Standards (NITFS). Per that standard, which currently applies only to still images, Joint Photographic Experts Group (JPEG) is preferred.

3.5.2 System Processing and Control Functions

Standards for this functional area are:

- *None*

This area refers to those functions that are typically implemented in the platform's subsystems to effect overall control of the reconnaissance payload (e.g., sensors and processing subsystems). The principal function is making real-time commands to the front-end and DSP functions* to manage and control the remote

* Commanding the DSP functions is applicable only if they are performed in the platform's subsystems (e.g., on-board SAR processing and/or SIGINT signal processing). If DSP functions are performed in

sensing process (collection) and real-time processing of the sensors' data. This may involve executing a preplanned target acquisition plan (e.g., in the case of autonomous UAV operations), or it may involve responding to operator command and control received from operator workstations either on-board or remotely through the data link. In the case of operator-invoked commands, latency is a key design concern (i.e., delay from operator action to execution of the command, and return of the expected response back to the operator).

Functionally, as shown in the FRM (Figure 3-1), the system processing and control functions use the high speed data flow network for the real-time interfaces with the front-end and DSP functions. The C² and multimedia networks are used for interfaces with other functions.

Other system processing and control functions include the following:

- System initialization and downloading/uploading application programs
- System diagnostics, fault detection/isolation, recovery, and calibration
- Automated reporting (readouts) and dissemination
- Encryption and decryption of data
- Sensor cross-cueing (either same platform or multiple platforms)
- Data correlation fusion

Currently there are no technology standards identified for system processing and control functions.

3.5.3 Encrypted Storage Functions

Standards for this functional area are:

- *None*

Encrypted storage provides the capability to store classified algorithms, data, etc. necessary to support the mission while allowing the platform to be operated at an

ground/surface subsystems (e.g., IMINT common imagery processor functions), real-time commanding is limited to the special pre-processing functions and remote sensor controls in the front-end functional area.

unclassified level when unkeyed. Currently, there are no technology standards identified for encrypted storage functions.

3.6 Operator Oriented Processing Functions

This part of the airborne reconnaissance functional reference model (color coded purple in Figure 3-1) refers to the functions provided in operator workstations, databases, servers, and product libraries. In general, these processing functions are those which are ordinarily implemented in software application programs hosted on general purpose computer equipment (e.g., COTS workstations and associated peripherals). Therefore, most of the standards lead to “open systems” by guiding the design of the underlying software operating environment. In modern design practice, these standards are collectively referred to as “information technology” (IT) standards which are the primary subject of most technical architectures (e.g., IEEE POSIX and DoD JTA).

The technical reference model and IT standards presented later in Section 4 apply specifically to the operator oriented processing functions described in this section. In addition, specific technology standards that should be applied, such as critical common software applications or hardware-oriented standards, are identified in this section.

3.6.1 Operator Workstations

Standards for this functional area are:

- *Refer to Section 4*

Operator workstations can be located on-board the airborne reconnaissance platform or in associated ground/surface systems. Workstation functions are highly reconfigurable through software-only changes (e.g., configuration loads for different mission requirements) and, therefore, allocations of specific functions over a number of distributed workstations can be determined by the system users/administrators.

All functions available to the users/operators are accessible through the human-computer interface (HCI) implemented at the operator workstation. Workstations host application programs locally that provide specific mission functions, such as data processing and intelligence analysis tools, but they also host various software

clients that provide access to programs and functions hosted on other distributed systems. The choice of where specific software actually resides is, and should remain, strictly a system design trade. Through the selection of appropriate IT standards, the technical architecture strives to enable independence of application software from the underlying hardware infrastructure. The rapid growth in computer technology and effective IT standards is finally beginning to show some progress towards this ultimate goal.

The general functions available to the users/operators through the operator workstations include the following:

- System Planning and Control Functions described in Section 3.8
- SIGINT, IMINT, and MASINT sensor control functions described in section 3.2.1.2
- High Performance Processing Functions described in Section 3.5
- SIGINT, IMINT, and MASINT analysis/exploitation and exploitation management functions
- All source analysis and data fusion/correlation functions
- Multi-INT and multi-platform cross-cueing functions
- Communications and network management functions
- System administration and management functions

There are no specific technology standards that apply to operator workstations other than the IT standards identified in Section 4.

3.6.2 Database Functions

Standards for this functional area are:

- *None*

The database functions in the airborne reconnaissance FRM apply to storing, indexing, linking, managing, maintaining, and accessing reference information used throughout the airborne reconnaissance system (i.e., by various functions defined in the overall FRM). A representative list of the types of information required in the total system is given in Section 3.8.2, Mission Planning Functions and Interfaces. Although this is only one of the functional areas, it requires a

wealth of information to support the required functions, and the same information is also needed by many other system functions. The database functions serve to make this information available to all functions with no duplication and, therefore, simplifies database management procedures.

Applicable IT standards for the database functions are identified in Section 4 of this document.

3.6.3 Server Functions

Standards for this functional area are:

- *Imagery Exploitation Support System (IESS)*

Server functions refer to the various subsystems supporting the overall system operations. Examples include communications servers (e.g., for formatted message traffic) and other software applications not hosted directly on the workstations such as the Imagery Exploitation Support System (IESS). The IESS “host” is considered a server function, and the specific capabilities provided for image analysts will be accessible through client software running on their workstations. IESS provides imagery exploitation management functions and is the designated “standard” to be used in imagery ground/surface systems. No other standardized servers have been designated for airborne reconnaissance systems.

3.6.4 Product Library Functions

Standards for this functional area are:

- *Image Product Archive (IPA)*
- *Image Product Library (IPL) (emerging)*

The primary function for product libraries is to maintain a complete set of all reconnaissance products produced (in a given system) and make them available to all potential users on a “pull” or “smart push” basis.* Although the products may

* “Pull” refers to capabilities where users can query and/or browse the product library and download selected products. “Smart push” is the case where a user defines a specific profile of interest and the product library automatically sends matching products to that user when they are put in the library. Emerging technology,

include conventional formatted message reports, product libraries are most useful for disseminating newer “specialized” products such as video and audio clips, imagery, graphics, multi-media, and hypertext products like those available on the Internet. Dissemination of these products and access to the product libraries will be through the Internet protocol router networks – NIPRNET, SIPRNET, and JWICS – as described in Section 3.7.2, Operator Reporting Functions.

Metadata is probably the single most important consideration for designing effective product libraries. Metadata is essentially data about data. It consists of key elements of information that serve to completely describe and uniquely identify the product. When users search for specific information, their search is usually performed against the metadata, not against the products themselves. For example, rather than viewing massive volumes of digital products, users would perform a query against the metadata to identify a small number of specific products of interest. These could then be viewed to select the one or two which could be used to satisfy the particular need.

The imagery community’s IPA (to be replaced by the emerging IPL) is the only current technology standard for product library functionality and will be used in airborne reconnaissance imagery ground/surface systems. IPLs will contain metadata in accordance with the CIO’s *Standards Profile for Imagery Access* and the *Profiles for Imagery Archive Extensions*. IPLs will also comply with the CIO’s Standards Profile for Imagery Dissemination.

3.7 Reporting and Connectivity Functions

Reporting and connectivity functions, color coded yellow in the FRM diagram, provide the communications pathways and protocols required to integrate airborne reconnaissance systems with the “rest of the world.” The four types of interfaces and multi-level guard functions are described in the following subsections.

3.7.1 Direct Reporting Functions

Standards for this functional area are:

such as intelligent agents, will soon enable “smart pull” where the software agent automates the information discovery and retrieval process on behalf of the user.

- *The J-Series Family of TDLs (DoD JTA Section 4.2.4.2.1)*
- *IBS*
- *JBS/GBS*

The direct reporting interface provides the required pathway(s) to disseminate intelligence data directly to the warfighters or "shooters." The specific products/reports disseminated through this interface will generally be automatically generated. This pathway also allows the airborne reconnaissance system to receive direct reporting from other airborne intelligence, surveillance, and reconnaissance (ISR) systems (e.g., to facilitate cross-platform cueing).

Airborne reconnaissance systems will support the J-Series family of Tactical Data Links (TDLs), the Integrated Broadcast System, and the Joint Broadcast System (JBS) as described in the following paragraphs.

The J-Series family of TDLs allow information exchange using common data element structures and message formats which support time critical information. The family consists of Link 16, Link 22, and the Variable Message Format (VMF) and interoperability is achieved through use of J-Series Family messages and data elements. The Link 16 tactical data link is a secure, high capacity, jam resistant time division multiple access (TDMA) data link which is implemented with the Joint Tactical Information Distribution System (JTIDS) and Multifunctional Information Distribution System (MIDS) transceiver suites. Applicable standards for the ARITA are cited in the following JTA Sections: 3.2.3.2.5, 3.3.3.2, 4.2.4.2.1, and 4.3.4.

IBS is a migration system selected by the DoD to merge several legacy UHF broadcast systems into a common implementation. IBS will be a single broadcast dissemination architecture based on a single receiver family (i.e., the Joint Tactical Terminal). The Military Communications Electronics Board (MCEB) directed that the Navy assume executive oversight, the Army take the lead for tactical terminal migration, and the Air Force take the lead for broadcast migration. By the objective year FY2000, IBS will route low data rate transmissions to non-GBS satellites, defer high data rate transmissions (e.g., imagery) to GBS, and provide additional capability for interactive two-way line-of-sight communications.

The Joint Broadcast Service (JBS) is the first phase of the Global Broadcast System (GBS) and was made operational primarily to support immediate

operations in Bosnia. JBS is a commercial SATCOM service based on commercial television Direct Broadcast Service (DBS) technology. The JBS was implemented as an element of the Predator UAV communications architecture, specifically for the dissemination of EO and IR video sensor information (including audio annotation/narration). In this implementation, the processed/exploited video information is relayed from the UAV ground station via T-3 transoceanic cable to the JBS injection site located at the Naval Research Laboratory (NRL), from where it is transmitted to an Atlantic Ocean Region (AOR) to JBS receivers.

The message format standards for direct reporting are cited in the JTA:

- Section 4.2.4.2.1 Bit Oriented Data
- Section 4.2.4.2.2 U.S. Message Text Format (Character Oriented Data)
- Section 4.3.4 Information Standards (emerging)

3.7.2 Operator Reporting Functions

Standards for this functional area are:

- *References to the DoD JTA will be included in a future version of the ARITA.*

Operator reporting includes dissemination of formatted message traffic, imagery, imagery products, database transaction updates, and graphical situation display data. In general, these products are widely disseminated through the DoD communications infrastructure which includes the following:

- NIPRNET — Non-secure Internet Protocol Router Network; replaces the unclassified subnet of the Defense Data Network (DDN)
- SIPRNET — Secure Internet Protocol Router Network; replaces the collateral secret subnet of the DDN
- JWICS — Joint Worldwide Intelligence Communications System; replaces the TS/SCI subnet of the DDN
- Plain Old Telephone System (POTS) — includes commercial analog and digital circuits, including circuit-switched and packet-switched technology

The Internet protocol router networks – NIPRNET, SIPRNET, and JWICS – provide worldwide communications services for authorized users. General services include electronic mail, file transfer, and remote terminal functions. Additional services are provided by specific open systems software applications which typically offer client/server functions through the network for a large population of users. Access to the Internet protocol router networks from within airborne reconnaissance systems may be provided either directly (e.g., when a ground/surface system is located at a major operational base and can be connected to a local node) or through other tactical data networks and/or satellite communications links (e.g., when a ground/surface system is deployed and linked back to its home node).

Intelink may become the preferred service for disseminating airborne reconnaissance products. It uses COTS software to provide Internet-like (browser) services over JWICS and SIPRNET. Authorized users can use the service to access information on any server in the network. That is, external users can access information contained in airborne reconnaissance systems, and internal users can access information on external servers. Although Intelink is fairly easy to use already, more robust information discovery and retrieval tools will be available to Intelink users as the Internet information technology continues its explosive growth.

Many airborne reconnaissance products are disseminated as formatted AUTODIN messages in today's systems. This method of dissemination will continue to be used as appropriate for disseminating USMTF messages. The Defense Message Service (DMS) is another service which rides over the Internet protocol router networks and will replace AUTODIN.

The CIO's Image Product Library (IPL) will be another primary means for dissemination of airborne reconnaissance imagery and imagery-derived products. These libraries are part of the CIO's A3I program to provide an open architecture for the widest possible imagery access and dissemination. Using IPL client software, external users can access airborne reconnaissance products (stored in national, regional, and command level libraries) through the internet protocol router networks and tactical data circuits (e.g., ship-to-shore). Internal users can access products on other servers. IPL client software will be available on Joint Deployable Intelligence Support System (JDISS), Global Command and Control System (GCCS), and other workstations and integrated with Intelink client software for even wider use.

3.7.3 Command and Control Interface Functions

Standards for this functional area are:

- *See ARITA Sections 3.7.2 and 3.8*

The C² interface functions provide the primary means for warfighter command and control over airborne reconnaissance systems. This pathway provides the various communications services for passing information such as command and control messages, mission tasking, intelligence database updates, etc. The networks, services, and technology standards are the same as those used for the operator oriented reporting functions described in the previous section. However, the information and specific data formats communicated are different.

Additional C² interface functions for airborne reconnaissance are with collection management systems, mission planning systems, and mission control systems. Detail on these functions is given in Section 3.8, System Planning and Control Functions.

3.7.4 Reach Back / Reach Forward Functions

Standards for this functional area are:

- *None*

The reach back / reach forward functions provide the interfaces required for near-real-time integration with other intelligence community systems and to support split-base operations. Reach back generally refers to an operation where airborne reconnaissance sensor data is passed back to supporting site facilities for processing and/or exploitation/analysis. This is required in cases where the airborne asset does not have the capacity or capability to support analysis/exploitation of sensor data on-board. Reach forward generally refers to capabilities for data from supporting intelligence centers to be forwarded to the airborne reconnaissance system for relay, exploitation, cross-system cueing, data correlation, or other intelligence functions.

High data rate point-to-point communications circuits are used to support the reach back / reach forward functions. These functions can be implemented on commercial circuits (e.g., INMARSAT, Intelsat, PANAMSAT, etc.) or on military assets (e.g., Defense Secure Communications System (DSCS), Trojan

Spirit). Data communications protocol standards are selected on a case-by-case basis tailored to the communications circuits available, airborne reconnaissance systems involved, and mission requirements. Minimum data link requirements for SIGINT are 192 kilobits per second return link and 64 kilobits per second command link. IMINT missions often require tens to hundreds of megabits per second on the return link, and the data rate for MASINT missions are still being worked but will not exceed IMINT requirements.

3.7.5 Multi-Level Guard Functions

The multi-level guard functions provide appropriate security protection/filters that securely implement and enforce the required airborne reconnaissance system security perimeter. These functions include firewalls, security guards, and link encryption as appropriate. Standards in this area will be addressed in a future version of the ARITA.

3.8 System Planning and Control Functions

The ARITA defines three general areas for dealing with planning and control functions and related standards. These are:

- Collection management,
- Mission planning, and
- Mission control.

Collection management is a process that is performed by a Collection Management Authority (CMA) who uses a specific collection management system. The interfaces with those systems are covered in Section 3.8.1 below. Mission planning is a process that may be performed within an airborne reconnaissance system or it may be performed externally. These functions and interfaces are covered in Section 3.8.2. Mission control is a process which deals with execution of specific reconnaissance missions and is therefore an integral part of airborne reconnaissance systems (i.e., internal functions). The mission control functions and associated technology standards are covered in Section 3.8.3.

3.8.1 Collection Management Interfaces

Standards for this functional area are:

- *Form 1684 (de facto)*
- *RMS Aircraft Tasking Message (emerging)*

There are currently two basic procedures for tasking airborne reconnaissance missions. Normal peacetime operations are under Sensitive Reconnaissance Operations (SRO) rules and undergo rigorous and time intensive tasking and planning procedures. These procedures are detailed in CJCSI 3250.01, 02, and 03 and the various theater reconnaissance operations directives. These will not be discussed here. Contingency and wartime reconnaissance missions follow the same general procedures as SRO missions, except that the planning, tasking and execution focus is dictated by the theater or JFCC operations orders. Collection requirements are generated by warfighters and then allocated to collectors by the CMA. The CMA typically uses a system such as the JCMT to provide an overview of the requirements database. Next JCMT conducts a feasibility assessment considering all classes of collection assets, ranging from ground to airborne to space collectors. Once a particular collector is deemed appropriate and able to conduct the operation, JCMT will perform a more detailed feasibility analysis using a model of the reconnaissance system and sensors. With these results, the CMA will task a collection system; this requires coordination with the Air Operations Center (AOC) for the scheduling of reconnaissance missions. Actual tasking then flows to the operational unit potentially twice: the mission route and timing sequence is generated as an integrated part of the Air Tasking Order (ATO) and approved by the AOC while specific sensor tasking is generated directly by the collection management system (in the form of sensor tasking messages such as the Form 1684 for imagery). The CMA's collection management system provides the reconnaissance feedback to the warfighters who originated the requests for information. The notional tasking flow is depicted in the following diagram.

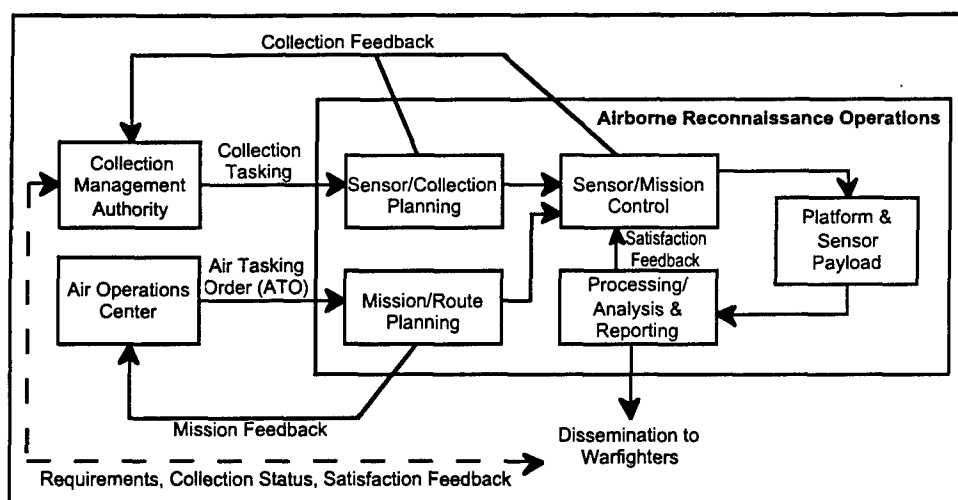


Figure 3-7: Notional Flow for Collection and Mission Tasking

The collection tasking and feedback messages form the key interface functions for airborne reconnaissance systems. These messages will vary depending on which collection management system the CMA is using, and what type of collection is being tasked (i.e., SIGINT, IMINT, or MASINT). The interface between airborne reconnaissance and collection management systems is effected through the Command and Control Interface Functions (Section 3.7.3).

IMINT collection tasking has long been dependent on a machine readable message format – the Form 1684, which was eliminated in November 1994 by DIA/CL (the collection management authority). However, systems such as CARS and ETRAC, functioning as U-2 ground stations, continued to use this message format since there is still no replacement. Other airborne reconnaissance systems are equally dependent on a standard machine-readable tasking message. In some systems, collection tasking is not automated and telephone conversations (voice) may be the sole means for receiving and coordinating tasking from the CMA.

SIGINT collection tasking is highly structured and follows priorities similar to those expressed in the National SIGINT Requirements Listing (NSRL). The collection operator is provided with a prioritized listing of collection needs with detailed descriptions of known operating procedures and intelligence needs. From this prioritized listing, the SIGINT collection system managers allocate resources to meet tailored mission needs. For airborne collection, SIGINT Numerical Tasking Requirements (SNUTRs) usually detail a prioritized set of target signals

(and specific collection and/or processing requirements) for any number of collection scenarios.

Collection tasking for MASINT systems is limited to selecting airborne platforms with future areas not yet fully defined for airborne reconnaissance systems.

An RMS Aircraft Tasking Message is proposed to come into use by RMS during the 1999 to 2000 time frame. JCMT also plans to use the new RMS Aircraft Tasking Message format for imagery tasking. This format could be adapted for SIGINT and MASINT, thereby making this message effective for *multi source* tasking. This would require coordination among DIA, NRO, CIO, NSA, DARO, and CMO etc. With this standard a commander at any echelon can forward his collection request to the appropriate collection management office for validation. The CMA will be able to forward the request for national satisfaction or route the request to the appropriate tactical airborne collector. Organic tactical collection assets will continue to be tasked by their tactical commanders without change from current practice.

Airborne reconnaissance systems must provide feedback to the CMA who, in turn, provides status to the warfighters. This includes the following information:

- When collection requirements were accepted
- Which collection mission was tasked
- When the collection mission was completed
- Which ground/surface system was tasked
- When the reconnaissance product will be delivered
- How the reconnaissance product will be delivered

3.8.2 Mission Planning Functions and Interfaces

Standards for this functional area are:

- *None*

In general, all of the following high-level "mission planning" functions have to be accomplished for any airborne reconnaissance mission, whether it be for UAVs or manned platforms:

- Route planning (navigation aids, radar predictions, way points, turn points, flight plans, air space deconfliction, refueling points, etc.)
- Calculations for takeoff and landing, fuel consumption, etc.
- Maneuvers and tactics for target penetration and threat avoidance (SAM/AAA lethality, detection avoidance, radar cross section, etc.)
- Planning for escape and evasion (including preplanned search and rescue operations)
- Communications planning (frequency allocations for data links and radios, link acquisition and tracking, IFF initialization, etc.)
- Collection strategy and sensor planning (time on target, sensor and mode selection, acquisition parameters, etc.)

Not all airborne reconnaissance systems have their own integral mission planning capabilities. In some cases, the planning functions are performed externally by flight operations personnel (e.g., flight crew), and the detailed plans are then passed to the associated ground/surface system so they can plan for the subsequent processing, exploitation, and reporting. In other cases, processing, exploitation, and reporting functions are performed on-board the platform, so passing the detailed mission plans is not a necessary interface.

AFMSS and TAMPS are the mainstream mission planning systems currently used with many types of aircraft. Both AFMSS and TAMPS have the requisite functions and capabilities needed to perform most of the mission planning functions for airborne reconnaissance platforms, but they do not have capabilities for collection strategy and sensor planning, nor do they have the platform-specific parametric data, performance models, etc. Nevertheless, AFMSS and TAMPS are the preferred technology standards for meeting airborne reconnaissance mission planning needs. Using a DoD standardized capability, even a de facto one, is preferable to proliferating custom-built, unique subsystems just for airborne reconnaissance.

Mission planning requires a wealth of information, some of which is listed below. Acquiring and managing this information in a “standardized” mission planning system is (arguably) the prime benefit realized by picking a standardized system/technology. In addition, much of the information can and should be shared with other functional areas, although this is too often not the case in current systems. In the context of the airborne reconnaissance FRM, the information

should be stored and managed in the database functional area described in Section 3.6.2. Examples follow:

- Operations and tasking messages/data such as air tasking orders, airspace control orders, special instructions, airlift mission schedules, etc.
- Detailed meteorological data and weather forecasts
- Digital Aeronautical Flight Information File (DAFIF) and installations data
- Intelligence data (ostensibly in DIA MIIDS/IDB format) including:
 - Orders of Battle including Air, Electronic, Missile (fixed), Tactical (mobile), Naval, and Ground
 - Data correlated and fused from multiple theater sources (e.g., from JIC/JAC)
 - Near-real-time intelligence from broadcast or tactical data links
 - Local intelligence from post mission analyses and briefings
- Aircraft/platform performance models, parametric data, and radar cross section data (e.g., from the Technical Orders and manuals)
- Sensor models and parametric models
- Threat models and parametric data
- Mapping, cartography, and geodesy data (e.g., from DMA)
 - Global Navigation Charts, 1:5,000,000
 - Jet Navigational Charts, 1:2,000,000
 - Operational Navigational Charts, 1:1,000,000
 - Tactical Pilotage Charts, 1:500,000
 - Joint Operations Graphics-Air, 1:250,000
 - Topographic Line Maps, 1:50,000
 - City Graphic (variable scales from 1:5,000 to 1:15,000)
 - Digital Terrain Elevation Data (DTED)
 - Probabilistic Vertical Obstruction Data (PVOD)

- Digital Features Analysis Data (DFAD) Level 1
- Vector Smart Map (VMAP)
- Digital Nautical Chart
- Digital Bathymetric Database
- Navigation Information Network
- Tactical Terrain Data
- Digital Chart of the World (DCW)
- Vector Product Family (VMAP0, VMAP1)
- Urban Vector Map
- Electronic Chart Updating Manuals (ECHUMs)
- Digital Point Positioning Database (DPPDB)
- Reference imagery including SPOT, LANDSAT, and target imagery

The interfaces required for mission planning functions vary depending on specific system operational requirements and mission needs. For example, systems operated by the USAF will receive intelligence data from the unit-level Combat Information System (CIS), whereas Special Operations Forces will be served by SOCRATES (their intelligence system), and the Army will generally rely on their All Source Analysis System (ASAS). Regardless of the *source* of the data, it will generally be received in airborne reconnaissance systems through the Command and Control Interface Functions described in Section 3.7.3 or via bulk digital media such as magnetic tape and CD-ROM.

3.8.3 Mission Control Functions

Standards for this functional area are:

- *None*

Mission control functions provide for real-time and near-real-time control of the platform, sensor suite, and communications subsystems during the execution of reconnaissance missions. This functional component of the FRM refers to the control functions implemented in ground/surface subsystems. Real-time control functions in the airborne components are covered in the System Processing and

Control Functions part of the FRM described in Section 3.5.2. Obviously, there is an interface between these two functional components which is implemented through the data link (Section 3.4.4).

The three highest-level types of mission control functions are listed below. Note that different implementations may provide none of the functions, any combination, or all of the mission control capabilities depending on specific systems employed, their configuration, and mission operational requirements.

- Remote piloting functions and telemetry data;
- Remote sensor control functions; and
- Dynamic retasking functions.

In the case where a UAV is remotely piloted, telemetry data is transmitted to the ground/surface system and piloting commands are transmitted to the vehicle via the data link in real-time. The telemetry data essentially provides the same data that would otherwise be displayed to a cockpit pilot, but it is processed and displayed on ground-based equipment. As an aide to the ground-based "pilot," telemetry data also includes real-time video (e.g., in the visible part of the spectrum). The remote piloting functions are also used to facilitate take-off and landing for UAVs that may otherwise operate autonomously by executing programmed flight and sensor operations plans. Currently there are no standards for remote piloting and telemetry data interfaces.

Remote sensor control functions serve to extend real-time, direct control of the collection equipment to operators stationed in ground/surface systems. Remote commands may include, for example, tuning receivers, aiming directional antenna, changing sensor modes, pointing cameras, adjusting focal length and exposure, setting on-board processing parameters, and a host of other operator-controlled functions. Currently, there are no standards for remote commanding functions.

However, a standardized command set for each major type of sensor (e.g., for tuners, cameras, SAR, MTI, spectral, video, etc.) would likely facilitate a much higher degree of interoperability among systems (e.g., a step towards enabling common ground/surface systems to interoperate with multiple platforms). Standardized command sets would also enable the manufacture of interchangeable sensors (e.g., same form, fit and function components from multiple vendors).

Dynamic retasking functions enable reconnaissance operations to be changed in near-real-time by designated users/operators. Changes may affect the platform, such as navigating to a new track (flight path), or they may affect the sensor suites, such as switching SAR modes or switching from SIGINT to imagery collection. Dynamic retasking increases mission effectiveness by enabling reasonably rapid response to unexpected events such as changes in weather, tip-offs from other collection systems (e.g., national), cross-cueing among multiple interconnected platforms, and changes in ISR needs. Retasking generally involves preparing revised mission and sensor plans in near-real-time and “up loading” the new information to the affected platform. Currently, in the case of manned platforms, the retasking is usually communicated to the Mission Commander via voice or message. In the future, as for UAVs, retasking will involve transmitting updated data to the platform electronics and sensor subsystems (including reinitializing the navigation systems). Functions and standards for preparing mission and sensor plans are discussed in Section 3.8.2 above.

3.9 Summary of Technology Standards for the FRM

The specific technology standards cited for the various functional areas of the FRM are summarized in the following table. In addition to listing the existing standards, the table includes the areas which were specifically identified as key areas where new standards would be particularly beneficial.

Table 3-1: Summary of Technology Standards

Section	Title	Existing Standard(s)	Standard(s) Needed
3.2.1	Common Front-End Functions		
3.2.1.1	Sensor/Platform Integration Mechanics	MIL-STD-704E (Prime Power)	
3.2.1.2	Sensor Control Functions	None	Standardized command set
3.2.1.3	Special Pre-Processing Functions	None	
3.2.1.4	Mission Recorders	High rate digital imagery: • DCRSi • ANSI ID-1 Legacy analog video: • VHS and Super VHS • Hi 8mm Migration to digital video: • Y/C component analog • SMPTE VITC (timing) • Dual-capable analog/ SMPTE 259M recorder Digital video: • SMPTE 259M SIGINT recorders: • AN/USH - 28 • DTSR • Hi 8mm Timing data: • IRIG-B	
3.2.2	SIGINT Front-End Functions		
3.2.2.1	RF Distribution	50Ω coax cable	
3.2.2.2	Low and High Band Tuners	IF distribution via 50Ω coax cable, frequencies at: 21.4 MHz 70 MHz 160 MHz 1000 MHz 5000 MHz	
3.2.2.3	Set-On Receivers	None	
3.2.2.4	IF Distribution	None	

Table 3-1: Summary of Technology Standards, continued

Section	Title	Existing Standard(s)	Standard(s) Needed
3.2.2.5	IF Digitizer	None	
3.2.2.6	Sub-Band Tuners	None	
3.2.3	IMINT Front-End Functions		
3.2.3.1	Film Cameras	None	
3.2.3.2	Electro-Optical Sensors	Common practice: 8 to 11 bits/pixel greyscale, 24 bits/pixel color (typical) Up to 274 Mb/s data rate (CDL limit)	
3.2.3.3	Infrared Sensors	None	
3.2.3.4	Video Cameras	NTSC/RS-170 (analog) HDTV/MPEG-2 (digital) • CCIR 601 4:2:2 • SMPTE VITC - SMPTE RP173 - SMPTE RP179 • MPEG-2 4:2:2 profile@ main level - ISO 13818-1 Systems - ISO 13818-2 Video - ISO 13818-3 Audio	Video metadata
3.2.3.5	Synthetic Aperture Radars	None	Future standards from Common Image Processor
3.2.3.6	Moving Target Indicator Radar	None	
3.2.3.7	Spectral Sensors	None	
3.2.3.8	Image Quality Standards	Image interpretability scales for visible, IR, and SAR	Image interpretability scale for video
3.2.4	MASINT Front-End Functions		
3.2.4.1	Chemical/Biological Weapons Sensors	SEIWG-005	
3.2.4.2	Laser Warning Sensors	None	
3.2.4.3	Unattended Ground Sensors	SEIWG-005	
3.2.4.4	Air Sampling	None	

Table 3-1: Summary of Technology Standards, continued

Section	Title	Existing Standard(s)	Standard(s) Needed
3.2.4.5	Synthetic Aperture Radars		Future standards from Common Image Processor
3.2.4.6	Spectral Sensors	None	
3.2.4.7	RF Sensors	None	
3.3	Navigation, Timing, and Ancillary Data	Global Positioning System USNO-UTC synchronized MIL-STD-1553B bus IRIG-B SMPTE VITC (video)	"Across-the-board" data element and format standard(s)
3.4	Networking Functions		
3.4.1	Command and Control Network	Ethernet (10 Mb/s) Fast Ethernet (100 Mb/s) FDDI (100 Mb/s) ATM/SONET (155 Mb/s) Fibre Channel (800 Mb/s)	
3.4.2	High-Speed Data Flow Network	Fibre Channel	
3.4.3	Multimedia Network	Ethernet (10 Mb/s) Fast Ethernet (100 Mb/s) FDDI (100 Mb/s) ATM/SONET (155 Mb/s) Fibre Channel (800 Mb/s)	
3.4.4	Data Link	Common Data Link	
3.5	High Performance Processing Functions		
3.5.1	Digital Signal Processing Functions	Image compression algorithms: JPEG for still imagery, MPEG-2 for digital video	Future standards from Common Image Processor and SIGINT R&D (e.g., shoe-box size super computer technology)
3.5.2	System Processing and Control Functions	None	
3.5.3	Encrypted Storage	None	
3.6	Operator Oriented Processing Functions		
3.6.1	Operator Workstation	ARITA Section 4	
3.6.2	Database Functions	ARITA Section 4	
3.6.3	Server Functions	Image Exploitation Support System	Standard applications for SIGINT and MASINT

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Table 3-1: Summary of Technology Standards, concluded

Section	Title	Existing Standard(s)	Standard(s) Needed
3.6.4	Product Library Functions	Image Product Archive Standards Profile for Imagery Access (SPIA) Profiles for Imagery Archive Extensions	Image Product Library
3.7	Reporting and Connectivity Functions		
3.7.1	Direct Reporting Functions	J-Series Family of TDLs IBS JBS/GBS Message Formats per JTA	
3.7.2	Operator Reporting Functions	DoD IP Router Networks Defense Message Service Intelink Message Formats (TBD)	
3.7.3	Command and Control Interface Functions	DoD IP Router Networks Defense Message Service	
3.7.4	Reach Back/Forward	None	
3.8	Planning and Control Functions		
3.8.1	Collection Management Interfaces	Form 1684 (de facto) RMS Aircraft Tasking Message (emerging)	
3.8.2	Mission Planning Functions and Interfaces	None	
3.8.3	Mission Control Functions	None	

4. Airborne Reconnaissance Technical Reference Model and Information Technology Standards

The airborne reconnaissance Technical Reference Model (TRM) provides a common framework depicting the open systems software environment to be followed in migrating or developing airborne reconnaissance systems. The TRM was derived from the Technical Architecture Framework for Information Management (TAFIM). Information technology (IT) standards follow the DoD Joint Technical Architecture (JTA) – Draft Version 1.0, 12 July 1996.

4.1 Relationship to the Functional Reference Model

The FRM (Figure 3-1) represents information flow from an operational or functional view, whereas the TRM represents the software interactions in satisfying discrete services or functions associated with IT. These services/functions associated with IT apply to various areas of the FRM, especially Operator Oriented Processing Functions (purple), High Performance Processing Functions (orange), Networking Functions (red) Reporting and Connectivity Functions (yellow).

4.2 TRM Overview

The TRM shown in Figure 4-1 does not imply any specific system design; rather, its purpose is to provide the framework for defining IT standards. As with the TAFIM, the airborne reconnaissance TRM is based on the POSIX Open System Reference Model and includes three entities and two classes of interfaces. The three entities are the *Application Software Entity*, the *Application Platform Entity*, and the *External Environment Entity*. The classes of interfaces are the *Application Program Interfaces (APIs)* and the *External Environment Interfaces (EEl)s*.

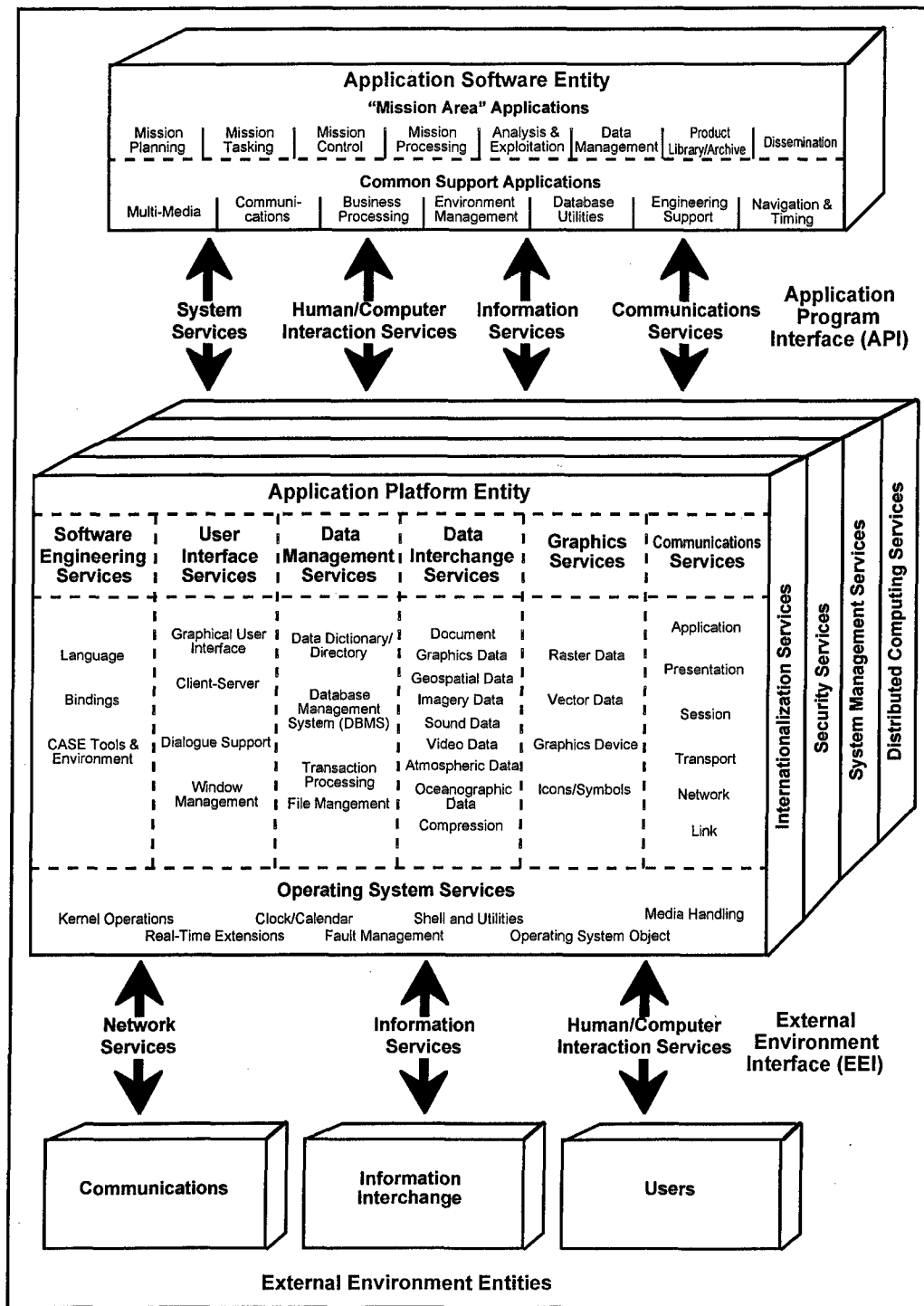


Figure 4-1: Airborne Reconnaissance Technical Reference Model

The Application Software Entity includes the Intelligence Mission Area Applications (SIGINT, IMINT, MASINT), as well as common support applications. The Application Software Entity resides on the Application platform. The Application Platform Entity provides platform services and processing capabilities. The External Environment includes entities (such as operators, removable disks/tapes, and communication pathways) with which the application platform exchanges information.

A description of each entity and interface identified in the TRM is given in the following subsections together with identification of standards selected for airborne reconnaissance systems (i.e., mandated), and references to standards which are not yet mature enough to select but show promise for resolving specific technical architecture issues.

4.3 Application Software Entity

The Application Software Entity comprises the airborne reconnaissance Mission Area Applications and Common Support Applications. This application software may be commercial off the shelf (COTS), government off the shelf (GOTS), custom-developed software, or a combination of these. The following mandate applies:

- All airborne reconnaissance developers shall identify their common support applications and mission area applications. Common support and mission area applications shall transition to the DII COE to the maximum extent possible.

4.3.1 Mission Area Applications

Mission area applications implement specific end user requirements (e.g., multi-sensor information processing, control of real-time systems, decision support, analysis of order of battle). These applications encompass all software embedded in airborne reconnaissance and associated ground/surface systems. The Imagery Exploitation Support System (IESS) is the only “standardized” mission area application identified for the ARITA to date (see Section 3.6.3). This system was selected by the ISB (with CIO and DARO concurrence) to be the migration

system for imagery exploitation management functions.* Future applications will address the SIGINT and MASINT areas.

4.3.2 Common Support Applications

Common support applications (e.g., message handling, graphics, imagery) can be standardized across individual or multiple mission areas. The services they provide can be used to develop mission-area-specific applications or can be made available to the user. The TAFIM TRM defines six (6) common support application categories: Multimedia, Communications, Business Processing, Environment Management, Database Utilities, and Engineering Support. The definitions of these categories are found in the TAFIM, Volume 2, Section 2.4.2. One additional category has been added for the airborne reconnaissance TRM: Navigation and Timing.

- The imagery community has identified RULER as a standardized common support application for imagery processing/exploitation applications. RULER software performs imagery mensuration calculations using standardized math models formally controlled by the imagery community.

4.4 Application Platform Entity

The Application Platform Entity includes the standard services upon which the required functionality is built. The Application Platform Entity is used by support applications and unique mission area applications software. The TAFIM TRM version 3.0 defines seven (7) service areas within the Application Platform Entity: Operating System, Software Engineering, User Interface, Data Management, Data Interchange, Graphics, and Communications. The TAFIM TRM also defines four (4) Application Platform cross-service areas: Internationalization, Security, System Management, and Distributed Computing services. The definitions of these services are found in the TAFIM, Volume 2, Section 2.4.3 and 2.4.4 respectively. The corresponding mandates are provided in the following subsections.

* Although JCMT and RMS are also selected migration systems, they are not embedded in airborne reconnaissance systems.

4.4.1 Operating System Services

These core services are necessary to operate and administer a computer platform and to support the operation of application software. They include kernel operations, shell, and utilities. The kernel controls access to information and the underlying hardware. These services are accessed by applications through either the standard Portable Operating System Interface (POSIX) (e.g., VX Works, Solaris 2.3, HP-UX 9.01) or WIN32 APIs. The standards for ARITA are:

- Mandated: JTA Section 2.2.2.1.7, Operating Systems Services
- Emerging: JTA Section 2.3.5, Operating Systems

4.4.2 Software Engineering Services

The software engineering services provide system developers the tools appropriate to the development and maintenance of applications. These include programming languages, language bindings and object code linking, and Computer Aided Software Engineering (CASE) environments and tools.

4.4.2.1 Programming Languages

Language services provide the basic syntax and semantic definitions for use by developers to describe the desired software function. Ada is mandated in DoD Directive 3405.1. This directive requires that Ada be used for custom developed software in all DoD system developments. This mandate does not include software that is developed and maintained commercially. Software development will be based on Ada 95. Ada 95 is backward compatible with Ada 83 language specification. The standards for ARITA are:

- Mandated when Ada is used: ISO/IEC 8652: 1995 (Ada 95), Ada Reference Manual, Language and Standard Libraries.
- Mandated standard when C is used (Ada waiver required): ANSI/ISO 9899 C Language

If a waiver to Ada is sought, the guidelines documented in Assistant Secretary of Defense Memorandum, "Delegations of Authority and Clarifying Guidance on Waivers from the use of Ada Programming Language," must be followed.

4.4.2.2 Language Bindings and Object Linking

Language bindings and object code linking provide the ability for software to access services and software through API's that have been defined independently of the computer language. Ada bindings will be used to provide the interface to COTS or GOTS software that is developed in other languages. The standards for ARITA are:

- IEEE 1003.5b: 1992: POSIX: Ada Language Interfaces Part 1: Binding for System API.
- ISO/IEC 9075: 1992: Database Languages-SQL (Embedded SQL to Ada Bindings).
- ISO 12227: 1994: SQL Ada Module Description Language
- ISO/IEC 9593-3: 1990: PHIGS Language Bindings-Part 3: Ada
- ISO/IEC 9638-3: 1994: Interface techniques for dialogues with graphical devices Computer Graphics Interface (CGI)-Language Bindings-Part 3: Ada

4.4.2.3 Computer Aided Software Engineering (CASE) Environments and Tools

CASE provides the environment and tools, include systems and programs that assist in the automated development and maintenance of systems (hardware and software). The standards for ARITA are:

- ANSI/IEEE 1209-1992, Case Tools and Environment

4.4.3 User Interface Services

These services implement the Human-Computer Interface (HCI) style and control how users interact with the system. The ARITA follows the JTA which mandates either Common Desktop Environment (CDE) version 1.0 based on X window system and Open System Foundation (OSF) Motif APIs, or the applicable native windowing WIN32 APIs The standards for ARITA are:

- Mandated: JTA Section 2.2.2.1.2, User Interface Services
- Mandated: JTA Section 5.2, HCI Mandates

- Emerging: JTA Section 2.3.2, User Interface
- Emerging: JTA Section 5.3, HCI Emerging Standards

4.4.4 Data Management Services

These services support the definition, storage, and retrieval of data elements from monolithic and distributed, relational Database Management Systems (DBMSs). These services also support platform-independent file management (e.g., the creation, access, and destruction of files and directories). The ARITA follows the JTA which mandates conformance to Entry level ANSI Structured Query Language (SQL) standards and adds Ada interfaces. The standards for ARITA are:

- Mandated: JTA Section 2.2.2.1.3, Data Management Services
- ISO 9075 SQL
- ANSI X3.168 Embedded SQL
- ISO 12227: 1994, SQL Ada Module Description Language
- FIPS Pub 156 (IRDS) Data Dictionary
- Emerging: JTA Section 2.3.3, Data Management

4.4.5 Data Interchange Services

The data interchange services provide specialized support for the exchange of data and information between applications and to and from the external environment. These services include document, graphics data, geospatial data, imagery data, product data, audio data, video data, atmospheric data, oceanographic data, and compression interchange services.

The ARITA follows the JTA for the following mandated standards. Emerging standards are identified in JTA Section 2.3.4.

- Document data: JTA Section 2.2.2.1.4.1
- Graphics data: JTA Section 2.2.2.1.4.2
- Geospatial data: JTA Section 2.2.2.1.4.3
- Imagery data: JTA Section 2.2.2.1.4.4

- Product data: JTA Section 2.2.2.1.4.5
- Audio data: JTA Section 2.2.2.1.4.6
- Video data: JTA Section 2.2.2.1.4.7
- Atmospheric data: JTA Section 2.2.2.1.4.8
- Oceanographic data: JTA Section 2.2.2.1.4.9
- Compression: JTA Section 2.2.2.1.4.10

Additional standards for data interchange services that apply to imagery-related systems are identified in Section 4 of the *USIS Standards and Guidelines* document, Version 1, dated 13 October 1995.

Message standards for airborne reconnaissance reporting functions are cited in ARITA Sections 3.7.1 and 3.7.2.

4.4.6 Graphics Services

These services support the creation and manipulation of graphics. They include device-independent, multidimensional graphic object definition, and the management of hierarchical database structures containing graphics data. The ARITA follows the JTA which mandates standards for non-COTS graphics development in JTA Section 2.2.2.1.5, Graphics Services. Additional standards for the ARITA are:

- MIL-STD-2525 Graphic Situation Display (GSD) (Icons/symbology)
- *USIS Standards and Guidelines* document, Version 1, dated 13 October 1995, Section 4 provides additional standards for graphics services that apply to imagery-related systems.

4.4.7 Communications Services

These services support the distributed applications that require data access and applications interoperability in networked environments. The mandated and emerging standards identified in Section 3 of the JTA apply to the ARITA.

4.4.8 Internationalization Services

The internationalization services provide interfaces that allow a user to define, select, and change between different culturally related application environments supported by the particular implementation. These services include character sets, data representation, cultural convention, and native language support. The standards mandated in Section 2.2.2.2.1 of the JTA apply to the ARITA.

4.4.9 Security Services

These services assist in protecting information and processing platform resources. They must often be combined with security procedures, which are beyond the scope of the information technology service areas, to fully meet security requirements. Security services include security policy, accountability, assurance, user authentication, access control, data integrity and confidentiality, non-repudiation, and system availability control. The mandated and emerging standards identified in Section 6 of the JTA apply to the ARITA.

4.4.10 System Management Services

These services provide capabilities to manage the Application Platform Entity (Section 4.4), its resources and users. System management services include configuration management, performance management, and fault management. There are no standards currently mandated for systems management in the JTA (Section 2.2.2.2.3). Additional standards that apply to the ARITA are:

- NMF Omnipoint 1

4.4.11 Distributed Computing Services

These services allow various tasks, operations, and information transfers to occur on multiple, physically- or logically- dispersed, computer platforms. These services include but are not limited to global time; data, file and name services; thread services; and remote process services. In addition to the standards mandated in the JTA Section 2.2.2.2.4, the ARITA mandates:

- ISO 9579-1, 2:1993 Remote Data Access (RDA)

4.5 External Environment Entity

An external environment entity exchanges information with the application platform. These entities include system users (e.g., operators) with information interchange through a keyboard, display monitor, mouse, track ball, etc.; information interchanges (e.g., tape drives, disk drives, etc.), and networking (e.g., terrestrial landlines, satellite circuits, data links, LANs, etc.). As with the JTA, standards in this area will be addressed in a later version of the ARITA.

4.6 Application Program Interfaces

An application software entity communicates with the Application Platform Entity through application program interfaces (APIs). Application portability, system interoperability, and application interoperability can be realized through use of standardized APIs.

The Reference Model API is based on the POSIX.0 API, as defined in the *Draft Guide to POSIX Open Systems Environment*, IEEE P1003.0 (also known as POSIX.0), which has four (4) parts:

- System Services API
- Human-Computer Interaction API
- Information Services API
- Communications Services API

Standards in this area will be addressed in a later version of the ARITA.

4.6.1 System Services API

The *System Services API* provides access to resources that are internal to the application platform entity. These include API's for Software Engineering Services and Operating System Services. Two such services are listed below:

- Programming language support services, which provide for program control, math functions (e.g., IEEE 754 Floating Point), string manipulation, etc., through a programming language API.

- Language-independent services, which provide for inter-process communications, inter-object messaging, access to the user interface, data storage, etc., through language-binding APIs.

Standards in this area will be addressed in a later version of the ARITA.

4.6.2 Human/Computer Interaction Services API

The Human-Computer Interaction Services API supports User Interface and Graphics Services. Access to other services in the TRM are provided through the User Interface Services. Standards in this area will be addressed in a later version of the ARITA.

4.6.3 Information Services API

The Information Services API supports Data Management and Data Interchange Services. Standards in this area will be addressed in a later version of the ARITA.

4.6.4 Communications API

The Communications Services API supports services associated with Communications Services.

Many application platform entities will interact through communications networks that are part of the external environment. Application software entities typically will request access to communications services through an API that will, in turn, take the appropriate action at the EEI to provide requested connectivity. Communication will then occur via external entities that provide data transport functions. By providing distributed computing through a standardized API, the distributed system can be viewed by a user and by an application software entity as being only a single application platform entity.

Standards in this area will be addressed in a later version of the ARITA.

4.7 External Environment Interfaces

The EEIs are the interfaces with which the application platform entity exchanges information with the outside world, whether that outside world is a user, a

peripheral storage device, communications system/network, or another application platform entity. There are three (3) types of EEIs provided by the application platform entity:

- Human-Computer Interaction (HCI) Services EEI (User/Human)
- Information Services EEI (Messages, Database exchange, Secondary Imagery, voice, video, etc.)
- Network Services EEI (Communications System/Network)

Standards in this area will be addressed in a later version of the ARITA.

4.7.1 HCI Services EEI

The *HCI Services EEI* is the physical interface across which interaction between the application platform and the human user takes place. As such, it includes, display monitors, keyboards, mouse, track balls, joysticks, printers, removable disk/tapes, and additional input/output devices (e.g., scanners, digitizers). Standardization of this interface, as is the general trend, allows the user to access the services of multiple systems with relative ease and access the services of compliant systems without retraining.

4.7.2 Information Services EEI

The *Information Services EEI* defines the boundary across which external peripheral, persistent information storage is provided and where standards for format and syntax need be defined for data portability and interoperability. Examples of the types of devices to which these interfaces are found include diskettes, hard disks, and CD-ROM, write-once read-many (WORM), Electro-Optical (EO), and Magneto-Optical (MO) drives.

Standards in this area will be addressed in a later version of the ARITA.

4.7.3 Network Services EEI

The *Network Services EEI* supports services for interaction between application software entities, running on the local application platform, (e.g., single board computers) with remote application platforms and application software entities running on them. Thus, it provides support for external data transport facilities

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and devices using standards for protocol state, syntax, and format to ensure application interoperability through the application platform(s). When the application platform is a device such as a single board computer or a memory unit then the EEI may be a set of backplane standards such as VME Bus.

- ANSI/VITA 64VME (6U circuit cards)

Additional standards in this area will be addressed in a later version of the ARITA.

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5. Follow-On ARITA Activities

The following subsections summarize the key initiatives required for further development of the ARITA. Some of the initiatives are currently on-going and some are new initiatives recommended by the ARITA Working Group.

5.1 Integrated Airborne Imagery Architecture

This proposed initiative would focus on the IMINT front-end and high-performance processing functions defined in the ARITA FRM. An integrated airborne imagery architecture (similar to JASA) would enable greater flexibility in equipping the airborne reconnaissance fleet through commonality and enhanced interoperability. For example, sensor suites could be highly interchangeable among multiple platforms and more tightly integrated with other subsystems to beneficially affect inter-system cross cueing. In this architecture, planned sensor suites (IR, EO, SAR, SAR/MTI, MSI, and video) would be modular and interoperable with existing and planned airborne platforms. Emphasis would be placed on all-weather platform and sensor capabilities with room for specialized platforms and sensors as required. The common imagery ground/surface systems would be able to process, exploit, and report on imagery and imagery-derived information irrespective of sensor or platform type. Workstations interconnected by local or wide area networks would operate in such a manner that common routines would be transparent for cross-service users, while accommodating specialized procedures for mission specific needs. The common, interoperable, modular, and scaleable elements of this architecture would provide the highest degree of flexibility needed to support the warfighter in unpredictable future mission scenarios.

5.1.1 Video Metadata

The CIO-chaired Video Working Group (VWG) was formed in July 1995 to define standards for video imagery data formats, metadata formats and compression algorithms, and address overall end-to-end quality standards. A VWG subgroup was formed in February 96 to analyze current tasking, reporting, exploitation, and dissemination system requirements for video metadata. The metadata group is also actively engaged with CIO's Accelerated Architecture Acquisition Initiative (A3I) Program Office on archive and retrieval requirements

for video metadata. The initial plan is to develop, in coordination with the DARO, minimum metadata standards for collection system(s) to provide with the video imagery by Fall 96, followed by a migration plan for enhancements to video metadata to reflect SPIA requirements.

- Terminology. Metadata is information about the video, not information in the video. Other terms used in describing metadata include: support data, auxiliary data, annotation data, ancillary data, as well as the exploitation support data (ESD) and ephemeral data generally associated with satellite derived imagery.
- Elements. Some of the information contained in “data about the data” or data about the video as provided by the National Exploitation Laboratory (NEL) include: location of the image with respect to the ground via UTM or latitude-longitude coordinates, data and time the image was taken, north indicator on the image, location accuracy, and map reference. This information must be associated with or “tagged” to the image frame. Other aspects of metadata include: positional element or information related to the geolocation of the imagery being acquired, (e.g., position, heading of the air vehicle); status element or information regarding the characteristics of the imagery being acquired (e.g., sensor being acquired, compression mode); and interpreted element or information the user adds to the data stream (e.g., audio annotation, content tagging). The following information also may be included as part of the metadata description: plane position, roll, pitch, heading, gimbal elevation, azimuth, altitude-mean sea level is provided (requires elevation source), GPS time and date, camera fields of view booth vertical and horizontal, compression mode, sensor being sent, and communications link.
- Transmission. Metadata can be down linked from the platform via a separate channel or as part of the image, if imagery format allows it.
- Retrieval. Query data (part metadata and part data inputted on the ground) necessary to retrieve imagery and imagery products include: target location, target type, date and time of the image, quality of the image (NIIRS), country code, target name, number of targets by type, and weather conditions.

5.2 Joint Airborne MASINT Architecture

The Joint Airborne MASINT Architecture is a new and much needed effort to define the overall architecture for airborne MASINT systems. It is organized around seven broadly defined MASINT functional areas of sensor systems:

- Chemical and Biological Weapons (CBW)
- LASINT/Laser Warning Receivers (LWR)
- Unattended Ground Sensors (UGS)
- Spectral (Non-literal)
- Air Sampling
- Radio Frequency (RF)
- Synthetic Aperture Radar Phase History (SAR PH)

SAR and Spectral overlap with the Airborne Imagery Architecture initiatives, and RF overlaps with the ongoing JASA development activities.

Traditional MASINT systems have been unique, stand alone systems that required extensive post processing and analysis to supply information of intelligence value. Now that MASINT technologies are rapidly maturing, much of this processing has become real-time and is often incorporated within the sensor sub-processing system for immediate use. In addition, MASINT has developed multiple sensor correlation systems to provide real-time target identification (automatic target recognition). These systems are quickly evolving to highly capable multiple-sensor "smart systems" that can provide identification and location coordinates to sensor-to-shooter systems. The Central MASINT Office (CMO) will be developing a flexible architecture over the next couple of years that will maximize interoperability through standard hardware and software interfaces that will streamline the integration of new MASINT systems as they come on line.

It is also CMO's intent to create standards for MASINT systems that allow for growth and technical innovation to reduce acquisition and training times, increase capability, and lower long-term costs. The key is to identify areas between systems that serve common functions and therefore, lend themselves to degrees of commonality and interoperability.

5.3 MASINT Ground/Surface System Architecture

MASINT does not have any dedicated ground/surface systems at present. Instead, data is either processed in real-time on-board the platform or it is recorded for non-real-time processing in laboratory facilities. Within the DARO Objective Architecture 2010, all ground processing and dissemination functions will be migrating towards the Distributed Common Ground Station (DCGS). MASINT will most likely evolve quickly towards the DCGS and immediately adopt the hardware and software configurations within this document. In the near term, MASINT systems will merge with SIGINT and IMINT where possible for ground processing. MASINT systems that are similar or common with the IMINT CIGSS architecture will adopt the CIGSS standards. CIGSS has a multi-INT processor function that is the main tie between the two disciplines. On the RF side, MASINT will leverage the JASA architecture established to develop common standards. The rest of the MASINT systems could eventually evolve to provide data through the Joint-STARS Common Ground Station and disseminate through GCCS/TIBS as the DCGS comes on line. The notional concept of a Common MASINT Ground/Surface System will require considerable effort to reach an effective near term solution with a migration strategy towards the eventual DCGS.

5.4 Distributed Common Ground/Surface System Architecture

A migration strategy for IMINT, MASINT, SIGINT, and multi-intelligence ground/surface systems to the Distributed Common Ground/Surface System (DCGSS) is planned. The DCGSS evolution will reflect continuing commonality, interoperability, modularity, and scalability efforts. The DCGSS strategy and architecture will unify the subsystems and components in current stove-piped ground/surface systems. The CIGSS architecture and standards referenced in Section 2.2.2 is the first step in this strategy. The migration to DCGSS will introduce common imagery, SIGINT, and MASINT processors, field one scaleable and modular workstation type, develop one database system tailored, via software, to handle different mission requirements and multi-echelon needs, and provide common communications interfaces able to keep pace with developing C4I for the Warrior concepts and architectures.

5.5 Integrated Communications Architecture

The proposed integrated communications architecture would reflect ongoing initiatives to achieve interoperability through selection of standard message and data formats and signal waveforms for both collection and dissemination data links between ground, air and satellite systems. The communications architecture would also show the interrelationships of the following components:

- Overall data flow and ISR products produced by airborne reconnaissance systems
- The Common Data Link (CDL) and Airborne Information Transmission (ABIT) programs
- Link 16 dissemination and other intelligence broadcast links (TDDS, TADIXS-B, TIBS, TRIXS, IBS)
- UHF Communications (TACSAT/DAMA, LOS, HQ I/HQ II, Saturn)
- Commercial SATCOM (Ku Band, Ka Band, IMARSAT, etc.)
- Communications Infrastructure and Networks (IP Router Networks, Intelink, GBS, etc.)

APPENDIX A
LIST OF ACRONYMS

APPENDIX A
List of Acronyms

A/D	Analog to Digital
A ³ I	Accelerated Architecture Acquisition Initiative
ABIT	Airborne Imagery Transmission
ACTD	Advanced Concept and Technology Demonstration
AFMSS	Air Force Mission Support System
AGL	Above Ground Level
AOC	Air Operations Center
AOR	Atlantic Ocean Region, Area of Operational Responsibility
API	Application Program Interface
ARL	Airborne Reconnaissance Low
ARTA	Airborne Reconnaissance Technical (Information) Architecture
ARTAWG	Airborne Reconnaissance Technical (Information) Architecture Working Group
ASARS	Advanced Synthetic Aperture Radar System
ASAS	All Source Analysis System
ATA	Army Technical Architecture
ATARS	Advanced Tactical Airborne Reconnaissance System
ATC	Automatic Target Cueing
ATD	Advanced Technology Demonstration
ATO	Air Tasking Order
ATR	Automatic Target Recognition
AUTODIN	Automatic Digital Network
AWE	Avionics/Weapons/Electronics
BCD	Binary Coded Decimal
C ²	Command and Control
C ³ I	Command, Control, Communications and Intelligence
C ⁴ I	Command, Control, Communications, Computers, and Intelligence
C ⁴ ISR	Command, Control, Communications, Computers, and Intelligence Surveillance and Reconnaissance
CASE	Computer Aided Software Engineering

List of Acronyms, continued

CBW	Chemical and Biological Weapons
CCD	Charge-Coupled Device
CCIR	CoChannel Interference Reduction
CDE	Common Desktop Environment
CDL	Common Data Link
CGI	Computer Graphics Interface
CIGSS	Common Imagery Ground/Surface System
CINC	Commander In Chief
CIP	Common Imagery Processor
CIS	Combat Information System
CJCSI	Chairman Joint Chiefs of Staff Instruction
CMA	Collection Management Authority
CMO	Central MASINT Office
COE	Common Operating Environment
COMINT	Communications Intelligence
CONOPS	Concept of Operations
COTS	Comercial Off-the-Shelf
CSE	Client Server Environment
CSMA	Carrier Sense Multiple Access
CTT	Commanders Tactical Terminal
DAFIF	Digital Aeronautical Flight Information File
DAMA	Demand Assigned Multiple Access
DARO	Defense Airborne Reconnaissance Office
DARP	Defense Airborne Reconnaissance Program
DARSC	Defense Airborne Reconnaissance Steering Committee
DBMS	Database Management System
DBS	Direct Broadcast Service
DCE	Distrbuted Computing Environment
DCGS	Distributed Common Ground Station
DCGSS	Distrbuted Common Ground/Surface System
DCRSi	Digital Channel Recorder System - Improved
DCT	Discrete Cosine Transform
DCW	Digital Chart of the World

List of Acronyms, continued

DDN	Defense Data Network
DF	Direction Finding
DFAD	Digital Features Analysis Data
DIA	Defense Intelligence Agency
DIAL	Differential Absorption LIDAR
DII	Defense Information Infrastructure
DISA	Defense Information System Agency
DMA	Defense Mapping Agency
DMS	Defense Message Service
DNC	Digital Nautical Chart
DoD	Department of Defense
DPPDB	Digital Point Positioning Database
DSCS	Defense Satellite Communication System
DSP	Digital Signal Processing
DSS	Direct Satellite Service (DBS)
DTED	Digital Terrain Elevation Data
DTSR	Digital Temporary Storage Recorder
ECHUM	Electronic Chart Updating Manual
EEI	External Environment Interface
EHF	Extra High Frequency
EIA	Electronic Industries Association
ELINT	Electronic Intelligence
EO	Electro-Optical
ESD	Exploitation Support Data
ESM	Electronic Support Measures
ETRAC	Enhanced Tactical Radar Correlator
FC	Fiber Channel
FC-PH	Fibre Channel Physical and Signaling Interface
FDOA	Frequency Difference of Arrival
FFT	Fast Fourier Transform
FIPS	Federal Information Processing Standard
FLIR	Forward Looking Infrared
FOPEN	Foliage Penetration

List of Acronyms, continued

FOWG	Fiber-Optic Wave Guide
FRM	Functional Reference Model
FTIR	Fourier Transform Infrared
GBS	Global Broadcast System
GCCS	Global Command and Control System
GCSS	Global Combat Support System
GHz	Giga Hertz
GOTS	Government Off-the-Shelf
GPS	Global Positioning System
GSD	Graphic Situation Display
HAE	High Altitude Endurance
HCI	Human-Computer Interface, Human-Computer Interaction
HDTV	High Definition Television
HF	High Frequency
HIPPI	High Performance Parallel Interface
HSI	Hyperspectral Imagery
HTML	Hyper Text Mark-up Language
HUMINT	Human Intelligence
Hz	Hertz
I&Q	In-phase and Quadrature
IBS	Integrated Broadcast System
IDB	Integrated Database
IDEF	Integrated Definition
IEC	International Electrotechnical Commission
IESS	Imagery Exploitation Support System
IF	Intermediate Frequency
IFF	Identification Friend or Foe
IFSAR	Interferometric Synthetic Aperture Radar
IMINT	Imagery Intelligence
IMS	Ion Mobility Spectrometer
INMARSAT	International Maritime Satellite
INS	Inertial Navigation System
INT	Intelligence

List of Acronyms, continued

IP	Internet Protocol
IPA	Image Product Archive
IPI	Intelligent Peripheral Interface
IPL	Image Product Library
IR	Infrared
IRDS	Information Resource Dictionary System
IRIG	Intra Range Instrumentation Group
ISAR	Inverse Synthetic Aperature Radar
ISB	Intelligence Systems Board
ISMC	Imagery Standards Management Committee
ISR	Intelligence, Surveillance, and Reconnaissance
IT	Information Technology
IUGS	Internetted Unattended Ground Sensor
JAC	Joint Analysis Center
JASA	Joint Airborne SIGINT Architecture
JBS	Joint Broadcast Service
JCMT	Joint Collection Management Tool
JCRD	Joint Capstone Requirements Document
JCS	Joint Chiefs of Staff
JDISS	Joint Deployable Intelligence Support System
JFCC	Joint Force Component Command
JFIF	JPEG File Interchange Format
JIC	Joint Intelligence Center
JPEG	Joint Photographic Experts Group
JROC	Joint Requirements Oversight Council
JSIPS	Joint Service Image Processing System
JTA	Joint Technical Architecture
JTIDS	Joint Tactical Information Distribution System
JWICS	Joint Worldwide Intelligence Communications System
Ka	Above K band (20-40 GHz)
KCOIC	Korean Combined Operations Intelligence Center
KHz	Kilo Hertz
LANDSAT	Land Observation Satellite

List of Acronyms, continued

LASINT	Laser Intelligence
LF	Low Frequency
LIDAR	Laser Imaging Detection and Ranging
LWIR	Long Wavelength Infrared
LWR	Laser Warning Receivers
MACOM	Major Command
MAE	Medium Altitude Endurance
MAGTF	Marine Air Ground Task Force
MASINT	Measurement and Signatures Intelligence
MCEB	Military Communications Electronic Board
MET	Meteorological
MIDS	Multi-functional Information Distribution System
MIES	Modernized Imagery Exploitation System
MIIDS	Military Imagery Intelligence Database System
MO	Magneto-Optical
MPEG	Motion Picture Expert Group
MSI	Multi-Spectral Imagery
MSL	Mean Sea Level
MTI	Moving Target Indicator
MWIR	Middle Wavelength Infrared
NEL	National Exploitation Laboratory
NIIRS	National Imagery Interpretability Scale
NIPRNET	Non-secure Internet Protocol Router Network
NIR	Near Infrared
NITFS	National Imagery Transmission Format Standards
NRL	Naval Research Laboratory
NRO	National Reconnaissance Agency
NSA	National Security Agency
NSRL	National SIGINT Requirements List
NTSC	National Television Standards Committee
OASD	Office of Assistant Secretary of Defense
OB	Order of Battle
ODMG	Object Database Management Group

List of Acronyms, continued

OMA	Object Management Architecture
OMG	Object Management Group
OODBMS	Object-Oriented DataBase Management System
OPWG	Optical Planar Wave Guide
OSD	Office of the Secretary of Defense
OSF	Open Software Foundation
PANAMSAT	Pan American Satellite
PEO	Program Executive Officer
PH	Phase History
PHD	Phase History Data
PHIGS	Programmer Hierarchical Interactive Graphics System
PM	Program Manager
POSIX	Portable Operating System Interface for Computer Environments
PPS	Pulse Per Second
PVOD	Probabilistic Vertical Obstruction Data
RC	Remote Controls
RCS	Radar Cross Section
RDA	Remote Data Access
RF	Radio Frequency
RMS	Requirements Management System
SAE	Service Acquisition Executive
SAR	Synthetic Aperture Radar
SATCOM	Satellite Communications
SAW	Surface Acoustic Wave
SCSI	Small Computer System Interface
SEI	Specific Emitter Identification
SIGINT	Signals Intelligence
SIPRNET	Secure Internet Protocol Router Network
SMPTE	Society of Motion Picture and Television Engineers
SNUTR	SIGINT Numerical Tasking Requirement
SOFPARS	Special Operations Forces Planning and Rehearsal System
SPIA	Standards Profile for Imagery Access
SPO	System Program Office

List of Acronyms, continued

SQL	Structured Query Language
SRO	Sensitive Reconnaissance Operation
SWIR	Short Wavelength Infrared
TACSAT	Tactical Satellite
TADIXS	Tactical Data Information Exchange System
TAFIM	Technical Architecture Framework for Information Management
TAMPS	Tactical Aviation Mission Planning System
TBD	To Be Determined
TCP	Transport Control Protocol
TDDS	TRAP Data Dissemination System
TDL	Tactical Data Link
TDMA	Time Division Multiple Access
TDOA	Time Difference of Arrival
TEG	Tactical Exploitation Group
TIBS	Tactical Information Broadcast Service
TRAP	TRE and Related Applications
TRE	Tactical Receive Equipment
TRIXS	Tactical Reconnaissance Intelligence Exchange System
TRM	Technical Reference Model
UAV	Unmanned Aerial Vehicle
UDP	User Datagram Protocol
UGS	Unattended Ground Sensor
USAF	United States Air Force
USI	Ultra-Spectral Imagery
USIS	United States Imagery System
USMTF	U.S. Message Text Format
USN	United States Navy
USNO-UTC	United States Naval Observatory – Coordinated Universal Time
UTM	Universal Transverse Mercator
VHS	Video Helical Scan Recording Standard, Video Home System
VIQCB	Video Imagery Quality Control Board
VITC	Vertical Interval Time Code
VITD	Vector Product Interim Terrain Data

List of Acronyms, continued

VMAP	Vector Map
VME	Versa Module European
VMF	Variable Message Format
VWG	Video Working Group
WAM	Wide Area Munitions
WGS-84	World Geodetic Survey 1984
WORM	Write-Once Read-Many
WWMCCS	World-Wide Military Command and Control System