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ASSESSMENT REPORT

Department of Defense Air Traffic Control and Airspace Systems Interface with the National Airspace System

Contract No. F19628-87-C-0172

Prepared for:

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March 30, 1990

From Concepts Into Practice

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This report assesses the intra-agency interoperability of a broad spectrum of ATC and airspace management systems. The FAA NAS plan is summarized to describe the national system that will exit in 1999. Military ATC systems are projected to the same period and evaluated by type of system (i.e., fixed or tactical), application (i.e., radar,position/navigation, communications, etc.), and branch of military service. The evaluation includes a discussion of the expected interfaces between military and civil system components. The assessment describes potential impacts of incompatible and non-interoperable systems on the DoD in terms of safety and operational effectiveness and probable impacts on specific Air Force mission requirements. The report does not assess in depth the DoD's tactical ATC components or the tactical command and control systems that are not directly related to ATC.

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1.0 INTRODUCTION

The Federal Aviation Act of 1958 led to the establishment of the Federal Aviation Administration (FAA) as the government agency responsible for providing and maintaining the nation's air navigation and air traffic control system. The FAA's domain, the National Airspace System (NAS), includes all air navigation facilities, airports, aeronautical regulations and procedures, and the facilities, equipment, and personnel used to control and manage the airspace under U.S. jurisdiction. The NAS also incorporates system components shared jointly with the military.

In 1981, the FAA published the National Airspace System Plan to establish the schedule for system modernization into the 21st century. The NAS Plan primarily involves the modernization of the FAA facilities, hardware, and software that are a predominant part of the NAS infrastructure. Implementation of the NAS Plan drew attention to the Department of Defense (DOD) role as a co-provider of the nation's air traffic control (ATC) services. DOD's 300 ATC facilities handle approximately 25% of the air traffic in the NAS. As a consequence, military ATC, air navigation, and airspace management system components must interoperate and/or compatibly interface with modernized FAA systems to an extent which assures the user of a transparency of ATC service origin and no derogation of services. The need for DOD - FAA systems integration was formally recognized in the September 1989 update of the NAS Plan, which included a new chapter detailing DOD's goals, assumptions, and planning efforts for NAS Plan implementation. This report reviews the status of the integration at the 1999 near end-state NAS, as set forth in military and civil documents, for the purpose of identifying interoperability and compatibility issues and their affect on Air Force flight operations. Interoperability involves a greater degree of integration than compatibility, the technical capability to exchange information. Interoperable systems are compatible systems which are capable of directly integrating and utilizing the information exchanged.

1.1 Background

The FAA has been and is required to accept the interface of military ATC systems. To date, this integration has not posed extraordinary problems for the FAA because military and civil ATC equipment has been generally similar and compatible, if not identical. For this reason, interoperability between current DOD and FAA system components has not been an imperative to the safe and efficient performance of ATC operations. However, the installation of new civil equipment and automation software could transform the issue of future interoperability or compatibility into a system modernization problem for both the FAA and the DOD.

Recognition of potential DOD - FAA interface problems brought about several efforts to study the near-term integration of military and civil NAS components. Previously conducted and well-received studies that have examined the overall system include the February 1987 Hart Report entitled "Requirements for Air Traffic Control Interoperability Between FAA and DOD" prepared by the MITRE Corporation, and the July 1986 staff study "Qualitative Assessment of Potential Impacts of Lack of Modernization of the Department of Defense Air Traffic Control System on Expected FAA Benefits and Costs of the NAS Plan," prepared by the Martin Marietta Corporation. Both studies were conducted at the request of the FAA.

DOD activities have concentrated on the location and configuration of military ATC facilities and equipment which would be required to meet future mission and NAS requirements. Traditionally, each military service managed their individual systems independently, which hindered them from evolving in balanced recognition of both the individual service and the collective DOD roles of supporting peacetime and wartime military flight operations. Service planners analyzed departmental programs, mission requirements, and ATC system configurations to produce a DOD ATC architecture that will meet the future requirements of the individual and joint military services. As a result of these efforts and extensive negotiation, the DOD and the FAA implemented a Memorandum of Agreement on Radar Approach Control in the National Airspace System in December, 1988.

The purpose of the memorandum of agreement was to "...identify locations of approach control authority for military and FAA radar approach controls in the...(NAS) and their relationships to Area Control Facilities (ACF)" (refer to Appendix D). Interagency Agreement A to the memorandum establishes the DOD - FAA ATC architecture for the NAS and states that the DOD and FAA shall, "...to the extent possible, accomplish joint purchase of equipment for ATC facilities providing services in the NAS." Toward this goal, the DOD is undertaking a technical engineering and integration services contract to provide technical guidance in determining the required upgrades and other modifications necessary for interoperability with FAA systems. The FAA published NAS Change Proposal 11526 in late 1989 to baseline key DOD systems for inclusion in NAS system specifications (NAS-SS-1000) as a starting point for future systems integration.

1.2 Objective

The efforts of the DOD and the FAA have necessarily been directed towards the implementation of NAS Plan programs and, to a lesser extent, their ramifications upon military systems. The longer-term, post-NAS Plan inter-agency systems interface requirements remain to be studied in-depth. Recognizing this need, the U.S. Air Force Electronics Systems Division, in April 1987, approved a contract for innovative research into potential post-2000 military ATC and airspace management system concepts. This report is part of the contract. The objective of the report is to identify the potential problems associated with anticipated interoperability and compatibility between military ATC systems and the FAA systems with which they must interface in 1999. The report, and the planned DOD - FAA interfaces and system architectures from which it was written, are the basis for final documents which will detail the post-2000 military ATC interface requirements and concept of operations. The overall objective of the research effort is to identify the preliminary system level concepts necessary to support the development of future command, control, and communications (C^3) systems that include provisions for ATC.

1.3 Scope

This report assesses the intra-agency interoperability of a broad spectrum of ATC and airspace management systems. The FAA NAS plan is summarized to describe the national system that will exist in 1999. Military ATC systems are projected to the same period and evaluated by type of system (i.e., fixed or tactical), application (i.e., radar, position/navigation, communications, etc.), and branch of military service. The evaluation includes a discussion of the expected interfaces between military and civil system components. The assessment describes potential impacts of incompatible and non-interoperable systems on the DOD in terms of safety and operational effectiveness and probable impacts on specific Air Force mission requirements. The report does not assess in depth the DOD's tactical ATC components or the tactical (battlefield) command and control systems that are not directly related to ATC. The assessment concentrates upon the interface of DOD and FAA systems with the 1999 NAS, an arena in which the use of tactical systems is usually limited to training exercise activities or to temporary replacement of fixed components. All of the information presented in this report is unclassified and was freely provided by military, federal, and commercial sources.

1.4 Document Organization

The remainder of this document is organized in the following manner. Section 2 consists of the technical report, which is divided into two sub-sections. The first sub-section provides an overview description of the forecast FAA systems and the interfacing DOD facilities and equipment in the 1999 NAS. The second discusses the interface, compatibility, and interoperability of the military systems. Section 3 presents the findings and results of the analysis.

2.0 TECHNICAL REPORT

In order to develop systems interface and operational concepts for post-2000 military ATC and airspace management systems, a database of current ATC and airspace management system components was developed. The database was used to write the "Assessment Report of Department of Defense Air Traffic Control and Airspace Management Systems", published in August 1989. The report detailed the status of military ATC and related systems and assessed, in general, their compatibility and interoperability with current NAS systems. This second report extends the assessment to the 2000 NAS environment for the purpose of identifying potential interface problems and compatibility/interoperability issues.

The report addresses the NAS as it is forecast to exist in 2000 to present a turn of the century review of civil and military ATC systems at a "near" end-state NAS level of development. The September 1989 update of the NAS Plan forecasts that 10 of the 12 major projects will be complete by the year 2000. The exceptions, the Area Control Facility (ACF) and Microwave Landing System (MLS) projects, are forecast to be completed in 2002 and 2004, respectively. Approximately half of the planned MLS systems will be installed by 2000. Additionally, the 1989 NAS Plan shows that most of the remaining projects are part of the longer-term "Other Capital Needs" and "Transition" chapters of the NAS Plan. Finally, evaluation of the national system in 2000 provides a logical and documented near-future systems foundation for the development of the follow-on post-2000 interface requirements and operational concepts document.

The following sections discuss the composition of and key systems used in the projected NAS. Key NAS projects and systems, for the purposes of this report, are those which are expected to interface with military ATC facilities and system components. The majority of military ATC radar facilities addressed in the report are the installations shown in the 1989 NAS Plan and listed in Interagency Agreement A "Designating Selected Radar Approach Control Jurisdictions" of the 1988 DOD - FAA Memorandum of Agreement. The 43 Military Radar Approach Control Facilities (MRACF) identified are the major DOD ATC installations which will be part of 2000 NAS (refer to Table 2-1). The military radars not listed in the agreement function as Ground Controlled

DOD AIR TRAFFIC CONTROL FACILITY EQUIPMENT LISTING

CATEGORY OF FACILITY		SURVEILLANCE RADAR		TOWER		PRECISION LANDING SYSTEMS			COMMUNICATIONS SYSTEMS	
AGENCY:	FACILITY	ASR	SSR	PROCESSOR	DISPLAY	PAR	ILS	MLS	VCS	FLT DATA
Stand-Alone Approach Controls Facilities:										
Army:	Ft Campbell, KY	ASR-9	ATCBI-5	PIDP II	DBRITE	FPN-61	MK-1A	YES	FSC-92	FDIO
	Ft Hood, TX	ASR-9	ATCBI-5	ARTS IIA	DBRITE	FPN-40	MK-1E	YES	FSC-92	FDIO
	Ft Rucker, AL *	ASR-9	ATCBI-5	ARTS IIIA	DBRITE	FPN-40	MK-1F	YES	FSC-92	FDIO
	Ft Drum, NY **	FPN-66	(ATCBI-5)	PIDP II	DBRITE	FPN-40	NONE	YES	FSC-92	FDIO
Navy:	NAS Agana, Guam	GPN-27	TPX42(V)10	RATCF DAIR	BRANDS	FPN-63	(FAA)	YES	OJ-314	FDIO
	NAS Adak, AK	GPN-27	TPX42(V)10	RATCF DAIR	BRANDS	FPN-63	MK-1F	YES	OJ-314	FDIO
	NAS Bermuda	GPN-27	TPX42(V)10	RATCF DAIR	BRANDS	FPN-63	(FAA)	YES	IVCSS	FDIO
	NAS Fallon, NV	GPN-27	TPX42(V)10	RATCF DAIR	BRANDS	FPN-63	NONE	YES	FSA-58	FDIO
	NAS Key West, FL	GPN-27	TPX42(V)10	RATCF DAIR	BRANDS	FPN-63	NONE	YES	FSA-58	FDIO
	NAS Lemoore, CA	GPN-27	TPX42(V)10	RATCF DAIR	BRANDS	FPN-63	(ACLS)	YES	OJ-314	FDIO
	NAS Oceana, VA	GPN-27	TPX42(V)10	RATCF DAIR	BRANDS	FPN-63	(ACLS)	YES	IVCSS	FDIO
	NAS Patuxent River, MD	GPN-27	TPX42(V)10	RATCF DAIR	BRANDS	FPN-63	NONE	YES	IVCSS	FDIO
	NAVSTA Roosevelt Roads, PR	GPN-27	TPX42(V)5	NONE	BRANDS	FPN-63	(ACLS)	YES	FSA-58	FDIO
	NAS Whidbey Island, WA	GPN-27	TPX42(V)10	RATCF DAIR	BRANDS	FPN-63	NONE	YES	IVCSS	FDIO
USAF:	Cannon AFB, NM	GPN-20	TPX42(V)10	PIDP II	DBRITE	FPN-62	GRN-29	YES	OJ-314	FDIO
	Castle AFB, CA	GPN-20	TPX42(V)10	PIDP II	DBRITE	FPN-62	GRN-29	YES	OJ-314	FDIO
	Columbus AFB, MS	GPN-20	TPX42(V)10	PIDP II	DBRITE	NONE	GRN-29	YES	OJ-314	FDIO
	Ellsworth AFB, SD	GPN-20	TPX42(V)10	PIDP II	DBRITE	FPN-62	GRN-29	YES	OJ-314	FDIO

NOTES: Above listing excludes DoD ATC facilities which will be transferred to the FAA. Included are the stand-alone FAA Approach Controls which will be transferred to DoD, and the DoD Approach control facilities identified in Interagency Agreement A of the DoD-FAA Memorandum of Agreement on Radar Approach Controls in the NAS. See Appendix D.

* Facility status pending results of regional DoD studies.
** Facility status questionable due to Dept. of Army Decision to reduce Division size and aviation support requirements.

Table 2-1

DOD AIR TRAFFIC CONTROL FACILITY EQUIPMENT LISTING (Page 2)

CATEGORY OF FACILITY		SURVEILLANCE RADAR		TOWER		PRECISION LANDING SYSTEMS			COMMUNICATIONS SYSTEMS	
AGENCY:	FACILITY	ASR	SSR	PROCESSOR	DISPLAY	PAR	ILS	MLS	VCS	FLT DATA
Stand-Alone Approach Controls Facilities (Cont'd):										
USAF:	England AFB, LA	GPN-20	TPX42(V)10	PIDP II	DBRITE	FPN-62	GRN-29	YES	OJ-314	FDIO
	Galena AFS, AK *	GPN-20	TPX42(V)10	PIDP II	DBRITE	FPN-62	GRN-29	YES	GSA-135	FDIO
	Holloman AFB, NM	GPN-20	TPX42(V)10	PIDP II	DBRITE	FPN-62	GRN-29	YES	OJ-314	FDIO
	Laughlin AFB, TX	GPN-12	TPX42(V)10	PIDP II	DBRITE	NONE	GRN-29	YES	GSC-37	FDIO
	Luke AFB, AZ	GPN-12	TPX42(V)10	PIDP II	DBRITE	FPN-62	GRN-29	YES	OJ-314	FDIO
	King Salmon AFS, AK *	GPN-20	TPX42(V)5	NONE	NONE	FPN-62	GRN-29	YES	ICSS	FDIO
	Moody AFB, GA	GPN-12	TPX42(V)10	PIDP II	DBRITE	FPN-62	GRN-29	YES	OJ-314	FDIO
	Mountain Home AFB, ID	GPN-20	TPX42(V)10	PIDP II	DBRITE	FPN-62	GRN-29	YES	OJ-314	FDIO
	Myrtle Beach AFB, SC	GPN-20	TPX42(V)10	PIDP II	DBRITE	FPN-62	GRN-29	YES	OJ-314	FDIO
	Nellis AFB, NV	ASR-9	TPX42(V)10	EARTS	DBRITE	GPN-22	GRN-29	YES	OJ-314	FDIO
	Seymour-Johnson AFB, NC	GPN-12	TPX42(V)10	PIDP II	DBRITE	GPN-22	GRN-29	YES	OJ-314	FDIO
	Shaw AFB, SC	GPN-20	TPX42(V)10	PIDP II	DBRITE	FPN-62	GRN-29	YES	OJ-314	FDIO
	Shemya AFS, AK	GPN-20	TPX42(V)5	NONE	NONE	FPN-62	GRN-29	YES	OJ-314	NONE
	Vance AFB, OK	GPN-20	TPX42(V)10	PIDP II	DBRITE	NONE	GRN-29	YES	GSA-135	FDIO
	Vandenberg AFB, CA	GPN-12	TPX42(V)10	PIDP II	DBRITE	NONE	GRN-29	YES	OJ-314	FDIO
USMC:	MCAS Kaneone Bay, HI	GPN-27	TPX42(V)10	RATCF DAIR	BRANDS	FPN-63	NONE	YES	OJ-314	FDIO
	MCAS Beaufort, SC	GPN-27	TPX42(V)10	RATCF DAIR	BRANDS	FPN-63	NONE	YES	IVCSS	FDIO
	MCAS Yuma, AZ (with ATC responsibility for NAF El Centro, CA)	GPN-27	TPX42(V)10	RATCF DAIR	BRANDS	FPN-63	MK-1F	YES	OJ-314	FDIO

NOTES: Above listing excludes DoD ATC facilities which will be transferred to the FAA. Included are the stand-alone FAA Approach Controls which will be transferred to DoD, and the DoD Approach control facilities identified in Interagency Agreement A of the *DoD-FAA Memorandum of Agreement on Radar Approach Controls in the NAS*. See Appendix D.

* Facility status pending results of regional DoD studies.

Table 2-1

DOD AIR TRAFFIC CONTROL FACILITY EQUIPMENT LISTING (Page 3)

CATEGORY OF FACILITY AGENCY: FACILITY	SURVEILLANCE RADAR ASR	 SSR	TOWER PROCESSOR	 DISPLAY	PRECISION LANDING SYSTEMS PAR	 ILS	 MLS	COMMUNICATIONS SYSTEMS VCS	 FLT DATA
DoD Consolidated Radar Facilities (CRF):									
Cherry Point CRF, with ATC responsibility for:									
MCAS Cherry Point, NC	GPN-27	TPX42(V)10	RATCF DAIR	BRANDS	FPN-63	NONE	YES	IVCSS	FDIO
MCAS New River, NC	GPN-27	TPX42(V)5	NONE	BRANDS	FPN-63	NONE	YES	FSA-58	FDIO
NAS Corpus Christi CRF, with ATC responsibility for:									
Corpus Christi, TX									
NAS Chase, TX	GPN-27	TPX42(V)10	RATCF DAIR	BRANDS	FPN-63	NONE	YES	FSA-58	FDIO
NAS Corpus Christi, TX	GPN-27	TPX42(V)5	NONE	BRANDS	FPN-63	NONE	YES	FSA-58	FDIO
NAS Kingsville, TX	GPN-27	TPX42(V)10	RATCF DAIR	BRANDS	FPN-63	NONE	YES	IVCSS	FDIO
NAS Pensacola ACF, with ATC responsibility for:									
Eglin AFB, FL (CRF) *	GPN-12	TPX42(V)10	PIDP II	DBRITE	NONE	GRN-29	YES	OJ-314	FDIO
NAS Pensacola, FL *	GPN-27	TPX42(V)10	RATCF DAIR	BRANDS	FPN-63	NONE	YES	IVCSS	FDIO
Ft Rucker, AL *	ASR-9	ATCBI-5	ARTS IIIA	DBRITE	FPN-40	MK-1F	YES	FSC-92	FDIO
Tyndall AFB, FL *	GPN-20	TPX42(V)10	PIDP II	DBRITE	FPN-62	GRN-29	YES	OJ-314	FDIO
(and Gulfport, MS/Mobile, AL)									
Sheppard CRF, with ATC responsibility for:									
Altus AFB, OK	GPN-20	TPX42(V)10	PIDP II	DBRITE	FPN-62	GRN-29	YES	OJ-314	FDIO
Ft Sill, OK	ASR-8	TPX42(V)10	ARTS IIA	DBRITE	FPN-40	MK-1A	YES	FSC-92	FDIO
Sheppard AFB, TX	GPN-20	TPX42(V)10	PIDP II	DBRITE	FPN-62	GRN-29	YES	OJ-314	FDIO

NOTES: Above listing excludes DoD ATC facilities which will be transferred to the FAA. Included are the stand-alone FAA Approach Controls which will be transferred to DoD, and the DoD Approach control facilities identified in Interagency Agreement A of the DoD-FAA Memorandum of Agreement on Radar Approach Controls in the NAS. See Appendix D.

* Facility status pending results of regional DoD studies.

Table 2-1

Approach (GCA) facilities providing precision approach capability to military airfields or as Military Radar Units (MRU) handling aircraft in airspace set aside for military activities. The continuance of the GCA units into the next century is subject to the discretion of the owning military service and has yet to be determined. The decision to retain or retire these radars is, to some extent, dependent on the fielding of new precision landing systems (MLS) and associated aircraft avionics equipment (see Section 2.2.1.2). The MRUs will be discussed further as DOD range control facilities.

2.1 The National Airspace System

The NAS consists of the equipment, facilities, personnel, and procedures that control and service aircraft operating in airspace under U.S. jurisdiction. The functional areas herein discussed include the en route and terminal ATC systems, flight /ice and weather systems, communications systems, and position and navigation systems. Ancillary support systems are included in the most representative functional area.

2.1.1 En Route Systems

By the year 2000, the FAA will have implemented most of the NAS modernization programs associated with the Area Control Facility (ACF) project. The project transforms the 20 Air Route Traffic Control Centers (ARTCC) and four off-shore centers that make up the national en route system into 23 ACFs. The ACFs' will control IFR aircraft in the terminal and en route environments, as well as provide traffic separation, traffic and weather advisory, and emergency assistance functions. Project improvements include the installation of IBM 4341 Host computers, the expansion of ARTCC buildings to meet ACF requirements, and the installation of new communications networks and the Advanced Automation System (AAS) with its Area Control Computer Complex (ACCC). In addition to improved en route software capabilities, the AAS project will consolidate the functions of most of the 188 FAA Terminal Radar Approach Control (TRACON) facilities into the ACFs, along with the necessary remoting of radar and communications sites.

The September 1989 NAS Plan added DOD ATC facilities to the NAS en route structure. These include a military ACF in northwestern Florida and three military Combined Radar Facilities (CRF) at Sheppard Air Force Base (AFB) in Texas, Naval Air Station Corpus Christie in Texas, and Marine Corps Air Station (MCAS) Cherry Point in North Carolina. The military ACF is under evaluation to determine the location and jurisdiction of the planned facility. The military CRFs will provide en route and terminal air traffic services identical to those provided by FAA ACFs. The CRFs will service the military and civil airports within their delegated areas of authority. The Florida ACF and the CRFs will procure and use ATC, communications, and support equipment that will be fully interoperable with FAA end-state components, to the maximum extent practical. DOD range control radar facilities may also perform en route control functions as ancillary tasks associated with control of the airspace delegated to the weapons test and training ranges. These facilities include the Navy coastal Fleet Area Control Surveillance Facilities (FACSFAC), which control air operations in offshore warning areas, and the range control functions at Eglin AFB and Tyndall AFB, Florida; Hill AFB, Utah (Utah Test and Training Range); Holloman AFB, New Mexico (White Sands Missile Range); Nellis AFB, Nevada (Tactical Fighter Weapons Range); Naval Air Station Patuxent River, Maryland (Naval Flight Test Center); and MCAS Yuma, Arizona (Yuma Proving Grounds and Marine Corps Air Warfare Range).

While not included in the NAS Plan, the concept of the Metroplex Control Facility (MCF) and Local Control Facility (LCF) is emerging as an addendum to the ACF plan. As introduced at the September 1989 NAS Plan Users Conference, an MCF would function as an en route/terminal ATC facility serving complex, high-density terminal areas (e.g., Los Angeles, Denver, Dallas-Fort Worth, etc.). An MCF would be configured and equipped like an ACF and would consolidate the functions of nearby TRACON and Terminal Radar Approach Control in the Tower Cab (TRACAB) facilities. An LCF is a TRACON operating at a unique location requiring a stand-alone radar facility. The FAA is studying the operational and economic feasibility of the new ACF/MCF/LCF configuration. The concept is addressed to explain qualifying statements in the following evaluation regarding FAA facility consolidation. The MCFs and LCFs would be functionally similar to the DOD's CRFs and MRACFs. Neither the NAS Plan nor the systems design documents presently include provisions for stand-alone terminal radar facilities, civil or military.

2.1.1.1 En Route Radar Systems

The ACFs' long-range surveillance radars will be supplemented through the ACCC interface with other military and civil radar systems to provide national coverage. The ACCC provides the automation support for air traffic control services within the ACF while communicating and coordinating radar and operational data with other ACCCs and the Traffic Management System (TMS) processor. An ACCC will include computers, computer software, displays, controller work-stations, interconnecting communications and interfaces to other FAA systems. The Voice Switching and Control System (VSCS) will supply the ACF with programmable ground-air radio communications, internal communications (intercom), and interfacility communications (interphone) with other ACFs, ATC Towers, Automated Flight Service Stations (AFSS), and the FAA Headquarters Air Traffic Control Command Center (ATCCC). The AAS/ACCC, TMS, VSCS and their interface with military ATC facilities will be discussed in depth in following sections.

The radar coverage for the ACFs is obtained from a composite of long-range and terminal radar systems. Long-range coverage is provided by FAA Air Route Surveillance Radars, ARSR-3s and ARSR-4s. The ARSR-4 radar facilities are part of the Joint Surveillance System (JSS), which is jointly operated by the FAA and the Air Force to accomplish both ATC and national defense functions. Both systems are solid-state radars with horizontal coverage to over 200 nautical miles (NM) and are or will be used in conjunction with a ATC secondary (radar beacon) radar or a Mode Select (Mode S) sensor (refer to Section 2.1.2.1). The newer ARSR-4 is, additionally, a three-dimensional radar (i.e., with a height-finder) with improved weather detection and remote maintenance monitoring capabilities.

By the mid-1990s, the NAS Long-Range Radar project will have replaced or retrofitted many of the JSS and FAA long-range radars, and integrated terminal radars into the en route network. Over 40 ARSR-3 and older JSS radars at sites on the perimeter of the conterminous 48 states, at Hawaii, and at Guam will be replaced with ARSR-4 systems as part of a joint DOD - FAA acquisition. Eleven of the replaced JSS ARSR-3s will be relocated to U.S. interior locations to replace older FAA radars. The project will replace vacuum tube assemblies in 76 older ARSR radars with solid-state components and improve power distribution and remote monitoring capabilities. The Long-Range Radar project will also integrate remote radar data from existing FAA Airport Surveillance Radars (ASR) and 23 additional ASR gap filler radars to form the ACF surveillance network. All ARSR-3 facilities will be interfaced with the Remote Maintenance Monitoring System (RMMS).

NAS surveillance coverage will be supplemented by at least two other military long-range radars. Like the ARSR-4s, the Air Force FPS-117 is a JSS solid-state, three-dimensional radar. The FPS-117s in Alaska are presently integrated into the FAA en route system through the EARTS to Anchorage ARTCC. The EARTS will be replaced with the Anchorage ACF's ACCC. Another long-range system, the Air Force's Over-The-Horizon Backscatter (OTH-B) phased-array radar, may augment traditional ASR/ARSR radars for oceanic coverage by the turn of the century. The radar lacks the means of determining aircraft altitude (i.e., by height-finding radar or IFF/Mode C interrogation), but can provide highly accurate positional coverage to resolve potential oceanic track conflicts. The military air defense weapons controllers at the coastal OTH-B sites are now receiving instruction in fundamental ATC procedures in order to differentiate between authorized and unauthorized air traffic approaching the North American Continent.

2.1.1.2 Advanced Automation System (AAS)

The AAS project will incorporate new automated systems including improved controller workstations, computer software, and processors in FAA ACF and terminal facilities. The AAS will enhance the ACF interface with additional radars and provide for the use of higher radar data transmission rates. By the mid-1990s, the Initial Sector Suite System will replace ARTCC controller work stations with common consoles. Implementation of the next AAS phase, the Terminal Advanced Automation System (TAAS), will provide the advanced automation software, data processors, and additional sector suites required to process terminal radar inputs and provide arrival and departure control of terminal traffic from ACF. The AAS Terminal Control Computer Complex (TCCC) will provide radar processing support for the ATC Towers. When fully implemented in the late 1990s, Advanced Automation System equipment with the ACCC will replace the TAAS. AAS will assimilate many earlier radar improvements, such as the Direct Access Radar Channel system and the En route Automated Radar Tracking System (EARTS) now used at FAA facilities to process and integrate radar data from remote sites. The AAS also incorporates the conflict alert (IFR/VFR) and Mode C Intruder capabilities and the Conflict Resolution Advisory function.

The DOD intent to procure common equipment presupposes the installation of AAS components in the CRFs and the ACF in Florida. The Air Force is lead service for this acquisition. The nature and implementation date of the system or systems is unknown. Current funding for the program is limited to the preliminary system requirement engineering studies. However, an AAS interoperable automation system will have to be fielded if the respective military ATC facilities are to achieve CRF or ACF status. The Air Force is also considering the procurement of a "hybrid"-TCCC system to support the stand-alone approach control facilities and control towers.

2.1.1.3 Automated En Route ATC (AERA)

AERA will be a significant ATC automation and controller productivity enhancement. By 2000, the first two of the three phases of the program will be implemented. The first phase, AERA 1, implemented computer software to assist the controller by automatically identifying common ATC problems, such as conflicting aircraft flight paths, penetrations of protected airspace, and deviations from flight plans and flow control restrictions. The second phase, AERA 2, enhanced the problem recognition capability by adding new software designed to provide the controller with a selection of computer generated solutions to each identified ATC problem. Once selected, the correcting ATC instructions will then be automatically transmitted by data link to the aircraft concerned, if suitably equipped, or manually transmitted by controller-to-pilot voice communications. AERA 3, the controller-monitored automatic detection and resolution of ATC problems, will be implemented after the year 2000. DOD participation in the program has consisted of mission requirements definition for AERA 1 flight profile planning. The ramifications of AERA for future DOD ATC and airspace management are discussed in Section 3.3.

2.1.1.4 The Traffic Management System

The Traffic Management System (TMS) is designed to improve air traffic management system efficiency, minimize delays, expand services, and respond more effectively to user requirements. The traffic management system operates at the national level through the Central Flow Control Function (CFCF) at the FAA Headquarters ATCCC, and at the local level through traffic management units (TMU) in each ACF and designated terminal facilities. By 2000, TMS will include the Central Altitude Reservation Function (CARF), the Airport Reservation Function, the Emergency Operations Facility, the Central Flow Weather Service Unit, the National Airspace Management Facility (NAMFAC), various flow management programs with integrated en route metering functions, and the hardware to support them. To support these functions of the TMS, the Traffic Management Processor (TMP), will access and process information on aircraft flight plans from the national database, actual traffic conditions for each ATC sector and most airports in the NAS from the ACFs, and altitude/airspace reservation data from CARF and NAMFAC. The TMS will function as the "central clearing house" for traffic flow information, including requests for future airspace needs, and will interface with commercial and military flight operations remote data terminals (refer to Section 2.1.4.1). TMS will access military flight planning information through the ACCC but will not have accurate target information from most military ATC facilities due to the nature of the DOD - FAA radar data interface.

The TMS goal, to provide for the smooth and expeditious flow of air traffic in the NAS, mandates interfaces with military "airspace management" systems. This term is normally used to include the categories of airspace which comprise the terminal and low altitude civil aviation environment. In this case, "military airspace management" is used to identify efforts directed towards Military Training Routes (MTR), Special Use Airspace (SUA), and other unique airspace requirements provided for military operations. SUA is airspace set aside for aerial activities that must be contained and segregated due to their nature, or from which non-participating aircraft must be separated to ensure aviation safety. The FAA's NAMFAC is a newly proposed branch activity charged with agency SUA oversight responsibilities. NAMFAC will be collocated with the CFCF in the ATCCC, and will administer to the Special Use Airspace Management System (SAMS), a centralized, automated airspace information system. When activated, the SAMS will receive SUA and MTR advanced schedule data from appropriate FAA and military sources. It will also provide real-time updates to the schedules and summary analyses of airspace utilization. The advanced and real-time data will be input to the TMP, and distributed to the ACFs' TMUs, Flight Service Stations, and other traffic management functions.

By the year 2000, SAMS will interface with the proposed Military Airspace Management System (MAMS). The MAMS is planned to be the DOD's centralized, airspace management information system. The system will interface with the various military airspace scheduling agencies and automated sub-systems to receive and process the separate airspace scheduling products. The consolidated airspace schedules and management reports will be transmitted by MAMS to the scheduling agencies and appropriate DOD management activities, and to FAA traffic management functions through SAMS. The MAMS is an established, but unfunded, DOD requirement.

2.1.2 Terminal Systems

Contemporary FAA terminal control facilities include Airport Traffic Control Towers (ATCT), TRACONs, and TRACABs. Over 400 ATCTs currently separate and sequence aircraft in the airport traffic pattern, control aircraft on the airport surface and during takeoff and landing, and provide flight clearance, terminal, and weather information to the pilots. TRACONs separate and sequence arriving and departing aircraft in the airspace around moderate to high density airports. The FAA TRACABs are located within ATCTs and perform functions similar to TRACONs at civil airports with lower traffic density. By the end of the century, the functions of the majority of TRACONs and TRACABs will be integrated into the terminal and en route ATC functions of the ACFs.

The DOD counterparts to the ATCTs and TRACONs/TRACABs are the Military Control Towers (MCT) and the MRACFs, respectively. The individual service designations for the MRACFs are the Army Radar Approach Control (ARAC) facilities, the Air Force Radar Approach Control (RAPCON) facilities, and the Navy and Marine Corps Radar Air Traffic Control Facilities (RATCF).

2.1.2.1 Terminal Radar Systems

The terminal surveillance radar systems supporting TRACON/TRACAB facilities will be replaced under the NAS Plan Terminal Radar (ASR) program. The ASR-9 and the next generation ASR-10 will take the place of the older vacuum-tube ASR-4s, -5s, and -6s, and the solid-state ASR-7s and -8s in current use. According to the September 1989 NAS Projects Master Schedule Baseline Report, over 100 ASR-9s will be installed at higher density airports to replace ASR-4 through ASR-8 radars, and at the FAA Technical and Aeronautical Centers. The ASR-7 and -8s freed by the ASR-9 installations will, in turn, replace the remainder of vacuum tube radars at the lower density sites that did not receive an ASR-9. Upon completion of the ASR-9 and the ASR-7/8 "leapfrog" programs in 1992, the NAS terminal radar architecture will consist primarily of ASR-8 and -9 radars, with about 20 remaining ASR-7s. The ASR-7s and -8s will, in turn, be replaced by the ASR-10 now being designed. Preliminary estimates of completion of the ASR-10 program indicate that the system will be operational by the turn of the century. It is also highly probable that a few ASR-8s scheduled for replacement will remain in 2000. However, for evaluation purposes, the terminal surveillance architecture will be considered to consist of ASR-9 and ASR-10 radars, as described in the NAS Plan. Other planned terminal radar improvements like new Airport Surface Detection Equipment and Parallel and Converging Runway Monitors will improve the safety and capacity of civil airport operations.

A brief review of key ASR characteristics is necessary for assessment purposes. The design of the digital ASR-9 provides an exceptional improvement in aircraft and weather surveillance capabilities compared to previously fielded systems. The radar has a separate weather channel capable of presenting weather information in six levels of intensity simultaneous with aircraft target returns. With the exception of the weather receiver, the antenna, and some monitoring/control sub-systems, the ASR-9 is a dual channel, totally redundant system. In the air surveillance mode, improved radar data processing and moving target detection functions significantly reduce the effects of angle clutter, weather, and ground vehicular traffic, and improve low-altitude target detection. The ASR-9 will interface with ARTS-IIIA, ARTS-IIA, and radar beacon systems initially, and with the AAS, Mode S, and the RMMS by the year 2000 (see figure 2-1).

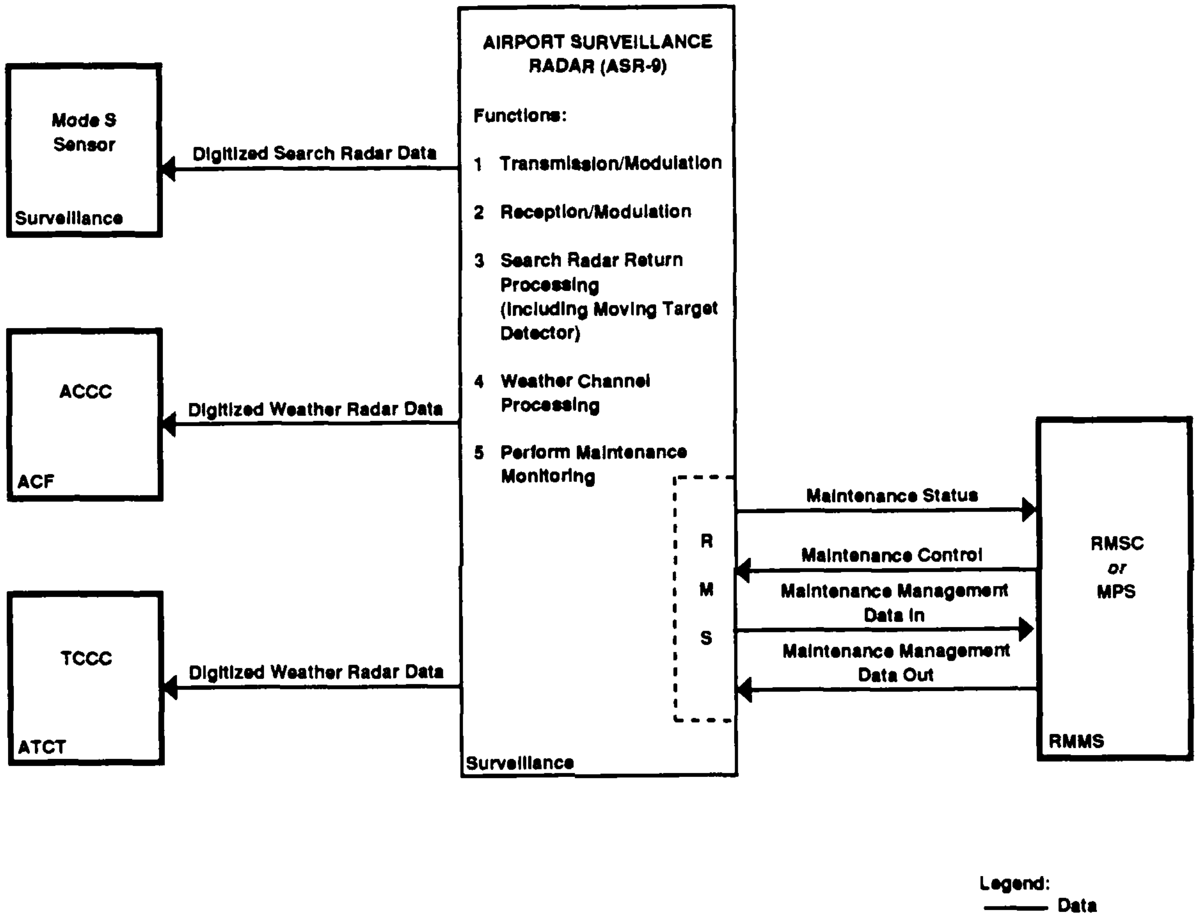

Figure 2-1: Airport Surveillance Radar (ASR) - 9

The system specifications of the ASR-10 are now being established. The NAS Level One Design Document (June 89) describes the ASR-10 system as a generic, terminal, short-range radar with radar processing capabilities identical to those of the ASR-9. The ASR-10 is expected to have two separate, redundant weather channels capable of producing six-level weather contours, which will be used to supplement the weather surveillance network. System interfaces are identified with the Mode S, the AAS (ACCC and TCCC), and the RMMS (see figure 2-2). The ASR-10, like the ASR-9, will provide primary radar data formatted for ACF/AAS use. The new format allows for the increased range and azimuth accuracy, surveillance file numbers, system integrity data, beacon addresses, and doppler velocity associated with the improved NAS radars.

Surveillance (primary) radar is normally augmented by ATC Radar Beacon System (ATCRBS), a secondary radar which interrogates and receives coded responses from aircraft transponder equipment. It provides synthetic position symbology, aircraft discrete beacon codes, and altitude data to the collocated radar data processor and, in turn, to the control displays. The two common systems forecast for use at the turn of the century are the ATC *Beacon Interrogator - 5* (ATCBI-5) and the Mode Select (Mode S) Sensor. The ATCBI-5 is being modified to accept Mode S as well as ATCRBS airborne transponder replies, and to enhance remote monitoring capabilities. Almost 200 Mode S systems will have replaced ATCRBS equipment at ARSR-3/4 and ASR-9/10 sites. The Mode S will be a monopulse beacon surveillance radar and data communications system. Mode S surveillance will be capable of all-call interrogation of ATCRBS anu Mode S equipped aircraft and discrete contact with Mode S equipped aircraft. The system will process surveillance data, including beacon tracking and primary radar/beacon correlation, and provide a formatted surveillance radar data stream to the ACFs and/or the ATCTs. The Mode S data link provides for intra-facility transmission of radar data and messages and for ground-to-air message communications. The sensor will interface with the AAS (ACCC), ARSR-3/4 and ASR-9/10 radars, the Weather Communications Processor (WCP), and the RMMS (see to figure 2-3). Mode S data link capabilities will be discussed further in Section 2.1.4. By the year 2000, Mode S will be used at almost 200 FAA en route and terminal radar sites.

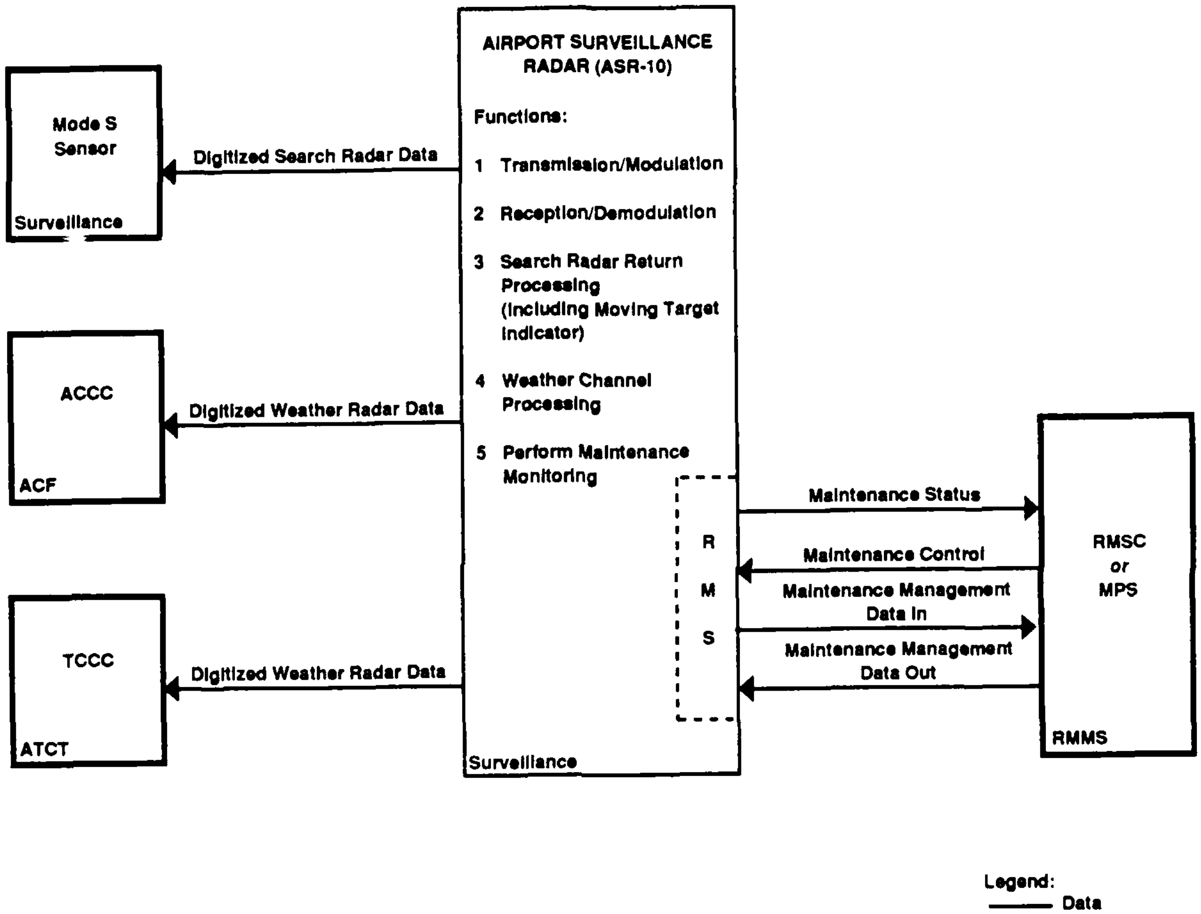

Figure 2-2: Airport Surveillance Radar (ASR) - 10

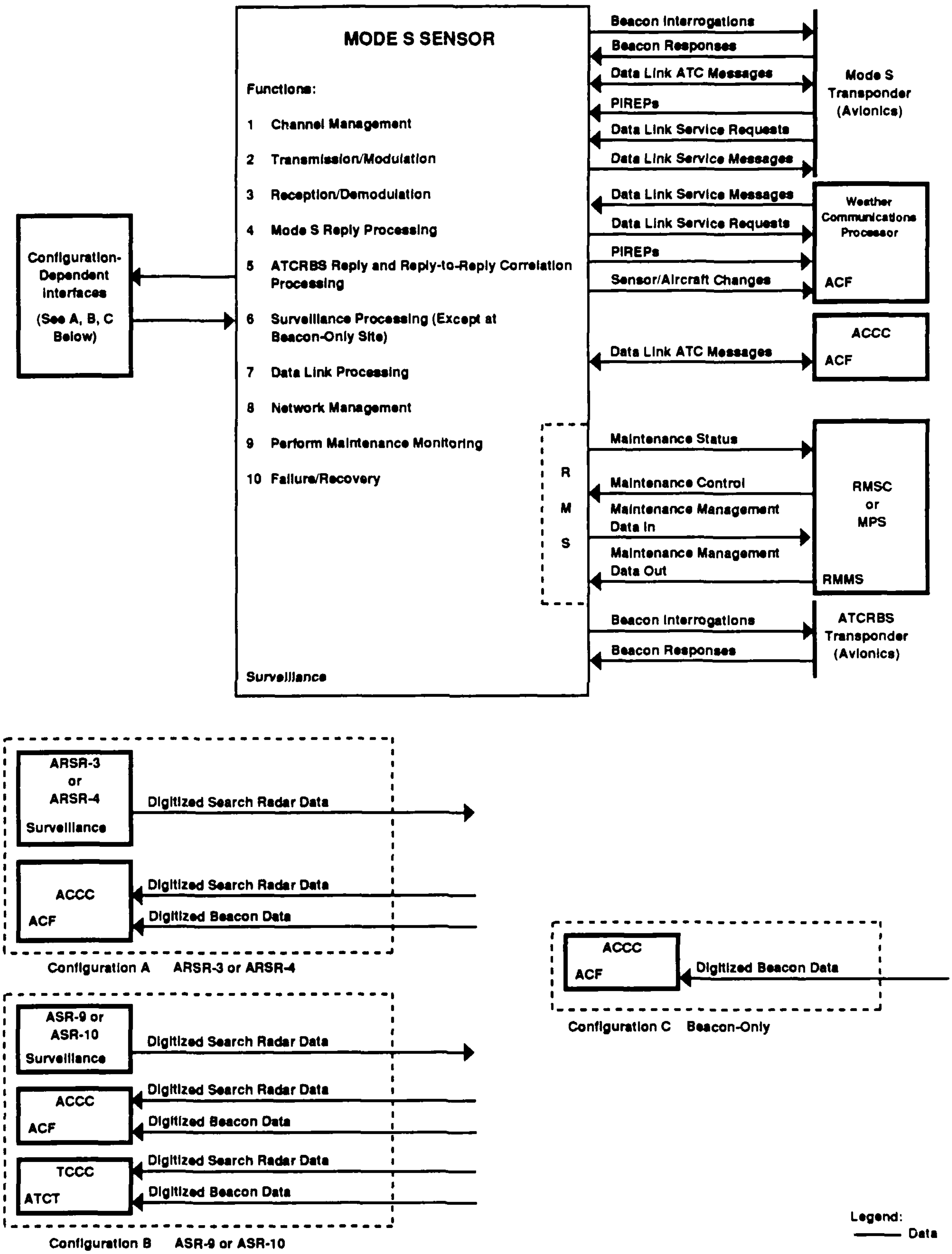

Figure 2-3: Mode-S Sensor

Several NAS Plan projects will upgrade Automated Radar Terminal Systems (ARTS) IIA and IIIA equipment. ARTS is an automatic, digital radar data processing and presentation system that is integrated with primary and secondary terminal radar. The system produces real-time aircraft identification, altitude, ground speed, and flight plan information overlays on surveillance radar displays and data link connectivity to the serving ARTCC/ACF. After the NAS Plan upgrades, the ARTS IIA systems will assist the controller with automatic beacon tracking, Conflict Alert, and Minimum Safe Altitude Warning (MSAW) of aircraft from obstructions, capabilities which are now found only in the ARTS III/IIIA. In addition to the above, ARTS IIIA can receive and process data from multiple primary and secondary radars for correlated real-time tracking of beacon-equipped aircraft. Its also provides the mechanism through which ATC personnel can manually enter flight data into the system. Other ARTS-IIIA software and hardware modifications are enabling the transmission/reception of data from local and remote tower locations and improving interfacility communications, memory capacity, failure recovery, conflict alert and MSAW capabilities. ARTS will be replaced by TAAS and decommissioned, as the TRACON/TRACAB functions are merged into the ACF. However, the ARTS-IIA/IIIA to ACF inte[illegible] may continue past the year 2000 to accommodate military ATC components.

Military terminal radar equipment will differ substantially from the above description of FAA systems. The military radars operating in the 2000 NAS will be predominantly ASR-7 and -8 systems. The Air Force GPN-12 is an ASR-7 radar employed at 21 Air Force ATC installations in the NAS. Delivered to the Air Force in 1970-1971, the GPN-12 will be logistically unsupportable by the early 1990s. Only seven systems are likely to be operational in future stand-alone approach control facilities. The newer ASR-8 is the most numerous military fixed-base surveillance radar. Most ASR-8s were procured under a joint DOD - FAA procurement contract in the 1970s. The system will be used at Fort Sill in Oklahoma to support the Combined Radar Facility (CRF) at Sheppard AFB. Designated the GPN-27 by the Navy, the ASR-8 will support 18 Navy and Marine Corps RATCFs.

Two other ASR-8 type systems will exist in the year 2000 DOD ATC inventory. The Air Force will continue to rely on the GPN-20, a lower powered version of the ASR-8 equipped with a magnitron radar transmitter. Programmed for service through 1999, the GPN-20 will be used at 14 Air Force Bases (AFB) to support 12 approach controls and two CRFs. The newest military ASR-8 to enter service is the Army's FPN-66. The system has single-channel primary surveillance combined with a dual-channel secondary and also uses a magnitron transmitter. The FPN-66 will used for ATC surveillance at Fort Drum in New York and at four other Army GCA facilities. The system will be operated at Fort Rucker in Alabama as a range gap-filler radar.

The ASR-7 and -8 share some common characteristics and limitations. Both systems are normally dual-channel systems employing analog-to-digital radar data processing and moving target indicator functions. The ASR-8 features more redundant components, a modular klystron transmitter for greater reliability and maintainability, and improved clutter rejection and target enhancement. Unfortunately, ASR-7/8 limitations may affect their integration with future NAS systems. The most important shortcomings are marginal weather detection capabilities during air surveillance and incompatible radar data format. The radar data supplied by the two systems is not compatible with the FAA's advanced format for radar beacon target reports, the format planned for the ASR-9/10.

The other surveillance radar to be found in military approach controls of the future is the ASR-9. Eleven ASR-9s will be procured for military applications through the FAA contract. Most of the systems will be dedicated to military weapons range control functions at Hill AFB, Utah, Holloman AFB, New Mexico, and Nellis AFB, Nevada. The ASR-9 will be used for ATC functions at the Fort Campbell ARAC in Kentucky, the Fort Hood ARAC in Texas, and the Cairns ARAC at Fort Rucker in Alabama. In addition to a new ASR-9, the Nellis AFB Air Traffic Control Facility will continue to use two prototype ASR-9s, designated the GPN-25, as remote gap-filler radars for range control. Since the ASR-9 planned for Nellis will be located in the terminal area, the system will serve in a dual ATC and range control capacity.

Military primary radar will continue to use ATCRBS to interrogate and receive coded transponder signals. The DOD standard ATCRBS will be the TPX-42 in two versions, the TPX-42A(V)5 and TPX-42A(V)10. The TPX-42A(V)5 has a non-programmable beacon decoder.

The TPX-42A(V)10 employs a Programmable Indicator Data Processor (PIDP) for computer tracking of secondary radar returns, computation of ground speed, generation of alphanumeric target data blocks, and the (present) capability for intra-facility semi-automatic hand-offs. The system includes false target discrimination and Minimum Safe Altitude Warning (MSAW) features. The Navy version of the TPX-42A(V)10, called the RATCF Direct Altitude Identification Readout (RATCF DAIR), uses a dual processor. The Fort Campbell ARAC, 23 Air Force and 16 Navy and Marine Corps facilities use TPX-42 systems. Many TPX-42(V)5 systems will be replaced by the TPX-42(V)10 by the year 2000. DOD plans to further modify the "10" system to increase its processor speed and memory capacity in order to incorporate conflict alert functions and to meet future ATC requirements. The modification, generally known as PIDP II, will also have the capability to process and coordinate additional local flight information that is not communicated by the Flight Data Input/Output (FDIO) or the interfacility network. Most locations are expected to have an interfacility semi-automatic hand-off capability with serving ACFs. The Fort Hood and Fort Rucker ARACs will continue to use an ARTS/ATCBI-5 system. The ATCBI-5 will be installed at Fort Campbell, as well, supported by a PIDP II processor.

Automatic radar tracking systems will be employed by a few DOD facilities. By 1992, the Fort Hood ARAC and Fort Sill radar will be upgraded to ARTS-IIA. However, the capability at Fort Sill will transition to the Sheppard AFB CRF when Fort Sill equipment is integrated. The Cairns ARAC at Fort Rucker will employ the ARTS IIIA. Nellis AFB is expected to continue enhanced EARTS integration of the ASR-9, GPN-25s, and FAA radars currently used for terminal and range control. The system provides conflict alert, Mode C intruder warning, and MSAW capabilities. Although the FAA EARTS will be replaced by the ACCC, no replacement for the Nellis system has been identified. The Navy coastal Fleet Area Control Surveillance Facilities (FACSFAC) will incorporate the FACSFAC Air Control Tracking System (FACTS) 3200, an advanced 32 bit digital processor, to automatically track and control aircraft operating to, from, and within offshore warning areas. FACTS will accept input from multiple FAA and military radars and the Navy's Tactical Data System. It will interface with NADIN. The system will also be employed for military range control operations at Naval Air Station Fallon, Nevada, and at Hill AFB, Utah. The FACSFAC installations receiving the FACTS 3200 upgrade are located at Naval Air Stations Oceana, Virginia; Jacksonville, Florida; North Island, California; Whidbey Island, Washington; Barbers Point, Hawaii; and Roosevelt Roads, Puerto Rico.

2.1.2.2 Airport Traffic Control Towers

Turn of the century ATCTs will perform terminal control functions with a number of new automation and communications support systems. Surveillance coverage of the airport control area will be provided by ASRs located at or near the airport or by long-range radar transmitted from the ACF. The TCCC will provide the automated tower cab information system and the primary work stations (data entry, display and processing) in the 258 FAA ATCTs programmed for the upgrade. It will use ACF sector suite components adapted to the ATCT environment, and will interface with the serving ACF. The TCCC will replace the Digital Bright Radar Indicator Tower Equipment (DBRITE) displays installed in FAA tower cabs in the early 1990s and the FDIO system used to process civil flight plan data. The configuration of TCCC components and the extent of terminal radar support will be tailored to traffic density and situational requirements. Tower communications will be upgraded by the installation of the Integrated Communications Switching System (ICSS) and the Tower Communications System (TCS). TCS and ICSS are discussed further in Section 2.1.4. Another NAS Plan project will replace obsolete Automatic Terminal Information System (ATIS) recorders with solid state units used to transmit airport environment and hazardous in-flight weather information to pilots.

The functions of Military Control Towers (MCT) will be equivalent those of civil ATCTs, but will be executed without the full automation support provided by the TCCC and TCS. All service branches plan to modernize or replace problematic MCTs to correct physical deficiencies and to reduce limitations caused by obsolete equipment. Automation support hardware and software is under evaluation, with the significant factor of funding yet to be determined. The Air Force is evaluating the requirement for a system similar to the FAA's proposed TCCC with a lesser amount of computer processing support and Digital Bright Radar Indicator Tower Equipment (DBRITE) display capabilities. DBRITE will be installed in most MCTs with serving ASR systems. The Air Force and the Army are obtaining over 140 DBRITE systems through a joint procurement program with the FAA. The system will allow the tower controller to perform semi-automated hand-offs to associated military approach controls and FAA facilities with similar capabilities. Naval and Marine Corps Air Station control towers will be equipped with the UYX-1(V) Bright Radar Alphanumeric Display System (BRANDS), a real-time alphanumeric generation and digital scan conversion kit that is similar in capability to DBRITE. The communications systems employed by the MCTs are discussed in the Section 2.1.4.

2.1.2.3 Precision Landing Systems

The nature of precision landing systems used in the NAS will change dramatically in the next 10 years. The Instrument Landing Systems (ILS) presently used will be replaced by Microwave Landing Systems (MLS) by the year 2004. As interim measures, older ILS vacuum tube components will be converted to solid-state and new solid-state ILS units will be installed at high-growth airports requiring near-term precision approach support. The MLS replacement project will be well underway by the year 2000, with the MLS providing over half of the precision landing capability in the NAS. According to the Federal Radionavigation Plan (FRP), the turn of the century is an important transition period for the MLS, one which will find most airports and military/civil aircraft equipped with ILS and MLS systems. Both the MLS and ILS are all-weather guidance systems that produce highly reliable localizer, glideslope, and marker beacon signals for aircraft instrumented approach and landing. Additionally, the MLS is a digital system employing micro-processor technology for greater reliability and flexibility, and easier maintainability than the ILS. It provides aircraft with multiple approach paths and pilot-selected azimuth and glide path angles. Precision Distance Measuring Equipment (DME/P) will provide range information.

Considerable change will occur in the area of military landing systems as a collateral development to the NAS conversion to MLS. The MLS is the designated future precision landing system for DOD. During the transition period from ILS to MLS, precision landing capabilities at most military installations will be provided by a combination of both systems. The ILS fixed-base systems remaining in use include the Army's (FAA) Mark 1A/E systems, Air Force's GRN-29, and the Navy's Mark-1F. In a manner similar to the NAS Plan (interim) ILS project, additional Air

Force GRN-29 systems may be installed at critical-need locations where mission requirements cannot await the production and deployment of the MLS.

Several exceptions to the DOD MLS standard will continue the requirement for Precision Approach Radar (PAR) support. Current plans call for MLS avionics in only 20 percent of Army aircraft. Consequently, the Army PAR requirement will continue into the 21st Century. The Army will rely on their FPN-40 ASR/ PARs, upgraded with solid-state components, until a new system is procured. Some Air Force, Navy, and Marine Corps installations may remain equipped with PAR as a secondary precision approach and landing system during the MLS transition period. PAR systems will also be retained to meet specific mission requirements. These needs can be met by retaining inventories of current PARs, such as the Air Force FPN-62 and Navy FPN-63. The Air Force will also modernize and retain the GPN-22 (Hi-PAR), a solid-state, high-performance precision radar.

Another exception to the DOD changeover to the MLS will be the Navy's Automatic Carrier Landing System (ACLS), a precision radar guidance and control system used on aircraft carriers and select air stations servicing carrier based aircraft. Like the TACAN, the ACLS is programmed to provide carrier fleet support into the next century and to remain in use at Naval Air Stations Lemoor, in California, Oceana and Whidbey Island.

2.1.3 Flight Service and Weather Systems

The NAS Plan flight service and weather automation projects are intended to improve user access to reliable, real-time aeronautical and meteorological information and to simplify flight planning. All projects will be completed by the end of the century.

2.1.3.1 Flight Service Automation

The consolidation of over 300 flight service stations into 61 Automated Flight Service Stations in the mid-1990s will be made possible by the ICSS and the Flight Service Automation System (FSAS), which includes the Flight Services Data Processing System (FSDPS) and the automated specialists position equipment. Twenty-one FAA ACFs will host the FSDPS to support the operations of all AFSS in their respective flight advisory areas. The FSDPS will provide processor support for the AFSS work stations and interface with: the serving ACF's ACCC and Aviation Weather Processor for flight planning/system status data and regional weather products; the National Aviation Weather Processor for national weather products and Notice To Airmen (NOTAM), Pilot Report (PIREP), and law enforcement data; the TMP for airport reservation and demand data; military base operations for flight plan, training route and area information; the RMMS; and other ACF/FSDPS. AFSS to pilot contact will be possible by telephone or Direct User (computer) Access Terminals (DUATS). ICSS will provide the AFSS with intercom, interphone, and radio communications and an automatic telephone information management system.

Military Base Operations (MBO) functions at DOD airfields, augmented by weather and command and control systems, support military aviation with most of the services provided by the AFSS. The MBO specialists will not have the degree of automation support found in an AFSS, but will be able to access and use FAA systems and information. The MBO will interface with the appropriate FAA facilities (*i.e.*, TMS, AFSS, and ACF) through the FDIO or interfacility voice communications, as required (refer to Section 2.1.4.2).

2.1.3.2 Weather Detection and Advisory Systems

Weather systems projects implemented as part of the NAS Plan will enhance the detection, forecasting, and reporting of adverse weather conditions in every phase of ATC operations by the year 2000. In the en route sector, the Next Generation Weather Radar (NEXRAD) is the cornerstone surveillance project. The NEXRAD program is jointly-funded by the Department of Commerce, DOD, and FAA. The program will field over 110 new S-band Doppler weather radar units nationwide that combine high-signal accuracy with advanced processing techniques to perform comprehensive storm surveillance and severe weather prediction. NEXRAD coverage will be augmented by Terminal Doppler Weather Radar (TDWR) systems installed in high-density terminal areas to detect hazardous weather, such as microbursts, gust fronts, wind shifts, and precipitation.

FAA NEXRAD units will be linked to Central Weather Processors (CWP) in ACFs serving the respective coverage areas. These processors receive weather data and products from the National Weather Service (NWS), the DOD, the Geostationary Operational Environmental Satellite (GOES), and the National Aviation Weather Processing Facility, and will generate and disseminate tailored weather products to the ACCC/FSDPS in the ACFs. TDWR units will provide weather products to the associated TCCCs, which will transmit the information to the appropriate ACFs' ACCC. ATCT weather displays and information will be transmitted to the TCCC from the serving ACF's ACCC, and directly, from local TDWR units. The dual weather processors in the ATCCC (Central Flow) provide composite weather products to the TMP for traffic flow management. This weather radar coverage and processing capability will be supplemented for ATC purposes by ASR-9 digital weather radar data inputs to the ACCCs and TCCCs, as previously mentioned.

The NAS weather radar network will be supplemented or supported by several other weather information sources. Over 110 Low-Level Windshear Advisory Systems (LLWAS) composed of multiple, wind sensing stations positioned about the airport runway environment will provide mircoburst and windshear detection and runway oriented alert information to the ATCT through the TCCC. LLWAS will be interfaced with collocated NEXRAD and TDWR facilities. Complementing LLWAS are the Automatic Weather Observation Systems (AWOS) and NWS Automatic Surface Observing Systems (ASOS), which automatically collect airport meteorological data (e.g. temperature, dew point, wind velocity, visibility, cloud height, and precipitation), updated at one-minute intervals. AWOS/ASOS data and supplemental information from qualified observers is provided to the AWOS Data Acquisition System located in the ACF and, in turn, to FAA facilities through the AAS (TCCC/ACCC/FSDPS). The information will be merged into ATIS messages at towered airports, or weather broadcasts on discrete communications and navigational radio frequencies.

The remaining NAS weather projects provide means of disseminating weather information. The High-Altitude En route Flight Advisory System (EFAS) will offer a clear communication channel at 18,000 feet and above for PIREPs and the dissemination of en route weather information. Twenty AFSS facilities will be equipped with the EFAS, providing discrete frequencies for each

ACF. The Hazardous In-Flight Weather Advisory System (HIWAS) will produce continuous prerecorded broadcasts of weather advisories over selected radionavigational frequencies separate from those used by AWOS/ASOS. Finally, the Mode S data link will be used to convey weather reports and advisory messages to suitably equipped aircraft.

Weather support to military approach controls and towers will improve substantially with the advent of NEXRAD and several DOD weather information collection and distribution systems. These systems will supply weather and NOTAM alphanumeric and graphic information to military controllers, but will not provide the weather radar displays found in FAA facilities. Forty-four Army and Air force installations are scheduled to host NEXRAD facilities, in many cases, as replacements for older FPS-77 weather radars. Each military NEXRAD radar will be linked to FAA and NWS systems and to NEXRAD interactive principal user processor (PUP) terminals located in designated military weather facilities within the radar coverage area. The terminals will provide a comprehensive picture of severe weather for analysis and forecasting. The resulting information will be distributed by military weather information networks, such as the Air Force's Automated Weather Distribution System (AWDS) and the Navy Environmental Display Station (NEDS) program.

The AWDS is an emerging military weather network which will collect and distribute meteorological information and tailored weather products to Army and Air Force installations. The system will interface with the Air Force Global Weather Central, NWS and FAA weather processors, NEXRAD, and other external systems. Local AWDS processors will automatically capture and store local weather products/observations and transmit the data, along with regional and national weather products, to user terminals in participating Army and Air Force ATC facilities and flight operations areas. The system will also capture and transmit information received from the DOD Consolidated NOTAM Facility. Local AWDS networks will be interconnected to exchange data between networks and to interoperate with national systems.

The NEDS program provides a national weather support capability for Navy and Marine Corps installations. By the year 2000, NEDS will link the Navy's Fleet Numerical Oceanography Center in Monterrey, California, to three fleet (regional) oceanography centers in the U.S. and, in turn, to the individual installation weather detachments for the distribution of satellite and conventional weather facsimile maps and other national weather products. The local weather detachments will continue to support their respective Navy and Marine Corps ATC facilities, as they do today.

Automated terminal weather sensing and reporting systems will transmit local weather related data to military Approach Controls and MCTs. The Navy is purchasing NWS ASOS systems for Navy and Marine Corps air stations. According to present joint planning, Air Force and Army airfields will receive an ASOS equivalent, the Automatic Observation System, to provide automatic measurement, processing, and transmission of terminal weather conditions to the local AWDS network.

2.1.4 Communications and Support Equipment

Communications systems are the central element of the FAA modernization effort, and account for 19 NAS projects. Communications, as used in the NAS, are normally categorized as ground-air or inter/intra-facility components. Ground-to-air voice and data link communications equipment permits contact between FAA facilities and aircraft by means of High Frequency (HF), Very High Frequency (VHF), and Ultra High Frequency (UHF) radios. These communications enable the pilot to obtain flight clearances; emergency assistance; weather, traffic advisory and ATC information and instructions; and to report flight progress and weather observations. Inter/intra-facility systems are used to exchange surveillance radar data, flight operations and weather information, facility and equipment status, and ATC coordination messages by voice and digital data link through the use of landline, microwave, or radio.

The major communications systems and related NAS Plan improvements that are scheduled to be operational by the year 2000 are discussed below under the functional categories of ATC communications, interfacility communications and other support equipment.

2.1.4.1 ATC Communications

By the turn of the century, completed NAS projects will significantly improve and simplify ATC communications. The projects include the Facility Consolidation, Air/Ground Communications Equipment modernization, and Radio Control Equipment projects, and several communications control and switching system projects.

The Facility Consolidation project will reduce the number of separate ground facilities now used for the transmission and reception of radio communication between aircraft and FAA facilities. The ARTCCs utilize remote center air/ ground (RCAG) communications stations located to provide coverage for each en route air traffic control sector. Similarly, terminal facilities use remote transmitter-receiver (RTR) stations and flight service stations employ remote communications outlets (RCO). Facility Consolidation will condense the FAA's 2,700 RTR, RCAG, RCO and backup emergency communications facilities into a network of approximately 2,000 larger and more cost effective consolidated remote communications facilities (RCF). The Air/Ground (A/G) Communications modernization will replace obsolete tube transmitters and receivers with solid-state models capable of operating in a 25-kHz channel environment. The project will also replace old antennas with more effective designs that will enhance the ground-to-air communication system and permit the use of lower transmitter output power. Complementing both of these projects, new Radio Control Equipment (RCE) will be installed in ACF, high-density ATCT, AFSS, and their associated RCFs to effect voice channel signaling and control functions for A/G communications. The RCE will interface with FAA facility voice switching systems (VSCS, TCS, and ICSS) and with the RMMS.

As discussed in preceding sections, new communications control and switching systems will be installed in the NAS facilities to provide FAA controllers and specialists with enhanced communications capabilities (e.g. A/G radio, intercom, and interphone) integrated into the modernized display consoles and interfacing with supporting computer systems. The systems include the Traffic Management Voice Switch (TMVS) to support the ATCCC's Traffic Management System, the VSCS for the ACFs, the TCS for the ATCTs, and the ICSS for the AFSSs, TRACONs/ TRACABs, and remaining ATCTs.

The TMVS is the communications control system configured to support the transfer of voice communications within the ATCCC and between the ATCCC and other traffic management and meteorological activities. TMVS will provide voice connectivity with the traffic management units in designated ACF, ATCT, and AFSS facilities through appropriate communications control and switching systems. Furthermore, it will connect the ATCCC to the FAA Communications Control Center and to designated military and federal telephone and radio networks and to other non-government dedicated lines (e.g. law enforcement, airline, and foreign agencies).

The VSCS will function as the voice switch connecting ATC, traffic management, and staff meteorologist positions within an ACF. It will also function as the NAS interfacility voice communications switch interconnecting the ACFs and connecting the ACFs to other FAA and military facilities and systems (see Section 2.1.4.2). In addition to the above positions within an ACF, the VSCS interfaces with the ACCC for communications configuration and control information. Externally, the system will interface with the TCS, ICSS, other VSCS, the traffic management voice switch of the ATCCC, remote radio equipment and facilities (RCE/RCF), military ATC and base operations, telephone switches, foreign ATC, and airline dispatch offices. The VSCS provides communications equipment status information to monitoring and control units in the national interfacility network.

By the early 1990s, the ICSS will be installed in 61 AFSSs; in new, replaced, or modernized ATCTs and TRACONs (previously provided with leased equipment); and in terminal facilities which have obsolete equipment. Small ATCTs and TRACONs having up to 15 operator positions will receive integrated intercom, interphone and radio communication (Type 1) systems. Larger TRACONs with 16-80 positions will receive Type 2 ICSS having Type 1 capabilities plus automatic display, reconfiguration, and data collection features. The Type 3 ICSS for the AFSSs have Type 2 features and additional automated call management functions. In some ATCTs, the ICSS will be an interim voice switch that will be replaced by the TCS. The ICSS units displaced by the TCS will be relocated to towers that do not have a modern voice switch and are not scheduled for ICSS or TCS installations. ICSS will interface with the VSCS for voice communication trunk connectivity to the ACFs, with radio equipment/facilities, and with the TCS.

In the mid-1990s, TCS voice communications switching and control units will replace the ICSS or the leased systems used in approximately 250 ATCTs. TCS will provide the ATCT with a programmable intercom and interphone with other FAA and military facilities, and will support ground-air radio communications between ATCT controllers and pilots. The TCS will interoperate with the TCCC for voice communications configuration management and for ATIS message generation, or operate as an independent system in ATCTs without a TCCC. The TCS will interface with the VSCS, ICSS, other TCS, the traffic management voice switch of the ATCCC, the tower voice recorder, radio equipment/facilities, local navigational stations (for ATIS broadcasts), telephone switches, and voice communications monitoring and reporting equipment.

NAS ATC communications will be further enhanced by the data link capabilities of the Mode S system. The FAA is implementing data link to meet the demands of increased air traffic, to reduce workload on controllers, and to derive the benefits of automated services. The FAA Plan for Research, Engineering and Development states that:

> "It is anticipated that the bulk of ATC communications will use digital data link techniques to permit high efficiency in information flow. Data link communications are an essential ingredient in ATC automation, in permitting automatic communications between ATC system elements, and in facilitating the information flow which is the basic ingredient in improved ATC services."

The FAA will implement ground-to-air digital data communications on an incremental schedule commencing in the early 1990s. The Data Link Processor (DLP) located in the ARTCCs/ACFs will provide the communications and weather applications processing required for operations with the Mode S network. As currently scheduled, complete ATC data link services will be available in conjunction with the ACCC by the year 2000. By taking advantage of the Mode S capability to discretely identify targets through a 24 bit address contained in message formats, the

ACFs will be able to transmit digital messages pertaining to altitude assignment/confirmation; transfer of communications; En Route Minimum Safe Altitude Warning (EMSAW); and free text directly to Mode S equipped aircraft. The FAA estimates that, in the post 1995 time period, approximately 95% of commercial aircraft and 11% of general aviation will be equipped with the Mode S data link.

The DOD's ATC communications are functionally equivalent and basically interoperable with systems now used by the FAA. The primary air-ground VHF (GRT-21, GRR-23, and GRC-211) and UHF (GRT-22, GRR-24, and GRC-171/215) radios are modern, reliable, solid-state components capable of 25 KHz channel spacing and are used by most military tower and radar facilities in the NAS. The radios are and will continue to be compatible with civil systems. The communications control and switching systems and the associated remote facilities and component equipment in the DOD inventory are less standardized within and between the services. However, efforts such as the Air Force "Rivet Switch" follow-on program are modernizing A/G radio transmitter and receiver sites, installing new antennas, and upgrading remote RCE and user terminal equipment. The Air Force program will be completed in 1990. Similar Army and Navy programs will continue to improve their respective communications support equipment.

The most significant efforts with regard to the DOD NAS communications interface are the military services' acquisition of interoperable control and switching systems. The systems in current application range from the relatively unadaptable OJ-314 voice communications switch used by Air Force and some Navy/Marine Corps facilities to the Integrated Voice Communications Switching System (IVCSS) undergoing field evaluation with the Navy. Military flight data communications systems are evolving from Flight Data Entry and Printout (FDEP) equipment to the NAS common FDIO.

The OJ-314 communications switching and control system integrates radio, intercom, and telephone sub-systems in small and large ATC facilities. Under the Standard Communications Control System program, Air Force fixed control towers and radar facilities are being equipped with the OJ-314 to meet short term (1992) requirements. The system is a 1970's analog system with limited reconfiguration capability. The Air Force is evaluating the FAA's proposed VSCS and TCS as candidate replacement system for the OJ-314. No specific replacement has been identified or `unded.

The Army utilizes the FSC-92 ATC communications switching system, a micro-processor controlled system that includes tower, radar, and flight operations consoles and the interface devices necessary to operate with existing VHF and UHF radio, telephone, and intra/interfacility communications equipment. The system will be operational at 32 Army ATC facilities by 1990. The FSC-92 is essentially an early model of the FAA's ICSS. A scaled-down version of the system FSC-92, called the LATCOM (Low Activity Tower Console), will be installed at low-density airfields. LATCOM incorporates all the communications, electronics, and meteorological equipment needed to operate an MCT. Although no FSC-92 replacement has been identified, Army planners are reviewing the need for 35 new NAS interoperable communications switching systems to meet forecast aviation support requirements.

The mix of communications switching systems employed at Department of Navy facilities will continue into the next century. The OJ-314 will support five of the RATCFs identified in Interagency Agreement A. Communications plans indicate that six other facilities will continue to use the FSA-58 communications central control, a modular switching system that links from five to 20 hardwired control positions. The remaining RATCFs and the seven FACSFACs will be equipped with the IVCSS. The IVCSS is digital, modular system, that employs micro-processor controlled switching for a high degree of flexibility in configuring control positions to satisfy unique A/G and intra/interfacility communications requirements. The RATCFs will also receive the FSC-104(V), an independent Emergency Communications System (ECS) that can access nine separate VHF and UHF AM ground-to-air channels and one VHF FM crash net radiophone channel. The FSC-104 provides control, monitoring, and switching functions at the operator positions and a fully automatic quality monitoring system.

Unlike the diversity of communications switches, DOD ATC facilities are achieving standardization in flight data communications. By the year 2000, FDIO or FDIO equivalent systems will replace the FDEP at all DOD facilities required to process flight plan information. The systems will promote intra-facility transfer of aircraft control between the MRACFs and the ACFs, where possible, and serve as the flight data interface between the FAA and most military facilities. Although the AAS (TCCC) will replace the FDIO in civil ATC facilities, military use of the system will continue past the turn of the century.

Although the DOD intention to use "common equipment" in ATC facilities includes Mode S ground stations, the specific commitment to Mode S, or to Mode S data link communications is neither well defined nor funded. Army aviation planners include Mode S equipment as part of the end-state configuration of the ARACS. Air Force plans describe the only need for a Mode S compatible system. However, the fact that only military transport aircraft are presently programmed to have Mode S receivers undermines the operational value of the system to DOD and may jeopardize it's funding.

2.1.4.2 Interfacility Communications

The NAS Plan includes the implementation of several national communications networking systems to modernize, centralize, and optimize communications between FAA facilities. These systems are the NAS Interfacility Communications System (NICS), the National Airspace Data Interchange Network (NADIN), the Data Multiplexing Network, and the National Radio Communications System (NARACS).

The NICS will combine and integrate the voice and data communications functions of the FAA's NAS facilities into one network to assure that the most efficient and reliable switching and transmission modes are used (see figure 2-4). NICS includes the equipment which will provide this connectivity. The consolidation will be accomplished by interconnecting "backbone" voice (VSCS/TCS/ICSS) and data (NADIN) switching systems with a "backbone", microwave radio communications link (RCL) transmission system. Network management equipment and monitoring and control equipment will be distributed throughout the NICS architecture.

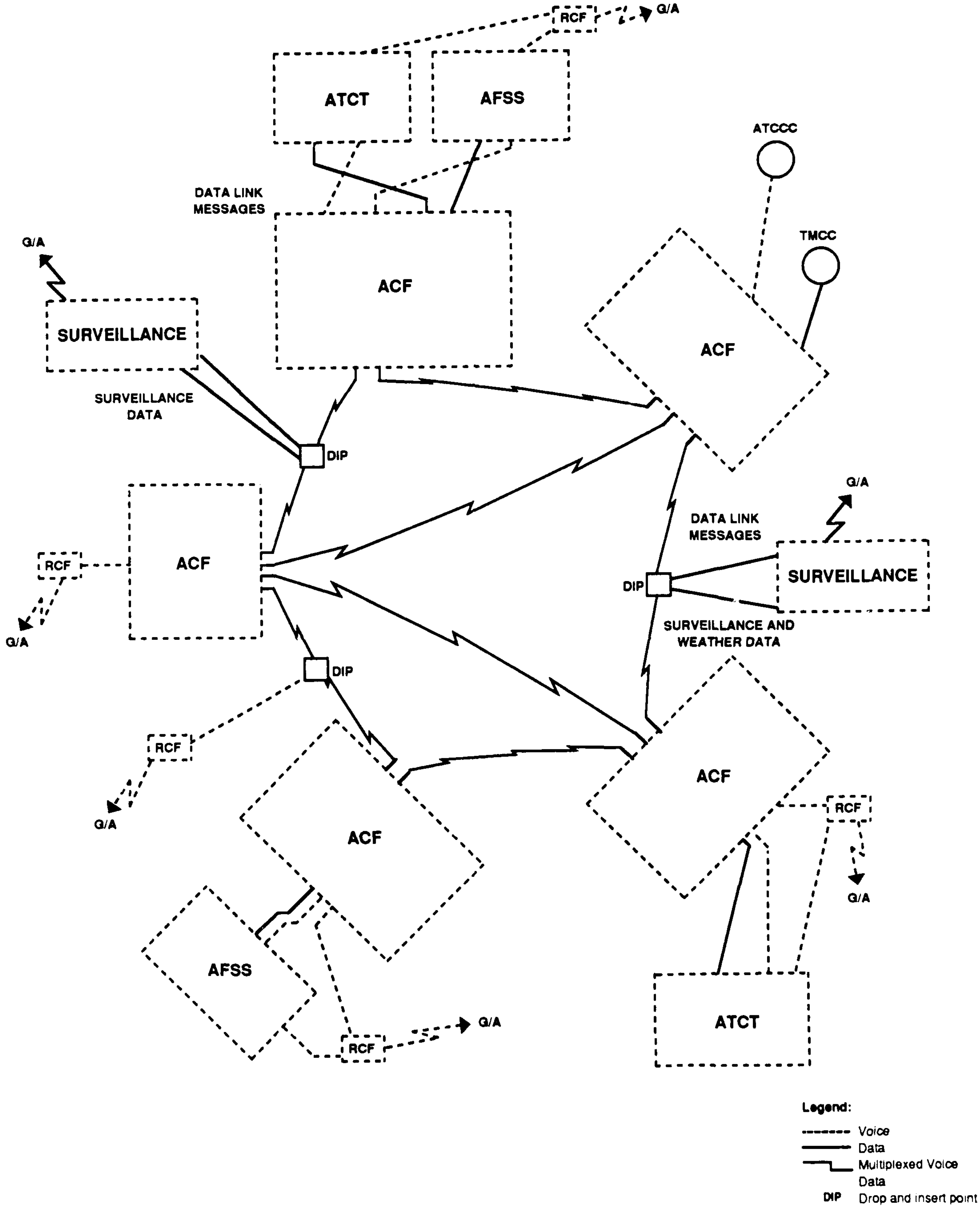

Figure 2-4: NAS Interfacility Communications System Architecture

The NADIN is a digital switching network to communicate aeronautical data between NAS facilities and provide service to other using agencies. It consists of the NADIN II Packet Switched and the NADIN IA Message Switched Networks. NADIN II provides packet switched service to NAS communications data users by means of network control centers located at Salt Lake City and Atlanta which will be linked to packet data switching (PDS) nodes in each ACF. The system will have alternate routing capability and will absorb almost all independent FAA data circuits. It is designed to meet the future data switching and network monitoring functions of other emerging FAA systems, including the RMMS, AAS, Aeronautical Data Link, and NEXRAD. The NADIN IA network provides the gateway connection between NADIN II and system users requiring message switching service, such as the airlines, DOD, and international ATC/using organizations. The NADIN IA connection to the Automatic Digital Network (AUTODIN) permits access by DOD ATC and MBO facilities, North American Aerospace Defense Command (NORAD) components, and other users.

The NICS voice switches and (NADIN) data switching nodes will be interconnected by a backbone national communications transmission and trunking network consisting of FAA-owned microwave RCLs and leased dedicated landlines. The backbone system is being developed by upgrading outdated equipment at 750 former radar microwave link locations to RCLs and by installing RCLs at 250 additional sites. Each RCL in the network will function as a (voice/data) drop and insert point (DIP) connected to the appropriate ACF's VSCS/NADIN switching node, or to the ATCTs, AFSSs and remote facilities, such as RCFs, VORs, and radar sites (see figure 2-5). The system will include diagnostic monitoring and control equipment to ensure system integrity, reliability, and rerouting capability. The Data multiplexing network project will further improve the NADIN transmission efficiency by allowing for the consolidation of multiple, independent transmissions onto a single circuit. The network will incorporate the monitoring and control functions needed for real-time circuit failure recovery.

The NARACS is an FAA owned and operated HF single sideband radio network that will provide minimum essential command and control communications between FAA headquarters and field facilities, aircraft, and other Federal, state and local government activities. The NARACS is

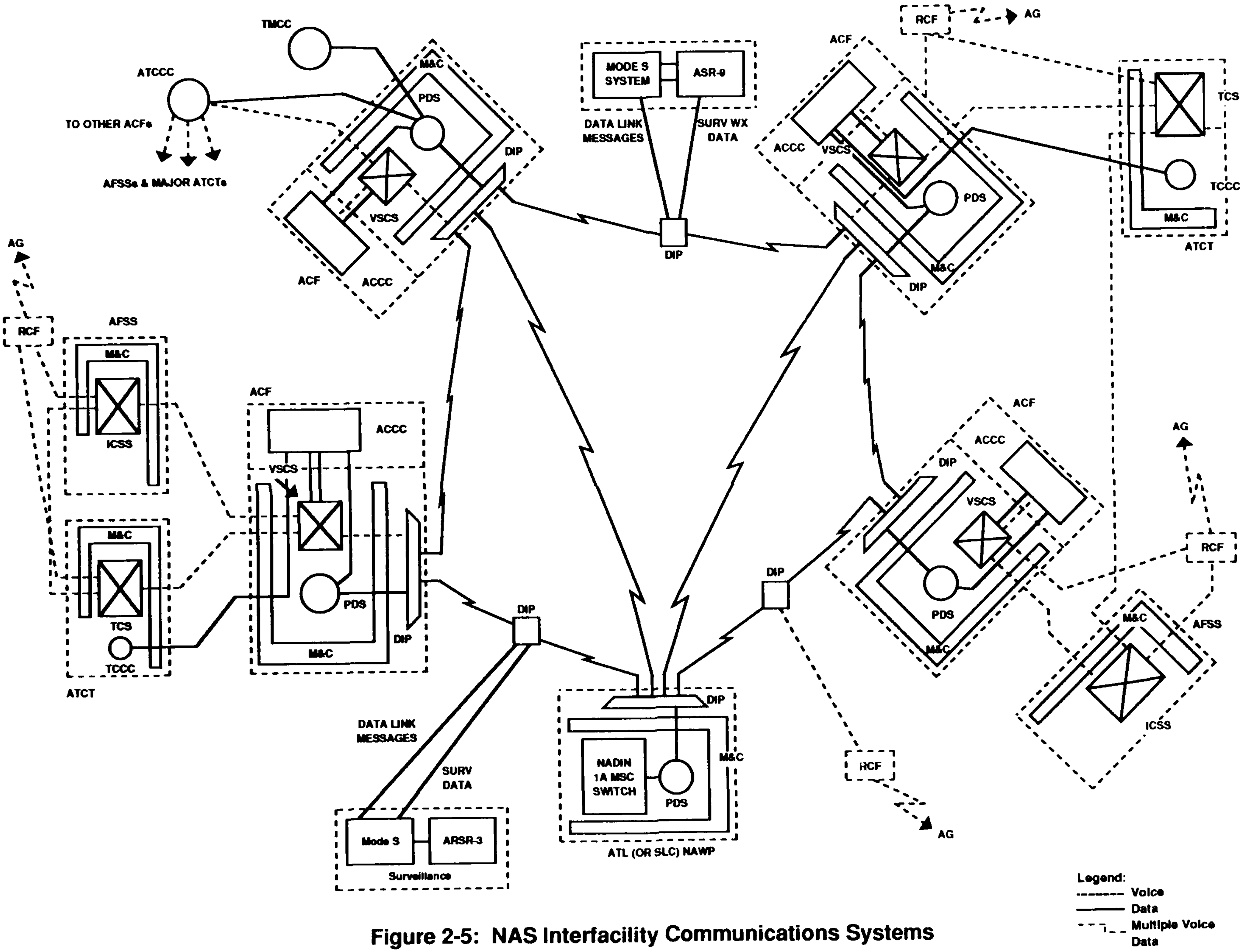

Figure 2-5: NAS Interfacility Communications Systems

intended for use during national or local emergencies which may disrupt normal landline-based systems. The backbone network connects the FAA Headquarters Command Center to three National Emergency Operating Facilities (NEOF). The FAA Headquarters primary emergency relocation site is NEOF-1 and provides network control functions. The Eastern (NEOF-2) and Western (NEOF-3) Command Centers communicate with all FAA Regional Headquarters and EOFs, FAA facilities, airports, and aircraft in their respective areas of responsibility east and west of the Mississippi River. Regional networks originate from the FAA Regional Operations Centers to all FAA facilities, offices, units, and aircraft in that region. NARACS is connected to DOD, the Federal Emergency Management Agency, the National Command Authority, and civil public service agencies and communications facilities. The network will be available for daily management of FAA maintenance, security, and safety activities, as well as for the coordination of military operations.

In addition to the data (AUTODIN - NADIN) and non-ATC voice (AUTOVON) communications discussed above, military ATC elements will primarily use direct interfacility voice communications to serving FAA facilities. The DOD control towers, approach controls, and the CRFs will be connected to the appropriate ACFs through dedicated landlines or microwave relays for the flow of ATC, flight plan, and traffic management information. Interphone Service F will interconnect the DOD control facilities for voice communications. Military direct access to the ACFs will be accomplished through the NICS DIPs and the transmission and trunking network.

2.1.5 Position/Navigation Systems

The position/navigation systems in use in the turn of the century NAS are the Very High Frequency Omnidirectional Range/Distance Measuring Equipment (VOR/DME), the Long Range Navigation - C system (LORAN-C), Non-directional Radiobeacons, Inertial Navigation Systems (INS), the Global Positioning System (GPS), and hybrid systems. These systems can be used as a "sole means" or a "supplemental means" of navigation. A sole means system is one that can be used for specific phases of air navigation in controlled airspace without the need for any other navigation system. A supplemental means system is used in conjunction with a sole means system. The paragraphs below describe the expected status of each of these systems.

Presently, the VOR/DME is the only sole means system for overland navigation. The VOR system defines the airways in the NAS and is an integral part of civil and military ATC procedures. It is also the internationally designated standard short-distance radionavigation aid for Instrumented Flight Rules (IFR) operations, and is expected to remain in service well into the next century. No system has been identified by the FAA as a replacement for VOR/DME. However, by the year 2000, it is expected that LORAN-C, GPS and some hybrid combinations will also be sole means systems.

The number of civil aviation users of the LORAN-C system has increased dramatically due the expansion of system coverage (about two-thirds of the conterminous 48 states) and reductions in user receiver costs. In response to this upsurge in civil use, the U.S. Coast Guard and the FAA are completing LORAN-C coverage over the 48 states and improving coverage in southern Alaska. Based on the expanded coverage and upsurge in interest, LORAN-C will be another sole means navigation system in the year 2000 NAS.

Nondirectional beacons (NDB) are a low-cost, less capable alternative to the VOR and are used where traffic density does not justify the more expensive system. According to forecasts in the Federal Radionavigation Plan, NDB use is projected well into the next century. Used primarily at remote general aviation airports, the NDB will continue to fill their niche as a low-cost terminal NAVAID.

An INS is a self-contained airborne navigation system which uses gyroscopes to sense acceleration from which velocity, position, direction and attitude can be derived. Older mechanical, spinning-mass gyroscopes are being replaced by the more accurate ring laser gyro and an even more accurate and reliable fiber optics gyro, that is being developed. Due to system cost, the INS is primarily used by commercial airline and military aircraft. Although the INS is a supplemental system in the NAS, a triple redundant INS can be used as sole means system for oceanic en route navigation. This situation will likely remain the same through the post NAS period. Significant technological improvements must occur to improve unit accuracy and reduce the system cost before the INS can become a sole means system within the NAS.

The GPS is being developed as a military space-based radio positioning and navigation system which will be available for use by civil aviation. Scheduled to be operational in 1993, the twenty-four NAVSTAR satellites will make up the space segment of the GPS will provide position, velocity, and system time to suitably equipped ground and airborne users worldwide. GPS will initially be a supplemental system for en route navigation. Future FAA monitor sites throughout the U.S. will check satellite signal integrity and provide the user with current system status and information. As a consequence, the GPS is expected to be a sole means system by the year 2000. Refer to Section 2.2.5.

Hybrid systems use the data from two or more navigation systems to calculates unique solutions, thereby incorporating the most advantageous aspects of the individual systems. The DOD's planned integration of GPS and INS is one example. Aircraft avionics manufacturers are exploring several other combinations of systems. The FAA will analyze and test prototype hybrid systems on an as needed basis to substantiate their suitability as sole means navigation systems. There may be several sole means hybrid systems in the end state NAS.

It is important to note the change in the method of navigation represented by these systems. The older VOR system, which is the international overland standard, is normally used by aircraft for station-to-station en route navigation on a published air route structure. The evolving sole means systems, represented by LORAN-C, GPS, and the hybrids, are area navigation (RNAV) systems which provide accurate aircraft navigation along any desired course within the coverage of the station-referenced navigation signal (LORAN-C and GPS) or within the limits of self-contained system capability (INS). It is expected that as these systems mature to sole means status, along with the FAA's traffic management, surveillance, and communications capabilities, RNAV will become a preferred means of navigation. RNAV may replace the VOR federal airways/jet route system, but not by the year 2000. The significance of the growth of RNAV capable navigational systems will be discussed in Section 3.3.

2.1.6 Tactical Air Traffic Control Systems

Although this assessment does not evaluate at length the DOD's tactical components, the DOD - FAA systems interface must consider the involvement of key tactical ATC systems used to support military exercise activities, special mission requirements, and the restoration or installation of fixed components. The tactical systems addressed are those expected to interface with NAS components in the year 2000.

The tactical surveillance radars include the Army's FPN-40 ASR/PAR, the Air Force's MPN-14K, TPN-19, and GPN-24 RAPCONs, and the Marine Air Traffic Control and Landing System (MATCALS). The older FPN-40 and MPN-14K will be modified extensively to integrate modular, solid state components, increased power and performance characteristics. Their continued use is dependent on the fielding of replacement systems. The TPN-19, GPN-24, and MATCALS are a solid-state, modular systems with ASR, PAR, and beacon interrogation components, supported by modern communications, environmental, and power-generation sub-systems. The later two systems have unique features relevant to operation in the NAS.

The GPN-24(V) transportable RAPCON is composed of a GPN-20 surveillance radar, an FPN-62 or GPN-22 precision radar, and a TPX-42 secondary radar...the standard components of an Air Force fixed ATC facility. The operations shelter houses the ASR/PAR displays, remote controls, and communications controls for UHF and VHF radios, remoting terminals, and telephone and microwave communications. This air-transportable ASR-8 system has been and will continue to be used as a replacement for fixed ATC facilities undergoing major modification.

The Marine Corps' MATCALS will include the new TPS-73 surveillance radar, the TPN-22 precision radar, and a control and communications sub-system. The TPS-73 S-band ASR is complemented by a mono-pulse secondary radar and a beacon sub-system for IFF/SIF. Two identical and independent processors automatically initiate and maintain target tracks. The processors input target information to a dual-channel data interface unit for interface with the control and communications sub-system. The ASR uses a dual-beam antenna, circular and linear polarization, adaptive moving target detection, and a solid-state transmitter for improve target detection, resolution, and accuracy. The secondary radar is also dual-channel and is compatible with Mode S. The MATCALS is the only tactical ATC system capable of automatic radar tracking.

Tactical MCTs and communications components will also link with NAS systems during exercise and fixed-based facility restoration activities. Two MCT systems, the Army and Air Force TSW-7 and the Marine Corps TSQ-120, are self-contained units that can operated autonomously or as part of a terminal landing system. The older Army TSW-7 system is undergoing a communications upgrade. The Air Force version will be modernized with the addition of new monitoring and alarm systems, voice recorders, and the capability for direct communications with other military and civil ATC facilities. The TSQ-120 incorporates modern communications, operations, and support equipment. In both mobile MCT systems, aircraft operations will be coordinated by voice communication to other ATC facilities over telephone, intercom, and radio networks.

The communications radio equipment deployed as part of military tactical ATC systems will be comparable to year 2000 NAS systems in technological sophistication. Military radios components designed with secure, anti-jam capabilities will be capable of operating in conventional modes for ATC purposes. However, tactical components will not be equipped with the modern integrated control and switching systems found in NAS facilities until the next generation of mobile ATC systems, such as the Army's Air Traffic Navigation, Integration, and Coordination System (ATNAVICS) and the Air Force's Automated Tactical Aircraft Launch and Recovery System (ATALARS), are fielded.

2.2 NAS Systems Interoperability

Military air traffic control components will be fully interoperable with FAA systems, according to current DOD and FAA policies. At present, it is the means and time frame of accomplishing interoperability that is unknown, not the issue of it's occurrence. As stated in the 1989 NAS Plan, the DOD has agreed to "...procure ATC, Ground-to-Air Communications, Interfacility Communications, and Maintenance and Operations Support systems to maintain full interoperability with those procured by the FAA, to the maximum extent practical." Towards this common objective, the FAA approved NAS Change Proposal (NCP) 11526 in late 1989 to baseline essential DOD systems for inclusion in NAS design documents (NAS-DD-1000D) and system specifications (NAS-SS-1000). The system interfaces detailed in the NCP and, ultimately, in NAS documents will continue the present system-to-system interaction into the end-state NAS or until interoperability is achieved by the use of common ATC components. The interfaces include the ACCC with EARTS, ARTS IIA, ARTS IIIA, PIDP II, RATCF DAIR, and FACTS; the ACCC with DBRITE/BRANDS; the ACCC with FDIO; and the VSCS, TCS, ICSS, and TMVS with military voice communications switches. The following discussion reviews issues and considerations pertaining to the interoperability of year 2000 military and civil NAS systems, as previously described.

2.2.1 Surveillance Systems

The installation of the ARSR-4s and the upgrade of the Anchorage ARTCC/ EARTS to an ACF/ACCC will complete the integration of modern military long-range radar systems into the national surveillance network. The remainder of this sub-section will address the interoperability of DOD terminal radar systems. The DOD radar architecture projected for the year 2000 is the ASR-7/ 8/9/ATCRBS mosaic listed in Table 2-1. It is also the least interoperable of the possible combinations of military primary and secondary radar systems with respect to future FAA systems. Prior to FAA approval of NCP 11526, only the military ASR-9s were end-state NAS components.

Fortunately, end-state interoperability of the DOD ATC radar facilities with the NAS improved as a result of NCP 11526. In order to implement the NCP, NAS design and system specification changes must restore or add the required systems and communications interfaces between the ACFs and the MRACF surveillance systems. Many of the former specifications for advanced automation systems interface with older surveillance components were dropped after the FAA decided to replace aging analog radar and beacon interrogator equipment with the ASR-10 and Mode S systems. The ASR-7/8, TPX-42, and the ATCBI-5 are not included in current NAS specifications. The previous interface between the ACCC/TCCC and the ASR-9/10 or ARSR-3/4 radar data processor is now limited to the transmission of weather radar data. According to the 1989 NAS Plan, the ACCC/TCCC will receive search radar/beacon data correlated by the Mode S processor and transmitted by Mode S data link.

NCP 11526 will institute the end-state ACCC interface with DOD's radar processors, including the EARTS (Nellis AFB), ARTS IIA and ARTS IIIA (Army ARACs), PIDP II (USAF RAPCONs), RATCF DAIR (Navy and Marine Corps RATCFs), and FACTS (Navy FACSFACs). This interface, along with that of the ACCC to FDIO, will provide the means of exchanging ATC flight plan, tracking, and coordination messages for automatic interfacility handoffs "...in a manner identical to an ARTS/Host interface", according to the NCP. This interfacility ATC coordination data exchange will not be the same as the radar interoperability that will exist between the ACCC and FAA terminal ASR-9/10 and Mode S facilities. However, the NCP communications flow mirrors the existing state of MRACF to ARTCC interoperability and one which satisfies present military ATC service requirements. The processor to Host/ACCC data exchange may also continue between PIDP/RATCF DAIR equipped, independent GCA facilities (i.e., not the PAR positions of an MRACF) and their serving ARTCCs/ACFs. This will depend upon near term DOD decisions and joint agency agreements on the function and configuration of the GCAs. Of course, the least compatible are the remainder of DOD's GCA facilities which will continue to coordinate flight plan and target information with adjacent radar facilities by landline voice communications. The degree of compatibility in voice and (non-radar) data communications between the MRACFs and adjacent FAA facilities is discussed under communications.

The integration of DOD terminal surveillance components into a modern NAS will necessitate restoration of a different processor interface for the ASR-9s procured for the Army's ARACs and Nellis AFB. The NAS specifications do not provide for an ASR-9 interface with the ACCC except through the Mode S. The DOD ASR-9s will operate in conjunction with ATCRBS, either a TPX-42 or ATCBI-5, into the next century. Thus, their interoperability may depend upon the restoration of an ACCC to ASR-9 (with beacon interrogator) processor interface as an end-state configuration (see figure 2-6).

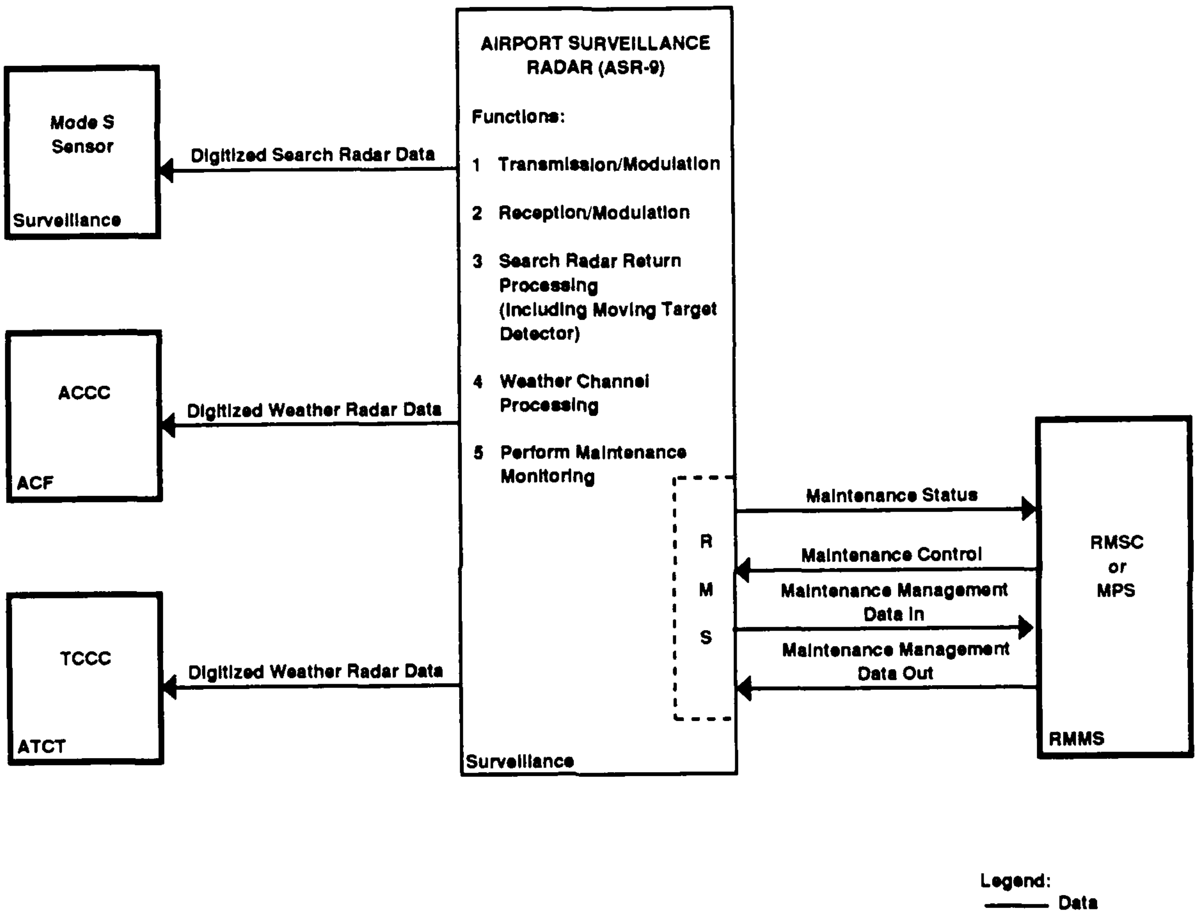

Figure 2-6: Airport Surveillance Radar (ASR) - 9

2.2.2 Terminal Control and Landing Systems

NAS interoperability will influence the evolution of DOD terminal ATC and landing systems other than the radar components discussed above. It is a factor in planning for year 2000 MCTs and in the service decisions regarding future precision landing systems. The future MCTs will be interoperable with parent MRACFs/GCAs or compatible with the appropriate terminal sectors of the serving ACFs, depending upon the local ATC architecture. The MCT's DBRITE/BRANDS units will interface with the radar processors/automation systems of the surveillance facilities providing terminal area coverage. The degree of communications compatibility or interoperability between the MCTs and adjacent FAA facilities will vary according to the military communications systems used. The Air Force OJ-314 and the Army FSC-92 systems will be compatible with FAA's ICSS/TCS/VSCS, while the Navy IVCSS will be interoperable. All the MCTs must do without the automation systems support found in the FAA's end-state ATCTs.

Military ILS, MLS, and ACLS precision landing systems will remain relatively autonomous in operation. They will continue to interface with monitoring and control circuits in the responsible ATC Facility, and provide guidance information to qualified aircrews flying properly equipped aircraft. Interoperability in precision landing systems will be achieved with the installation of the MLS at DOD airfields.

2.2.3 Flight Information and Weather Systems

The NAS voice and data communications architectures contain broadly defined communications channels between the DOD and FAA organizations responsible for coordinating aeronautical and meteorological information. For Example, the NAS-DD-1000D data flow diagrams at figures 2-7 and 2-8, show "MBO", "MILITARY", and "PILOT(s)" as the exchangers of flight information with the ACCC, the FSDPS, and the TMP. The NCP 11526 modifications to the NAS system specifications will list in more detail the interfaces between the FDIO and the ACCC, and between military and FAA voice communications systems. These interfaces insure the communication of

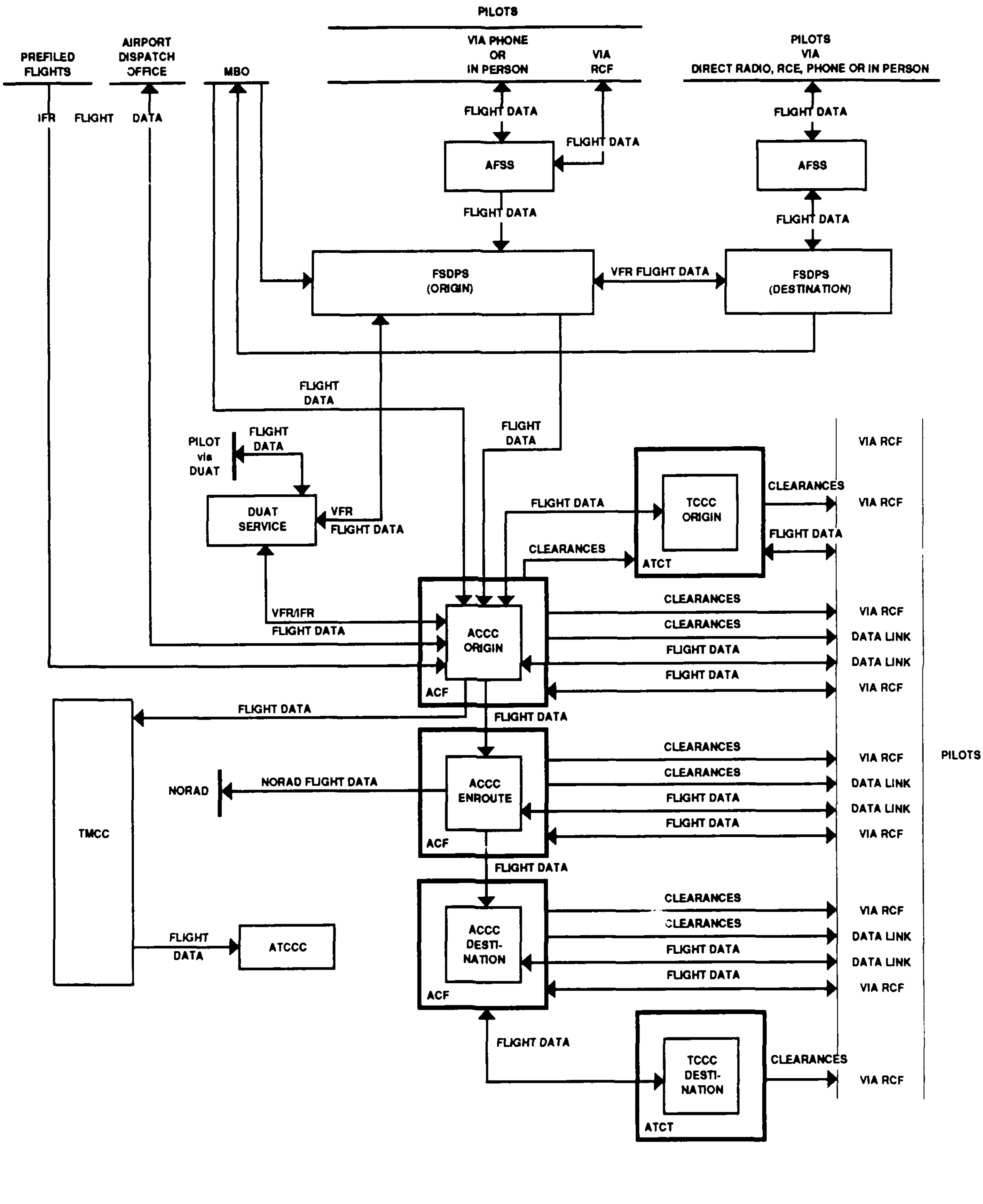

Figure 2-7: Flight Data Flow

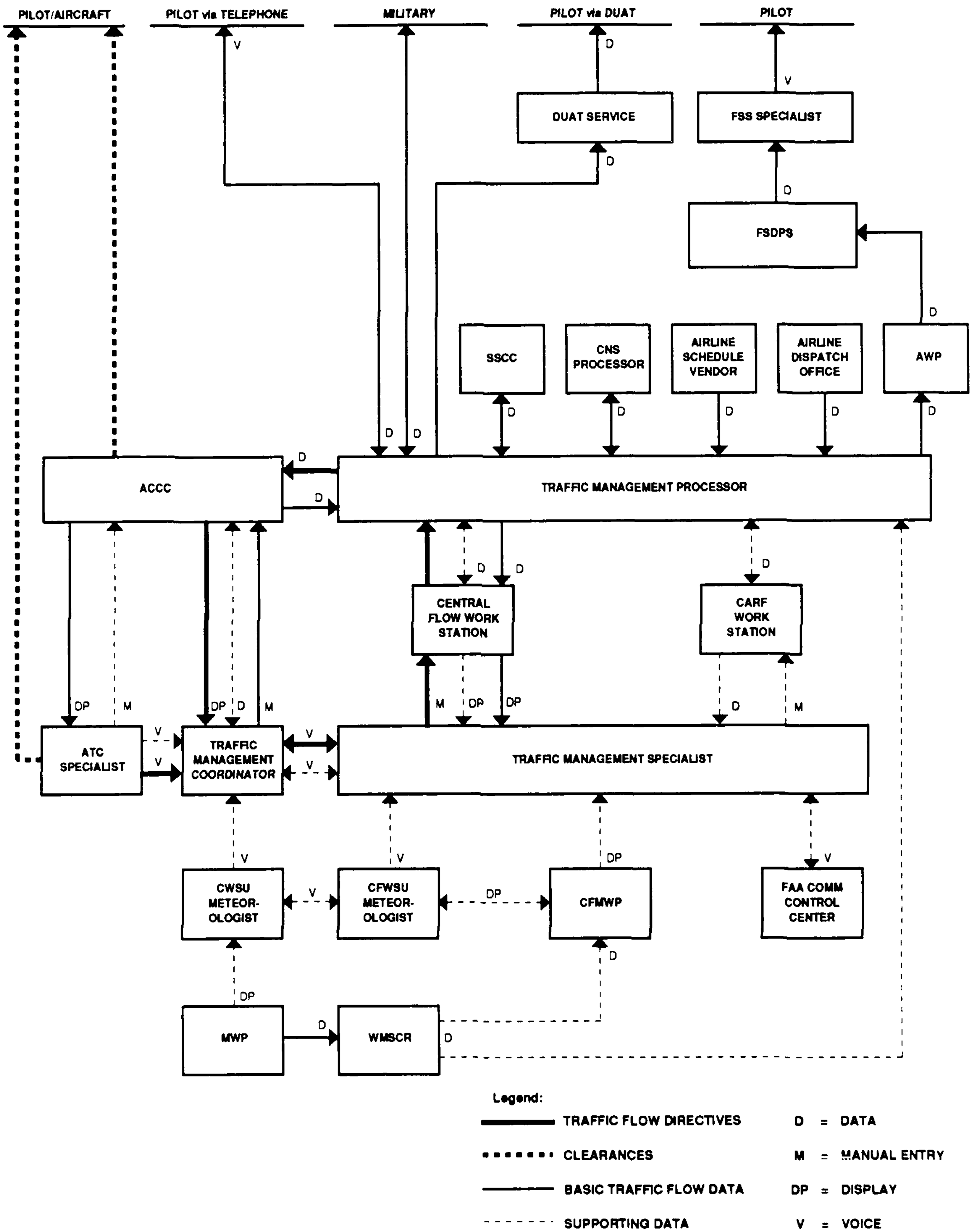

Figure 2-8: Traffic Management Data Flow

military flight planning data, system status information, and operational requests to the appropriate NAS facilities. FDIO data will be NAS interoperable, whereas the information passed by voice will be compatible.

Weather information flows are compatible and, frequently interoperable. Both the DOD and the FAA are connected to the NWS for the distribution of digital weather data. Military regional and local weather units interoperate with their parent and/or joint service central weather organizations, which enables them to receive weather graphics and to exchange weather and NOTAM information. Funded modernization programs will field NEXRAD radars and/or PUPs, weather information networks, and automated observation systems comparable to the FAA's AWOS at most military airfields. Assuming the information is rapidly accessible to military ATC, the projected year 2000 configuration of military weather systems will provide excellent coverage and forecasting capabilities in support of NAS responsibilities and aviation requirements. However, without the capabilities of the FAA's advanced automation system and data-link communications, much of this information must be relayed by voice to pilots operating under military ATC.

2.2.4 Communications Systems

The FAA's system-wide modernization of communications under the NAS Plan is not matched by DOD programs. The DOD is implementing two new major communications systems and upgrading other systems which will support wartime command and control, and, possibly, wartime ATC. However, the systems, used in their battlefield modes, have no application in the NAS and are not compatible with the NAS communications systems. Defense ATC planners are evaluating NAS Plan communications projects (VSCS, ICSS, TCS, data link) for future military ATC application but have not made commitments toward any NAS system.

The FAA's end-state A/G communications will employ the (appropriate) voice communications switch for the type of facility, the RCE/RCF, and Mode S...the primary differentiator between the military and civil systems. Consequently, FAA facilities and properly equipped aircraft will exchange messages by both voice and data link. The DOD system will use only the voice switch and the RTR to transmit and receive voice communications. Thus, military ATC facilities are interoperable in A/G voice communications and incompatible in A/G data communications.

The DOD facilities will also be interoperable with NAS interfacility communications, despite the fact that they will lack the automated and highly flexible support provided to civil NAS facilities by the FAA owned NICS. In the post NCP 11526 configuration, MRACFs and MBOs will rely primarily upon leased communications lines (dedicated telephone or Western Union telegraph circuits) to connect (directly or indirectly) with NICS and the NADIN 1A/II system to the appropriate FAA facility.

2.2.5 Position/Navigation Systems

In the navigation area, civil access to DOD's GPS is the only end-state interoperability issue. The DOD will have phased-out land-based TACAN and the use of VOR/DME, LORAN-C and Omega, and further reduced the use of radiobeacons. The DOD's one hybrid system, the GPS/INS, will be as interoperable with civil systems as will the GPS.

The GPS will be the primary military system. It will be available to civil users and is expected to be heavily used. The functional interfaces are being developed to insure that GPS fulfill it's role as a fully interoperable sole means navigation system for civil and military aviation. These interfaces include requirements for: GPS (military and civil) avionics software support for an area navigation (RNAV) capability compatible with the NAS en route system; a DOT civil interface office to provide information to, and be the point of contact for, civil users of the GPS; military service plans for GPS equipment installation according to weapons system requirements; and the FAA GPS monitor stations previously discussed.

2.2.6 Tactical Air Traffic Control Systems

An understandable limitation of the current inventory of mobile and tactical surveillance systems is their incompatibility with the digital radar data format required for "end-state" NAS

ASRs. The communications components integral to or operated in conjunction with the radar systems are compatible with NAS components. The radars and their supporting systems were designed for battlefield ATC and airspace management, not NAS operation. However, next generation military surveillance radars, such as the Army's ATNAVICS and the Air Force's ATALARS, include NAS interoperability as a system requirement. Neither system is likely to be fielded before the year 2000. The Marine Corps plans to insure at least NAS radar compatibility in the TPS-73 system.

Military tactical terminal systems are compatible with NAS communications. DOD mobile control towers can tap into local telephone systems and verbally exchange flight data with other military and FAA ATC facilities. Tactical military radios components designed with secure, anti-jam capabilities will be capable of operating in conventional modes for NAS ATC purposes. The ongoing communications upgrades in these systems will improve system reliability, maintainability, and interoperability with battlefield command and control systems, without significantly improving NAS compatibility.

3.0 Conclusions and Recommendations

Today, as in the recent past, military ATC planning activity continues to focus on the radar facility architecture and on the individual and cumulative impacts of the NAS Plan projects to DOD mission requirements. The DOD's technical engineering and integration studies are identifying the modernization requirements and options for each of the military radar facilities listed in Interagency Agreement A. The studies provide the needed configuration alternatives for the budget decisions which will initiate the procurement of the planned common ATC equipment. Later studies will develop the transitional plans needed to achieve the modernization, if so decided.

In spite of this recent progress, the fact remains that nine years into the FAA's NAS Plan modernization, the DOD continues to be a non-participant. Although a clear statement of intent (Interagency Agreement A) has been made to "...accomplish joint (DOD -FAA) purchase of equipment for ATC facilities...", the military services have failed to make major budgetary commitments toward NAS advanced systems acquisition. Some progress toward modernization has occurred. The Air Force and Navy are committed to MLS for the tactical capabilities of the system. The Army has dedicated funds to acquire modern ASR-9 radars for the three ARACs and digital FPN-66s to support DBRITEs at GCA-level, lower traffic density Army airfields. However, from a national perspective, DOD's "common equipment" remains a hoped for goal instead of an emerging reality for the obvious budgetary reasons and the difficulty in quantifying the impacts of failing to modernize military ATC.

3.1 Flying Safety

The NAS in the year 2000 will be a safe and efficient flying environment. Enhanced aviation safety is a planned end-product of the FAA's modernization of surveillance, communications, and automation systems. The forecast military ATC environment will likewise be safe, albeit without many of the enhancements available to civil components. Military ATC is likely to be a more labor intensive activity conducted at moderate or low activity locations. To varying degrees of commonality, the MRACFs will be capable of providing a comparable, safe, but not equivalent level of service to military and civil aviation. The potential impact of DOD's forecast lack of modernization will be felt in the area of mission effectiveness.

3.2 Operational Effectiveness

The MRACF to ACF "ARTS/Host interface" baselined for the end-state by NCP 11526 is equivalent to the present DOD to FAA radar connection and should be sufficient for the safe and expeditious control of aircraft in the year 2000. This is part of the problem in quantifying impacts. In terms of FY 1988 dollars, the cost of an ASR-10/Mode S equipped terminal radar system is projected to be $13 million. It is difficult to justify this costly modernization for an effective system. Ultimately, military ATC modernization will occur and the most viable, interoperable alternative available in the near term is an ASR-10/Mode S based system backed by an AAS interoperable automation system. Until DOD modernization occurs, the operational issues and potential costs associated with the DOD's forecast posture are summarized as follows:

- The DOD projected radar architecture, the ASR-7/8/9/ATCRBS, is the least functional and interoperable of the possible combinations of military primary and secondary radar systems with respect to future FAA systems. Qualitatively, except for ASR-9 equipped facilities, the MRACFs will not have the reliability or the highly accurate surveillance information available to the modern, digital NAS radar systems.
- The DOD must bear the high cost of logistically supporting older radar systems. The Air Force GPN-12 will be unsupportable well before the turn of the century. The military must also continue to upgrade the software and hardware/memory of the various radar processors (ARTS/PIDP II/RATCF DAIR) in order to remain interoperable with NAS automation systems and capable of responding to system demand. FAA fielded ARTS enhancements will assist the DOD upgrade effort only until the systems are replaced in the late 1990s. The processor upgrades are needed to insure that important ATC automation tools like enhanced terminal conflict alert and MSAW are available to military controllers.

- Military ATC systems will function without the automation systems found in FAA facilities or with systems which are non-interoperable. This includes the functions of the MRACFs and MCTs (without ACCC or TCCC), the MBOs (without FSAS support), and many MRU/range control facilities (i.e., no continuing support for the Nellis AFB EARTS).

- The NAS will not automatically include air traffic within delegated military airspace. FAA systems will access military flight planning information but will not have accurate target information from most military ATC facilities due to the nature of the DOD - FAA radar data interface.

- There is no DOD equivalent to the NAS Plan communications modernization. The degree of communications compatibility or interoperability between military and FAA facilities will vary according to the military systems used, due to independent service acquisition policies and budget constraints.

- The DOD's does not plan to have Mode S, or Mode S data link communications capability, except in some transport aircraft. This constitutes a communications shortfall and a major incompatibility between the FAA and the DOD systems. Without data link, DOD ATC facilities and aircraft are likely to be receive reduced service priorities.

Interoperability is required to insure that DOD ATC facilities continue to execute en route and expanded terminal ATC responsibilities. Without interoperability, military ATC facilities cannot provide services equivalent to those furnished by FAA facilities in a manner "transparent to the user". While the ATC operational consequence of this shortfall is difficult to precisely forecast, it reasonably follows that the new service standard, as provided by modern NAS facilities, will be linked to enhanced aviation safety and demanded by the aviation user community. The failure or inability of the MRACFs to render the expected level of service and safety (real or perceived) could cause the FAA to invalidate the Memorandum of Agreement for the DOD's failure to "commonly equip" and relegate the MRACFs to terminal airspace responsibilities. This would considerably reduce the larger service area now planned for the MRACFs, CRFs, and ACF, and compromise the specialized military ATC functions upon which military test and training mission effectiveness depends. Alternatively, the failure of DOD to refurbish ATC facilities and equipment to NAS standards may provoke Congressional appropriation activities for a forced and fiscally disruptive modernization.

Unfortunately, the DOD retrogressive position, as now forecast, occurs in an environment potentially detrimental to the military. The "Peace Dividend", as the Eastern European/Soviet political upheaval has been deemed, suggests a difficult era for DOD activities. The concurrent increased civil demand for airspace use and the FAA's ATMS, NAMFAC, SAMS, and AERA, presage a DOD defensive posture regarding the retention of and continued access to military delegated airspace. Acknowledged cornerstones in this defense of airspace are the military ATC and range control facilities, the same facilities constrained by the lack of modernization.

Finally, the modernization of military facilities should be undertaken by DOD in lieu of FAA funding. The FAA's surveillance requirement is frequently stated as a fiscal determinant for the modernization of specific military radars whose area of coverage is important to the NAS radar networking plan. The Volume I of the NAS-SS-1000 identifies 19 military radar sites used as gap fillers by the FAA. However, the FAA has not committed to funding new radar equipment for the MRACFs and GCAs used by the FAA network, except for those military facilities which will be transferred from DOD to FAA jurisdiction under Interagency Agreement A. It is reasonable to assume that an FAA commitment to buy modern equipment for military gap fillers would be accompanied by site-specific selection decisions based on optimum area coverage, which may not be coincidental with military operational requirements. For example, the FAA could purchase a Mode S system for a gap filler site near but not on Luke AFB, Arizona. This may meet NAS requirements while falling short of the needs of Luke RAPCON.

3.3 Air Force Mission Impact

The potential impact of DOD's lack of ATC modernization on mission effectiveness is based upon the assumptions that (1) DoD delays in ATC equipment procurement will necessitate a greater degree of FAA control over ATC responsibilities and airspace now assigned to military facilities and (2) that expanded FAA control will adversely affect the conduct of military flight operations. Both assumptions are reasonably supportable. The first stems from DOD's own recognition that the failure to provide equivalent ATC service is unacceptable to NAS users. The second assumption stems from practical, current experience. The best of FAA service to military missions must conform to span of control and manning standards. In order to provide service to all users, the FAA cannot normally dedicate the necessary controllers to military-unique aviation requirements as can the DOD. This is most obvious where terminal or special use airspace is contested by civil aviation requirements. The FAA is obligated by the Federal Aviation Act of 1958 to provide for all users. In a contested area, without dedicated military ATC/MRU service, the FAA must provide for the needs of the entire aviation community, often to the derogation of service/access to DOD users. This premise is fact for many military flying activities located near a major commercial airline hub airports. Thus, interoperability is required to insure that DOD ATC facilities continue to execute en route and expanded terminal ATC responsibilities. With DOD-FAA systems interoperability, the competition for ATC services and airspace from civil users will be difficult to deter. Without interoperability, the competition will be overwhelming and the military mission will undoubtedly suffer.

APPENDIX A

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APPENDIX B

GLOSSARY

ADVANCED AUTOMATION FUNCTIONS - The ACCC shall receive from other ACCCs trail plans, trajectory update information, and messages containing inputs to and/or outputs from advanced automation functions such as Flight Plan Conflict Probe. The messages shall include flight plan conflict and airspace conflict alerts and displays.

AERODROME - A defined area on land or water (including any buildings, installations, and equipment) intended to be used either wholly or in part for the arrival, departure, and movement of aircraft. Aerodromes may include airports, heliports, and other landing areas.

AIR NAVIGATION FACILITY - Any facility used in, available for use in, or designated for use in, aid of air navigation, including landing areas, lights, any apparatus or equipment for disseminating weather information, for signaling, for radio-directional finding, or for radio or other electrical communication, and any other structure or mechanism having a similar purpose for guiding or controlling flight in the air or the landing and take-off of aircraft.

AIRCRAFT - Device/s that are used or intended to be used for flight in the air; when used in air traffic control terminology may include the flight crew.

AUTOMATIC ALTITUDE REPORTING - That function of a transponder which responds to interrogations by transmitting the aircraft's altitude in 100-foot increments.

CONFLICT ALERT - A function of certain air traffic control automated systems designed to alert specialists to existing or pending situations recognized by the program parameters that require their immediate attention/action.

DISTANCE MEASURING EQUIPMENT/DME - Equipment (airborne and ground) used to measure, in nautical miles, the slant range distance of an aircraft from the DME navigational aid.

EN ROUTE - One of three phases of flight services (terminal, en route, oceanic). En route service is provided outside of terminal airspace and is exclusive of oceanic control.

EN ROUTE AIR TRAFFIC CONTROL SERVICES - Air traffic control service provided aircraft on IFR flight plans, generally by ARTCCs (ACF), when these aircraft are operating between departure and destination terminal areas. When equipment capabilities and controller workload permit, certain advisory/assistance services may be provided to VFR aircraft.

EN ROUTE MINIMUM SAFE ALTITUDE WARNING/E-MSAW - A function of the NAS Stage A en route computer that aids the controller by providing an alert when a tracked aircraft is below or predicted by the computer to go below a predetermined minimum IFR altitude.

FLIGHT PLAN - Specified information relating to the intended flight of an aircraft that is filed orally or in writing with an ATC facility.

FLIGHT SERVICE STATION/FSS - Air traffic facilities which provide pilot briefing, en route communications, and VFR search and rescue services; assist lost aircraft and aircraft in emergency situations; relay ATC clearances; originate Notices to Airmen; broadcast aviation weather and NAS information; receive and process IFR flight plans; and monitor NAVAIDS. In addition, at selected locations FSSs provide En Route Flight Advisor Service (Flight Watch), take weather observations, issue airport advisories, and advise Customs and Immigration of transborder flights.

HANDOFF - An action taken to transfer the control of an aircraft from one controller to another if the aircraft will enter the receiving controller's airspace and radio communications with the aircraft will be transferred.

IFR AIRCRAFT/IFR FLIGHT - An aircraft conducting flight in accordance with instrument flight rules.

IFR CONDITIONS - Weather conditions below the minimum for flight under visual flight rules.

INSTRUMENT FLIGHT RULES/IFR - Rules governing the procedures for conducting instrument flight. Also a term used by pilots and controllers to indicate type of flight plan.

INDIRECT-ACCESS VOICE COMMUNICATIONS - Means whereby a specialist can establish voice communications with a designated position through multiple actions on one or more physical devices.

INSTRUMENT LANDING SYSTEM/ILS - A precision instrument approach system which normally consists of the following electronic components and visual aids:

1. Localizer
2. Glide Slope
3. Outer Marker
4. Middle Market
5. Approach Lights

INTERROGATOR - The ground-based surveillance beacon transmitter-receiver, which normally scans in synchronism with a primary radar, transmitting discrete radio signals which repetitiously request all transponders, on the mode being used, to reply. The replies received are mixed with the primary returns and displayed on the same plan position indicator. Also applied to the airborne element of the TACAN/DME system.

NAS STAGE A - The en route ATC system's radar, computers and computer programs, controller plan view displays (PVDs/radar scopes), input/output devices, and the related communications equipment which are integrated to form the heart of the automated IFR air traffic control system. This equipment performs Flight Data Processing (FDP) and Radar Data Processing (RDP). It interfaces with automated terminal systems and is used in the control of en route IFR aircraft.

NATIONAL AIRSPACE SYSTEM/NAS - The NAS includes U.S. airspace; air navigation facilities, equipment and services; aeronautical charts, information and services; aviation rules, regulations, and procedures; technical information; and the labor and material used to control and/or manage flight activities in airspace under the jurisdiction of the U.S.

NAVIGATIONAL AID/NAVAID - Any visual or electronic device, airborne or on the surface which provides point-to-point guidance information or position data to aircraft in flight. NAVAIDS (VOR, VORTAC, and TACAN) aids are classed according to their operational use. The three classes of NAVAIDS are:

T - Terminal
L - Low altitude
H - High altitude

ROUTE - A defined path, consisting of one or more courses in a horizontal plane, which aircraft traverse over the surface of the earth.

SPECIAL USE AIRSPACE - Airspace of defined dimensions wherein aerial activities must be contained because of their nature, and/or wherein air traffic control limitations may be imposed upon aircraft operations that are not part of the contained activities. Special use airspace includes prohibited areas, restricted areas, warning areas, military operations areas, controlled firing areas, and alert areas.

SURVEILLANCE - The detection, location, and tracking of aircraft within NAS airspace for the purposes of control, separation, and identification. Surveillance systems are electronic in nature; visual methods are purposely excluded. In the case of dependent surveillance, the aircraft provides all flight information. Surveillance systems are differentiated as independent, independent cooperative, and dependent:

1. Independent Surveillance - A system which requires no airborne compatible equipment

2. Independent Cooperative Surveillance - A system which requires airborne compatible equipment (e.g., ATCRBS, Mode S)

3. Dependent Surveillance - A system which requires input from navigation equipment aboard the aircraft either via a data link (e.g., LOFF) or via voice transmission (pilot reports)

TACTICAL AIR NAVIGATION/TACAN - An ultra-high frequency electronic rho-thea air navigation aid which provides suitably equipped aircraft a continuous indication of bearing and distance to the TACAN station.

TERMINAL AREA - A general term used to describe airspace in which approach control service or airport traffic control service is provided.

TERMINAL AREA FACILITY - A facility providing air traffic control service for arriving and departing IFR, VFR, Special VFR, Special IFR aircraft and, on occasion, en route aircraft.

TOWER/AIRPORT TRAFFIC CONTROL TOWER - A terminal facility that uses air-ground radio communications, visual signaling, and other devices to provide ATC services to aircraft operating in the vicinity of an airport or on the movement area. Authorizes aircraft to land or takeoff at the airport controlled by the tower or to transit the airport traffic area regardless of flight plan or weather conditions (IFR or VFR). A tower may also provide approach control services.

USER - The external individual or group that receive services from the NAS (e.g., Pilot, Air Carrier, General Aviation, Military, Law Enforcement Agencies).

VFR AIRCRAFT/VFR FLIGHT - An aircraft conducting flight in accordance with visual flight rules or operating on a Special VFR clearance.

VFR CONDITIONS - Weather conditions equal to or better than the minimum for flight under visual flight rules.

VISUAL FLIGHT RULES/VFR - Rules that govern the procedures for conducting flight under visual conditions. The term "VFR" is also used in the United States to indicate weather conditions that are equal to or greater than minimum VFR requirements. In addition, it is used by pilots and controllers to indicate type of flight plan.

VISUAL METEOROLOGICAL CONDITIONS/VMC - Meteorological conditions expressed in terms of visibility, distance from cloud, and ceiling equal to or better the specified minima.

VORTAC/VHF OMNI-DIRECTIONAL RANGE/TACTICAL AIR NAVIGATION - A navigation aid providing VOR azimuth, TACAN azimuth, and TACAN distance measuring equipment (DME) at one site.

APPENDIX C

ACRONYMS/ABBREVIATIONS

ACRONYM	MEANING
AAS	Advanced Automation System
ACLS	Automatic Carrier Landing System
ACCC	Area Control Computer Complex
ACF	Area Control Facility
ADS	Automatic Dependent Surveillance
AERA	Automated En Route Air Traffic Control
AFSS	Automated Flight Service Station
ARAC	Army Radar Approach Control
ARSR	Air Route Surveillance Radar
ARTCC	Air Route Traffic Control Center
ARTS	Automated Radar Terminal System
ASR	Airport Surveillance Radar
ATC	Air Traffic Control
ATCBI	Air Traffic Control Beacon Interrogator
ATCCC	Air Traffic Control Command Center
ATCRBS	Air Traffic Control Radar Beacon System
ATCT	Air Traffic Control Tower
ATNAVICS	Air Traffic Navigation, Integration and Coordination System
BRITE	Bright Radar Indicator Tower Equipment
CA	Conflict Alert
CONUS	Continental, Contiguous, or Conterminous United States
DBRITE	Digital Bright Radar Indicator Tower Equipment
DoD	Department of Defense
EARTS	En Route Automated Radar Tracking System
EMSAW	En Route Minimum Safe Altitude Warning
FAA	Federal Aviation Administration
FACSFAC	Fleet Area Control and Surveillance Facility
FDEP	Flight Data Entry and Printout
FDIO	Flight Data Input/Output
FSS	Flight Service Station
GPS	Global Positioning System
HF	High Frequency
ICSS	Integrated Communications Switching System
ILS	Instrument Landing System
MAMS	Military Airspace Management System
MHz	Megahertz
MLS	Microwave Landing System
MMLS	Military Microwave Landing System
Mode C	Altitude Reporting Mode of Secondary Radar
Mode S	Discrete addressable Secondary Radar System with Data Link
MOA	Military Operation Area
MSAW	Minimum Safe Altitude Warning

NARACS	National Radio Communications System
NAS	National Airspace System
NASP	National Airspace System Plan
NAVAID	Navigational Aid
PAR	Precision Approach Radar
PIDP	Programmable Indicator Data Processor
RAPCON	Radar Approach Control
RATCF	Radar Air Traffic Control Facility (Navy)
RCF	Remote Communication Facility
TAAS	Terminal Advanced Automation System
TACAN	Tactical Aircraft Control and Navigation
TCAS	Traffic Alert and Collison Avoidance System
TCCC	Tower Control Computer Comples
TCS	Tower Communications System
TPX	Military Beacon System
TRACAB	Terminal Radar Approach Control in the Tower Cab
TRACON	Terminal Radar Approach Control Facility
UHF	Ultra High Frequency
USA	United States Army
USAF	United States Air Force
USMC	United States Marine Corps
USN	United States Navy
VFR	Visual Flight Rules
VHF	Very High Frequency
VOR	Very High Frequency Omnidirectional Radio
VORTAC	Collocated VOR and TACAN