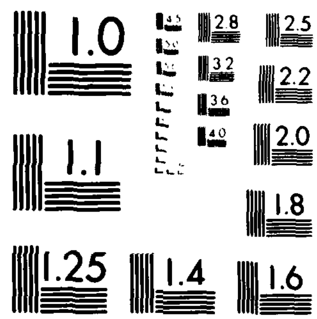
AD-A085 180 MITRE CORP MCLEAN VA METREK DIV F/6 17/7

DISCRETE ADDRESS BEACON SYSTEM/AUTOMATED TRAFFIC ADVISORY AND R--ETC(U)

APR 80 J E DIEUDONNE, R W LAUTENSCHLAGER DOT-FA80WA-4370

UNCLASSIFIED MTR-79W00436 FAA/RD-80-42 NL

1 2




MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

Report No. FAA-RD-80-42

LEVEL II

# DISCRETE ADDRESS BEACON SYSTEM/AUTOMATED TRAFFIC ADVISORY AND RESOLUTION SERVICE/AIR TRAFFIC CONTROL OPERATIONAL SYSTEM DESCRIPTION



J.E. Dieudonne

R.W. Lautenschlager



APRIL 1980

Final Report

Document is available to the U.S. public through the National Technical Information Service, Springfield, Virginia 22161.

Prepared for

**U.S. DEPARTMENT OF TRANSPORTATION**
**FEDERAL AVIATION ADMINISTRATION**
**Systems Research & Development Service**
**Washington, D.C. 20590**

NOTICE

**Technical Report Documentation Page**

| 1. Report No. | 2. Government Accession No. | 3. Recipient's Catalog No. |
|---|---|---|
| FAA/RD/80-42 | AD-A085 180 | |

**4. Title and Subtitle**
Discrete Address Beacon System/Automated Traffic Advisory and Resolution Service/Air Traffic Control Operational System Description

**5. Report Date**
APR[redacted]80

**6. Performing Organization Code**
~~W-41,~~ W-46

**7. Author(s)**
J. E. Dieudonne, R. W. Lautenschlager

**8. Performing Organization Report No.**
MTR-79W00436

**9. Performing Organization Name and Address**
The MITRE Corporation
Metrek Division
1820 Dolley Madison Blvd.
McLean, VA 22102

**10. Work Unit No. (TRAIS)**

**11. Contract or Grant No.**
DOT-FA80WA-4370

**12. Sponsoring Agency Name and Address**
U.S. Department of Transportation
Federal Aviation Administration
Systems Research and Development Service
Washington, DC 20590

**13. Type of Report and Period Covered**

**14. Sponsoring Agency Code**
ARD-200

**15. Supplementary Notes**
Final rept.,

**16. Abstract**

This document describes the Discrete Address Beacon System (DABS) sensor and the collocated Automatic Traffic Advisory and Resolution Service (ATARS) function relative to their interactions with the Air Traffic Control (ATC) facilities. A general description of the Terminal and En Route ATC facility modifications for integration with the initial deployment of DABS sensors is provided. The document discusses: the characteristics and use of the surveillance data, the exchange of messages between the ATC facility by means of the DABS air-ground data link and some potential applications, the interaction between ATARS and the ATC facility, and the exchange of information between DABS and the ATC facility relative to status and control information. The actions performed by the DABS sensor are summarized, the messages involved in the transactions between DABS and the ATC facility are described and the actions by the ATC facility are discussed.

**17. Key Words**
Discrete Address Beacon System
DABS
Surveillance
Communications
Data Link
Air Traffic Control
ATARS

**18. Distribution Statement**
Document is available to the U.S. public through the National Technical Information Service, Springfield, Virginia 22161.

| 19. Security Classif. (of this report) | 20. Security Classif. (of this page) | 21. No. of Pages | 22. Price |
|---|---|---|---|
| Unclassified | Unclassified | 120 | |

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

409 890

# METRIC CONVERSION FACTORS

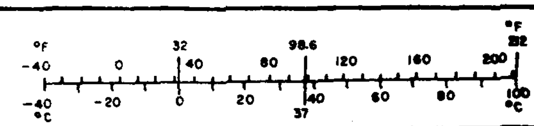
## Approximate Conversions to Metric Measures

| Symbol | When You Know | Multiply by | To Find | Symbol |
|---|---|---|---|---|
| | | **LENGTH** | | |
| in | inches | *2.5 | centimeters | cm |
| ft | feet | 30 | centimeters | cm |
| yd | yards | 0.9 | meters | m |
| mi | miles | 1.6 | kilometers | km |
| | | **AREA** | | |
| $in^2$ | square inches | 6.5 | square centimeters | $cm^2$ |
| $ft^2$ | square feet | 0.09 | square meters | $m^2$ |
| $yd^2$ | square yards | 0.8 | square meters | $m^2$ |
| $mi^2$ | square miles | 2.6 | square kilometers | $km^2$ |
| | acres | 0.4 | hectares | ha |
| | | **MASS (weight)** | | |
| oz | ounces | 28 | grams | g |
| lb | pounds | 0.45 | kilograms | kg |
| | short tons (2000 lb) | 0.9 | tonnes | t |
| | | **VOLUME** | | |
| tsp | teaspoons | 5 | milliliters | ml |
| Tbsp | tablespoons | 15 | milliliters | ml |
| fl oz | fluid ounces | 30 | milliliters | ml |
| c | cups | 0.24 | liters | l |
| pt | pints | 0.47 | liters | l |
| qt | quarts | 0.95 | liters | l |
| gal | gallons | 3.8 | liters | l |
| $ft^3$ | cubic feet | 0.03 | cubic meters | $m^3$ |
| $yd^3$ | cubic yards | 0.76 | cubic meters | $m^3$ |
| | | **TEMPERATURE (exact)** | | |
| °F | Fahrenheit temperature | 5/9 (after subtracting 32) | Celsius temperature | °C |

*1 in ≡ 2.54 (exactly). For other exact conversions and more [illegible] tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.


## Approximate Conversions from Metric Measures

| Symbol | When You Know | Multiply by | To Find | Symbol |
|---|---|---|---|---|
| | | **LENGTH** | | |
| mm | millimeters | 0.04 | inches | in |
| cm | centimeters | 0.4 | inches | in |
| m | meters | 3.3 | feet | ft |
| m | meters | 1.1 | yards | yd |
| km | kilometers | 0.6 | miles | mi |
| | | **AREA** | | |
| $cm^2$ | square centimeters | 0.16 | square inches | $in^2$ |
| $m^2$ | square meters | 1.2 | square yards | $yd^2$ |
| $km^2$ | square kilometers | 0.4 | square miles | $mi^2$ |
| ha | hectares (10,000 $m^2$) | 2.5 | acres | |
| | | **MASS (weight)** | | |
| g | grams | 0.035 | ounces | oz |
| kg | kilograms | 2.2 | pounds | lb |
| t | tonnes (1000 kg) | 1.1 | short tons | |
| | | **VOLUME** | | |
| ml | milliliters | 0.03 | fluid ounces | fl oz |
| l | liters | 2.1 | pints | pt |
| l | liters | 1.06 | quarts | qt |
| l | liters | 0.26 | gallons | gal |
| $m^3$ | cubic meters | 35 | cubic feet | $ft^3$ |
| $m^3$ | cubic meters | 1.3 | cubic yards | $yd^3$ |
| | | **TEMPERATURE (exact)** | | |
| °C | Celsius temperature | 9/5 (then add 32) | Fahrenheit temperature | °F |



## TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

## TABLE OF CONTENTS
(Continued)

## TABLE OF CONTENTS
(Continued)

TABLE OF CONTENTS
(Continued)

## TABLE OF CONTENTS
(Concluded)

## LIST OF ILLUSTRATIONS

## LIST OF ILLUSTRATIONS
(Concluded)

# 1. INTRODUCTION

## 1.1 Background

The need for a Discrete Address Beacon System (DABS) was highlighted in recommendations by the Department of Transportation Air Traffic Control Advisory Committee and accepted by the Federal Aviation Administration (FAA) to provide improved surveillance and ground-air communications in support of air traffic control automation. Development was recommended for an improved radar beacon interrogator/transponder system, which provides integral digital data link communications, as an evolutionary replacement for the existing Air Traffic Control Radar Beacon System (ATCRBS). This development offered the potential for integration of a new collision avoidance system that would perform automatically, using the same basic surveillance and data link capabilities -- that companion system has become the Automatic Traffic Advisory and Resolution Service (ATARS).

A DABS Experimental Facility (DABSEF) was established at MIT's Lincoln Laboratory to support DABS concept validation and system definition. Testing at this facility resulted in the development of specifications for engineering developmental model DABS sensors and avionics.

Three DABS Engineering Model sensors were procured and installed in the vicinity of the National Aviation Facilities Experimental Center (NAFEC) for developmental, test and evaluation purposes. These DABS Engineering Models were also interfaced with the simulated En Route and Terminal Air Traffic Control (ATC) systems, at NAFEC, via connections to the En Route System Support Facility (ESSF) and the Terminal Automation Test Facility (TATF).

## 1.2 DABS Overview

DABS will provide improved surveillance data reliability and accuracy over the present-day secondary surveillance radar system and a high capacity, reliable, general purpose ground-air-ground data link capability. Improvements in surveillance data reliability will alleviate certain deficiencies in the quality of the data inherent in the present system. The general purpose, flexible, two-way data link communications capability will support an extensive variety of services necessary for advanced ATC system automation. Surveillance accuracy improvements in conjunction with the data link capability will support the ATARS collison avoidance service. The ATARS function, which will be collocated with DABS, will give pilots information about aircraft in close proximity, and in the event of a potential collision, will transmit collision avoidance advisories. The DABS sensors will contain the capability to monitor their own performance, allowing for operation at remote, unmanned sites. DABS will send sensor status data and, when necessary, fault diagnosis information to the facilities served. Finally, DABS will be fully compatible with ATCRBS. This will permit DABS to operate with the present ATC system and will also enable a gradual, evolutionary transition into an ATC environment which will benefit fully from the advanced DABS capabilities.

## 1.3 Scope

The DABS Engineering Models have undergone extensive testing at NAFEC leading to the Engineering Requirements (Reference 2) for a production system. Modifications to the simulated Terminal and En Route ATC facilities at NAFEC, to interface with DABS, have also been made for developmental, test and evaluation purposes. This document describes the DABS sensor and the collocated ATARS function relative to their interactions with the ATC facilities based on the production DABS specified in Reference 2. In addition, a general description is provided of the Terminal (ARTS IIIA) and En Route ATC facility modifications necessary for interface with DABS during the early deployment stages. The descriptions represent the current DABS design concepts. The ATC facility modifications for DABS reflect the results of the R&D software development activities at NAFEC, to date. The descriptions are based on the assumptions of an evolutionary implementation of DABS and the existence of a continuing, longer term development effort to further upgrade the ATC systems from their initial state as described herein.

Section 2 of this document discusses the characteristics and use of surveillance data; Section 3 discusses the exchange of messages between the ATC facility and an aircraft by means of the DABS air-ground data link and also describes some potential operational applications in the Terminal and En Route ATC facilities; Section 4 discusses the interaction between ATARS and the ATC facility; Section 5 discusses the information exchanges between DABS and the ATC facilities relative to status and control information; and Section 6 describes the initial integration of DABS with the Terminal and En Route ATC facilities.

This document is intended to complement other descriptive documents pertaining to DABS: Reference 1 provides the detailed formats of the surveillance and communications messages transmitted between DABS and an ATC facility; Reference 3 provides a functional description of the DABS sensor; and Reference 6 provides a functional description of ATARS.

# 2. SURVEILLANCE

## 2.1 General

DABS will provide an improved surveillance system over the present-day secondary surveillance radar system. Implementation of DABS will result in a reduction of synchronous garble, an improvement in ATCRBS reply degarbling, and a means of identifying false ATCRBS targets. The use of monopulse direction finding techniques on ATCRBS replies, in addition to improving accuracy, also allows the DABS sensor to operate at a significantly reduced ATCRBS interrogation rate. This will result in an immediate and significant reduction in the ATCRBS interference environment.

### DABS Compatibility with ATCRBS

DABS is compatible with ATCRBS permitting DABS sensors and existing ATCRBS sensors to service both DABS and present-day ATCRBS transponders. DABS transponders will respond to ATCRBS interrogations (from present-day ATCRBS sensors) with standard ATCRBS replies. ATCRBS transponders will respond to ATCRBS/DABS "All-Call" interrogations, from a DABS sensor, with standard ATCRBS replies. The "All-Call" interrogations are the equivalent of the standard interrogations from an ATCRBS sensor (except that an additional pulse is added) and will be transmitted at a lower interrogation rate.

### DABS Address

A fundamental feature of DABS is the DABS Address. Each DABS aircraft transponder will be permanently assigned a unique 24-bit DABS Address code. The Discrete Address will permit each DABS-equipped aircraft to be individually interrogated, only in the vicinity of its known azimuth, with a "roll call" DABS interrogation. Only a DABS transponder which has the particular address will reply to the "roll call" interrogation. This reply will be unambiguously identified with the proper aircraft.

### Sensor Roll Call

In order to be discretely interrogated a DABS-equipped aircraft must be on the sensor's roll call (i.e., a file containing the DABS Address and approximate position of each such DABS aircraft, within the defined coverage volume of the sensor). The ATCRBS/DABS All-Call interrogation will be used to acquire DABS targets which are not yet on the sensor's roll call. A DABS-equipped aircraft, not on the sensor's roll call, will respond to the All-Call interrogation with its unique DABS Address and will be then added to the roll call.

DABS Transponder Lockout

Once on a sensor's roll call the DABS-equipped aircraft may be locked-out from replying to ATCRBS/DABS All-Call* interrogations from any DABS sensor, thus eliminating unnecessary replies. Lockout is indicated to the DABS transponder by setting the appropriate lockout indicator in the discretely-addressed interrogation. All-Call lockout is under the positive control of the sensor and thus may be used only where desired. Lockout will automatically terminate if an aircraft does not receive a discretely-addressed interrogation indicating lockout within approximately 16 seconds. Once the lockout has expired, the aircraft may be acquired by a DABS sensor using the ATCRBS/DABS All-Call interrogation. It should be noted that a DABS transponder which is not locked-out for some reason and is still on the sensor's roll call, will reply to ATCRBS/DABS All-Call interrogations as well as discretely-addressed interrogations from the same sensor. In this case, only one surveillance report will be disseminated from a given sensor to the ATC facility - that report will be based on the reply to the discretely-addressed interrogation.

Multiple DABS Sensors

In regions of airspace covered by more than one DABS sensor, each DABS-equipped aircraft will be normally on the roll call of at least two sensors (and locked-out to any other DABS sensor providing coverage) to maintain the continuity of surveillance and data link services in the event of a link fade or sensor failure. ATC facilities, to the extent possible, and ATARS will use the multiple coverage to enable immediate backup for surveillance data.

*A DABS transponder which is locked out will only reply to a discretely-addressed interrogation, containing its DABS Address, from DABS sensors. It will still reply to standard ATCRBS interrogations from ATCRBS sensors.

If, initially, DABS aircraft is on the roll call of a single sensor only (and thereby, usually, locked out to All-Call interrogations from other sensors), it will be placed on the roll call of an adjacent DABS sensor, with overlapping coverage, using either of two procedures:

1. If the sensors are connected (netted) with sensor-to-sensor ground links, the sensor will coordinate the DABS aircraft's position and DABS Address with the adjacent sensor via a hand-off procedure, triggered on the basis of the aircraft's location relative to an adapted sensor map. The receiving sensor will use the data to place the DABS aircraft on its roll call and begin transmission of discretely-addressed interrogations. The DABS aircraft will thus be on the roll call of both sensors. This procedure will continue as the aircraft proceeds from sensor to sensor, provided the sensors are netted.

2. If the adjacent sensors are not connected (non-netted configuration), The DABS multi-site protocol (References 3 and 4) will permit a DABS transponder to reply to ATCRBS/DABS All-Call interrogations from all other DABS sensors which do not have the respective DABS aircraft on roll call. The adjacent sensor(s) will then acquire the DABS aircraft on roll call using ATCRBS/DABS All-Call interrogations.

Primary Status

Once two or more sensors have a DABS aircraft on their roll call, certain ambiguities in sensor operations may occur. To avoid this, only one of the sensors, at a time, will be designated "Primary"* for a particular DABS aircraft. Section 5.3 contains a discussion of Primary assignment and the special function of a Primary sensor (among the special functions assigned to the Primary sensor is the management of the lockout to ATCRBS/DABS All-Call interrogations, the readout of pilot-originated downlink messages and the uplinking of ATARS traffic advisories). The determination of which DABS sensor will be assigned Primary

* DABS "Primary" status should not be confused with "primary radar". In this document the term "primary radar" is not used further.

for a controlled DABS aircraft will be made by Air Traffic Control (ATC) facilities controlling the aircraft (see Section 5.3). For uncontrolled aircraft the assignment will be made by the DABS sensors on the basis of an adapted map.

Sensor Coverage

The volume of airspace in which a sensor will provide coverage will be assigned, in each sensor, by an adapted coverage map. This coverage map will be defined by a range-azimuth grid. An example is depicted in Figure 2-1. Among other pertinent information required for sensor operation, each cell in the grid will contain data indicating whether or not active surveillance is required. (Active surveillance includes maintaining DABS aircraft on roll call.) The DABS sensor will track targets within these adapted boundaries of required surveillance. In addition, the coverage map will define regions of airspace into which the sensor can expand its coverage of active required surveillance if, for example, the sensor detects (or is notified) that an adjacent sensor, with overlapping coverage, has failed (refer to Figure 2-2).

As mentioned earlier, normally, each sensor's coverage map will be adapted such that in airspace of overlapping coverage, an aircraft will be in the required surveillance regions of *at least two sensors*. Thus, for example, when overlapping DABS sensors are connected to an En Route ATC facility, the facility may expect to receive surveillance reports on a given aircraft from two or more DABS sensors.

Netted/Non-Netted Sensor Configurations

DABS sensors that share areas of overlapping coverage may be installed with or without sensor-to-sensor ground data links connecting them. Regardless of whether the sensors are netted or non-netted, the Network Management function in each sensor (see Reference 3 for a more detailed description) will control the operation of the DABS sensors to insure adequate surveillance and communications in areas of common coverage.

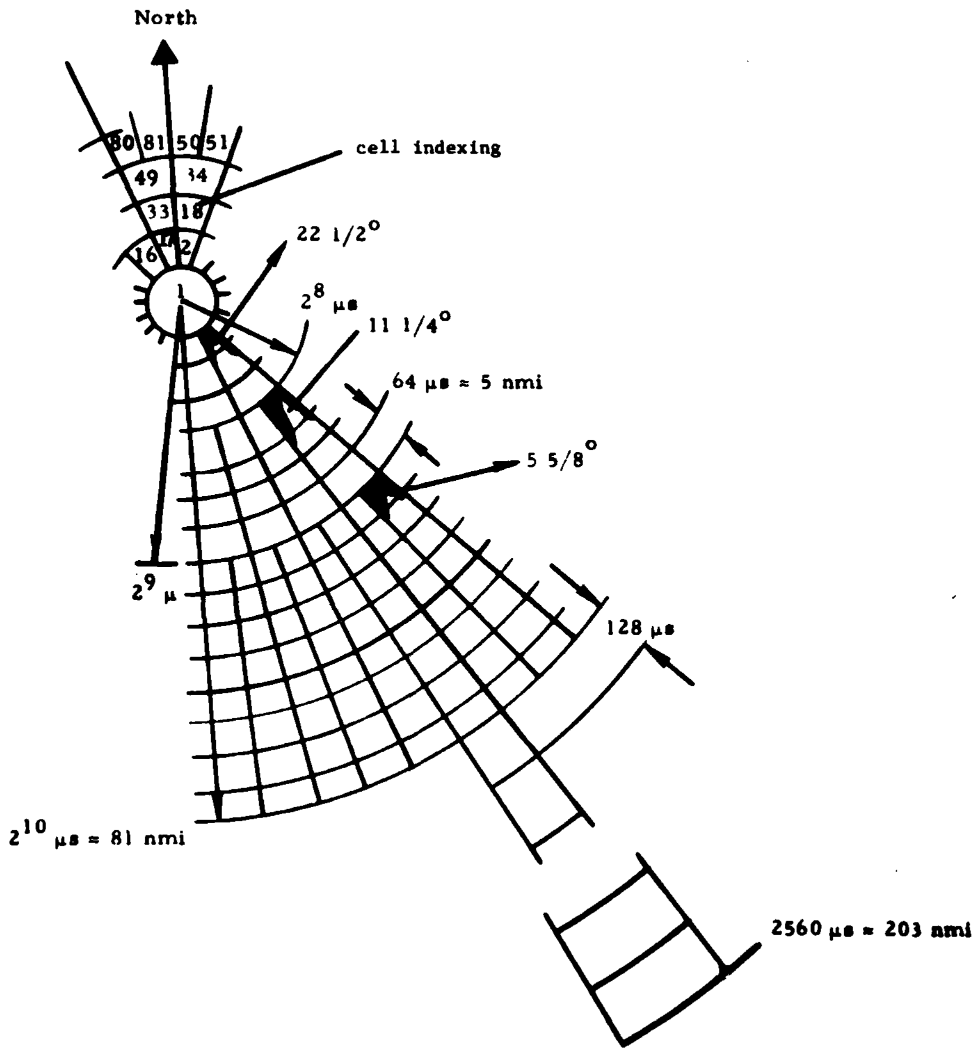



**FIGURE 2-1**
**EXAMPLE OF COVERAGE MAP GRID STRUCTURE**

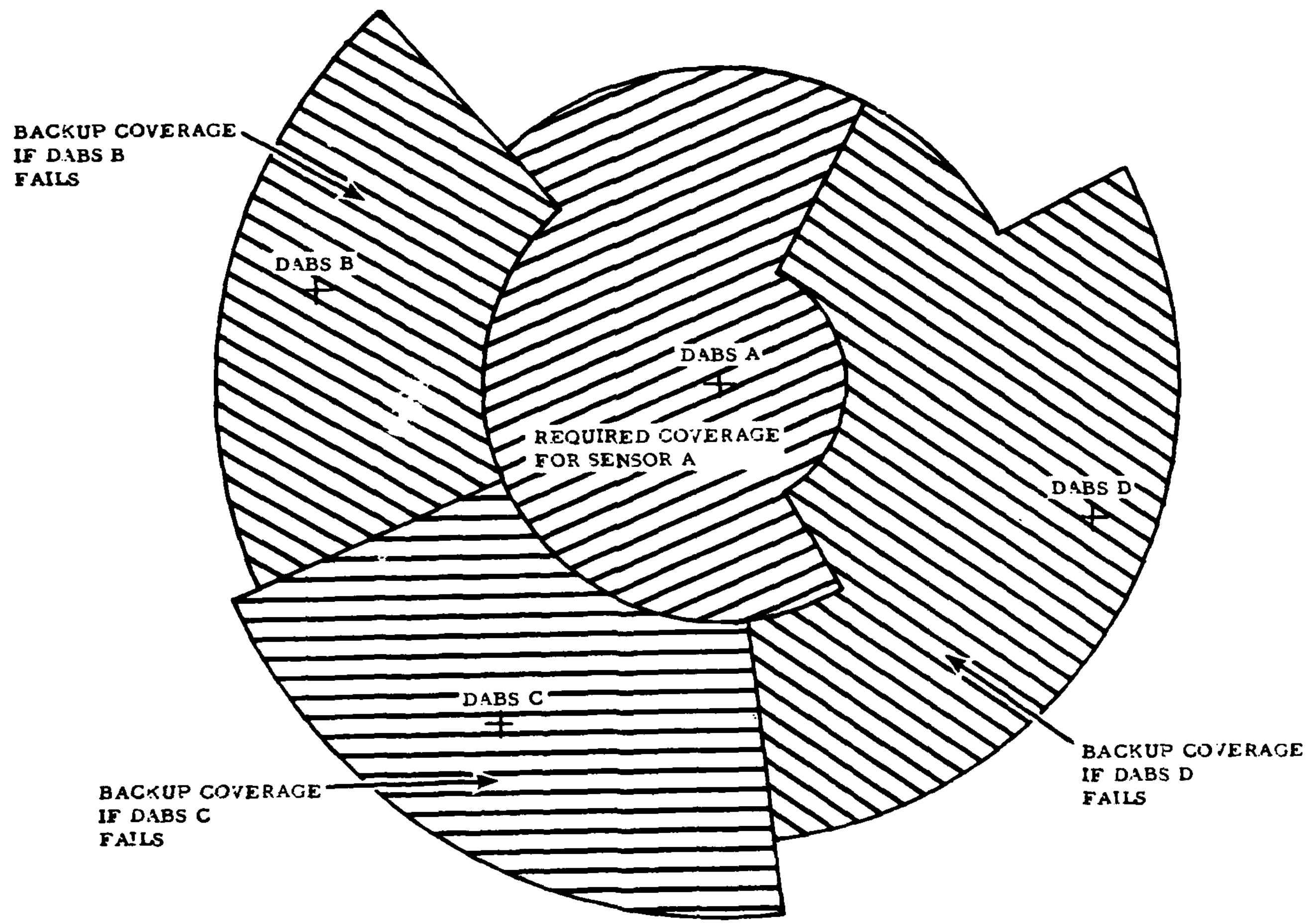



**FIGURE 2-2**
**EXAMPLE OF REQUIRED AND BACKUP DABS COVERAGE**

Sensor netting, however, improves the efficiency and reliability of DABS and will be the normal implementation mode where a considerable degree of sensor overlap occurs.*

The non-netted configuration may be the permanent implementation mode for some sensors. However, sensors that are netted will have the provision to operate in a non-netted mode as a backup in the event of a sensor-to-sensor link failure. The non-netted configuration is thus considered a subset of the netted configuration.

Among the capabilies provided by the netted configuration are:

1. Management of DABS transponder lockout (as described previously) to assure that at least two sensors have acquired the same target.

2. Requesting data from an adjacent sensor in order to assist in reacquiring a DABS target and maintaining ATCRBS and DABS tracks - thus providing surveillance continuity and for a DABS target, data link continuity, and providing an immediate source of backup surveillance data for ATARS.

3. Coordination of ATARS functions to assure that only one sensor has responsibility for generation and uplinking ATARS conflict resolution advisories to an aircraft.

4. Coordination of Primary assignment among sensors to assure that only one sensor is designated Primary for a particular uncontrolled DABS aircraft.

5. Transmission of sensor status information to adjacent sensors in order that surveillance and ATARS coverage reconfiguration can be effected in the event of sensor failure.

In a non-netted configuration some of these capabilities cannot be accomplished, or will be accomplished by alternate means: DABS transponder lockout will be managed by the

---

* The decision to connect two sensors will be based upon the operational and environment characteristics in the region where the sensors are located and the needs of ATARS for coordination between sensors (see Section 4). It can be expected that sensors installed in areas of relatively dense traffic will be netted with ground data links.

multi-site protocol mentioned earlier; adjacent sensor data cannot be obtained; ATARS Resolution Advisories (but not Traffic Advisories) coordination will be effected by special coordination messages transmitted on the airlink; the "Primary" assignment among sensors, will rely solely on the coverage map adaptation permitting small regions of multiple-primary assignments (multi-site protocols - see Reference 4 - will be used to effect coordination) in the seams between sensors; and the adjacent sensor failure (or recovery) information will be received only from the connected ATC facility (or other remote maintenance source).

Surveillance Reports

The DABS surveillance reports will be transmitted over one-way data channels dedicated for that purpose. The contents of a surveillance report and its format depend on the source of the surveillance data. A report may be derived from (1) replies from a DABS transponder, (2) replies from an ATCRBS transponder or (3) digitized radar data received from a collocated search radar. In addition, non-target reports (e.g., weather) may be received from a collocated radar digitizer.

Beacon reports received from a DABS sensor, whether derived from DABS or ATCRBS transponders, will provide more accurate position (range and azimuth) information than that which is provided with the present-day ATCRBS system. Additionally, the surveillance processing capabilities of the DABS sensor provide new items of information for use in the aircraft identificaion and track/report correlation functions performed by an ATC facility.

All report formats whether new or modified are based on current Common Digitizer (CD) formats to maintain compatibility with existing En Route ATC automation.

Surveillance-Related Communications Messages

A two-way communications link will also connect a DABS sensor to an ATC facility primarily for the transfer of air-ground data link messages. A set of messages referred to as surveillance-related communications messages will be used to maintain surveillance compatibility with the present ATCRBS system during the period of time when reports for a particular DABS-equipped aircraft are received both from DABS and present-day ATCRBS sensors. Additionally, information will be available via these messages to enhance flight identification capabilities. More detail on these surveillance-related messages is provided in Section 2.8.

The surveillance reports transmitted from the sensor on the one-way surveillance link and the surveillance-related communications messages transmitted between the sensor and the ATC facility on the two-way ground communications link comprise the DABS surveillance data.

## 2.2 Sensor Types

The basic types of DABS sensors considered for implementation are the Terminal DABS and the En Route DABS sensors. Although alike in hardware and software the DABS sites will differ in antenna configurations, scan periods and radar digitizer interfaces.

The Terminal DABS sensors will have a single face antenna (beacon and search antennas aligned in azimuth) rotating at the rate of 12-15 rpm (4-5 second scan period). The range of these sensors will be nominally 60 nmi. Although it is possible under certain situations to extend the beacon range beyond 60 nmi, the useful range for search will remain nominally 60 nmi. A Terminal DABS sensor will be interfaced, via a digital link, with the radar digitizer associated with its collocated search radar. Depending upon implementation schedules, the radar digitizer may be either a Moving Target Detector (MTD) or a modified Sensor Receiver and Processor (SRAP), referred to herein as the Radar Data Acquisition System (RDAS).

The En Route DABS sensor will use a back-to-back antenna. The front face will consist of a beacon and search antenna; the back face, which will be aligned 180° from the front face, will consist of a beacon antenna only. The back-to-back antenna will rotate at a rate of 6 rpm. This will result in a scan period of 5 seconds for beacon data and 10 seconds for search data. The higher data rate for beacon data is required for the proper performance of ATARS in the En Route sensor. The range of an En Route DABS sensor, with its slower antenna rotational rate, extends to 200 nmi. An En Route DABS sensor will be interfaced with the CD (or CD-2)* associated with its collocated search antenna.

* For the purpose of this document, when reference is made to the CD it also implies CD-2, except in the case of a joint-use site where only the CD-2 will be used.

A Terminal DABS sensor will be connected to a Terminal ATC facility and can also be linked to an En Route ATC facility, if desired. En Route DABS sensors will, of course, be connected to En Route ATC facilities. Figure 2-3 depicts the interfaces of the DABS sensors and respective radar digitizers with the ATC facilities.

For joint-use sites an En Route DABS sensor will be used with back-to-back beacon antenna faces, established to provide beacon, search radar and weather data to both the FAA and the Air Defense Command (ADCOM). In addition, this type of sensor will be capable of transmitting Mode 4 interrogations from its front face while DABS interrogations are being transmitted from the back-face. ADCOM will notify the DABS sensor (via the CD-2 and the Mode 4 Controller - AN/GPA-124) that the front face of the en route antenna is required for Mode 4 transmissions within a designated azimuth wedge. In response the DABS sensor will dedicate the front-face beacon antenna to Mode 4 operation only within the designated azimuths. Beacon and radar reports received from the Mode 4 azimuth sectors will be appropriately flagged, by the sensor, and transmitted to the CD-2 for dissemination to ADCOM. The DABS sensor will have the optional provision to temporarily override the Mode 4 request if a high priority ATARS message is pending to an aircraft in the requested Mode 4 region. Also, if an ATCRBS report is detected with a Mode 2 code, the Mode 2 code, in addition to the Mode 3/A and Mode C codes, will be appropriately stored in an ATCRBS surveillance message which will be disseminated to ADCOM (via the CD-2). The same report will be disseminated to the ATC Facility with the ATCRBS Surveillance File Number (see Section 2.3) in place of the Mode 2 code. Figure 2-4 illustrates a joint-use En Route DABS sensor.

## 2.3 Sensor Tracking

The DABS sensor will track all DABS and ATCRBS beacon targets. A Terminal DABS sensor which will be connected to an MTD or RDAS will also track radar-only targets (an En Route DABS sensor connected to a CD will not track radar-only targets). Tracking of DABS beacon targets is necessary in order for the sensor to predict at what azimuth to begin selectively interrogating a particular DABS target. Tracking of ATCRBS and radar targets, however, will provide certain benefits which will result in improved surveillance reporting and new items of information in addition to that which is available from the present-day ATCRBS sensors.

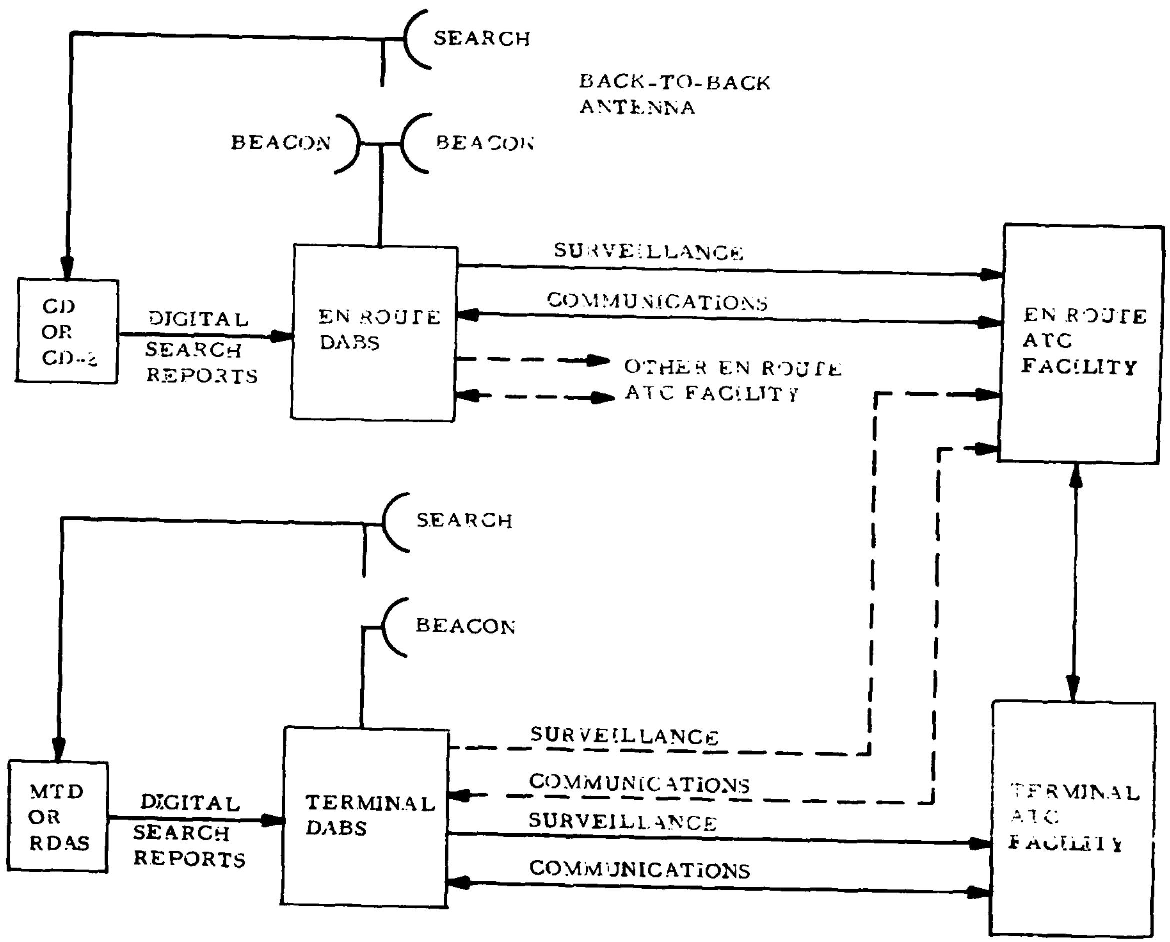



**FIGURE 2-3**
**EN ROUTE AND TERMINAL DABS SENSORS CONNECTED TO ATC FACILITIES**

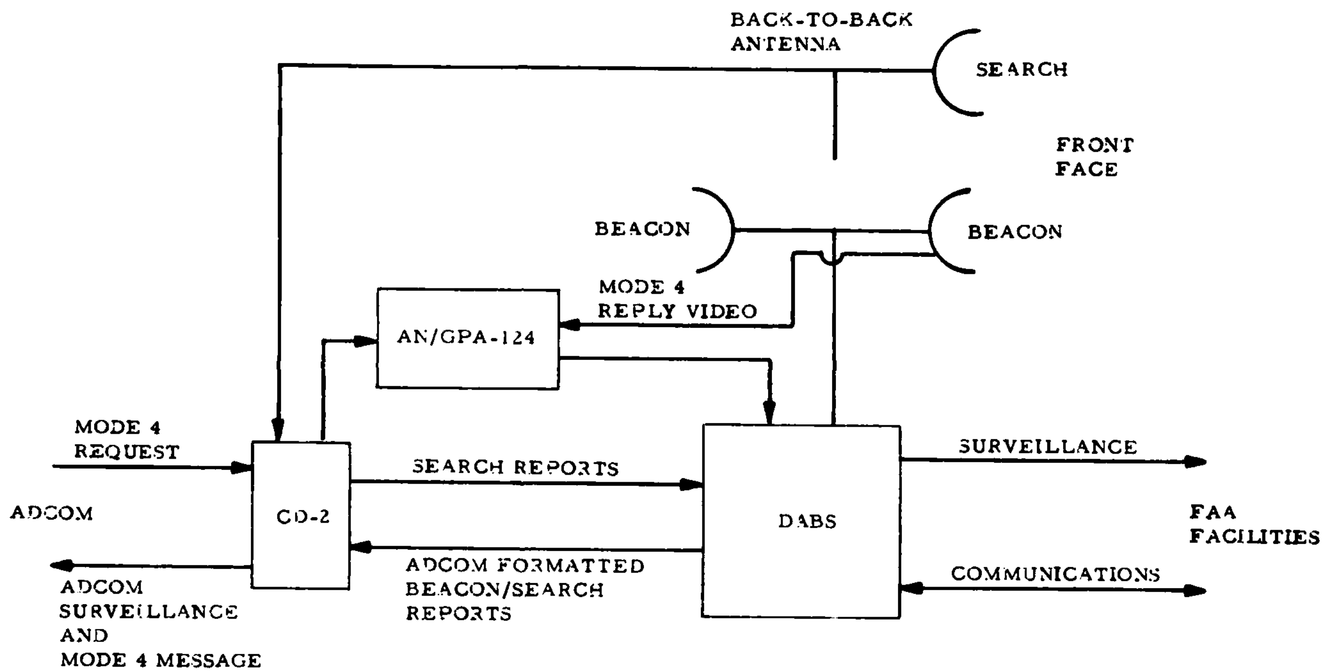



**FIGURE 2-4**
**JOINT-USE EN ROUTE DABS SENSOR**

An important item of information which will be provided in each tracked ATCRBS beacon and radar report will be the DABS sensor's uniquely assigned track number, designated the Surveillance File Number (SFN). An SFN will not be included in a DABS beacon report because of the unique and unambiguous identity features (24 bit DABS Address) resulting from the surveillance processing of DABS beacon replies. However, in the case of ATCRBS beacon and radar-only tracking, the DABS surveillance processing function will make decisions regarding the selection of the "best" target report to correlate with a particular sensor track. In some cases, for example, for certain proximate aircraft, the resolving of multiple track, multiple report correlation ambiguities will be necessary to select the best track/report pair. The track/report correlation function performed by the DABS sensor for ATCRBS and radar data parallels similar track/report correlation functions currently performed in ATC facility software. Since track/report correlation will be performed by the DABS sensor, the product of this function will be useful to aid the correlation function in ATC facilities and the local ATARS.

## 2.4 Noncorrelating and Correlating Users

The users of the DABS surveillance data will be categorized into two types - noncorrelating and correlating. Each ATC facility, or user, connected to a particular DABS sensor may be adapted, separately, as a noncorrelating or correlating user.

### 2.4.1 Noncorrelating User

A noncorrelating user will rely on the sensor to peform the track/report correlation function and therefore will do no (or very limited) correlation of its own. The ARTS IIIA facility which will interface with DABS (see Section 6.1) and ATARS (see Section 4.) are examples of noncorrelating users. The SFN in the surveillance report will be the chief means of conveying the results of the correlation for non-DABS tracks. If an ATCRBS beacon or search report cannot be correlated, the SFN will not be contained in the transmitted surveillance report. This uncorrelated report will not be utilized by the noncorrelated user (except, possibly, for display purposes in an ATC facility). Since the SFN will be critical to the noncorrelating user, the sensor may under some circumstances delay slightly the dissemination of certain ATCRBS or search reports until a "best" track/report correlation can be determined and the SFN included. For the ARTS IIIA interface with DABS, this slight delay will not cause the overall time, from the time the particular aircraft is in the antenna beam to the time it will be displayed to the controller, to exceed current ARTS IIIA response times (since the correlation function will be performed by the DABS sensor it will not have to be repeated by the noncorrelating user).

There are some special processing rules which affect the dissemination of MTD and RDAS originated radar-only reports. These rules are described in Section 2.7.5.2.4.

### 2.4.2 Correlating User

A correlating ATC facility will perform all track/report correlation functions, as is presently done in the operational En Route and ARTS IIIA facilities, independent from the sensor. While a correlating ATC facility may use the SFN for some purposes, it will not solely rely on it for correlation. The sensor will not delay dissemination for the particular reasons cited for the noncorrelating user. Rather, each report will be disseminated within the maximum delay time specified for the sensor (Section 2.5), whether or not it has correlated with a sensor track. The En Route ATC System which will interface with DABS (see Section 6.2) will be a correlating user.

### 2.4.3 DABS Beacon Reports

It should be noted that the distinction between correlating and noncorrelating user will not apply to DABS beacon reports, which contain the DABS Address.

## 2.5 Reporting Delay

The maximum allowable time that surveillance reports may be delayed by the sensor for transmission to an ATC facility depends on whether the receiving facility is a correlating or noncorrelating user (see Section 2.4). In the case of a correlating user, surveillance reports will be ready for transmission not later than 3/32 of an antenna scan period (3/16 of the effective scan period* for any back-to-back antenna) after the target report has been detected. For a 4-second rotator with a single face antenna, this maximum delay will be 3/8 second; for a back-to-back antenna mounted on a 10-second rotator, the maximum delay will be 15/16

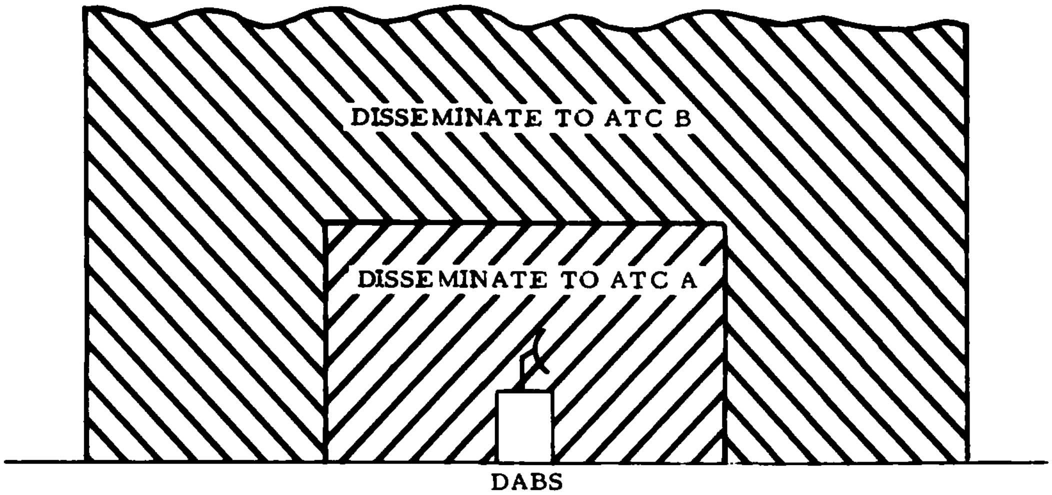
* The effective scan period for a back-to-back antenna is considered, herein, as one half the period of the antenna shaft rotation. For example, a back-to-back beacon antenna mounted on a shaft rotating with a 10 second period will have an effective beacon scan period of 5 seconds.

second. In the case of a noncorrelating user, the maximum allowable delay for surveillance data within 10 miles of the sensor may be greater to allow for resolution of certain multiple report/multiple track correlation possibilities. For example, this may occur for some reports in regions of dense, nondiscrete Mode 3/A beacon traffic. Surveillance reports which have not correlated with a track within the maximum allowable time consistent with each user type (correlating or noncorrelating) will be transmitted to the respective user as "uncorrelated" (i.e., the report will not contain an SFN). The delay time will be reported in the Time in Storage field of the surveillance message (quantized to 1/8 second as in the existing CD message).

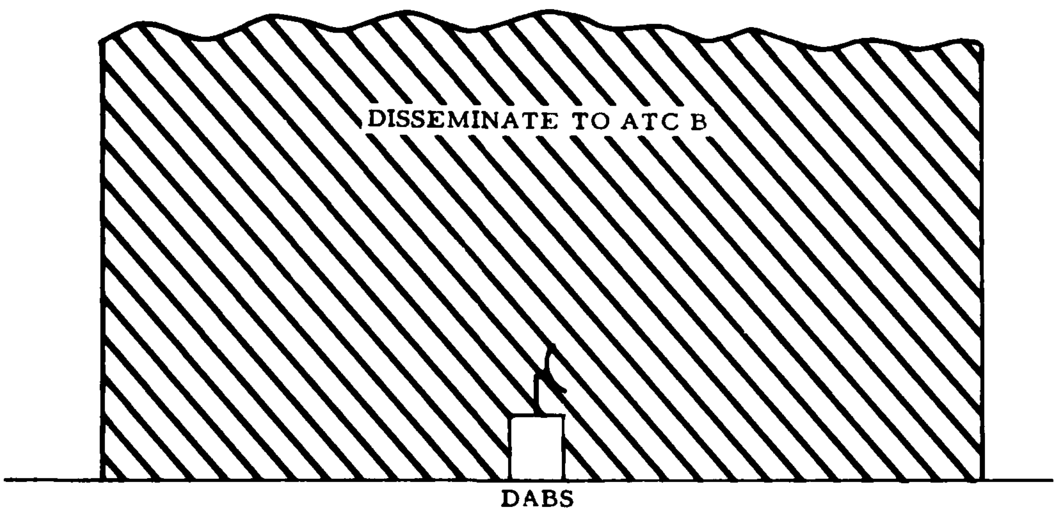
## 2.6 Data Dissemination

A DABS sensor will not necessarily transmit all of its aircraft reports to each ATC facility linked to it. Instead, it will use a data dissemination map to transmit reports on only those aircraft located within the area of interest to each ATC facility connected, thereby reducing the volume of unnecessary reports for the facility to process. Thus, each data dissemination map, corresponding to the different surveillance needs of each ATC facility, may be different for each ATC facility. The dissemination decision will be based on a simple criterion of range, azimuth and altitude. Of course, the report must also have been derived from within the sensor's region of required surveillance. This dissemination map will be fixed for each ATC facility but may change as part of backup operations if one (or more) of the connected ATC facilities fails. For example, when a sensor is notified of an ATC facility failure, (e.g., via an ATC Failure/Recovery Message received on the Communications link, see Section 5.2.4) the dissemination map will be reconfigured to a new dissemination map based on the remaining connected ATC facilities (refer to Figure 2-5).

An additional dissemination feature will be available for a sensor configured with a back-to-back antenna. The option, set in adaptation, will be provided to disseminate surveillance reports derived from only the front face of the back-to-back antenna. This permits surveillance report dissemination at a 10 (or 12) second scan rate until such time as the En Route ATC facility and telephone line capacity is available to handle the 5 (or 6) second surveillance update rate.




SEPARATE DISSEMINATION TO ATC A AND ATC B




DISSEMINATION TO ATC B, FOR BACKUP, AFTER ATC A FAILS

**FIGURE 2-5**
**EXAMPLE OF DISSEMINATION MAP CHANGE AFTER ATC FACILITY FAILURE**

## 2.7 Surveillance Reports

### 2.7.1 Surveillance Report Types

Surveillance reports transmitted on the surveillance link will utilize formats and coding which are modified versions of those presently used for CD messages. The surveillance report types are:

1. Beacon Reports: ATCRBS and DABS

2. Radar Reports, based on radar targets, received from a collocated Radar Digitizer (CD, MTD or RDAS): CD Search, MTD Search and RDAS Search Reports, respectively.

3. Radar Substitution Reports: When a radar report correlates with a beacon track and beacon replies for the track from the current scan are missing, a Radar Substitution Report will be transmitted. This report will contain the identity of the beacon track in addition to the search data. Depending on whether the radar report correlated with a DABS track or an ATCRBS track, the report types are DABS Radar Substitution and ATCRBS Radar Substitution, respectively.

4. Non-target Reports

    a. Derived from the CD: Strobe, Map (including weather), CD Status, and Fixed Search RTQC Target

    b. Derived from either the MTD or RDAS: Weather message in the format of the CD Weather message.

The beacon reports, the Radar Substitution reports, the MTD Search reports and the RDAS Search reports will have a long (91-bit) format, whereas all the others will have a short (52-bit) format. All of the non-target reports input to DABS will be transmitted to the ATC facility without being altered by processing in the DABS sensor. The processing and output of search target reports by the DABS sensor is described in Section 2.7.5.

The following sections describe the target reports disseminated by DABS. Also, Reference 1 presents complete formats and detailed field definitions for the various types of surveillance messages.

### 2.7.2 Common Surveillance Data Elements in Beacon Reports

Beacon reports, whether based on DABS or ATCRBS replies, will contain basic surveillance data in common. Reflecting the improved accuracy of the DABS sensor, 15 bits of slant range information (to a precision of 0.0078 nmi or approximately 50 feet) and 13 bits of azimuth (to 0.044 degree) will be provided. Range and azimuth data are raw measurements which will not be smoothed by the sensor tracker. Altitude data will be provided as in the present day ATCRBS: converted from Mode C data, quantized to 100 feet and not pressure corrected. Certain target identification data will always be present: the 24-bit DABS Address in a DABS report and the 12-bit Mode 3/A Code in an ATCRBS report. Storage delay will be reported in the message Time-in-Storage field (quantized to 1/8 second as in the present CD surveillance message). Other information included in the various types of surveillance reports is provided in the subsection below.

### 2.7.3 Beacon Reports from ATCRBS-Equipped Aircraft

In addition to data pertaining to range, azimuth, altitude (when Mode C replies are available) and storage time, an ATCRBS aircraft report from a DABS sensor will include several additional data fields that are the same as those in a present-day beacon report from the CD and some new ones. The data fields contained in the present-day reports include indicator bits (Test, Mode 3/A, Mode C, SPI (Ident), Radar Reinforcement, Emergency-Code 7700, Radio Failure-Code 7600, and FAA) and the 12-bit Mode 3/A code (when available as indicated by the Mode 3/A bit). The Test bit will be set when the report correlated with a stationary test track (i.e., based on the adapted location of the Calibration Performance Monitoring Equipment - CPME). As with the present beacon formats, the presence of Radar Reinforcement will indicate that a radar report has correlated with a beacon report and that the radar report has been suppressed. The new ATCRBS report data fields will include the ATCRBS Surveillance File Number, Confidence, Code-in-Transition, False Target, Radar and Data Relay. Each of these fields are discussed in the following paragraphs.

The ATCRBS Surveillance File Number (SFN), as mentioned earlier is the sensor-assigned number used within the DABS sensor software to identify a particular aircraft track. The presence of a nonzero value in this field will indicate that the ATCRBS replies being reported have been successfully correlated with an existing track. The presence of all zeros will mean the report has not correlated with a track. The number will provide a reference track number for a given aircraft, which will be unique for the sensor - therefore, two tracks will not have the same number at a given time within a single sensor. The assignment of these numbers will not be coordinated among sensors. Thus, the same aircraft reported by two sensors will have independently chosen SFNs. Twelve (12) bits are available, so that a duplicate on simultaneously active tracks will not occur. A sensor track which does not correlate with any report for an adaptable number of scans will be dropped and its SFN will be placed at the end of the list of SFNs available for reassignment.

Confidence is a 1-bit indicator which will denote whether or not the target-to-track correlation has been performed with high or low confidence; specifically, whether or not correlation was successful using the smallest range-azimuth correlation box. This indicator will have significance only when a correlation is reported, as shown by a nonzero SFN. The indicator will be useful in refining the track/report correlation processing in the ATC facility software.

Code-in-Transition is another 1-bit tag, which, when set, will indicate that the report is based on Mode 3/A replies, of which the code value did not match that of the track's stored Mode 3/A code although all other requirements for correlation were met (the report and the track are therefore considered to be correlated). The Mode 3/A code of the presently corelated target report will be transmitted. If the same (new) Mode 3/A code correlates for three successive scans, the code of the stored track will be changed to this new code and the Code-in-Transition indicator reset to zero. The Code-in-Transition indicator can provide a signal that the pilot is changing the transponder's Mode 3/A code.

False Target is a 1-bit tag which will indicate when a report has been identified as being caused by a reflection from a building or other terrain feature. A map of known reflectors will be maintained in sensor storage for this purpose. The "false target" decision will be based upon an examination of the reflection path geometries resulting from a true target and the known position of a reflector. This information will be useful in eliminating reports, or giving low priority to reports for the track/report correlation function in ATC software.

A format control bit designated "Radar", will be provided to denote whether the message is an ATCRBS beacon report or a message containing search data (including Radar Substitution). Section 2.7.5 describes the message when "Radar" is indicated.

Data Relay is a one-bit indicator which, when set, will indicate that the surveillance report has originated with a sensor not connected to this ATC facility (i.e., the remote sensor) and should be used with consideration of some of the restrictions noted below. This surveillance data may be relayed under certain conditions when a sensor-to-sensor data link connects the originating (remote) sensor to the relaying sensor (the local sensor connected to the ATC facility receiving the reports is the relaying sensor) and the Relay Mode option* is selected, under parameter control, by the sensor (see Reference 2). The relayed ATCRBS surveillance report received by the ATC facility will be similar to a report originating with the relaying sensor in its principal data fields; range and azimuth however will be converted to local (relaying) sensor coordinates and the position estimated for the time of measurement in the local sensor; Mode 3/A code and Mode C altitude will not be affected; SFN will be given for the local sensor. Other data fields will be unaffected, except that Radar Substitution, Confidence, Code-in-Transition and False Target will not be used. It should be noted that neither ATCRBS report data without Mode C nor Search data will ever be relayed. There will be no indication in the relayed surveillance report identifying the originating sensor.

### 2.7.4 Beacon Reports from DABS-Equipped Aircraft

As mentioned in Section 2.7.2, DABS reports include range, azimuth, storage time and altitude data as included in ATCRBS

---

* Relaying of data under this option should not be confused with the use of surveillance data from an adjacent sensor for ATARS purposes; that is a different function (see Reference 6).

reports. Both altitude and the DABS Address will be present in each DABS report whenever the aircraft is on roll call, the normal surveillance mode. During acquisition, however, replies from a DABS transponder may consist of only All-Call replies, which do not provide altitude (and therefore the Mode C bit will not be set). Under normal conditions this situation should not last for more than one or two scans. The presence of altitude will be indicated by a 1-bit "Mode C" tag, as in ATCRBS reports. It should be noted, however, that the setting of the Mode C bit does not always insure that a valid altitude is present. In the case where the altitude encoder is turned off (failed), an all zero (incorrect) altitude will result but the Mode C bit will be set.

DABS reports also include SPI, Codes 7700, 7600, Radar Reinforcement, Radar and Data Relay fields and are the same as those designated for ATCRBS. The new types of information provided in a DABS report are the DABS Address, P/S (Primary/Secondary) Status and Alert. These are discussed in the following paragraphs.

DABS Address is the 24-bit code that will uniquely identify each aircraft equipped with a DABS transponder. Since this DABS Address will provide a very high confidence for correlation of replies to tracks, no other identification data will be needed or included (such as the Mode 3/A code or SFN). Provision will be made for handling the extremely low probability error condition of two targets having the same DABS Address; this is discussed in Section 2.8.3.

P/S (Primary/Secondary) Status (see Section 5.3) will be designated in a one-bit indicator. The indicator will be used to assure that a data link connectivity is being maintained between the ATC facility and the respective DABS-equipped aircraft the facility is controlling.

Alert is a 1-bit indicator signifying that a pilot has changed the ATCRBS Mode 3/A code of the transponder (see Section 3.3.4.4). (When codes 7600 or 7700 exist, the Alert bit will be set redundantly with the Code 7600 or Code 7700 indicator). The corresponding ATCRBS code received by the sensor from the transponder will be transmitted to the ATC facility on the ground communications link in an ATCRBS ID Code Message (see Section 2.8). When a DABS beacon report is received by the ATC facility with the Alert bit set, it will be a general indication that an ATCRBS ID Code Message will be received on the ground communications link providing the new (changed) setting of the ATCRBS Mode 3/A code for the respective DABS-equipped aircraft.

For a DABS beacon report with the Data Relay bit set, the various data fields are to be interpreted as for an ATCRBS data relay report; the following fields which will be unique to DABS, however, will not be used: P/S Status and Alert .

2.7.5 Radar Reports

Radar (Search) reports from a DABS sensor may originate from one of the following types of collocated radar digitizer: CD, MTD or RDAS. Different kinds of surveillance messages derived from radar data will be transmitted to the ATC facility depending upon (1) the originating radar digitizer, (2) whether radar-only tracking will be performed for the data from the particular digitizer and (3) the extent to which the radar reports correlate with tracks maintained in the sensor. The following general rules are summarized:

1. When the sensor correlates the Radar report with either a DABS or an ATCRBS beacon report, the beacon report will be tagged as "Radar Reinforced" and the radar measurement will not be separately reported (only the range and azimuth measurement of the beacon report will be used).

2. When the Radar report unambiguously correlates with a beacon track and the beacon replies from the current scan are missing, the radar data will be reported in a "Radar Substitution" report. In a Radar Substitution report the radar data will be reported using a modified 91-bit ATCRBS or DABS beacon format (depending upon the particular track type) rather than the "Search" report format so that its correlation with the respective sensor track can be indicated. The range and azimuth measurement of the radar report will be transmitted.

3. When a Radar report correlates with a radar-only track (in the case of MTD or RDAS originated reports) it will send a "Radar-only" report including the track's unique SFN. In this case the correlated Radar-only report will be sent in a modified 91-bit beacon format.

4. When a Radar report does not correlate with either a beacon or radar-only track or when the Radar report originates from a radar digitizer type for which no radar-only tracking will be done (e.g., CD), it will be sent as a Radar-only report without a track number. This uncorrelated Radar-only report will either be sent in a 52-bit CD Search format or a 91-bit format depending upon the originating radar digitizer.

Surveillance messages transmitted in the 91-bit format which are based on radar reports will be distinguished from beacon reports by examination of a 1-bit Radar indicator. If the Radar indicator is set, another field in the message is examined to determine whether the message is based on radar data originating from the MTD or RDAS and whether the message is Radar Substitution or Radar-only.

#### 2.7.5.1 Collimation Correction

Each radar report will be altered, if necessary, by the addition of a collimation correction to the value of search azimuth and/or range received from the radar digitizer. The collimation correction is intended to eliminate bias errors between the radar and the beacon antennas. Collimation correction values will be computed and applied dynamically in a manner analogous to the correction presently performed in the En Route ATC System. This capability relieves the ATC facilities from performing this function.

#### 2.7.5.2 Processing and Output of Radar Data

The particular differences of processing and output of radar data by DABS, depending upon the type of collocated radar digitizer, are summarized below.

#### 2.7.5.2.1 Common Digitizer (CD)

A DABS sensor interfaced with a CD will not track radar-only targets. Therefore, any radar reports which do not correlate with beacon tracks will be sent in a format identical to the 52-bit CD Search Message. However, the Time-in-Storage of the radar report received from the CD is adjusted, prior to transmission to the ATC facility to reflect the additional time elapsed while the report is in the DABS sensor. Except for the collimation correction and the addition of the DABS sensor time-in-storage, the message is transmitted as received from the CD, unaltered.

A Radar Substitution report, however, will be sent in the 91-bit beacon format, DABS or ATCRBS. The appropriate fields in the message will designate it uniquely as a Radar Substitution report based on a radar report from the CD. The message will contain the DABS Address or the Mode 3/A code and SFN of the beacon track with which it correlated, depending upon whether correlation was with a DABS or ATCRBS track, respectively. When correlation is with an ATCRBS track, the Mode 3/A code of the last ATCRBS beacon report to correlate with the track will be sent along with the SFN. Time-in-Storage will be adjusted as noted in the previous paragraph. Additionally, the Run Length of the original radar report will be retained and sent in the Radar Substitution report, replacing part of the Mode C field, which, of course, cannot be used for radar data. Other fields of the 91-bit format pertaining to beacon data will not be used. It should be noted that if the sensor track fails to correlate further with beacon data, Radar Substitution reports will be transmitted only up to a maximum number of (site-adaptable) scans before the respective track is dropped. Subsequent reports will be sent in the 52-bit search report format.

2.7.5.2.2 Moving Target Detector( MTD)

In addition to tracking beacon targets, a Terminal DABS sensor will track radar-only targets when the radar reports originate from an MTD. The resulting MTD Radar-only Messages will be sent in a 91-bit format and contain some data elements different than what is included in the 52-bit CD search message. Fields in common will be Range and Azimuth (except that the MTD message contains a 15 bit range with a least significant bit of 0.0078 nmi and a 13-bit azimuth with a least significant bit of 0.044 degrees) and Time-in-Storage. The MTD message, however, will not contain a Run Length field. The new data elements in the MTD Radar-only message will be: SFN, Doppler #1, Doppler #2, Quality, MTD Confidence, False Target Flag and Ground Traffic Indicator.

The SFN for a radar-only track will be identical to that of the ATCRBS message. All sensor tracks, however, whether beacon or MTD Radar-only, will be contained in one file resulting in a single set of nonduplicate SFN's for a given sensor. An MTD Radar-only message which has not correlated with any track will have an all-zero SFN.

The Doppler #1 and Doppler #2 fields will express the interpolated values of the doppler velocities measured at the low and the high PRF of the radar, respectively.

Quality is a 2-bit field which will denote a figure of merit for the reported azimuth value.

MTD Confidence is a 4-bit field which will provide an estimate, by the MTD, that the measurement represents a real aircraft rather than a false alarm. Each bit will give a confidence estimate (1=high, 0=low) in a different category.

False Target is a one-bit flag which will indicate that the report has been generated from search returns that are close to the sensor and have velocities less than a site-adaptable parameter.

Ground Traffic is a one-bit flag which will denote that the report has been generated in regions of known ground traffic (e.g., cars) adapted in the MTD.

The Quality, Confidence, False Target and Ground Traffic fields will be useful to provide a controller with additional display filtering options for radar-only reports.

Radar Substitution reports originating with radar data from the MTD will be uniquely identified as such and will be otherwise identical to Radar Substitution reports generated on the basis of CD radar reports, with the following exceptions: The Quality field will be included (as described previously) and there will be no Run Length field. In addition, a beacon track from which only Radar Substitution reports have been generated for a site-adaptable number of scans will be dropped and replaced with a radar-only track.

2.7.5.2.3 Radar Data Acquisition System (RDAS)

A Terminal DABS sensor will also track radar-only targets when the radar reports originate from an RDAS. The resulting RDAS Radar-only Messages sent from the DABS sensor to the ATC facility will be sent in a 91-bit format and will be identical to the MTD radar-only format with the following exceptions: Quality will be reported in a 4-bit field, unaltered as received from the RDAS (RDAS Quality will be derived from the radar run length); and the RDAS report will not contain the Doppler #1, Doppler #2, Confidence and Ground Traffic fields.

## 2.7.5.2.4 Special Dissemination Rules for MTD and RDAS Radar-Only Reports

Special rules will apply to the dissemination of Radar-only reports from the MTD (or RDAS) to noncorrelating ATC facilities. The purpose of these rules is to minimize sending radar-only reports which do not represent real aircraft. Restrictions on the dissemination of MTD (or RDAS) radar-only data to noncorrelating ATC facilities will be applied in accordance with one of the following options, determined by site adaptation:

1. Uncorrelated reports will not be disseminated,

2. Uncorrelated reports will not be disseminated unless Quality and Confidence values meet site adaptable thresholds,

3. The second report of each pair used by the sensor to initiate a new radar-only track will be disseminated provided its Quality and Confidence values meet site-adaptable thresholds. Subsequent reports which correlate with the track will also be disseminated on the basis of these thresholds until a site-adaptable number of correlations have occured.

The definition of uncorrelated radar reports is also modified slightly for noncorrelating users, affecting the value of the SFN fields. An MTD (or RDAS) radar report that correlates with an existing radar-only track will be disseminated as correlating data (i.e., the report will contain an SFN) only after the track has been declared "mature" by the sensor. (Maturity is defined as the occurrence of correlation for a site-adaptable number of scans). Prior to maturity, within the constraints of the aforementioned options, the sensor will send such a correlated MTD (or RDAS) radar report to a noncorrelating user with an all-zero value in its SFN fields.

In addition, dissemination of uncorrelated MTD radar reports will be restricted by a special site-adaptable coverage map.

The ATC facility will have the capability to display to the Controller, when desired, uncorrelated radar-only reports. The option to delay the insertion of an SFN into the radar-only report will prevent the noncorrelating ATC facility from starting a track until sufficient confidence has been gained that the track represents a real aircraft. This, in turn, will reduce the false track load in the ATC facility without compromising the ability to display the targets (as uncorrelated) to the controller. Further, in this regard, the DABS sensor will only be permitted to process an adaptable, maximum number of radar-only tracks. If the maximum radar track capacity is reached, the additional radar-only reports will be transmitted to the ATC facility as uncorrelated.

#### 2.7.5.2.5 MTD and RDAS Interface Without Radar-Only Tracking

When interfaced with the MTD or RDAS, the Terminal DABS sensor will have the provision of handling search reports similar to the way described in Section 2.7.5.2.1 for the CD (i.e., without radar-only tracking).

## 2.8 Surveillance-Related Communications Messages

Included in the messages transmitted on the two-way ground link between DABS and an ATC facility are a class of messages designated "Surveillance-Related Communications Messages". The purpose of these messages is to aid the survillance and aircraft identification functions performed by the ATC facility. These messages are the ATCRBS ID Request, the ATCRBS ID Code Message, the Track Alert Message and surveillance-related applications of the Request for Downlink Data and its corresponding Tactical Downlink Message containing requested aircraft identification data. The use of these messages for surveillance purposes is discussed in the following paragraphs.

### 2.8.1 ATCRBS ID Code

The ATCRBS ID Code Message (see Section 3.3.4.4) is a DABS-to-ATC facility message which will communicate the ATCRBS Mode 3/A Code setting of the respective DABS transponder to the ATC facility. The message is generated either as a result of an ATCRBS ID Request (see Section 3.3.1.4) originating from an ATC facility or automatically by the sensor as a result of certain conditions.

The ATCRBS ID Request and the ATCRBS ID Code Message will be used as a means to maintain the compatibility, for DABS-equipped aircraft, between DABS and ATCRBS identification codes in the ATC facilities by permitting the association betwen the DABS Address and the Mode 3/A Code setting of the DABS transponder on a particular aircraft. During the DABS transition period, in many instances a DABS-equipped aircraft will be traversing the coverage of both DABS and ATCRBS sensors (for example, ATCRBS coverage of a controlled, DABS-equipped aircraft in a DABS/ARTS facility may result from a nearby ATCRBS sensor connected to an adjacent non-DABS En Route ATC facility).

If an adjacent non-DABS facility is scheduled to receive a handoff of the aircraft from a DABS facility, internally stored flight plans in the ATC faclity receiving the handoff will contain the Assigned Mode 3/A code which will be used to maintain the proper identification of the inbound DABS-equipped aircraft. Proper Mode 3/A identification is, of course, required both for the controller and for automatic computer routines. For these reasons, the proper setting of the Mode 3/A code of a DABS-equipped aircraft should be maintained at the value assigned by ATC though the track may be still controlled by an ATC facility connected to a DABS sensor.

Additionally, a DABS-equipped aircraft in En Route airspace may be in the coverage of both DABS and ATCRBS sensors. In order to maintain proper identification of the aircraft, the En Route ATC facility must maintain the correspondence between the DABS Address contained in the DABS beacon report from DABS and the Mode 3/A code received in the surveillance report from the ATCRBS sensor (refer to Figure 2-6).

### 2.8.2 Aircraft Identification Information

An ATC facility may obtain the variable flight identification (e.g., TWA462) from an appropriately equipped DABS aircraft by issuing a Request for Downlink Data (see Section 3.3.1.3) to the DABS sensor. The DABS transponder will supply the variable flight identification in a following Tactical Downlink Message (see Section 3.3.4.1).

Use of the variable flight identification (if any) is important since it will enable the ATC facility to associate the DABS Address for that aircraft directly with the flight identification. Thus, if a flight plan is filed with the aircraft's flight identification, but with no DABS Address, an immediate association between the proper flight plan and the DABS Address in the surveillance messages may be made.

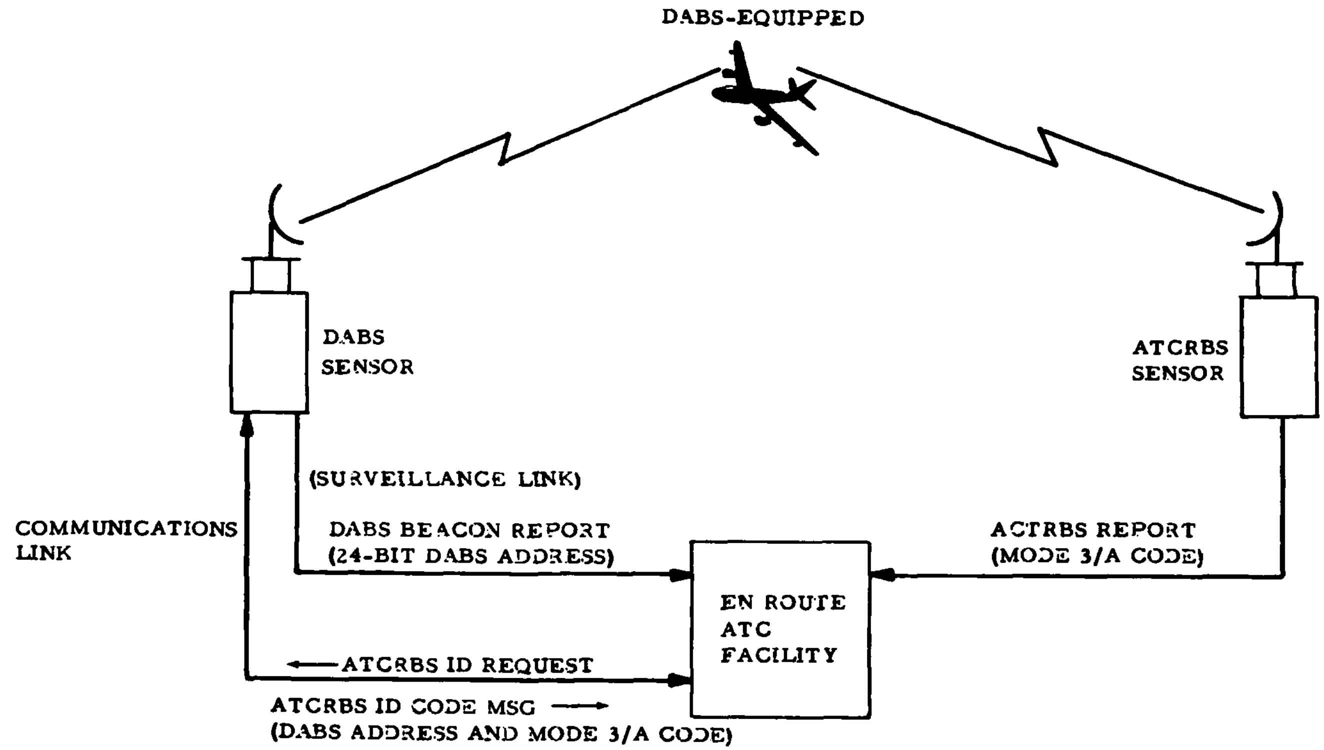



**FIGURE 2-6**
**DABS ADDRESS AND ATCRBS CODE CORRESPONDENCE USING SURVEILLANCE-RELATED COMMUNICATIONS**

This will permit automatic track initiation and track identification to occur though no DABS address information is available in the stored flight plan. The procedure could simplify the filing and handling of flight plans for DABS-equipped aircraft using variable flight numbers. An example is the case of commercial airliners where various aircraft (therefore different DABS Addresses) may fly the same scheduled route, using the same flight identification on different days.

If the DABS Address is contained in the flight plan, the use of the DABS-provided flight identification can serve as verification of DABS Address/flight identification association.

### 2.8.3 Track Alert Message

The Track Alert Message generated by the sensor will inform the ATC facility regarding a highly specific, low probability error condition. This condition is the detection by the sensor of two distinct tracks containing the same DABS Address. Since DABS transponders will be designed to encode a unique hard-wired address, this duplicate address situation will only arise if (1) either a transponder or the sensor makes a systematic error that converts the true address into a different address in a consistent manner, and (2) another aircraft happens to be on the local sensor roll call (or in some cases on an adjacent, connected sensor's roll call) at the same time and its DABS Address matches the erroneous one.

When a DABS sensor detects a duplicate address condition, the respective DABS Address will be deleted from the interrogation roll call so that surveillance interrogations on both aircraft are generated in the All-Call mode only. As a result, the DABS uplink and downlink is no longer available for the aircraft as long as the problem persists and only DABS beacon reports based on All-Call replies will be disseminated. In addition, the Track Alert Message will be transmitted to each ATC facility connected to the sensor via the ground communications link. The message will contain the DABS Address in question and the position (range and azimuth only) of each of the two targets.

A similar error condition may arise in which two aircraft simultaneously report the same DABS Address to two different DABS sensors, which in turn report to the same ATC Facility.

If there is non-overlapping coverage of these two aircraft or if the sensors are not connected, each sensor will be aware of only one aircraft, and the DABS cannot alert the ATC Facility to the situation.

# 3. AIR-GROUND COMMUNICATIONS

## 3.1 Introduction

DABS not only provides an improved surveillance system, but also provides an integral data link. In the performance of its surveillance responsibilities DABS can accomplish two-way message delivery, from the ground to an aircraft and from an aircraft to the ground. This digital data link will allow the automation of ATC services to evolve.

In order to discuss the DABS data link, it is necessary to define the types of messages handled by DABS. Both uplink (ground-to-aircraft) and downlink (aircraft-to-ground) messages consist of two types, "standard" and "extended length". Standard messages are fixed in length and each message requires a reply. (Every downlink reply is an acknowledgement of message acceptance by the transponder.) A standard uplink message is sometimes referred to as a "Comm-A" transaction while a standard downlink message is called a "Comm-B" transaction. Extended length messages (ELM's) are used for applications which require the transfer of a large amount of text. Basically an ELM consists of a variable number of fixed length messages linked together and only requiring one reply for the entire message. The uplink ELM is a collection of "Comm-C" interrogations while the downlink ELM makes use of the "Comm-D" replies.

The remainder of this chapter will describe the DABS data link in terms of: (1) its characteristics, (2) messages, (3) the necessary interaction with the ATC facility, and (4) example applications. Messages associated with ATARS will be discussed in the ATARS section of this document.

## 3.2 Characteristics of Air-Ground Data Link

The DABS sensor provides all the necessary data link management to ensure accurate delivery of a properly formatted message to an aircraft within its area of responsibility. In general, the ATC facility is only required to formulate message inputs to the data link, and to route outputs from the data link to the appropriate device.

Figure 3-1 depicts a simplified data link system concept. As shown, the DABS site has a surveillance ground link to one or more ATC facilities over which target reports are sent. In addition a full duplex communication ground link exist between

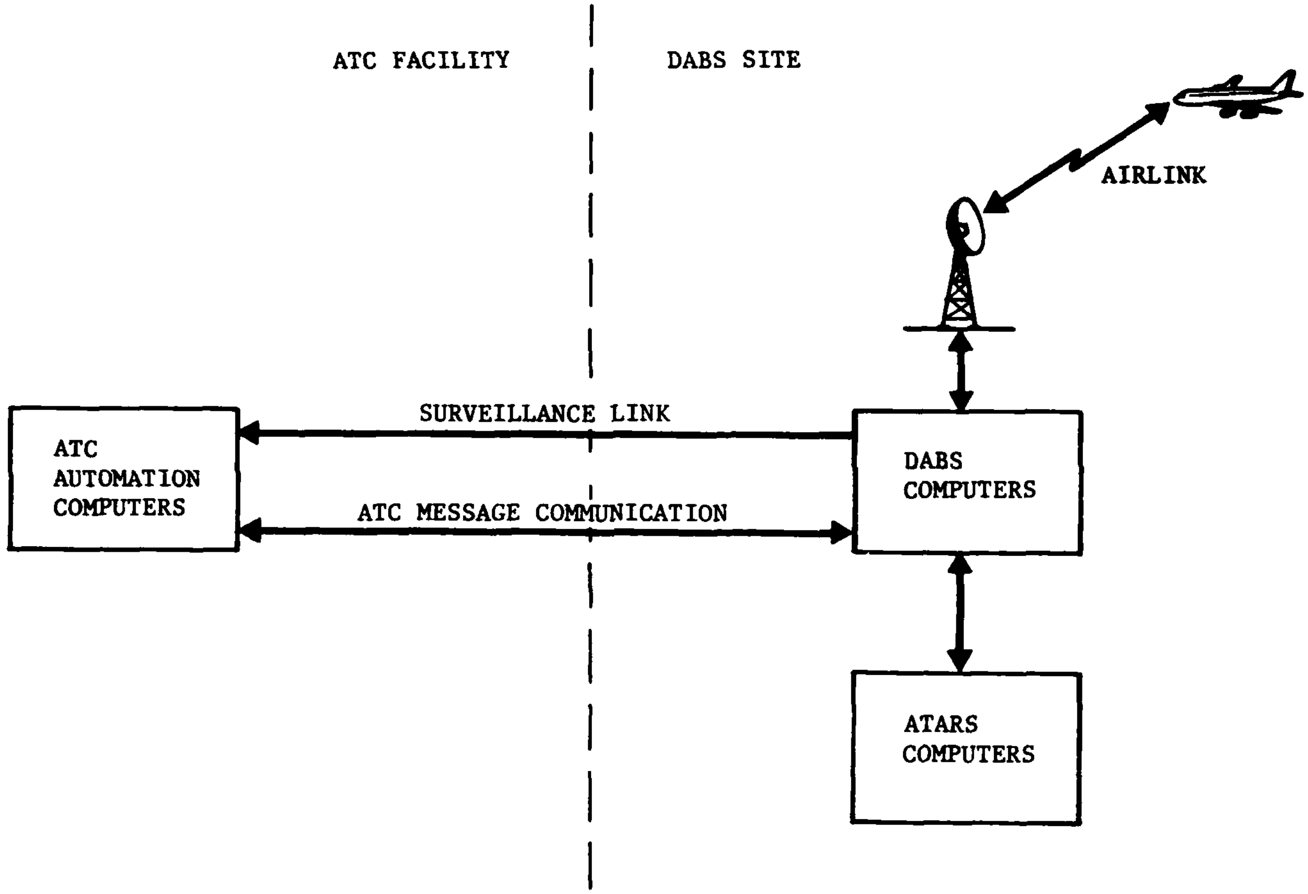



**FIGURE 3-1**
**SIMPLIFIED DATA LINK SYSTEM**

the DABS site and the ATC Facility. This link is connected to the ATC facility automation computers to provide ATC message services such as Altitude Clearance Confirmation and Minimum Safe Altitude Warning (MSAW) advisories.

Communications among the ATC facility, the DABS sensor, and the transponder is a process that is actually comprised of two data links. The "ground link" is a two-way data link between the DABS sensor and an ATC facility. The "air link" is the data link between the DABS sensor and the transponder consisting of an "uplink" and a "downlink". In its basic form, the communication process between the ATC facility and the pilot consists of:

1. A message transmitted from the ATC facility to a DABS sensor,

2. Processing that message by the DABS computers to set up a ground-to-air message

3. Transmission of the uplink message, and

4. Processing of the message in the aircraft for display to the pilot.

Data link communication from the pilot to the ATC facility begins with a request to use the "airlink". This step is necessary since the airlink is under control of the sensor, not the transponder. The transaction begins with the pilot arranging his message on an input device and pushing a "send" button. This causes a flag to be set in every subsequent surveillance/standard message reply. When the sensor reads the reply, it knows that a message is waiting and schedules an interrogation calling for a standard downlink reply containing the message data. After the message has been correctly received the sensor sends up a signal in a subsequent interrogation that resets the flag and indicates to the pilot that the transaction has been completed.

Each of the data link message transmissions requires the use of a protocol that protects the message against loss and notifies the originator when the message has been received or if it cannot be delivered. Further brief discussions of both message formats and protocols are contained in other sections of this document; however, detailed information on message formats and protocols can be found in References 1 and 4.

The remainder of this section will include some general characteristics of message handling, as well as a discussion of the capabilities and performance characteristics of the data link.

### 3.2.1 DABS Message Routing*

#### 3.2.1.1 Uplink Message Routing

For the purpose of delivering uplink messages, DABS sensors normally act independently (even though they may be netted and two or more sensors may be interrogating the same aircraft). Thus, if a sensor receives a message for an aircraft, it will attempt delivery without knowledge of whether or not other sensors are handling the same message. In the case of a sensor receiving an ELM uplink, transmission will be attempted only if the sensor is designated Primary for the particular aircraft.

#### 3.2.1.2 Downlink Message Routing

For pilot-originated messages (downlinks), processing by multiple sensors cannot be permitted without risking the loss of messages under some circumstances. DABS (see Reference 2, Section 3.4.8) solves the problem with the "Primary/Secondary sensor" assignment scheme, which allows only the Primary sensor to extract the downlink message.

For controlled aircraft the Primary/Secondary designation of a sensor will depend on an explicit assignment contained in a message from the ATC facility (Section 5.2.6). For an uncontrolled aircraft, the Primary sensor is the "best" sensor defined by the coverage map. For uncontrolled aircraft in "transition" zones (irregularly shaped strips along the Primary/Secondary boundaries between sensors), DABS network management allows a "Dual Primary" designation on the coverage map. For "netted" sensors (sensors connected by ground lines),

---

* In conjunction with message handling, it is useful to consider ATARS as functionally distinct from DABS sensor processing. Thus, ATARS acts as an originator and recipient of messages, (1) to aircraft, using collocated and/or adjacent DABS sensors, (2) to ATC facilities, and (3) to adjacent ATARS. In this sense, ATARS is treated as another external user of DABS communications.

actual Dual Primary is prevented by coordination between the sensors. In the "non-netted" case, all Primary sensors will attempt to extract downlink messages. However, loss of messages is prevented by special DABS "multi-site protocol" (see References 2 and 4).

The DABS sensor receiving a downlink message has responsibility for routing the resulting output on the ground links. When the downlink is a specific response to a particular ATC facility input, the message will be directed only to that user. When the downlink is pilot-originated, the DABS sensor will disseminate the output, following the same site adapted dissemination map (Section 2.6) that is used for surveillance data outputs.

### 3.2.2 Data Delays

In DABS data link communications, time delays in the transmission and receipt of data naturally occur. The total time that may elapse between the initiation of a message at an ATC facility and its receipt by the aircraft is a function of many elements. For an ATC generated uplink message the delays include:

1. Processing within the ATC facility's processor,

2. Processing and waiting time at the ATC ground link transmission interface,

3. Ground link transit time including possible delays for "reject" replies and subsequent retransmissions in cases of link difficulties,

4. Processing time at the DABS ground link receive interface,

5. DABS software processing delays,

6. Waiting time for antenna to reach aircraft azimuth, and

7. Possible delays for retransmissions in cases of airlink difficulties.

For normal operations of the uplink, messages will be delayed no more than 1/16 of a scan (0.25 seconds for a 4-second rotating antenna) from the time of receipt by the sensor until they are processed and available for delivery to the aircraft. The average delay time for item 6 in the preceding list is 1/2 a scan, while the delay for item 7 could be substantial if a link fade extends over an entire beam dwell period.

For downlink messages, the delays occur in reverse order but are comparable. A delay of no more than 3/32 of a scan period (0.375 seconds for 4-second rotating antenna) will occur from the time the target was in the beam until the data is processed by the sensor and is available for transmission to the external user. In some cases there will be an additional 1-scan delay between transmission of a pilot's "send" request and the subsequent extraction of his message. Messages handled under the Data Relay Mode (Reference 3) undergo additional delays for processing by the relaying sensor and for transmission on the sensor-to-sensor link.

A simple priority system for uplink message transmissions has some bearing on data delays. Standard transmissions (Comm'A's) and ELM's carry an explicit 1-bit tag (determined by message originator) representing "high" or "standard" priority. All "high" priority standard transmissions are handled first followed by the remaining Comm-A's, then any ELM's, which are assigned to a class below "standard". It should be noted that ATARS "high" priority messages may be given preference over other "high" priority messages by the setting of a global "precedence" parameter (Reference 2). Also all messages within a priority class are handled on a first-in-first-out basis.

These priority levels do not affect the handling of a message on the ground link or in most of the DABS processing. They do affect the order of message delivery on the uplink but the effect will only be noticed in times of heavy message queuing when a low priority assignment would increase the probability that the message transmission would be delayed to the next scan.

Related to the subject of data delays is an uplink message parameter "expiration time" which is determined by the user (standard default value supplied by DABS). This parameter defines the number of scans during which the DABS sensor will continue to attempt delivery of the message, and in turn, defines an upper bound to the range of possible data delays.

### 3.2.3 Capabilities and Performance Characteristics

The DABS sensor is designed to provide a high capacity, reliable, two-way digital data link for all DABS-equipped aircraft. The sensor has a capacity that exceeds all projected data link applications. This includes ATARS, ATC messages, weather services, terminal information services, downlink of airborne measurements, etc.

To help insure a reliable data link,, all "airlink" messages include a 24 bit Address/Parity field (Reference 3) which allows for detection of most uplink transmission errors, and detection and correction of most downlink transmission errors which are caused by ATCRBS interference. Another feature which adds to data link reliability is the ability of the sensor to reinterrogate an aircraft within a beam dwell when an expected reply is not received.

### 3.2.4 Data Link Protocols

#### 3.2.4.1 "Airlink" Channel Protocol

For proper operation of the "airlink", adherence to basic protocol principles is necessary. First, for a particular DABS target, only one sensor (the Primary sensor) at a time is allowed to read out pilot-originated messages, deliver altitude echo (ALEC), deliver traffic advisories, provide synchronized interrogations (optional DABS mode), and perform ELM transactions. However, additional sensors may perform surveillance, deliver uplink messages (Comm-A's) and read out ground-requested downlink messages (Comm-B's). Next, the "airlink" always operates under ground (sensor) control, meaning that the transponder must notify the sensor that a downlink message is awaiting delivery ("B" bit set) and that the sensor must then schedule an interrogation for extraction of the message. Once extracted, the sensor positively resets the transponder's downlink status ("Cancel B"). Another basic protocol principle is that every downlink reply is a "technical acknowledgment" of an uplink interrogation, implying that the uplink message was received and properly decoded.

The procedures for uplink message delivery begin with the tagging of the messages with the sender's ID code and then the placement of the messages in a single buffer in the order received. (This buffer is read at least 16 times during an antenna scan period.) DABS data link processing then searches the surveillance file for the aircraft addressed in the message and:

1. If the aircraft is not on file, the message is deleted and a Message Rejection Notice (Section 3.3.3.1) is sent to the sender indicating "rejection".

2. If the aircraft is on file, but not being tracked with roll call data (sensor fade exists), the message is accepted but a Message Delay Notice is sent indicating "delay".

3. If the message is an Uplink ELM addressed to an aircraft for which the sensor is not assigned Primary, a Message Rejection Notice is sent indicating "rejection" for the reason specified.

4. If the message is an uplink ELM and the aircraft addressed lacks ELM capability, a Message Rejection Notice is sent indicating "rejection" for the reason specified.

5. If the message is being "relayed" to another DABS sensor for delivery, a Message Delay Notice is sent indicating "delay" for the reason specified.

6. Otherwise, the message is accepted.

Each accepted message is then placed in a file for the particular aircraft by message type (Standard or ELM) and priority level. Within a type and priority level the messages are processed in the order received. No message will be delivered until those preceding it in the list have been completed. Delivery of all messages in the list is attempted the next time the aircraft is in the sensor antenna beam. However, if any message is not successfully delivered during the beam dwell it is saved for the next scan unless expiration occurs.

In the case of message expiration, the message is deleted and a Message Delivery Notice (Section 3.3.3.2) is sent to sender indicating "expired". For each tactical uplink and complete ELM delivered, a Message Delivery Notice is sent to the sender indicating "delivered".

#### 3.2.4.2 Ground Link Protocol

Messages between DABS sensors and ATC facilities conform to the protocol and formats of the Common International Civil Aviation Organization (ICAO) Data Interchange Network (CIDIN). The purpose of this protocol is to help provide confidence and reliability in the ground link operation. None of the protocol operations, other than parity encoding and error detection, involves the link data field contents (message data).

In order to use the DABS data link the ATC facility will need to provide a proper interface (hardware/software) which provides translation between the CIDIN protocol and message formats and the protocol and formats used on the corresponding ATC computers. Under normal operating conditions the interface (hardware/software) will be transparent to the user. A discussion of both the interface with an ARTS IIIA facility and an En Route facility is presented in Section 6, and in Reference 7.

### 3.2.5 Considerations for Multi-Sensor Configurations

A multi-sensor configuration allows the ATC facility software to designate which sensor is "Primary" for controlled aircraft by issuance of an "Aircraft Control State" message. This will insure a data link between the ATC facility and the aircraft in control areas not normally serviced by the attached sensor (e.g., early interfacility handoff).

A sensor failure will be transparent to the controller in terms of interaction with the data link. (This assumes all aircraft of interest are provided surveillance and data link services by reconfiguration of coverage areas of remaining operational sensors). With a sensor failed, the multilink feature may be lost, but the actions by controller/ATC software will be unchanged.

## 3.3 Data Link Messages

The purpose of this section is to operationally describe the various messages and message types to effect the use of the DABS data link. For specific message type codes and formats, see References 1, 2, and 4.

### 3.3.1 ATC-to-DABS Uplink Messages

Among the messages that are defined for the link from the ATC Facility to a DABS sensor, specific types are classified as "uplink messages" -- messages that are sent to DABS for further transmission to an aircraft. The information content as well as the DABS sensor handling of each type are characterized in the following paragraphs.

### 3.3.1.1 Tactical Uplink

This will be the basic message for transmitting information from an ATC facility or ATARS to the pilot. Each tactical uplink message transmitted on the ground link causes the DABS sensor to dispatch a standard (Comm-A) uplink transmission to a particular DABS-equipped aircraft. The tactical uplink format includes a DABS Address to identify the intended aircraft, a message number to permit references to the uplink message in DABS response messages, expiration time, priority, and the message text field which contains the actual data to be sent on the uplink. The message text field consists of 56 bits. The contents of this field are not interpreted by the DABS sensor but are passed intact as part of the Comm-A interrogation.

The originating facility (ATC or ATARS) will supply the DABS aircraft ID and the message text. Expiration time and priority are optional and will assume nominal values unless set by the originator. For transmisson of urgent messages, maximum speed and reliability are obtained by sending the message via all available DABS sensors, e.g. "multilink" handling.

### 3.3.1.2 ELM Uplink

This message type will be used for longer messages from the ATC facility to the pilot. The protocol associated with ELM's is intended to make more efficient use of the air-ground channel than is possible with standard (Comm-A and Comm-B) transmissions, which require two-way transmissions for each segment. The ELM only requires one reply for the complete message. The ELM uplink format includes the DABS address, message number, priority, and expiration time defined as for the tactical uplink. The remainder of the message is a "length" parameter, which is a segment counter with a maximum of 16 and a minimum of 2 segments, and an ELM text field.

The ELM text is variable in length in multiples of 80 bits with a maximum of 1280 bits. If longer messages were to be sent, they would have to be subdivided and would be treated by DABS as independent ELM's. The ELM text field is not interpreted by the DABS sensor but is used intact in a sequence of Comm-C uplink transmissions. Coding for this field must satisfy the requirements of an ELM output device.

Only the DABS sensor designated as Primary for a particular aircraft will transmit an uplink ELM, therefore the ATC facility must route the message to the Primary sensor.

### 3.3.1.3 Request for Downlink Data

This message will be used to obtain data from a device on a DABS-equipped aircraft using an air-to-ground standard (Comm-B) transmission. The message format contains the DABS address, message number, expiration time, priority, and a 4-bit field indicating the requested data.

### 3.3.1.4 ATCRBS ID Request

Since DABS transponders incorporate an ATCRBS capability, provision is included to read out the Mode 3/A code via the DABS link. The ID request is similar to a request for downlink data, except the Comm-B downlink is not required. Instead, the standard reply transmission format (short or long) may include the mode 3/A code in place of altitude. The ATCRBS ID Request format comprises simply a DABS address and message number. A DABS sensor, without waiting for a request, will routinely ask for a Mode 3/A reply and disseminate a response whenever a DABS equipped aircraft is acquired, reacquired, and whenever the pilot changes his Mode 3/A code.

ATC surveillance processing software will automatically generate this message whenever a new DABS aircraft is reported and an ATCRBS ID message is not received promptly.

### 3.3.1.5 Message Cancellation Request

For various reasons, at times, it may be desirable to cancel either a tactical or ELM uplink message. (Other types of uplink messages do not result in display of data to the pilot, therefore no cancellation is necessary.) This is the function of the message cancellation request. The format contains the DABS address, message number, reference message number and type that identify the message to be cancelled. Following the attempt to delete, there is no further specific response from the sensor to the message originator as to the status of the cancellation request. The user has no guarantee of stopping message delivery.

### 3.3.1.6 Data Link Capability Request

This message is a request for the "data link capability field" which identifies the capability of the onboard equipment to generate and/or receive specific types of communications. The message format contains only the DABS address. This capability information is needed by the ATC facility and ATARS before they attempt sending uplink messages to an aircraft.

Upon receipt of a Data Link Capability Request the sensor will transmit to the user via a Data Link Capability Message (Section 3.3.4.3) the contents of the capability field in the aircraft's surveillance file.

ATC software will automatically generate this message whenever a new DABS aircraft is reported and a Data Link Capability Message is not received within a predetermined time.

### 3.3.2 ATC-to-DABS Status/Control Messages

DABS status/control messages are used to determine the operational status of a DABS sensor and to provide network control. These messages are discussed in Section 5 of this document, but are listed here for completeness:

- Test Message
- Altimeter Correction Message
- ATC Failure/Recovery Message
- Sensor Failure/Recovery Message
- Aircraft Control State Message (ATCRBS and DABS)

### 3.3.3 DABS-to-ATC Sensor Response Messages

Response messages are generated by the DABS sensor as part of two distinct processes that take place sequentially following the receipt of an uplink message. The first process is acceptance testing, which determines the deliverability of each uplink message of any type. The second process is that of technical acknowledgement, and it is carried out after uplink transmission of tactical or ELM message types, provided they have passed the acceptance test. There are two types of response messages, and they correspond exactly to the two processes.

#### 3.3.3.1 Message Rejection/Delay Notice

Acceptance testing of each uplink message consists of a search of the DABS sensor surveillance file for the aircraft addressed and a test on the track state of that aircraft. For an uplink ELM, acceptance also depends on the sensor being Primary for the aircraft addressed. There are five possible outcomes to the acceptance testing:

1. Rejection, because target is not on file
2. Rejection, because sensor is not Primary (uplink ELM only)

3. Rejection, target lacks ELM capability
4. Delay, because target is not in roll call mode
5. Delay, because of data relay (with or without local delivery), and
6. Acceptance (no Notice sent)

which are explained in Reference 1. The message contains three data fields, the DABS address, the reference message number, and a "qualifier" representing the test outcome.

Upon receipt of a Message Rejection Notice (for cases 1 and 2 above) the ATC software will provide for automatic re-issuing of the message to another connected DABS sensor. For a Message Delay Notice no action is required, except possibly for a high-priority message which would require re-initiation of the message using another sensor if available.

#### 3.3.3.2 Message Delivery Notice

When a tactical uplink message is delivered by means of a Comm-A transmission, the received transponder reply constitutes a technical acknowledgment of the receipt of that message. For segments of ELM uplinks, the procedure is more elaborate and results in technical acknowledgements specific to each segment. Whenever a tactical uplink message or all segments of an ELM uplink message have been acknowledged, the DABS sensor generates a Message Delivery Notice for the originator indicating successful delivery. If any segment of an ELM is not acknowledged on the downlink, the sensor will continue to attempt delivery until the expiration time of the message is reached. If any part of the message remains undelivered at expiration time, a delivery notice is generated indicating failure. The Message Delivery Notice contains three data fields, the DABS Address, referenced message number, and delivery indicator.

ATC software will provide for indication of a successful message delivery to the originator. A notice indicating failure of delivery will also be displayed, allowing re-initiation via another sensor by action of originator.

### 3.3.4 DABS-to-ATC Downlink Messages

Downlink messages to ATC are generated by the DABS sensor as a result of information received via the DABS downlink. Such information may originate with the pilot or it may result directly from a previous uplink message. There are five specific types of downlink messages, each of which is characterized in the following sections.

#### 3.3.4.1 Tactical Downlink and Utility Messages

A Tactical Downlink Message is generated whenever a DABS sensor receives a Comm-B reply. A tactical downlink message is comprised of a single segment of data; consequently, if an airborne device is used that generates more than one Comm-B segment, separate independent messages will result. The tactical message generated will be routed to either: (1) all ATC Facilities receiving DABS surveillance data on the aircraft if the Comm-B was extracted at the request of the pilot, or (2) the specific ATC Facility or ATARS that requested the information.

The downlink message format contains two fields, the DABS address and the 56-bit message text (MB) which is not interpreted by the DABS sensor. Any desired control data must be coded into the MB field.

The ATC processing software must interpret the MB data and extract the definition subfield. If it matches the address code in a pending "Request for Downlink Data" for that aircraft then the proper association has been made, and (1) the message will be routed to the appropriate device, (2) the message contents displayed and, (3) the pending request deleted from the software files. If there is no definition subfield code match or no pending request, the downlink message is assumed to be pilot-originated and routed accordingly.

The Utility Message is routed like a pilot-originated tactical message. The message contains the DABS address and the 6-bit UM data field (References 1 and 4) not interpreted by the DABS sensor, which is contained in both surveillance and standard (Comm-B) replies. The DABS sensor generates a Utility Message only when the UM field contains information (Non-zero) which has not been requested by the sensor.

#### 3.3.4.2 ELM Downlink Messages

An ELM downlink message can be pilot originated or requested by the ground. Only one message at a time can be in progress and only the DABS Primary sensor for that aircraft will attempt to extract it. The message corresponds to a sequence of Comm-D replies, each containing one segment of data. The message format consists of three data fields; the DABS address of the sending aircraft, the "length" parameter specifying the number of segments in the message, and the ELM text (not interpreted by the DABS sensor). The ELM text is variable in length in multiples of 80 bits to a maximum of 1280. The text field is assembled by copying the MD fields of the Comm-D replies in the proper sequence. The ELM message will not be sent to the ATC facility until all segments of the downlink have been received by the DABS sensor. The ATC processing software will have to perform routing to appropriate devices and in addition, check for completion of the message.

#### 3.3.4.3 Data Link Capability Message

This message is used to report the data link capability field. It is generated automatically by DABS either (1) when a new DABS aircraft is acquired, or (2) the aircraft reports a change in its data link capability, or (3) when requested by an ATC facility or ATARS by means of a Data Link Capability Request Message (Section 3.3.1.6). In the latter case, the message is transmitted to only the requesting facility; in the former case, to all facilities receiving surveillance reports. The message format simply contains the DABS address and the capability field (Reference 1).

A data link capability message will require ATC software processing. The data contained in the message will indicate to the ATC software the capability of the onboard equipment to generate and/or receive specific types of communications for a particular DABS aircraft. This information must be stored and made available to the appropriate data link function as part of the aircraft status or data link display maintained in the ATC software.

#### 3.3.4.4 ATCRBS ID Code Message

This message is generated whenever a DABS sensor receives a reply from a DABS transponder containing a Mode 3/A code. Such a reply may occur for any of several reasons: (1) an ATCRBS ID code request is received from an ATC facility, (2) the pilot has changed his ID code creating an "Alert" status which indicates his wish to have his code read out, (3) the pilot has dialed an emergency code 7500, 76xx, or 77xx, or (4) the aircraft has been newly acquired or reacquired after a link fade by the DABS sensor. In the latter case, this message is disseminated only if the code shows a change. If the reply results from a code request message from a single facility, the resulting output message is transmitted to only that user. In all other cases, the ATCRBS ID code message is transmitted to all facilities receiving surveillance reports on the particular aircraft. The message format contains only the DABS address and the 12-bit Mode 3/A code.

Receipt of an ATCRBS ID Code Message requires the ATC software processor to check any pending ATCRBS ID code request; if an association is made the message is then routed to the appropriate device for display and the request deleted. The software processor will check all messages of this type (including surveillance replies) for emergency codes and if found, route the message for display on all appropriate devices.

### 3.3.5 ATARS-to-ATC Operational Messages

The Controller Alert Message is discussed in the ATARS section of this document (Section 4) and is only listed here for completeness:

States of the Controller Alert Message (Section 4.3.1)

- Conflict Resolution Data
- Resolution Notification
- Terrain Avoidance Alert
- Restricted Airspace Avoidance Alert
- Obstacle Avoidance Alert

### 3.3.6 DABS-to-ATC Performance/Status Messages

Continuous knowledge of the status of the DABS sensor is important to an ATC Facility for two reasons. First, it is necessary to observe the functioning of the sensors as part of an ongoing monitoring of overall ATC performance. Second, since the DABS sensors operate in general as remote unmanned stations, it is important to continuously monitor the existence of malfunctions in redundant equipment that could result in non-scheduled maintenance or repair activity. The messages listed below are used to monitor the conditions of the sensor and related activities. These messages are discussed in Section 5.

- Test Response Message
- Status Message
- Track Alert Message (Section 2.8.3)

## 3.3.7 ATARS-to-ATC Recording System Messages

These messages are discussed in the ATARS section of this document (Section 4) and are only listed here for completeness:

ATARS Recording System Messages (Section 4.3.2)

- Duplicate ATARS Uplink Message
- Duplicate ATARS Message Delivery Notice

## 3.4 Example of ATC Data Link Applications

The delivery of ATC coordination messages is chosen as an example application, since these messages are usually highly structured and often require rapid delivery to the aircraft.

This type of data link application lends itself to Comm-A message delivery since the message can be delivered on a priority basis, and the information content of the message can be encoded within the available message field. The delivery of two different coordination messages, the Minimum Safe Altitude Warning (MSAW) Alerts and Altitude Assignment Clearance Confirmation, using the DABS data link will be discussed in detail in the following sections. It should be noted that the following sections are suggested guidelines for the use of the DABS data link, and that they only reflect example implementations of the applications.

### 3.4.1 Minimum Safe Altitude Warning (MSAW) Alerts

The ARTS III processors include MSAW algorithms which provide the controller with a visual warning and an aural alarm when tracked Mode-C equipped aircraft are projected to violate altitude criteria programmed into the ARTS III computer. The DABS data link extends the MSAW capability by making it possible to automatically send the same alert to DABS data link equipped aircraft.

Data link MSAW messages consist of two messages types. One is used to provide the MSAW alert and the second to clear the alert. The MSAW alert message contains the contraction "MSAW" and includes the minimum safe altitude value, in feet, in the number field. This message is delivered to the aircraft each scan as long as the MSAW alert is active. When the MSAW alert is dropped, a clear-MSAW message is delivered to the aircraft to clear the alert from the cockpit display. In the event that the clear-MSAW message is not received by the aircraft, the airborne display system clears the MSAW message if it has not been updated for a period of time (e.g., 15 seconds).

When an alert is declared and is not inhibited from the ARTS display output (e.g., inhibit code segment or controller keyboard entry), a five second aural alarm is sounded in the tower cab/IFR room as well as in the cockpit. The letters "LAT" indicating "Low Altitude Alert transmitted to the pilot" are displayed blinking in field "zero" of the Full Data Block (FDB) for the aircraft involved in the alert. The aircraft's identity (ACID), Mode C altitude, and "LAT" are displayed in the MSAW display area of the ARTS output device. When an alert is declared but inhibited from the ARTS display output, the MSAW alert is not transmitted to the pilot.

When the alert has been acknowledged by the pilot through keyboard entry the aural alarms (if still active) will be terminated. On the controllers display the "LAT" in the FDB and in the MSAW display area will be replaced by "ACK" (acknowledged).

### 3.4.2 Altitude Assignment Clearance Confirmation

The Altitude Assignment Clearance Confirmation message is an uplink message to the cockpit indicating the altitude to which the En Route controller has cleared the aircraft. The message provides the pilot with a visual confirmation of the standard voice clearance and the controller with a visual indication of the pilot's "WILCO" of the clearance. The Altitude Assignment Confirmation message (transmitted in the MA field of a Tactical Uplink Message) is triggered, for a controlled DABS track in DABS coverage, by a controller's manual entry of an assigned (or interim) altitude. When a DABS-equipped aircraft is eligible to receive this message a "D" will be displayed to the controller in the FDB (B5 character). When an Altitude Assignment Confirmation is sent to the DABS sensor and the sensor replies with a Message Delivery Notice, indicating that the message was successfully delivered to the aircraft, the "D", in the FDB will be replaced with an "A" indicating "awaiting the pilot's WILCO". Upon receipt of the WILCO (received in the MB field of a Tactical Downlink Message), the "A" will be replaced with a "W" indicating that the WILCO has been received. The "W" will be displayed for a short time period before reverting again to "D". If a WILCO is not received within a timeout period after the Message Delivery Notice has been received, the "A" will also revert to a "D".

The altitude clearance message is typical of the type of ATC coordination message which does require quantitative data within the message. Besides the message identifier, the specific altitude value associated with the clearance and proper message qualifiers are required.

There are three basic qualifiers associated with the Altitude Assignment Clearance Confirmation. These are "Maintain", "Climb and Maintain", and "Descend and Maintain." The assigned altitude is given in terms of either "Flight Level (FL)", or "Feet" as appropriate for the particular situation. Examples of message text displayed to the pilot are "CAM FL 260" and "MTN 5000".

## 3.5 Other Data Link Applications

Other applications of the DABS data link are now under investigation. As experience with data link services is gained from an operational DABS system, additional applications are likely. At present, some of the other possible data link applications are:

- Takeoff Clearance Confirmation
- Weather Services
- Enhanced Terminal Information Services
- Downlink of Airborne Measurements

Note: Some of these data link services will be provided by a data link ground system not involving ATC automation. For example, a data link ground system could provide weather data to a pilot on request via DABS.

# 4. AUTOMATIC TRAFFIC ADVISORY AND RESOLUTION SERVICE (ATARS)

## 4.1 ATARS-ATC Facilities Interface

ATARS is a totally automated ground-based collision avoidance system which provides protection to aircraft equipped with an ATARS display within DABS surveillance coverage. ATARS provides separation assurance information to the pilot via the DABS airlink, and also provides alert messages to the controller if a potential conflict involves a controlled aircraft. In this way ATARS will be a backup to the ATC system's separation assurance role for ATARS equipped aircraft. ATARS is designed to operate in both the Terminal and En Route environments, and provides the same services to all ATC facilities. However, ATARS can be site adapted (Section 4.4) to the needs of a particular ATC facility.

As shown in Figure 4-1, a simplified diagram of the DABS Computer Complex, the ATARS function is part of the complex and is located at the DABS site. The interface between ATARS and the ATC facilities consists entirely of ATARS sending operational messages and recording system messages (described in Section 4.3) via the two-way ground communications link between DABS and the ATC facilities. ATC software accepts these inputs, interprets them, and displays the appropriate information to the controllers. Terminal and En Route ATC software may process ATARS messages differently based on operational requirements. In the cases where the ATC facility is also operating an independent separation assurance system (Terminal or En Route Conflict Alert) the ATC software combines the outputs of both systems and generates messages to the controller which contain all the useful information.

## 4.2 ATARS Operation Involving Controlled Aircraft

ATARS interacts with controlled aircraft to accomplish its function of providing back-up separation assurance services by issuing the following advisory messages as required:

1. Proximity advisories - to advise the pilot of nearby (non-threating) aircraft.

2. Threat advisories - to advise the pilot of potentially threatening aircraft.

3. Negative Resolution Advisories - to advise the pilot not to turn in a particular direction or to limit its vertical speed.

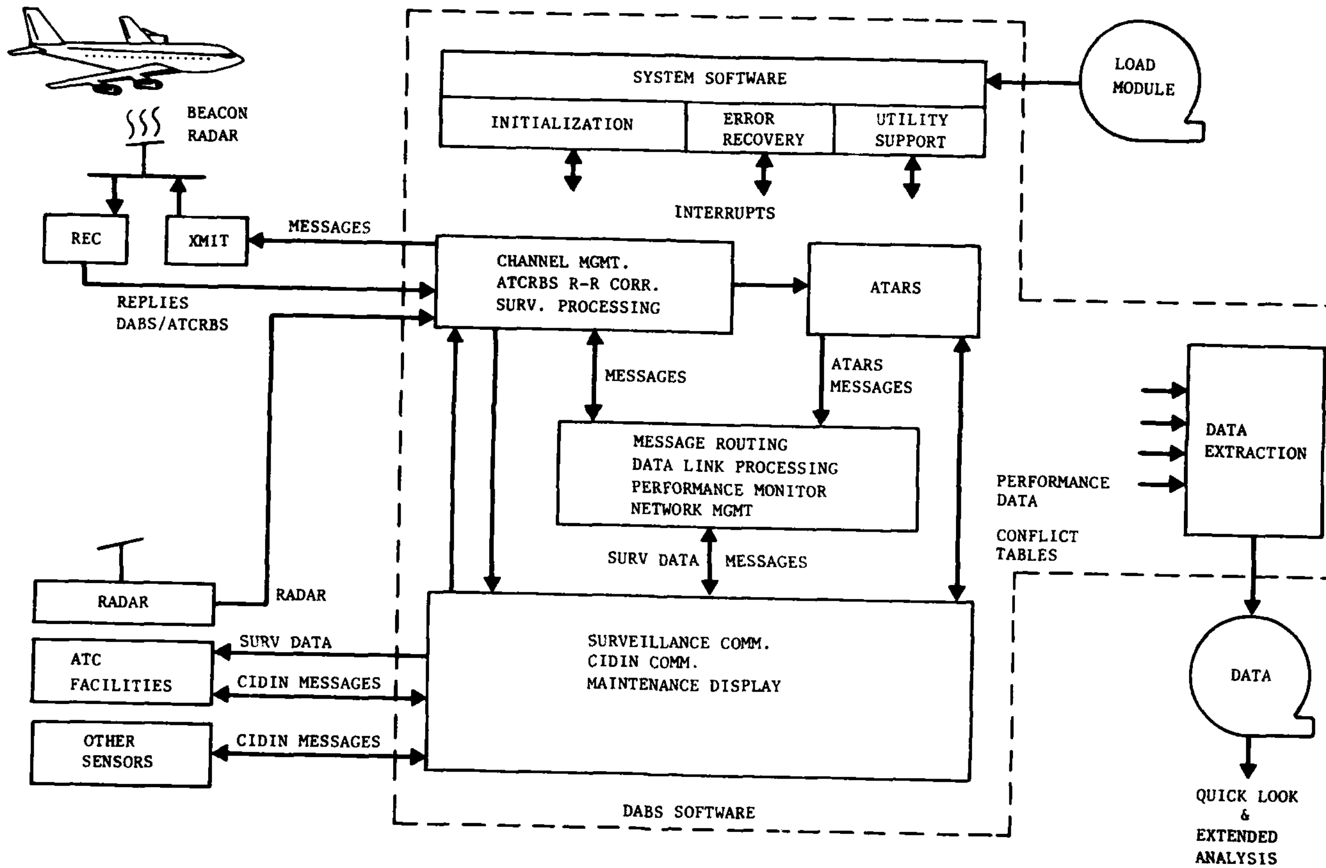



**FIGURE 4-1**
**DIAGRAM OF DABS COMPUTER COMPLEX**

4. Positive Resolution Advisories - to provide the pilot with the recommended collision avoidance maneuver.

ATARS interacts with the ATC facilty whenever a conflict or potential conflict exists involving at least one controlled aircraft; that is, ATARS interacts with the ATC facility whenever a resolution or threat advisory is sent to a controlled aircraft. This interaction takes the form of a "Controller Alert Message with Conflict Resolution Data" at the time a threat advisory is issued, and the form of a "Resolution Notification" at the time a resolution advisory is issued. Table 4-1 depicts the time relationship of ATARS interaction with pilots and controllers.

The ATARS to ATC messages, described in Section 4.3, alert the controller to the conflict, advise him of the suggested ATARS conflict resolution data, and inform him of the status of message delivery to the aircraft. It is a function of the ATC facility software to format and route these messages to the proper device for display. To be compatible with current operational procedures the ATARS controller alerting logic incorporates the basic features of Terminal Area Conflict Alert. ATARS accounts for the maneuvering and expected close spacing of aircraft in the terminal area. Thus, protection is provided to controlled aircraft in predefined maneuvering, landing, and takeoff areas from other aircraft in the area not following accepted operating procedures. A reduction in the number of "unnecessary alarms" is accomplished by mapping the geographical areas around the airports in which these operations normally occur. This feature provides conflict protection but allows normal in-line following and parallel paths that would occur in take-off and landing operations. (In the En Route environment these ATARS features are not normally exercised.)

ATARS uses different conflict thresholds (lead times) depending on whether the aircraft are under ATC control or uncontrolled. Therefore, ATARS should be informed of all aircraft under ATC control. This information is passed to ATARS through DABS by ATC's initiation of an Aircraft Control State Message (Section 5.2.6).

### 4.2.1. Controlled/Uncontrolled Encounters

ATARS attempts to resolve conflict situations between controlled and uncontrolled aircraft by maneuvering the uncontrolled

TABLE 4-1

TIMING OF ATARS INTERACTION WITH PILOT AND CONTROLLER

| RELATIVE TIME (SEC) | ATARS INTERACTION WITH | | COMMENTS |
|---|---|---|---|
| | PILOT | CONTROLLER | |
| Prior to $T_o$ | • Proximity Traffic Advisory Sent to Both Aircraft | • No Interaction With Controller | |
| $T_o$ | • Threat Advisory Issued to Pilot Via DABS Data Link | • Controller Alert and Conflict Resolution Data Sent to ATC Facility | • Designed to Coincide With ARTS III Conflict Alert for Associated Tracks |
| $T_o + 15$ | • Resolution Advisory Sent to Uncontrolled Aircraft | | |
| $T_o + 35$ | • Resolution Advisory Sent to Controlled Aircraft | • Resolution Notification Sent to ATC Facility | • Issued 20-30 Seconds Prior to Closest Approach |

aircraft first. Only if the resolution advisory to the uncontrolled aircraft fails to resolve the encounter will ATARS issue a resolution advisory to the controlled aircraft.

At the time a threat advisory is issued to the aircraft involved in the potential conflict, a "Controller Alert Message with Conflict Resolution Data (Section 4.3.1.1) is issued by ATARS to the ATC facility. This message alerts the controller to the potential conflict and provides Conflict Resolution Data pertaining only to the uncontrolled aircraft. The Conflict Resolution Data represents the resolution advisory that ATARS would issue to the uncontrolled aircraft if it were to issue one at the time of the threat advisory. The Conflict Resolution Data can, therefore, be thought of as a preview of the resolution advisory that ATARS will issue if the geometry of the encounter remains the same as the aircraft converge. The controller observes the warning and may elect to maneuver the controlled aircraft to avoid the uncontrolled aircraft or issue an advisory on the traffic.

If the potential conflict continues to develop ATARS will issue a resolution advisory to the uncontrolled aircraft and will initiate a "Resolution Notification" message (Section 4.3.1.2) to the ATC facility indicating the resolution advisory issued to the uncontrolled aircraft. The controller is now aware that the indicated resolution advisory has been sent to the uncontrolled aircraft. At a later time if the potential conflict has still not been resolved, ATARS takes a final step, which is the issuance of a resolution advisory to the controlled aircraft and the issuance of the Resolution Notification to the ATC facility to indicate that a resolution advisory has been sent.

### 4.2.2 Controlled/Controlled Encounters

For encounters in which both aircraft are under ATC control, ATARS is intended to serve as a last-instant-back-up system. It is not intended to supplant the ATC system or routinely maneuver controlled aircraft. Its operation is very similar to the previously discussed encounter and the controller(s) are informed of ATARS actions through the Controller Alert Messages except that the Conflict Resolution Data provided within the Controller Alert Messages now pertains to the controlled aircraft and hence can be used by the controller as an aid in selecting some controller action if deemed appropriate.

## 4.3 ATARS-to-ATC Messages

The messages generated by ATARS for delivery via the DABS groundlink to ATC facilities are of two distinct types, operational and recording system messages, each of which is discussed in the following sections.

### 4.3.1 Controller Alert Message

ATARS-to-ATC operational messages can be classified as "Controller Alert Messages." They advise the controller of the state of potential conflict between two aircraft or between an aircraft and an obstacle, restricted airspace, or the terrain. For a Controller Alert Message to be issued at, least one aircraft involved in the potential conflict must be under ATC control. When a potential conflict involves more than two aircraft, ATARS will issue a separate Controller Alert Message for each pair. ATARS will continue to issue a Controller Alert Message as long as ATARS determines that conditions warrant the attention of the controller.

Functionally, a Controller Alert Message can be interpreted as having five states: (1) Conflict Resolution Data, (2) Resolution Notification (3) Terrain Avoidance, (4) Obstacle Avoidance, and (5) Restricted Airspace Avoidance, each of which will be discussed in the following sections. The data block format of the Controller Alert Message (References 1 and 6) contains: an 8-bit message type, the DABS ID or ATCRBS Mode 3/A code plus Surveillance File Number for each aircraft involved in the potential conflict, the control status and equippage (DABS/ATCRBS) of each aircraft, resolution fields containing the ATARS resolution advisory for each aircraft, and delivery status of the resolution advisories.

#### 4.3.1.1 Conflict Resolution Data

If ATARS projects a potential conflict with another aircraft within a predetermined lead time, the ATC facilities responsible for those aircraft will be alerted to the problem (Reference 6) by generation of a Controller Alert Message with Conflict Resolution Data. (If the ATC facility is equipped with its own conflict alert capability, the ATC software must be designed to handle the receipt of both messages.) For this message the delivery status fields would indicate that this message contained preliminary conflict resolution data and that ATARS had not attempted delivery to the aircraft involved. The message's resolution fields contain the ATARS resolution advisories which would be issued by ATARS if it were to resolve the potential conflict at this time.

4.3.1.2 Resolution Notification

If a conflict (involving at least one controlled aircraft) progresses to a more serious stage, ATARS will generate for uplink transmission, resolution advisories for the DABS equipped aircraft, and at the same time send the responsible ATC facility an alert message. The message's resolution fields contain the ATARS resolution advisories issued to each aircraft with delivery status fields indicating that delivery has been completed, or is currently being attempted.

4.3.1.3 Terrain Avoidance

If ATARS projects a potential conflict of a controlled aircraft with the terrain within a predetermined lead time, the responsible ATC faiclity will be alerted to the potential problem by the generation of a message indicating a Terrain Avoidance alert. At the same time the pilot will be issued a Terrain Avoidance Advisory by ATARS.

4.3.1.4 Obstacle Avoidance

If ATARS projects a potential conflict of a controlled aircraft with an aerial obstacle within a predetermined lead time, the responsible ATC facility will be alerted to the potential problem by the generation of a message indicating an Obstacle Avoidance alert. At the same time the pilot will be issued an Obstacle Avoidance Advisory by ATARS.

4.3.1.5 Restricted Airspace Avoidance

If ATARS projects that a controlled aircraft will be penetrating unauthorized airspace within a predetermined lead time, the responsible ATC facility will be alerted to the problem by the generation of a message indicating a Restricted Airspace Avoidance alert. At the same time the pilot is being issued an advisory by ATARS.

4.3.2 ATARS Recording System Messages

For administrative reasons, it is necessary to make a complete recording of ATARS-generated transactions. The recording system for these messages will be located at the ATC facilities and in the case of multi-site DABS configurations certain ATC facilities would house the recording system for more than one DABS site. Two types of messages are transmitted from DABS for recording purposes. Details of these messages follow.

#### 4.3.2.1 Duplicate ATARS Uplink Message

A "Duplicate ATARS Uplink Message" is generated by the ATARS processor for transmission to the ATC facility whenever an ATARS tactical uplink is generated for transmission to an aircraft. Note that advisories that are not actually transmitted, such as those for non-DABS equipped aircraft, are not included. The format of a Duplicate ATARS Uplink Message, except for the 8-bit type code, is precisely that of the ATARS-generated tactical uplink message that it duplicates. The DABS sensor, upon receipt of this message, routes it to the appropriate ATC facility which in turn routes the message to the ATARS recording system.

#### 4.3.2.2 Duplicate ATARS Message Delivery Notice

A "Duplicate ATARS Message Delivery Notice" provides for the recording of the technical acknowledgement/delivery failure of an ATARS uplink message. This type of message is generated within the DABS sensor which attempts uplink delivery, rather than within the ATARS function itself.

The message format is that of an ordinary message delivery notice, but with the addition of a "referenced sender ID" field. This field contains the sensor ID code of the originating ATARS. It will, therefore, match the implicit sensor code of the duplicate ATARS uplink message. This match, together with a match between the explicit "message number" and the "reference message number", enables message association.

The DABS sensor generates the duplicate delivery notice and routes it to the appropriate ATC facility at the same time that it generates an ordinary delivery notice and routes it to the originating ATARS. Upon receipt, the ATC facility routes the message to the ATARS recording system.

### 4.4. ATARS/ATC Site Adaptation

The ATARS fu ction located at each DABS sensor uses both the surveillance and data link capabilities of the network of sensors (to which it may be netted) to effect separation assurance of aircraft currently under surveillance. The nominal ATARS range is 90 nmi for horizontal resolution advisories, beyond this range resolution advisories will be limited to the vertical dimension due to increased errors in horizontal position and velocity estimates. However the particular areas of airspace for which ATARS services (traffic, and resolution advisories) are provided at a site are dependent on many factors such as on geographical constraints, the location of adjacent DABS sensors (if any), the number and types of ATC facilities being serviced, and the linking of the adjacent DABS sensors by ground lines (netting). Within ATARS there are many features which allow the separation assurance system to be adapted to the particular site configuration. These features provide additional services such as restricted airspace avoidance, and prevent high "unnecessary alarm" rates due to standard traffic patterns in the ATARS coverage area.

#### 4.4.1 ATARS Service Zone Map

In the case of a single DABS sensor providing surveillance for an isolated volume of airspace the ATARS Service Zone is simply defined as the DABS coverage area. (This definition is also true for adjacent sensors whose nominal ATARS Service Zones don't overlap.) Within a range dependent on DABS surveillance accuracy (nominally 90 nmi) ATARS will provide full conflict resolution service. Beyond this range resolution advisories will be limited to the vertical dimension due to increased errors in horizontal position and velocity estimates.

Interior to the ATARS service zone is a boundary, the BCAS Service Zone boundary, at which the airborne collision avoidance system known as the Beacon Collision Avoidance System (BCAS) is not allowed to perform active interrogations. As shown in Figure 4-2 the height of the floor of this boundary is established sufficiently above the DABS coverage floor so that BCAS would provide protection against any aircraft climbing at reasonable rates from below the coverage floor. Likewise, the position of the BCAS active interrogation boundary in range is established so that BCAS protects against threats with reasonable speeds approaching from beyond the ATARS service zone range boundary.

In the cases of multiple DABS sites, with overlapping ATARS Service Zones, another method of constructing the ATARS service zone boundaries must be used. First, a nominal ATARS service

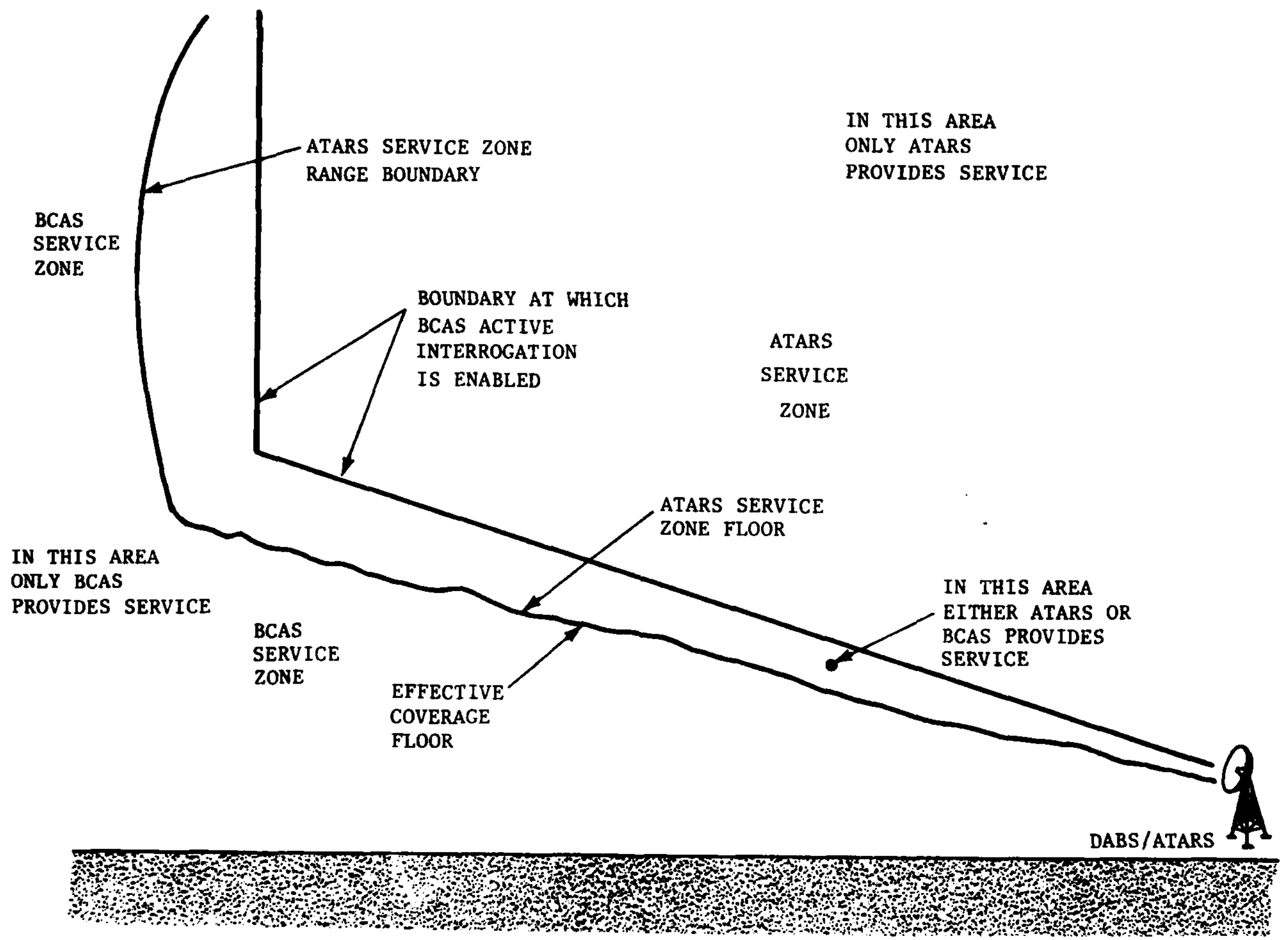



**FIGURE 4-2**
**SERVICE ZONE DEFINITION**

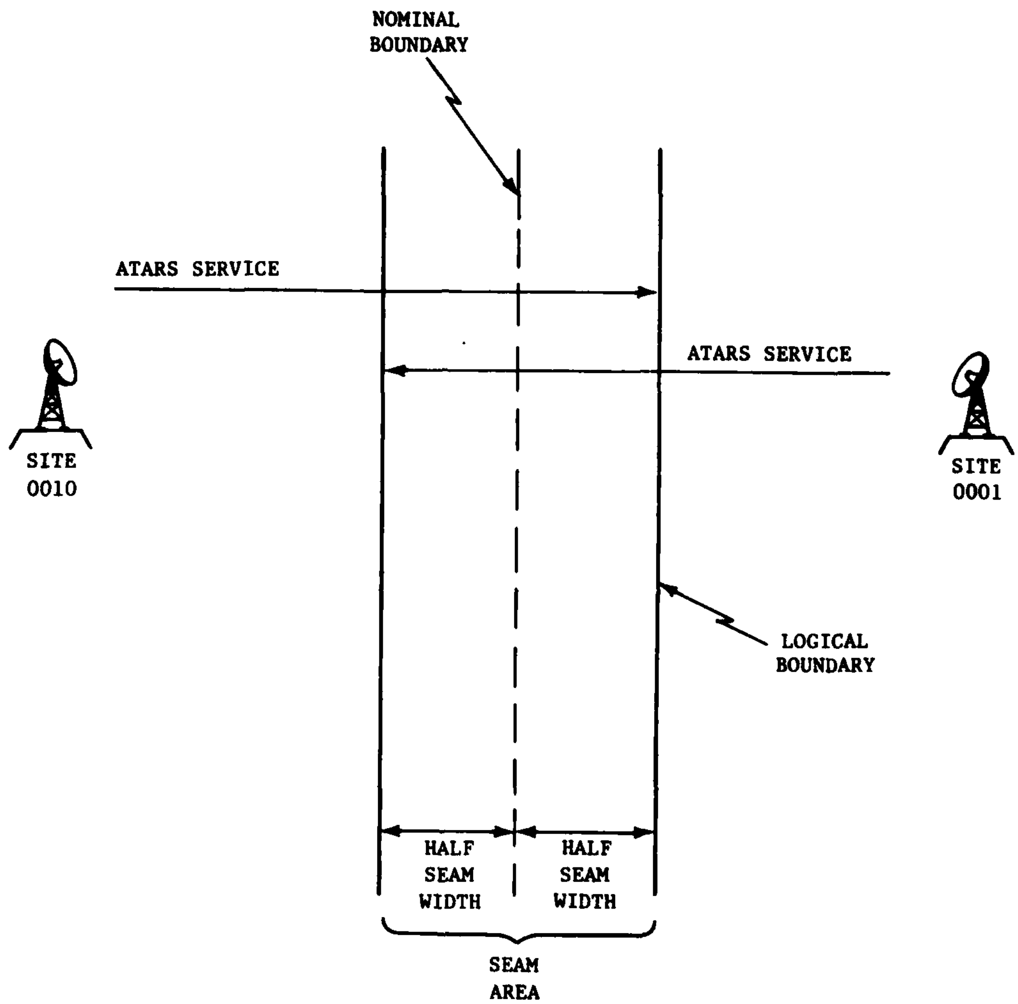



**FIGURE 4-3**
**ATARS BOUNDARIES AND SEAM AREA**

boundary (see Figure 4-3), must be chosen which provides division of ATARS conflict resolution responsibility for pairs of aircraft between the two DABS sites. (Location of this boundary is dependent on expected site loading and local terrain features, e.g., for sites with equal expected loads, the boundary could be placed at the intersection of the floor of coverage of the two sensors.) For ATARS to assure conflict resolution service to pairs of aircraft straddling this boundary, a seam area of overlapping coverage is created across this boundary. The width of this seam is chosen to allow timely detection of conflicts across the nominal boundary, plus a small increment to account for registration errors between the two sensors' perception of that boundary.

The ATARS logic and coordination between the adjacent ATARS determines uniquely which site will be responsible for a conflict that occurs in this seam area. However, the choice of the ATARS site ID's will determine the edge of the seam at which the "logical boundary" will be placed. (Note: This is not the DABS site ID, the only valid ATARS site ID's are 0001, 0010, 0100, 1000). As shown in Figure 4-3, the "logical boundary" is always the edge of the seam nearest the site with the lowest ATARS site ID. In general the site with the higher ID resolves conflicts on its side of the logical boundary, and the site with the lower ID solves conflicts on its side, as well as those with one aircraft on its side and one in the seam area. Figure 4-4 is an example of possible ATARS service zones for the Los Angeles Basin.

Additional ATARS Service Zone Maps must be created to account for the reconfiguration of the local ATARS Service Zone in the event of the failure of an adjacent DABS sensor. As a minimum a map for normal operation (no sensor failure) and one for each possible configuration with one adjacent sensor failed need be developed for each DABS site.

### 4.4.2 BCAS Performance Level Control Map

To insure that ATARS reolves all potential conflicts with ATCRBS aircraft within the ATARS Service Zone, the intersection of the ATARS Service Zone and the BCAS Service Zone (shown in Figure 4-2) must be mapped. The BCAS Performance Level Control Map performs this function and is created in the following manner. First the area of intersection is mapped into zones and is defined as the BCAS Performance Control Area. Within this area smaller zones are inserted to define areas of different BCAS

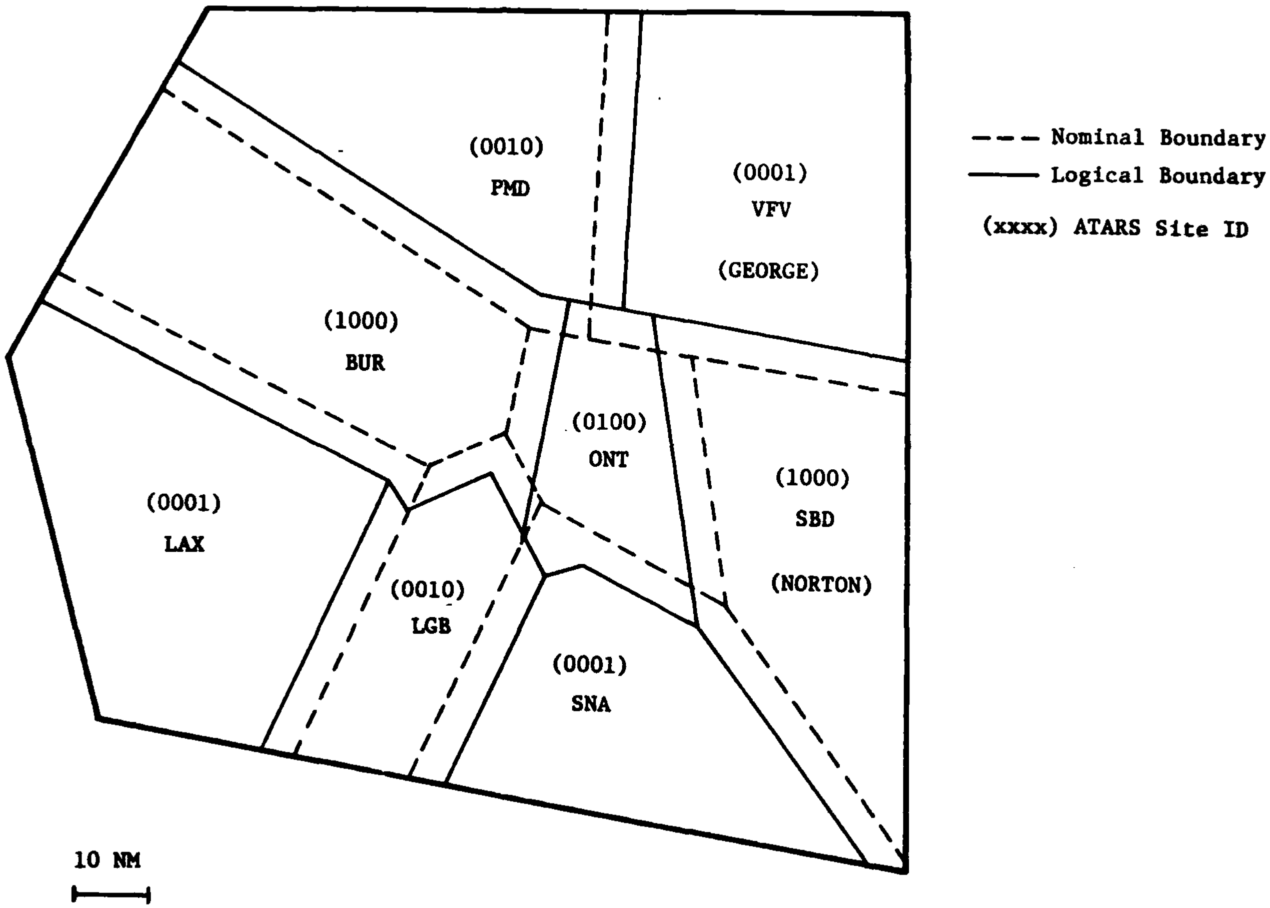



**FIGURE 4-4**
**ATARS SERVICE MAP LAX BASIN**

performance levels. These smaller zones represent the intersections of the BCAS Performance Control Area with the various ATARS Area Types defined in the ATARS Area Type Map.

### 4.4.3 ATARS Area Type Map

To reduce unnecessary alarms around the airport and airport approaches, ATARS provides for the establishment of airport area types. ATARS conflict detection considers the airport area type in determining the appropriate separation criteria and detection logic to be employed.

To achieve these goals it is necessary that an ATARS "Area Type Map" be created for each airport. This would basically consist of defining the airspace in which certain operations (which contribute to unnecessary alarms) occur. The separation criteria in each of these area types is site adaptable allowing ATARS to be "tuned" for each airport.

The ATARS detection logic allows for four different area types, with Area Type 4 having the largest protection volume, and Area Type 1 having the smallest. Area Type 1 encompasses the immediate vicinity of an airfield and is defined as a "right parallelpiped". Area Type 1, however, may be modified with "legs" or straight line segments that may be used to remove corners of the parallelpiped. Area Type 2 encompasses approach areas for each runway between specified altitudes and is also defined as a right parallelpiped. As part of the definition of Area Types 1 and 2, minimum and maximum altitudes must be specified. Area Type 3 is the balance of airspace within a cylinder whose base is centered on the airport and has a radius equal to a site selectable value of range. All airspace beyond Area Type 3 is defined as Area Type 4. Figure 4-5 gives an example of a two-dimensional representation of area types around an airport. For Area Types 1 and 2 the value of a site adaptable parameter determines whether or not "controller alerts" will be generated for conflicts occurring within these areas.

### 4.4.4 ATARS Final Approach Zone Map

Another feature of ATARS, which is site adaptable, is the definition of the "Final Approach Zone Map". The Final Approach Zone (FAZ) is a volume of airspace in which ATARS is inhibited from transmitting resolution advisories (pertaining to potential conflicts totally within the FAZ) to an aircraft. Basically,

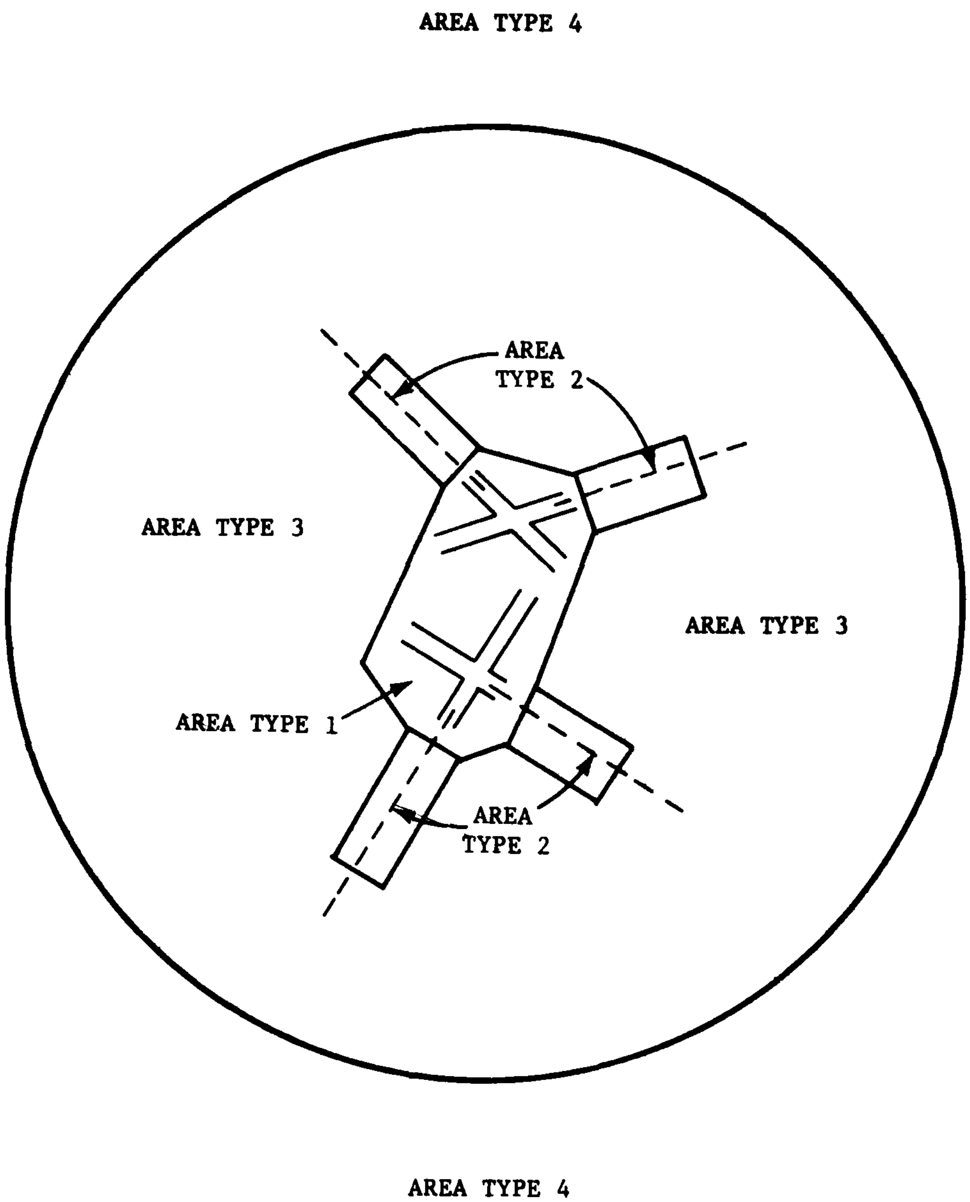



**FIGURE 4-5**
**EXAMPLE OF ATARS AREA TYPE MAP**

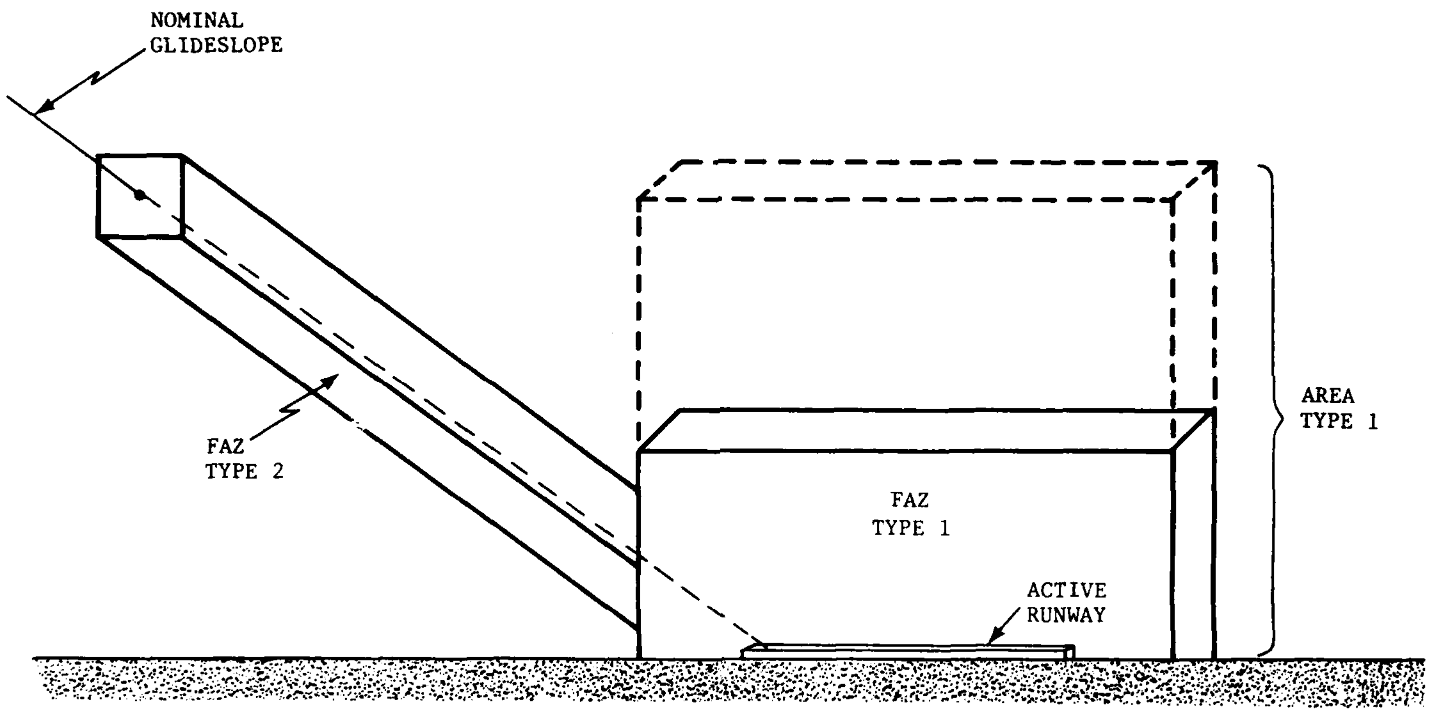



**FIGURE 4-6**
**FINAL APPROACH ZONE (FAZ)**

the Final Approach Zone is divided into two types, type 1 encompassing the airfield (and generally to a lower altitude than for Area Type 1), and type 2, encompassing a sloping rectangular region containing the normal approach path for each runway, see Figure 4-6.

### 4.4.5 ATARS Restricted Airspace Map

In order for ATARS to provide "Restricted Airspace Alerts" both to pilots and to controllers (if controlled aircraft are involved), it is necessary that for each DABS/ATARS site a Restricted Airspace Map be created. The map defines each volume of airspace that is restricted within the ATARS service zone and identifies each as to the type of restriction (TCA's, restricted military areas, etc.). The coded identity of each volume will enable ATARS to generate the proper alerts, such as "Restricted Airspace Entered" to the pilot and "ABC462 Has Entered Restricted Airspace" to the controller.

### 4.4.6 ATARS Terrain Elevation Map

The ATARS Terrain Avoidance function is dependent upon the definition of an ATARS "Terrain Elevation Map" for each DABS/ATARS site. Since the effectiveness of a terrain avoidance system (safety without excessive unnecessary alarms) is heavily dependent upon the quality of the terrain map, the ATARS's Terrain Elevation Map incorporates features which allow high resolution. Figure 4-7 shows that a variable cell size structure is used. As shown in the picture, geographical locations with large changes in altitude over a small area would be mapped with many small cells. Locations with relatively constant altitude over larger areas would be mapped with fewer larger cells.

### 4.4.7 ATARS Obstacle Avoidance List

In order for ATARS to provide "Obstacle Avoidance Alerts" both to pilots and controllers, it is necessary that for each DABS/ATARS site a list of the position and height of each obstacle (radio towers, skyscrapers, etc) within the ATARS service zone be created. ATARS then performs obstacle conflict detection for all aircraft within the service zone, and generates alerts to pilots and controllers (if controlled aircraft are involved) indicating the presence of a near obstacle.

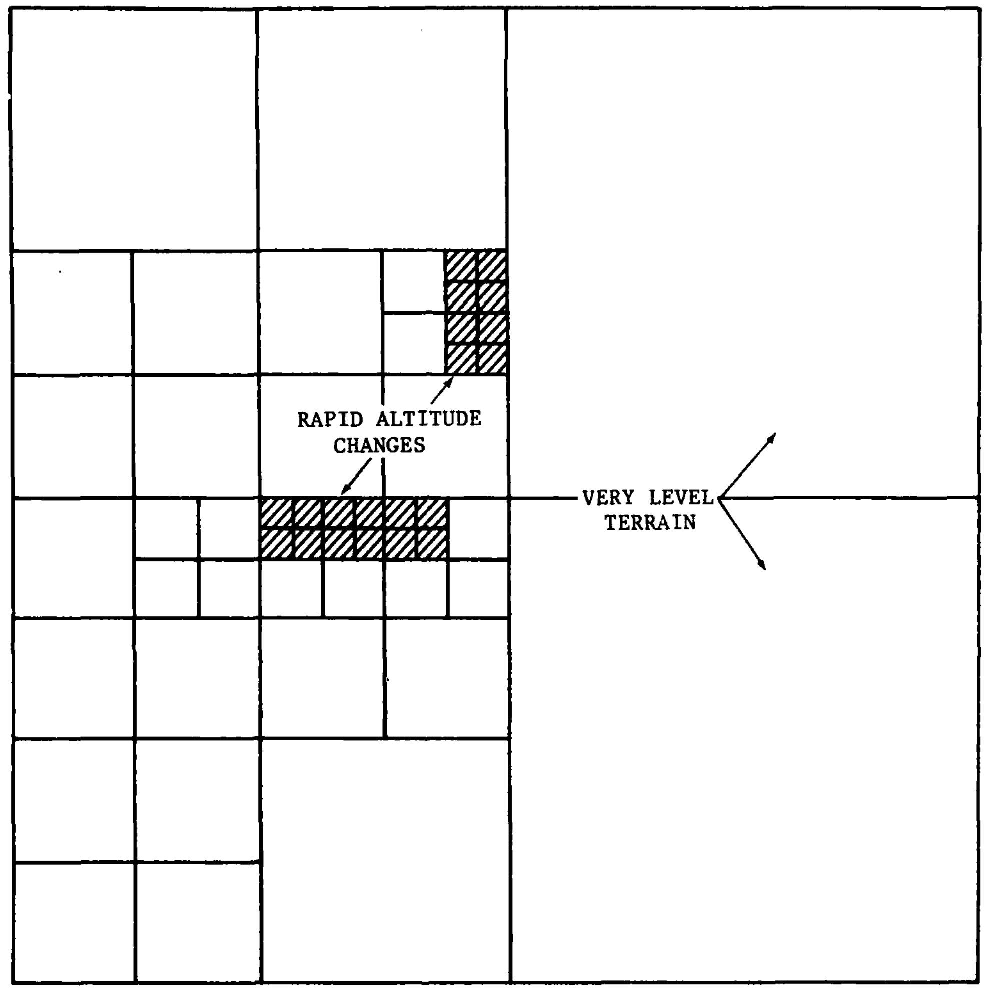



**FIGURE 4-7**
**EXAMPLE OF ATARS TERRAIN ELEVATION MAP**

#### 4.4.8 Diffraction Zone Map

Azimuth degradation due to diffraction around obstructions on the skyline has been shown to be a significant problem for ATARS. While data link contact can be maintained in these areas, the azimuth errors in some cases are so great as to preclude ATARS service. Therefore, a map will be maintained that can indicate when a target is in an area of known diffraction effects. The information required for this map is the azimuth of obstructions and elevation angle below which diffraction occurs.

### 4.5 Operational Considerations for Areas of Overlapping Terminal and En Route Sensors

To insure that ATARS provides separation assurance in areas of overlapping terminal and en route sensors additional factors must be considered. First, in the development of the ATARS Service Zone Maps (Section 4.4.1) for each site, the ATARS multi-site seam area must be sufficiently wide to preclude a conflict from occurring across the seam as shown in Scenario A in Figure 4-8. The ATC handoff seam is defined as the volume of airspace in which aircraft handoff between Terminal and En Route ATC facilities normally occurs plus additional airspace for late and early handoff. Next, the location of the ATARS multi-site seam is adjacent to the ATC handoff seam and is always on the side of the En Route coverage area. It should be noted that both horizontal and vertical seams are defined (see Figure 4-8.). The ATARS connected to the terminal facility will be responsible for all conflicts which occur in the handoff seam and will generate the appropriate advisories to the aircraft, and controller alerts to the ARTS facility. Upon receipt, the Terminal ATC facility relays a duplicate of the Controller Alert Message to the En Route facility sharing the handoff seam via the interfacility link between the Terminal and En Route facilities. If the En Route facility is controlling at least one of the aircraft, the Resolution Notification is displayed by the ATC computers to the controller. In the case where neither aircraft are controlled by the En Route facility the En Route computers discard the message.

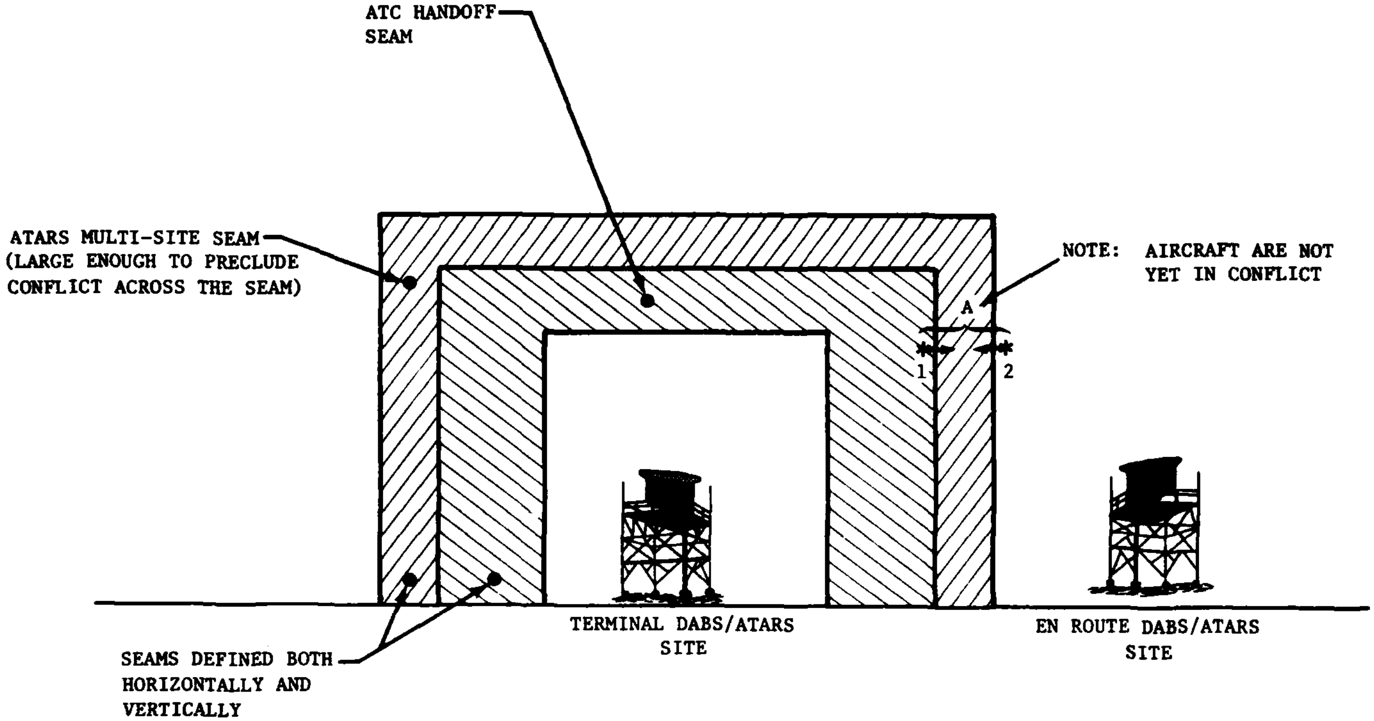



**FIGURE 4-8**
**RELATIONSHIP OF ATARS MULTI-SITE SEAM TO ATC HANDOFF SEAM AT A TERMINAL/EN ROUTE BOUNDARY**

## 5. STATUS AND CONTROL

### 5.1 General

The DABS sensor is designed such that, when deployed, maintenance personnel need not be stationed at, or near, the sensor. To support this "unmanned" maintenance concept, the DABS sensor will interchange certain status and control messages with the connected ATC facilities, and when implemented, the Remote Maintenance Monitor System (RMMS). The effect of these messages will be twofold: (1) indicate sensor performance to maintenance personnel for appropriate action and (2) support failure and recovery mode processing in order that surveillance, communications and ATARS services will continue, to the maximum extent possible, in the event of sensor or ATC facility failure (and recovery from failure).

In addition, certain messages will be sent from the ATC facilities to the DABS sensors to indicate control information needed for the normal operation of surveillance, communications and ATARS services.

Following is a description of the status and control messages which will be transmitted between the DABS sensor and the ATC facility.

### 5.2 Status and Control Messages

#### 5.2.1 Sensor Status Message

Each DABS sensor issues a Status Message once per antenna scan period to each ATC Facility (or RMMS) to which it is linked. (The format of this message is defined in Reference 1, and its information contents are specified in Reference 2.) Determination of sensor status is the task of the Performance Monitoring function within each sensor. Performance Monitoring will regularly perform many tests on the operation of other functions within the sensor, both hardware and software. For example, software checks will include overflow status of various queues and buffers, and the number of uplink messages delivered and expired. Among the hardware parameters checked will be transmitter peak power.

In addition, inputs will be included from Calibration and Performance Monitoring Equipments (CPMEs). These are transponder-like devices at known ground locations. CPME replies will provide a check on software and hardware relating to uplink modulation and transmission, downlink reply processing, and data link and surveillance processing, including position measurement calibration and surveillance report accuracy. All of these inputs will enter into a determination of the sensor status category (normal operation, marginal operation, or failure). The status category will also be issued by the sensor to adjacent connected DABS sensors. (In most cases the ATC facility will control sensor reconfiguration by issuance of a Sensor Failure/Recovery Message, Section 5.2.5). A failure status will cause the sensors notified to modify their surveillance/communications coverage areas and ATARS responsibility areas in a predetermined manner so as to take over (in regions of overlapping coverage) for the failed sensor.

The types of information which will be included in a Status Message are: sensor loading statistics (the number of DABS, ATCRBS and radar-only tracks), the status category of the sensor and its associated ATARS function and the specific conditions that resulted in any declaration of marginal or failed status. During non-normal status, the particular problem areas will be indicated in the message. Status messages sent to the ATC facilities will be routed to the output device of the responsible personnel. A flag contained in the message will indicate whether the current message has changed from the one sent in the previous scan. This feature will allow the ATC facility software to print only the messages which will have "change" indicated.

### 5.2.2 Test Message

A "Test Message" and the resulting response will comprise a transaction that can be initiated by an ATC facility. The message format will simply contain the 8-bit message identifier and a 48 bit free text field. A test transaction will serve to verify proper operation of the ground communications link and sensor software such as message routing and test response.

### 5.2.3 Test Response Message

The "Test Response Message" will be issued by the sensor in response to a Test Message. Its data format will consist of an 8-bit message identifier, and a 48-bit free text field which upon proper operation will echo the data sent in the corresponding "Test Message".

### 5.2.4 ATC Failure/Recovery Message

The ATC Failure/Recovery message is used to inform a DABS sensor and collocated ATARS of a change in operational status of a ATC facility. Its text will contain a message identifier along with a 2-bit data block that indicates failure, recovery from failure, or recovery from failure with loss of data base.

When a sensor is notified of an ATC facility failure the dissemination map of the sensor will be reconfigured to a new dissemination map based on the remaining ATC facilities connected in order for these facilities to provide backup operations. When a sensor is notified of the ATC recovery, the dissemination map will be restored to its original configuration.

### 5.2.5 Sensor Failure/Recovery Message

The Sensor Failure/Recovery Message will be initiated by the ATC facility (or RMMS) upon determination of a change in the status (failure/recovery) of a particular DABS sensor or sensor-to-sensor communications link. This message will be sent to all other DABS sensors sharing overlapping coverage with the particular sensor changing status. The receipt of this message by a DABS sensor may initiate reconfiguration of the sensor's coverage area and area of Primary status. The contents of the message will include the ID of the DABS sensor being reported and the status (failure or recovery) of the sensor or the sensor-to-sensor communications link.

### 5.2.6 DABS and ATCRBS Aircraft Control State Messages

The Aircraft Control State (ACS) Messages are sent by the ATC facility to indicate to DABS sensors which aircraft (DABS and ATCRBS) are under control of an ATC facility. The message will also be used to notify a DABS sensor of its Primary/Secondary status with respect to a controlled DABS aircraft. The assignment of Primary/Secondary status using the ACS message is discussed in Section 5.3.

The DABS ACS message format consists of the 8-bit message type, an "index" field indicating the number of aircraft referenced in the message for each aircraft control state and the DABS Address for each aircraft.

The ATCRBS ACS message format consists of the 8-bit message type, an "index" field indicating the number of controlled and uncontrolled aircraft referenced in the message and the Mode 3/A code and SFN for each aircraft.

### 5.2.7 Altimeter Correction Message

The altimeter correction message is generated by an ATC facility to provide altimeter corrections to DABS equipped aircraft in particular geographic areas based on changes in barometric pressure for those areas. This message is used to support the ATARS terrain avoidance function and the DABS altitude echo (ALEC) feature. The message contains the barometric pressure correction (in hundreds of feet) for a particular area. The number of such correction blocks in a message and the geographic interpretation of each correction is predetermined for a particular ATC facility-DABS sensor pair.

### 5.2.8 Track Alert Message

This message, reporting the detection of two aircraft with the same DABS Address, is discussed in section 2.8.3 and is listed here only for completeness.

## 5.3 Primary/Secondary Assignment

Regardless of whether the sensors are netted or non-netted, the Network Management function in each sensor (see Reference 3) will coordinate the network of DABS sensors to insure adequate surveillance and communications in areas of common coverage. Included in this function will be a task involving the cooperative management among sensors and the ATC facilities to which they are connected to assure that for a given DABS-equipped aircraft at a given time, only one sensor will be designated as "Primary". Among the DABS sensors, Primary status means that only that sensor will be permitted to carry out certain exclusive functions related to the particular DABS-equipped aircraft. These functions include the readout of pilot-originated downlink messages, the uplink of ground-originated ELM's, uplink of ATARS Traffic Service Advisories (Reference 6), and the management of DABS transponder lockout. Other sensors extending coverage to the aircraft will be designated "Secondary". Limited regions of dual Primary assignments for an aircraft may exist and be acceptable under certain circumstances between non-netted sensors. However, within the DABS coverage area, regions of airspace where no sensor is designated as Primary for an aircraft will not be permitted since the necessary functions pertaining to Primary status will not be performed.

Primary/Secondary (P/S) status may be unambiguously determined and maintained solely from information contained in each cell of the sensor's adapted coverage map, and sensor-to-sensor protocol. However, when data link services are introduced into the ATC system and sensor deployment results in considerable coverage overlap it will be necessary for the ATC facilities to designate which DABS sensor will be Primary for a particular DABS-equipped aircraft in order to insure aircraft-to-ATC data link connectivity. Not every DABS sensor extending coverage into the control boundary of an ATC facility will be necessarily connected to that facility and the coverage map may designate an unconnected sensor as Primary. It is therefore necessary for the ATC facility controlling a DABS aircraft to be connected to the sensor designated as Primary for that aircraft in order to provide a direct communications connectivity between that controlling facility and the aircraft.When a controlled DABS-equipped aircraft is within DABS sensor(s) coverage, the ATC facility which that sensor is serving will provide, to the sensor(s), information which allows each sensor to be appropriately designated Primary or Secondary for that particular DABS aircraft. This information will be communicated to the sensors via an ACS Message (see Section 5.2.6)., and the sensor will update the control state as indicated.

P/S assignment will be based on the control status of a DABS aircraft in each ATC facility. Since only one ATC facility at a time has control of an aircraft, this control status will be used as a basis for the ATC facilities to designate the P/S status of each sensor via the DABS ACS messages for the particular aircraft.

If a DABS sensor receives no explicit information from any ATC facility as to its Primary or Secondary status for a given DABS aircraft, or if an ATC facility explicitly designates the DABS aircraft as Uncontrolled, the sensor will determine the Primary/Secondary status from the location of the target relative to the adapted coverage map, and sensor-to-sensor coordination rules.

The information provided to the sensor indicating whether an aircraft is controlled or uncontrolled will also be used by the ATARS function.

A DABS ACS Message is initiated by the ATC facility and is sent to the DABS sensors under any of the following conditions:

1. Whenever an ATC facility assumes control of a new DABS aircraft. In this case, appropriate ACS data will be sent to each DABS sensor which is supplying surveillance data on the aircraft. A Terminal ATC facility can routinely assign its sensor "Primary" for all aircraft controlled by it.

2. Whenever there is a change in control state or Primary/Secondary assignment of an aircraft already under control. In this case, dissemination of the ACS data may be limited to those DABS sensors which have been supplying surveillance data and are therefore affected by the change. When an aircraft is handed off to another facility, the ATC facility relinquishing control will send the appropriate ACS assignment (e.g., "Controlled Secondary") to the DABS sensors providing surveillance data on that aircraft.

# 6. INTEGRATION OF DABS WITH THE AIR TRAFFIC CONTROL SYSTEM

The implementation of DABS will require certain modifications to the Terminal and En Route ATC systems in order to accommodate the improvements and features provided by DABS surveillance, utilize the integral data link capability for ATC purposes and interface with the ATARS function. The following sections provide descriptions of initial changes to the existing Terminal and En Route ATC systems for interface with the first deployment of DABS sensors. Section 6.1 describes the modified Automated Radar Terminal System (ARTS) and Section 6.2 describes the basic modifications to the En Route ATC System. The Terminal and En Route ATC systems have been modified at the National Aviation Facilities Experimental Center (NAFEC) to provide an experimental and developmental capability for interface with DABS. Changes to these systems are being evolved to develop and test future DABS/ATC software and to evaluate DABS-related activities (e.g., data link applications and ATARS). As a result of this ongoing research and development, functional requirements will be defined and the ATC system software for DABS modified accordingly.

## 6.1 Integration of DABS with the ARTS IIIA System

### 6.1.1 Overview

In the present ARTS IIIA system, existing terminal search and beacon radars provide only analog data to the ATC facility. Both the analog search and beacon data are then digitized in the ARTS, generating digital controller symbols and alphanumeric data blocks. The search data is digitized by the RDAS or MTD (depending on the particular ARTS configuration). The digital data generated by the ARTS IIIA processors is superimposed on the analog (video) search and beacon data and displayed to the controller on the ARTS Time-Shared Display.

DABS, however, is designed for integration with an all-digital ATC system. The Terminal ATC system for implementation with DABS, therefore, will be based on the Tampa-Sarasota ARTS All-Digital System with exceptions discussed in the following paragraphs. The Tampa-Sarasota System will be modified to provide for the processing of surveillance and communications data from a Terminal DABS sensor. Surveillance data processing will differ significantly from the current ARTS IIIA system: the track/report correlation, the tracking and the flight data association functions will be distributed between the DABS sensor and the modified terminal system. All track/datum correlation will be performed by the DABS sensor while the Terminal ATC system performs flight data association and tracking (i.e., track position and velocity prediction/update), utilizing a new tracker called the Thresholded Alpha Beta Gamma (TABG) tracker. This tracker is designed to take advantage of the increased accuracy of DABS.

The original ARTS enhancement plan called for the conversion to a Full Digital Display system (FDAD) in which the displays used would be equipped with vector generators. Using Full Digital Displays requires the digital generation of all data presented to the controller. With the scheduled implementation of DABS, the Full Digital Displays will not be available in time to be used with the early DABS/ARTS facilities. Therefore, the DABS/ARTS facilities at these early sites will continue to use the presently available Time-Shared Displays. The Time-Shared Displays do not contain vector generators nor do they have the capability to handle the total volume of digital data (e.g., target, weather and map) which would be required in a full digital mode of operation. Since DABS has been designed for an all-digital system, there will be no analog signals from DABS to provide a video display on the Time-Shared Displays in conjunction with the digital target and track symbology. Therefore, in order to accommodate this interim period during DABS implementation, a Video Reconstitutor will be provided to permit the continued use of the Time-Shared Display until future replacement with Full Digital Displays.

When DABS is integrated with an ARTS IIIA system, the MTD (or RDAS) associated with the ARTS will be located at the transmitter site. Digital search reports will be transmitted directly from the MTD (or RDAS) to DABS for correlation with beacon reports. The digital surveillance data, including search and beacon reports and weather messages, will be transmitted from DABS directly to the ARTS IIIA system (indicator site). The Video Reconstitutor will be used to convert the digital target reports from DABS to a representation of the normal beacon, search and weather map video signals to drive the existing ARTS Time-Shared Displays. The reconstituted video data will also be available as a backup mode during this period in the event of an ARTS computer failure.

The terminal system designed for implementation with the Time-Shared Displays will hereafter be referred to as the DABS/ARTS IIIA Time-Shared Display System (TSS)*.

The principal DABS/ARTS IIIA TSS hardware and software components involved with the acquisition, transmission, processing and display of surveillance (beacon and search) and with groundlink communications data are depicted functionally in Figure 6-1. This figure will be referred to in the following sections which provide more information on the DABS/ARTS IIIA TSS. Figure 6-2 is a functional diagram showing the subsequent integration of DABS with an all-digital terminal system.

The remaining sections describe the DABS/ARTS IIIA TSS for initial implementation with DABS. Additional capabilities will be added as requirements evolve.

6.1.2 Surveillance Input Processing

All DABS, ATCRBS and radar-only targets will be tracked by the DABS sensor. The DABS/ARTS IIIA TSS will be adapted as a non-correlating user by the sensor; therefore, the maximum attempt will be made by DABS to perform report/track correlation for ATCRBS and radar-only targets. Correlated beacon target reports (beacon reports containing a DABS Address and ATCRBS beacon reports containing a Surveillance File Number - SFN) will be transmitted to the DABS/ARTS IIIA TSS on the digital surveillance links labelled S1 in Figure 6-1. Additionally, with the integration of the collocated search antenna and MTD (or RDAS) at the DABS site, the target reports transmitted on link S1 may indicate that the beacon reports are radar reinforced or that the reports are Radar Substitution, or that the reports are correlated MTD (or RDAS) radar-only reports (i.e., correlated with a radar-only track and containing an SFN). Uncorrelated target reports will be transmitted from DABS to ARTS for display only. The digital target reports transmitted on Surveillance link S1 will be received at the DABS/ARTS IIIA TSS Communications Multiplexer Controller (CMC) and passed on to the Data Processing Subsystem (DPS). All DABS, correlated ATCRBS and correlated radar reports will be tracked by the DABS/ARTS IIIA TSS.

*DABS/ARTS IIIA TSS, in this document, refers to the modified ARTS IIIA hardware and software to process DABS sensor data, exclusive of the DABS sensor.

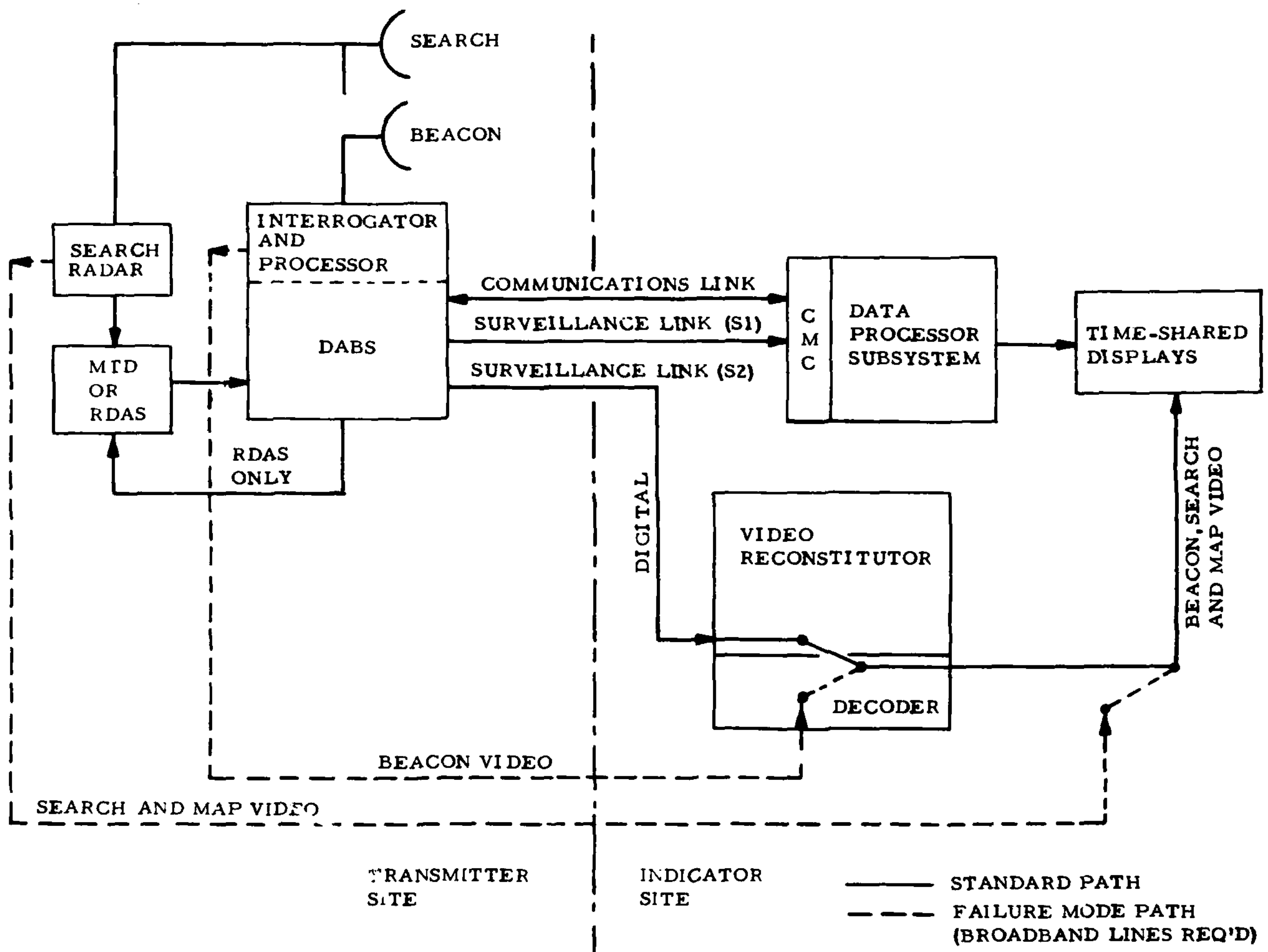



**FIGURE 6-1**
**DABS/ARTS IIIA TIME-SHARED DISPLAY SYSTEM**

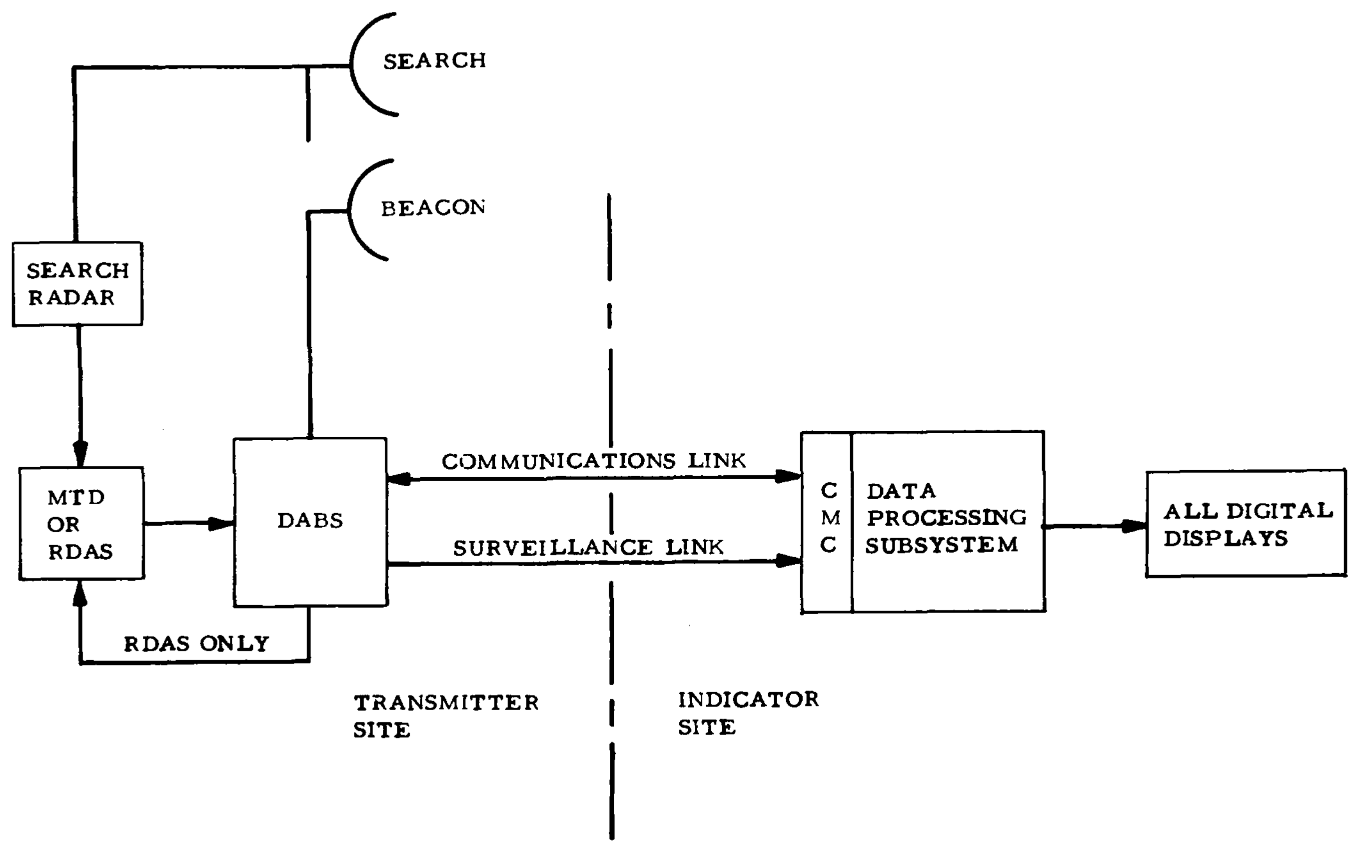
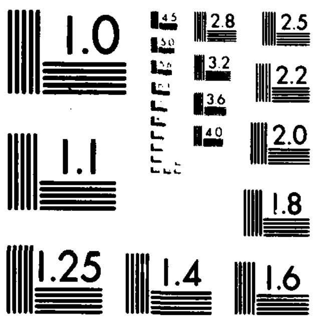



**FIGURE 6-2**
**ALL DIGITAL DABS/ARTS IIIA SYSTEM**

AD-A085 180 MITRE CORP MCLEAN VA METREK DIV F/G 17/7
DISCRETE ADDRESS BEACON SYSTEM/AUTOMATED TRAFFIC ADVISORY AND R--ETC(U)
APR 80 J E DIEUDONNE, R W LAUTENSCHLAGER DOT-FA80WA-4370
UNCLASSIFIED MTR-79W00436 FAA/RD-80-42 NL

2 - 2

END
DATE FILMED
6 80
DTIC




MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS 1963 A

Surveillance processing in the ARTS IIIA DPS will consist primarily of track file management and maintenance of proper flight data association between the correlated reports received from DABS and the tracks maintained in the Central Track Store of the ARTS.

For DABS reports (both Beacon and Radar Substitution), the processing will consist simply of matching the DABS Address in the report with the DABS Address of the respective DABS Class track in ARTS storage. If there is no track in storage with a matching DABS Address, a new DABS track will be initiated. For ATCRBS and radar-only reports, the key element in the report-to-track matching task will be the SFN. When a correlated ATCRBS or radar-only report is received from DABS, the ARTS processor will attempt to match the SFN in the report with a corresponding SFN for a track in storage. Again, if no match is found, a new track will be initiated - ATCRBS or Radar Class, corresponding to the report type. If an SFN match is found, several other checks will be made, as necessary, to further ensure that the match is correct, including a gross position check between the location of the report and the track. Reports which are received as correlated but otherwise fail these checks, will not be used further, but displayed to the controller as uncorrelated data.

All correlated reports (beacon and search) received from DABS will be tracked. A newly initiated track will be considered "unassociated" until such time as it becomes associated with a flight plan (either automatically or manually) or is manually assigned an aircraft flight identification. It will then be considered "associated". Unassociated and associated tracks will be displayed differently to the controller (the associated track usually denotes controlled status) and will be processed differently in some respects. For example, unassociated tracks will be dropped more quickly than associated tracks in the absence of correlated surveillance reports.

The DABS/ARTS IIIA TSS software processes target information on a sector (11.25 degree) basis. This is accomplished by using a special Northmark message, which is generated once per scan by the sensor, to dynamically compute the sensor scan period. The computed scan period is then divided into the 32 sectors.

### 6.1.3 TABG Tracker

When a correlated report is matched to its respective track, the report and track will be processed by the TABG Tracker. The TABG Tracker has been designed to use the increased accuracy and precision provided in the surveillance reports from DABS to produce track velocity estimates that are more accurate than those available from the current ARTS III tracker. The TABG Tracker will use "gamma" smoothing (i.e., take acceleration into account) requiring more accurate data than is available from th present ATCRBS sensors in order to improve tracking. The TABG Tracker will be used in the ARTS IIIA TSS to improve long-range predictions for functions (e.g., Conflict Alert and MSAW) where track velocity estimation accuracy is crucial to effective performance.

The TABG Tracker will provide these functions with a long-term smoothed estimate of each track's velocity. Additionally, it will provide predicted positions for coasting tracks. Since the tracker will require the use of the highly accurate surveillance data from DABS, additional precision will be maintained in the storage and computations involving surveillance data.

### 6.1.4 Communications Link Interface

All communications messages between the DABS sensor and the DABS/ARTS IIIA TSS will be transmitted on the two-way communications link. Both the receive and transmit channels of the communications link will interface with the CMC in the modified ARTS IIIA. Programs residing in the DABS/ARTS IIIA TSS will process the communications messages in accordance with the protocol and formats of the Common ICAO* Data Interchange Network (CIDIN). Processing for the following Surveillance-Related and Status Control type communications messages will be provided initially: ATCRBS ID Request, ATCRBS ID Code Message, Message Rejection/Delay Notice, Track Alert, Sensor Status Message, Test Message, Test Response Message, the Aircraft Control State Message and the Altimeter Correction Message. The application of these messages is described in subsequent sections.

The processing of additional message types will be included as implementation progresses and new requirements (e.g., for data link applications) evolve.

---

* ICAO - International Civil Aviation Organization.

### 6.1.5 Surveillance-Related Communications

The processing of the following DABS Surveillance-Related Communications messages will be provided for in the DABS/ARTS IIIA TSS: the ATCRBS ID Request, sent from ATC to DABS; the ATCRBS ID Code Message and Track Alert Message sent from DABS to ATC. Additionally, the Message Rejection Notice, sent by DABS, will be processed when it applies to an ATCRBS ID Request.

#### 6.1.5.1 ATCRBS ID Code

Track storage for a DABS-equipped aircraft maintained in the DABS/ARTS IIIA TSS will contain the aircraft's DABS Address and the respective Supplied Beacon Code.* The Supplied Beacon Code will be updated each time an ATCRBS ID Code Message is received for the track. The ATCRBS ID Code Message will be received either "unsolicited" from the DABS sensor (see Section 3.3.4.4) or in response to an ATCRBS ID Request (see Section 3.3.1.4). This latter "Request" will be based on a controller's manual input action or may be triggered automatically by the DABS/ARTS IIIA TSS software under certain conditions. The Supplied Beacon Code received as a result of a controller's action will be displayed specifically to the requestor. Other display provisions relative to the Supplied Beacon Code are described in Section 6.1.7.

The association between the DABS Address and Mode 3/A code provided in the ATCRBS ID Code Message will also be useful in aiding Flight Plan Processing as described in Section 6.1.6.

#### 6.1.5.2 Message Rejection Notice

The DABS/ARTS IIIA TSS will process a Message Rejection Notice if it is received in response to an ATCRBS ID Request resulting from a Controller's manual action. If the Message Rejection Notice indicates a rejection of the ATCRBS ID Request (the DABS-equipped aircraft is no longer on the sensor's roll call) or a delay of the anticipated ATCRBS ID Code Message (e.g., an air-ground link fade has occurred), then the reason (reject or delay) will be displayed to the requesting controller in the Message Readout Area.

---

* The Mode 3/A received in the ATCRBS ID Code Message for the respective DABS-equipped aircraft is referred to as the Supplied Beacon Code.

The contents of the Message Rejection Notice will not be displayed if it results from an automatically generated ATCRBS ID Request.

### 6.1.5.3 Track Alert Message

If the sensor detects two different aircraft with the same DABS Address (an unlikely event), it will send a Track Alert Message (see Section 2.8.3). The DABS/ARTS IIIA TSS will process the message in order to alert the controller to initiate a procedural solution (when this condition occurs, the DABS sensor prevents the duplicate tracks from being placed on roll call thus eliminating the use of data link).

The controller will be notified of the duplicate DABS Address condition via limited data blocks blinked at the coordinates (provided in the Track Alert Message) of each of the aircraft. The displays will continue as long as the condition exists and Track Alert Messages are received; however, the controller may inhibit the alert display.

### 6.1.6 Flight Plan Processing

The DABS/ARTS IIIA TSS will process flight plans and amendments for DABS-equipped aircraft which may contain either the DABS Address or the Assigned Mode 3/A Code individually or which contain both the DABS Address and the Assigned Mode 3/A Code. Flight plans for DABS-equipped aircraft will be processed analogously to the way they are processed in the present ARTS IIIA system for ATCRBS-equipped aircraft. If a DABS Address is contained in a flight plan, a match of the DABS Address directly from a DABS beacon report will be used to establish an associated DABS Class track.

The flight plan for a DABS-equipped aircraft, however, will not need to contain a DABS Address (the flight plan then will be identical to those currently in use for non-DABS aircraft). In this case, the use of the ATCRBS ID Code Message will permit an unassociated DABS track to be associated with a flight plan which does not contain a DABS Address. The "Supplied Beacon Code" (see Section 6.1.5.1), received in the ATCRBS ID Code Message for an unassociated DABS track, when discrete, will be compared with the Assigned Mode 3/A Code* of each unassociated flight plan. When a match is found,

*The Assigned Mode 3/A Code is usually automatically determined within the ATC system and generally unchanged for major portions of the flight. It is communicated to the pilot, via voice, prior to takeoff and subsequently during the flight if a code change is necessary.

automatic track association will be attempted using the same time and distance proximity checks as performed in ARTS IIIA for ATCRBS Class track associations, but with the Supplied Beacon Code treated as if it were the ATCRBS Mode 3/A Code received in a surveillance report. If the DABS track associates, the respective flight plan in storage will be updated with the corresponding DABS Address.

By not requiring the entry of a DABS Address in a flight plan, external interface requirements, and thus implementation, will be simplified. Not imposing this constraint will permit the DABS/ARTS IIIA TSS to interface with other facilities whether or not they have been modified to accommodate the DABS Address. It will also alleviate the necessity for flight plans derived from Bulk Store to include a DABS Address. The use of the variable flight identification available from appropriately equipped aircraft via the DABS data link, as described in Section 2.8.2, will also be included to aid Flight Plan processing in future versions of the DABS/ATC Terminal System.

### 6.1.7 Controller Operational Inputs and Digital Displays

The keyboard entries and digital displays for tracked ATCRBS-equipped aircraft, radar-only tracks, uncorrelated ATCRBS targets and uncorrelated radar targets in the DABS/ARTS IIIA TSS will be essentially similar to the keyboard entries and digital displays in the ARTS All-Digital System for Tampa-Sarasota. To accommodate DABS, the keyboard entries applicable to ATCRBS tracks will be expanded to apply to DABS tracks as well. Also, the digital displays for DABS-equipped aircraft will be identical to the digital displays for ATCRBS-equipped aircraft with some exceptions to enable the distinction of DABS targets and to provide for the display of the DABS Address. These differences in keyboard entries and displays, related to DABS, are briefly described below:

1. Beacon Readout Entry

A Beacon Readout entry may be applied to a DABS track as well as an ATCRBS track. If the entry is taken for an unassociated (uncontrolled) DABS track, a Limited Data Block will be displayed as for an ATCRBS beacon track except that the DABS Address will be displayed in place of the Mode 3/A code. If the action is applied to an associated (controlled) DABS track, the track's Aircraft Identification (ACID), DABS Address, Assigned Mode 3/A code and Supplied Mode 3/A code will be displayed in the Readout Area. A Beacon Readout for a DABS track will also result in the transmission of an ATCRBS ID Request to the DABS sensor.

2. Entries Using Aircraft Identification

As an option to using the trackball to identify a track, the capability will exist to identify ATCRBS-equipped aircraft by use of the four digit Mode 3/A code in certain keyboard entries (e.g., Track Start, Track Drop, Track Suspend, Track Handoff, Track Reposition). DABS-equipped aircraft, in the modified system, may also be referenced by these keyboard inputs except that the DABS Address would be used in place of the Mode 3/A code.

3. Flight Data and Flight Plan Related Entries

The capability will be provided to enter the DABS Address as well as the Assigned Mode 3/A code for these entries also.

4. Position Symbol

The position of a DABS report which correlated with an unassociated DABS track or a DABS report which is untracked will be uniquely identified with a hexagon (⬡). Unlike ATCRBS aircraft, where special symbols distinguish between Mode C and non-Mode C, the ⬡ symbol will indicate Mode C.

The position symbol for a Radar Substitution report (DABS or ATCRBS), whether uncorrelated or correlated with an unassociated track, will be identical to the symbol displayed for a radar-only report in the Tampa-Sarasota All-Digital System.

5. Mode 3/A Code

The DABS ARTS IIIA TSS will provide the capability to monitor the Mode 3/A code of a DABS track by using the information provided in the ATCRBS ID Code Message. When differences are detected between the Mode 3/A code received in the ATCRBS ID Code Message (the Supplied Beacon Code) and the Mode 3/A code assigned to the DABS track, the controller will be notified on the display.

The blinking display will be the same as is provided in the present ARTS IIIA system when the Mode 3/A beacon code of the datum correlated to a track is not equal to the track's Assigned Mode 3/A Code, except that in the DABS/ARTS IIIA TSS the Supplied Beacon Code will be treated as if it were the Mode 3/A code of a correlated ATCRBS beacon report.

6. Coast/Suspend List

DABS Class tracks in the Coast/Suspend List will be displayed identically to coasted or suspended discrete code tracks except that a hexagon (⬡) will also be displayed to denote a DABS track.

7. Arrival/Departure Tabular List

DABS Class tracks in the Arrival/Departure List will be displayed in a manner similar to ATCRBS tracks except that the DABS Address, instead of the discrete Mode 3/A beacon code, will be displayed along with the ACID.

8. Full Data Block

The Full Data Block (FDB) for DABS and ATCRBS tracks will be identical to the FDB in the Tampa-Sarasota All-Digital System. However, if a Radar Substitution message is correlated with a DABS/ARTS track, "RDR" (radar) will be displayed blinking (as in the present Tampa-Sarasota System) in Field 2 of the FDB.

The video display of target and weather data processed through the Video Reconstitutor is described in Section 6.1.11.

6.1.8 Status and Control Message Processing

The Status and Control Messages (see Section 5.) to be processed initially by the DABS/ARTS IIIA TSS are: Sensor Status Message, Test Message and Test Response Message, Aircraft Control State Message (DABS and ATCRBS) and the Altimeter Correction Message.

As DABS implementation progresses and a high degree of overlapping DABS coverage occurs and a number of contiguous DABS/ATC facilities exist, processing for the Sensor Failure/ Recovery Message and the ATC Failure/Recovery Message will be included. The processing for these messages, in conjunction with the other Status and Control Messages, will be determined by the requirements for an integrated DABS/ATC facility failure and recovery mode processing capability interfaced with the Remote Maintenance Monitoring System (RMMS).

### 6.1.8.1 Sensor Status Message

A Sensor Status Message (Section 5.2.1) will be received once each scan from DABS; the contents of this message will be stored by the DABS/ARTS IIIA TSS when received. Under certain conditions (e.g., if a significant change in DABS sensor status occurs or a missing status message is detected), an automatic printout displaying the appropriate information will result. Additionally, an operator at the supervisory position will be able to request a printout of the entire contents of the last stored Sensor Status Message.

### 6.1.8.2 Test and Test Response Message

A Test Message (Section 5.2.2) sent from the DABS/ARTS IIIA TSS to DABS will be used as a means of verifying proper communications operation between the two systems. A Test Message may be initiated by an operator's manual action or it may be generated automatically by the software in response to certain conditions (e.g., ARTS Startover or no messages sent on the communications link for an adapted period of time). Upon receipt of the Test Message, the DABS sensor will repeat the contents of the Test Data field received in a Test Response Message (Section 5.2.3) sent back to ARTS. The DABS/ARTS IIIA TSS will output the appropriate information to the operator depending upon the comparison of the data received with the data sent.

### 6.1.8.3 Aircraft Control State Message

Processing related to the Aircraft Control State (ACS) Message (Section 5.2.6) will be a locally controlled option in the DABS/ARTS IIIA TSS. (If it is not initially required at a particular facility, it may be turned off.) The DABS ACS Message will indicate to the DABS sensor the control status (Controlled Primary, Controlled Secondary, Uncontrolled) of each DABS-equipped aircraft tracked by the DABS/ARTS IIIA TSS. Similarly, the ATCRBS ACS Message will indicate the control status (Controlled, Uncontrolled) of each tracked ATCRBS-equipped aircraft.

The DABS/ARTS IIIA TSS will determine and maintain the ACS status for each DABS track under its control. Basically when a DABS-equipped aircraft (track) becomes controlled by the terminal facility, an ACS Message will be sent automatically to the sensor, designating the respective DABS track as Controlled Primary. Conversely, if a controlled DABS track reverts to an uncontrolled status after having been controlled (e.g., track handed-off to another ATC facility or a track association is dropped), the DABS/ARTS IIIA TSS will send an ACS Message to the sensor designating the respective DABS track as Uncontrolled or Controlled Secondary depending upon the particular cause for the change in control state.

The DABS/ARTS IIIA TSS will examine the P/S (Primary/Secondary) status bit (see Section 5.3) in each DABS beacon message received for a controlled DABS track to assure that the sensor is properly maintaining the status of Primary for the respective DABS-equipped aircraft. If it is not (i.e., P/S Status bit set to S instead of P), an ACS Message will be sent to the sensor to again designate the respective DABS track as Controlled Primary.

The DABS/ARTS IIIA TSS will also determine the control status for each ATCRBS Class track under its control. In this case only the Controlled and Uncontrolled status is determined for a particular track and transmitted to the sensor along with the Mode 3/A Code and SFN.

#### 6.1.8.4 Altimeter Correction Message

The Altimeter Correction Message (Section 5.2.7) will be sent to the DABS sensor as required. One altimeter setting value, which covers the terminal controlled airspace will be maintained by the DABS/ARTS IIIA TSS. An altitude correction factor, based on this altimeter setting value, will be sent to DABS in the Altimeter Correction Message whenever the altimeter setting value is changed or after a communication link startup or startover.

### 6.1.9 Data Link Applications

The transmission of Minimum Safe Altitude Warning (MSAW) alerts to appropriately equipped aircraft is a possible early application of the DABS data link in the DABS/ARTS IIIA TSS. A description of this application is contained in Section 3.5.1.

In order to accommodate ground-air data link applications, it will be necessary for the controller (and the ATC automation system) to know whether or not an aircraft is equipped for data link. The extent of the equippage must be known to the ATC facility in order to determine whether the aircraft is capable of receiving a particular type of message. This information will be provided in the Data Link Capability Message (Section 3.3.4.3) which will be sent by the sensor, automatically when DABS first acquires the aircraft, or in response to the Data Link Capability Request (Section 3.3.1.6). When data link applications are provided, it will also be necessary for the DABS/ARTS IIIA TSS to process additional messages related to the status of the message delivery. These messages are the Message Rejection/Delay Notice (Section 3.3.3.1), Message Delivery Notice (Section 3.3.3.2) and Message Cancellation Request (Section 3.3.1.5) as applied to uplink messages generated by an ATC facility. The capability to process these messages will be included in conjunction with the particular data link application to be supported. In addition, appropriate displays will be provided to indicate to the controller the status of the message delivery and, if applicable, whether or not standard voice communication of the uplinked message is necessary in the event of a delay or non-delivery.

#### 6.1.10 Interface with the Automatic Traffic Advisory and Resolution Service (ATARS)

A description of this interface is provided in Section 4.

#### 6.1.11 Video Reconstitutor

A separate digital surveillance link, labeled S2 on Figure 6-1, will be provided by the DABS sensor to transmit surveillance messages to the Video Reconstitutor. ATCRBS Beacon, Radar Substitution, Radar Reinforced Beacon, Radar-only messages and Weather Map messages will be transmitted on this link. These messages will be sent while corresponding messages are simultaneously being sent to the CMC on link S1. The formats will be identical to the surveillance formats transmitted to the CMC with the exception of the DABS surveillance target messages (containing the DABS Address), which are not sent. Instead, reports on DABS aircraft generated by the sensor will be converted to an equivalent ATCRBS beacon message prior to transmission to the Video Reconstitutor. The Mode 3/A code used on this ATCRBS message will be derived from the Mode 3/A code setting of the respective DABS transponder. Converting the DABS Address to the respective Mode 3/A code will be done to permit beacon code filtering by the Video Reconstitutor decoder. The procedure described elsewhere in this document for the DABS sensor to acquire, store and update the Mode 3/A code value of a corresponding DABS Address will be employed to maintain the Mode 3/A code current.

The Video Reconstitutor will convert the digital target reports to normal analog beacon (Mode 3/A and Mode C), search and weather map video signals. These signals will then be used to drive the existing ARTS Time-Shared Displays. The Video Reconstitutor will generate beacon signals for the digital ATCRBS beacon messages received and search video signals for the Radar-only, Radar Substitution and Radar-Reinforced beacon messages. The Video Reconstitutor can be procured with or without a beacon decoding function. The beacon decoder will enable beacon code filtering for the displayed video symbols.

The display symbology resulting from the reconstituted video will be similar to the video symbology on the current Time-Shared Display. However, the run length of both the beacon and search symbols will be fixed to independently preset (adjustable) values which are centered on the range and azimuth values provided in the digital surveillance reports. Additionally, if the Video Reconstitutor is purchased without the decoding function, a single slash will be displayed for each detected bracket pair and an additional slash displayed for SPI.

Weather will be displayed as high and low intensified areas which encompass the respective weather. These areas will be generated on the basis of the azimuth, start and stop ranges and the high/low intensity indicator provided in the received digital weather message. It should be noted that the corresponding digital weather map messages transmitted on Surveillance Link S1 to the CMC will be discarded by the DABS/ARTS IIIA TSS.

### 6.1.12 Broad Band Backup

A backup mode can be provided in the unlikely circumstance that there is a failure in the digital portion of the DABS sensor, or of the links between DABS and ARTS, resulting in the loss of digital data from DABS. In this event, the failure mode path shown in Figure 6-1 will be used and a switch in the Video Reconstitutor will be set to receive video inputs rather than digital inputs. The DABS sensor will be switched to operate as a conventional ATCRBS interrogator and provide raw beacon video, based on standard beacon interrogation and reply signals. This beacon video will be passed through the Video Reconstitutor. Likewise, the search radar will provide search and map video to the Reconstitutor. These video signals, rather than the reconstituted digital signals, will then be used to drive the Time-Shared Displays.

## 6.2 Integration of DABS with the En Route ATC System

### 6.2.1 Overview

During the time period of the initial stages of DABS deployment, the basic architecture of the En Route ATC System (i.e., using the 9020 computers) will remain unchanged from the present. Initial integration of DABS with En Route ATC facilities will therefore necessitate modifications to the current (9020) software system.

The following sections provide a general description of the modifications to the En Route ATC facility software required for the initial, basic integration with DABS. The system will be referred to, herein, as the DABS/En Route ATC System. Additional capabilities will be added as requirements are defined.

The modified ATC facility software will have the capability to process, track and display surveillance data on DABS-equipped and ATCRBS-equipped aircraft received from multiple, mixed DABS and ATCRBS sensors. Surveillance data processing (track/datum correlation and tracking) and display of data derived from DABS, ATCRBS and search target reports received from DABS will be similar to the processing performed in the current En Route ATC System for target data received from ATCRBS sensors.

Surveillance-related communications will be used to support the processing of DABS beacon reports. Processing of communications messages according to the CIDIN protocol and formats will be accomplished in a DABS Communications Front End Processor (FEP). The interface between the FEP and the 9020 computers, however, will be handled in the DABS/En Route ATC system by a communications protocol function. Processing of DABS data for the Real Time Quality Control (RTQC) function for surveillance will be similar to the processing in the current system for data originating from ATCRBS sensors.

Figure 6-3 shows an overall diagram of the DABS/En Route ATC System connected to DABS and ATCRBS sensors.

### 6.2.2 Surveillance Processing

The En Route ATC System will be modified to accept, process and display surveillance reports from DABS sensors in addition to its current capabilities with respect to processing surveillance reports from ATCRBS sensors. The surveillance reports from the DABS sensors which will be processed are: DABS beacon reports derived from DABS-equipped aircraft, ATCRBS beacon reports derived from ATCRBS-equipped aircraft, CD Search reports and Radar Substitution reports based on CD search data. If a DABS Terminal Sensor is interfaced with the DABS/En Route ATC System, the capability will also be provided to process MTD (or RDAS) Search Reports and Radar Substitution Reports based on MTD (or RDAS) reports. Surveillance reports received from DABS sensors will be processed identically to those received from ATCRBS sensors except for the differences to accommodate the new message formats and processing of DABS reports on DABS-equipped aircraft (i.e., containing a DABS Address for identification).

The precision maintained in the present En Route ATC software for data storage and computations involving position and velocity will remain unchanged in the initial DABS/En Route ATC System. This will be done to avoid the extensive changes to existing instructions and the increased storage necessary to accommodate the additional precision provided in the surveillance reports from DABS. The changes are not justified initially because the ATC system will be processing the combined surveillance data from DABS and ATCRBS sensors.

Each DABS sensor will adapt the DABS/En Route ATC System as a correlating user for dissemination purposes (i.e., the ATC facility does its own track/report correlation and does not rely on the SFN in an ATCRBS beacon or radar message from DABS for correlation purposes). Further, the option to disseminate front-face (beacon and search) data only will be selected. This option will be selected to avoid increases of the surveillance data load to the DABS/En Route ATC System from each En Route DABS sensor with the back-to-back antenna configuration.

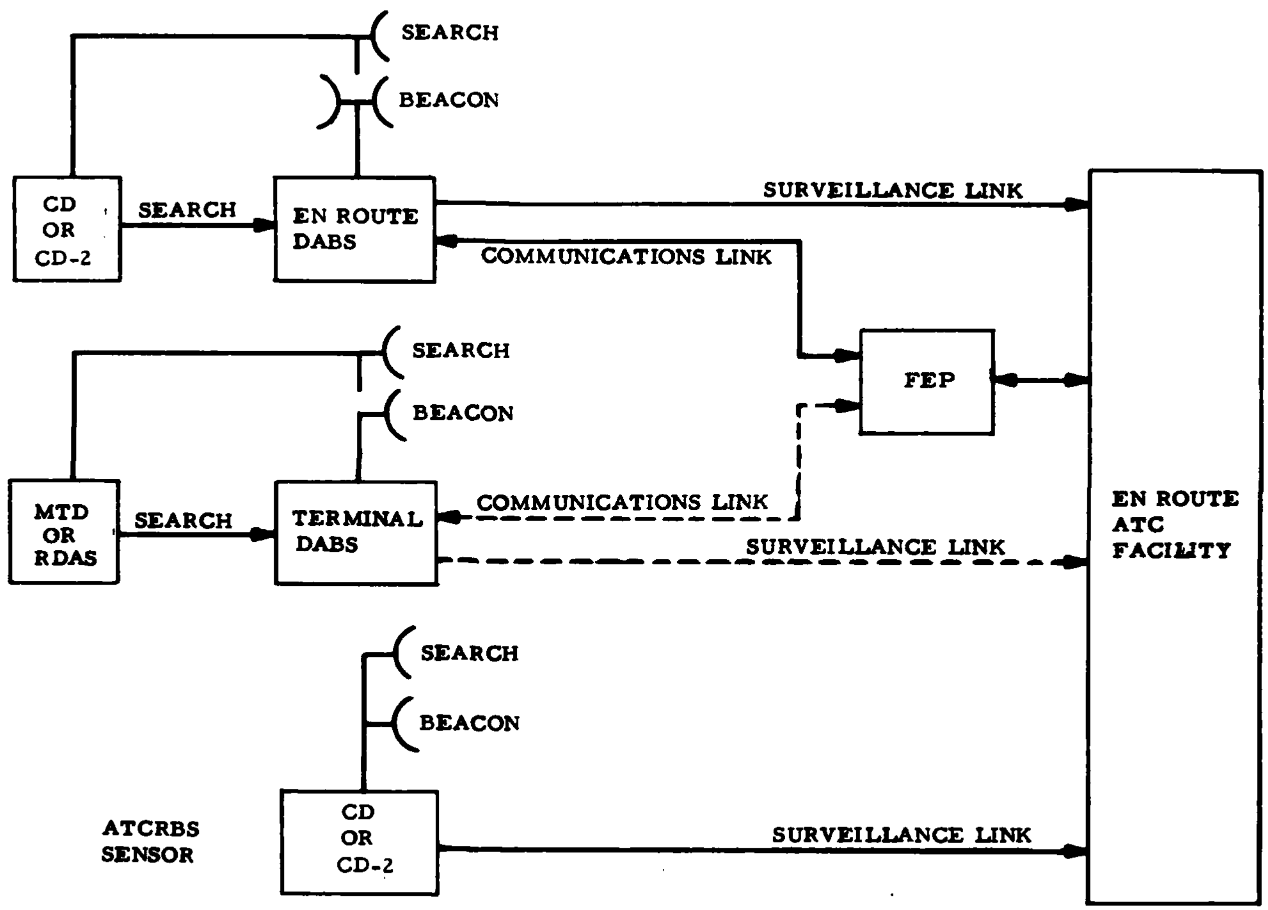



FIGURE 6-3
DABS/EN ROUTE ATC SYSTEM

#### 6.2.2.1 ATCRBS Beacon Reports and Search Reports

ATCRBS beacon reports from DABS will be processed, correlated and displayed the same as ATCRBS beacon reports from ATCRBS sensors. Input processing, of course, will recognize the different message formats. Likewise, search reports and Radar Substitution reports will be correlated, tracked and displayed identically to the way CD search reports received from ATCRBS sensors are. If a Terminal DABS sensor is connected, reformatting to the CD Search format will be necessary for MTD and RDAS Search reports and Radar Substitution reports. Additionally, to account for the lack of run length information in target reports derived from the MTD or RDAS, an equivalent short/long run length decision, for track/report correlation purposes and display, will be made on the basis of the value of the MTD (or RDAS) Confidence field (i.e., a high Confidence report will equate to a report with a long run length).

#### 6.2.2.2 DABS Beacon Reports

A new input procedure will be used to accommodate the processing of the 24-bit DABS Address in a DABS beacon report. The key to this procedure will be a DABS association table which will associate each DABS Address in the DABS/En Route ATC System with its respective Supplied Mode 3/A ATCRBS Code and when tracked, the track identifier. The procedure to correlate DABS beacon reports to tracks will use this table. The DABS association table will also be used to convert the DABS Address to the equivalent Mode 3/A code for display (e.g., Limited Data Block) and display filtering purposes. The minimum input to start an entry in the DABS association table will be a DABS beacon report. If it is the first message received containing a given DABS Address, an entry will be opened and an ATCRBS ID Request issued to the sensor. The Supplied Mode 3/A code contained in the responding ATCRBS ID Code Message will then be related to the DABS Address in the table. The Supplied Code will be updated and maintained current whenever an ATCRBS ID Code Message is received for the respective DABS Address, whether requested by the ATC facility (via an ATCRBS ID Request) or received unsolicited as a result of the sensor automatically triggering the "request" to the DABS-equipped aircraft.

### 6.2.3 Communications Link Interface

All communications messages transmitted on the two-way link between each DABS sensor and the DABS/En Route ATC System will be processed by the Front End Processor (FEP) located at the ATC facility. The FEP is a DABS communications message processor which will provide for translation between the CIDIN protocol and the message formats used on the communications links, and a FEP/9020 protocol function which will be included in the DABS/En Route ATC software. The FEP concentrates the multiple DABS communications link interfaces into a single interface with the DABS/En Route ATC System. The FEP will provide the capability for addressing messages to the desired DABS sensor and for identifying the source of inputs to the ATC facility. Additionally, the FEP will provide information to the DABS/En Route ATC System regarding the status of the FEP and the status of the communications links between the FEP and each DABS sensor. The FEP interfaces with the General Purpose Input (GPI) and General Purpose Output (GPO) adapters located in the 9020 Peripheral Adapter Modules (PAMs). A single two-way data interface will be used between the FEP and the PAMs.

The FEP/9020 Protocol function will provide the interface between the other application computer programs and the FEP. This Protocol function will receive and error-check messages from DABS which are used by other functions (e.g., surveillance processing, data link applications). Also, the FEP/9020 Protocol function will format, for output to the sensor, communications messages from the appropriate En Route functional software. The Protocol function will maintain the specific message number sequence used for each aircraft-sensor combination being serviced. A 4-bit message number, the DABS Address and the sensor address will unambiguously identify each message.

Initially, processing will be provided for the following communications message types transmitted between the sensor and the DABS/En Route ATC System: ATCRBS ID Request, ATCRBS ID Code Message, Message Rejection Notice applied to the ATCRBS ID Request, Sensor Status Message, Test and Test Response Message, Track Alert Message and Altimeter Correction Message. The processing of these messages in the DABS/En Route ATC System is briefly described in the following sections. Processing for other communications messages will be included when the requirements are defined.

## 6.2.4 Surveillance-Related Communications

The surveillance-related communications messages to be processed initially by the DABS/En Route ATC System are the ATCRBS ID Request, ATCRBS ID Code Message and the Track Alert Message. In addition, the Message Rejection Notice will be processed when it applies to an ATCRBS ID Request.

### 6.2.4.1 ATCRBS ID Code

As described in Section 6.2.2, the ATCRBS ID Request and the ATCRBS ID Code Message will be used, for each DABS-equipped aircraft, as a means to maintain the association between the DABS Address and the Mode 3/A Code setting of the DABS transponder. In addition, this association will be required to indicate that, for a particular DABS-equipped aircraft, DABS reports originating from a DABS sensor and ATCRBS reports originating from an ATCRBS sensor are the result of interrogating the same aircraft.

If an ATCRBS ID Request is issued by the DABS/En Route ATC System, it will time-out and transmission will be stopped if no ATCRBS ID Code Message is received. Transmission will cease also if a Message Rejection Notice for the particular request is received from the sensor.

### 6.2.4.2 Track Alert Message

Processing of the infrequent Track Alert Message (Section 2.8.3) will be similar to the processing of the message in the DABS/ARTS IIIA TSS (Section 6.1.5.3). Since a duplicate DABS Address condition results in the sensor(s) detecting the condition not being able to use the ground-air data link (e.g., an ATCRBS ID Request cannot be made), the controller will be notified of the situation via special symbology displayed at the coordinates (which are provided in the Track Alert Message) of each aircraft. The information will be displayed for as long as the condition persists and Track Alert Messages are received; however, the controller may inhibit the alert display.

## 6.2.5 Flight Plan Processing

The DABS/En Route ATC System will process flight plans and amendments for DABS-equipped aircraft which may contain either the DABS Address or the Assigned Mode 3/A Code individually or which contain both the DABS Address and the Assigned Mode 3/A Code. Flight plans (including automatic track initiation) for DABS-equipped aircraft will be processed analogously to the way they are processed in the present En Route ATC System for ATCRBS-equipped aircraft.

If a flight plan contains a DABS Address it will be eligible for use in automatic track initiation when a DABS beacon report is received containing an identical DABS Address (subject of course to time and distance checks). If the flight plan contains a DABS Address but no Assigned Mode 3/A Code, automatic track initiation may be attempted also with an ATCRBS beacon report if the Mode 3/A code of the report is discrete and matches the "Supplied" code corresponding (via the DABS association table) to the DABS Address stored in the flight plan. Conversely, if the flight plan contains a discrete Assigned Mode 3/A Code but no DABS Address, automatic track initiation may be attempted on a DABS beacon report if the "Supplied" Mode 3/A Code associated with the DABS Address (in the report) matches the Assigned Mode 3/A Code. As mentioned in Section 6.1.6, not requiring the entry of a DABS Address in a flight plan will simplify external interface requirements (and implementation) with facilities not yet modified for DABS.

Local Flight Data outputs (i.e., Flight Strips, Flight Plan Readouts, Flight Plan Data Printouts, Flight Plan Data Printouts and the Beacon Code Update Message) will be modified to include the DABS Address as an option.

The use of an aircraft's flight identification available from appropriately equipped aircraft via the DABS data link, as described in Section 2.8.2, will also be included to aid Flight Plan processing in future versions of the DABS/En Route ATC System.

### 6.2.6 Controller Operational Inputs and Displays

Controller inputs and displays in the DABS/En Route ATC System will be essentially identical to those in the current En Route ATC System. Since a DABS Address in a DABS beacon report is converted to a corresponding Mode 3/A report for display purposes, the position symbols (correlated and uncorrelated) for a DABS-equipped aircraft will be identical to the ones for an ATCRBS-equipped aircraft. Likewise, the position symbols (correlated and uncorrelated) for a Radar Substitution report

(DABS or ATCRBS) and a Radar-only report (whether derived from a CD, MTD or RDAS), received from a DABS sensor, will be identical to the position symbol displayed for a CD search message in the present En Route ATC System.

The Full Data Block (FDB) will be identical to the FDB in the present system. The Limited Data Block (LDB) for an uncorrelated DABS beacon report will also be identical to the LDB for an uncorrelated ATCRBS beacon report. The identity code displayed in this first line of the DABS LDB, however, will be the "Supplied" Mode 3/A code associated with the DABS Address of the uncorrelated DABS beacon report (see Section 6.2.2). If there is no Supplied Code available "0000" will be displayed. In either case the altitude displayed in the second line of the LDB will be taken from the DABS beacon report.

### 6.2.7 RTQC Processing

Initially, minimal changes will be made for the DABS/En Route ATC System to process DABS data for RTQC purposes. The Test Message Monitoring task and the Radar Data Counts task will be modified to reflect DABS surveillance message types. The Radar Site Registration task for DABS sensors will be able to use data derived from DABS-equipped aircraft using the corresponding Mode 3/A code (as described in Section 6.2.2). The collimation task can, generally, be turned off for DABS sites since the radar/beacon collimation function is performed independently by the DABS Sensor (see Section 2.7.5.1). The Permanent Echo Verification task also need not be done for the DABS sensor. As a part of the Performance Monitoring task, once each scan, each sensor compares the reported position of each CPME located around it with the actual position stored in sensor adaptation. The results of this accuracy check will be transmitted to the ATC facility in qualitative form (i.e., Acceptable, Marginal, Failed) in the Sensor Status Message. The Status Message Monitoring task will also be modified to process the Sensor Status Message recieved on the two-way communications link. This is described in the next section.

### 6.2.8 Status and Control Message Processing

The Status and Control Messages (see Section 5.) to be processed initially by the DABS/En Route ATC System will be the Sensor Status Message, Test and Test Response Message and the Altimeter Correction Message. In addition certain messages transmitted between the DABS/En Route System and the FEP to monitor communications status will be processed.

As DABS implementation progresses and a high degree of overlapping DABS coverage occurs and a number of contiguous DABS/ATC facilities exist, processing for the Sensor Failure/Recovery Message and the ATC Failure/Recovery Message will be included. The processing for these messages, in conjunction with the other Status and Control Messages will be determined by the requirements for an integrated DABS/ATC facility failure and recovery mode processing capability interfaced with the Remote Maintenance Monitoring System (RMMS). Additionally, when operational data link functions are added to the DABS/En Route ATC System, processing of the Aircraft Control State Message (see Section 5.2.6) will also be added as a necessary support to that function.

6.2.8.1 Sensor Status Message

Processing of the Sensor Status Message will be identical to the processing described for the DABS/ARTS IIIA TSS in Section 6.1.8.1.

6.2.8.2 Test and Test Response Message

Processing of the Test and Test Response Message will be identical to the processing described for the DABS/ARTS IIIA TSS described in Section 6.1.8.2.

6.2.8.3 FEP Status

The FEP will send a FEP Status Message to the DABS En Route software whenever a change in its status occurs or whenever a change in the communications link interface between the FEP and the sensor occurs. This FEP Status Message will be printed when received.

In order to test the interface between the FEP and the En Route system, the system engineer may enter a FEP Test Message. Upon receipt, the FEP will return the contents, for comparison, in a FEP Test Response Message.

6.2.8.4 Altimeter Correction Message

An Altimeter Correction Message (Section 5.2.7) will be sent to each appropriate DABS sensor whenever an Altimeter Setting Message is entered into the DABS/En Route ATC System. A number of altimeter reference points will be adapted in each DABS site. The DABS/En Route ATC System will transmit to the respective DABS sites the appropriate altitude correction data with respect to each one of the altimeter reference points.

### 6.2.9 Data Link Applications

The transmission of an Altitude Assignment Clearance Confirmation (triggered automatically when an Altitude Assignment is entered into the En Route ATC System) to appropriately equipped aircraft is a possible early application of the DABS data link in the DABS/En Route ATC System. A description of this application is provided in Section 3.5.2.

The processing and display considerations regarding the application of the DABS data link functions in the DABS/ARTS IIIA TSS (see Section 6.1.9) will apply to the DABS/En Route ATC System as well.

### 6.2.10 Interface with the Automatic Traffic Advisory and Resolution Service (ATARS)

A description of this interface is provided in Sections 4.

## APPENDIX A

## REFERENCES


1. DABS/ATC Facility Surveillance and Communications Message Formats, FAA-RD-80-14, April 1980.

2. Department of Transportation: "Federal Aviation Administration Engineering Requirement: Discrete Address Beacon System (DABS) Sensor", FAA-ER-240-26A, April 1980.

3. DABS Functional Description, FAA-RD-80-41, April 1980.

4. DABS National Standard, Order________.

5. Automatic Traffic Advisory and Resolution Service (ATARS) Multi-site Algorithm, FAA-RD-80-3, The MITRE Corporation, MTR-80W00100, April 1980.

6. ATARS Functional Description, FAA-RD-80-46, The MITRE Corporation, MTR-80W00101, July 1980.

7. ATC Facility Hardware Interfaces for DABS, FAA-RD-80-38, April 1980.

8. DABS Front End Processor/En Route Central Computer Complex Protocol, FAA-RD-80-37, April 1980.

## APPENDIX B

## ACRONYMS

ACID - Aircraft Identity

ACK - Acknowledged

ACS - Aircraft Control State

ADCOM - Air Defense Command

ADS - All Digital System

ALEC - Altitude Echo

ARTS - Automated Radar Terminal System

ATARS - Automatic Traffic Advisory and Resolution Service

ATC - Air Traffic Control

ATCRBS - Air Traffic Control Radar Beacon System

BCAS - Beacon Collision Avoidance System

CA - Conflict Alert

CD - Common Digitizer

CIDIN - Common International Data Interchange Network

CMC - Communications Multiplexer Controller

CPME - Calibration and Performance Monitoring Equipment

DABS - Discrete Address Beacon System

DABSEF - DABS Experimental Facility

DPS - Data Processing Subsystem

ELM - Extended Length Message

ESSF - En Route System Support Facility

FAZ - Final Approach Zone

FDB - Full Data Block

FEP - Front End Processor

GPI - General Purpose Input

GPO - General Purpose Output

ICAO - International Civil Aviation Organization

ID - Identification

IFR - Instrument Flight Rules

LDB - Limited Data Block

MA - Message, Comm-A

MB - Message, Comm-B

MC - Message, Comm-C

MD - Message, Comm-D

MSAW - Minimum Safe Altitude Warning

MTD - Moving Target Detector

NAFEC - National Aviation Facilities Experimental Center

PAM - Peripheral Adapter Module

P/S - Primary/Secondary

RDAS - Radar Data Acquisition System

RMMS - Remote Maintenance Monitor System

RTQC - Real Time Quality Control

SFN - Surveillance File Number

SPI - Special Position Identification

SRAP - Sensor Receiver and Processor

TABG - Thresholded Alpha Beta Gamma

TATF - Terminal Automation Test Facility

TCA - Terminal Control Area

TSS - Time-Shared Display System

UM - Utility Message