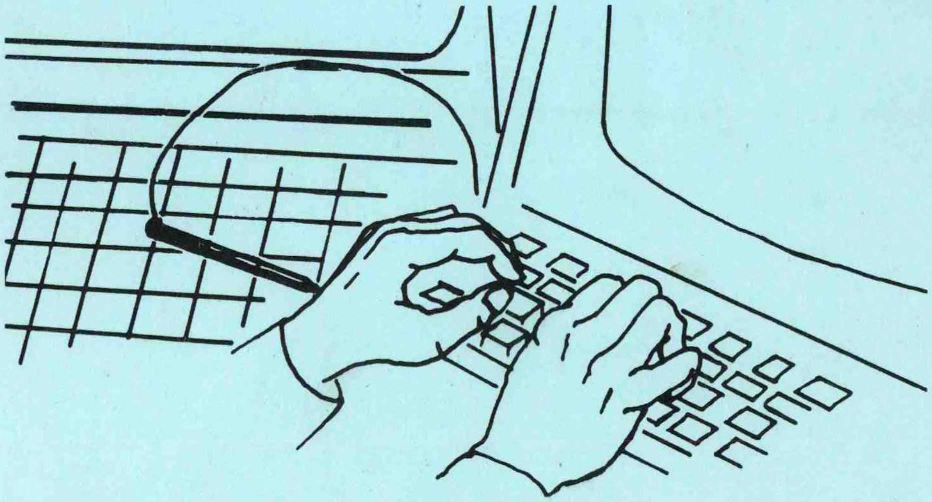
U.S. DEPARTMENT OF COMMERCE / National Oceanic and Atmospheric Administration

FEDERAL COORDINATOR FOR METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH

Automated Weather Information Systems (AWIS):

Considerations for Intra- and Intersystem Operations and Interagency Considerations In Development and Coordination



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FOR

METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH

INTERDEPARTMENTAL COMMITTEE FOR METEOROLOGICAL SERVICES

AND SUPPORTING RESEARCH

AUTOMATED WEATHER INFORMATION SYSTEMS (AWIS):

PART I: CONSIDERATIONS FOR INTRA- AND INTERSYSTEM OPERATIONS

PART II: INTERAGENCY CONSIDERATIONS IN THE DEVELOPMENT AND COORDINATION OF AWIS

Washington, D. C.
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FCM-R5-1982

PREFACE

The role of Automated Weather Information Systems (AWIS) in the Federal Government is increasing rapidly. Agencies are improving their systems daily, using the most up-to-date technology that is possible. Two major areas of concern that agencies face as the level of sophistication increases and as AWISs expand are coordination of the developing systems and the management of intra- and intersystem operations. This report addresses these areas and presents a number of factors which should be considered by all levels of management, particularly top management. Part I of this report is titled "Considerations for Intra- and Intersystem Operations of the Major Automated Weather Information Systems (AWIS)" and Part II is titled "Interagency Considerations in the Development and Coordination of Automated Weather Information Systems (AWIS)."

The General Accounting Office (GAO) and the Office of Management and Budget (OMB) have expressed concern about overlapping Federal programs and, in particular, automated weather information systems. The FCM-R1-1981, "Report on the Plans for Coordination of Major Automated Weather Information Systems," responded to some of their concerns. The Federal Coordinator is taking a more active role, with the cooperation of agencies, in coordinating Federal weather programs in response to GAO's and OMB's concerns. Recently, a standard was developed at the technical level and approved by agencies for "Standard Formats for Weather Data Exchange Among Automated Weather Information Systems." This standard evolved as a result of the findings presented in the FCM-R1-1981 which stated that "efficiency and economy of operations can be best realized through the establishment of mutually agreed standards for system specifications, standard operating procedures and practices."

This report, FCM-R5-1982, is intended to foster understanding so that cooperation and coordination will continue to seek economies and efficiencies without unduly constraining the intra-system flexibility that is needed to satisfy mission-oriented agency requirements.

William S. Barney
Federal Coordinator for Meteorological
Services and Supporting Research

FEDERAL COORDINATOR

FOR

METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH

<u>INTERDEPARTMENTAL COMMITTEE FOR METEOROLOGICAL SERVICES</u>

<u>AND SUPPORTING RESEARCH</u>

CONSIDERATIONS FOR INTRA- AND INTERSYSTEM OPERATIONS OF THE MAJOR AUTOMATED WEATHER INFORMATION SYSTEMS (AWIS)

Prepared by the

Working Group on Automated Weather Information Systems

FCM-R5-1982
Part I

FOREWORD

The Working Group on Automated Weather Information Systems (AWIS) has been conducting some detailed analyses of the nature of AWISs incident to its objective to recommend appropriate standards and mutually agreed upon practices and procedures. An initial report, published as FCM-R1-1981, dealt with the concepts of mission orientation, procurement procedures and some operations implications. This report introduces some potential concepts of interoperability and identifies the key management decisions required to refine the plans for multisystem operations. A third report, Part II of this publication, treats in greater depth the implications of alternative approaches to AWIS operations.

The objective of this report is to acquaint management with results of our deliberations and to initiate actions toward the establishment of certain basic management guidelines, critical to our continued activity.

Russell G. McGrew
Chairman, Working Group on Automated Weather Information Systems

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EXECUTIVE SUMMARY

The Department of Defense (DOD), National Oceanic and Atmospheric Administration (NOAA), and the Federal Aviation Administration (FAA) have automated or are in the process of automating their weather information and distribution systems. The replacement of archaic facsimile and teletypewriter systems with modern distributed data processing systems will be a force multiplier in support of weapon systems and afford greater protection to and reinforcement of our Nation's land, sea, and aviation resources.

However, the introduction of automated distributed data processing systems will affect conventional agency standard operating procedures, especially in the area of interagency backup, and will require even greater interagency cooperation in the interfacing of the various systems. This paper provides a detailed background on the intricacies of operating and interfacing major automated weather information systems, highlights the differences between AWISs and current systems, and recommends that agencies consider the merits of an interservice backup procedure.

The major conclusions and recommendations are:

CONCLUSIONS

The new technology and concepts being introduced are powerful sources of new capabilities, but are potential sources of service operational problems in a variety of failure modes.

Since there is no established tradition and operational experience in the multidistributed data processing system environment, a measured program of interagency coordination is required on the way to total implementation.

The nature and direction of coordination activities are contingent on basic management decisions relative to the infrastructure of the individual systems and the interdependencies of the systems for both normal and contingency operations.

RECOMMENDATIONS

The WG/AWIS recommends that:

a. ICMSSR provide policy guidelines related to the degree of interagency backup of AWISs and the degree of interoperability desired among the systems.

b. ICMSSR consider the Terms of Reference and scopes of the Working Groups concerned with the exchange of weather information among agency systems.

CONSIDERATIONS FOR INTRA- AND INTERSYSTEM OPERATIONS OF THE

MAJOR AUTOMATED WEATHER INFORMATION SYSTEMS (AWIS)

I. CONTEXT OF AUTOMATED WEATHER INFORMATION SYSTEMS (AWIS)

In a recent report of the Federal Coordinator for Meteorological Services and Supporting Research (FCM-R1-1981), the Working Group/Automated Weather Information Systems (WG/AWIS) of the Subcommittee for Systems Development (SC/SD) developed a definition of AWIS with respect to other components of a total weather service system. Figure 1 illustrates that definition. To set the stage for the further discussion of potential areas for coordination and cooperation in the operation of these systems, we wish to extend the functional description somewhat.

Typically, the AWISs of the individual services are the means by which raw meteorological data and the central guidance products of the Numerical Meteorological Processing Centers are considered and/or processed to provide meteorological products and/or interpretations for direct or indirect presentation to the users of the individual services.

At the "output" end of the AWIS is typically a briefer, a staff weather officer, an advisor or a port to a display or processor on the customer's premises. Less typically now, but perhaps more typically in the future, the port may be an open port to third party service organizations -- a communications or information service company or a common data base.

At the front (or "input") end of the AWIS we can interpret three principal sources of information, viz. the data acquisition activities of the individual services (usually entering at distributed locations), the center guidance products (usually entering at one principal location), and the data and/or products of the other services (the bulk of which usually enters at a single location, but lesser amounts may enter at distributed locations).

Between these two gates of the individual systems, three major functions take place:

- Intermediate Processing. This is a function that essentially supports the people or systems that provide the direct support to the users of the individual services. Typically these functions take the form of a refinement or extension of the center guidance products (refined in geographic scale or in terms of specific classes of users) or the direct production of "displays" or assemblages of information for the use of the direct interface to the user.

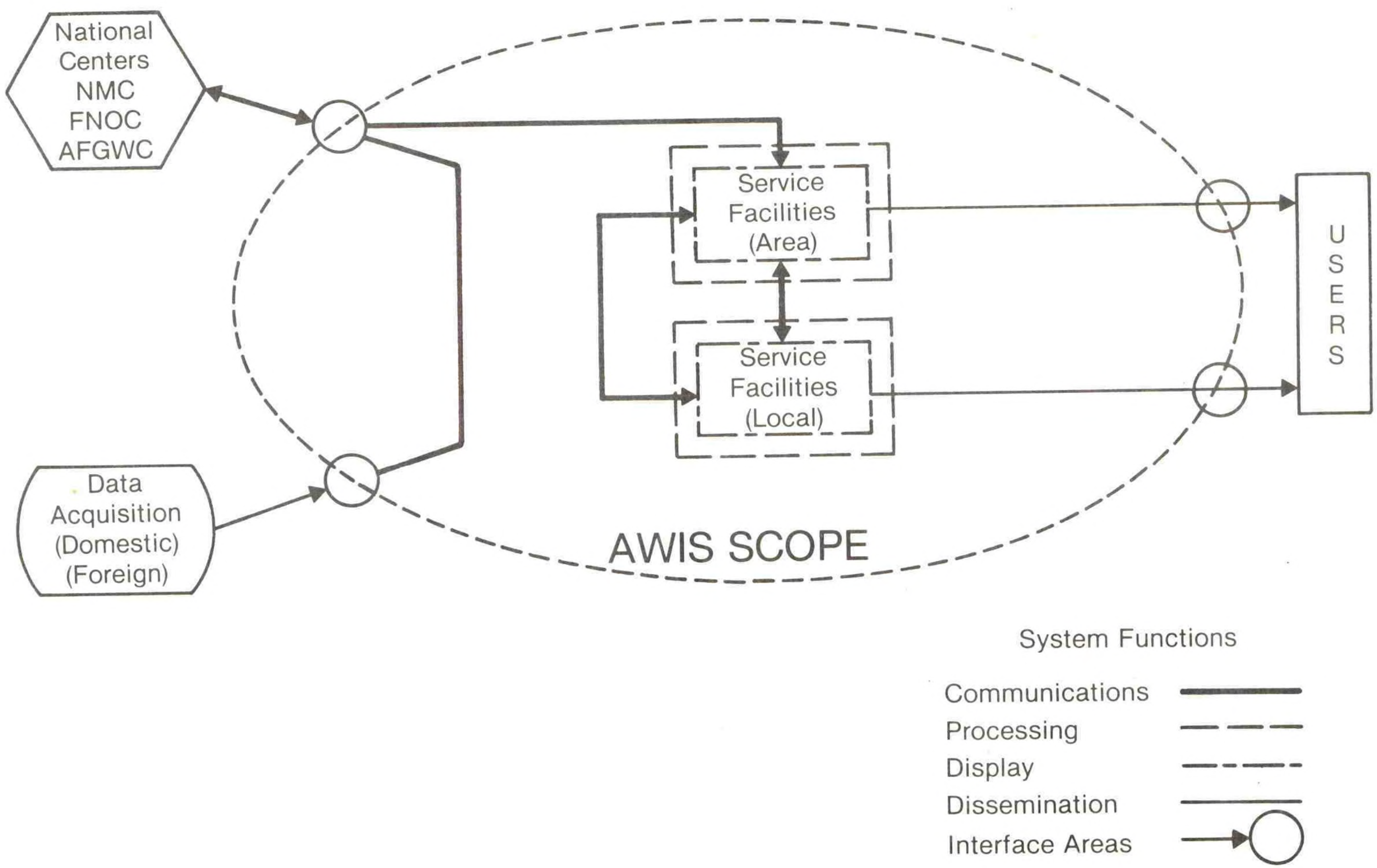

Figure I. Automated Weather Information System (AWIS).

- Data Base Management. This is mainly the means of assuring that the distributed data bases are adequately supplied and, by inference, that the required interdata-base transfer takes place within the individual systems. These interdata-base transfers include communication systems that are national/international in scope.

- Intersystem Gateway Operations. This function assures that raw data and products from each system are exchanged as required.

The real systems of the separate services may not keep these functions physically separate in terms of processing hardware. The same hardware may perform center and certain data acquisition functions; however, the software will generally maintain a functional separation.

II. INTERSYSTEM RELATIONSHIPS

There are several levels of intersystem dependency among the four principal meteorological systems:

A. Basic Observations

The location of the basic observation stations of the individual services are largely a function of the location of requirements for end services. (Only certain acquisition functions of the NWS are based primarily on geographic coverage (e.g. upper air stations and network radar)). As a result, the sets of acquisition sites of the individual services are almost completely coterminous. The interdependency for basic observations has been accentuated in recent years due to the conscious efforts of the services to avoid multiservice redundancy in the acquisition network. The purest interdependence across the services is represented in this data acquisition (observation) area.

B. Center Products

The interdependency among the systems for Center Products is less even in degree and direction. The Flight Service Automation System (FSAS) of the FAA relies totally on the National Weather Service (NWS) for guidance products. The bases for interdependency among the remaining major services for Center Guidance Products fall into three categories. The first is in the form of operational backup among the centers. None of the services operates a fully redundant, geographically separated Center for full service to its AWIS. The second is what might be interpreted as an independent information source (for cross checking purposes), and the third is somewhat in the embryonic stage, viz. the Centers of Specialization concept* -- in which individual centers representing specific skills and interests would provide certain types of services to the other agencies for which the subject area is of significant but not dominant interest.

*Cross Cut Review of Federal Weather Programs, Numerical Meteorological Processing Centers Sub Task, Final Report, Prepared by Economics Technology Associates, Inc. for the Office of the Federal Coordinator for Meteorological Services and Supporting Research.

The advent of the AWISs will provide opportunities for significantly greater amounts of intersystem exchange due to the introduction of Automatic Data Processing (ADP) at nearly all echelons of the individual services.

III. AN OVERVIEW OF AWIS OPERATIONS

Following the lead of the WG/AWIS report (FCM-R1-1981), AWIS functions may be interpreted purely in systems terms. To set the stage for this however, let's look at the combination of the AWIS and the staffs immediately involved. The job of this combination, as a whole, is to take raw and processed information and deliver services to a set of end users.

The AWISs of the individual services are hierarchical distributed systems and, to complicate matters, each interfaces with hierarchical distributed systems on both the input and output ends. To complicate matters even more, none of the hierarchies are pure. To clarify -- raw observations taken at distributed locations are collected in various groupings for certain purposes but each is also an individual end product for other purposes.

Comprehensive global inputs from the major processing centers are interpreted into smaller regions within the AWISs -- but the comprehensive input is also an end product for certain purposes. While some major users, e.g. the United States Navy (USN) and the United States Air Force (USAF), may be more purely hierarchical in organization, the supporting meteorological services are provided at all echelons -- in effect, simultaneously.

A. System Functions of the Individual AWISs

One can view the individual systems as consisting of the normal functions of any data processing system:

- o Input
- o Output
- o Processing
- o Storage

The major impacts of a Distributed Data Processing (DDP) system, which all AWISs are in a sense, are felt in two areas. First, by its very nature, i.e. "distributed," the communications aspects become internal rather than being restricted to the input and output functions. Second, the processing and storage functions almost have to be viewed in a different way.

Traditionally, the functions have lined up as presented in Figure II.

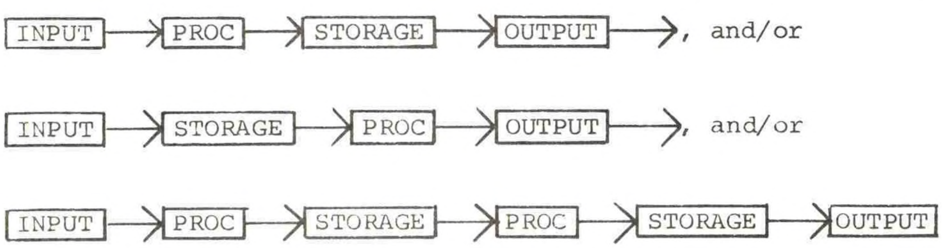

Figure II. TRADITIONAL AWIS FUNCTIONS

With the advent of DDP has come the flexibility of performing different degrees of processing in different locations which, in turn, impacts the nature of the storage function. (That is, what is basic storage at some locations may be processed or semi-processed versions of the basic storage at other locations.) For these reasons, it may be more revealing to split out the computational parts of the processing function and leave the remainder (the data handling processing) to be combined with the storage and communications functions to yield a Data Base Management (DBM) function. Thus the linkage at each location looks more like that presented in Figure III.

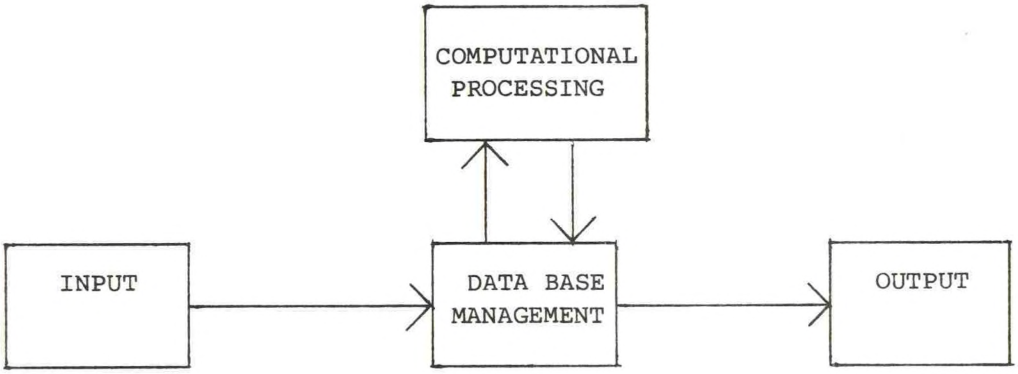

Figure III. DISTRIBUTED DATA PROCESSING LINKAGE

The AWIS may then be viewed as largely a Data Base Management system (DBMS) with computational adjuncts. This concept may appear to be somewhat abstract, but it is important, if not central, to maximizing the efficiency of internal operations through mutually agreed practices and procedures. What this really says is that the grist for the AWIS mill is not just basic observational data and the several levels of end products (either locally or remotely produced) but may substantially consist of other kinds of operable or manipulatable data bases, locally or remotely produced -- even to the extent of other system sources (more about this later).

One other subfunction, formerly simplified under the title of formats and codes, needs to be better understood. This is what is now named in some references as schema. Format and code refers to the structure and meaning of the bits and/or characters in storage or transit. Schema refers to the additional knowledge required to make full use of the structure. This may relate to the order (linkage) of data in the file or communications stream or of the decompression of a data structure that has undergone compression for communications or storage purposes. In a larger sense the schema refers to the structure and distribution of the entire AWIS data base among all of its components.

B. Constituents of the Function Modules of the AWISs

Let us view the AWIS as an entity and, to begin with, assume that the principal inputs are observations and the global products of the major processing centers. (Discount, for the moment, the fact that some functions we will mention happen to be performed on the processors of the major centers.)

1. Input Module

At this end of the systems, the following types of intelligence enter:

a. Observations

- Direct in situ measurements of one or more parameters from many sites (surface observations)
- Indirect measurements from a lesser number of sites (upper air, radar, geostationary satellites)
- Indirect and direct measurements from moving sensors (orbiting satellites, aircraft reports)
- Event oriented manual reports (spotter nets, flash flood alarms)

b. Global Products

Analyses of the atmosphere/oceans and predictions in the following forms:

- Scan line image and graphics
- Vector encoded isopleths
- Uniform grid representations
- Text expansions.

2. The Computational Processing Module

This module applies certain mathematical algorithms to the input or stored data forms to develop predictions or interpretations. These are in terms or parameters most useful to the customers of the AWIS or to the forecasters in the preparation of services. In current parlance, this operation may be interpreted to be "applications software." Typical computational functions are:

- Interpolation
- Extrapolation
- Linear regression
- Matrix conversion
- Matrix mathematics
- Complex dynamic modelling on a limited basis.

The functions of this module can be centralized when looking at the AWIS as an entity or they can be distributed to individual sites.

3. <u>Data Base Management Module</u>

This module at a particular site may be considered to be composed of these submodules: physical storage, data handling, and interactive control.

a. The function of the physical storage submodule is obvious.

b. The data handling module operates on the basic input data to aid the service people in the process of tailoring end products by selecting from or combining individual data base items or by producing additional data bases for review. The kinds of activities that take place within this module are:

- Individual data recall
- Simple sort
- Multiple sort
- Combination of data units to collectives
- Combinations of point data to plat format (plotted data fields)
- Isopleth analyses
- Plat analysis to uniform grid
- Plat analysis to vector format
- Selection of local or regional portions from global products in grid, vector or image format
- Horizontal accumulations (area averaging) in all formats
- *Vertical accumulations in all formats
- *Time accumulations in all formats
- *Accumulation of effects in all formats
- *Projections of accumulative effects in all formats
- Conversion of products to communications schema
- Conversion of products to storage schema
- Conversion of stored schema to display formats.

*These could be interpreted to be "applications" routines if done "on call"; conversely, if automatically produced on a routine basis, they are considered part of the Data Base Management module.

c. The interactive control submodule orders these above processes (3.b) to take place and performs the necessary message composition functions required in the production of end services.

d. Stepping back and viewing the individual AWIS an as entity, the Data Base Management Module (of the individual site) becomes a subset of a Network Data Base Management System (NDBMS). This super-module consists of the schema that establish:

- The distribution of data among distributed locations
- The method of maintaining the distributed bases
- The internal backups (for data base maintenance)
- The distribution of the data handling processes (i.e. whether centralized or distributed)
- The "requirements" or "specifications" of the internal communication system
- The management (including quality control) of the real intrasystem operations from a data base standpoint.

4. Output Module

This module readies the service products for transmission to the customers of the services, to the premises of the customers for the use of certain on-site representatives of the weather service or, in some cases, to third parties (e.g., private meteorologists) who provide direct services. Major output forms consist of synchronous or asynchronous communications in a number of protocols to drive remote Cathode Ray Tube displays or printer/plotters and to drive landline, radio or satellite circuits to communicate with user computers or recorders.

While the AWIS systems handle weather information for the most part, those of the Department of Transportation (DOT) and DOD handle other flight related information (e.g., NOTAMS and flight plans), and all may handle certain information associated with the individual AWIS system operations.

C. System Functions of the Set of AWISs

It is interesting to interpret our little model (Figure III) in terms of the set of all AWISs. This can be done only in a very conceptual sense -- but in those terms:

1. Input Module

The inputs are those data that enter the set from outside sources, i.e. foreign data, the total set of information from all National Processing Centers, satellite data.

2. Output Module

The total set of all outputs to all users.

3. Computational Processing

The best analogy for the Computational Processing Module that we can think of would be the set of agreements on the operations of the National Centers.

4. Data Base Management

The data base management function can best be represented by those interagency memoranda of understanding, sets of standards, and agreed practices and procedures that govern the amount, type, format, timing, and location of the data exchange among the AWISs.

IV. IMPLICATIONS FOR ORGANIZATIONAL PLANS AND OPERATIONS

Two features of AWISs have been both welcomed and understood, viz, the so-called message composition and the enhanced communications capability. Two other capabilities, local data storage enhancement and the ability to manipulate data, have been equally welcomed. However, there is much to learn, in a system sense, about how to control and manage these capabilities. Available technology provides few bounds -- certainly looser bounds than teletypewriter and facsimile circuits provide. So, bounds must be established.

The most obvious factor in establishing the bounds is cost. The second that comes to mind is system efficiency. This would appear to be a sufficient set of considerations, except that efficiency is too frequently measured relative to conditions when the system is operating as designed. Effectiveness would be a better term, for it should imply the worth of the operations, the manageability of the system, the susceptibility to failure or other aberrations in its performance, and the facility for change.

While there is a great temptation to yield to the user's desire for unlimited access to the system or to the designer's inclination toward supreme efficiency as the immediate objective, the management of the major affected agencies should face these problems individually and in concert.

An imbalance in the user-designer considerations versus the parameters we specify under "effectiveness," can transform the potential for improved services into sources of major operational problems.

While our principal emphasis is on the management of the operation of the AWISs, there are additional management factors that may be impacted. Many of the quality control functions (in the weather services area) are established through directives, review of standing operating procedures, and through strict centrally established quality control operations. With today's systems, adherence to guidance is relatively straight forward because of our limited ability to transform information. However, with the AWIS, the implementing vehicle for these processes is often software (not universally understood by functional managers), and unless due care is exercised, the ability to alter procedures at the individual level can be a source of concern.

While the ability to implement change quickly at a single location within an AWIS is relatively great, the ability to detect and assess total system impact and thus to respond to an imposed and unannounced change is significantly more complex and challenging. Thus, change should be either contained within very definable boundaries or be subject to an orderly implementing procedure. This is more readily accomplished within the individual AWISs, although equally important to the operation of the community AWISs. It would appear that additional procedures are needed to respond to intersystem requirements.

V. OPPORTUNITIES FOR COOPERATIVE ACTIVITIES

To repeat, the objective of our recommendation for cooperative activities is to maximize the efficiency and effectiveness of operations within individual AWISs, without detracting from the ability of the individual services to meet their unique missions.

To help assess the major opportunities for cooperation, let's list, then review the major system phases and elements of an AWIS.

Phases

Concept
Plan
Design
Development
Procurement
Operations
Major Transition

Elements

Hardware
System Software
Applications Software
Data Base Schema
Intrasystem Communications
Intersystem Interfaces
Logistics

A. Past Experience

It may be instructive to first consider these components in terms of our past experience, and thus gain an impression of the dimensions of the problem of managing and operating in the AWIS/DDP era.

Let's first limit our consideration to the equivalent of AWIS in "field operations." Over the past 40 yars the only really significant hardware change has been the addition of facsimile (and that about 35 years ago). The changes have been mostly in speed or quality of presentation -- all transparent to the field office operations.

Software did not exist as such; the principal communications were supplied by AT&T and Western Union and operated and managed by major agencies, and all were broadcast circuits which could be accessed via a "drop."

Data Base Schema problems were limited to balancing the number of circuits versus amount of information to be transmitted per time unit and to mutual agreement on message codes. The latter was simplified because a single format was used for entry, transmission, storage, and display. For most of this period intersystem interface was accomplished via papertape edit and transfer.

Extending beyond the AWIS scope of interest, the first real ADP center was introduced 25 years ago. Activity picked up during the 60's and early 70's, but none of these systems were DDP in nature. Interprocessor considerations were primarily limited to the exchange of ordered inputs or finished outputs.

B. Discussion of System Phases and Elements

Table 1 summarizes our views of the specific areas in a matrix sense in which different degrees of coordination are recommended.

1. System Phases

The system phases are all standard. They are delineated here only because they now reach a higher level of importance within the AWIS scope of interest; that becomes evident only as we discuss the elements. "Transition" relates to the introduction of major system modifications.

2. System Elements

The elements listed may not be exhaustive but should serve the purpose of establishing a basis for identifying critical areas for implementing coordination.

a. Hardware

Our report (FCM-R1-1981) dealt with this subject in detail. In essence, it concluded that hardware requirements are reflected more by mission and the organizational environments. Interservice coordination should take place primarily in the procurement stage and then for the purposes of taking advantage of coincident requirements for the same hardware. There is significant probability of this happening in some hardware components.

b. Systems Software

System Software includes Operating System (Processing Resource Management) software and Executive (Job Management) software. These categories of software are usually linked closely with the hardware and the service mission. Thus, there is not a driving force for identicality. The services should inform or advise for the purposes of taking advantage of fortuitous coincidence of requirements.

c. Applications Software

Applications software (as defined in this report) consists of two types, viz. a technical adaptation to user (mission) requirements and a science-oriented process for the further use of the meteorologist. The potential benefit of identicality of software in this element is frequently overemphasized -- primarily because portability among different equipment types even within common program languages is often overestimated. However, a degree of coordination is recommended, particularly in the second type, for two purposes:

- to understand the derivation of certain "products" in order to assess their "acceptability" for exchange.

- to adopt or adapt certain techniques. (This implies some higher level of program exchange, e.g. flowchart).

d. Data Base Schema

This element is the most complex, the newest and the least understood element of the AWIS systems. At the same time, it is one of the two elements for which the application of appropriate standards and mutually agreed practices and procedures can best benefit the operations of the individual services.

To gain a data processing view of this subject, refer to reports of the CODASYL Systems Committee on DDP. A particularly good reference may be found in Portfolio 63-03-01 of Auerbach's Information Management Series: Distributed Processing Management. Figure IV is a representation of a Figure 3 from that portfolio. The central activity of the individual AWISs may be equated to the Network Data Base Management System (NDBMS) and the individual user consoles to the "User." The interests of WG/AWIS is the intersection of multiple NDBSs. This particular system element of our discussion involves the Data Base, Data Base Definition (schema), User Schema as well as certain communications schema.

(1) Data

(a) Message Unit Structure

- Free text, variable length
- Ordered text, fixed length
- Fixed format, absolute
- Fixed format, logical
- Identifier

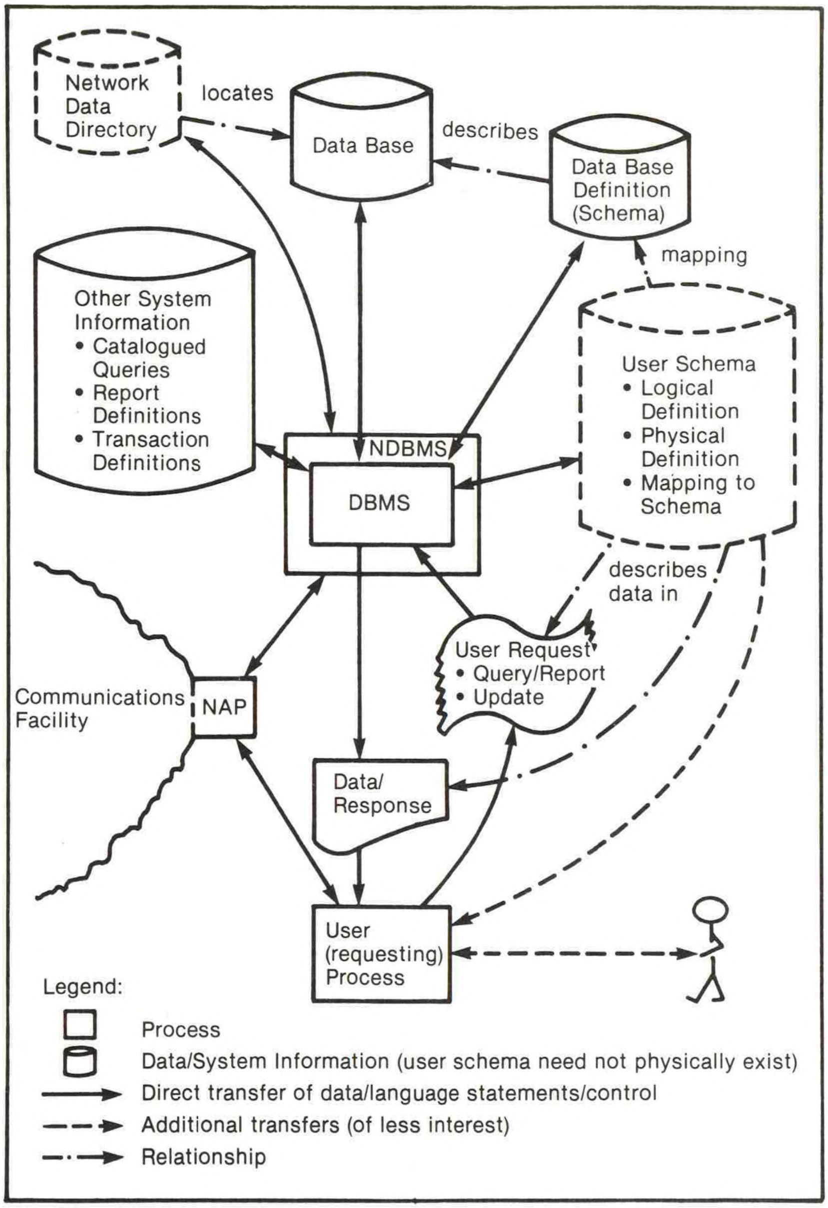

Figure IV. A Complete Node in a Distributed Data Base

(b) Locator Reference Structure

- Uniform grid
  - Latitude, longitude
  - Arbitrary fixed
- Organizational structure
  - Political-geography
  - Administrative Organization
  - Geographic feature (River basin)
- Geographic reference
  - Latitude/longitude
  - Quasi-climatological zone

(c) File Structure

- Chronological, serial, by message unit
- Synoptic, chronological, by message unit
- Relocatable by serial trail
- Fixed, absolute
- Fixed, adjustable

(d) Transform Algorithms

- Translation from one locater reference structure to another
- Matrix operations (derived interpretations to form new data bases)

(e) Retrieval Algorithms

- Collective operations

(2) Communications

As we have mentioned, there is no longer a constraint that transmission formats equate to storage or display formats. Thus the following types of considerations are made relative to the message transmission:

(a) Message Information Compression Techniques

- Character string compression
- Scan-line dot compression
- Vector encoding
- Null suppression (variant of string compression)

(b) Intermessage Information Compression Techniques

- Chronological serial delta fields
- Deviation from "Normal" fields
- Selective change (exception-only)

(c) Protocol Options

This extensive, but not necessarily exhaustive, set of features and alternatives related to the Data Base Schema are considerations within each AWIS. The extent to which interservice consideration applies is sensitive to the degree of intersystem communication above the raw data level. We do conclude, however, that this element deserves intense attention -- and we will say more in Section VI.

e. Intrasystem Communications

The communications of all except the AFOS system are subsets of the more general communications of a parent organization. For this reason, there is little of common interest among the intrasystem communications of the AWISs below the concept level.

Interest at that level is generated to consider opportunities for intersystem backup or exchange (Gateway) operations.

f. Intersystem Interfaces

This is the other element that requires close coordination and agreement. The constituents of this element are wholly transparent to and independent of the information content of the data base. Most simply put, they are the hardware specifications for the physical interface and the protocols employed in the actual data transfer. As we have learned from our AFOS-NEDS experience, the method for implementing the protocol is an important consideration.

g. Logistics

The intersystem consideration of the logistics element is completely parallel with the hardware element.

C. Summary

Table 1 summarizes our assessment of the degree of coordination pertinent to the System Elements in each System Phase.

Table 1. Levels of Coordination Pertinent to Selected System Phases and Elements

ELEMENT/PHASE*	CONCEPT	PLAN	DESIGN	DEVELOP-MENT	PROCURE-MENT	OPERA-TIONS	TRAN-SI-TION
Hardware	I	I	I	I	C-	I	I
Software:							
o Operating System/ Executive	I	I	I	I	I	I	I
o Applications	I	C-	C-	C-	N/A	C-	C-
Data Base Schema	C+	C+	C+	C+	N/A	C+	C+
Intrasystem Comms	I	I	I	I	N/A	I	I
Intersystem Interface	C+	C+	C+	C+	C+	C+	C+
Logistics	I	I	I	I	C-	N/A	I

* See page 10

Note: I = Inform
C- = Advise and review together at appropriate intervals
C+ = Conscious coordination with formal plans for maintaining coordination.

At this stage of our collective experience with Distributed Data Processing systems, we deem it important that we emphasize the coordination at the advanced stages of planning for both operations and the introduction of major transitions. We feel this is especially true because the systems are so new and different in character that in situ operations people will not have a bank of experience on just how to work cooperatively in this kind of environment.

VI. SOME VIEWS ON IMPLEMENTING COOPERATIVE ACTIVITIES

We have tried to address some of the opportunities for coordinated actions and some of the reasons therefor. From these discussions we see three important areas in which decision is indicated, viz.:

- o To what depth the systems should be coordinated
- o In what environment coordination should be accomplished
- o Through what instruments the coordination should be reflected.

A. Levels of Coordination

Based on our previous deliberations, we have rejected the option of a single, fully integrated system to meet all mission requirements of all agencies. Although such an option may be appealing in an academic sense, it is our judgment that if such a system could be designed to meet all of the separate mission requirements, it would be unmanageable and almost impossible to implement.

The minimum level of coordination would require the ability to exchange the basic observational data originated within each system and some subset of the meteorologically oriented end products of each system. The largest minimum requirement would exist in an AFOS to FSAS sense. At this minimum level, coordination of the physical communications interface, protocols, and the form and format of the data transferred would be required.

The next higher level of coordination would probably involve considerations of mutual backup and the concept of "Centers of Specialization." In both cases, some accommodation would be required that would involve the use of the information within the system on the "receive" side of the transfer.

The alternatives that remain involve the degree that some intermediate processing functions of each system can be profitably used by one or more of the other systems and the degree that all can profit by mutually agreed upon features of the data base structure (identification practices and locator reference structures).

B. Environment for Coordination

The two principal alternative environments are: within the OFCM structure or specific multilateral agency agreement or a combination. Theoretically, there is no reason why all coordination could not take place within the OFCM structure. However, there may be pragmatic reasons for accomplishing certain phases of the coordination in a multilateral context.

During the concept and early planning phases of both initial systems and major transitions there may be two deterrents to free and open exchange -- reticence toward discussing preliminary plans in too broad an audience and among agencies prior to approval at higher levels within the individual agencies.

Given mutual agreement on the discussion in A above, there would appear to be logical reasons for acting in the OFCM environment for the operations phase and some logic for a multilateral environment for the concept and planning phases. The best procedure for some of the intermediate phases (design, development, and procurement) may be open to more discussion.

C. Instruments of Coordination

There are a number of types of instruments potentially available for use. The precise ones are sensitive to the answers to the determinations under A and B above.

The two gross types of instruments are:

- o Standards which may be applied to any system.
- o Implementing instruments which deal with specific agreements on which standards to use and other special provisions.

1. Standards

A relatively large number of standards relating to the ADP field already exist. Some are recognized internationally and some nationally. There is the additional possibility for establishing program standards (e.g., on an AWIS basis). In most cases, standards in a certain category of information are not unique. In other words, to assure definitive agreement among systems, an implementing instrument of some type would be required to specifically identify the standard to be used.

In considering implementing instruments, the instruments, interagency Memoranda of Understanding, may take three forms:

- Guidelines which establish no commitment.

- Notifications, which entail an agreement to notify interfacing systems a certain length of time before change.

- Mutual consent prior to any change.

The last type is the equivalent of establishing singular program standards at the AWIS level.

VII. CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions

There is unanimous agreement that coordination on AWIS plans and operations is required. The specification of the degree is a more difficult question; how to implement the program is the most difficult question.

1. Preliminary Management Determinations

Some insight concerning these latter questions could be gained by expressions from top management of the individual services concerning the strategy of their master ADP designs. The two most sensitive issues are:

a. Degree of inter-service dependence for information transfer in the event of catastrophic failure at the center hub of the individual systems. (This is not the same as product backup.) Essentially, it involves the SMCC function of NWS, the AWP function of FAA, and similar functions associated with AWDS and NEDS -- which are the information feed (or message switching) functions that provide the information to the field operations. The essential information is: to what level each service provides its own redundancy (or back-up plan) or for what level there is an interservice involvement. (For example, the FAA plan calls for a fully redundant capability, physically separated at Salt Lake City and Atlanta). The reason this is important is that reliance on interservice backup almost surely dictates an extremely high level of adherence to common standards and practices.

b. Position of AWIS feed operations in master ADP scheme. This is more of a parochial interest to the WG/AWIS. The question is whether the master feed is considered within the AWIS, the agency communication system, or the associated communications functions of the principal processing centers of the services. (Again, the FAA is unique and would contribute to the problem only if the other services relied on the AWP as an alternate feed source.)

2. Routine Planning

For at least the next several years, it is highly desirable that the coordination of plans take place in a rather consistent manner. We conclude this because the process of adjusting to change in the DDP environment is very complicated and will probably remain so until we all accumulate the experience and facility to recognize and evaluate the implications of change.

3. Operations

By now it is very obvious that there are many aspects of routine operations within each service that can affect the operations of the others -- for good or evil. The biggest job facing each agency is to educate all personnel who will be ultimately involved in these operations to that fact. One way to reduce the size of that job is to develop a sound structure of standards or agreed practices and procedures.

B. Recommendations

We recommend that ICMSSR consider two activities that will be most helpful to the further deliberation of WG/AWIS:

1. (Reference conclusion Ala). Develop a set of guidelines that reflect agency policy concerning:

a. The degree of interservice backup of AWISs desired.

b. The degree of interoperability desired among the AWISs (i.e. in the sense of the exchange of information with the least amount of processing required).

2. (Reference conclusion Alb). Clarify the relative scopes of the WG/OPC (SC/BS) and WG/AWIS relative to the exchange of information among AWISs. Specifically, this relates to the full gateway function, which, by precedence, has been more closely allied to the OPCs than to field communications.

APPENDIX A

ACRONYMS AND ABBREVIATIONS

ADP	Automatic Data Processing
AFGWC	Air Force Global Weather Central
AFOS	Automation of Field Operations and Services
AWDS	Automated Weather Distribution System
AWIS	Automated Weather Information Systems
AWP	Aviation Weather Processor
DBM	Data Base Management
DBMS	Data Base Management System
DDP	Distributed Data Processing
DOD	Department of Defense
DOT	Department of Transportation
FAA	Federal Aviation Administration
FNOC	Fleet Numerical Oceanography Center
FSAS	Flight Service Automation System
ICMSSR	Interdepartmental Committee for Meteorological Services and Supporting Research
NDBMS	Network Data Base Management System
NEDS	Naval Environmental Display Station
NMC	National Meteorological Center
NOAA	National Oceanic and Atmospheric Administration
NOTAM	Notice to Airmen
NWS	National Weather Service
OFCM	Office of Federal Coordinator for Meteorology
SC/SD	Subcommittee on Systems Development
SMCC	Systems Monitoring and Coordination Center
TG/CIDE	Task Group on Communications Interfaces and Data Exchange
USAF	United States Air Force
USN	United States Navy
WG/AWIS	Working Group on Automated Weather Information Systems

FEDERAL COORDINATOR

FOR

METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH

INTERDEPARTMENTAL COMMITTEE FOR METEOROLOGICAL SERVICES

AND SUPPORTING RESEARCH

INTERAGENCY CONSIDERATIONS IN THE DEVELOPMENT AND COORDINATION OF AUTOMATED WEATHER INFORMATION SYSTEMS (AWIS)

Prepared by the

Working Group on Automated Weather Information Systems

FCM-R5-1982
Part II

FOREWORD

This report has twin objectives: to provide further background to our report, "Considerations for Intra- and Intersystem Operations of the Major Automated Weather Information Systems (AWIS)," and to extend some of the concepts to both intra- and intersystem considerations. By discussing alternatives in both senses and discussing their implications, the report portrays the sensitivity of the relationship between system designer decisions and basic management decisions.

Russell G. McGrew
Chairman, Working Group on
Automated Weather Information Systems

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EXECUTIVE SUMMARY

INTRODUCTION

Two prior reports of the Working Group on Automated Weather Information Systems (WG/AWIS) addressed the nature of weather information systems and considerations pertinent to their procurement and operations.

The first report (FCM-R1-1981), "A Report on the Plans for Coordination of Major Automated Weather Information Systems," dated March 1981, described the systems of DOC, DOD, and DOT and analyzed the coordination requirements in terms of procurement and operations. The principal conclusions were that:

- o The configuration and functions of AWISs were related more to mission than discipline.
- o Economics in procurement could be better realized through the use of shelf-proven modules of equipment that have met the test of broad market acceptance than through joint procurement of identical equipment.
- o Further economies could be realized through coordination of interface specifications and common subfunctions of the respective systems (through the adoption of appropriate standards and mutually agreed upon practices and procedures).

The second report, "Considerations for Intra- and Intersystem Operations of the major Automated Weather Information Systems (AWIS) introduced a way of thinking about an AWIS, identified phases most appropriate to different degrees of coordination, and pointed out some basic policy decisions that are required. The major conclusions of that report were:

- o New technology and concepts being introduced are powerful sources of new capabilities, but are potential sources of service operational problems in a variety of failure modes.
- o Since there is no established tradition or operational experience in the multidistributive data processing system environment, a measured program of interagency coordination is required on the way to total implementation.
- o The nature and direction of coordination activities are contingent on basic management decisions relative to the infrastructure of the individual systems and the interdependencies of the systems for both normal and contingency operations.

This report enlarges on the conclusions of the second report and provides more detailed background to the ideas presented in both. In it we try to project the full implications of the introduction of Automation of Field Operations and Services (AFOS), Naval Environmental Display Station (NEDS), Automated Weather Distribution System (AWDS), and Flight Service Automation System (FSAS). Unlike the implementation of a new sensor, which may significantly impact the amount and type of data being transmitted and the nature of some service products, the introduction of AWISs can impact not just the traditional processing functions but the kinds of services that may be provided, where they are provided, and how they may be provided. Moreover, they add new dimensions to the requirements for systems management and, even more particularly, to the management of the implementation of change.

The terms "Distributed Data Processing" and "Data Base Management," which apply to basic functions of the AWISs, have been used freely in recent years, but are both subject to a broad spectrum of definitions. The first several pages of this report illustrate interpretations in the context of providing weather services. The concepts are applied to local site operations, single system (Intra-AWIS) operations, and the operations of the Community of Automated Weather Information Systems (CAWIS). Although this provides some difficult reading, it is necessary background to the more traditional management problems that are presented in the remainder of the report.

MAJOR ALTERNATIVES

Each AWIS, for the first time, brings high performance systems to both the communications and the information processing functions of field operations. For each individual service organization, the potential for changes in operations is so great that the design problem is not limited to the selection of the best system design to fit the organizational structure, but presents the problem of selecting the best combination of system and organizational configurations.

Assuming that management will review current practices (organization and operations) in light of the potential capabilities of these new systems, we present alternative types of servicing locations and alternative general system characteristics:

o Alternative Types of Servicing Locations

a. Nonmanned (Direct delivery of meteorological service products to the user -- whether user staff or user system.)

b. Direct briefing (Uses only prepared information -- unchanged in any way.)

c. Adaptive briefing (Essentially only organizes or reorganizes prepared information to adapt to particular problems -- e.g., flight briefing.)

d. Adaptive forecasting (Limited processing to adapt basic weather products to user terms or to specific locale.)

e. Limited basic forecasting (Local or limited parameter forecasting -- originates meteorological products for direct delivery to user -- uses unique routines.)

f. Guidance forecasting (Originates products for the use of other forecasters for limited regions or limited user sets.)

g. Center comprehensive broad scale guidance -- or concentrated high volume processing.)

- Major System Characteristic Alternatives

  a. Local Storage vs. Central Storage

  b. Local Processing vs. Central Processing

  c. Local Program Development vs. Central Program Development

  d. Active vs. Passive Central Management of Data Bases

  e. Local vs. Central Graphics

  f. Highly Structured Data Bases vs. Serial Trail (address linking).

We discuss certain implications of these sets of alternatives with respect to each other. However, management of the individual services makes its decisions in the context of broader organizational management concerns such as the proper allocation of fiscal and personnel resources, organizational goals and user satisfaction (mission), and evaluate the alternative courses of action in terms of:

System Cost
System Maintainability
System Responsiveness
Operations Management
Service Reliability
User Satisfaction
Human Factors

<u>INTER-AWIS CONSIDERATIONS</u>

There are three types of Inter-AWIS considerations:

- Co-Operations - Routine interchange of information during the normal operating mode.

- Backup Operations - Providing various support functions by one system when failure occurs in another.

- Efficiency - Following certain common conventions to make each system more efficient.

<u>Co-Operations</u> include the consideration of system unique information, whether the interdependency is absolute (as it is in the case of basic observations and forecast products that flow from NWS to FAA) or by choice (as might be exemplified by the "Centers of Specialization" concept). The consideration of the nature of the network interfaces (i.e., single or multiple "Gateways" and echelons) is also included.

<u>Backup Operations</u> include two broad considerations. The first is backup for the source of system-unique products; the second is backup in the area of

Data Base Management, i.e., the delivery of products. The latter includes the "Gateway" considerations and even alternatives for driving one individual AWIS from another one.

System Efficiencies include those subjects that affect only the efficiency with which each system does its job. The principal categories are those that impact just the exchange of information (hardware and protocols at the interface) and those that impact the use of the information (standards and conventions related to using the information from other systems within each individual system).

CONCLUSIONS

There are two major conclusions.

- The nature of AWIS systems is so different from current operations that the consequence of system failures present quite different patterns. The operations management factor should duly weigh both maintaining service during failure and the responsiveness of the recovery from failure. It is further suggested that the capability for change be considered, i.e., how efficiently can one introduce change without undue interruption to service or how easy is it to maintain operations in a changing environment (changes in personnel, users, or user requirements).

- The alternatives that may be considered for multisystem operations cover a broad range of subject matter, from concept to extreme detail. The degree to which these different levels should be considered hinge strongly on nonengineering matters, largely on the concept of management of the individual systems.

The report aims to stimulate thinking on these matters.

INTERAGENCY CONSIDERATIONS IN THE DEVELOPMENT AND COORDINATION OF AWISs

The ICMSSR Working Group on AWIS has issued the "Report on the Plans for Coordination of Major Automated Weather Information Systems" (FCM-R1-1981) and is issuing "Considerations for Intra- and Intersystem Operations of the Major Automated Weather Information Systems" as a companion to this report. The purpose of this paper is to suggest to managers some broad considerations that might be made in defining the requirements for future AWISs and the agreements among agencies operating such systems. It is not our purpose to define unique solutions to systems planning problems but to illustrate the implications of certain alternatives as they might be realized in the resulting systems and to suggest some alternatives that might be considered, given different concepts of operations.

In our prior reports, we focused on the subjects of procurement and the coordination of the operations of Automated Weather Information Systems. In this report, we deal with some fundamental management considerations that underlie the system operations. Although our principal concern is with the intersystem aspects, we try to show the sensitivity of intersystem operations to intrasystem decisions.

We speak extensively of Distributed Data Processing and Data Base Management. These are relatively new terms and subject to a rather broad spectrum of definitions. Therefore, we devote several pages to illustrating our interpretations in the context of the provision of weather services and in the management of those processes. We also take an evolutionary approach in applying the concepts to local operations, the operations within a single service (Intra-AWIS) and then the Community of Automated Weather Information Services (CAWIS).

These preliminary discussions provide some difficult reading; we ask the reader's indulgence, for we believe some understanding of these considerations is necessary to the understanding of the more familiar management considerations presented in Section III.

I. MACROMODULE DISCUSSION

For purposes of this discussion, we use the simplified model from our prior paper, "Considerations for Intra- and Intersystem Operations of Major Automated Weather Information Systems (AWIS)." See Figure 1. We will concentrate on the Data Base Management Macromodule and address the others only to the extent of defining the unique features that differentiate them from DBM. First, we will consider the model from the viewpoint of the local site; then from that of the single AWIS; and finally, from that of the community of AWISs. Figure 2 illustrates a conceptual view of the nesting we wish to consider.

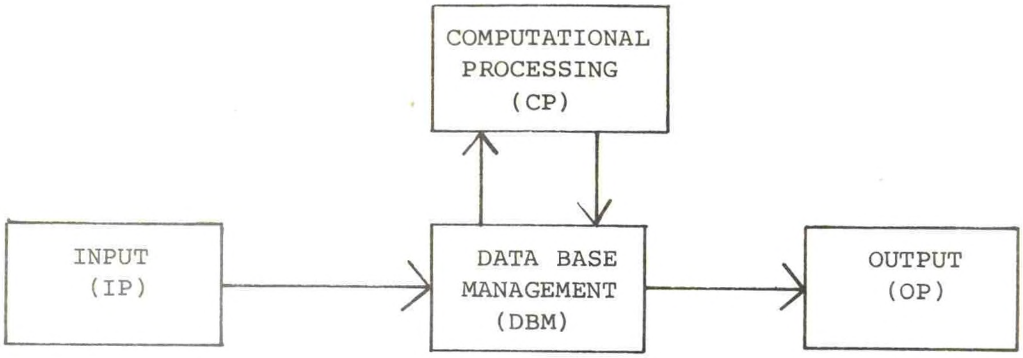

Figure 1. AWIS Model

A. <u>Input Module (IP)</u>

The IP consists only of those actions necessary to accept data from external sources and prepare those data for storage in the data base and/or to relay it to other sites or systems. The degree of activity can vary from negligible (if the source prepares the information within the same standards observed by the local Data Base Management Module) to extensive (if dissimilar codes, identification, or other conventions were employed by the source).

1. <u>Local Site</u>

At the local site, the actual inputs are of three (occasionally four) types:

a. <u>Messages from Original Information Sources</u>

Normally these will consist of information from an interfacing data acquisition system. The data acquisition system may be an AWOS (Automated Weather Observing System) module, a local communication circuit, or a direct entry terminal (for local manual observations or telephone-relayed reports).

b. <u>Originally Composed Messages</u>

These will normally consist of forecasts, warnings, statements, and interpretations prepared for other service personnel or for end users. These are generally destined for the local data base and the output module (OP).

c. <u>Messages from the NDBMS</u>

These are all of the products relayed from other stations within the AWIS or through the AWIS Control Center (CC) from all external sources.

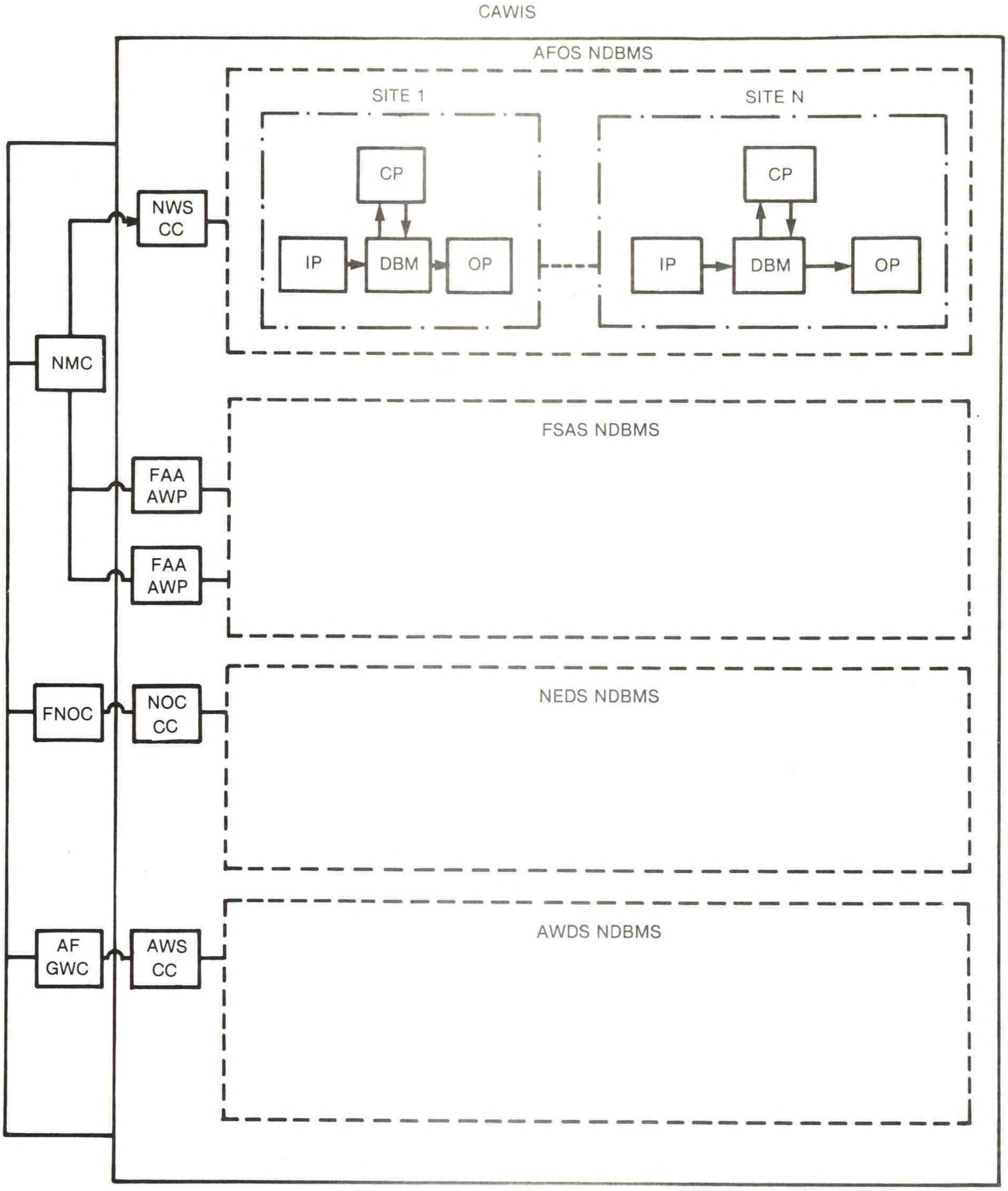

FIGURE 2. NESTED AWIS'S

Note:
CAWIS - Community of Automated Weather Information Systems (AWIS)
AFOS - NWS AWIS
FSAS - FAA AWIS
NEDS - USN AWIS
AWDS - USAF AWIS
AWP - Aviation Weather Processor
NDBMS - Network Data Base Management System
DBM - Data Base Module
NMC - National Meteorological Center
FNOC - Fleet Numerical Oceanography Center
AFGWC - Air Force Global Weather Center
CP - Computational Processing
IP - Input
OP - Output
CC - Control Center

d. Messages from Parallel Systems

There may be instances where parallel systems deliver information directly to a local interface. These are most likely to be satellite data or information from systems of a special nature, e.g., hydrology, forestry.

Within an individual AWIS the functions of the site Input (IP) module should be very few and simple.

2. Individual AWIS

The functions of the input module for the individual AWIS (as a whole) are determined by the overall designs of the individual services and the degree of standardization employed by the set of systems. This module exists primarily at the CC side of the "Gateway" functions. Through it flows all information generated outside of the AWIS. Its principal function is to assure that all information is in the proper form for entry to its (the CC) data base and the comprehensive data base of the total AWIS. The "proper form" implies that individual messages meet the standards of message identification and format and routing information employed within the AWIS. The greater the commonality of these characteristics among the systems, the less complex are the functions of this module. (The individual services may choose to place this function in the major communications installation associated with the collocated Numerical Processing Center (NPC).)

The types of information flowing through the input module are:

a. Information originated within other AWISs.

b. Products from the associated NPC.

c. Products from other NPCs.

d. Products from systems of other agencies.

e. Products from foreign sources.

f. Data and products from other acquisition systems (e.g., weather and communications satellites).

3. CAWIS

There is no meaningful function of input to the CAWIS (the Community of Automated Weather Information Systems) -- beyond the net sum of the inputs to the individual AWISs.

B. Output Module (OP)

The OP consists of those functions necessary to transmit information from the data base to a scheduled recipient. Normally, these functions will consist only of meeting those standards of identification, format, and routing expected by the recipient. If the transmitter and the recipient observe common standards, the functions are minimal; if they employ different standards, agreement must be made concerning which performs the necessary transformations (i.e., the sender's output module or the recipient's input module).

1. Local Site

The local site will normally transmit to two types of recipients, viz., other sites within the NDBMS and to users (internal and external).

a. NDBMS

Within the NDBMS, common standards will normally be employed. There may be situations wherein higher echelon sites may send information in different modes and forms to certain classes of lower echelon sites. For example, some lower echelon sites may be, in essence, remote terminals or remote displays of either soft or hard-copy types.

b. External User Interface

A wide variety of transmission standards may apply in these cases due to the variety of requirements at the user end. The latter may include interfaces with:

- o Low or medium speed alphanumeric (A/N) circuits.
- o Computer to computer link of either synchronous or asynchronous types in a variety of protocols.
- o Remote soft display.
- o Remote digital or analog storage device.

c. Internal User Interface

In the strictest sense of the word, local display and auxiliary storage devices may be considered to be served by the Output (OP) module of the local DBMS.

2. Individual AWIS

The primary function of the OP module of the individual AWIS is to serve as the feed of the AWIS component of the Gateway operations. It will normally be located at the Control Center of the Network Data Base Management System (NDBMS). This is an oversimplification, for it is at this point that some implications of multisystem design strike home.

In Figure 3, we illustrate three alternatives for intersystem communications. In that figure the Communications Adjunct-Control Centers (CA-CC) combination (or AWP-NADIN), is what we commonly call the Gateway operation and Alternative 3C is the more or less assumed intersystem design. This may be because it corresponds in concept with current exchange practices, but it also meets requirements for information exchanges beyond inter-AWIS meteorological requirements. In the latter category are operational requirements for aviation operations and information of interest only to the National Processing Centers (NPCs).

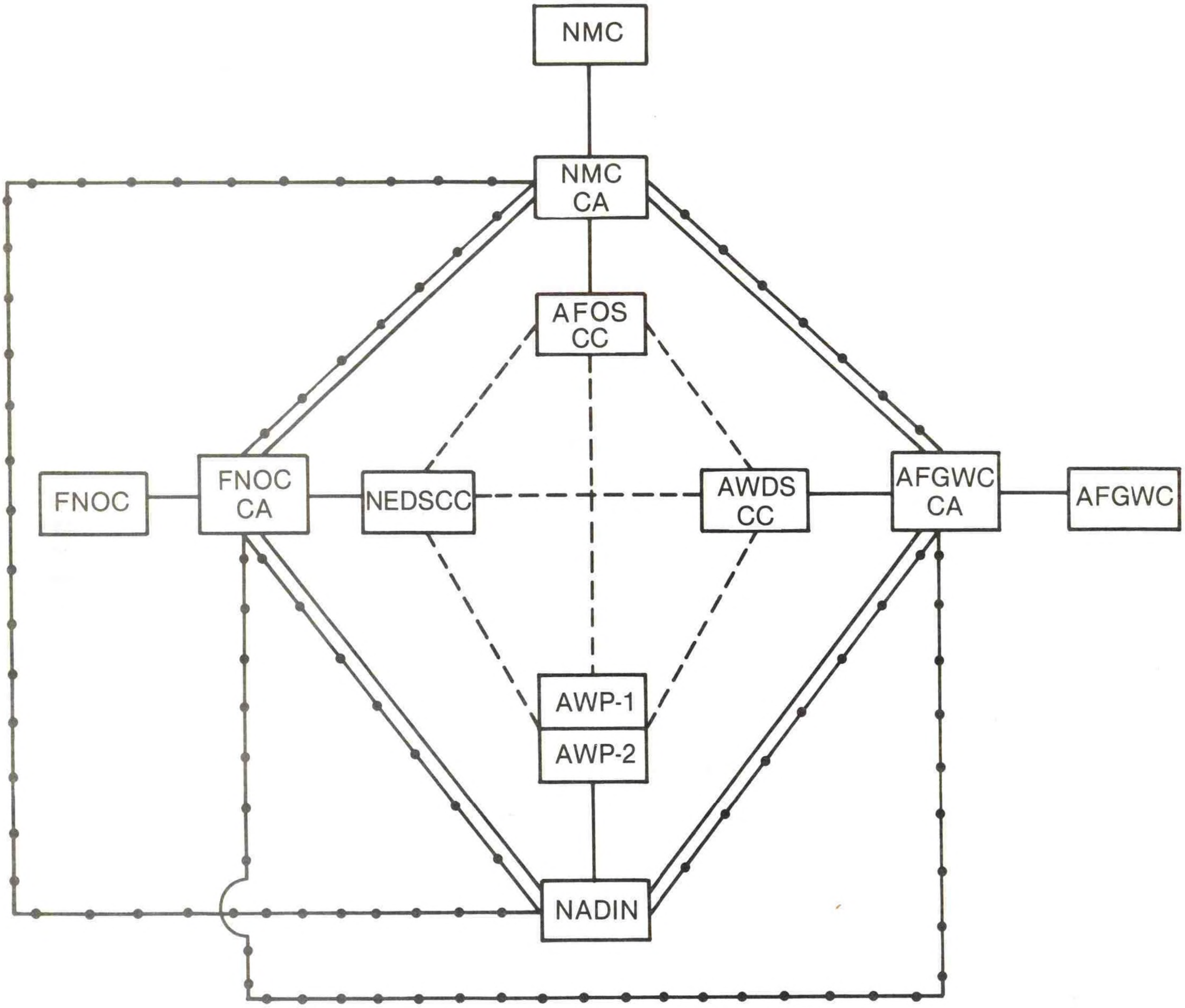

Figure 3. Intersystem Communications Alternatives

Legend: CC - Control Center (NDBMS)
CA - Communications Adjunct
AWP - CC for FSAS
- - - - Alternative A - Direct AWIS NDBMS Interface
—— - Alternative B - Integrated CA Exchange Net
●—● - Alternative C - Multi-Circuit CA Exchange

The potential impact on the individual Output or Input modules is best illustrated through Alternative 3A. Under 3A, all information exchange between AWISs would take place at the CC level. It becomes rather obvious that if completely dissimilar standards were to be employed, each system would have to either transform its traffic to three different standards in the OP or transform three different standards to its own in the IP.

With alternative 3C, the same kinds of problems are presented except that for transformations associated with the IP's and the OP's we speak only to pure communications interfacing (format, protocol, routing, and identifier coding). We will discuss a more extensive corollary <u>within</u> the message under the DBMS module.

3. <u>CAWIS</u>

As with the Input Module, there is no real meaning that can be attached to the function of Output Module in the CAWIS sense. This function is usually handled by the Communications Adjunct of the National Processing Center.

C. <u>Computational Processing Module</u>

We intentionally play down discussion of this module -- for under the concept we are trying to pursue, the precise functions performed may vary by site mission, site climatology, season or even by individual forecaster. The functions really deal more with the techniques employed in the forecast formulation process and the requirement for standards may more logically lie in the area of documentation than in actual operations.

D. <u>Data Base Management Module (DBM)</u>

Given the state of our experience with Distributed Data Processing Systems, this is the module that cries for the most study, the most analysis, and the most innovative thinking. It may also require the most decisions relating to concepts of operations -- in the people and service sense as well as in the sense of overall reliability of operations.

We spoke, in the prior paper, of three submodules, viz., physical storage, data handling and interactive control. These submodules have quite different connotations at the various echelons we have been speaking to and at each level create many opportunities for both management and engineering decisions.

1. <u>Local Site</u>

For local sites let us deal only with the so-called field site (Weather Service Forecast Office (WSFO), Weather Service Office (WSO), Weather Service Meteorological Observatory (WSMO), Flight Service Station (FSS), Center Weather Support Unit (CWSU), Operating Location (OL), Base Weather Station (BWS), Command Center (COMCEN), Command Detachment (COMDET). We will speak to the singular CC (Control Center) sites only at the individual AWIS level.

To gain further insight into the DBM, let us break down the submodules into a further substructure (See Figure 4).

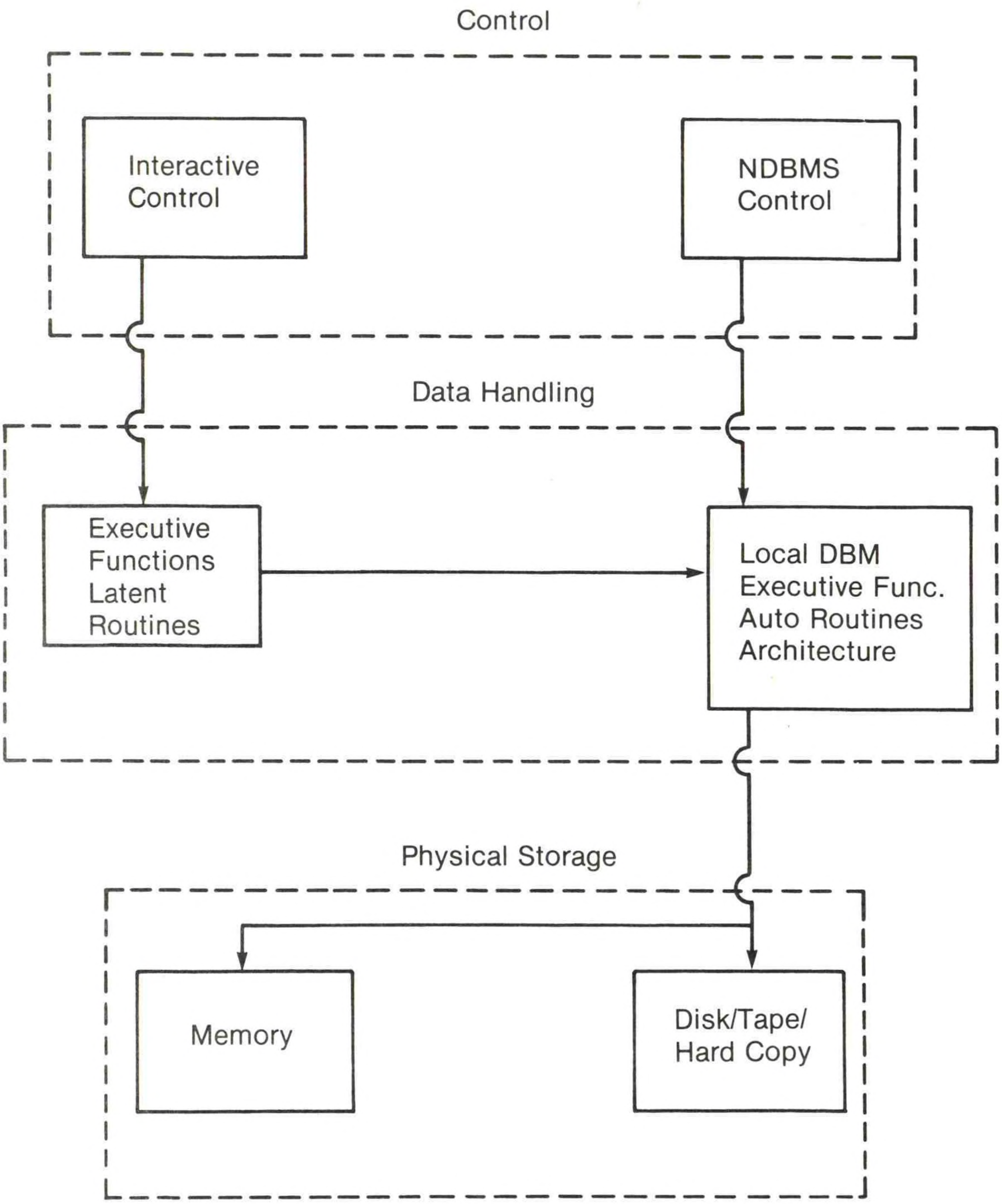

Figure 4. Local DBM Substructure

a. Control Submodule

The Control Submodule may be viewed as consisting of two parts, viz., an Interactive Control function and a control exercised by the network manager system (the Control Center). How this control is balanced is directed by ADP management policy and is reflected in the software design.

(1) Interactive Control

The Interactive Control function is exercised by the local operator and takes two forms. The first and most obvious one is that of executing routines and processes that are not tied to a definitive schedule. They may consist of the message composition jobs, the generation of displays or products that are required seasonally or with certain weather situations, routines preferred by only certain individuals and the routines that are involved in the computational processing modules (such as scientific applications). The second class of functions may involve any local optional control over the local DBM, e.g., changing DBM directories or the order of execution of automated routines.

(2) Network Data Base Management System (NDBMS) Control

This is an externally applied control. This may take the form only of software-imposed constraints on the Interactive Control function. However, in a more sophisticated system, it could consist of a remotely managed quality control of the resident data base -- i.e., assurance that appropriate subsets of the national data base actually exist in the local base and that automated routines for local data generation are, in fact, executed. The latter function represents a very positive and comprehensive NDBMS.

b. Data Handling Submodule

The Data Handling Submodule is the key to efficient and responsive system operations and a vital cog in network (NDBMS) control. It consists of all the logic that determines the information to be stored, how it is stored and maintained, the operations that are performed on the information, the local generation of new products and the schedule of all operations. Let us look at this submodule in three parts: executive functions, supporting routines and structural characteristics (architecture).

(1) Executive Functions

There are two classes of executive functions, the first (the Local DBM set) governs the scheduling of all of the inputs, output, processing operations and, as a subset, the executive functions associated with the interactive control part of the

Control Submodule. The latter consists of all of the commands and associated software that enable the operator to exercise his or her options. (It is important to understand that this arrangement does not necessarily mean that the operator's wishes are completely subservient to the DBM Executive; it merely means that the DBM Executive must be designed to serve the operator's requirements under a known set of rules.)

(2) Routines

The second part of the Data Handling Submodule consists of all of the "routines" needed to perform all of the processing and operations functions. One set of these routines (marked "AUTO" in Figure 4) are those that are used and activated directly by the Executive functions of the DBM. The others, which we call "Latent" are those activated only by the operator through the Interactive Control. These are noted separately only because their actual functions are not important to the operations of NDBMS -- except to the extent that they must be compatible with overall operations software.

(3) Architecture

The architecture of the data base is really implemented through the Executive Function -- but is treated separately here only because of its significant influence on the efficiency of systems operations. The data base architecture really determines how many operations must take place to store and retrieve sets of data for whatever purpose. Thus, it influences such diverse measures of performance as response to query and mean time between failure (MTBF) (as it may be influenced by the number of disk accesses per operation). The appropriate architecture must be selected on the basis of the kinds, frequencies, and urgencies of processing requirements. This determines the relational aspects of the architecture -- e.g., the comparison of requirements for synoptic retrieval (all places for one time), chronological series by place, vertical profile, vertical cross section, all places by parameters, all parameters by place, collectives by political subdivision, and various combinations of these.

Another component of the architecture may be thought of as the physical representation of the stored information. This would involve the degree that absolute location is assigned and the degree that compression is employed in the stored data state. This component is relational in certain respects but mainly impacts the actual amount of physical storage required.

c. Physical Storage

As the name implies, this submodule consists of the sets of devices in which the data reside. The appropriate mix is determined by the balance of performance requirements versus economies. In general, the net cost per unit of storage is positively correlated with performance requirements, i.e., low access time and low maintenance equals high capital cost.

2. Individual AWIS

For an AWIS entity, it is useful to think of the AWIS CC as the control submodule, the combined set of approved software (CC, NPCAC, and local) and approved procedures as the Data Handling submodule and the total controlled storage of all sites as the physical storage submodule. Figure 5 shows the individual AWIS analogy to Figure 4.

a. Control Submodule

There are two major parts to the control submodule of the AWIS. The first, the interactive corollary, consists of the personnel who act as network and/or information controllers. It handles all of the reactions to errant operations. The second is the set of approved software that controls normal operations. The set should be considered to include all germaine software within the NPCAC (National Processing Center Adjunct Communications, CC software, and all of the DBM software local to each site).

b. Data Handling Submodule

There are partitions of the Data Handling Submodule that react to the two control partitions.

The "latent" routines, associated with diagnosing problems or with executing backup operations, support the interactive control function. The backup operations may include the use of alternative communications paths (dial around or remote operation), data base refresh, etc. With these, we should consider those rules and standard procedures that require manual intervention.

The routine automated data handling function is executed through a series of routines that accept, schedule, and route the information. Two further types of routines may be required. One such function would perform all of the necessary conversions required to handle information input from external sources that do not observe AWIS standards. The second would perform the quality control function. Options within this function range from mere accounting of all inputs to the positive verification of the storage of all scheduled data at the individual sites.

The architecture at the AWIS level would consist primarily of the set of individual directives and the communications network design.

c. Physical Storage

The physical storage can be considered to consist of the CC storage required in-transit to the archives or record retention facility and all that storage at local sites reserved for positive data base control.

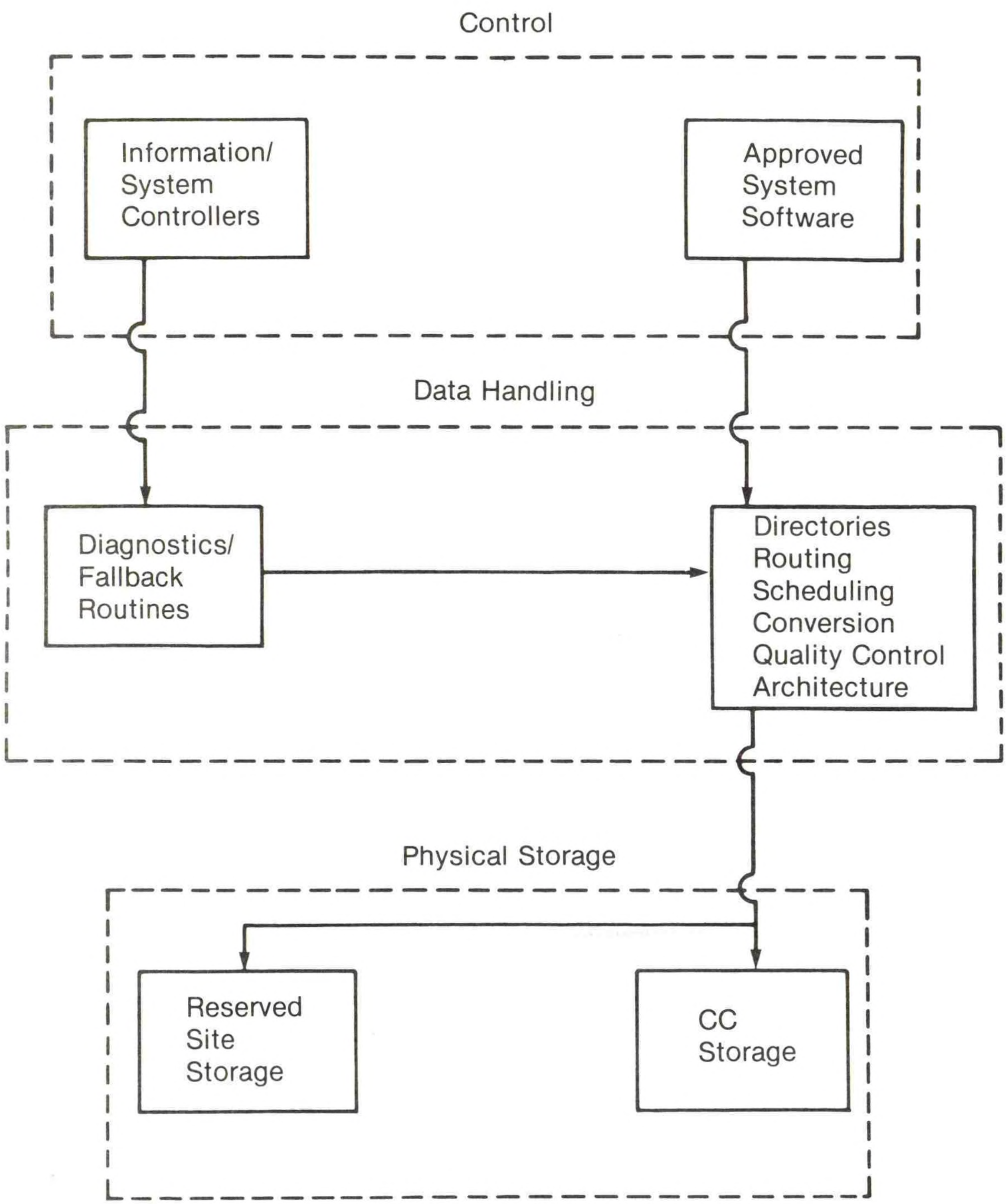

Figure 5. AWIS DBM SUBSTRUCTURE

3. CAWIS

The only submodule of the DBM module that is applicable at the CAWIS level is that set of standards and mutually agreed practices and procedures to which the individual agencies agree. Even at this level one can consider the control submodule to consist of two subsets corollary to those we discussed for the lower echelons. The first would consist of those backup procedures or arrangements made to inject backup support from another AWIS in the event of system failure. The other, of course, would be for routine intersystem operations. It would consist of those specifications dealing with physical exchange of information and those dealing with the internal form and format of the information. (It may be said here, parenthetically, that the more restricted these agreements are, the greater risk of a requirement for each receiving system to have an extensive set of conversion routines within its Data Handling Submodule.)

II. MAJOR AREAS OF INTRA-AWIS CONSIDERATION

We speak to the Intra-AWIS area first, for in many ways decisions in the individual AWISs determine the flexibility available for Inter-AWIS consideration. The extremely rapid advances in processing technology have added many dimensions to the systems design problem -- for they impact not only the traditional processing functions, but the services that may be provided, how they may be provided, and where they may be provided. This proclivity for rapid change also adds new dimensions to the requirements for system management and, even more particularly, to the management of the implementation of change. Another tempering thought that should be kept in mind in the excitement of the opportunity for putting new technology to work is that just because something can be done, it does not necessarily follow that it should be done. To the old golden rules of system design -- Economy, Efficiency, and Effectiveness -- should be added the practical considerations of operability and manageability which should be, but are seldom considered under "Effectiveness."

A. Some Alternatives for Consideration

The major alternatives provided in the era of distributed data processing (DDP) lie basically in the:

- o Distribution of stored information bases
- o Distribution of types of processing capabilities

These may be translated into two major decision areas:

- o How much of what kinds of information should be stored at how many places?
- o What kinds of processing should be permitted at how many places?

Before addressing the system alternatives and their implications, we will address briefly the nonsystem alternatives.

1. Nonsystem Alternatives

The degree to which these alternatives must be considered is determined basically by whether the new system is to be fitted to current practice (organization/operations) or practice is to be fitted to the potential capabilities of the new system. The direction of this determination is usually based on how new the new system is to the organization. (In the current context, the Navy might be more inclined to change practice than perhaps the FAA or AWS.)

The principal alternatives germaine to the question of the system alternatives deal with the distribution of the following kinds of servicing locations:

a. Nonmanned (Direct delivery of meteorological service products to the user -- whether user staff or user system.)

b. Direct briefing (Uses only prepared information -- unchanged in any way.)

c. Adaptive briefing (Essentially only organizes or reorganizes prepared information to adapt to particular problems -- e.g., flight briefing.)

d. Adaptive forecasting (Limited processing to adapt basic weather products to user terms or to specific locale.)

e. Limited basic forecasting (Local or limited parameter forecasting -- originates meteorological products for direct delivery to user -- uses unique routines.)

f. Guidance forecasting (Originates products for the use of other forecasters for limited regions or limited user sets.)

g. Center guidance (Comprehensive broad scale guidance -- or concentrated high volume processing.)

The number, types, and locations of data organization activities impact the above considerations but not necessarily in a primary way. The primary determinants can be the grade and skill mix of personnel which, in turn, may be dictated by the balance of availability vs. requirements vs. constraints of budgetary authorization vs. relative priorities for the application of human resources.

2. System Alternatives

Some of the system alternatives we shall present may be viewed independently of the determinations discussed under nonsystem alternatives; the consideration of others should be tempered by them.

There is no obvious order in which the following considerations should be made -- so we will go through them and try to get the tie-in under the discussion of implications.

a. Local Storage versus Regional or Central Storage

With the sharp decline in the unit cost of storage, there is a great temptation to design toward local storage. From a pure cost viewpoint one must adequately consider the net system cost resulting from a small multiplier times a large cost versus a large multiplier (numerous locations) times a small cost.

At the level of the facility where only finished products are used, this may be a yes or no determination. At other levels, however, the storage question must be considered in conjunction with the associated processing required. Further, the practical question will usually be one of how much of what kind of information is stored locally and how much remotely.

b. Local Processing versus Regional or Central Processing

Again the question is usually not one of simply none or some, but how much, where. However, the principal breakpoints in the determination come at the following functional requirements:

- Retrieval and display
- Display synthesis from stored matrices
- Sort and simple 4-function operations (+, -, x, ÷)
- Complex mathematical functions

c. Local versus Regional or Central Program Development

Somewhat allied to the processing alternatives, there is one of restricting local operations to the execution of prepared programs (or the stringing together of subroutines) or to permitting the local generation of programs.

d. Active versus Passive Central Management of Data Bases

The kernel of this set of alternatives is whether a central facility monitors the completeness and accuracy of the information base at the distributed locations, whether the onus is placed on the receiving site to monitor its data base and to query for suspected omissions or whether the whole problem is considered part of the risk to be assumed.

e. Local or Central Preparation of Graphics

This question boils down to whether the bulk of the isopleth graphics are transmitted in vector-encoded form or whether gridded data are transmitted and "isoplething" is performed locally. The main discriminating factor should be the relative requirement for using the information as a briefing aid vs. a basis for further computation at the lower echelon site. Local computation may take different forms. The grid data may be used as a basis for conversion into user terms or user applications. It may also be used to update information provided at long cycle times, thus yielding "running" briefing or monitoring aids. Finally, in the event of isolation from the source of graphics products, the local entry provides a backup of sorts. Other alternatives, of course, are to deliver both vector graphics and grid data or to deliver the graphic data via a parallel system for interfacing at the local level.

f. Highly Structured Data Base versus Directory/Serial Trail

The responsiveness of the system is very sensitive to the number of search operations required to generate a product or respond to an operator's command. Alternatives range from a highly structured one, where storage assignments are absolute with respect to data type, space, and time, to the more common adaptive system of assigning space with a provision for seeking via the directory of product and source location and chain through time (serial trail). There are other alternatives which would permit absolute assignment for certain types of products and chaining assignment for others.

3. Summary of Alternatives

We have enumerated sets of both system and nonsystem alternatives. While neither set is exhaustive, the alternatives should illustrate areas that should be subject to consideration in individual systems planning and also serve as a basis for discussions of intersystem alternatives. Table 1 summarizes the alternatives.

TABLE 1. SUMMARY OF INTRASYSTEM ALTERNATIVES

	Nonsystem Alternatives		System Alternatives
1.	Nonmanned	1.	Local Storage vs. Central* Storage
2.	Direct Briefing	2.	Local Processing vs. Central Processing
3.	Adaptive Briefing	3.	Local Program Dev. vs. Central Program Dev.
4.	Adaptive Forecasting	4.	Active vs. Passive Central Management of Data Bases
5.	Guidance Forecasting	5.	Local vs. Central Graphics
6.	Center Guidance	6.	Highly Structured Data Base vs. Serial Trail

*Central includes Regional

B. Implications

While the implications we will discuss will be of interest to personnel involved in site operations, our orientation is toward the interests of organizational management. Thus, we will concentrate mostly on costs, responsiveness, reliability (from the standpoint of service continuity) and tradeoffs among these parameters. We will address what might appear to be technical tradeoffs in these same terms and, where appropriate, mention other management interests.

For purposes of discussion, let us first divide our system alternatives into three groups:

Group I -- those dealing with the degree of distribution of basic processing functions (storage, processing, and program development) which have potentially strong hardware/cost implications.

Group II -- the data base structure and graphics generation options which add system software considerations to a greater degree, and

Group III -- the data base management alternatives which relate principally to reliabiliity (degree of risk of service deficiencies).

We will address the system alternatives, attempt to link them with the nonsystem considerations, and then speak to management implications.

1. System Implications

Different kinds of implications will apply to the different groups of alternatives.

a. Group I

Let us first look at the extremes of alternatives as they relate to storage, processing, and programming and then consider some guidelines for compromise positions. This group of considerations has the broadest set of implications -- so, consider them in terms of:

- System cost
- System maintainability
- System responsiveness
- System operations management
- Service reliability
- User satisfaction
- Human factors

(1) Most Extensive Distributions of Processing Capability vs. Most Centralized Concentration

We summarize, qualitatively, in Table 2, the direction of the implications at the extremes of the alternatives.

It would appear rather obvious that neither extreme is a desirable alternative. Moreover, it is suggested that the answer is not one of how many places to put full capability -- rather it is one of selecting the appropriate level of each capability at each location.

TABLE 2. COMPARISON OF IMPLICATIONS OF

DISTRIBUTED VS. CENTRALIZED PROCESSING FUNCTIONS

DESIGN FACTORS	DISTRIBUTED PROCESSING, STORAGE AND PROGRAMMING	CENTRALIZED PROCESSING, STORAGE AND PROGRAMMING
1. System Cost (Capital)	Overall system cost very high.	Central facility cost high and comms cost higher; overall cost somewhat lower than "Distributed."
2. System Maintainability	Personnel costs high. High logistics costs. High pipeline requirements. Some barren spots for contract maintenance (if applicable). Requires responsive backup system.	Concentration lessens cost and operational maintenance problems. Increases personnel utilization.
3. System Responsiveness	Most responsive to immediate site needs (lacking a very sophisticated center and communications system).	Contention for service can lead to slow response to site requirements. Usually can be more responsive to very sophisticated or broad scale requirements.
4. Operations Management	Increased configuration management problems. Increases security problems (physical; software integrity; sensitive information). Increased problems in implementing change in both software and hardware. Increased training/retraining problems.	More manageable due to concentration of problems and narrower span of management. More prone to isolation of end services (for response to user requirements).
5. Service Reliability	Provides a better "tide over" capability to provide services during short-term communications failures. Failures impact a smaller proportion of the user set.	More prone to end user service interruption. Risk of failures impacting a larger proportion (or all) of the user set simultaneously.
6. User Satisfaction	Provides potential for more extensive services (i.e., other than highest priority). Provides potential for faster response to changing user requirements.	Will usually introduce lag in responding to new user requirements. Usually can provide more sophisticated responses to user requirements.
7. Human Factors	Provides incentives and challenge to highly motivated personnel. Can be viewed as unnecessary obstacle for people not motivated toward systems. Can encourage participatory view between internal user and "system."	Can provide better career ladder for systems oriented people. Can encourage a confrontation attitude between field user and center system.

Although there are a number of objective analyses and more qualitative analyses that may contribute to a decision, the final decision is a management decision, and as in most other decisions, the overall governing factors are:

- o Operational manageability

- o Prudent application of resources to meet mission requirements

- o The amount of risk of less-than-satisfactory performance of mission that management is willing to assume.

In light of these governing factors, some additional considerations that must be made are:

- o Given that sufficient funds were available to install a widely distributed processing capability:

  -- Is the talent available in sufficient numbers to take advantage of it?

  -- Is that the best application of the available talent?

  -- Are all of the implied costs for operating and maintaining the system covered?

  -- Can the system be effectively managed to deliver the promised performance?

- o Given the appeal of lower cost, better manageability and more sophisticated service of a centralized system:

  -- Has the risk of catastrophic failure been covered?

  -- Is the delivery system adequate to maintain a responsive service?

(2) Intermediate Alternatives

At this point, it is suggested that the alternatives may be developed within a narrower range to ameliorate some of the extremes presented in the two alternatives. For this purpose, it will be useful to consider the nonsystem alternatives.

The nonsystem alternatives are intended to describe the maximum functional complexity of sites which may be equipped with AWIS capabilities. To repeat the alternatives:

Class 1. Nonmanned
Class 2. Direct Briefing
Class 3. Adaptive Briefing
Class 4. Adaptive Forecasting
Class 5. Guidance Forecasting
Class 6. Center Guidance

Strictly speaking, the first classification is not a true AWIS component -- but is an extension of service from a higher level facility. It would be more appropriate to interpret Class 1 as an automated version of Class 2 (the direct presentation of prepared materials).

Although varying somewhat in nature, all classes of facilities apply equally to the operations of AWS, NOC, and NWS. The FAA system would be or could be composed of the first 3 classes; although Class 4 would apply for certain installations manned by the NWS but served by FSAS.

For purposes of discussion at this point, let us ignore Class 1 (because its facilities are likely to be provided by the user) and Class 6 because our interest will be limited to its potential use as a large scale processing facility.

Because of the potential impact on total system costs, the relative numbers of the types of facilities is germaine. Of Classes 2 through 5, Class 5 sites are least numerous -- while Class 3 or 4 is likely to be the most numerous. Disregarding current AWIS plans, Table 3 represents an estimate of the distribution of sites by facility class.

TABLE 3. ESTIMATED NUMBER OF FACILITIES BY CLASS

CLASS/AGENCY	NWS	AWS	NOC	FAA
2. Direct Briefing	---	---	---	---
3. Adaptive Briefing	---	---	---	325
4. Adaptive Forecasting	243	163	48	22
5. Guidance Forecasting	54	3	8	---

Now let us address, by station class, the level of "requirement" for storage and processing power.

(a) Class 2 - Direct Briefing

By definition, the function of this facility is limited to briefing with no substantial interpretation required. Therefore, the prime data base required is one consisting of briefing aids, i.e., finished products. The principal question presented is whether those aids are stored locally or requested from remote storage on an as-needed basis. The adequacy of the latter approach is determined by the capability of this remote location and the intervening communications. The tradeoff then becomes the requirement for responsiveness vs. the cost of separate on-site storage of data bases as opposed to a common or concentrated storage base elsewhere (assuming communications costs are equivalent in the two approaches).

The tradeoff in processing power requirements is less pronounced, viz., storage and retrieval functions vs. terminal request/reply functions.

In any event, the most challenging developmental job is that of product design and the placement of the function of supporting this class of facility.

(b) Class 3 (Adaptive Briefing)

For the adaptive briefing facility, it is less likely that final products will suffice. The most appropriate illustration of this kind of facility is that of the aviation briefing office. The trend is toward more tailored briefings and thus there is a requirement for piecing together "subproducts," e.g., individual terminal forecasts and observations, selected warning reports, PIREP'S, etc. into a specific flight briefing.

Unless the local requirements are very homogeneous (e.g., local flying or limited routes), thus being capable of being served by a limited set of displays, there is a greater requirement for either:

- a local data base, or

- a very responsive request/reply system.

The consequences of isolation are also somewhat more serious.

The principal determinations are sizing the local storage to meet the bulk of requirements and installing the capabililty to serve the unique requirements or those that occur less frequently.

The processing requirement, though somewhat more complicated than Class 2, is limited essentially to simple procedures of sort, select, and synthesize.

(c) Class 4 - Adaptive forecasting

The function of adaptive forecasting adds another level of processing complexity, due to the requirement for originating forecasts. In addition to the review of a wider range of products, the local site personnel must inject some new techniques -- algorithms for converting general forecasting parameters to terms most useful to the end user -- algorithms for adapting more general guidance to specific local conditions -- or procedures for evaluating a number of "guidance" products.

The inclination toward distribution of processing and storage facilities to this class of sites would be much more supportable. Each limitation of these capabilities puts greater pressure on the development of greater sophistication at a higher level supporting site.

There may be a wide variation in the requirements presented by Class 4 sites -- due to differences in the complexity of the local problem. These may range from sophisticated processing on a small data base (for very specialized support) to simple processing (4-function) on a moderate data base.

Subclassifying certain types of these sites may be useful -- but precise tailoring to absolute requirements may unduly complicate the configuration management and supporting logistics functions.

(d) Class 5 - Guidance forecasting

The first level of consideration to intra-AWIS management is whether this class of facility is required. The requirements for data base and processing can be substantial -- again depending on the concept of structuring the guidance organization. (Alternative concepts range from pure geographical responsibility, to matching user organization structure, to subject matter. Examples of the last are: agriculture, fisheries, en route flight control, terminal operations, missile operations, and submarine operations.)

It is suggested that except for some extreme geographic considerations (overseas operations), serious consideration should be given to moving the more sophisticated and demanding processing to the Class 6 facility and adding somewhat to the capability of the Class 4. The principal system impacts would lie in the assurance of reliable servicing from the NPC; the net increased field system costs could prove to be somewhat lower. The principal management determination might lie in the adequate availability of skills to operate the higher level Class 4's that would result.

b. Group II

It will become obvious that there are direct linkages between the Group II considerations and those in Group I. Let us take up the two components of Group II separately.

(1) Data Base Structure

The prime consideration in data base structure design is responsiveness. It is particularly applicable to sites above Class 2 and becomes increasingly important at the local site with increasing data base sizes and/or increasing processing capability. It becomes even more important at the regional or central site -- the more such functions are remoted up the line.

The more synthesis of information that takes place, the greater number of retrieval processes that must take place, and the more operations that must be performed to fetch the data required for synthesizing a product, the lower the responsiveness. As we mentioned before, the precise design is very sensitive to the precise requirements as defined by the use of the system. Requirements other than time sequences by parameter set and place will ordinarily be met more responsively by increasing the absolute location structure of the data set. This, in turn, will ordinarily result in greater requirements for storage capability. A somewhat related tactic for increasing responsiveness is to precompute and store the most commonly required synthesized products. (Examples are certain collectives and plat presentations of regional observations.) This tactic also ordinarily requires additional storage capability.

The final determination in this area must also include the considerations of whether the distribution of this "final product" version of information can, in fact, substitute for the distribution and storage of the individual observation data set. However, this is more likely to be true only for the Class 2 or 3 facility.

(2) Graphics Generation

The alternatives, with respect to the generation of graphics, are subject to rather straightforward analysis. To review, the alternatives are:

- Distribute vector encoded isopleth charts.
- Distribute "grid data" and perform curve-fitting functions at the lower echelon sites.
- Distribute both.
- Distribute "grid data" via main AWIS and use a parallel facsimile-type system for distributing the "graphics."

The following may be held to be generally true with respect to the consideration of these alternatives:

(a) Where the graphics subject matter is required for subjective consideration (direct briefing) only (i.e., not a basis for computation), the transmission and storage of the information in vector-encoded form is least expensive (due to data compaction and the low cost of microprocessors).

(b) If grid data are required to support computation and graphics are required for briefing, local curve fitting should be adequate and will save the extra storage and transmission time.

(c) The last alternative should arise only due to circumstances that would justify the graphics communication for non-AWIS system reasons.

(d) The single largest problem associated with this determination is that of sizing the acceptable grid data base. An increase in any of the factors (areal coverage, number of versions in time, weather parameters) will cause a very sizable increase in the amount of digitial storage required. The basic hemispheric grids may vary from 4- to 5,000 points per parameter, per time increment, per level. Data compression techniques may be employed to reduce transmission time requirements, but compression in storage must be weighed against responsiveness of the site equipment vs. remoting the processing to a higher level facility. In any event the potential magnitude of the storage implications should cause one to carefully weigh the true requirements at the field site.

c. <u>Group III</u>

Data Base Management Alternatives. To review, the Data Base Management alternatives presented were active vs. passive central management of data bases -- completeness and correctness, from a communications point of view. These alternatives are presented partially because there is a greater capability to perform this function centrally, partially because there is a greater risk of mission failure if end-point monitoring is required, and partially because "straight-thru" computation of end products (automated terminal forecasts, verification monitoring) requires a higher level of confidence of the accuracy of the received information.

Under current systems, visual inspection at the receiver end is easily accomplished. Under facsimile, pictures may be distorted or obscured, but not changed. The collective arrangement on A/N circuits are such that data may be obscured (garbled) but omissions can be spotted by the regular order of the presentation -- and all receivers on the single circuit are affected by such observations. And finally, all local manipulation of the data is accomplished by an individual.

Under AWISs, the information may not be subject to review until retrieved and, quite frequently under current plans, other products may have been derived from it before a human review takes place. Each AWIS certainly has the capability to monitor the completeness of data being distributed and could have the capability of verifying the information resident in the distributed storage locations. This potential affords the opportunity to minimize the risk of service deficiencies due to "lost information." The cost side of the question is represented in the software overhead and the increased demands on the communications loading.

2. <u>Management Implications</u>

There is no clear <u>best</u> path that can be defined for management. At the very least, management must either establish its absolute priorities among a number of factors or identify specific areas within which it will accept tradeoffs.

At the zero-th level, the tradeoff is between Resources and Mission Performance (user satisfaction). The next level might be seen as resources for the AWIS-supported functions vs. other responsibilities and user satisfaction relative to these functions vs. other functions.

Then, with respect to the AWIS-supported functional area, the arguments we have presented come to the fore with the following kinds of considerations and interplay.

a. Resources

What proportion of the remaining resources should be invested in the people who use the system (as reflected in our "Nonsystem Alternatives") vs. how much in the system that supports them. This judgment will largely depend on the generalized "Mission Performance" or "User Satisfaction" evaluation. The latter, though, will usually have two components -- one, the degree of satisfaction while all goes well and two, the degree of dissatisfaction when failures occur. The latter deserves the greater attention since it can ultimately be the most damaging to true mission accomplishment.

Failures to perform stem from system component failures and failures of management. Ergo, the guiding rule should be toward simplicity and manageability.

If one were to hold day to day user satisfaction paramount, it would probably lead to distributing the greatest capability to the broadest extent -- i.e., highly qualified people and high performance in situ systems at a broad set of locations. Unfortunately, this is directly correlated with highest cost and greatest risk of failure (due to high complexity and most difficult manageability).

b. Manageability

Systems are too frequently designed within a narrow definition of "Performance" -- i.e., performing a specific set of functions with a high degree of efficiency when they are performing these functions. Our term "manageability" is directed toward:

How efficiently can one maintain acceptable service during periods of system failures.

How responsive is the recovery from failure in the system.

How efficiently can one introduce changes to the system without undue interruption to services.

How easy is it to maintain operations in a changing environment (changes in personnel or users).

The principal intent of this section is to try to illustrate that management views in a broader sense are important to the development of internal system designs.

III. INTER-AWIS CONSIDERATIONS

We have discussed the Intra-AWIS considerations in Part II, primarily to provide a basis for illustrating the ways that intra-system concepts may support or constrain Inter-system considerations.

As we have stated in prior reports, there are certain absolute interdependencies among the AWIS systems. Principally these consist of basic observations originating within each service and the dependency of the FAA system on the NWS system for all meteorological products other than observations. There are other instances where agencies rely on each other for support at the "AWIS" level, usually because of peculiar interests in peculiar areas, e.g., NWS to NOC in Hawaii. The interface, though, is usually not a true system interface in the two-way sense, but the installation of a "drop" on the other system.

With the advent of the true AWISs, more opportunities for coordinated action will be presented; they may, perhaps, be mandated in the interests of economy and reliability. We will address three major areas of consideration:

- o Co-Operations - Routine operational exchange of information on a real-time basis
- o System Backup - Source materials, data base management
- o System efficiencies - Standards, conventions, protocols

and then address the subject of the instruments of implementation.

We have pointed out, in other papers, that in the weather service stream there is a high coincidence of interests among the services on the input side of the AWIS segment, but that in the formulation and delivery of services the character of the individual AWIS is influenced much more by the peculiar missions of the agencies and the specific requirements of the users. Thus, identicality in products, procedures, and systems can be a detractive influence on the quality of services. Our key job is to identify those areas that are mutually supportive without unduly constraining the quality of end services.

A. Co-Operations

By this term we mean the intersystem considerations in their normal operating mode. Two aspects of Co-Operation are of interest: the intersystem exchange of system-unique information and the nature of network interfaces.

1. System-Unique Information

System-unique information is that which is originated within a specific AWIS. There are two levels of interest with respect to this type of information, viz. that for which there is an absolute interdependency and that for which the interdependency is established as a matter of choice.

a. Absolute Interdependency

We have mentioned the extent of interdependency for basic observations and that between the FAA and NWS for a more extensive list products. There are more extensive lists, e.g., the products of the National Hurricance Centers and the National Severe Storm Forecasting Center and the NOTAM exchange between the DOD systems and the FAA.

It would appear obvious that every effort should be made to facilitate those exchanges among the systems and the internal usage of this basic information. Thus, these products and the systems functions for handling them should receive prime attention for standard practices.

b. Interdependency by Choice

Up front, it should be stated that the net difference between absolute interdependencies and those by choice is, for all practical purposes, zero, i.e., the dependency relationship is the important point and the same recommendations for standard practices will apply. However, there could be certain differences in the consequences of not adhering to standards to the same degree.

The principal types of information involved are:

- The direct services of "Centers of Specialization," now being more precisely defined. The subjects that are likely to be involved are actual prediction services (e.g., oceanographic predictions) or analysis products that require extensive processing facilities (e.g., satellite derived information).
- Derived assemblages of data (essentially ways of displaying information) which are required by more than one service, but predominantly by one (e.g., drought, estuary, or soil moisture).
- The processing of intermediate products (i.e., used by internal personnel) -- for the sole purpose of the efficient use of processing capability.

2. Nature of Network Interfaces

All agencies have consciously, or otherwise, adopted the concept of interfacing AWISs at the system level, i.e., the "gateway" approach. However, there are potential alternatives that would permit interfaces farther down the hierarchies. The gateway approach has the characteristics of greater consequences from failure, but it also limits the potential number of places at which failure can occur. At this stage of our combined experience with operating multidistributed processing systems, it would appear that the gateway approach would present a more predictable risk. It is suggested that where unique requirements exist at a lower echelon site for extensive multisystem information (and for which system exchange is not justified) that separate terminal accesses should be considered until the whole operational problem can be studied further.

B. System Backup

Three aspects of system backup need to be considered. The first, and simplest in many respects, is that of backup for system-unique products; the second is backup for system interfaces (or alternative gateways); and the third, and most troublesome, backup for functions of the Control Centers.

1. System-Unique Products

The two general types of products involved are point-source information (originating deep within the individual systems) and synthesized products which ordinarily originate at the NPCs. It seems only practical that basic failures (i.e., failure to originate) be either assumed as a risk or that backup be assumed within the responsible service. Failure to deliver is in the systems backup category.

The backup for synthesized products may take place either within the service or via interservice backup. Intraservice backup should have no interservice impact, providing the delivery emulates the logical routing of the original source.

Interservice backup may have serious implications in that the backup originator must have the resident software to fully emulate the form of the final products or the various system interfaces must have resident the software to perform those emulating functions.

The component of source reliability having to do with equipment reliability, and perhaps some measure of the reliability of communications and power sources, may be enhanced by redundancy in place. The component stemming from the risk of catastrophic events would point toward a measure of interservice backup rather than geographically dispersed redundant intraservice NPCs.

2. Data Base Management

Data Base Management in the CAWIS sense deals with backup for the delivery of products. Potential interruptions can take place deep within the individual systems: at the individual sources or at the destinations (within the NDBMS shown in Figure 2), at the individual CC's of the NDBMSs (see Figure 3), or at the Gateways which are the junctions of the Communications Adjuncts of the NPCs and the Control Centers of the individual AWISs (Figure 3).

Interruptions (failures) of the first type almost assuredly should be the responsibility of the individual services. To almost the same degree of assuredness, there should be alternative intersystem paths through the gateways (i.e., from the various CA's to the individual CC's). The principal implication of this conclusion is that there should be a high degree of standardization of form and procedure for all products destined for intersystem transfer.

The remaining subject of system backup rests with the CCs of the individual AWISs. This requirement is most relevant to communications Alternative (A) in Figure 3, although it is a consideration in all other alternatives. The real planning of interservice backup of the CC is that one service could drive the complete AWIS network of another's.

This is almost too complex to contemplate. Moreover, unless extreme care is taken, it could prove to be a very constraining influence on the ability of the individual services to respond to mission changes and to tailor their services to mission requirements. It would require an extremely high degree of standardization -- almost to the point of common configuration management. It appears that the risk of nonresponsive mission performance outweighs advantages in the economy/efficiency areas.

This does not mean that this type of backup requirement should be ignored -- for it is of multiagency interest. However, it points towards individual agency responsibility for maintaining backup for normal systems risks and some kind of contingency planning for the catastrophic event.

C. System Efficiencies

To this point we have spoken mostly to the Inter-AWIS aspects of original information sources and the networks of traffic. There remain the matters affecting how the traffic traverses the network interfaces and the matters that impact performance within the individual systems.

1. Interfaces and Protocols

These factors are essential to the exchange of information among the systems. Ideally, they should be completely independent of the information content of the traffic and, if so, could be independent of the protocols employed within the systems. It is essential that agreement is reached for each juncture; it would be desirable to have a common agreement among the systems to avoid subtle variations in their individual relationships and to provide a high degree of flexibility for alternative routing.

2. Standards and Conventions

We have spoken to the subject matter of the information packages and the means of delivery of the package. This subject deals with what's inside -- specifically dwelling on impacts in the Data Handling Submodule in Figure 5 with an indirect impact on the Physical Storage Submodule.

The number of operations that take place within these submodules really determine the efficiency (responsiveness) of the systems. The number of operations is determined by the functions required to place the information into the storage structure and to retrieve and aggregate it upon query. It is the nature of these systems that a particular piece of information is stored only once but may be retrieved many times. In addition, the measure of responsiveness is most closely linked to query (and resultant retrieval). Thus, the data base structure should be designed more toward ease of retrieval than to ease of storage. The ease of storage, in turn can be influenced by the internal nature of the information package.

The characteristics of the information package that influence ease of storage are:

- The degree of packaging -- how data are aggregated, e.g., numbers of parameters, numbers of places.

- The dimensions employed -- mps, knots, mph; °C, °F.

- The explicit or implicit order within the package (T=characters 10 through 14 or T is always the second field).

- The form of communications coding -- ASCII, binary.

- Other packaging conventions -- data compression techniques.

- The reference structure used -- grid (mesh and base), Latitude/Longitude (degrees-tenths; degrees-minutes).

Before proceeding, we should clarify that when we speak of data base structure we don't mean the actual physical structure -- but the logical structure i.e., not the addresses of information but the patterns of activity required to store or retrieve individual data or groups of data.

Some of these matters are so steeped in tradition that no new effort is required, e.g., dimensions. Others have been traditional because the conventional systems required them, e.g., current implicit orders of data, communications code; but the AWISs provide at least the opportunity to revisit those subjects.

There are no absolute answers to the question of the most desirable levels of standardization and multisystem conventions. All are subject to a degree of quantitative analysis; but alternative answers will undoubtedly imply some measure of qualitative judgment.

At this stage none of us has a sufficient insight into the various systems to come to absolute conclusions. However, a danger is presented that if we defer considerations, development activity may negate opportunities for our doing so.

IV. CONCLUSIONS

In this paper we have presented a number of alternative considerations that might be made in the design, implementation, and operations of the community of AWISs. They range from the consideration of the degree of risk that individual service managers may wish to accept to some very detailed aspects of the systems operations.

The degree to which many of the more specific options may be applicable hinge to a significant degree on the decisions of the service managers and their judgments relative to the net effect of their individual inclinations.

This paper adds additional insight to our prior paper, but it cannot form a full basis for management decision. We do hope it stimulates some additional thoughts and provides sufficient basis to suggest directions for further considerations.

APPENDIX

ACRONYMS AND ABBREVIATIONS

A/N	-	Alphanumeric
AFGWC	-	Air Force Global Weather Central
AFOS	-	Automation of Field Operations and Services
ARTCC	-	Air Route Traffic Control Center
AUTO	-	Automatic
AWDS	-	Automated Weather Distribution System
AWIS	-	Automated Weather Information Systems
AWOS	-	Automated Weather Observing System
AWP	-	Aviation Weather Processor
AWS	-	Air Weather Service
BWS	-	Base Weather Station
CA	-	Communications Adjunct
CAWIS	-	Community of Automated Weather Information Systems
CC	-	Control Center
COMCEN	-	Command Center
CP	-	Computational Processing
CWSU	-	Center Weather Support Unit
DBM	-	Data Base Module
DDP	-	Distributed Data Processing
DET	-	Detachment
DOC	-	Department of Commerce
DOD	-	Department of Defense
DOT	-	Department of Transportation
FAA	-	Federal Aviation Administration
FCM	-	Federal Coordinator for Meteorology
FNOC	-	Fleet Numerical Oceanography Center
FSAS	-	Flight Service Automation System
FSS	-	Flight Service Station
ICMSSR	-	Interdepartmental Committee for Meteorological Services and Supporting Research
IP	-	Input
OL	-	Operating Location
OP	-	Output
MTBF	-	Mean Time Between Failures
NADIN	-	National Airspace Data Interchange Network
NDBMS	-	Network Data Base Management System
NMC	-	National Meteorological Center
NPC	-	Numerical Processing Center
NPCAC	-	Numerical Processing Center Adjunct Communications
NOC	-	Naval Oceanography Command
NWS	-	National Weather Service
WG/AWIS	-	Working Group for Automated Weather Information Systems
WSFO	-	Weather Service Forecast Office
WSMO	-	Weather Service Meteorological Observatory
WSO	-	Weather Service Office

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SPACE ENVIRONMENT FORECASTING

SYSTEMS DEVELOPMENT

Working Groups

- Automated Surface Observations
- Automated Weather Information
- Radiological, Gaseous and Particulate Transport Models
- Weather Radar Systems

OPERATIONAL ENVIRONMENTAL SATELLITES

BASIC SERVICES

Working Groups

- Agricultural Meteorological Services
- Cooperative Backup Among Operational Processing Centers
- Dissemination of NMC Products
- Hurricane Operations
- Marine Environmental Predictions
- Meteorological Codes
- Metric Implementation
- Operational Processing Centers
- Severe Local Storms Operations
- Surface Observations
- Upper Air Observations
- Weather Radar Observations
- Winter Storms Operations
- World Weather Program

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