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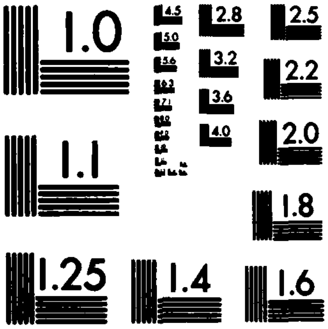
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FEASIBILITY STUDY FOR AN AIR FORCE ENVIRONMENTAL MODEL AND DATA EXCHANGE

Volume I: Model and Data Requirements with Recommendations

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FINAL REPORT
MARCH 1981 - FEBRUARY 1983

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The study assesses Air Force needs and capabilities for environmental consequence modeling, Air Force model application capabilities, and proposes resources available to overcome identified deficiencies. Needs for environmental information and analytical techniques were studied, and strategies proposed by which the modeling capabilities could evolve toward a comprehensive environmental information network, user community, and data exchange. The recommended information network would be known as the Air Force Environmental Model and Data Exchange (AFEMDEX). The technical report consists of four volumes. (continued)

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This report presents:

Volume 1: MODEL AND DATA REQUIREMENTS WITH RECOMMENDATIONS. The study recommends evolution of a computer-based network to enhance Air Force access and exchange of environmental information, and to match models with required data sources for effective application. The AFEMDEX network development is proposed in three evolutionary stages: (1) coordination; (2) information exchange; and (3) networking. Coordination would involve linking existing Air Force modeling needs to existing modeling resources in the Air Force and elsewhere, plus establishing a network of model support and use centers for operational modeling. Information exchange would involve developing techniques for transporting model data, analytical techniques and computer software from one model center to another, and promoting the distribution of coordinated hardware for a distributed network of model support centers. Network application involves the full linkage of distributed modeling computers into an integrated network. Other Air Force environmental information needs that could be addressed by AFEMDEX include: a hazardous chemical information system with chemical auditing, tracking, and disposal and accident planning; an improved environmental law information system; improved techniques for environmental data capture, storage, transportation, formatting, management and interpretation; computer cartography and site design aids; management information systems for facility planning, construction and operation; and a computer bibliographic reference database for environmental literature of special interest to the Air Force.

Volume 2: AIR FORCE NEEDS AND CAPABILITIES SURVEY. The survey instrument, survey results, and result analyses which constituted the Air Force needs and capabilities fact-finding task are presented. Air Force agencies which require, or desire environmental information or model application were surveyed to define operational needs and capabilities. Evaluation of present Air Force capabilities, plus capabilities of other federal agencies available to the Air Force, is discussed. A listing of existing environmental models which may be applicable to satisfying mission needs, with a preference rating, is presented.

Volume 3: MODEL REVIEW AND INDEX - WATER MODELS. A brief introduction to water models, by application category, precedes an extensive directory of water quality and quantity models. Reviews of models presented include (in general): (1) model name; (2) sponsor/developer; (3) contact; (4) model availability; (5) model abstract; (6) citation references; (7) current user; (8) implementation hardware/software; (9) input requirements; (10) output products; (11) synopsis of major parameters.

Volume 4: MODEL REVIEW AND INDEX - AIR, MULTIMEDIA AND OTHER MODELS, PLUS DATABASES. A brief introduction to air models, by application category, precedes an extensive directory of air quality models. The directory further provides reviews of multimedia, geology and soil, ecology, socioeconomic, exposure, noise, waste disposal, chemical spill, and traffic models. Further, a brief introduction to databases is followed by reviews for water, air, chemical and noise databases. Reviews of models presented include (in general): (1) model name; (2) sponsor/developer; (3) contact; (4) model availability; (5) model abstract; (6) citation references; (7) current user; (8) implementation hardware/software; (9) input requirements; (10) output products; (11) synopsis of major parameters.

EXECUTIVE SUMMARY

1. AIR FORCE MODELING FEASIBILITY STUDY

This is the final report of a feasibility study conducted by General Software Corporation (GSC) for the U.S. Air Force Engineering and Services Center (AFESC) and the President's Council on Environmental Quality (CEQ). The study assessed Air Force needs and capabilities for environmental simulation modeling, identified deficiencies in present Air Force modeling capabilities, identified resources now available to overcome these deficiencies, and proposed strategies to coordinate and deliver modeling resources to areas of Air Force need. General Air Force needs for environmental information and analytical techniques were also assessed, and ways were studied by which the modeling capabilities could evolve towards a more comprehensive environmental information network capable of providing data exchange services for a large and diverse user community.

Environmental simulation models are symbolic representations of environmental processes. Mathematical equations representing the physical and chemical processes of air and water are the most common, but there are also models of such processes as geologic movement, food webs, human transportation, and economic systems. In theory, any natural or human environmental process can be represented by a symbolic model. These models can be used to simulate the behavior of environmental and human systems and to predict interactions between them.

In practice, however, environmental systems are so complicated that present scientific understanding and modeling tools are limited in their capacity to represent reality. Most models must be used carefully with a clear understanding of the assumptions, limitations and simplifications used in the design of the modeling technique. Within these limitations, however, models are providing increasingly accurate predictions and are quickly becoming one of the most powerful tools available to environmental scientists, planners, designers and managers.

Models are objective and give numerical predictions which can be repeated independently, tested, and verified. Models are the only technique which can represent the dynamic nature of the environment: No other technique has a comparable record for accuracy and validity.

The U.S. Air Force has recognized the power of models and uses them increasingly for both classified and unclassified activities. The first Air Force modeling activity, and still the most sophisticated, is the meteorological analysis and weather forecasting so vital to the primary combat mission of this airborne service. More recent Air Force modeling requirements have resulted in development models for assessing air and water quality, noise pollution, and accidents. Models have been used increasingly to: 1) locate and design Air Force facilities, 2) evaluate alternatives for proposed Air Force development and operations, 3) provide information for environmental impact assessment mandated by laws regulating Air Force building and operations, 4) aid the management and operation of Air Force facilities, 5) ensure safe working conditions, and 6) plan for accident control and recovery.

The development and distribution of environmental models in the Air Force has been mainly project-by-project, as needed. The Air Force Engineering and Services Center (AFESC), the Air Force focal point for environmental research and development, has long recognized the value of environmental simulation. With an awareness of expanding model applications, AFESC researchers determined that an overview survey of Air Force model usage and modeling needs was required. This survey, coupled with a desire to consolidate and coordinate modeling information, was the impetus for this study.

For some time the President's Council on Environmental Quality (CEQ) has been working with the Environmental Protection Agency (EPA) to create an integrated modeling library. AFESC made this study a joint project with CEQ to draw on the resources of the CEQ-sponsored studies.

The statement of work developed by AFESC for this feasibility study can be summarized as a related series of five questions which are to be answered by the study:

- What are Air Force needs for environmental models and related data?

- What are present Air Force modeling capabilities?

- What are present Air Force modeling deficiencies?

- What resources are now available, both in the Air Force and from outside sources, to overcome deficiencies?

- What development strategies would improve access to deficient modeling resources?

These questions are linked in the following way:

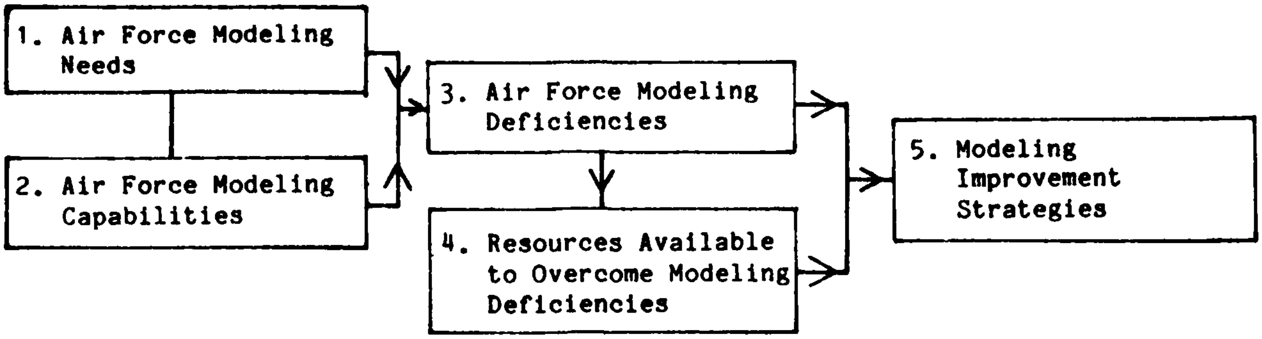


Figure i. Flow Chart of Steps in Model Feasibility Study.

The first two study areas used an interview and mail survey to establish Air Force modeling needs and capabilities. Seventy-three responses were obtained from 52 Air Force groups involved with the development, support, or use of models. Surveying time and funds were limited and the sample does not represent all Air Force modeling activity; however, all types of model developers and users were contacted, including most major representatives of each type. All four of the Air Force laboratories or special centers directly involved in modeling and environmental analysis were surveyed, three in person. A fifth center which develops model-related systems (Rome Air Development Center) was contacted for information. Six of the seven Major Command Headquarters (including the Air Force Reserves) were surveyed.

Six of the 103 Base Environmental Planning or Bioenvironmental Engineering groups at Air Force installations were surveyed. The Air Force project staff are satisfied that the sample is sufficiently complete and representative to form a realistic basis for preliminary recommendations.

The identification of Air Force modeling deficiencies was the third area of study: it consisted of analyzing the survey answers, comparing needs with capabilities, and identifying areas of deficiency. While information was being collected for this study, the first stage of an information study was taking place in AFESC. This involved collecting information at the base level and ascertaining vertical reporting information requirements, including environmental information. The AFESC study complemented and enlarged the findings of the survey conducted for this report. Findings of the two studies showed much overlap, further confirming that the sample selected for this report represented at least the most widespread and urgent Air Force modeling needs.

The study of resources available to overcome deficiencies was the fourth area of study. This started with an analysis of areas of deficiency and reviewed resources available in the Air Force and elsewhere to overcome identified deficiencies. These resources included models and modeling software, model-related data, hardware, and modeling support centers and networks. Thousands of model citations and documentation for hundreds of models and databases were studied. General Software Corporation (GSC) drew upon its own experience and contacts, as well as those of subcontractors, Production Systems, Inc. (PSI), and Arthur D. Little (ADL), to make a list of available resources.

The fifth and final part of the study involved making recommendations for technical and organizational schemes which would coordinate Air Force modeling activities and improve access to deficient resources. These recommendations were based on the analysis of Air Force modeling deficiencies and the review of available resources (Steps 3 and 4), and on GSC experience in designing and operating a modeling library for the EPA Office of Toxic Substance (OTS). This report is laid out as brief answers to these five questions with appendices to provide more detail. A summary of the most important findings and recommendations concludes this executive summary.

2. AIR FORCE MODELING NEEDS

Information on Air Force environmental modeling needs was collected through interviews and a questionnaire survey. Table i categorizes the areas needing models.

TABLE i. AIR FORCE MISSION AREAS NEEDING MODELS

- Unclassified Mission Area* (Mainly Unrestricted Information)
  - Air Force Facility Planning and Management
    - Outline Planning*
    - Site Layout and Design*
    - Impact Assessment*
    - Facility Management*
  - Hazard Planning and Management*
    - Accident Contingency Planning*
    - Hazardous Waste Disposal Planning*
    - Occupational Health Planning*
    - Risk Assessment*
    - Exposure Calculation*
    - Radiation Analysis*
    - Hazardous Chemical Auditing*
    - Hazard Indicator Monitoring*
    - Industrial Hygiene Management*
    - Accident Management*
  - Weather Analysis**
    - Meteorological Data Management**
    - Special Air Analysis **
    - Weather Forecasting
- Classified Mission Area (Mainly Restricted Information)
  - Surveillance and Reconnaissance
  - Intelligence Analysis
  - Flight Simulation
  - War Games
  - Weapon Systems Analysis
- Etc.

* Mission Areas Surveyed in this report.

** Mission Areas Partly Surveyed in this report.

The information concerning classified mission on Page V and classified modeling on Page 9 does not contain classified information per Capt. G. E. Tapio, AFESC/RDV

3. AIR FORCE MODELING CAPABILITIES

Some of the needed modeling capabilities already exist within the Air Force. Table ii summarizes the present capabilities by centers and activities.

TABLE ii. MAIN AIR FORCE GROUPS WITH MODELING CAPABILITIES.

AIR FORCE CENTERS OF MODELING CAPABILITIES	SUBGROUPS AND MODELING ACTIVITIES
Air Force Engineering and Services Center (AFESC)	Environics Division (AFESC/RDV) Model research and development Directorate of Environmental Planning (AFESC/DEV) Model operation and user support
Occupational and Environmental Health Laboratory (OEHL)	Environmental sampling, data management and interpretation for model input, environmental quality and occupational health modeling
Environmental and Technical Applications Center (USAFETAC) management for model input,	Climatological studies center. Meteorological data collection, and analyses.
Directorate of Computer Science (DCS/Eglin AFB)	Computer support of model software and databases
Rome Air Development Center (RADC)	Research, development and management of data capture, computer hardware and software relevant to modeling
HQ Air Training Command (ATC)	Facility siting and environmental quality model development and use

TABLE ii. MAIN AIR FORCE GROUPS WITH MODELING CAPABILITIES (CONTINUED)

HQ Strategic Air Command (SAC)	Environmental quality and occupational health model use
HQ Military Airlift Command (MAC)	Air and water quality model use
HQ Air Force Reserves (AFRES)	Environmental planning and management model use

4. AIR FORCE MODELING DEFICIENCIES

a. Model Data Deficiencies.

There are severe and widespread data deficiencies in major areas of Air Force modeling. The limited extent, currency and quality control of data and incompatible data formats are especially urgent problems. Areas of special data deficiency are: 1) ground water flow, 2) toxic chemistry, 3) local and current air and water quality, and 4) applicable environmental regulation. Machine-readable data and automated database management are especially deficient resources.

b. Model Technique Deficiencies.

There are modeling techniques now available which are largely adequate for Air Force needs, although the state of the art of ground water and ecology modeling is limited. However, there are severe deficiencies in practical access to existing models, particularly in: 1) ground water and heavier-than-air gas modeling, 2) hazardous waste management modeling, 3) accident planning, and 4) legislative analysis. Easily accessible simple techniques are needed.

c. Model Software Deficiencies.

There is little model software routinely operational on Air Force computers. Most of what exists is experimental and difficult to operate and suffers from deficiencies of documentation. Diverse Air Force hardware and operating systems create problems of software compatibility and interoperability.

d. Model Hardware Deficiencies.

Air Force access to computer hardware is limited almost completely to laboratories, special centers, and some major command headquarters. There is insufficient computer hardware available to Air Force base environmental staff: even simple terminals linked to remote computers or desk top microcomputers are not widely available. There is no standardization of hardware or operating systems between the computers that are available for modeling: modeling computers are separate and do not exchange information. Standard base level minicomputers are proposed in the near future to support the Uniform Hospital Chart of Accounts. These could be made available for environmental tasks. If accessible, these could remove many of the deficiencies in the hardware needed for modeling.

e. Model Organization Deficiencies.

Air Force organizational modeling deficiencies are much more severe than technical deficiencies. If existing Air Force capabilities were coordinated and linked to resources elsewhere available to the Air Force, great improvements could result from little effort. Model organization deficiencies cited are the lack of:

- Library of available models suitable for Air Force needs.
- Clearing house to establish contacts and collect and distribute information.
- Established procedures for linking modeling needs to capabilities.
- Accumulation of modeling knowledge and contacts in a durable corporate memory.
- Established network of model producers and users.
- Operational routines for selecting, testing and validating models.
- Development of integrated, user-friendly computer operation and learning techniques to spread model use.
- Regular schedule of user training and support.

5. RESOURCES AVAILABLE TO OVERCOME DEFICIENCIES

There now exists within the Air Force, and in other organizations accessible to the Air Force, a variety of resources which could overcome many of the modeling deficiencies. These are listed in two broad groupings: specific modeling resources and modeling organizations or systems. Table iii summarizes these groups.

TABLE iii. MAJOR RESOURCES TO OVERCOME AIR FORCE MODELING DEFICIENCIES

RESOURCE: MODELS

SOURCE: U.S. Air Force

Air Force Engineering and Services Center (AFESC), Air water, and noise models.

U.S. Army Corps of Engineers (COE)

Construction Engineering Research Laboratory (CERL). Economic, environmental and legal models.

Hydrologic Engineering Center (HEC). Hydrologic models.

Federal Government

Environmental Protection Agency (EPA). All types of environmental quality models.

Private Organizations

Society for Computer Applications in Engineering Planning and Architecture (CEPA). Civil Engineering models.

RESOURCE: MODEL DATA

SOURCE: U.S. Air Force

AFESC. Environmental and socioeconomic data.

Occupational and Environmental Health Laboratory (OEHL). Environmental quality and occupational health data.

Environmental Technical Applications Center (ETAC). World meteorological data (DATSAV).

U.S. Army Corps of Engineers

CERL. Demographic and socioeconomic data.

HEC. Water data.

Federal Government

EPA. Air, water, land and ecological quality data. (SAROAD, STORET, BIOSTORET). Hazardous chemical data (CCIS).

U.S. Geological Survey (USGS). Land surface and geological data, water data (NASQAN, WATSTORE).

Soil Conservation Service (SCS). Soil data.

TABLE iii. MAJOR RESOURCES TO OVERCOME AIR FORCE MODELING DEFICIENCIES (CONTINUED)

World Meteorological Organization (WMO). Meteorological data.

National Oceanic and Atmospheric Administration (NOAA). Meteorological and marine data and agencies: Environmental Data and Information Service (NDIS) and National Climatic Center (NCC).

Fish and Wildlife Service (FWS). Wildlife and habitat data.

U.S. Bureau of the Census. Demographic data.

Bureau of Labor Statistics (BLS). Socioeconomic data.

National Institute of Health (NIH). Public health data.

Department of Transportation (DOT). Traffic data.

RESOURCE: COMPUTER SYSTEMS TO SUPPORT MODELS

SOURCE: U.S. Air Force
Rome Air Development Center (RADC). Image interpretation, pattern recognition, geographic database management, spatial analysis and computer graphic display.

National Aeronautical and Space Administration (NASA)
Geographic data management, image interpretation and remote sensing analysis.

U.S. Army COE
CERL. Microcomputer and network systems development.

Engineering Topographic Laboratory (ETL). Air photo interpretation, geographic data capture and information system development. Cartography display.

Federal Government
Fish and Wildlife Service Office of Biological Service (FWS-OBS). Geographic information system development. Cartographic display.

RESOURCE: COMPUTER HARDWARE TO SUPPORT MODELS

SOURCE: U.S. Air Force
AFESC. Mainframe.

TABLE iii. MAJOR RESOURCES TO OVERCOME AIR FORCE MODELING DEFICIENCIES (CONCLUDED)

Directorate of Computer Science (DCS). Eglin AFB. Mainframe, Minicomputers.

ETAC. (Selected Air Models). Mainframe, Minicomputer. Procurement underway at many bases for Uniform Hospital Chart of Accounts. Standard minicomputers. Proposed at many major commands and bases for remote connection to CERL ETIS system. Terminals.

U.S. Army COE.
CERL. ETIS only. Minicomputer.

RESOURCE: GROUPS AND SYSTEMS TO SUPPORT MODELS

SOURCE: U.S. Air Force
AFESC Environics (/RDV). Model and database research and development. Knowledge of modeling state of the art. Science skills.

AFESC Environmental Protection (/DEV). Scientific expertise, model and database operation and user support. User contacts and knowledge of user needs.

OEHL. Environmental sampling, databases and data management techniques. Air and water quality modeling knowledge. Science skills.

ETAC. Air data and data interpretation. Meteorological analysis, weather forecasting and other air modeling techniques. Statistical analysis and environmental simulation of weather and climate.

RADC and Defense Mapping Agency (DMA). Research and development in geographic and cartographic hardware and software relevant to models.

Air Force Geophysics Laboratory (AFGL). Environmental data and analysis techniques.

Headquarters Air Training Command (HQATC). Land use modeling. Potential prime user.

Space and Missile Center (AFESC WSMC/SEM). Rocket and missile data and models.

U.S. Army COE

CERL. ETIS system, environmental modeling research and development, databases, computer support, contact network, skill and experience with coordination, network establishment and maintenance and user support, social economic earth science skills. Air Force use of ETIS presently growing.

HEC. Water data and modeling, geographic information system development. Products and consultant advice available.

ETL. Air photo interpretation, pattern recognition, geographic information systems. Products and consultant advice available.

Federal Government

Environmental Protection Agency, Office of Research and Development (EPA-ORD). Model research and development. Environmental science skills, knowledge of data and analytical techniques. Products and consultant advice available.

Office of Toxic Substances (EPA-OTS). Coordination of Chemical Substances Information Network (CSIN) a network of hazardous chemical information and analysis techniques. Access through CSIN to chemical databases. Analysis techniques proposed for future distribution through CSIN include U.S. Coast Guard Hazardous Chemical Information and modeling system CHRIS/HACS and OTS VAX UPGRADE integrated user-friendly library of chemical fate and transport models. CSIN also has experience establishing environmental information networks and research and development of computer networking for environmental systems. Air Force membership is encouraged and many kinds of assistance are available in the areas of toxic chemical modeling.

U.S. Geological Survey (USGS) National Water Data Exchange (NAWDEX). Contacts with water data procedures and users, access to WATSTORE, water database including EPA STORET data and USGS water files. Operational model of environmental data exchange. U.S. Air Force now has NAWDEX membership and this could be extended for model support.

6. STRATEGIES FOR IMPROVING AIR FORCE MODELING

If modeling capabilities are to be improved, there are a number of organization structures and operation and distribution techniques available. The alternatives, advantages, disadvantages, and recommendations are summarized in Table EXS-4. Basic design criteria should include the following:

- Build on existing resources or resources planned for other purposes whenever possible.
- Coordinate development and avoid duplication.
- Tailor modeling capabilities to existing skill levels.
- Demonstrate practical benefits at all stages of development.
- Plan system growth in modest evolutionary stages.
- Directly address Air Force needs.
- Build in user feedback procedures.
- Use techniques with proven Air Force success.

7. RECOMMENDATIONS FOR AIR FORCE MODELING

This study recommends a structure for fully operational Air Force modeling and three development stages which would move Air Force modeling from its present state to the recommended structure.

GSC recommends that the goal for operational Air Force modeling support is a network of functionally distinct centers, most already in existence, integrated by a model coordination center. Figure ii illustrates this organization structure.

The model coordination center would have two main roles: model operation and network administration. Model operation would involve: 1) selecting and establishing models and model databases, 2) coordinating resources from other Air Force model support centers to provide an operational Air Force modeling capability, 3) coordinating access to needed modeling resources available outside the Air Force, 4) providing resources needed for operational modeling not available elsewhere, and 5) promoting distributed model use through documentation, training and user support.

Network administration would consist of: 1) establishing and maintaining agreements between model network supporters and users, 2) analyzing Air Force model user's needs, 3) assembling modeling teams for particular modeling projects, 4) administering and enhancing contacts and information flow in the network, and 5) promoting the acquisition of compatible hardware to establish a linked network of modeling computers.

As time passed and the modeling network became established, the coordination center would promote distributed modeling operation, retaining central operation only for the largest, most complex models

TABLE iv. AIR FORCE MODELING IMPROVEMENT STRATEGIES

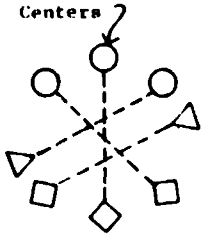
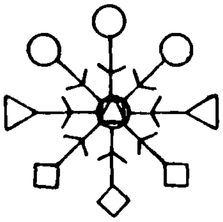
ORGANIZATION ALTERNATIVES	ORGANIZATION DIAGRAM	ADVANTAGES	DISADVANTAGES	RECOMMENDATIONS
Existing Organization for Model Distribution	Separate Centers  Uncoordinated links on case by case basis KEY ○ = Model User △ = Model Data Producer ◇ = Model Research and Development	Status quo, requires no further development.	Does not address needs. Does not efficiently use resources. Does not distribute access sufficiently. Does not accumulate knowledge. Does not provide training or user support.	Inadequate for Air Force needs. Not recommended.
Central Operation (All modeling activities, development and operation at one center)	 KEY ○ = Model User (not operator) △ = Model Data Producer ◇ = Model R&D ◬ = Modeling Center* *(data integration, model development and operation)	Efficient integration of development. Avoids duplication. Good quality control. Models correctly used by specialists.	Poor use of existing resources. Resistance from established capabilities. Remoteness of central capabilities. Variety of user needs may not be addressed. Capability easily overloaded. High communication costs. Poor use of developing technology of small distributed computer users.	Best for model development and operation of largest, most complex models. Suitable for earliest development of coordinated modeling. Evolving to central distribution.

TABLE iv. AIR FORCE MODELING IMPROVEMENT STRATEGIES (CONTINUED)

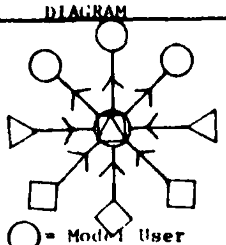
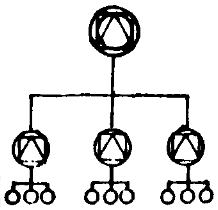
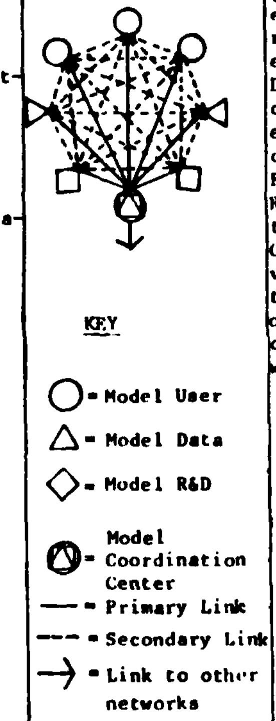
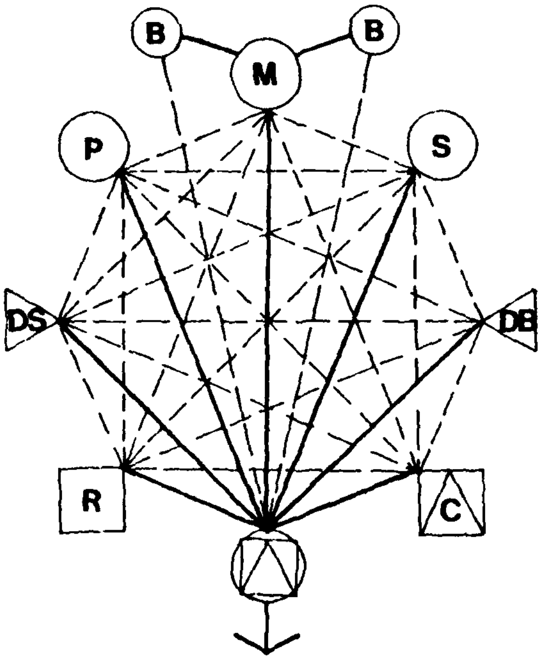
ORGANIZATION ALTERNATIVES	ORGANIZATION DIAGRAM	ADVANTAGES	DISADVANTAGES	RECOMMENDATIONS
Central Distribution (Model coordination and data integration centralized; some development and operation distributed from a central computer)	 ○ = Model User (some operation) △ = Model Data Producer ◇ = Model Research and Development ◬ = Modeling Center* *(Data interpretation, some development, some operation)	Efficient integration of development. Avoids duplication. Better use of existing resources than central operation. Most complex models controlled by specialists. Operational capability higher than central operation because some operation distributed.	Possible resistance from established capabilities. Some loss of control of model use. Poor use of developing technology.	Good for model development and user training, less good for maximum use of existing resources for operation. Suitable for intermediate stages of development of coordinated modeling. Can evolve from central operation and to network.
Command Hierarchy (Modeling centers distributed in the Air Force command structure)	 ◬ = Modeling HQ ◬ = MAJCOM Modeling Center ○ = AFB Modeling User	Uses established familiar organization structure with well-developed vertical connections. Many other Air Force activities occur in this structure. Good user feedback.	Horizontal connections poorly developed. Technical coordination difficult Magnitude of Air Force modeling does not justify this many modeling centers and groups.	Not recommended for model development or operation. Some hardware procurement and organization authority must occur in this structure. Contact and user feedback routes established through these connections.

TABLE iv. AIR FORCE MODELING IMPROVEMENT STRATEGIES (CONCLUDED)

ORGANIZATION ALTERNATIVES	ORGANIZATION DIAGRAM	ADVANTAGES	DISADVANTAGES	RECOMMENDATIONS
Functional Network (Distributed new and existing centers provide different functional capabilities in a coordinated network)		Uses existing resources efficiently. Does not compete with established capabilities. Flexible. Responsive to needs. Can use developing technology of small computers well.	Coordination and integration more complex than other alternatives	Recommended as goal for model operation if sufficient authority is available to ensure coordination. Can evolve from central distribution.



KEY

MODEL USER CENTERS

M = MAJCOM MODEL CENTER
e.g. HQ ATC, HQ SAC

S = SPECIAL MODEL CENTER
e.g. Missile Modeling, AFB with special model need

P = PILOT MODEL CENTER
e.g. Projects to develop modeling. May evolve to Special Model Center if modeling becomes operational.

B = AIR FORCE BASE MODEL CENTER
May evolve to Special Center if modeling continues.

MODEL DATA CENTERS

DS = MODEL DATA SAMPLING CENTER
e.g. OEHL, ATAC, AFB's

DB = MODEL DATABASE STORAGE CENTER
e.g. OEH, ETAC

MODEL COMPUTER CENTERS

C = MODEL COMPUTER CENTER
e.g. AFESC, DCS

MODEL RESEACH AND DEVELOPMENT CENTERS

R = MODEL R. AND D. CENTER
e.g. AFESC/RDV, ETAC, RADC

MODEL COORDINATION CENTER

= MODEL COORDINATION CENTER
Perhaps in AFESC or OEHL

NETWORK LINKAGES

—— = PRIMARY AIR FORCE MODELING LINK

– – = SECONDARY AIR FORCE MODELING LINK

→ = LINK TO MODELING RESOURCES OUTSIDE AIR FORCE

Figure ii. Recommended Network Organization Structure for Air Force Modeling.

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PREFACE

This report was prepared by General Software Corporation, 8401 Corporate Drive, Landover, Maryland, 20785 under subcontract from M/A-COM Sigma Data Computing Corp., 5515 Security Lane, Rockville, Maryland 20852,under Contract No. WQ1Y03, Task 6, with HQ AFESC/RDV, Tyndall Air Force Base, Florida 32403.

This report documents work performed between March 1981 and February 1983. Dr. Carol Graves of Sigma Data Computing Corp., was the Project Officer for the IAG with the President's Council on Environmental Quality. Mr. John Ficke was the Project Officer for the IAG with the President's Council on Environmental Quality. Mr. Larry Milask was the Project Manager and Mr. Stewart McKenzie the primary author for the IAG with General Software Corporation. Captains George W. Schlossnagle, and Glenn E. Tapio were Project Officers for the Air Force Engineering and Services Center (AFESC/RDVS).

The authors wish to thank the Air Force personnel who participated in the questionnaire/survey and gave valuable comments and suggestions which enabled this feasibility study to accurately reflect the USAF capabilities and needs.

This report has been reviewed by the Public Affairs Office (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS it will be available to the general public, including foreign nationals.

This technical report has been reviewed and is approved for publication.

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INTRODUCTION

In the course of the feasibility study there has been much discussion of the desired scope of this final report. The original statement of work focused narrowly on Air Force use of and needs for environmental simulation models. A preliminary letter survey conducted before this study began indicated that the Air Force was interested in better access to environmental models, but this was only one of a number of improvements needed in the area of environmental data and analysis techniques. Other environmental information areas mentioned in the initial survey were data management improvements, hazardous waste and legislative information systems, and planning and management information systems for facility construction and operation.

The idea of an Air Force environmental information network which included organizational support and contacts, models, data, mapping, other environmental analyses, display techniques, and text references received more widespread support than a library consisting solely of models. For this reason, the scope of the study was enlarged somewhat in the early stages to establish Air Force needs and capabilities for environmental data and analysis techniques generally, with special, though not exclusive, emphasis on simulation models. The wider questions used the survey framework to collect additional information on more general Air Force environmental needs which are the context of modeling.

A part of the needs survey invited comments on the survey itself. Among the comments received were statements of concern that the original emphasis on modeling was becoming too diluted and that the objectives of the original statement of work might not be fully realized.

The difference between an environmental modeling library and an environmental information exchange is not as great as might at first appear. Environmental models require extensive databases. All but the simplest models need computer support and a telecommunication system to allow distributed users access to the computerized models. If models can be linked to other computerized manipulation and display techniques, such as user-friendly command structures, statistical analysis, database management, and mapping, the usefulness of the models greatly increases. A fully equipped modeling library with distributed access is, therefore, well on the way to being a comprehensive environmental information network and can be thought of as the first stage of establishing such a network.

This final report, therefore, concentrates largely on the modeling library concept exactly as stated in the original statement of work. There is reference to more general Air Force environmental needs in Section II of this report and in Appendices C, D, and E, which discuss the needs survey. Section VII discusses AFEDEX, an Air Force Environmental Data Exchange, which is a more general information network growing from the model network AFMDEX, discussed in Sections VII 3 and 4. Otherwise, this report closely follows the original statement of work, establishing Air Force modeling needs, Section II and Appendices C and E; Air Force modeling capabilities, Section III and Appendices C and E; resources available to overcome deficiencies, Section IV and Appendices C, A, D; model directories, Appendix B; and strategies for modeling capability, Section VII. Major conclusions are summarized in Section VIII.

SECTION II

AIR FORCE MODELING NEEDS

1. NEEDS SURVEY

Information on Air Force Environmental modeling needs was collected in a number of ways. A questionnaire was designed to establish specific modeling needs and general environmental needs which could benefit from better access to models (see Appendix B). The objectives of this questionnaire were:

a. to establish current AF needs and capabilities for environmental models;

b. to determine the specific tasks undertaken by existing groups involved in environmental modeling activities;

c. to determine the skill and educational levels required to carry out the mission elements for environmental modeling activities;

d. to determine the level of computerization by the various groups involved in environmental modeling activities;

e. to identify the computer hardware, networking, and modes of accessing databases now used in USAF environmental model processing;

f. to determine the present levels of coordination in computer, database, and networking activities for environmental model processing;

g. to determine potential benefits for increased coordination in computer, database, and networking activities for environmental model processing;

h. to identify and rank the inhibitors to effective information networking for environmental modeling activities;

i. to identify those existing AF facilities which could be effectively integrated into an information/database network for purposes of distributing programs, data, expertise and hardware capabilities in order to enhance current environmental modeling activities;

j. to detail those specific modeling environmental activities now being performed;

k. to determine the current requirements within each activity and how these requirements are being met and the resource deficiencies overcome.

Seventy-Three questionnaires were completed, 52 interviews and 21 by mail. Table 1 shows the Air Force groups responding to the survey and the number of environmental staff reported in each group.

All four laboratory headquarters and special centers directly associated with environmental modeling were surveyed (AFESC, ETAC, OEHL, AFGL), all but AFGL in depth and with personal interviews. A fifth center, the Rome Air Development Center (RADC), was contacted. RADC does research and development indirectly contributing to modeling. The Construction Engineering and Research Laboratory (CERL), an U.S. Army Corps of Engineers facility which coordinates Army modeling, was contacted in person, by phone, and by mail.

Of the seven Major Command Headquarters, six (86 percent) were surveyed. The Tactical Air Command was not included. Base-level staff at six Air Force Bases (AFB's) were surveyed (about 6 percent of the 103 AFBs in the United States). Although the sample was small, base modeling needs surveyed showed great similarity, suggesting that modeling needs at base level are simpler than in Major Commands or laboratories.

During the survey, project staff also held informal discussion with Air Force environmental staff and collected mission descriptions and documentation of models and model related products and projects. Notes from these meetings and the collected documents were an additional source of information. In several cases, followup telephone interviews were conducted to clarify and enlarge understanding of modeling activities.

While the survey results were being analyzed, the findings of the first part of a closely related concurrent AFESC study were published. This report, Engineering and Services Information Requirements Study, Vol. 1. Base Level and Vertical Requirements AFESC, August, 1981, summarized Air Force engineering and services information requirements in a standard format. Sections on environmental planning and engineering overlapped with this study and the findings are summarized in Table 2.

These various sources of information were studied, summarized, and combined to produce the following outline of Air Force modeling needs.

2. OUTLINE OF AIR FORCE MODELING NEEDS

a. Unclassified Modeling

Air Force needs for environmental models can be grouped broadly into unclassified and classified. Unclassified modeling needs occur when an Air Force activity requires the use of mainly unrestricted

TABLE 1. DISTRIBUTION OF AIR FORCE ENVIRONMENTAL STAFF REPORT IN SURVEY SAMPLE

AIR FORCE GROUPS		NUMBER OF STAFF REPORTED	
		BY GROUP	SUBTOTAL
LABORATORY HEADQUARTERS & SPECIAL CENTERS			AFESC 72 + (Min 75)
Headquarters Air Force Engineering and Services Center	HQ AFESC	SUBTOTAL	
HQ AFESC/Environics	HQ AFESC/RDVA	30	
HQ AFESC/Environmental Sciences	HQ AFESC/RDVS	+	
HQ AFESC/Environmental Sciences	HQ AFESC/RDVC	10	
HQ AFESC/Bioenvironmental Engineering	HQ AFESC/RDVW	+	
HQ AFESC/Environmental Engineering	HQ AFESC/RDVP	+	
(HQ AFESC/Engineering and Services Laboratory	HQ AFESC/RD	30)	
HQ AFESC/Environmental Planning	HQ AFESC/DEV	37	
(HQ AFESC/Natural Resources	HQ AFESC/DEVN	4)	
(HQ AFESC/Environmental Protection	HQ AFESC/DEVP	9)	
(HQ AFESC/Community Planning	HQ AFESC/DEVC	+)	
HQ AFESC/Computer Services	HQ AFESC/ACD	+	
HQ AFESC/Meteorology	HQ AFESC/WE	+	ETAC (+AWS) 15 + (Min 21)
Environmental and Technical Application Center	USAF ETAC(+AWS)	SUBTOTAL	
USAF ETAC/Technical Services	USAF ETAC/TS	7	
USAF ETAC/Environmental Simulation	USAF ETAC/DNS	5	
USAF ETAC/Bioenvironmental Engineering	USAF ETAC/ENB	+	
USAF ETAC/Aerospace Sciences	USAF ETAC/DNP	+	
USAF ETAC/Automation Branch	USAF ETAC/AD	+	
USAF ETAC/	USAF ETAC/CCX	+	
USAF ETAC/Applications Programs	USAF ETAC/ADL	+	
HQ Air Weather Service/Aerospace Physics	HQ AWS/[illegible]NP	3	
HQ AF Global Weather Center/Plans and Policies	AFGWC/DOX	+	
Air Weather Service/Global Weather Central	AWS/DCX	+	OEHL 23 + (Min 26)
Occupational and Environmental Health Lab.	USAF OEHL	SUBTOTAL	
USAF OEHL/Environmental Assessment (Air Quality)	USAF OEHL/ECA	5	
USAF OEHL/Environmental Assessment(Water Quality)	USAF OEHL/ECW	5	
USAF OEHL/Environmental Assessment	USAF OEHL/ECE	10	
USAF OEHL/Radiation Services	USAF OEHL/RZI	3	
USAF OEHL/Health Branch	USAF OEHL/ECO	+	
USAF OEHL/Environmental Chemistry	USAF OEHL/SAN	+	
USAF OEHL/Data Automation	USAF OEHL/	+	AFCL
Air Force Geophysics Laboratory	AFGL	+	Min 1
Laboratory Headquarters and Special Centers (AFESC, USAF ETAC, USAF OEHL, AFGL)		SUBTOTAL	LAB HQ'S & CENTERS 110+ (Min 123)
MAJOR COMMAND HEADQUARTERS HQ ATC, SAC, MAC, AFSC, AFLC, AFRES	HQ MAJCOM	SUBTOTAL	MAJCOM 28+* (Min 31)
HQ Air Training Command/Env. Planning	HQATC/DEV	18	
HQ Air Training Command Bioenv. Eng.	HQATC/SGP	+	
HQ Strategic Air Command/Bioenv. Eng.	HQSAC/SGP	2*	
HQ Military Airlift Command/Bioenv. Eng.	HQMAC/XGP	5	
HQ Air Force Systems Command/Energy & Nuc. Eff.	HQAFSC/DLWM	+	
HQ Air Force Logistics Command/Env. Planning	HQAFLC/DEV	+	

KEY
+ = Staff Exist. No number reported
( ) = Duplicate number not in subtotal
* = Further interest too late for analysis

TABLE 1. DISTRIBUTION OF AIR FORCE ENVIRONMENTAL STAFF REPORT IN SURVEY SAMPLE (CONCLUDED)

AIR FORCE GROUPS		NUMBER OF STAFF REPORTED	
		BY GROUP	SUBTOTALS
MAJOR COMMANDS (CONTINUED)		SUBTOTAL	
HQ Air Force Reserves/Env. Plan	HQ AFRES/DCS	1	AFB 29 + (Min 34)
AIR FORCE BASE ENV. PLAN & BIOENV.. ENG.		SUBTOTAL	
Tyndall Air Force Base/Bioenv. Eng.	/SGP	7	
Tyndall Air Force Base/Env. Plan	4756CES/DEEV	+	
Scott Air Force Base/Env. Plan	375ABG/DEEV	3	
Scott Air Force Base/Bioenv. Eng.	/SGPE	+	
Eglin Air Force Base/Bioenv. Eng.	/SGPE	+	
Randolph Air Force Base/Bioenv. Eng	/SGPM	14	
Randolph Air Force Base/Env. Plan	/DEEV	+	
Kelly Air Force Base/Env. Plan	2851ABG/DEPD	+	
Wright Patterson Air Force Base /Env. Plan	2750ABW/DEEX	5	
OTHER AIR FORCE GROUPS LISTED BELOW		SUBTOTAL	OTHER GROUPS 34+
Air Force Regional Civil Engineer-Central Reg.	AFRCE-CR	8	
Air Force Regional Civil Engineer-Eastern Reg.	AFRCE-ER	+	
Titan II Systems Management	/MMGF	19	
Titan II Systems Engineering	TRW/DSSG	3	
Directorate of Computer Sciences/Civil Eng.	DCS/CIVIL	+	
Armaments Division/Computer Systems	AD/KRESS	+	
Armaments Division/Env. Plan	AD/DEEV	4	
HQ Air Force Systems Command(Space)/Env. Plan	HQSD/WE	+	
Air Weather Service Headquarters 3rd Weather Wing	HQ3WW/DNC	+	
Vandenberg AFB Space & Missile Center	WSMC/SEM	+	TOTAL
TOTAL ALL 56 GROUPS			201 + (Min 227)

KEY + = Staff Exist. No number reported

( ) = Duplicate number not in subtotal

TABLE 2. AIR FORCE BASE ENVIRONMENTAL INFORMATION REQUIREMENTS

*Not AFB	MIS PROJECT PLANNING**	MIS PROJECT CONSTRUCT**	COMPUTER MAPPING	HAZARDOUS CHEMICAL INFO. SYSTEM	HAZARDOUS CHEMICAL TRACKING	ENV. PERMIT TRACKING	AICUZ NOISE PLANNING	POLLUTION ABATEMENT INFO.	ENV. SAMPLING INFO. SYSTEM	LAND USE PLANNING INFO	AFB ENV. DATABASE	MEDICAL INFO. SYSTEM	EMPLOYEE DATABASE	ENV. REPORT PREPARATION	BASE COMP. PLAN	ENV. ASSESSMENT
HQ MAC/DCS Eng. & Serv.*	X	X														
HQ AFESC/DEV*			X	X	X	X										
McCHORD AFB WASH.				X	X		X	X								
HICKAM AFB HAWAII					X		X									
BROOKS AFB TEX.				X												
VANCE AFB OK	X	X			X											
RANDOLPH AFB TEX.				X					X							
KELLY AFB TEX.	X	X				X	X			X	X	X	X			
MACDILL AFB FL.				X	X									X		
LACKLAND AFB TEX.					X	X								X	X	X
AFB ONLY (EXCLUDES*)	2	2	0	4	5	2	3	1	1	1	1	1	1	2	1	1
TOTAL (INCLUDES*)	3	3	1	5	6	3	3	1	1	1	1	1	1	2	1	1
RANK ORDER OF TOTAL	3	3	5	2	1	3	3	5	5	5	5	5	5	4	5	5

Summarized from Engineering and Services Information Requirements Vol. 1, Base Level and Vertical Requirements, August, 1981, AFESC.
** MIS Management Information System

information and techniques to simulate possible future activities and their effects. These unclassified modeling areas are the focus of this study. There are three main mission areas in the Air Force which, survey has revealed, need unclassified models: planning and management of Air Force facilities and operations; hazard management and emergency response; and weather analysis and forecasting.

(1) Facility Planning and Management

The planning and management of Air Force facilities and operations increasingly need models. Place optimization and cost benefit models are needed for early designs to analyze and evaluate alternative facilities and operations and seek optimum sites. Environmental simulations of proposed sites are needed to assist more detailed planning. Models of drainage, microclimate, land, structure, earthquakes, floods, vehicle movement, social and economic interactions, and other processes involved with the successful building and operation of Air Force facilities are needed to help planners and designers. Models comparing and evaluating alternative site layouts are needed as well.

Models are increasingly essential to predict the magnitude of environmental impacts of proposed actions. This is required by federal laws such as the National Environmental Policy Act, the Clean Air and Water Act, the Clean Air and Water Pollution Control Acts, and the Toxic Substances Control Act. Air and water quality models, especially ground water, and models of the behavior and effects of toxic and hazardous substances in the environment are urgent Air Force modeling needs. State and local laws vary but increasingly require numerical impact predictions. The effect of aircraft noise on surrounding land use is a widespread Air Force area of modeling need involving local government. Finally, models are needed with monitoring information to regulate Air Force operations and provide a framework and strategy for maintenance and management.

The planning and management of Air Force facilities takes place at various command levels. Air Force headquarters sets policy at the highest level and broadest extent. Major Commands make more detailed plans within the general headquarters strategy for areas of functional responsibility. Air Force Base staff are responsible for day-to-day operation. Each level has different but related modeling needs: operational management needing detailed and specialized models, while strategic planning requires broader brush, more flexible simulation techniques.

(2) Hazard Management and Emergency Needs

Another major area of Air Force modeling needs is hazard management and emergency response. The Air Force routinely handles many dangerous chemicals, such as explosives, radioactive materials, inflammable and toxic fuels, and a variety of toxic chemicals used in the cleaning and repair of aircraft. These hazardous materials generate three areas of modeling needs: 1) models to ensure that workplace exposure to risk is within acceptable limits, sometimes called occupational health or industrial hygiene planning and management; 2) models to assist the tracking of toxic materials and safe disposal; and 3) contingency simulation to allow the Air Force to respond rapidly and effectively to accidents. These emergency response procedures must be based on accurate predictions of the nature and gravity of the accident hazard, and models can provide useful information to these studies. Models of accidental release of toxic heavy gases into the atmosphere and toxic waste into groundwater are specially urgent Air Force modeling needs in the area of hazard management.

(3) Weather Analysis and Forecasting

Weather analysis is another major area of Air Force modeling need; it includes site collection, integration, and archiving of meteorological analyses such as storm tracking and prediction and visibility analyses. Weather modeling applications in the Air Force are highly organized and specialized. The rapid collection and dissemination of weather information, weather forecasting, and weather analysis for mission support are so fundamental to the basic Air Force combat mission that weather modeling is a special subject outside the general scope of this report. The means of satisfying weather study needs and the data, analysis and results produced may, however, help to satisfy other Air Force modeling needs as discussed under Air Force modeling capabilities.

b. Classified Modeling

Classified Air Force modeling simulates combat and mainly uses restricted information. War gaming, flight simulation, and modeling of the effects of weapon systems are examples. This group of needs is not the subject of this report, although it should be noted that there is overlap in the data, analysis techniques, and hardware needs of classified and unclassified models and, if security can be maintained for restricted information, classified use facilities have the potential to enlarge unclassified modeling capabilities.

3. SUMMARY OF AIR FORCE MODELING NEEDS

These Air Force mission areas needing modeling are listed in Table 3 and are shown linked to the groups which responded to the survey.

TABLE 3. AIR FORCE MISSION AREAS SURVEYED WITH MODELING NEEDS

KEY

X = Major Needs

O = Minor Needs

	AIR FORCE FACILITY PLANNING AND MANAGEMENT																HAZARD PLANNING AND MANAGEMENT										WEATHER ANALYSIS		
	OUTLINE FACILITY PLANNING			FACILITY SITE LAYOUT/DESIGN		FACILITY IMPACT ASSESSMENT						FACILITY MANAGEMENT																	
	LOCATION ANALYSIS	COST BENEFIT ANALYSIS	OUTLINE DESIGN	SITE SIMULATION	FACILITY LAYOUT/DESIGN	AIR QUALITY ANALYSIS	WATER QUALITY ANALYSIS	ECOLOGICAL ANALYSIS	HAZARDOUS CHEM. ANALYSIS	NOISE ANALYSIS	COMMUNITY ANALYSIS	GENERAL IMPACT ANALYSIS	MONITORING DATA COLLECTION	MONITORING DATA ANALYSIS	OPERATION MANAGEMENT	OPERATION ASSESSMENT	ACCIDENT CONTINGENCY PLAN.	HAZARDOUS WASTE DISP. PLAN.	OCCUPATIONAL HEALTH PLAN.	RISK ASSESSMENT	EXPOSURE CALCULATION	RADIATION ANALYSIS	HAZARDOUS CHEMICAL AUDIT.	HAZARD INDICATOR MONITOR.	INDUSTRIAL HYGIENE MNGMNT.	ACCIDENT MANAGEMENT	AIR DATA MANAGEMENT	SPECIAL AIR ANALYSIS	WEATHER FORECASTING *
LABORATORIES AND SPECIAL CENTERS																													
AFESC	X	X	X	X	X	X	X	X	O	X	X	X	O	X	O	X	X	X	O	O	O		X	O	O	O	X	X	
ETAC						X		X			X	X	X	X					O								X	X	X
OEHL						X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X			X	X	
AFGL						X																					X	X	
MAJOR COMMAND HEADQUARTERS																													
HQ ATC	X	X	X	X	X	X	X	X	X	X	X	X	X	X	O	X	X	X	X				X	O			X		
HQ SAC	X	X	X	X	X	X	X	X	X	X	X	X	X	X	O	X	X	X	X				X	O			X		
HQ MAC	X	X	X	X	X	X	X	X	X	X	X	X	X	X	O	X	X	X	X				X	O			X		
HQ AFRES	X	X	X	X	X	X	X	X	X	X	X	X	X	X	O	X	X	X	X				X	O			X		
AIR FORCE BASES																													
TYNDALL													X	O	X	O	X	O	O				X	X	X	X			
SCOTT													X	O	X	O	X	O	O				X	X	X	X			
EGLIN													X	O	X	O	X	O	O				X	X	X	X			
RANDOLPH													X	O	X	O	X	O	O				X	X	X	X			
KELLY													X	O	X	O	X	O	O				X	X	X	X			
WRIGHT-PAT													X	O	X	O	X	O	O				X	X	X	X			
OTHER GROUPS																													
AD/DEEV						X	X	X	X	X	X	X	O	X		X	X	X	X				X	O	X	X			
TITAN II DRW					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
WSMC/SEM					X	X	X	X	X	X	X	X						X	X	X	X	O							

* Modeling weather forecasting capability for use in weather related studies.

NOTE: Other modeling needs exist, these mission areas were addressed in the survey.

SECTION III

AIR FORCE MODELING CAPABILITIES

1. AIR FORCE ENGINEERING AND SERVICES CENTER

Environmental models are developed and operated at several centers in the Air Force. The Air Force Engineering and Services Center (AFESC), with headquarters at Tyndall AFB, Florida, has initiated much of the Air Force development of unclassified environmental models for general use and is the originator of this study. The Environics Division (AFESC/RDV) is the lead laboratory and laboratory focal point (LFP) for Air Force Systems Command (AFSC) environmental research and coordinates this work with other Department of Defense (DOD) and federal agencies. The Directorate of Environmental Planning (AFESC/DEV) is an extension of Headquarters Environmental Planning (HQ LEEV) and has prime responsibility in the Air Force for developing operational environmental policy.

AFESC work which has involved model development includes Base Comprehensive Planning (BCP): air, water, and land quality studies; environmental, social and economic impact assessment; chemical hazard analysis; toxic spill management; aircraft noise analysis; and the environmental effects of weapons systems. AFESC has sponsored the design of models, notably the Air Quality Assessment Model (AQAM), the Air Force Runoff Model (AFRUM), and the Noise Contouring Model (NOISEMAP) of the Air Installation Compatible Use Zone planning technique (AICUZ).

AFESC has obtained environmental models from other sources and tested them in Air Force applications, notably the UNAMAP set of air quality models developed by the Environmental Protection Agency (EPA) and the Environmental Technical Information System (ETIS), developed by the U.S. Army Construction Engineering and Research Laboratory (CERL). AFESC has adapted some models from other sources for Air Force use, notably SAM (the Spill Assessment Model) adapted from HACS (the Hazard Assessment Computer System developed by the U.S. Coast Guard). AFESC has accessed large mainframe computers at Tyndall and Eglin Air Force Bases to run models for Air Force application.

AFESC work in the Directorate of Environmental Planning (AFESC/DEV) includes routine operation of established models. The AICUZ noise modeling process (NOISEMAP), the Local Economic Consequences System in the Army ETIS package, and the smaller UNAMAP models have been used only in experimental situations.

2. OCCUPATIONAL AND ENVIRONMENTAL HEALTH LABORATORY

The Occupational and Environmental Health Laboratory (OEHL) at Brooks AFB, Texas, is a key Air Force environmental capability which contributes to modeling by providing data from sample analysis and stored databases, but also by supporting occasional use of environmental quality and occupational health models. OEHL has extensive testing facilities for a wide variety of air, water, land and radiological sampling and experience with managing large environmental databases.

3. ENVIRONMENTAL TECHNICAL APPLICATIONS CENTER

The Environmental Technical Applications Center (ETAC) at Scott AFB, Illinois, and other Air Weather Service (AWS) groups, such as Global Weather Central (GWC) at Offut Air Force Base, form the meteorological data collection and weather analysis and forecasting capabilities of the Air Force. The models used are, on the whole, highly specialized and not generally available, but the meteorological and space environment data, and interpretative analysis are available as data input for models. Environmental simulation modeling of weather and climate is available.

4. OTHER AIR FORCE MODELING LABORATORIES AND CENTERS

The Directorate of Computer Sciences (DCS) at Eglin AFB has computing facilities generally available for Air Force modeling with software and databases installed.

The Rome Air Development Center (RADC) at Grifiss AFB is a research organization in the Air Force Systems Command (AFSC). RADC works in the area of reconnaissance, image analysis systems, computer science, and intelligence data handling, which could contribute to Air Force modeling capabilities. Remote sensing, image interpretation pattern recognition, terrain modeling, automated cartography, and computer graphics are being developed at RADC and could be available to enhance Air Force modeling capabilities when unrestricted.

The Air Force Geophysics Laboratory (AFGL) at Hanscom AFB, Massachusetts, is a center for research and exploratory development in land, air, and space environment and has developed middle atmosphere models.

5. MAJOR COMMAND MODELING CAPABILITIES

More specialized model development and operation and collection of model-related data take place at Headquarters of Major Commands (HQ MAJCOM). The Air Training Command Headquarters (HQ ATC), for example, develops and operates facility planning and environmental quality models. The Strategic Air Command Headquarters (HQ SAC) uses environmental quality and occupational health models. The Military Airlift Command Headquarters (HQ MAC) runs air and water quality models, and the Air Force Reserve Headquarters (HQ AFRES) uses models for environmental planning and management.

6. AIR FORCE BASE MODELING CAPABILITIES

There are few modeling capabilities available at Air Force (base) level. The results of models are used, such as hazard management tactics and accident contingency plans, and monitoring data is collected to input models; but the only modeling routinely done at bases uses simple models which can be run by hand or with a programmable calculator.

7. SUMMARY OF MAJOR AIR FORCE MODELING CAPABILITIES

Table 4 provides a cross-reference of laboratories and special centers with their capability groups.

TABLE 4. AIR FORCE MODELING CAPABILITIES BY GROUP

	MODELING POLICY	RESEARCH AND DEVELOPMENT	SCIENTIFIC TECHNIQUE	DATABASE CREATION	DATABASE STORE	DATABASE MAINTENANCE	SOFTWARE	HARDWARE	USER TRAINING AND SUPPORT	PILOT OPERATION	ROUTINE OPERATION	OUTPUT USE	ORGANIZATION AND COORDINATION
LABORATORIES AND SPECIAL CENTERS													
AFESC/RD	0	X	X	X	0		X	X	0	X		0	0
AFESC/DEV		0	X	X	X	X	X	X	X	0	X	X	0
OEHL	0	X	X	X	X	X	0		0	0	0	X	0
ETAC		X	X	X	X	X	X	*		X	0	X	
DCS EGLIN AFB		0	X		X		X	X	0	X	X		
RADC		X	X				X	*		0			
AFGL		X	X				X	*		0			
HEADQUARTERS MAJOR COMMANDS													
HQ AFSC	X												X
HQ ATC	0	0	X	X	X	X	X	R		0	0	0	
HQ SAC			X	X	X	X				0	0	0	
HQ MAC			X	X	X	X				0	0	0	
HQ AFLC			X	X	X	X				0	0	0	
HQ AFRES			X	X	X	X				0	0	0	

KEY

X = Group has capability

0 = Group has some capability

R = Group has access to remote capability

* = Group has capability but not generally available.

SECTION IV

AIR FORCE MODELING DEFICIENCIES

1. TYPES OF MODEL DEFICIENCIES

Deficiencies occur when needs exceed capabilities. Air Force modeling deficiencies are widespread and severe. Not only are the available modeling capabilities inadequate for needs, but the lack of an established organizing structure (which could link needs to capabilities and coordinate support) aggravates the deficiencies by limiting access to available capabilities.

Two groups of modeling deficiencies are discussed in this report: deficiencies in the modeling capabilities (including data, modeling techniques, model validation, software, and hardware) and deficiencies in the organization which provides modeling capabilities.

2. MODEL DEFICIENCIES

a. Model Input Data Deficiencies

The environmental data needed to support models are generally inadequate. This is not particular to the Air Force, nor will the Air Force be able to solve the problem alone. Accurate, up-to-date environmental data, correctly formatted for model input, is the most deficient modeling capability. Data available in a required location are sparse, of uncertain quality, and variable dates, while special data collection is slow and expensive. Machine-readable data formatted for model input is especially deficient. Hazardous chemical information, local current air quality, and groundwater flow and quality data also are particularly deficient subject areas.

b. Modeling Technique Deficiencies

Modeling techniques for Air Force purposes in general do exist. There are state-of-the-art limitations, especially in such areas as ecology and groundwater. In general, current Air Force modeling needs can be satisfied with existing techniques. There are, however, severe deficiencies in practical access to existing techniques in the Air Force.

Although there are existing modeling techniques which make accurate predictions, the use of many is restricted, due to lack of published validation studies. Proof that model predictions closely resemble observed reality is essential if models are to have scientific and legal credibility. This proof often is lacking.

c. Model Software Deficiencies

Most modeling equations are too complicated to be solved manually and must be converted to computer programs. The quality of the software code and its documentation, the degree of user-friendliness, and the compatibility of the software with available hardware and operating systems are, therefore, important considerations. Here a distinction must be drawn between generally available modeling software largely adequate for Air Force needs (documented, and could run on Air Force computers) and modeling software now available to Air Force users, which is seriously deficient. The general modeling software deficiency is that most programs are not user-friendly and require training and skill to use.

AQAM, the most ambitious Air Force development of generally available environmental modeling software, is a large program which has not been used operationally. The model is difficult, time-consuming, and expensive to run, and the documentation and validation are incomplete. AFRUM is documented and easy to run, but is not used operationally. NOISEMAP, the AICUZ model, is successfully used operationally, although enhancements are desired. Apart from minor operational use of software developed and maintained elsewhere, such as the CERL ETIS economic models and the EPA UNAMAP models, there is no other generally available environmental modeling software operationally accessible in the Air Force.

d. Model Hardware Deficiencies

Environmental research laboratories and centers and some environmental planners and bioenvironmental engineers at major command headquarters have access to computer hardware powerful enough to run most available modeling software, although the operating skills are not always present. Base level staff have limited access to computers (even to terminals connected to remote facilities). They usually have little modeling or computer operating skill and little opportunity to acquire it. There is almost no modeling software available for programmable calculators or minicomputers, which are increasingly available to base staff. Large areas of Air Force modeling needs are thus completely deficient in hardware, and the hardware acquisition process is generally lengthy and competitive.

3. MODELING ORGANIZATION DEFICIENCIES

More serious than the deficiencies described above are deficiencies in the Air Force organization which develops, collects, implements, tests, validates, supports, and distributes models. These organizational deficiencies are a major cause of the modeling deficiencies. Better organization could greatly improve model access even without improvement in modeling deficiencies themselves.

There is, for example, no model clearing house capable of providing information on available models and helping to connect needs with existing capabilities, nor is any Air Force group specifically charged with this task. When a modeling need is recognized (many are not because of lack of understanding of modeling capabilities), a special search must be initiated. The search for heavier-than-air gas dispersion models following a TITAN II accident, for example, took several months. Some time was spent simply locating persons knowledgeable of needed capabilities.

There is no group which surveys model development external to the Air Force for application to service issues, nor builds a working knowledge for transfer of such resources. There is no durability in the modeling knowledge which does accumulate, because short military tours of duty prevent the development of a corporate memory. There is no index of models available in the Air Force or elsewhere especially suited to Air Force needs. This report contains the beginning of such an index, but update and maintenance are needed.

There is no group which operationally tests and validates models and integrates needed capabilities into a coordinated Air Force modeling system. There is no development of a user-friendly, interactive computer system comparable to the Army ETIS, which could lower the skill level needed to access both computers and models and enhance model use beyond small groups of overworked specialists.

There is no operational production of model-user documentation and training material, no regular user training schedule, and no established network of users and developers of models which could distribute data, modeling techniques, contacts, and support.

This almost complete absence of an established organization which routinely collects, supports, and distributes environmental models can be seen as an opportunity. Many of the separate elements needed to create an operational Air Force modeling capability already exist, as discussed in Section V. A small amount of coordination could produce large improvements by linking these existing capabilities and efficiently addressing needs.

SECTION V

RESOURCES AVAILABLE TO OVERCOME DEFICIENCIES

1. TYPES OF AVAILABLE RESOURCES

There now existswithin the Air Force, and in other organizations accessible to the Air Force, a variety of resources which could overcome many of the modeling deficiencies discussed in the previous section. These are listed in two broad groupings: specific modeling resources and modeling organizations or systems.

2. MODELING RESOURCES

a. Models

There are many environmental models publicly available which the Air Force could use to address deficiencies. GSC performed a model search for the Environmental Protection Agency: seven large computer databases were searched and over 10,000 citations on environmental models were produced. The problem is how to identify, from this mass of reference material, the models most suited to specific Air Force needs.

Indices of models which were used to create the short list for this report were as follows:

- Environmental Protection Agency (EPA) Environmental Databases and Model Index Draft Directory, May 1981
- Society for Computer Applications in Engineering, Planning and Architecture (CEPA) Library of Program Abstracts, 1980
- Oak Ridge National Laboratory (ORNL) Inventory of Databases Graphics Packages and Models in Department of Energy Laboratories, 1978
- Digital Equipment Corporation (DEC) Engineering Systems Software Referral Catalog, 1981
- American Consulting Engineers Council (ACEC) Software and Hardware Catalog
- Holcomb Research Institute, Bulter University Ground Water Modeling Catalog, 1981

The following databases also have model citations which were used for reference: AGRICOLA (National Agricultural Library); APTIC (Air Pollution Technical Information Center); BIOSIS (Biological Abstracts); ENVIRONLINE (Environmental Information Center Line);

Environmental Bibliography (Environmental Studies Institute); DIALOG (Oceanic and Pollution Abstracts); and HOMS (Hydrological Abstracts World Meteorological Organization (WMO)).

GSC used a number of selection criteria to produce the model short list outlined in Table 5 and discussed in more detail in Appendices G and H. Air Force modeling needs were identified from the survey. Within each area of need, models were selected: 1) best suited to Air Force needs; 2) most scientifically correct; 3) most compatible with Air Force computers; 4) most established, operational and readily available; 5) best documented and most validated; 6) best served with input data; 7) recommended by experienced professionals who used them in real world applications; and 8) preferred or approved by regulatory agencies. Somewhat lower standards of documentation or validation were accepted for areas of special Air Force need, including ground water quality and heavier-than-air gas modeling and models suitable for use in handbooks, on calculators, or on microprocessors.

Each model on this list of about 200 models was then cataloged and compared with detailed needs of Air Force groups for analytical features collected in the survey. From this analysis a list of most recommended models was established. This analysis is discussed in detail in Appendix B.

Most of the models in the preferred lists come from a few key sources. The Air Force itself has good models which are either not used operationally or are used less than their potential. The biggest collection of operational models exists in the Environmental Protection Agency (EPA) which has developed, sponsored or collected a large number of models. Many of these EPA models are public and readily available at nominal cost. The Society for Computer Applications in Engineering, Planning and Architecture (CEPA) and the U.S. Army Corps of Engineers Center (HEC) have collections of surface hydrology and other environmental engineering models, which are available at low cost.

The U.S. Coast Guard has sponsored an integrated set of models and information known as CHRIS/HACS, the Chemical Hazard Response Information System Hazard/Assessment Computer System. This set contains data, models, and model-generated handbooks and contingency plans for the handling of hazardous chemicals and management of accidents both of which are urgent Air Force needs. Plans are now underway to make this system more widely available.

Table 5 summarizes key features of the most appropriate models available for Air Force needs. Appendices G and H contain more detail of a larger list.

TABLE 5. KEY FEATURES OF MOST PREFERRED MODELS

MODEL	OUTSTANDING MODELS	COMPOSITE RANK	TYPE OF MODEL	LEVEL OF VALIDATION	LOWEST FEASIBLE OPERATION	COMPUTER/CALCULATOR SUPPORTING MODEL	SOFTWARE LANGUAGE	WORD SIZE	OPERATING SYSTEM	APPROXIMATE LINES OF SOURCE CODE	STORAGE REQUIREMENTS	USER MANUAL AVAILABILITY	SYSTEMS DOCUMENTATION AVAILABILITY	DATE OF FIRST VERSION	DATE OF LATEST VERSION
AFRUM		102	W		L	CDC 6600	FOR		6 CPU		56K	Y		80	80
AT123D		102	W		L	IBM 360	FOR					Y	Y		
CLEARY GROUND WATER FLOW		240	W		C		FOR					Y			
CLEARY MASS TRANSPORT		222	W		C		FOR					Y			
DIURNAL		102	W	H	L		FOR				40K	N		70	
DOSA6 I		126	W	H	L		FOR				27K	Y	Y		
FEMWATER		105	W		L	IBM	FOR					Y		79	79
FLOOD ROUTING		136	W		P	HP-41C						Y	Y		
GSWIM		102	W		L	UNI-1100	FOR					Y		78	81
HSPF		126	W		L	IBM HP-3000 PRIME, HARRIS	FOR				128K	Y	Y	80	
MAGNUM 3D		102	W		L							N	N		

KEY

TYPE OF MODEL
- W = Water
- A = Air
- E = Ecology
- S = General Socioeconomic
- X = Exposure
- N = Noise
- D = Waste Disposal
- C = Chemical Spills
- M = Multimedia

LEVEL OF VALIDATION
- H = High
- M = Medium
- L = Low
- Blank = Not Validated

SOFTWARE LANGUAGE
- FOR = FORTRAN
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- L = Large (mainframe)
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LEARNING DIFFICULTY/OUTPUT INTERPRETATION DIFFICULTY
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USER MANUAL AVAIL./SYSTEM DOC. AVAIL./USER SUPPORT AVAIL./DEBUGGING MAINTENANCE/CONT. ENHANCEMENTS/CONFIDENTIALITY/STATUTORY AUTHORITY
- Y = Yes
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TABLE 5. KEY FEATURES OF MOST PREFERRED MODELS (CONTINUED)

MODEL	DATE/LATEST DOCUMENTATION	TYPE OF MACHINE INTERFACE	LEARNING DIFFICULTY	OUTPUT INTERPRETATION DIFFICULTY	USER SUPPORT AVAILABILITY	DEBUGGING MAINTENANCE	CONTINUED ENHANCEMENTS	CONFIDENTIALITY	STATUTORY AUTHORITY	GEOGRAPHIC AREA
APRUM	80	PLOT	M	M				N		
AT123D			M	L	Y					
CLEARY GROUND WATER FLOW	78		L							
CLEARY MASS TRANSPORT	78		L	L						
DIURNAL			L							
DOSA6 I			L	L						
FEMWATER					Y					
FLOOD ROUTING	81		L	L						
GSWIM					Y					
HSPF			H		Y					
MAGNUM 3D										

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THYSYS		104	W				FOR						Y	70	
TTM		96	W		L		FOR				50K	Y	Y		
WRTM		114	W		M	IBM 360/91	FOR					Y	Y	74	
WQAM		105	W		C	CALCULATOR						Y			
RECEIV II		126	W	H	L		FOR				400K	Y	Y	71	
SEM	*	246	W	H	C	CALCULATOR							Y		
SESOIL		99	W		L	VAX 11/780	FOR					Y		81	
SNSIM		114	W		L	IBM 370/155	FOR				16K	Y	Y		
SSM		216	W	H	C	CALCULATOR						Y		71	72
SWMM		120	W		L	IBM 360/370 AMDAHL 470 UNI 1108 CDC 6600	FOR				90K	Y		71	80

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THYSYS			L				Y			
TTM										
WHTM			H	M						
WQAM			L							
RECEIV II	74	BA	M							
SEM			L	L						
SESOIL			M							
SNSIM	78		L	L				N		
SSM	71		L	L						
SWMM	80		H		Y					

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ADOBE EQNS	*	360	A		M	IBM 1800						Y			
AERIAL SPRAY		264	A												
APRAC 1A		231	A		M	UNIVAC 1110 CDC 6400 IBM 360/50 VAX 11/780	FOR	60		2015	45K-CDC 32K-UNI	Y	Y	72	72
APRAC2		148	A	M	L	CDC 6400	FOR	60			55K				
AQAM		222	A		L	CDC 6700	FOR	60			140K	Y	Y	73	
AQDM		138	A	M	L	IBM 360/40	FOR	32			300K	Y		69	
ATDL		213	A	M	C	IBM 360/65	FOR	32		350		Y		70	
ATM		140	A	M	L	IBM 370 VAX 11/780	FOR	32	VMS	1550	215K	Y	Y	73	76
AVAP		156	A	M	L	IBM 370/195	FOR	32	OS NNT LASP	3000		Y	Y		
AVGTIME	*	384	A		S	UNIVAC	FOR								
BLP		142	A		L	UNIVAC 1100	FOR	36		2062	20K	Y	Y		
CDM		148	A		L	UNIVAC 1110 VAX 11/780 IBM 360	FOR	32	VMS	1313	20K	Y	Y	68	

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ADOBE EQNS	71		L	L						
AERIAL SPRAY										
APRAC 1A	73	BA	M	L	Y		Y	N	Y	
APRAC2										
AQAM	76	BA	H	L				N		
AQDM							N			
ATDL	72	BA	L	L	Y					
ATM	76	BA	M	L	Y	Y	Y			
AVAP		BA	M	M				N		
AVGTIME	77		L	L						
BLP										
CDM	73	BA	L	M	Y		Y	N	Y	

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CDMCQ		216	A		L	UNIVAC 1110 VAX 11/780	FOR	32	VMS	1988	48K	Y	Y	77	
CRSTER		219	A	M	L	UNIVAC 1110 VAX 11/780	FOR	36 32	VMS	1728	28K	Y	Y	72	77
CRSTER 2		142	A		L	UNIVAC 1110	FOR	36			28K	Y			
HIWAY		225	A												
HIWAY 2		213	A		L	UNIVAC 1110	FOR	36		1298	8K	Y	Y	80	
ISC		228	A		L	UNIVAC 1110	FOR	36		3500	65K	Y	Y		
LIRAQ		138	A												
LPAQSM		146	A		M	UNIVAC 1110	FOR	36			60K	Y	Y		
MODHIWAY		148	A		M	UNIVAC 1110	FOR	36			12K				
MODIFIED CRAMER-GAUSSIAN		195	A												
MOUNTAIN IRON		284	A		C	TI-59						Y			

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CDMCQ	77	BA	M	L	Y			N	Y	
CRSTER	77	BA	M	L	Y			N	Y	
CRSTER 2		BA								
HIWAY										
HIWAY 2	80	BA IN			Y					
ISC	79	BA	M	M	Y					
LIRAQ										
LPAQSM	79									
MCDHIWAY										
MODIFIED CRAMER-GAUSSIAN										
MOUNTAIN IRON			L	L						

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PTM		152	A		L	IBM 370/158 UNIVAC	FOR					N	N		
PLUVUE		136	A		L	UNIVAC 1110	FOR	36			25K	Y	Y	78	80
PTDIS		228	A	M	S	UNIVAC 1110 VAX 11/780	FOR	32	VMS	625	9K	Y	N		
PTMTP		154	A	M	S	UNIVAC 1110 VAX 11/780	FOR	32	VMS	661	10K	Y	N		
PTMAX		172	A	M	S	UNIVAC 1110 VAX 11/780	FOR	32	VMS	460	9K	Y	N		
PTPLU		228	A		L	UNIVAC 1110/82 IBM 360 CDC 6000	FOR	32 60		957	12K	Y			
RAM		228	A		L	UNIVAC 1110 VAX 11/780	FOR	32	VMS	4547	41K	Y	Y		78
RCDM		243	A		L	IBM 360	FOR	32			2K	N			
REED		150	A	M	L	UNIVAC 1108	FOR	36		4600	42K	Y	Y		
REGMOD		219	A		L	IBM 360	FOR	32			5K	N			
ROLLBACK		189	A		M	UNIVAC 1108 IBM 360	FOR	36 32				N			

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S = General Socioeconomic
X = Exposure
N = Noise
D = Waste Disposal
C = Chemical Spills
M = Multimedia

LEVEL OF VALIDATION

H = High
M = Medium
L = Low
Blank = Not Validated

SOFTWARE LANGUAGE

FOR = FORTRAN
C =

LOWEST FEASIBLE OPERATION

L = Large (mainframe)
C = Calculator
P = Programmable Calculator
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TABLE 5. KEY FEATURES OF MOST PREFERRED MODELS (CONTINUED)

MODEL	DATE/LATEST DOCUMENTATION	TYPE OF MACHINE INTERFACE	LEARNING DIFFICULTY	OUTPUT INTERPRETATION DIFFICULTY	USER SUPPORT AVAILABILITY	DEBUGGING MAINTENANCE	CONTINUED ENHANCEMENTS	CONFIDENTIALITY	STATUTORY AUTHORITY	GEOGRAPHIC AREA
PTM										
PLUVUE	80									
PTDIS	73	IN BA	L	L	Y		Y	N		
PTMTP	73	IN BA	L	L	Y		N	N		
PTMAX	73	IN BA	L	L	Y		N	N		
PTPLU		BA	L	L	Y					
RAM	78	BA	M	L	Y		Y	N	Y	
RCDM	80									
REED		IN								
REGMOD	80									
ROLLBACK	78			L						

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MPTER		219	A		M	IBM 300, CDC 6600, UNIVAC 1100/82	FOR	32 60		2448	48K	Y	Y	80	
OCEAN BREEZE DRY GULCH		284	A		C	TI-59 PACKARD BELL		23				Y			
OZIPP		198	A		L	UNIVAC 1100	FOR	36				Y	Y		
P23A, P23B	*	462	A		C	TI-59						Y			
PAL		152	A		L	UNIVAC 1100 VAX 11/780	FOR	32	VMS	3484	43K	Y	Y		78
RPM II		152	A	M	L	UNIVAC 1110	FOR	36			65K	Y			
SAIASP		138	A	M	L	UNIVAC 1110	FOR	36			70K	Y			
SIGMET		136	A	M	L	CDC 6600 CRAY	FOR	60 64		2-3000	350K	Y	Y	75	81
SLAB		138	A	M	L	CDC 7600	FOR	60	LTSS	5000	250K	N	Y	80	81
TCM2		146	A		L	BURROUGHS 6810	FOR	36		2004	60K	Y	Y		

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MPTER	80	BA	L	L	Y					
OCEAN BREEZE DRY GULCH			L	L						
OZIPP	78									
P23A, P23B			L	L						
PAL	78		M	L	Y					
RPM II	80									
SAIASP	79									
SIGMET	81	IN BA	L	L	Y	Y	Y			
SLAB	81	IN BA	M	L	Y	Y	Y			
TCM2	80	BA	M		Y				Y	

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TEM B		152	A		L	BURROUGHS 6810/11 UNIVAC 1100	FOR	36		3778	40K	Y	Y		
TRAJ		210	A	M	L	UNIVAC 1110 IBM 360/95	FOR	36 32			265K	Y	Y	75	80
TURNER'S WORKBOOK		225	A	M	B							Y			
VALLEY		152	A		L	UNIVAC 1110 VAX 11/780	FOR	32	VMS	1000	14K	Y	Y		79
ALWAS		70	M	L	M	PDP 11/40 IBM 370	FOR	16 32				Y	N		
UTM		204	M	M	M	VAX 11/780 IBM 370	FOR	32	VMS	11,000	800K	Y	Y	76	81
MS. CLEANER			E	M	M		FOR								
SSEG			E	M	M	UNIVAC 1100 PDP 11/45	FOR				64K	N			
VEG COMM.			E		M	IBM 1130 UNIVAC 1100	FOR				32K	N	N		
CELDS			S		M	VAX 11/780	C	32	VNIX			Y		75	78
EIFS			S		M	VAX 11/780	C	32	VNIX			Y			79
AIR DOS EPA	*	118	X		M	IBM 360	FOR	32				Y	Y	77	79

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TEM B	79	BA	M		Y				Y	
TRAJ	80	BA IN	M	L	Y		Y			
TURNER'S WORKBOOK	70		M							
VALLEY	79	BA	M	M	Y			N	Y	
ALWAS		BA IN	M		N	N				
UTM	81	BA	H	H	N	N	Y			
MS. CLEANER			H							
SSEG										
VEG COMM.										
CELDS	78	IN	L	L	Y	Y	Y	N		
EIFS	79	IN	L	L	Y	Y	Y	N		
AIR DOS EPA	79									

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ABTRES			D		M	IBM 370	FOR	32			100K	Y	Y		
IRS			D		M	UNIVAC 1108	FOR					Y	Y		
WRAP			D		M	IBM 370	FOR	32		7,000	264K	Y	Y		
CHRIS	*	360	C		M	CDC 3300						Y		74	79
HACS	*	306	C		M	CDC 3300	FOR	60	NOS	16,240		Y	Y	76	81
SAM	*	204	C		M	CDC 6600	FOR	60	NOS	17,000	68K	Y	Y	80	80
EXAMS	*	123	X	M	L	IBM 370, PDP II, CDC CYBER, HP-3000	FOR					Y	Y		
HEP	*	146	X		M	UNIVAC 1110	FOR	36			45K	Y	Y	80	
ACOUSTIC IMPACT PREDICTION		132	N		B	CALCULATOR									
NOISEMAP		92	N	H	M	CDC 6600	FOR	60	NOS	20,000	172K	Y	N	74	81

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ABTRES										
IRS	81	BA	H	H						
WRAP	77	BA								
CHRIS	79		M	M			Y	N	Y	
HACS	81	IN BA	M	H	Y	Y	Y		Y	
SAM	80	IN	M	L	N	N				
EXAMS	81		H	M						
HEP	80	BA								
ACOUSTIC IMPACT PREDICTION										
NOISEMAP	80	BA	M	L			Y	N		

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b. Model Data

Some models have associated databases to provide part of the input data. These are noted in Appendices G and H. The Air Force collects and maintains databases which can provide model input, including DATSAV world meteorological databases collected by the Air Weather Service (AWS) and environmental quality databases collected by the Occupational and Environmental Health Laboratory (OEHL). Other Federal Agencies have model-related databases: The Environmental Protection Agency (EPA) has STORET water and SAROAD air databases, the U.S. Geologic Survey (USGS) WATSTORE and NASQUAN water databases with topographic and geological maps. The Soil Conservation Service (SCS) has county soil maps. The National Oceanic and Atmospheric Administration (NOAA) has marine data. The NOAA Environmental Data and Information Service (EDIS) and USAF Environmental Technical Application Center has space environmental data. The Fish and Wildlife Service (FWS) has wildlife and habitat data, in particular the machine-readable National Wetland Survey. The National Climatic Center (NCC) has World Meteorological data. The National Center for Health Statistics (NCHS) and National Cancer Institute have public health data. The U.S. Bureau of Census, the U.S. Bureau of Labor Statistics (BLS), and the Department of Transportation (DOT) have social and economic data. Model data is discussed in more detail in Appendices G. and H.

c. Model Hardware

The Air Force Engineering and Services Center (AFESC) at Tyndall AFB and the Directorate of Computer Sciences (DCS) at Eglin AFB are the most notable of the several computing centers with hardware available from Air Force environmental tasks. The U.S. Army Corps of Engineers Construction Engineering and Research Laboratory (CERL) has a minicomputer which supports the ETIS models.

A major potential resource for enlarging the hardware available for Air Force environmental Modeling is the proposed procurement of minicomputers for many Air Force bases to support the Uniform Hospital Chart of Accounts for Air Force Hospitals. Hardware currently is being selected for this procurement, but from the specification in the request for proposal, it is clear that powerful minicomputers will be chosen. These widely distributed base-level machines, if accessible, also will be available for environmental tasks. The Occupational and Environmental Health Laboratory (OEHL) now has a proposal to support four occupational health and environmental databases on these minicomputers in a system called COHP, the Computerized Occupational Health Program. Environmental models could be distributed on the same machines and, in some cases, linked to OEHL data.

3. MODEL ORGANIZATION AND SYSTEM RESOURCES

a. Air Force

The organization resource most needed to overcome Air Force modeling deficiencies is formulation of a group within the Air Force to routinely coordinate and support Air Force modeling activities. There is no group that now has this explicit mandate, but there are two existing groups where skills and experience are available.

The Air Force Engineering and Services Center (AFESC) is the prime group resource available for a model coordination center. Both the Environics Division (AFESC/RDV) and the Environmental Planning Directorate (AFESC/DEV) have experience with environmental models (RDV with development and establishment, DEV with operational support). AFESC also has working contacts throughout the Air Force which could form the basis of a network of users, operators, and developers of Air Force models and model-related data.

The Occupational and Environmental Health Laboratory (OEHL) is another center of established skills and could either form a modeling group or be a major data center in support of one. OEHL has less extensive experience than AFESC with other environmental models, but through its sample testing program, it has both extensive contacts throughout the Air Force on environmental matters and skill with larger environmental databases.

If an Air Force modeling group were established, there are a number of organizations and systems in the Air Force and in other government agencies which have resources which could assist. The Environmental Technical Applications Center (ETAC) has meteorological data atmospheric science skill, and meteorological and weather modeling experience. Owing to the specialized nature of the Air Weather Service (AWS) mission, ETAC would not be a suitable center for general model coordination, but it could provide assistance with air modeling support and has indicated a willingness to do so.

The Directorate of Computer Sciences (DCS) at Eglin AFB has hardware and experience in establishing and operating environmental software with data. These computing skills and capabilities could be made available to enhance modeling capabilities.

The Rome Air Development Center (RADC) at Griffiss AFB, while not directly involved in unclassified Air Force modeling, is sponsoring development of hardware and software for image and terrain analysis, pattern recognition, spatial data manipulation, and computer graphics (which could benefit directly an established Air Force modeling center). RADC works closely with the Defense Mapping Agency (DMA) on techniques and could assist with problems of model data input.

Environmental planning and bioenvironmental engineering groups at the headquarters of major commands are key resources for organizing a network of contacts serving as focal points for the collection of model user needs and the distribution of developing modeling capabilities. The Air Training Command Headquarters (HQ ATC/DEV), in particular, has shown interest in being a pilot user for the next steps in this modeling project.

Throughout the Air Force there are specialized resources, largely uncoordinated, which could contribute to Air Force model development and use. The Space and Missile Center (AFESC WSMC/SEM) at Vandenburg AFB, for example, has models for rocket and shuttle launches, and the Air Force Geophysics Laboratory (AFGL) at Hanscom AFB has atmospheric models. While these resources would not be primary for a coordinated modeling capability, they could be more widely distributed once the coordination function was established.

b. Other Federal Agencies

There are several organizations and systems in other military and civilian federal government agencies with resources available which could directly address Air Force modeling deficiencies. The U.S. Army Corps of Engineers has three centers which could contribute with models, data, or support. These are the Construction Engineering and Research Laboratory (CERL), the Hydrologic Engineering Center (HEC), and the Engineer Topographic Laboratory (ETL).

CERL has developed a mini and microcomputer-based system called ETIS, the Environmental Technical Information System. It is an interactive, user-friendly computer system which contains a growing collection of integrated environmental and socioeconomic information and analysis techniques to support U.S. Army environmental work. ETIS includes models which are now used operationally in the Air Force by AFESC/DEV, and there are now AFESC proposals to expand Air Force use of ETIS by distributing terminals linked to the CERL computer center. The content of ETIS is of interest to Air Force modeling but limited in its capabilities. There are, for example, no quantitative environmental models. Of equal or greater interest is the organization and structure of ETIS which is used widely and successfully at Army major commands and bases. The philosophy of designing an easy-to-use, interactive computer system, with the capability of being widely distributed on economical hardware, has proven very successful and offers an example for an Air Force modeling user network.

The Hydrological Engineering Center (HEC), is an established software development center for hydrological analysis. The HEC runoff models are the most widely used storm water drainage analysis techniques in the civil engineering profession. HEC has also developed The Spatial Analysis Method (SAM), a system capable of geographic manipulation and display. HEC models would be essential elements in an Air Force model library, and HEC experience would be invaluable when evaluating development alternatives.

ETL, the Engineering Topographic Laboratory, is doing Computer-Assisted Air Photo Interpretation Research (CAPIR), which involves sophisticated image capturing, image interpretation, pattern recognition and development of minicomputer-based geographic information systems. This work, which overlaps the research of the Rome Air Development Center (RADC), could assist with model data input and display.

The Environmental Protection Agency, Office of Toxic Substances (EPA-OTS), is developing a computerized network of capabilities to assist with the management and regulation of hazardous chemicals CSIN, the Chemical Substances Information Network. Federal agencies are encouraged to become members of CSIN. Membership offers three kinds of resources to an Air Force modeling capability.

First, CSIN will provide a front-end computer giving access to an increasing variety of chemical databases and chemical modeling techniques located in a number of agencies. Included are the EPA Chemicals in Commerce Information System (CICIS) and Chemical Information System (CIS), and the Lockheed Dialog database. There is now discussion of distributing through CSIN the U.S. Coast Guard CHRIS/HACS hazardous chemical database and spill modeling capability, and the growing UPGRADE system, a user-friendly library of chemical fate and transport models being developed by General Software Corporation (GSC) for EPA-OTS.

Second, the CSIN development program has done a great deal of work on the development of computer networking for environmental applications. CSIN will contain no data or capabilities, but it will provide a front-end computer to mediate between a user and many distributed computer facilities. This computer networking technology could greatly assist in the coordination of the diverse Air Force modeling capabilities.

Third, CSIN offers a community of developers and users of hazardous chemical information. Concern over the management of hazardous materials and contingency planning for accidents is high on the list of Air Force modeling needs. The three kinds of resources offered by CSIN could satisfy many needs.

The U.S. Geological Survey (USGS) coordinates a water data exchange called NAWDEX, the National Water Data Exchange. Two resources are offered: access to a large computerized water quality databased (WATSTORE) and contact with a large community of water data users. The Air Force is already a member of NAWDEX and this membership could support some water modeling data needs.

The Federal Government supports a system of Information Analysis Centers which act as clearing houses for technical information. Some of these, such as the National Climatic Center, already have been mentioned. Others with potential to assist modeling include:

- Adivsory Center of Toxicology
- Biomedical Computing Technology Information Center
- Center for Climatic and Environmental Assessment (CCEA)
- Center for Experiment Design and Data Analysis
- Earth Resources Information Center (ERIC)
- Ecological Sciences Information Center
- Environmental Information Division
- Health and Environmental Studies Program
- International Demographic Statistics
- National Environmental Satellite Service
- X-Ray and Ionizing Radiation Data Center

Further information on these centers can be obtained from the National Referral Center, Library of Congress, Washington, D.C. 20540.

4. SUMMARY OF RESOURCES AVAILABLE

Table 6 summarizes the main areas of model resource deficiency and references each to major available model resources. Resources available in each deficiency area are roughly summed but clearly show:

- There are many resources now available to provide data, modeling techniques, software, and model research development.

- There are fewer resources now available for model validation, documentation, coordination, user training and routine model operation.

Development of new resources is most needed in these areas of deficiency.

TABLE 6. MAJOR AVAILABLE MODELING RESOURCES REFERENCED TO AIR FORCE MODELING DEFICIENCIES

KEY

● = Major resource available to overcome most of deficiency

◐ = Minor resource available to overcome part of deficiency

O = Resource available with potential to overcome deficiency

AIR FORCE MODELING DEFICIENCIES AVAILABLE MODELING RESOURCES	AIR MODELING DATA	WATER MODELING DATA	OTHER NATURAL MODELING DATA	SOCIOECONOMIC MODELING DATA	CHEMICAL MODELING DATA	MODELING TECHN. AND SKILLS	MODELING SOFTWARE	MODELING HARDWARE	MODEL REFERENCE INDEX	MODEL USER NEEDS KNOWLEDGE	MODEL NEED/CAPAB. COORD.	MODEL OPERATION	MODEL TESTING & VALIDATION	COMP. MODEL USER INTERFACE	MODEL USER DOCUMENTATION	MODEL USER TRAINING	MODEL NETWORK (PEOPLE)	MODEL NETWORK (COMPUTERS)	MODEL RESEARCH & DEVELOP.
AFESC	◐	◐	◐	◐	◐	●	◐	◐	O	◐	O	◐	O		◐	O	O	O	●
USAF ETAC	◐					◐	◐	◐				◐	◐					O	◐
USAF OEHL	◐	◐	◐		◐	◐	◐			◐								O	
AFGL	◐					◐	◐												◐
USAF RADC			O				O	O											◐
USAF MAJCOM HQ'S	◐	◐	◐	◐	◐	◐	◐	◐		●	O	◐				◐		O	
US AFB'S	◐	◐	◐	◐				●*		●		O	O					O	O
US COE CERL	◐	◐	◐	◐	◐	◐	◐	◐		◐		◐	◐	◐	◐	◐	◐	◐	◐
US COE HEC		◐	◐			◐	◐		◐				◐	◐	◐		◐		◐
US COE ETC						◐	◐												◐
US COASTGUARD					◐	◐	◐								◐				
NASA		◐	◐	◐		◐	◐								◐	O	◐	O	◐
EPA (ORD OTS)	●	●	●	◐	●	●	●		●				●	●	●		●	●	●
USGS		◐	●	◐		◐												O	
SCS		◐	◐			◐													◐
NOAA		◐				◐													◐
FWS			◐			◐													◐
NAT. CLIMATIC CENTER (NCC)	●					◐	◐												◐
NAT. CENTER HEALTH STATS (NCHS)				◐	◐														
NAT. CANCER INST. (NCI)				◐	◐														
US BUR. CENSUS				●															
US BUR. LAB. STATS (BLS)				◐															
DOT				◐															
FEDERAL INFORMATION ANAL. CENTERS	◐	◐	◐	◐	◐			◐											
WORLD MET. ORG. (WMO)	◐	◐							◐										
HOLCOMB RESEARCH INST.									◐										
CEPA							◐		◐										
TOTALS O = 1; ◐ = 2; ● = 3	24	27	29	27	19	34	27	* 14	11	12	2	9	11	7	13	6	11	12	28

*proposed

SECTION VI
AIR FORCE MODELING IMPROVEMENT STRATEGIES

1. BASIC DESIGN CRITERIA

The Air Force has urgent needs for environmental models. Present modeling capabilities are seriously deficient. There are many unused or underused resources which could be made available to overcome modeling deficiencies. This section of the report discusses alternative strategies for harnessing, coordinating, and developing resources to improve Air Force modeling capabilities.

There are a number of basic design criteria which must be addressed by any modeling improvement strategy. Unclassified modeling indirectly supports the primary Air Force mission of combat readiness, but is not the highest priority. Funds and resources for development will always be limited. Proposed improvements must, therefore, build as much as possible on existing resources or share resources planned for higher priority programs. Development must be coordinated to avoid duplication of effort.

Air Force environmental staff are loaded heavily with mission responsibilities. Especially at base level, they have limited scientific and computer skills and little time to acquire more. Improved modeling capabilities must be addressed to existing skill levels and must "pay as they go," demonstrating increased productivity or decreased staff requirements at each stage of development.

Improvement strategies must be planned in a series of evolutionary steps, each with a manageable objective offering quickly demonstrable benefits and ready evaluation to guide the next step. Overambitious plans which propose unrealistic objectives and use large amounts of resources for long periods without creating useful operational capabilities are destined for failure.

Modeling improvements must directly address Air Force needs, starting with the most urgent and widespread deficiencies. The survey in this report provides a starting place to understand needs, but techniques for user feedback must be built into improvement strategies to guide development.

Both the success and failure of past and present Air Force strategies for distributing models offer pointers for future planning. Two of the most successful have been: 1) the CERL/ETIS family of interactive computer techniques, and 2) handbooks containing models such as the CHRIS chemical hazard handbook and Bruce Turner's Workbook of Atmospheric Dispersion Estimates. Significantly, simplicity and ease of access have promoted the success of these techniques.

There are a number of strategic alternatives for developing modeling capabilities, the first of which is to do nothing beyond maintaining existing capabilities. Air Force modeling needs are sufficiently urgent and the deficiencies discussed elsewhere in this report sufficiently grave that GSC does not consider this to be a feasible alternative.

If modeling capabilities are to be improved, there are a number of alternative organization structures and operation and distribution techniques available. These are not necessarily mutually exclusive. The techniques best for one stage of development may differ from those for another, but it is useful to distinguish the separate techniques and to analyze the advantages and disadvantages of each.

2. ORGANIZATION ALTERNATIVE

a. Central Operation

All unclassified modeling activities in the Air Force, except weather forecasting, could be centralized in one group responsible for all model development, collection, selection, testing, implementation, data collection and maintenance, and operation (Figure 1). The models would not be distributed; expert staff would operate them as requested by users and distribute the results.

The advantage of central operation is that development is efficient because it is concentrated in one place without duplication. Integration and coordination of models and data are effective for the same reason. Quality control can be tight and uniform. Skilled specialists who understand model limitations operate the models and prevent inappropriate use. Large computer resources can be supported. For the most complicated models, central operation may be the only possible technique.

The major disadvantage of central operation is that existing distributed resources may be poorly used and agencies may resist the new center because it competes for funds with established functions. The wide variety of user needs may be poorly addressed by a single remote center. User access may be limited by the procedures of applying to a remote facility and the operational limits of a single group to handle fluctuating workloads. Communication costs are high because of the separation of needs and capabilities. The opportunities offered by the rapidly developing technology of small computers are not realized.

b. Central Distribution

Central distribution is a variation of the central operation alternative (Figure 2). A single central group collects, develops, establishes, and maintains models and model databases. It makes models

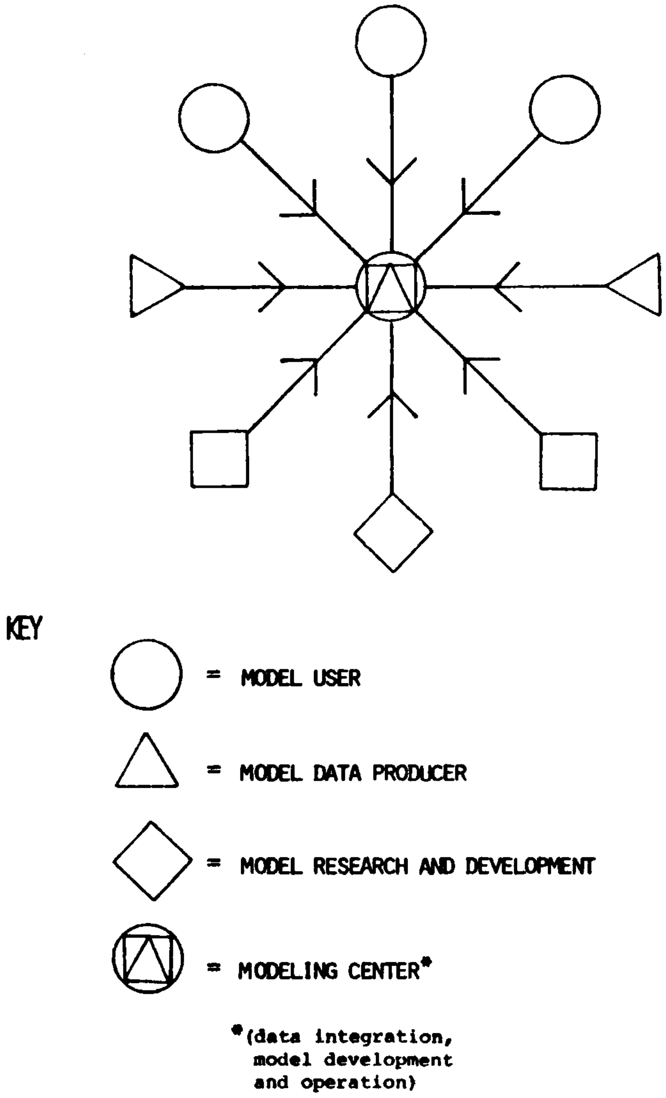


Figure 1. Central Operation.

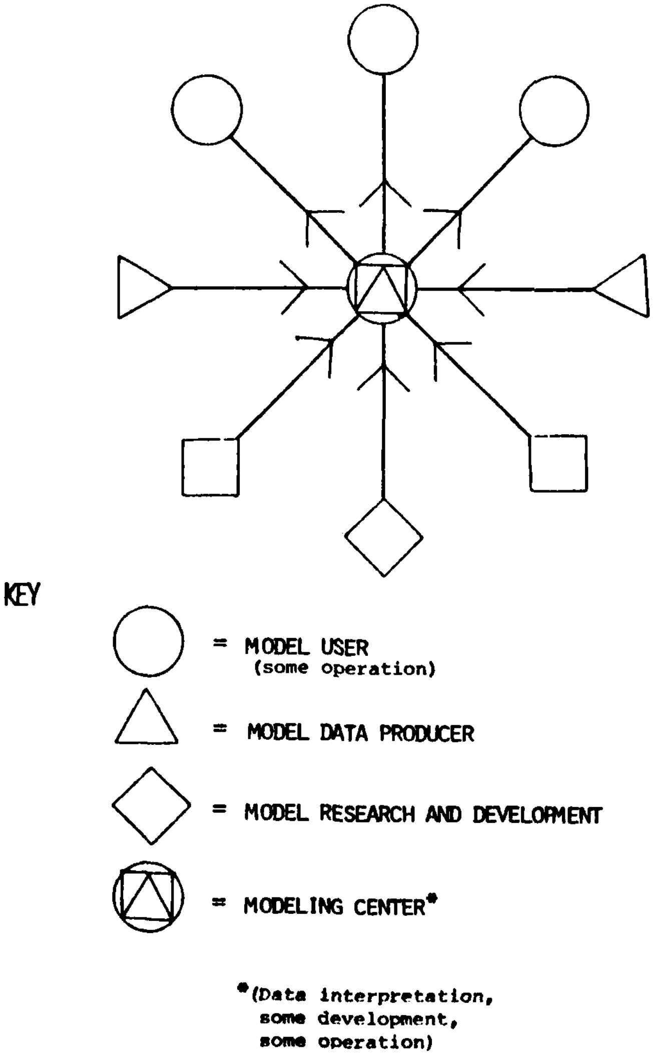


Figure 2. Central Distribution.

available for distribution through handbooks or a central computer system with either a training program or self-teaching materials. This is the solution adopted successfully by the U.S. Army Construction Engineering Research laboratory (CERL) for the ETIS models.

The advantages of central distribution are similar to central operation. Although there is less control over model use, there is more direct application of the models to their problems by distributed staff. There are, therefore, easier access and better user feedback. A smaller central group can serve a large user community.

One disadvantage of central distribution is inappropriate use of models, although a good user support service can prevent this. The opportunities for small machines are not realized presently in CERL. All users are supported directly from the central computer, but a central group controlling model distribution could develop some techniques which could be run locally by hand, on calculators, or small computers. CERL presently is studying this possibility. However, too much centralization in this alternative may usurp existing functions, causing competition rather than needed cooperation.

c. Command Hierarchy

The Air Force has a command hierarchy like an inverted tree (Figure 3). At the top, the headquarters of the U.S. Air Force (HQ USAF) has overall command and develops or approves general Air Force policy. This policy is applied to Major Commands (MAJCOMs)' at the next lower level; they, in turn, develop more detailed strategies within their areas of functional responsibility. The MAJCOMs have authority over Air Force Bases (AFBs), which develop and implement the tactics of day-to-day operation. The reality is more complicated than this simplified representation, with overlaps at both MAJCOM and AFB levels. The lines of communication up and down the command tree are, however, the most completely developed and offer an organizational structure for modeling.

In this alternative, HQ USAF would set general modeling policy and ensure overall coordination of modeling efforts. Each MAJCOM would develop a modeling center appropriate to its functional needs, and these centers would operate models for the MAJCOMs and their associated AFBs.

The advantage of this alternative is that it uses a well-established organizational structure already very familiar to Air Force personnel. Many other Air Force activities, communications, and procurements take place using this structure. The differing needs of MAJCOMs and associated AFBs are likely to be addressed well.

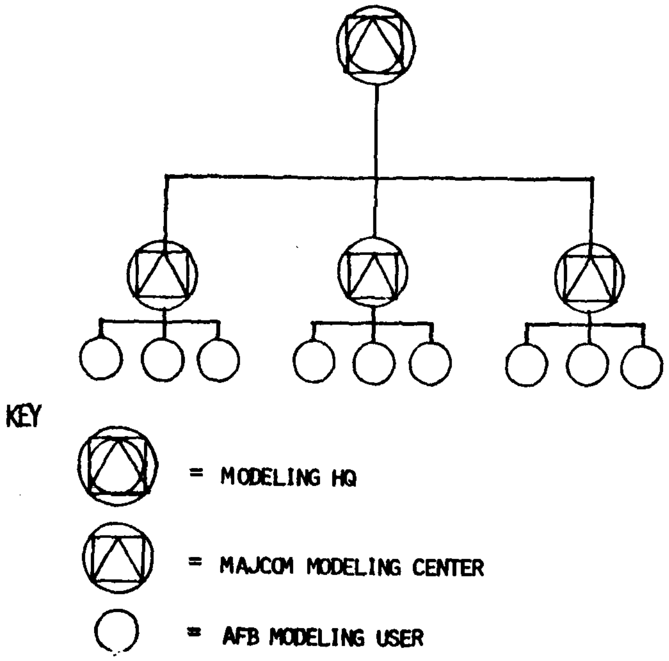


Figure 3. Command Hierarchy.

The disadvantage of this alternative is that lateral communications between MAJCOMs and AFBs are not as well developed. This makes difficulties for technical coordination of models, data integration, and software compatibility. The magnitude of Air Force modeling needs may not be great enough to justify the development of advanced skills needed to establish and support modeling operations in each MAJCOM. The modeling needs of MAJCOMs have large areas of overlap which raise the danger of duplicative effort if separate modeling centers are developed at each MAJCOM.

d. Functional Network

The final organization alternative discussed is the identification of existing groups in the Air Force capable of contributing to modeling and linking them into a coordinated network of centers, each providing differing functional inputs to the modeling process. A model coordination center would be needed to integrate existing resources and to provide missing resources needed for operational modeling. The networking of diverse facilities into a coordinated system is the organizational structure proposed by the Environmental Protection Agency (EPA) for the Chemical Substances Information Network (CSIN). The CSIN coordination center is to concentrate entirely on the administration of the network communication with data and analysis capabilities supported entirely by other centers.

Other functions could be performed appropriately by a modeling coordination center in the Air Force (Figure 4). Those functions appropriate to a modeling coordination center are:

- Data selection
- Quality control
- Reformatting and integration for Air Force model use
- Model selection
- Testing and establishment in an integrated format
- Administration and support of network communications
- Membership matters
- Newsletters and intermember communication
- Preparation and distribution of user manuals, handbooks, and training materials
- User training and support
- Management of seminars and conferences
- Contact with other centers, user groups, and contact networks with similar interests outside the Air Force

Existing Air Force groups which have resources that can contribute to modeling and which would be willing to provide them would be linked into the modeling system by the model coordination center. Contributions would be contingent upon skilled manpower and computer resource availability, as well as adaptation of databases

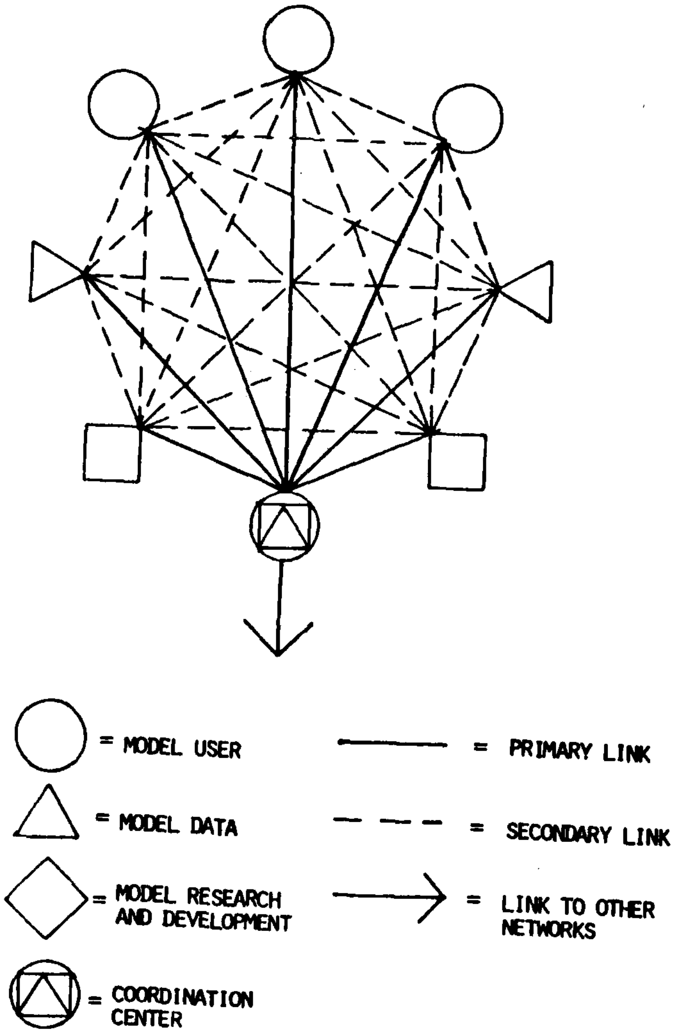


Figure 4. Functional Network.

which may contain errors or omissions to a common user format. The Environmental Technical Applications Center (ETAC), for example, could be a model data center providing either raw or formatted meteorological data for air modeling. The Occupation and Environmental Health Laboratory (OEHL) could be both a modeling data and application center, providing environmental quality data and supporting model operation.

The prime advantage of a modeling network is that existing resources are used efficiently. The role of the coordination center is mainly to coordinate existing data and capabilities necessary to operate models. New capabilities essential to modeling would be developed only if they did not exist elsewhere. This cooperative resource use lessens resistance to the introduction of new capabilities, because there is no competition with existing functions. Established expertise and facilities are used as much as possible. The system is very flexible; centers can appear and disappear as needs and technology change. The network can start small and grow at a manageable speed, providing practical benefits immediately and throughout the growth process.

The disadvantages of network are the problems of coordination and efficient communication, which are greater than in other organization structures. Since the procedures, formats, and protocols of each of the network components remain in place, the coordinating center must develop conversion techniques for translating each into an integrated modeling format. The technical problems of computer networking between diverse hardware, operating systems, data structures, and particular among software languages can be quite severe. The Air Force has, however, experience with ARPANET, a computer network which supports varied computer systems. The EPA CSIN project has addressed many of the organizational and computer networking problems associated with such a project and found them solvable. This understanding is available to aid Air Force development.

3. OPERATION AND DISTRIBUTION TECHNIQUES

Whichever organization structure is used to support the development and establishment of an operational Air Force modeling capability, there are a number of alternative ways of distributing access. Again, these are not mutually exclusive, and different mixes may be appropriate to different stages of development. Each can be analyzed separately for advantages and disadvantages.

a. Books and Hand Calculation

The simplest method of distributing access to model results, data, and the simpler calculation techniques is to publish them in books. These may contain results based on model calculation or enough information in the form of tables, charts, nomograms, or simple step-by-step calculations to operate models by hand or calculator. The U.S. Coast Guard CHRIS handbooks and Bruce Turner's Workbook of Atmospheric Dispersion Estimates are successful examples of modeling books.

The advantages of this method of distribution are considerable. Compared to other methods, books are economical to produce and distribute, require no additional equipment and, if well written, can be accessed easily wherever needed with little or no further support. Self-training can be built into the book for various skill levels; introductory training to model capabilities beyond the capacity of hand calculation can be included as well. These advantages are so great that handbooks should be used whenever possible, and the quality of written documentation and training materials should be a first priority of modeling development in the Air Force.

The disadvantages of books are the complexity of modeling that can be done by hand is severely limited and hand calculation is very time-consuming. As computing devices become more readily available, the tedium of long-hand calculation becomes less acceptable. However, most modeling applications are entirely beyond the scope of handbooks, and an Air Force modeling capability based only on this method would be inadequate.

b. Microcomputers and Programmable Calculators

Another method of distributing access to models is to establish data and calculation programs which can run on desk top microcomputers or programmable calculators. The technology of this scale of computer is advancing at great speed, and machines are becoming smaller, more economical, and more powerful. A stand-alone microcomputer system, with input and output peripherals costing as little as $5,000, is powerful enough to support quite sophisticated models. Programmable calculators are developing quickly into small microprocessors and can handle calculation elements of considerable complexity.

The chief advantage of this form of access is that the hardware is economical. If well-documented, user-friendly models are established they are easy to access. Recent technological advances are offering rapidly increasing cost benefit in terms of computing power per dollar at this scale of computer. There is also a rapidly evolving telecommunications technology, which can link microcomputers as super smart terminals to larger machines, forming hybrid systems which use each level of the computer hardware hierarchy with great efficiency.

The disadvantages are that there is very little environmental modeling software now available for small machines and programs are not user-friendly. GSC made an extensive search for any microcomputer or calculator software directly or indirectly contributing to environmental modeling; the few discoveries are listed in Section V and Appendices G and H. No doubt there are other sources of small machine software. The subject is so new that there are no established clearing house, no recent surveys, no indexes, and the search is difficult. The U.S. Fish and Wildlife Service recently published an advertisement in the Commerce Business Daily (CBD) requesting information on microprocessor-based environmental software, and they also are finding very little.

One of the problems is that until now small computers have been very diverse, with different operating systems, software languages and machine codes. Software has been very machine-dependent and limited in application. Most microcomputer software to date has been for business applications. With the recent introduction of the IBM personal computer, and the imminent release of the Radio Shack 16-bit microcomputer (both of which are compatible with the CP/M operating system), the compatibility problems of microcomputers are shrinking rapidly. This is likely to be the most productive area of software development in the near future. Many models are simple enough to run on microcomputers, if their code is converted, and these potential models are noted in Section V and Appendices G and H. The potential for a model to run on microcomputers weighed heavily in the model selection analysis described in Appendix B.

Another disadvantage is that many models require more data storage and computing power than will be available in microcomputers in the foreseeable future, even with user-friendly, documented software available for increasingly powerful microcomputers. Table 7 shows comparative running times of three models of moderate complexity on three different scales of computers from large mainframes, through minicomputers, to microcomputers.

From Table 7 it can be seen that with the present (admittedly) primitive) state of the art of microcomputers, the average running time for the four models shown is almost 600 times longer on a microcomputer than on a large mainframe. This is a serious disadvantage for larger models and precludes the use of microcomputers alone as a support for Air Force modeling. This disadvantage could be overcome, however, by networking the microcomputer with mini or mainframe computers and using the machine level most appropriate to the use. With this kind of hybrid system, microcomputers can become powerful elements in an integrated modeling capability.

c. Minicomputers

The last few years have seen rapid improvements in minicomputers, powerful computers in the $20,000 to $200,000 range. As the running time comparisons in Table 7 show, minicomputers are almost as fast as large mainframes and are more economical by several orders of

TABLE 7. TYPICAL RUNNING TIME COMPARISONS FOR ENVIRONMENTAL MODELS

MODEL	MAINFRAME		MINI		MICRO	
	UNIVAC OR BURROUGHS 670		IBM 11/30 OR PRIME 450/500		MICRONOVA OR OLIVETTI	
	RUNNING TIME (Min.)	COMPARISON FACTOR	RUNNING TIME (Min.)	COMPARISON FACTOR	RUNNING TIME (Hours)	COMPARISON FACTOR
HYDRAULIC PIPEFLOW MODEL (116 nodes, 186 pipes)	0.65	1	12.2	18.8	80.2	7403
STORM WATER RUNOFF MODEL HEC-2	0.38	1	4.22	11.11	4.6	726
SEWER SYSTEM MODEL (3.1 miles)	7.2	1	8.6	1.2	3.6	30
BACKWATER ANALYSIS MODEL	0.9	1	1.22	1.1	0.36	24
AVERAGE TIMES	2.3		6.53		22.2	
AVERAGE COMPARISON FACTORS		1		2.8		579

magnitude. Much machine-independent software can run on minicomputers with minimal conversion. Many environmental models have been implemented on minicomputers, notably the Construction Engineering Research Laboratory (CERL) ETIS system and the user-friendly library of chemical fate and transport models, which GSC has implemented for the Environmental Protection Agency, Office of Toxic Substance (EPA-OTS). Other models already available on minicomputers are noted in Section V.1 and Appendices G and H.

The advantage of distributing environmental models on minicomputers are that these machines can support all but the most complicated models; even these can be supported if two or more minicomputers are close-coupled and configured as integrated hardware. Compared with mainframes, minicomputers are economical and within the budget of quite small groups. The Air Force is proposing to acquire minicomputers for many Air Force Bases to support the Uniform Hospital Chart of Accounts, and these machines could be made available to support environmental modeling.

The only disadvantage of using this method of distributing models is that, without adequate training and technical support, there is a likelihood there will be inadequate understanding of limitations, causing models to be used inappropriately. Minicomputers tend to be more limited than large mainframes in the number of users who can be supported simultaneously, especially if large calculations are involved. Very large databases and calculations are more appropriately handled on mainframes. Small calculations and many input/output and display functions increasingly are handled more appropriately on microcomputers. The minicomputer is the optimum level for supporting most modeling development and operation and for building an integrated computer network. Therefore, GSC recommends minicomputers as the workhorses of an Air Force modeling system.

d. Mainframe Computers

Large mainframe computers have been, in the past, the only way of distributing access to complex environmental models. These computers cost millions of dollars and are centered in a few large computing centers with large, widely distributed user communities accessing them from remote terminals. There are still more models available for mainframes than for any other machine level, though this is changing rapidly as minicomputers spread. These large machines could be the prime method of distributing model access in the Air Force.

The advantages of using mainframes are that the computing power can handle any complexity of model mainframes that are established in the Air Force, and compatible modeling software that is available.

The disadvantages are the expense and difficulty of running large machines with remote users on long lines of communication. The disadvantages of centralized organization are inherent in these large machines: dependence on remote-user support, limited support capabilities at the center, delays and technical malfunctions in the remote access procedures, and slow and inadequate response to local user needs.

With the rapidly growing number of available minicomputers and advancing computer network technology, the older mainframes may play a different role in the future, serving as mass data stores and large "number crunchers" for a network of smaller machines. GSC recommends this role for mainframes in Air Force modeling, rather than as the primary means of model support.

4. OTHER TECHNICAL CONSIDERATIONS

The advantages and disadvantages of three other technical considerations need brief discussion. These are batch or interactive computer processing, computer networking, and computer languages.

a. Batch and Interactive Computer Processing

Batch processing involves preparing the complete data analysis specification for a computing task and then submitting the job in a batch. No on-line interaction with the software is possible, and no changes can be made without revising the entire job specification and resubmitting it as a new batch item. In interactive processing, on the other hand, there is a dialogue between the computer user and program. Data and analysis specifications can be entered on-line, calculations run immediately, and changes easily made. Both batch and interactive processing have advantages and disadvantages, and both are appropriate for different tasks.

The advantage of batch processing is that once the specification is complete, no further user involvement is needed. This is especially important for large calculations which can be submitted and left running for as long as necessary. Batch processing tends to be more economical because it is often done in off-peak hours when computing rates are cheaper.

The major disadvantage of batch processing is the slow and difficult program interaction. Iterative calculations, which depend on the user studying the result of a calculation, amending the input, and recalculating, are poorly supported. Batch programs tend to be user-unfriendly, and skill is needed to enter the input specification, although this can be overcome by designing interactive prompts to guide a use through the input specification for a batch job.

The advantages of interactive computer processing are that the user can enter an on-line dialogue with the program, set up specifications for calculation, run the calculation, study the output, and iteratively change and revise the input as needed. Interactive programs tend to be more user-friendly, since users can be prompted through the needed inputs a step at a time. The results of calculations usually are available more quickly with an interactive system than with a batch.

The disadvantage of an interactive system is that the cost may be higher, although this is of less concern as powerful mini and microcomputers become more readily available. Large calculations, typical of more complex models, are less suitable for interactive computing, because the user may be held at the terminal with nothing to do.

Both batch and interactive computing are appropriate for Air Force modeling, sometimes in the same model. Ideally the user should be able to choose which method best suits an application. Interactive computing is essential for program development and debugging and is highly desirable for user-friendly programs which guide the user through input specifications. Interactive computing is more suitable for small iterative calculations, while batch processing is more suitable for large noniterative calculations. Combination programs are ideal where a problem can be set up interactively then run interactively or in batch according to the user's choice.

b. Computer Networks

Over time, large institutions,such as the Air Force,acquire a formidable diversity of separately operating computer systems, from large mainframes to desk top microcomputers. While the applications of each of the separate systems may be very different, the fundamental objectives of all computer use are the same: the capture, storage, retrieval, management, manipulation, and display of information. Very often the information or analysis techniques in one system would be useful to another, if there was a way of linking systems. The problem is to coordinate the separate Air Force resources available to enhance environmental modeling and distribute modeling capabilities to areas of need.

The technology that links computers is known as computer networking and, like many other computer techniques, it is advancing very rapidly. The potentials and limitations of this technology must be borne in mind when considering development strategies for Air Force modeling coordination.

A computer network consists of: 1) two or more computers, each supporting compatible telecommunication software and hardware; 2) a linkage medium, either telecommunication cables or electromagnetic wave transmission, joining the computers; and 3) a user linked to one computer and making use of one or more of the other computers in the network.

There are established computer networks in existence. Some, such as DECNET, link only the machines of one manufacturer. Others, such as ARPANET (now used in the Air Force) can link many varieties of machines. The computer network proposed by EPA for the Chemical Substances Information Network (CSIN) proposes a front-end computer dedicated exclusively to administering the communication between a user and a variety of remote machines.

The capabilities of networking technology and the speed of transmission vary. Ideally, a network allows a user at one computer to access and use data and capabilities residing on another computer as easily as on the local machine. It also allows a user to transfer data files and, within limits, operational computer programs from machine to machine.

This network technology offers several important capabilities to Air Force modeling. Input data for models are collected and maintained at widely separate centers in the Air Force and elsewhere. If computer network links could be established between the computer data repositories and an Air Force modeling coordination computer, then data needed for models (and only those data) could be extracted rapidly, transferred to the Air Force system, correctly formatted, merged with input data from other sources, and distributed for use in Air Force modeling.

Computer software also may be transferred through networks. Programs will not run without modification, except on highly compatible computers, but standard base-level computers are proposed for the Uniform Hospital Chart of Accounts. If these were networked, modeling software could be distributed quickly thoughout the Air Force.

On-line user training and support and user contact through an electronic mailbox are capabilities which can be greatly enhanced by computer networking. These, with the network ability to distribute data and analysis techniques from development centers to users, would allow a small user-support group to service an increasingly large user community. Users could be trained to use their own distributed computing capabilities, make use of the network, and train others.

Finally, computer networking offers the possibility of very efficient use of the increasingly economical and powerful microcomputers. These small machines have increasing capabilities for data input and display and for computations that do not require large memory storage or high computing speeds. Many of the simpler environmental models could be adapted to run on microcomputers and this scale of machine is very attractive for distributed use. The U.S. Army Construction Engineering and Reseach Laboratory is presently experimenting with a microcomputer-based version of ETIS called SUDEIS, the Single-User-Dedicated Environmental Information System.

The U.S. Forest Service and the Fish and Wildlife Service are exploring microcomputers for environmental applications.

The capabilities of stand-alone microcomputers are still quite limited and, even with memory additions such as hard disks, will remain so for the foreseeable future. Mass data storage typically needed for environmental calculations cannot be supported practically. Calculations requiring large amounts of "number crunching," such as larger environmental models and complex geographic image processing, are prohibitively slow on microcomputers. These disadvantages largely disappear if the microcomputers are networked to larger machines which store large databases and do complex calculations. Technology is now available which would allow a user to use a microcomputer unit for a data or analysis request which exceeds the capacity of the local machine. At that time, the source of needed capabilities would be located and connected automatically, allowing the user to work transparently at different levels of a computer network. This would use limited computing capabilities very efficiently and reduce communication costs and the amount of needed user support.

The functional potentials offered to Air Force modeling by computer networks are very great, and development towards a modeling network is the most desirable direction. The technology of computerized networking, however, is quite complex and still partly experimental. Care must be taken that unsuccessful attempts at over-ambitious networks do not overwhelm the primary objective of enhancing Air Force access to environmental models.

GSC recommends integrated networking as a goal, with concentration in early development on a simplified organizational structure to distribute access to modeling and computers. Data, software, and hardware coordination should begin immediately.

c. Computer Languages

Computer languages for Air Force environmental modeling must work on a variety of computer scales, from mainframe to microcomputer, and in a variety of computer architectures and operating systems. A computer language with high machine independence is, therefore, very important.

Some computer models contain complex mathematical equations; a computer language which supports advanced scientific applications is, therefore, necessary. There is an established base of modeling software and Air Force computer hardware which must be considered in the choice of a computer language. There are Department of Defense (DOD) plans for a standard computer language which will affect the Air Force choice of a computer language for modeling. A single computer language for all Air Force modeling software development is most desirable for maximum transportability and minimum learning time, the most important considerations for Air Force application.

The scope of work for this study mentions FORTRAN, COBOL, C, and ADA as possible alternative computer languages for discussion. GSC adds PL1, PASCAL and BASIC to this list. The advantages and disadvantages of each for the development and operation of an Air Force modeling capability are outlined in Table 8.

The Air Force modeling operation, for the purpose of this evaluation, is assumed to consist of:

- Model research and development involving model software development and integration
- Software development or conversion in database management, display techniques (especially map display), and computer networking and communication
- Model establishment involving integration of software from the Air Force and elsewhere into standard Air Force modeling procedures
- Model database management, involving distributed acquisition, storage and management of data for models
- Model operation involving the operation of models of varying complexity by a distributed user community of varying skill on all sizes of computers

Wherever possible, networking of modeling computers is assumed to link the separate modeling centers and provide information exchange routes for data software and contracts.

The evaluation makes a distinction between languages most suitable for software acquired by the Air Force from elsewhere and converted for Air Force use, and modeling software entirely developed by, or for, the Air Force.

As can be seen, GSC recommendations for a computer language for Air Force modeling are not simple and depend somewhat on decisions not yet made. The modeling software goal in the short term is to acquire as much needed modeling source code as possible from elsewhere and, with a minimum of effort, provide operation access on as many Air Force computers as possible.

The best solution for this short-term goal is to 1) acquire existing source code developed elsewhere and to compile it for use on Air Force modeling mainframes, minicomputers and microcomputers as needed and feasible, and 2) distribute the model as standard object code to distributed Air Force users.

In some cases, this compiling of code may be a straightforward process running automatically. In other cases, particularly compiling

TABLE 8. EVALUATION OF COMPUTER LANGUAGES FOR AIR FORCE MODELING USE

Computer Lang.	Advantages	Disadvantages	Recommendations
FORTRAN	Most widely used computer language. Most transportable on mainframes and minis, especially ANSI standard. Suited to scientific applications.	Obselete. Cumbersome for some applications Limited portability to micros.	Best mainframe and minicomputer standard language for acquisitions from elsewhere in the short term. Not to be used for modeling software development entirely by, of or for, the Air Force
COBOL	Air Force standard language for business and administration. Powerful data handling capabilities.	Poorly suited to scientific applitions and not so used in the Air Force.	Unsuitable for Air Force modeling applications.
C	Powerful high level well suited to development of modeling software. Considered by CERL to be the key to ETIS success. Is supported on some mainframes mini and microputers.	Closely linked to UNIX operating system which is expensive and very machine-dependent.	Recommendation depends partly on choice of hardware for Uniform Hospital Chart of Accounts minicomputers. If these can support UNIX, C is much more attractive, but the high possibility of user exclusion caused by UNIX dependence tends to eliminate C.
ADA	Powerful high-level language well suited to modeling applications. Proposed as standard DOD language. Long system lifetime. Portability of mainframes and minis probably good but some uncertainties remain (see disadvantages).	Concerns exits in the data processing world at DOD (insistence that no variants exist from a single standard). This could limit flexibility and portability, especially on microcomputers.	If all Air Force modeling computers, including microcomputers, can support a transportable version of ADA, this is recommended as the standard language for all modeling software entirely developed by, or for, the Air Force.

TABLE 8. EVALUATION OF COMPUTER LANGUAGES FOR AIR FORCE MODELING USE (CONCLUDED)

Computer Lang.	Advantages	Disadvantages	Recommendations
PL1	Powerful high-level language, very good features and options well suited to modeling. Good portability on mainframes, minis and microcomputers. Steadily increasing use (e.g. SAS and CP/M written in PL1 or PL1 like languages).	Compiler is large. Existing distribution of compilers is limited. Complicated language. Limited number of qualified programmers.	If Ada cannot be successfully supported all machine levels, mainframe to micro, PL1 is recommended as the second choice for a standard language for all modeling software developed entirely by, or for, the Air Force.
PASCAL	Good for operations with complicated data structures. Good flexibility with string data. Bilevel structure enhances portability.	Not very good for scientific applications.	Some collection of existing microcomputer models may be in PASCAL. Otherwise, not recommended for Air Force modeling.
BASIC	Most widely used and portable microcomputer language. Some microcomputer modeling software already exists in BASIC.	Very limited, rather low-level language inadequate for many modeling applications.	Some existing microcomputer software acquistions in the short term may be in Basic. Otherwise, not recommended for Air Force modeling use.

FORTRAN to run on microcomputers, some source code modifications will be needed. In cases of large programs to run on small machines, or data structures assuming virtual machines, extensive source code modifications may be needed to introduce an overlay structure. Each model probably will be somewhat different, and this compiling should be done by a central group with model and systems knowledge. This central group could acquire compilers for language as needed and distribute object code for the Air Force computers from source code in varied languages.

This method of distributing models is a disadvantage in that users with varying needs cannot edit the source code. This can be overcome either by distributing the compilers or by networking computers to allow distributed users access to the central collection of compilers for editing and recompilation. The revised object code then could be returned to the distributed user computer. In practice, a mixture of these two techniques would be appropriate.

The task of preparing existing modeling software from various sources for Air Force use can be simplified by a very high degree of compatibility in the computers used for modeling. The acquisition of standard minicomputers for the Uniform Hospital Chart of Accounts offers this compatibility at the minicomputer level. GSC recommends that all other minicomputers acquired for Air Force modeling be compatible with these machines and that standards for fully compatible Air Force modeling microcomputers be established quickly.

The long-term goals for an Air Force modeling language are somewhat different. This language must be well suited to models, not obsolete, have as long a working life as possible, be transportable between all Air Force modeling computers, and be compatible with other Department of Defense (DOD) software development.

Of the languages discussed, GSC considers ADA the first choice for long-term development of all software developed entirely for Air Force modeling, provided some concerns about portability can be answered. DOD has sponsored ADA as the standard language for all defense-related software development and, to date, has promoted a single standard with no variants accepted. This may prove too inflexible and may limit the portability of the language, especially on microcomputers. PL1 is a very powerful and portable language and is GSC's second choice for long-term development if ADA cannot be made sufficiently portable.

GSC emphasizes that this preliminary feasibility study is insufficient to commit long-term development in a language. A formal systems analysis of the developing modeling operation would be needed to establish the preference of a long - term language. This is recommended for the next stage of the study.

SECTION VII

RECOMMENDATIONS FOR AIR FORCE MODELING

1. GENERAL CONSIDERATIONS

No one of the alternative organization structures or information distribution techniques discussed in the previous section will satisfy all the design requirements for an Air Force modeling capability at all stages of development.

The recommendations outlined in this section propose an evolutional growth from the existing Air Force modeling capability to an established and coordinated Air Force modeling operation. This growth would draw on the advantages of different mixes of alternative organizations and distribution techniques at different stages of development. The combination of scientific, technical and organizational skills; modeling techniques; computer software and hardware; and the creation and maintenance of networks of people and machines are difficult to establish and administer. While there are existing modeling capabilities in the Air Force, a considerable amount of development is needed to satisfy modeling needs.

Developmental steps must be of manageable size and significant benefit, progressing toward a clearly defined long-term goal (final operational system desired). This long-term goal may change with needs, technology, or tactical development techniques.

For these reasons the recommendations are an outline description of a fully operational Air Force environmental modeling library and network. The outline encompasses three developmental steps which would move Air Force modeling from an operational, growing nucleus towards the final recommended structure.

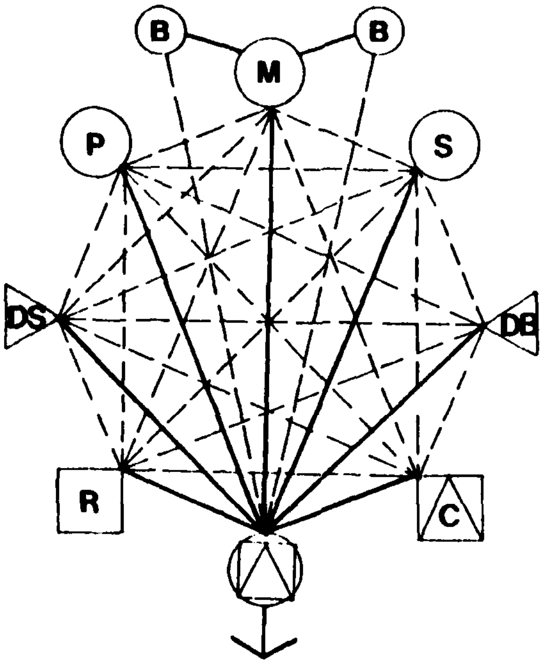
2. AIR FORCE MODEL NETWORK

a. Network Organization

The recommended long-range goal for an Air Force modeling organization is a network of functionally distinct centers structured as shown in Figure 5.

This network would be based largely on existing Air Force capabilities, with no loss of autonomy suggested for centers included in the network. Model support capabilities proposed for each center are essentially those now provided, with some adaptations of linkage points to promote needed or desired coordination.

The network would consist primarily of formal agreements between the model producers and the user centers proposed for the network. The agreements would describe the capabilities to be provided to Air



KEY

MODEL USER CENTERS

M = MAJCOM MODEL CENTER
e.g. HQ ATC, HQ SAC

S = SPECIAL MODEL CENTER
e.g. Missile Modeling, AFB with special model need

P = PILOT MODEL CENTER
e.g. Projects to develop modeling. May evolve to Special Model Center if modeling becomes operational.

B = AIR FORCE BASE MODEL CENTER
May evolve to Special Center if modeling continues.

MODEL DATA CENTERS

DS = MODEL DATA SAMPLING CENTER
e.g. OEHL, ATAC, AFB's

DB = MODEL DATABASE STORAGE CENTER
e.g. OEH, ETAC

MODEL COMPUTER CENTERS

C = MODEL COMPUTER CENTER
e.g. AFESC, DCS

MODEL RESEACH AND DEVELOPMENT CENTERS

R = MODEL R. AND D. CENTER
e.g. AFESC/RDV, ETAC, RADC

MODEL COORDINATION CENTER

= MODEL COORDINATION CENTER
Perhaps in AFESC or OEHL

NETWORK LINKAGES

——— = PRIMARY AIR FORCE MODELING LINK

– – – = SECONDARY AIR FORCE MODELING LINK

—〉 = LINK TO MODELING RESOURCES OUTSIDE AIR FORCE

Figure 5. Recommended Network Organization Structure for Air Force Modeling.

Force modeling by member centers, resources to be provided for their support, and procedures for their use. From these agreements would grow a network of daily working contacts between groups and individuals and, as resources became available, an integrated network of data processing devices.

b. Model Coordination Center

The network would be established, developed, and administered by a new entity called a model coordination center, which would have two functional roles in the network: 1) the linking of Air Force modeling needs to capabilities, and 2) the provision of capabilities needed for operational modeling not available elsewhere. The operational role would be minimized constantly by using existing skills and capabilities wherever possible and by promoting distribution of skills and capabilities through user training and procurement advocacy.

These two roles would provide two broad areas of responsibility: modeling and networking. Modeling would consist of model selection and establishment, database management, and model operation and would be arranged in three access tiers (handbooks, small computers, and large computers). Networking would link needs to resources, establish and maintain network coordination, and arrange modeling project teams. The networking function would, in time, distribute much of the modeling function to other centers in the network.

(1) Modeling

(a) Selection and Establishment

The model coordination center would collaborate with model research and development centers to select models for use in the Air Force, collect selected models and documentation, establish and test models in pilot projects for operational use, and integrate the most appropriate into a system of coordinated Air Force modeling and user access. The coordination center would neither research nor develop models, but it would be involved in development of model coordination, integration, training, and distribution techniques.

(b) Database Management

The model coordination center would establish information links with data centers, coordinate data formatting for model use, and establish ways to transport, store, manage and retrieve data needed for models. The model coordination center would not collect data except for special development projects, nor would it be a large data repository. It would coordinate data collection and distribution elsewhere. Model data storage and maintenance would remain as much as possible with existing data storage centers. The coordination center would develop and operate "data forklift" techniques which could extract from distributed data repositories information for specific models in correct input format.

(c) Operation

Insofar as possible, the center would coordinate other capabilities to maintain an operational modeling capability for Air Force applications. Existing centers of operational modeling, such as AICUZ, would remain unchanged except for improved communication with other modeling centers. Only modeling deficiencies that could not be provided elsewhere would be satisfied with operational resources from a model coordination center.

As a general rule, the model coordination center would develop and establish modeling capabilities, operate them for awhile, and introduce and train new users. It would continue to operate only the largest and most difficult models. In other cases, users would be trained, encouraged, and assisted to access models and model databases directly and to establish local modeling operations for their own uses.

The model coordination center would function as a central organization for the largest, most complex models, supporting them with scientific knowledge, model operating skills, and computer technology and by providing output results. New model development would start as a central operation. As the simpler models became established, the model coordination center would become a central distribution organization, promoting distributed model operation and training and supporting new users. The coordination center would give data assistance by locating data, coordinating the routing of data from producer to user, and assisting with quality control and data management. With the full establishment of distributed operation, the model coordination center would specialize in coordination, acting only as an occasional troubleshooting support center in a "functional network organization." Experienced users would operate their own models and directly access data centers as needed. The coordination center would concentrate almost entirely on enhancing the flow of information and improving coordinating modeling facilities.

The model coordination center would arrange Air Force access to models on three linked, but distinct, levels or tiers.

- Handbooks. The simplest tier would be model books with hand calculation techniques (such as simple equations, charts, or monograms) or written procedures established from the results of more complicated models (such as accident contingency plans). The model coordination center would select, develop, publish, and advertise model handbooks in response to needs. The center would distribute the handbooks and arrange training for their use if needed. Training books and manuals for more complicated models would be arranged.

- Small Computers. The second level of model access arranged would be simulations to run on small computers, such as programmable calculators or desk-top microcomputers. The model coordination center would assemble available microcomputer modeling programs and coordinate them for Air Force use. It would sponsor the conversion of some of the many simpler models, capable of being supported on small computers, to codes compatible with available machines. These micromodels would be operated largely by users on distributed hardware. The model coordination center would provide training and telephone support and would coordinate microcomputer hardware procurement to promote compatibility. GSC recommends that microcomputers be used as much as possible, within the limits of their power, as stand-alone computers (at first) and as distributed processors linked to larger machines (as soon as feasible).

- Large Computers. The third and highest level of modeling provided would be models which could only be supported on medium to large computers. Modeling on minicomputers and large mainframes would be handled in slightly different ways. GSC recommends that most unclassified Air Force simulation modeling be done on medium to large minicomputers. Minicomputers can handle all but the most complicated models, and there is an increasingly large amount of model software available for them. There soon will be available to all laboratories and centers, Major Command Headquarters, and many Air Force Bases standardized Uniform Hospital Chart of Account minicomputers, which can be used for environmental modeling. These standard minicomputers, besides offering distributed hardware capabilities for model operation, offer the framework for a minicomputer-based modeling network. This network would link model users to the model coordination center and to model data and research and development centers. The network would support integrated model operation at distributed user centers.

This minicomputer network is to support primarily the Uniform Hospital Chart of Accounts. Modeling must share a lower priority on access to the machines with other proposed systems such as the OEHL-COHP. In order to use most efficiently the minicomputer resources available to modeling, small models which can run on microcomputers should be converted as soon as resources are available, and the operation of the largest models should remain on the large mainframes available to modeling. For the same reason, the largest modeling database should reside on mainframes. The minicomputers then can concentrate on the storage of operational data, the operation of mid-size models, and on network functions (such as data and text selection and transfer, source code transfer, and user communication).

In the early stages of development of coordinated modeling, the coordination center would control access to the large modeling mainframes. These would be used for central model operation, database storage and management, and system development. Later, when the coordination center has developed user-friendly data management, model access, and a trained-user community, direct user access of modeling mainframes would be possible.

(2) Networking

The second main area of responsibility for the proposed center would be the establishment and maintenance of the network of operational capabilities which would support Air Force modeling. Many network administration activities are described above in the coordination activities necessary to assemble capabilities for operational modeling. Other administration activities would include the negotiation of agreements with potential model support centers, the establishment of contact with potential model support centers, the maintenance of channels of communication, the linkage of needs to capabilities, and the assembly and coordination of network skills and resources to address specific user needs.

As time passes, it is recommended that this coordination role be separated increasingly from the model operation role. As opportunity offers, the scope of coordination should be increased gradually to include other environmental information. This concept of an Air Force Environmental Model Data Exchange (AFEMDEX) is discussed in paragraph 6 of this section.

3. MODEL NETWORK USE, AN ILLUSTRATION

a. Modeling Need Occurs

An example of an Air Force modeling application using this proposed system will help to explain the recommended operation. Imagine an Air Force Base which, for some time in the past, disposed of waste (then considered safe) from base operations in a landfill on the base. Some of this waste is now known to be toxic, and from time to time there have been unusual occurrences in a nearby offbase stream which suggest that toxic chemicals are escaping from confinement and leaching through ground water to discharge into the stream. The neighboring municipality is planning a new well field between the stream and the landfill and is concerned that the aquifer may be contaminated. The municipal council has approached the Base Commander, seeking reassurance.

Continuing with the illustration, the Base Commander seeks the advice of the base environmental planning and bioenvironmental staff who study site records stored on a modeling microcomputer and do simple environmental calculations to make a first assessment of the situation. If the base staff were familiar with modeling and had worked before with the model coordination center, they might know some of the capabilities needed to address this problem and have established some of the needed data and modeling resources. In this case the staff might contact the model coordination center directly. If the base staff had never worked with models, they would inquire upward through their chain of command to Headquarters Major Command (HQ MAJCOM) Environmental Planners and Bioenvironmental Engineers.

b. Modeling Need Analyzed at MAJCOM

HQ MAJCOM staff would recognize that this situation needed environmental modeling. Each would have a model contact center. One or more staff would route model user needs, as they occurred, to the model coordination center and distribute model products and services to MAJCOM areas. Civilians in these positions are desirable because accumulation of knowledge is important. MAJCOMs which regularly use models also would have a model operation center providing model data storage and operational model techniques.

MAJCOM- level staff with environmental planning and engineering skills would review the problem, identify data and modeling capabilities needed, and establish locations of these models. In this illustrative example, models for landfill containment and water flow would be needed, as well as models for chemical fate and transport in ground and surface water. Data would be needed on toxic chemical structure and behavior; trends in site variables, such as ground and surface water flow and quality; and the state of toxic hazard indicators, such as records of unusual biological stress symptoms.

Typically, in the proposed Air Force modeling system, some HQ MAJCOMs would have model operation centers with some medium complexity models mounted on microcomputers and stores of those data heavily used for MAJCOM modeling missions. This could be enough modeling capability to give a first answer in most areas of major MAJCOM concern and even to provide full modeling support for primary MAJCOM modeling needs.

In the illustration, MAJCOM staff have site groundwater data available from the base in question because of historical problems in the stream. Ground water models of medium complexity have been also installed on the MAJCOM modeling minicomputer and skill has been gained in their use. Using these data and models, the MAJCOM staff quickly survey the problem. These studies show evidence of toxics escaping, but the escapes are intermittent and occasional. The models predict low levels of concentration in the proposed well-field area, but not far below levels of known concern. The health risk is enough that a decision could not be based on the marginal findings of limited models. The Base Commander is notified by the MAJCOM that there could be a problem and the model coordination center is contacted with a request for assistance.

c. Model Coordination Center Convenes Project Team

The model coordination center studies the history of the request, identifies the skills and resources needed to solve the problem and establishes the present location of these resources. As much as possible, the coordination center would have only an integrative function. Most operational capabilities (such as data, operational model support, or computer system operation) would be provided through agreements with model support centers. The coordination center would, however, have enough skills and resources to overcome remaining deficiencies.

In the illustration the model coordination center reviews the MAJCOM (or base) preliminary study and request for assistance; it ascertains that hydrogeological and toxicological skills are needed. The coordination center invokes assistance agreements with a number of model support centers to convene a project team with the needed resources. This project team would include base and MAJCOM staff (plus science and modeling specialists) and would have access to data retrieval, sampling, and modeling capabilities. The coordination center would monitor progress and arrange or provide facilities and additional assistance as needed.

d. Project Team Models

Ground water scientists on the illustrative project team identify monitoring tests needed and positions for new monitoring wells. The MAJCOM and base staff arrange well borings and obtain samples. These are analyzed by a modeling data sample analysis center such as OEHL. Project team staff enter the new data and run the large groundwater model at a computer modeling center.

e. Hazard and Accident Management

Again, for illustration, suppose that this investigation showed that the problem was worse than had been suspected and the new sampling showed increasingly dangerous toxic levels. Using these new data, the larger model predicts that not only the proposed well field but existing wells are in danger of contamination. Emergency action is needed to contain the problem immediately, while an alternative for permanent solution is selected and implemented. Immediate risk calculations are needed to determine the extent of the danger.

At this stage handbooks of emergency containment procedures based on modeling studies are sent by the project team to the base management staff. The groundwater monitoring wells are sampled constantly for hazard indicators and the aquifer model rerun to establish zones of dangerous exposure where wells should be condemned to protect public health.

f. Hazard Mitigation

The project team proposes alternative mitigation measures and accesses cost-benefit models to evaluate the most effective solution to the problem. The project team then submits mitigation recommendations to the MAJCOM and base staff for negotiation and implementation with the township.

g. Project End

Once the agreed mitigation is successfully in place, the project team would establish continued monitoring procedures to indicate further problems. The team would disband after adding to the operational Air Force modeling capabilities, as appropriate, any new model data or techniques developed for the project.

4. STEPS TO AN AIR FORCE MODEL NETWORK

a. Outline of Development Steps

The model coordination center and model support user network proposed in the previous section are some distance from the scattered, uncoordinated capabilities now available in the Air Force. A large, comprehensive, computerized information network should emerge from the developmental stages, progressing from the present realities. The stages should be measured and evaluated, providing alternative strategies for further growth.

The three stages are called coordination, information exchange, and networking. Coordination involves matching established Air Force environmental modeling needs to existing resources, wherever located, and obtaining operational access using existing facilities. Information exchange would establish procedures to exchange data and models between dispersed modeling centers. Networking means accessing, with almost equal ease, all modeling centers in a distributed network.

b. Coordination

The Air Force needs air and water models; the EPA has them. The Air Force needs toxic chemical information for model input; the Chemical Substances Information Network (CSIN) has it. The Air Force needs up-to-date information on environmental regulations; the Army has it. Very often the means to satisfy identified Air Force modeling needs are already available elsewhere. This feasibility study has begun the linkage of modeling needs and capabilities. Refining and updating this linkage would be the first task of the coordination stage of growth. Other tasks would be informing users to establish and maintain supportive agency contacts. Recommendations for this coordination stage include:

AD-A133 452 FEASIBILITY STUDY FOR AN AIR FORCE ENVIRONMENTAL MODEL AND DATA EXCHANGE..(U) GENERAL SOFTWARE CORP LANDOVER MD S MCKENZIE ET AL. JUL 83 AFESC/ESL-TR-82-13-VOL-1 2/2

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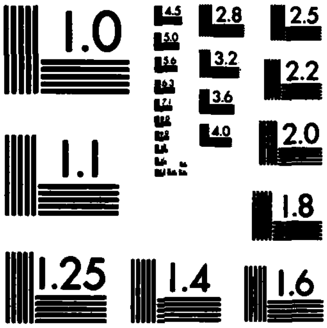

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- That the initiation of the model network be publicized throughout the Air Force and elsewhere, with association extended to any Air Force group or other government agency.

- That a model coordination center be established to start network growth with Air Force military and civilian staffing and contractor support. At first this need be only a small Air Force staff with part-time responsibilities for the development of the coordination procedures. There should be both military and civilian Air Force involvement from the beginning. The Air Force is a uniformed service and there are areas more accessible to military than civilian staff. Military tours of duty are, however, too short to develop a corporate memory, and continuity is essential to this project. Civilian staff can provide this continuity. Contractor assistance is desirable to advise on environmental data and analysis techniques available outside the Air Force; to advise on modeling and computer technology; to provide specialized user support to establish and maintain the first stages of growth.

- That a memorable acronym be immediately given to the network: AFEMDEX for Air Force Environmental Model Data Exchange or AFEDEX for Air Force Environmental Data Exchange.

- That the model coordination center make formal agreements with the centers for model research and development, modeling data, and computer modeling for the support of operational Air Force modeling.

- That HQ AFESC, Tyndall AFB, be the prime location for this model coordination center, since this project originated there. It is compatible with their mission and the necessary technical staff and computing facilities are there. OEHL, Brooks AFB, is another possible location for the program, dovetailing well with the information network proposed for occupational health data (SOHP and COHP). The coordination center should be given a visible and stable location in the Air Force as quickly as possible.

- That the model coordination center advertise the existence of the new service by mailing a regular newsletter and by promoting association and access to resources which could support membership needs.

- That the coordination center undertake a number of tasks designed to start an operational group of model users, including pilot studies involving active Air Force projects. The studies would primarily test, compare, and establish alternative coordination and model support techniques.

- That HQ ATC, Randolph AFB, be the prime candidate for such a pilot. They have working connections with AFESC, OEHL, and CERL and are presently a pilot for COHP development. They have extensive and representative needs for environmental information, including modeling, environmental data, information on regulations, and geographic analysis techniques for base comprehensive planning.

- That the model coordination center work immediately with OEHL to coordinate the plans for COHP and Air Force modeling.

- That the model coordination center promote acquisition of terminals by users, advise on acquisition specifications and funding sources, and maintain a pool of hardware for loan or rent to trial users. AFESC independently has proposed an extensive acquisition of terminals to provide Air Force bases access to ETIS. Once ETIS networking is complete, other capabilities should be added, such as AFESC and EPA models, CSIN, and other federal data and software.

- That the model coordination center establish compatibility for Air Force modeling computers, especially mini and microcomputers, and promote acquisition within these standards.

- That the model coordination center support a feasibility study to establish and promote use of computer language and software structure standards for all Air Force modeling.

- That the model coordination center establish and promote use of standard data definitions and formats for model use.

- That the model coordination center become a member of selected existing computer and information networks, including ARPANET, ETIS, NAWDEX, and CSIN, and promote direct association with these networks by Air Force users.

- That the model coordination center and pilot study be established quickly, preferably starting in early 1982, with the distribution of the final recommendations of this feasibility study.

- That the model coordination center be given enough authority to ensure that the problems of networking diverse resources can be overcome.

c. Information Exchange

The amount of information that can be exchanged in the loosely knit network established in the coordination stage is limited. Few computer connections, for example, can be created without further effort. The amount of information flowing between modeling centers is, therefore, limited. Operating procedures are varied and take time to learn; data transfer between one program and another is difficult, and communication costs are high. The programs are neither integrated nor tailored to user needs. The next stage of development of an Air Force modeling system is called information exchange, because the coordination center establishes procedures for moving information techniques easily from one modeling center to another.

The capabilities established in the coordination stage would be the foundation for the development of information exchange. The network of terminals established in the first stage of development would remain the prime hardware supporting the network. During this stage, the coordination center would enlarge its own computing facility for system development and user support. It would develop techniques for transferring model data and software from diverse sources into a more integrated structure to support Air Force model users. This integrated modeling system would be supported by the coordination center and would be accessible to users via remote terminals acquired in the first stage. As HQ MAJCOMs or bases acquired minicomputers, they would be linked to the coordination center computer and become part of the modeling system.

There would be three important goals in this information exchange stage of growth: 1) the advancement of techniques for transferring and integrating data and software from diverse sources into a coordinated system; 2) the establishment of a user-support capability emphasizing training and distributed operation; and 3) the preparation for a full network by establishing coordination and promoting coordinating distributed capabilities.

Recommendations for this intermediate stage include:

- That the coordination center establish local access to mainframes and minicomputers of maximum compatibility with facilities at other Air Force modeling centers. The CDC equipment, soon to be acquired by AFESC, satisfies the need for a mainframe. Access to a minicomputer compatible with those proposed for the Uniform Hospital Chart of Accounts is critical. The center should acquire a compatible minicomputer and dedicate it to model support and network development.

- That the choice of development directions be user-driven and, insofar as possible, user-funded. There are some system development tasks which are difficult to fund project by project, for example , the inclusion of a database management system or the development of communication procedures. These will need support from the coordination center. Much of the access to specific data and analysis procedures, however, can be established for particular user projects and wholly or partly supported by the users. After the project, these can be coordinated into the system for general use. The cost of enlarging the system can thus be distributed among the beneficiaries, while growth strategies respond to user needs.

- That a user steering committee be established to coordinate funding and support and to discuss growth strategy.
- That the coordination center use its computer resources to improve user access to needed environmental information resources. It could provide integrated capabilities tailored to Air Force user skill levels.
- That increasingly sophisticated techniques of moving and converting data and software from one system to another be explored as the move to full networking is prepared.
- That increasingly sophisticated data transfer procedures be acquired and developed to: 1) improve data access, 2) improve extraction, 3) improve management and transport between computers, and 4) allow controlled disk-to-disk data transfer between remote computers.
- That software compatibility areas be established and movement of needed capabilities from machine to machine within these areas be promoted.

d. Network

Although sophisticated information exchange procedures can produce many of the benefits of full networking, low communication speeds and incompatibilities among computer architecture, operating systems, and software limit the extent and speed of data and software exchange. A full network is a distributed pattern of computer centers containing identical or fully compatible computers linked by high-speed dedicated telecommunication lines or satellite linkages. In a full network, a user can access the local computer or any other computer in the network transparently and without noticeable loss of speed. Environmental models and data, and other environmental information and analysis procedures, can be distributed as needed throughout the network to maximize efficiency of maintenance and ease of access.

A distributed network of this kind can efficiently decentralize data and software development and still maintain an integrated system. A coordination center would still be necessary to standardize data formats and definitions and to ensure that developing software could be integrated into the coordinated command structure and operating system of the network.

A network of this kind should be the 3-year operational development goal. The capabilities that a full network can offer for the dissemination of access to environmental models and other environmental information throughout the Air Force are different and very much greater than the coordination or information exchange of the necessary first two stages of growth.

Given current technology, the primary building blocks for a network of this kind are minicomputers. As networking technology advances, minicomputer-mainframe and microcomputer-minicomputer connections are becoming easier to make, offering efficient and powerful network hardware hierarchies.

Figure 6 is a diagram of a typical arrangement of hardware hierarchies and connections proposed for an environmental information network in the U.S. Air Force. It illustrates the centers and connections comprising such a network: Ten users with varying terminal processing capabilities interact with three minicomputer nodes, which are part of sharing access to a large mainframe. Microcomputer evolution is progressively greater from minicomputer Node 1 to Node 3. A powerful micronode in the Mini 3 subset supports several users and is in the process of developing a local terminal network. Mini 3 and the mainframe node are linked to other networks. N.B. Direct Terminal - Minicomputer connections are also possible, but are not shown for reasons of clarity and because these connections would tend to occur outside the network proper.

Such a system could start with very few machines. As the needs and the success of the network evolve, directed growth could take place at any or all three levels (mainframe, mini, micro) independently or in structured combinations. This growth can be wholly user-oriented and largely user-supported.

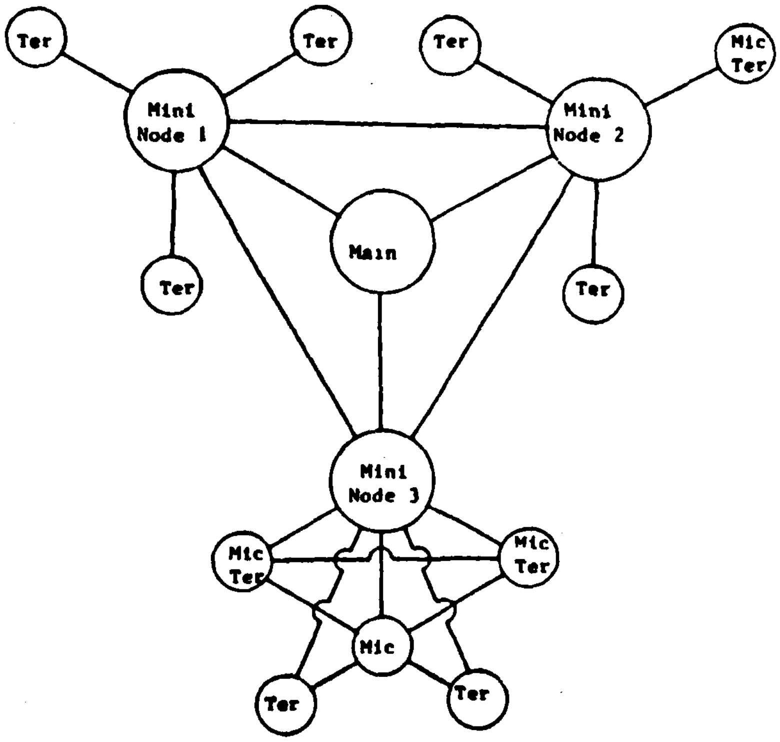
The following are preliminary recommendations for this stage of growth:

- That the coordination center establish all network connections and communication techniques, procedures, and protocols for an operational Air Force computer modeling network.

- That the coordination center promote association and provide connection assistance and user support to the full network.

- That the coordination center continue research and development to improve the system.

- That the coordination center charge users for its services: cost plus overhead and a small growth fund, which would be pooled for mutual benefit by central development to increase self-sufficiency through, for example, acquiring new system software.



Main = Mainframe
Mini = Minicomputer
Mic = Microcomputer
Mic Ter = Microcomputer Augment Terminal (smart terminal)
Ter = Terminal (dumb terminal)

Figure 6. Proposed Computer Network for Air Force Modeling.

5. BUDGET PROPOSALS

Precise costs at this early stage of planning are not possible. Estimates are necessary for multiyear program development, and approximate costs on the three stages of growth are suggested. These are outline estimates to aid long-range planning.

A 3-year $2.5-million program is outlined, which would establish an increasingly self-sufficient computerized environmental information system and network providing the Air Force with access to environmental modeling, environmental databases and data access procedures, and related environmental information and analysis. The system would be based on a distributed network of compatible minicomputers having extensively distributed terminals with and without microcomputer capabilities.

The following assumptions are made:

- The senior military and civilian staff are at the same salary level.
- The staff overhead is 100 percent (this is conservative).
- The same senior staff will remain throughout the project, their salaries advancing each year.
- The coordinating center will obtain a powerful minicomputer and peripherals ($250,000) exclusively for its own use. Piggybacking and sharing costs with other programs would reduce the cost but also would limit the support capabilities of the coordination center. GSC recommends exclusive purchase of a minicomputer, wholly committed to system development and user support.

Technical uncertainties hinder assessment of firm costs, but first estimates indicate that an operational network fund could be established and would continue to grow with little further input of funds. Such projects pass a threshold where their benefits demonstrably exceed their costs. A critical mass of human contacts, data, hardware, software, and successful cost-effective applications is gathered. This spontaneously attracts potential users, is increasingly supported from user projects, and continues to grow without further startup funding.

a. FY 82 Stage One - Coordination

Staff	
Air Force Officer, responsible for funding strategies, Air Force Liaison, administration, user needs survey, and user-related elements of development policy, one-half time or better, including overhead.	$ 30,000
Senior civilian technician. Experienced with computerized environmental data, models and analyses, computer networking and the establishment and support of user communities, full time, including overhead.	$ 60,000
Consultants	
Contract assistance with access to facilities outside Air Force, environmental modeling, data and analysis, data and software transfer, networking and user support.	$250,000
Computer Hardware	
Principally acquisition of terminals, printers, and modems for distribution to the user community.	$100,000
Computer and Communication Time	
To develop coordinating center capabilities and provide general user support.	$ 40,000
Documents, Software, Materials, Travel and Misc.	$ 20,000
(Some of this total reasonably could come from pilot studies or users.)	$500,000

b. FY 83 Stage Two - Information Exchange

Staff	
Air Force Officer, full time, including overhead.	$ 70,000
Senior civilian, full time, including overhead.	$ 70,000
Data processing technician	$ 40,000
Student Intern Assistance	$ 40,000

Consultants	
Contract assistance with extending modeling and environmental impact assessment system, establishing Air Force coordination center, computer facilities, establishing integrated environmental information system and user support.	$300,000
Contract assistance with software conversion and integration.	$100,000
Computer Hardware	
Minicomputer and peripherals for model development, networking capabilities, microcomputers and user terminals.	$300,000
Computer and Communication Time	
Reducing owing to increased local facilities.	$ 20,000
Documents, Software, Materials, Travel and Misc.	$ 60,000
Total	$1,000,000

The network, by this stage, should be providing operational assistance to the users. Direct funding for this assistance from user projects would be possible to reduce the central funding contributing to this total.

c. FY 84 Stage Three - Network

Staff	
Air Force Officer full time, including overhead.	$ 75,000
Senior Civilian full time, including overhead.	$ 75,000
Senior Data Processing Technician	$ 50,000
Junior Data Processing Technician full time, including overhead.	$ 30,000
Student Interim Assistance	$ 40,000

Consultant	
Contract assistance in establishing full computer network, implementing integrated databases and Air Force environmental information system to support distribution modeling, and other environmental analyses.	$300,000
Contract assistance with network software development.	$150,000
Computer Hardware	
Improved telecommunication hardware,enhanced computing power, and peripherals for center computer. Contribution to computer enhancements at other network centers.	$200,000
Documents, Software, Materials, Travel and Misc.	$ 80,000
Approximate Total	$1,000,000

As in FY 83, increasing user contributions could offset this cost.

Total estimated cost to establish an operational network over 3 years is $2.5 million dollars, divided between centralized funding to the coordinating center and distributed funding from users on project basis.

6. RECOMMENDATIONS FOR AFEMDEX, THE AIR FORCE ENVIRONMENTAL MODEL DATA EXCHANGE

As discussed in the introduction, an AFESC Survey preceding this study established that environmental modeling was only one of a number of Air Force environmental needs. The questionnaire designed for this study (Appendix D) included general questions about Air Force environmental activities both to establish the context of modeling and to survey these other environmental needs.

This study established that there are other environmental needs in the Air Force as great as those for modeling. Most important, and closely linked to modeling, is the need for better environmental information. This includes numerical data, explanatory text, bibliographic indexes and citations, news updates, and contacts with experts.

Management information systems to aid facility building and operation are needed, especially management and auditing systems for toxic and hazardous materials. Facility planning and design tools such as geographic information systems and computerized cartography are also needed.

A hazard chemical information system is an urgent Air Force need, as are hazard control and accident contingency planning techniques. Environmental consensus-building and dispute-settlement techniques, involving use of models, are desirable additions to the negotiation techniques available to the Air Force.

An up-to-date environmental information system is needed, which can list the legislative and regulatory requirements for a particular Air force activity. Analysis and display techniques to prepare legally required environmental assessments are also needed.

All these environmental information system needs either include modeling or occur in the same application context. The need can be thought of as an environmental information system with modeling as the most complicated of the needed capabilities. An operational modeling network, with environmental data, data management techniques, mathematical and scientific skills, integrated systems support, coordination software, and compatible, distributed hardware, is a comprehensive base on which to build a more extensive Air Force environmental information network.

GSC recommends that, once the environmental model network and coordination center is established, the two roles of the center (modeling and networking) begin to divide. The modeling section would concentrate on networked modeling; the networking section would study other Air Force environmental needs and capabilities and coordinate additional environmental resources to be distributed throughout the modeling network.

This network could be called the Air Force Environmental Model Data Exchange (AFEMDEX). Later, as more capabilities are added, this could be changed to the Air Force Environmental Data Exchange (AFEDEX). This pronounceable and easily remembered acronym proclaims the Air Force network as one of a family of existing and proposed federal environmental data exchanges, which includes NAWDEX, the National Water Data Exchange, in the U.S. Geological Survey.

Prime candidates for AFE(M)DEX development are:

- Establishment and maintenance of a hazardous chemical information system which includes data and text, chemical analysis procedures, environmental models, risk assessment procedures, tracking and auditing procedures, disposal planning tools, and accident contingency planning techniques.

- Coordination with the Army ETIS-CELDS, the Computer-Aided Environmental Legislative Data System, to enlarge and enhance the legal content and provide updating resources.

- Development of improved data techniques, including capture, storage, transportation, formatting, management, and interpretation. Digital remote and ground survey monitoring devices offer great improvements in the quality and currency of environmental data. Especially promising are the next generation of space platforms, LANDSAT -D and the French SPOT, and air surveys with new digital sensors (such as thematic mappers, synthetic aperture radar, and an increasing variety of laser scanners for special purposes). These very large databases must be on computers, and software is needed for database management, image analysis, pattern recognition, and graphic display. Networked data management is needed, allowing users on remote computers to access database storage computers and to select, transport, and reformat data.

- Development of CAD-CAM techniques for environmental planning and design. Computer -Assisted Design Computer-Assisted Manufacture is a rapidly growing technology which is increasingly automating the passage from a design idea to a manufactured artifact. Air Force environmental tasks have particular need for some CAD-CAM techniques (including computerized cartography, site analysis, and planning), report generation, and automated field techniques for construction and operation of facilities.

- Development of management information systems for facility planning, constructuion and operation.

- Development of a computerized bibliographic reference database of environmental literature of particular interest to the Air Force.

SECTION VIII

MAJOR CONCLUSIONS

- Air Force needs for unclassified environmental models are inadequately satisfied by, and growing faster than, existing capabilities.

- The main modeling deficiencies are poor data; limited access to modeling techniques; software and hardware; and, most important, the lack of an organization to coordinate operational modeling resources.

- Many of the deficient modeling resources either exist now (or will soon exist) in the Air Force or are available to the Air Force from other sources.

- A small coordinating group with sufficient authority to integrate existing resources could produce improvements of significantly greater proportion than the effort involved.

- The final organizational structure recommended for Air Force modeling is a network of model supporters and users, created largely from existing capabilities by a model coordination center.

- The center would have two tasks, modeling and networking. Modeling would only be done at the center if resources were not available elsewhere. Wherever possible the coordination center would network other model support centers to provide needed resources.

- The model network should be achieved in three growth stages, each lasting 1 year. These are called coordination, information exchange, and network. Coordination is the linkage of existing model needs and capabilities. Information exchange develops techniques of transferring data and analysis techniques from one model center to another. Network links modeling centers into an easily communicating network of people and machines.

- Modeling and model networking should be built at three levels: books, small computers and large computers. Books include handbooks, user's manuals, and training materials and should be used wherever possible. Small computers include desk-top microcomputers and programmable calculators. The rapidly growing technology of small computers offers great potential for simpler models if software is developed. Large computers include minicomputers and mainframes. Minicomputers should be the basic building block for Air Force modeling, mainframes being reserved for mass data storage and models involving large quantities of calculations. Networks of different size computers (micro, mini, mainframe), with computing tasks assigned to the appropriate level, are especially desirable.

- These three stages of growth would cost a total of $2 1/2 million, 1/2 million the first year, and 1 million each for the second and third years. The cost is inclusive of Air Force military and civilian staff and overhead, hardware procurement, contractual assistance , miscellaneous documentation, and clerical and travel expenses.

- The model network should be called AFEMDEX for Air Force Environmental Model Data Exchange.

- AFEMDEX should evolve towards AFEDEX (the Air Force Environmental Data Exchange), a network of people, information analysis techniques, and data processing machines in the Air Force dealing with environmental matters.

Other Air Force environmental needs that could be addressed by AFEMDEX include: a hazardous chemical information system with chemical auditing, tracking, disposal, and accident planning; an improved environmental law information system; improved techniques for environmental data capture, storage, transportation, formatting, management, and interpretation; computer cartography and site design aids; management information systems for facility planning, construction, and operation; and a computer bibliographic reference database of environmental literature of special interest to the Air Force.

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APPENDIX A

DETAILED RESPONSE TO STATEMENT OF WORK

TABLE A-1. REPORT REFERENCES FOR WORK ELEMENTS

SCOPE OF WORK REQUIREMENT	REPORT REFERENCE
OBJECTIVE	
Review Air Force environmental modeling requirements	Volume I Section II Appendices C, D, E
Identify existing Air Force modeling efforts	Volume I Section III Appendices C, D, E
Determine the feasibility of a modeling applications library	Volume I Section IV to VII Appendices B and E
SCOPE	
Review Air Force engineering calculation procedures	Volume I Section II and IV Appendices C, D, E
Catalog computer models and databases which could assist the Air Force	Volume I Section V Appendices F and G
Analyze and evaluate Air Force computer systems	Volume I Sections III and IV Appendices C and E
Analyze and evaluate alternatives to structure and use models	Volume I Section VI
Recommend a conceptual design for a computer applications library	Volume I Sections VI and VII
PHASE 1. REVIEW	
Review U.S. Air Force environmental modeling requirements and capabilities	Volume I Section II and IV Appendices E, D, E
Identify and catalog existing mathematical models and databases	Volume I Section V Appendices F, G, C, D, E
Prepare interim report	Appendices C, D, E

TABLE A-1. REPORT REFERENCES FOR WORK ELEMENTS (CONCLUDED)

SCOPE OF WORK REQUIREMENT	REPORT REFERENCE
PHASE 2. EVALUATION	
Determine feasibility of Air Force modeling applications library	Volume I Sections IV and VII Appendices B and E
1. Requirements for development	Volume I Section VII
2. Computer languages	Volume I Section VI Appendix E
3. Type and location of library	Volume I Section VII
4. Format of databases, models, other software, user guides, operating manuals, access procedures	Volume I Sections VI and VII
5. Nature of communications network	Volume I Section VII
6. Style of interaction	Volume I Section VI
7. Manpower requirements	Volume I Section VII
8. Potential Library expansion	Volume I Section VII
9. Maintenance and update requirements	Volume I Section VII
10. Recommendations for use of library	Volume I Section VII
11. Estimated Costs	Volume I Section VII
12. Alternatives to the recommended system	Volume I Section VII

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