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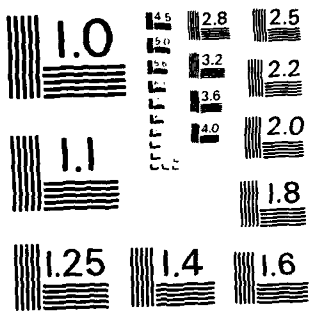

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CONSOLIDATION OF CONTINGENCY DATA AND ITS USE IN COMPUTER GRAPHICS TO PLAN BARE BASE FACILITY CONSTRUCTION AT A FORWARD OPERATING LOCATION

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LSSR 41-83

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Air Force civil engineering planners supporting a tactical aircraft deployment to a bare base in a forward operating location, need to be able to rapidly prepare a master plan for the layout of force beddown facilities. In an automated process, planners can draw on consolidated information concerning the sizing of eight major facility group functions: munitions storage area, aircraft maintenance area, aircraft refueling area, flight operations area, command area, base support area, cantonment area, and medical area. Using computer graphics, planners can rapidly locate facility groups and ensure fire, explosive, and airfield safety distance constraints are met. The authors have formulated algorithms to compute the functional area sizes, and a computer graphics program that allows facility group layout with computer subroutines that automatically check safety constraints.

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CONSOLIDATION OF CONTINGENCY DATA AND ITS USE IN COMPUTER GRAPHICS TO PLAN BARE BASE FACILITY CONSTRUCTION AT A FORWARD OPERATING LOCATION

A Thesis

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the Requirements for the

Degree of Master of Science in Engineering Management

By

William J. Carson, BS
Captain, USAF

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This thesis, written by

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and

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This thesis is dedicated to our wives, Diane Nadler and Carol Carson. Although we have not fully appreciated their sacrifices while we struggled with this challenge, we would like to publicly express our gratitude that they did not have us legally declared dead during the past year, but rather "Missing in Action."

— Jay Carson

— Bruce Nadler

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CHAPTER I

INTRODUCTION

Research Overview

"The ever-changing world situation, with its impact on national defense policy, places a large demand for mobile tactical air and supportive forces [65:p.1-1]." These mobile forces, in order to have any impact on critical events occurring anywhere in the world, must have bases close to where the events are taking place. The number of locations, where critical events have a high probability of occurring, and the high manpower and dollar cost of building and maintaining permanent bases, preclude complete coverage by permanent airfields. The capability to plan and erect expedient airfield facilities is essential. An automated, systematic facility group layout is needed to develop the master plans for the engineering and construction of expedient bases. The process should insure that base requirements are included and fire, explosive, and airfield safety limitations and sanitation are considered (61). In this thesis, a facility group prioritization was established, and the feasibility of using data automation was investigated, to include using computer graphics to produce a facility layout plan. The computer developed plan has the potential for saving time and improving the utility of a development plan.

The types of facilities needed for a contingency operation are outlined in Air Force Manual 86-3, Planning and Design of Theater of Operations Air Bases. They include munitions storage, aircraft maintenance, aircraft refueling, flight operations, base support, living quarters, dining, and medical facilities. The size of any of these divisions is determined, in general, by the type of aircraft to be deployed, the number of flying squadrons and support units, and the total number of personnel involved. The siting of these facilities is done sequentially, with the prioritization based on the mission importance of each facility group and on the flexibility associated with each group's siting constraints. For example, in AFM 86-3 aircraft refueling facilities have a higher priority than aircraft maintenance facilities (61). However, aircraft maintenance facilities are normally located adjacent to the aircraft parking apron. Often, the limited areas providing immediate access to the parking apron significantly confine siting the aircraft maintenance area. Refueling facilities have, however, more potential locations on an airfield. In the automated facility group layout the priority is reversed to account for this lack of flexibility in siting aircraft maintenance facilities.

Background

The Directorate of Engineering and Services, Planning and Resources Division, at Headquarters United States Air Force (USAF/LEEPP), has requested a computer program, in a common computer language, to provide a graphical layout of a force beddown plan. This in turn is to generate construction bills of materials (31).

The computer program is to supplement or replace the manual techniques currently used for contingency planning. The manual planning techniques are taught at the Contingency Engineering Course of the AFIT Civil Engineering School, Wright-Patterson AFB, Ohio (12). This course is the major formal contingency instruction given to Air Force civil engineer Prime BEEF and Red Horse teams. Related training to physically construct these bases is conducted by the Air Force Engineering and Services Center, Tyndall AFB, Florida and locally by the civil engineering Readiness and Logistics officer at each Air Force base. A level of contingency planning is normally being accomplished during operational and Prime BEEF exercises, by most Air Force civil engineers. A computer program will provide a time-saving, all-inclusive checklist approach for all of these practitioners. It will also ensure that all fire and explosive safety spacing criteria are accounted for in the final base layout (13).

Problem Statement

During the Normandy invasion in World War II, units of the IX Engineer Command established an expeditionary airfield for allied forces on the first day (5; 6). Later in the war, the superlative ME262 jet fighter could not be fully utilized in part because it could operate from only one in twenty Luftwaffe airfields (28). Brigadier General Price, commenting on the Air Force civil engineering deployment to Berlin in 1961, said "There is little point in moving a fighting unit halfway around the world if it is to become impotent at the new station for lack of facilities [39:2]." Air Force civil engineers faced similar difficulties in supporting flying forces in Santo Domingo in the early sixties, and throughout the Vietnam war. The challenges are similar today (34; 16; 10; 5).

The United States Air Force has the requirement to operate combat aircraft from austere locations near battle areas. Air Force Civil Engineering (AFCE) may be tasked with providing all necessary air base support facilities and utilities at these locations. Since neither missions nor locations can be predicted with certainty, and because of the number of possible locations and the high cost of establishing permanent air bases, AFCE mobile combat support capability has been and will continue to be expanded to meet the tasking requirements.

This capability must be flexible and rapid enough to meet a force deployment at any time, to any location, worldwide. Failure to provide a usable air base could degrade the operational flying mission by requiring aircraft to operate only from those existing airfields fully equipped prior to the contingency. Those airfields may be so far from the combat area or be so overloaded with other aircraft that their use is marginal (13). While some prepositioning of assets is being accomplished in potential operating theaters, prepositioning at all of the over 1400 potential austere airfields is not cost effective (6). Master planning for the use of mobile facilities, stored within the theater of operations, can make effective use of these austere airfields at an acceptable cost.

A successful airfield plan must be able to integrate the functional requirements of many different aircraft and support squadrons into a single cohesive unit. For planning purposes, the minimum resources already available at an austere location are a runway, a parking apron, taxiways, and "an adequate supply of water that can be made potable [67]." A site that meets these minimum requirements is called a "bare base." Planning required to make this base operational is a force beddown. Force beddown uses three systems: Harvest Bare, Harvest Eagle, and Local Assets. Portions of Harvest Bare assets and Eagle assets may be used alone or in combination, depending on the mission. Local Assets are those materials that are not components of a predetermined kit, but are purchased or ordered separately to complete the specific base requirements. Local Assets will be used when available but cannot be planned for in advance. Harvest Bare and Harvest Eagle assets alone or in combination will be programmed to meet contingency construction requirements under the Initial JCS Standard (12; 13; 73).

Harvest Bare and Harvest Eagle assets cover a wide variety of equipment. Most of the available assets are currently targeted against Southwest Asia missions (31). There are only two complete Harvest Bare kits presently in the inventory, but there are a number of Harvest Eagle kits positioned in Europe and the Pacific theaters (12). Harvest Bare, a prepackaged kit of prefabricated expandable buildings, contains specialized equipment for specific needs, such as a surgical hospital, Precision Measurement Equipment Laboratory (PMEL), or aircraft maintenance shop. Harvest Eagle contains "creature comfort" items such as "tents, field kitchens, cots, and other housekeeping items [67:p.1-1]." A more detailed description is contained in the literature review.

The present system for bare base planning, using Harvest Bare and Harvest Eagle assets, could be more systematic and better standardized (38). Developing a site plan depends on reference to numerous Air Force, Army, and Navy manuals as well as depending on the experience level of the planner. No comprehensive program to efficiently and effectively plan the physical layout of a force beddown presently exists. Standardization of facility group sizing and spacing between separate force beddowns is currently not consistent between Air Force units. Advance planning by supported units is dependent on the space and equipment allocated to them. Standardization will enhance this type of predeployment planning. Each site plan presently made is extremely time consuming, with the required criteria being re-researched by each planning team (32; 38).

Although computer graphics have been used for construction design and management purposes in both military and private industry, the application of this technique has not been used for force beddown planning (7; 47). The purpose of the research is to investigate if computer graphics can provide an efficient and effective design development system for force beddown projects.

Literature Review

Part I--Data Collection for Program Variables and Constraints

A large part of preparing a computer program is to collect data and determine which of it will be used as the variables and constraints to create a realistic solution.

A computer-developed layout for a bare base contingency operation must meet all Air Force requirements, as well as a great number of assumptions about operational needs and physical limitations. The Air Force Contingency Engineering Course provides a good starting point for collecting the data pertinent to a bare base layout.

The School of Civil Engineering, Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio presents a Contingency Engineering Course several times a year. This course teaches the method of laying out a proposed base (12). The following list identifies the policies followed in the program:

1. Consider mission and operational objectives of deployed forces.

2. Consider total force size to be deployed.

3. Minimize construction necessary for planned operations.

4. Adhere to space and criteria standards, while maintaining flexibility.

5. Allow for the characteristics of the objective area (topography, climate, etc.).

6. Consider the threat posed by the enemy.

The basis for the force beddown portion of the course is Air Force Manual (AFM) 86-3, Planning and Design of Theater of Operations Air Bases. The manual lists spacing requirements for liquid fuel storage, ammunition storage, troop housing (including between tents and/or buildings), administration, shops, warehouses, etc. These requirements are given for both normal and dispersed (for protection against conventional bombing) layouts. It also gives separation clearances needed between functional areas (housing, shops, POL areas, etc.) in dispersed layouts. Runway clearance factors are given for intermediate or temporary standards. Since these are reductions from the normal distance requirements given in AFM 86-8, Airfield and Airspace Criteria, they will be used only when the normal criteria cannot be met (61; 55).

The proposed computer program considers the facilities from the "two War Reserve Material kits for use at bare base sites: the Harvest Bare/System 437A and the Harvest Eagle kits [65:p.1-1]." Harvest Bare assets and capabilities are given in TACR 400-5. The buildings making up these kits are of a light, air transportable, collapsible modular design. They double as shipping containers for those items used in them after setup. TA 158 lists the equipment and facilities provided with the kits. Harvest Bare can be divided into four areas: Base Augmentation Support Set (BASS), Maintenance/Operations Support Shelters (MOSS), Modular Air Transportable Hospital (MATH), and standard mobility equipment.

The kits contain four basic types of shelters. By themselves or in combination, they fulfill the facility requirements. Since the shelters were ordered in lots, some size differences occur between lots; however, these differences are not important to the design problem. The shelters, an expanded size, and the uses of each are listed below.

1. Expandable Shelter/Container (ES/C)

a. 13 feet (ft) long x 9 ft wide x 8 ft high.

b. Used for shops, toilets, kitchens, administration, etc. and contains power panels, windows, lights, tools for setup, etc.

2. Expandable Personnel Shelters (EXP)

a. 33 ft long, 13 ft wide, and 8 ft high.

b. Used for administrative offices and has power panels, windows, lights, etc.

3. Aircraft Hangar (ACH)

a. 78 ft long x 58 ft wide x 21 ft high or 130 ft long x 76 ft wide x 25 ft high.

b. The first size is used as a vehicle maintenance shop or a supply warehouse. The other is for use as an aircraft maintenance shop.

4. General Purpose Shelter (GP)

a. 48 ft long x 31 ft wide x 12 ft high.

b. Used for maintenance and storage buildings and dining halls.

The MATH is an example of combining eight shelters into a group to create a useable facility. Each shelter is intended for an exact task (surgery, ward, clinic, etc.).

In using the Harvest Bare kits, terrain becomes an important variable. TACR 400-5 lists the maximum slopes on which the facilities can be erected. A slope of 18 inches over the spread-out floor area is allowed by the Expandable Shelter/Container, the Aircraft Hangar, and the General Purpose Shelter; only an 11-inch slope is allowed for the Expandable Personnel Shelters (66).

Harvest Eagle kits include tents, field kitchens, cots and other housekeeping items for 4400 personnel. These are broken down into four sets, each sized for 1100 personnel. Inventories are listed in TA 156 and their capabilities are outlined in TACR 400-12. The tents are mostly 18 x 52 (936 sf) and 16 x 32 (512 sf) general-purpose tents (67).

The Eleventh Meeting of the Quad-Service Advance Base Coordinating Group has provided another valuable source of contingency information. The responsibilities of each service were discussed so that efforts in forward areas will be coordinated in future operations. Each branch of the service briefed the advancements it has made in contingency operations. The Army's Facility Component System studies, along with the Navy's Advanced Base Functional Component System and Quickly Erectable 250 and 500 bed Hospitals, could have provided only general contingency information for this project, and were not used (4).

The Labor and Time Estimates booklet, prepared by the Air Force Engineering & Services Center at Tyndall Air Force Base, Florida, for the Contingency Engineering Course, has provided a reference listing for this thesis (14). While most reference publications were valuable, the following publications were reviewed, but not used.

1. Navy P437, Vol. 1, Book 1, Drawing Number (Dwg No.) 6008;

2. Navy P437, Vol. 2, Assembly No. 20004;

3. Navy P437, Vol. 2 and P437P, Vol. 1, Dwg. No. 1109788; and

4. Navy P437, Vol. 2, Part III.

The following Air Force Manuals, Regulations, Tables of Allowance (TA), and Pamphlets were also researched:

1. AFM 161-10, AFP 163-12, Personal Hygiene and Sanitation;

2. AFR 355-5, AFP 161-3, Chemical Warfare;

3. TA 156, Harvest Eagle Equipment; and

4. TA 158, Harvest Bare Equipment.

Some of the above references contained dimensions of facilities to be built or siting clearances to be considered. The information contained in the documents was either duplicated by other sources or was not considered directly applicable to the thesis.

Part II--Computer Graphics Applications

Computer graphics have been used in private industry for more than a decade. The term CAD, for Computer Assisted Design, has been coined to mean the use of a computer to replace both manual drafting functions and the more routine aspects of engineering design (43). An operator (user or customer) can use either batch or interactive techniques to input data into the computer. When batch is used, all data is prepared in advance and input to the computer using a medium such as cards or magnetic tape (40). The computer manipulates the data based on a controlling program called an applications *program*. The applications program directs the computer to use a graphics package, which in turn provides output on a graphics hardware device, such as a line plotter (24; 35; 41). A drawback to the batch technique is that it depends on trial and error. The entire cycle of preparing the input medium, the input data, and possibly reprogramming this applications package, must be completed for each design iteration.

Using the interactive technique, the operator sits at a terminal such as a Cathode Ray Tube-Keyboard device, inputs his data and applications program, and receives an immediate visual report on his work. Changes to either the program or the data can be made immediately. Only when the operator is satisfied with the output is the command given to have the graphics package produce a permanent copy (43). As a further possibility in application, combinations of batch and interactive can be developed.

Military application of computer graphics has both led and lagged industrial development. In the case of military facility construction, the lag is severe. While fairly extensive use has been made of geographical mapping techniques, by the Defense Mapping Agency, relatively little has been accomplished in construction design or construction planning (40; 49). The Navy has developed a program called LAYEVAL, which uses computer graphics to evaluate placement of aircraft on carrier decks (25). In 1971 the Army started a program called CAEADS, for Computer Assisted Engineering and Architectural Design System. This system was proposed to reduce the large number of draftsmen (and some engineers) in Corps of Engineers District design offices. CAEADS has only been introduced on a limited basis in the Army (51). Vandenberg AFB was the site of an Air Force contracted effort to prepare environmental and elevation data for graphical presentation. The program uses a "GRID" coordinate system developed at the Harvard University Graphics Center (11). A similar type of mapping has been used for the Santa Ana river basin in California (47). The Army has also used computer graphics in modeling tactical maneuvers (52; 53).

Air Force civil engineering has not yet adopted a computer graphics design system. A primary reason for this lack of action has been the high cost of these systems, which have only recently dropped into attainable prices. Since computer graphics software is not compatible with all computer hardware, a recent thesis research effort recommended that base civil engineers purchase only turnkey systems, where the hardware and software are complete for a single manufacturer (40).

No effort was found that has attempted to develop computer graphics techniques for contingency or bare base engineering design. An application could be made using AFR 86-3, Planning and Design of Theater of Operations Air Bases; TACR 400-5, Harvest Bare; and TACR 400-12, Harvest Eagle Logistical Management (61; 62; 66; 67). The computer graphics package available with the VAX 11/780 computer and the Tektronix Series 4014 terminal systems does provide a limited application. For example, the Tektronix system could be used to develop subroutines which would plot various graphics symbols such as one representing a general purpose medium tent (50). This canvas tent, part of a Harvest Eagle package, is rectangular, 16' x 32', and normally billets between ten and fourteen people in a field environment (12). Using the Tektronix Cathode Ray Tube (CRT) terminal, a subroutine can be developed using the MOVE (an invisible movement of the cursor) or DRAW (a visible line of movement) commands to sketch the tent to the scale desired (50). The system can automatically change scales. This is valuable to the civil engineer because it can produce drawings in familiar scales. This also permits facility groups and facilities to be depicted in different levels of detail, depending on the needs of the user. Subroutines for many different symbols can be developed, and used by the operator to design a base. An applications program, on a host computer, could add in constraints such as tent spacing for fire safety. For example, tents have to be spaced at least a certain distance apart to allow fire fighting vehicles to move between them (12; 42). This constraint could be stored in the applications program.

The Tektronix terminal and VAX 11/780 computer are the hardware the authors used for the application of graphics techniques (16; 50). In industry, much more sophisticated equipment with many types of input and output devices, exists. A few even produce three-dimensional viewing. Some devices have the capability for inputing contour lines by moving a stylus over an existing map. The map is laid on a sensitive surface that converts the stylus pressure into electrical impulses the computer can recognize (15; 21; 43).

General information has been gathered on computer graphics, algorithms, applications and graphics packages.

Past designs of Harvest Bare and Harvest Eagle camps, such as the "Coronet Bare" exercise, have been reviewed to develop a priority system for camp design. This was used to help design the computer program (6; 29; 56).

Research Objectives

1. Develop force beddown variables for computer manipulation. The resulting computer product must meet the following criteria:

a. Save time, since time is expected to be a critical factor in base development planning.

b. Allow a deployment team chief and all functional area chiefs to know what coordinated base construction efforts will be required upon arrival at the bare base site. The team chief can organize according to the computer generated plan and immediately implement the plan upon arrival at the site.

c. Provide a viable master plan, from which building materials can be planned and preordered at the headquarters level. The materials can then be sent with the team. This would provide a more accurate assessment of necessary materials than a "Push" logistics system would provide, and would be more efficient than having the team identify the materials after the team has arrived on site (69).

d. Provides an efficient and effective site plan given safety criteria distance limitations, and natural constraints.

e. Sets a priority sequence for establishing facility locations at a temporary base under JCS Initial or Intermediate conditions (71).

f. Permits development of tent row by column (nondispersed) sized cantonment area layouts. Dispersed layout, used when the bare base is in a hostile area and may be subject to air or ground attack, could be developed for the program (61; 62).

g. Provides flexibility to adjust assumptions and constraints concerning safety clearances or facility group sizes.

2. Determine an effective means of using computer graphics techniques: batch or interactive.

3. Determine if computer hardware for graphics application can be used effectively in contingency planning, with hardware choices among those available at AFIT (16).

4. Formulate computer software which can be integrated with existing software at Wright-Patterson AFB, for effective graphics application.

5. Develop a data base that contains bare base characteristics and constraints.

6. Using the local computer hardware and software, develop subroutines for a graphics package for plotting

symbols of force beddown facility groups. Symbols will include only selected groups of facilities. For example, a symbol for the cantonment area would be used, not an individual tent.

7. Develop an applications program incorporating constraint algorithms from force beddown planning to use the graphics package. The applications program must include a provision for input of a grid location system for consideration of existing facilities.

8. Operate a computer model from the applications program to show system feasibility.

Research Questions

1. Can a computer graphics program be developed as a decision support system for force beddown planning?

2. What are the variables that determine the number, size, and type of facilities to be used in force beddown planning?

3. Can essential variables such as spacing, equipment, etc. be quantified adequately for computer manipulation?

Scope and Limitations

The computer program is limited by the computer and computer graphics packages available at the Air Force Institute of Technology Computer Center; the greatest limitation is the graphics capabilities. The graphics capability of the Tectronix terminal, connected to the VAX 11/780 computer and utilizing the Plot 10 software, was limited when compared to what is available on the civilian market. It was, however, adequate to demonstrate the potential for using computer graphics as a quantitative decision-making tool for contingency planning.

The program will only consider those aircraft likely to be in a forward area (see "Assumptions" for more detail) and it is planned for a temperate or desert climate--not arctic. Chemical facilities are not being considered, nor are bunkers for mortar and/or bomb protection. These items are considered follow-on work and will be left to the on-site engineer. Revetments will also be considered the responsibility of the site engineer.

The literature indicates that the items listed in the appendices are the major functional areas needed in a contingency environment; therefore, this thesis will be limited to include these facilities.

Bills of Materials (BOMs) are not created from the computer program in its current form, due to the macro level of development. BOMs cannot be accurately prepared until the facility groups are each broken down into individual facilities.

Assumptions

1. The computer program is not for joint operations with another branch of the U.S. Armed Services.

2. Contour elevations are not considered. Relatively level ground must surround a runway to meet aircraft safety clearances, so major elevation changes are not expected. The computer program was developed with the expectation that minimal site adaptation can be made by forces in the field. Minor inclines were therefore not considered in facility group siting. Grid blocks that represent undesirable features such as swamps, lakes, mine fields, etc. can be coded into the data structure. The coding of an elevation change is beyond the scope of this program; only two choices exist, flat, or "unuseable."

3. Only certain aircraft types are considered for deployment. These are the F-4, F-4G (Wild Weasel), F-15, F-16, and A-10. Other aircraft types might be deployed to a forward operating location, but these were considered the most likely active duty aircraft to be deployed. B-52 and KC-135 aircraft assigned to the Strategic Projection Force (SPF) were not considered. Projected fighter aircraft overcrowding at forward operating locations indicates the SPF will operate from more secure rear area bases.

4. The deployment period is considered six months or less. The existing Air Force and Army regulations make a distinction on deployment length. This is required by

Joint Chiefs of Staff (JCS) Publication Number 3 and AFM 86-3 (draft) (62; 71). Longer deployments involve more permanent facilities and construction techniques than will be considered in this research.

5. The facility construction prioritization list found in AFM 86-3, Planning and Design of Theater of Operations Air Bases, will be modified for use in this program. The list was designed for planners using manual techniques. Its verbatim use is not conducive to computer manipulation (61).

CHAPTER II

METHODOLOGY

Methodology Overview

This chapter contains the research questions, a review of the types of data sources used, statement on the reliability and validity of those sources, data manipulation and reduction methods, operational definitions of variables, and the methods chosen to answer the research questions. The chapter provides a brief resume of the techniques and resources used to create a computer graphics program and its data files. The system created completes the thesis, answering the research questions:

1. Can a computer graphics program be developed as a decision support system for force beddown planning?

2. What are the variables that determine the number, size, and type of facilities to be used in force beddown planning?

3. Can essential variables such as spacing, equipment, etc. be quantified adequately for computer manipulation?

Data Sources

The single source designed to be the definitive work on force beddown is AFM 86-3, Vol. I, Planning and

Design of Theater of Operations Air Bases. This source was last published in 1967. A 1975 draft of a completely revised manual was obtained, but the draft was never finalized (61; 62). There is no current effort at HQ USAF to revise the manual. In the absence of an up-to-date force beddown reference, numerous Army, Navy, and Air Force publications previously listed must be reviewed for each aspect of force beddown. TA 158, Harvest Bare Equipment, is considered by planners engaged in base development to be the most current Harvest Bare document (54). The force beddown planners at the 4449th Mobility Support Squadron (MOBSS), use a Tactical Air Command 1974 plan for force beddown using Harvest Bare (65). The lectures and handouts of the contingency engineering course at AFIT are a valuable source of information. However, each source listed is not completely integrated with the other sources. "Experience is the current force beddown manual [31]."

A variety of sources were used to obtain reports in the field experiences of engineers concerning force beddown. The HQ USAF/LEEPP planner who originated the thesis concept requirement, the civil engineering force beddown planners and the contingency fuels personnel at HQ TAC, were personally interviewed (26; 31; 37). Personal interviews were also conducted with Air Force Logistics Command (HQ AFLC) munitions safety planners as well as an explosive safety expert from the Air Force Inspection and

Safety Center (1; 20; 22). Telephone interviews were conducted with the Air Force Engineering and Services Center (AFESC) Readiness Office, United States Central Command (USCENTCOM) force beddown planners, 4449th Mobility Support Squadron (MOBSS), the Air Force Medical Facilities Office, and the U.S. Army Natick Laboratories (44; 48). Unclassified portions of the After Action and trip reports of CORONET BARE and PROUD PHANTOM, the two major deployments of HARVEST BARE equipment, were reviewed (37; 56).

Current base development planning concepts as well as engineer experiences were reviewed in past articles from the Air Force civil engineering journal, Air Force Engineering and Services Quarterly (5; 8; 9; 10; 17; 19; 23; 34; 36; 75). An ongoing effort at the AFESC Readiness Center to develop a general force beddown plan for Southwest Asia deployments has produced a rough series of site plans that have been reviewed (2).

Reliability of Data Sources

Because each facility plan developed by manual means varies according to the experience level of the planner, the source reports collected are reliable on the macroscopic level but not at the microscopic level. On a macroscopic level, facility group sizing allows for adequate shelter square footage and "between facility" spacing. At the microscopic level, individual facilities are neither sited nor specified for a specific purpose or military unit. This did not present a problem for the thesis effort since the thesis computer program allows for microscopic level deviations, as long as macroscopic level performance is consistent.

Validity of Data Sources

The Air Force has been successfully conducting force beddown missions for many years. Predeployment plans are often altered on location, to meet existing site conditions. The results of these alterations have been an effective overall base development. Information acquired through referenced sources, related to field experience, is held to be valid when similar site conditions are encountered. In the case of generalized information, the sources selected had the latest information available in each respective functional area. In some cases the author of the latest printed data was interviewed. In other cases, the latest unpublished information was obtained from functional experts. Because of many expected changes in types of deployable facilities over the next several years, data bases will require revision to maintain validity.

Data Manipulation and Reduction Methods

Eight facility groups are prepared. They are the munitions storage, aircraft maintenance, aircraft refueling, flight operations, command, base support, cantonment, and medical areas. Data is manipulated and reduced by means of algorithm development for each facility group. For each of the eight groups, a mathematical formula is prepared with a percentage "padding" factor to allow for unknown conditions. In many cases the algorithm is simple. A specific space requirement for a specific type of facility is appropriate. In the computer program, as each facility group subroutine is called, the algorithm provides the space requirement and via interactive programming, the requirement is compared with other facilities previously located by the program on the bare base. If the siting meets fire and explosive safety requirements, then the operator may elect to designate that facility location on the bare base plan. If the siting does not meet requirements, the operator is prompted to alter the facility location.

Operational Definitions of Variables

Some operational variables are applicable to the entire program. The following variables are defined:

1. User--an individual knowledgeable in the contingency field.

2. Novice User--a user that is unfamiliar with the computer program.

3. Force Beddown--"The immediate beddown of mission forces plus the operation of critical facilities

and utilities. Beddown requires all types of facilities using Harvest Eagle and Harvest Bare sets [63]."

4. Siting Priority--the order of selection of major bare base components. The siting priority is munitions area, maintenance area, aircraft refueling areas, flight operations area, command area, base support area, cantonment area, and medical area.

5. Component--each facility or area used to define a bare base, specifically runway, taxiways, parking apron, water source, or unuseable areas. Each component is represented by a rectangle on the bare base site.

6. Facility--a structure or other civil engineering end item (such as erdlator water purification system), that performs a specific purpose at a bare base (64).

7. Facility Group--each of eight major functional areas (listed under "Siting Priority") used to develop a master plan. The facility groups are each defined by subroutine in the computer program. The following subroutines are defined:

a. Munitions Storage Area (MSA) subroutine.

(1) STAMP--Standard Air Munitions Package. A STAMP is a predetermined quantity of bombs, rockets, rounds, etc. tailored to a specific aircraft according to the general mission of that aircraft. "A STAMP is designed to support a particular weapon system for a specific period under combat operating conditions [60]."

(2) Munitions Storage Area--a large land area designated to safely store a quantity of STAMPs, and the necessary maintenance facilities required to prepare the munitions for mission operations. The STAMPs and facilities are separated and reveted as required to protect aircraft munitions and prevent "chain reaction" explosions (57).

b. Maintenance Area (MX) subroutine.

Maintenance Area--a land area designnated to contain the facilities necessary to maintain one type of fighter aircraft at a field level of maintenance. The facilities included are aircraft hangars, a reclamation shop, an aircraft weapons calibration shop, aircraft organizational maintenance squadron shops, an aircraft engine repair shop, an aircraft general purpose maintenance shop, a weapons maintenance shop, an avionics shop, a ground support equipment shop, a parachute/dinghy maintenance shop, and a cryogenic facility (32; 71).

c. Aircraft Refueling Areas (P) subroutine.

(1) POL--Petroleum, Oil, and Lubricants. The jet aircraft fuel (JP-4) required to operate fighter aircraft. Aviation gasoline (AVGAS), motor gasoline (MOGAS), and other petroleum products are not considered.

(2) R-14--a jet aircraft refueling and storage system that when in operation consists of hoses, pumps and related piping connected to two 50,000 gallon

collapsible coated fabric fuel tanks. The R-14 is also known as the ATHRS (Air Transportable Hydrant Refueling System).

(3) Aircraft Refueling Area--one to three land areas designated to contain the POL required by one or more assigned fighter squadrons operating under combat conditions. Each POL area contains one or more R-14 refueling and storage devices. Each R-14 is contained in an earthen berm to contain fuel spills if a tank should be ruptured (14; 27).

d. Operations Area (OPS) subroutine.

Operations Area--a land area designated to contain those facilities essential to flying operations. These facilities are base operations, weather facility, one or more flying squadron operations facilities, and the fire station. The fire station is included in the operations area to prevent space competition between the fire station and other operations facilities for runway access. Flightline access will be at a premium at almost any bare base, and must be allocated on a priority basis (71).

e. Command Area (CMD) subroutine.

Command Area--a land area designated to contain those support facilities that need to be close to flightline operations, but do not need to be adjacent to the flightline. These facilities are the wing command post, the communications area, the wing intelligence facility, and the security police compound (71).

f. Base Support Area (BSP) subroutine.

Base Support Area--a land area designated to contain those support facilities other than those contained in the command area. They do not require close proximity to the flightline. These facilities are civil engineering, transportation, and supply (71).

g. Cantonment Area (CTN) subroutine.

(1) Cantonment area--a land area designated to contain the sleeping quarters as well as all related personal and recreational facilities for deployed base personnel. The cantonment area consists of regular billets, mess facilities, latrines, shave/shower units, chapel, post office, barber shop, base exchange, Officer's club, NCO club, recreation center, theater, laundry, billeting office, flagpole, interior roads, and VIP billets. These facilities are defined specifically for this thesis, and may change depending on command policy (18; 74).

(2) Regular billet--the sleeping quarters of personnel. Under the Harvest Eagle scenario, personnel are billeted in General Purpose Medium (GPM) canvas tents. Ten enlisted personnel or six officers are billeted in each tent. Under the Harvest Bare scenario, personnel are billeted in expandable hardwall shelters (EXP). Ten

enlisted personnel or six officers are billeted in each shelter (12; 33; 42).

(3) Mess Facilities--the cafeteria style food preparation and eating facilities for deployed base personnel. These facilities include queueing, serving, and sign-in, seating, and cleanup. These mess facilities are operated for four, two-hour meal periods. Under the Harvest Eagle scenario, mess facilities serve 250 people and consist of a kitchen tent and several General Purpose Large (GPL) canvas tents for seating. Under the Harvest Bare scenario, mess facilities serve 350 people and consist of one ES/C, one EXP, and one general purpose shelter (6; 17; 73).

(4) Latrines--sanitary facilities. Facilities are constructed to accommodate 8 percent of the deployed base personnel at any one time. Under the Harvest Eagle scenario, latrines are either the pit or burnout type with 16 stalls in each designated GPM tent. Harvest Bare latrines are specially constructed and equipped EXP hardwall shelters containing both latrines and showers (6; 58).

(5) Shave/Shower Units--sanitary facilities. Harvest Eagle utilizes two GPM tents, one tent with a multi-person shaving stand and one tent with two, four head shower stands. Harvest Bare facilities are specially

constructed and equipped EXP hardwall shelters, containing both latrines and showers (6; 58).

(6) Chapel--a facility to house all requirements for religious activities, as well as to serve as a base theater. The Harvest Eagle facility is one General Purpose Large tent. The Harvest Bare facility is one general purpose shelter (12:33).

(7) Post Office--a facility to process all incoming and outgoing mail, to include outbound packaging of parcels. The Harvest Eagle facility is one GPM tent. The Harvest Bare facility is one EXP shelter (74).

(8) Barber--a facility built only if required and appropriate. Either Harvest Eagle or Harvest Bare planning uses a portion of another deployable facility (74).

(9) Base Exchange--the Harvest Eagle facility is one GPM tent. The Harvest Bare facility is one EXP shelter (65).

(10) Officer's Club--the Harvest Eagle facility is one GPM tent per 1000 people. The Harvest Bare facility is one EXP shelter per 1000 people (33).

(11) NCO Club--the Harvest Eagle facility is one GPM tent per 1000 people. The Harvest Bare facility is one EXP shelter per 1000 people (33).

(12) Recreation Center--the club facility primarily for junior enlisted personnel. Under Harvest

Eagle, two GPMs per 1000 people are used. Under Harvest Bare, two EXPs per 1000 people are used (6; 33).

(13) Theater--the chapel facility will be used.

(14) Laundry--a facility containing washers, dryers and sorting tables. Under Harvest Eagle, one GPM per 1000 people is used. Under Harvest Bare, one EXP is used for each 1000 people (65).

(15) Billeting Office--a facility for control of the cantonment area. Under Harvest Eagle, one GPM is used, under Harvest Bare, one EXP.

(16) VIP Billets--sleeping quarters for visiting personnel of senior rank. Under Harvest Eagle, two GPM tents are used, under Harvest Bare, two EXP shelters.

h. Medical Area (H) subroutine.

(1) Medical Area--a land area designated to contain those medical facilities necessary to support assigned personnel. The facilities may be an Air Transportable Clinic, an Air Transportable Hospital, or a Modular Air Transportable Hospital (30; 48; 68).

(2) Air Transportable Clinic--one GPM tent is used to support up to 1000 personnel (48).

(3) Air Transportable Hospital (ATH)--a seven-tent facility for supporting over 1000 personnel. It can be augmented as required (48).

(4) Modular Air Transportable Hospital (MATH)--a Harvest Bare facility capable of supporting a 4,500 personnel deployment (65).

Methods for Answering the Research Questions

The primary research question can be answered by the development of algorithms for each of the eight facility group subroutines and the operation of a computer graphics program. If the program, written in FORTRAN 77 and executed on the VAX 11/780 computer, can produce a bare base master plan, then the primary research question of feasibility is answered affirmatively.

Completion of the following research objectives will be judged by the Contingency Planners at HQ TAC/DE.

1. Develop force beddown variables for computer manipulation. The resulting computer product must meet the following criteria:

a. Save time, since time is expected to be a critical factor in base development planning.

b. Allow a deployment team chief and all functional area chiefs to know what coordinated base construction efforts will be required upon arrival at the bare base site. The team chief can organize according to the computer generated plan and immediately implement the plan upon arrival at the site.

c. Provide a viable master plan, from which building materials can be planned and preordered at the headquarters level. The materials can then be sent with the team. This would provide a more accurate assessment of necessary materials than a "Push" logistics system would provide, and would be more efficient than having the team identify the materials after the team has arrived on site (69).

d. Provide an efficient and effective site plan given safety criteria distance limitations, and natural constraints.

Examining the actual documentation of the thesis demonstrates accomplishment of the following remaining objectives.

e. Set a priority sequence for establishing facility locations at a temporary base under JCS Initial or Intermediate conditions (72).

f. Permit development of tent row by column (nondispersed) sized cantonment area layouts. Dispersed layouts, used when the bare base is in a hostile area and may be subject to air or ground attack, could be developed for the program (61; 62).

g. Provide flexibility to adjust assumptions and constraints concerning safety clearances or facility group sizes.

2. Determine an effective means of using computer graphics techniques: batch or interactive.

3. Determine if computer hardware for graphics application can be used effectively in contingency planning, with hardware choices among those available at AFIT (16).

4. Formulate computer software which can be integrated with existing software at Wright-Patterson AFB, for effective graphics application.

5. Develop a data base that contains bare base characteristics and constraints.

6. Using the local computer hardware and software, develop subroutines for a graphics package for plotting symbols of force beddown facility groups. Symbols will include only selected groups of facilities. For example, a symbol for the cantonment area would be used, not an individual tent.

7. Develop an applications program incorporating constraint algorithms from force beddown planning to use the graphics package. The applications program must include a provision for input of a grid location system for consideration of existing facilities.

8. Operate a computer model from the applications program to show system feasibility.

CHAPTER III

IDENTIFICATION AND DISCUSSION OF RESULTS

Results Overview

This chapter indicates the locations in the appendices of each thesis result needed to meet the research objectives and answer the research questions. The results are discussed to include general comments, a description of the computer graphics program, a summary of the reasons for selecting some variables for manipulation and not others, a macroscopic view of the program, and an outline of the program interactive features that make it "user friendly."

Identification

The essential data and criteria necessary to prepare a master layout plan, for contingency operations at a bare base, have been gathered for this thesis. Presently, each newly assigned contingency planner has to glean this type of information from numerous Air Force, Army, and Navy publications, as well as from the experiences and knowledge of functional area experts in the contingency field. This technique is time-consuming and does not always result in the most current criteria being used (32).

The results of this research effort are shown in Appendices A through J. Appendices A through H contain the techniques and compilation of data used to develop each facility group data base. Appendix I contains the users manual for the computer program found in Appendix J. The users manual contains descriptions of the main routine and its subroutines, a troubleshooting section, and a step-by-step development of a base layout. Examples of the master plans developed by the program, utilizing the data developed in Appendices A through H, are presented in Figures 1 through 8.

Four different deployment master plans are shown at two potential bare bases. Base X, shown in Figures 1 through 4, is similar to Berbera Air Station, Somalia (45). Base Y, shown in Figures 5 through 8, is similar to the bare base layout used by the 1974 TAC Harvest Bare plan as well as the recent Air Force Engineering and Services Center Southwest Asia bare base conceptual plan (65). These two base component layouts demonstrate the flexibility of the computer graphics program.

These master plans show one runway (RWY), four taxiways (TWY), one aircraft parking apron (PA), and a water source (W) as developed by the program. Figures 1, 2, 5, and 6 show facility group placement of Harvest Bare and Harvest Eagle assets for three squadrons and 3000 personnel. This is the largest deployment programmed.

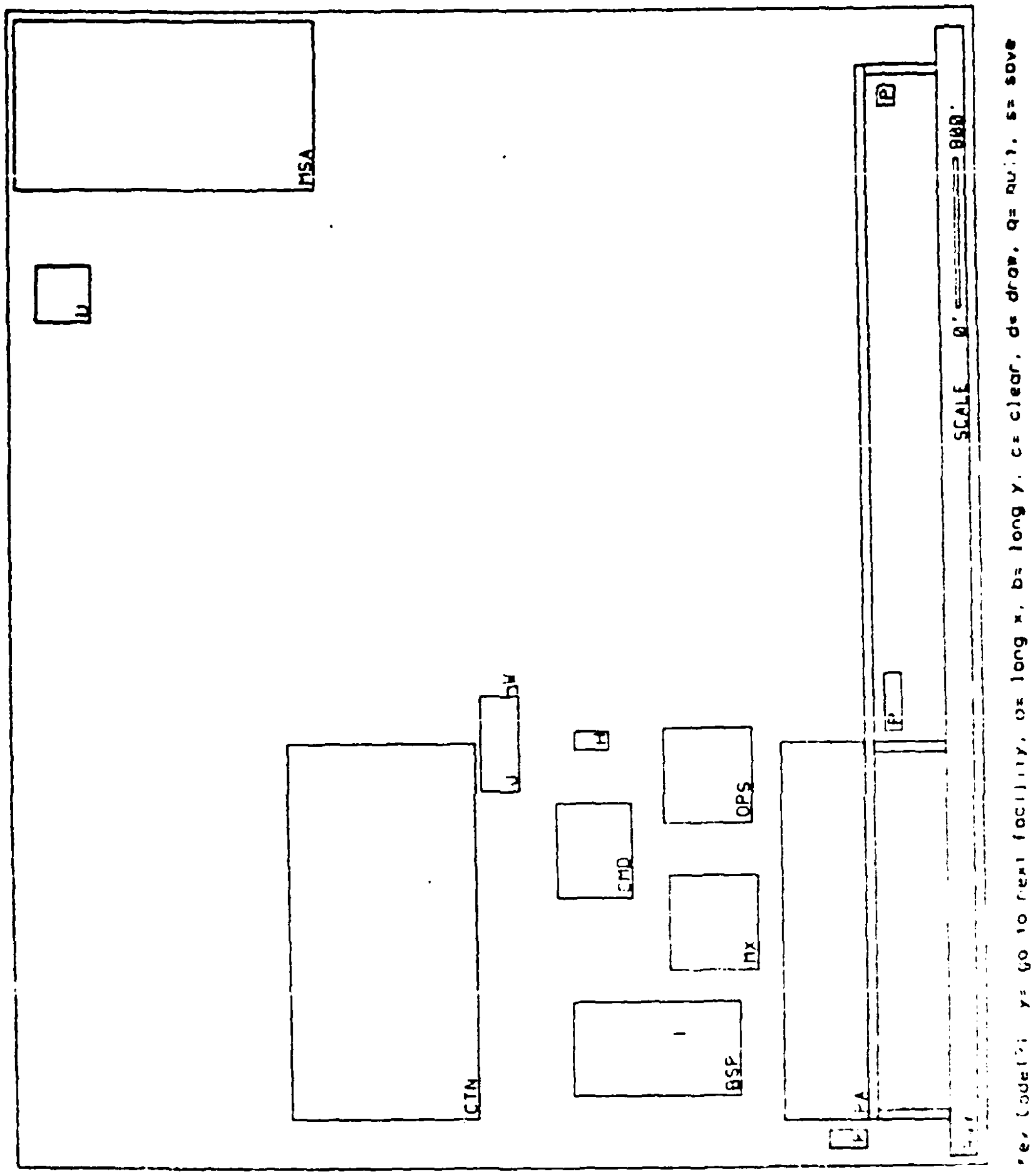

Fig. 1. Base X with Largest Facility Groups (Harvest Bare)

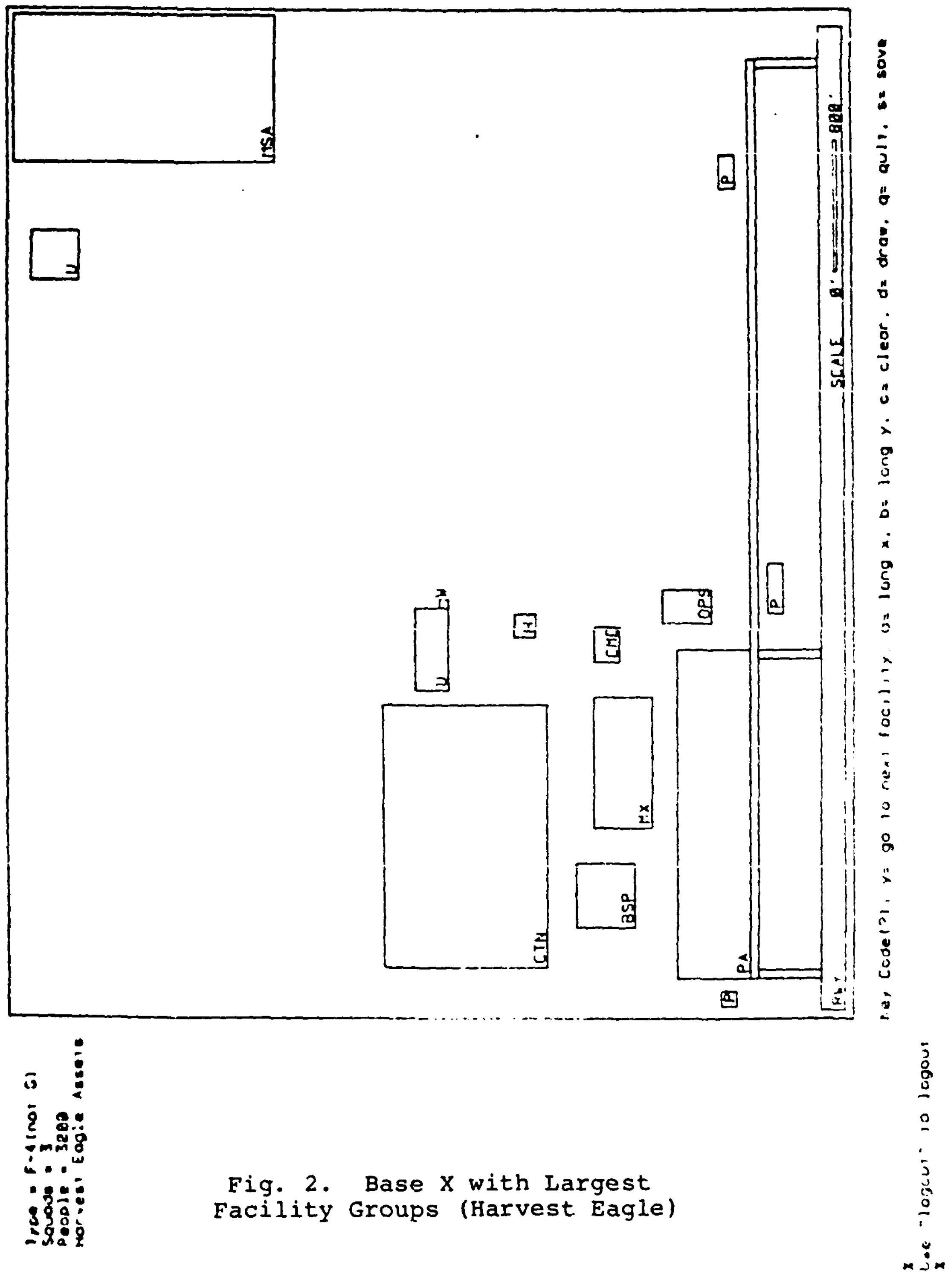

Fig. 2. Base X with Largest Facility Groups (Harvest Eagle)

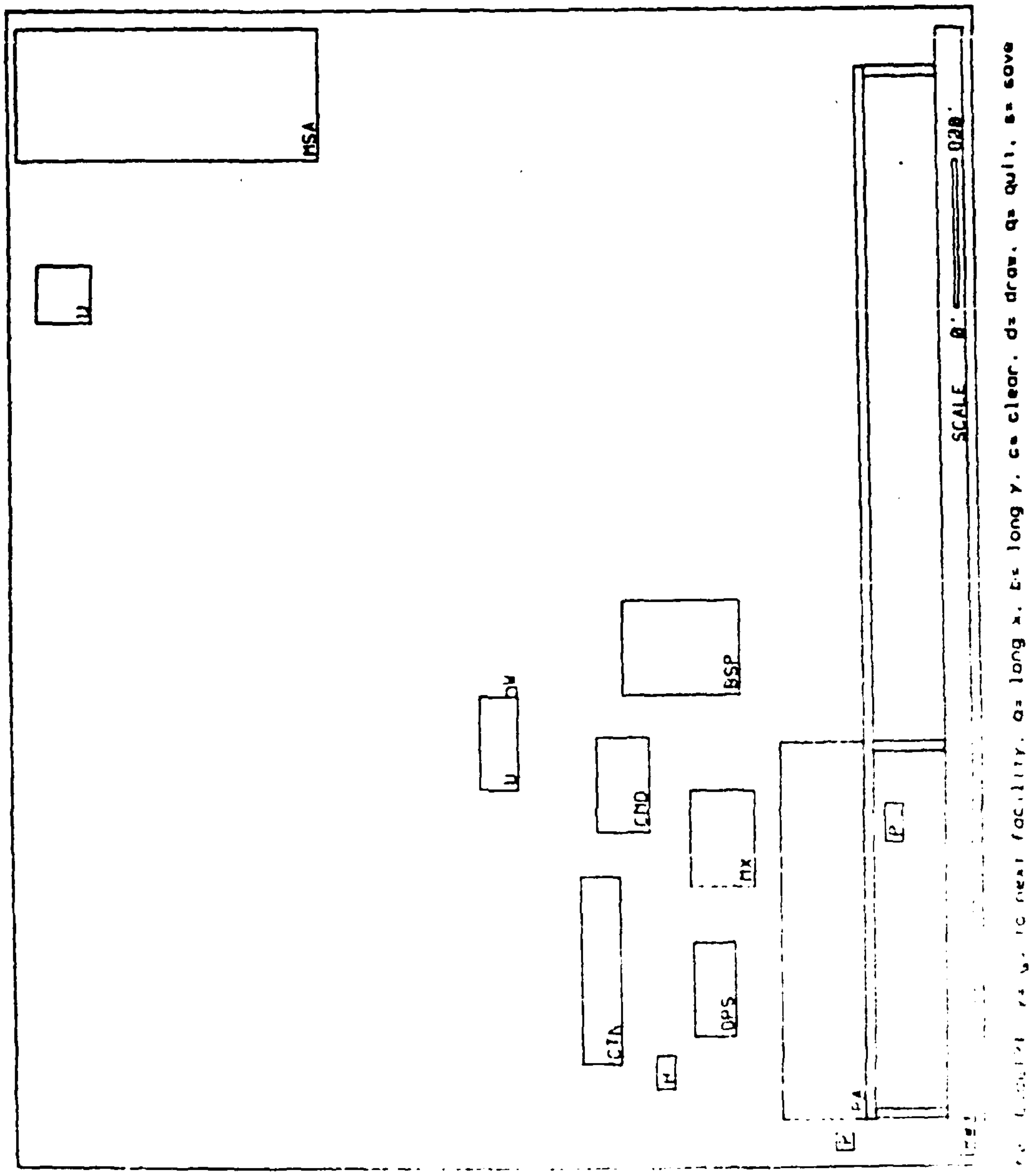

Fig. 3. Base X with Smallest Facility Groups (Harvest Bare)

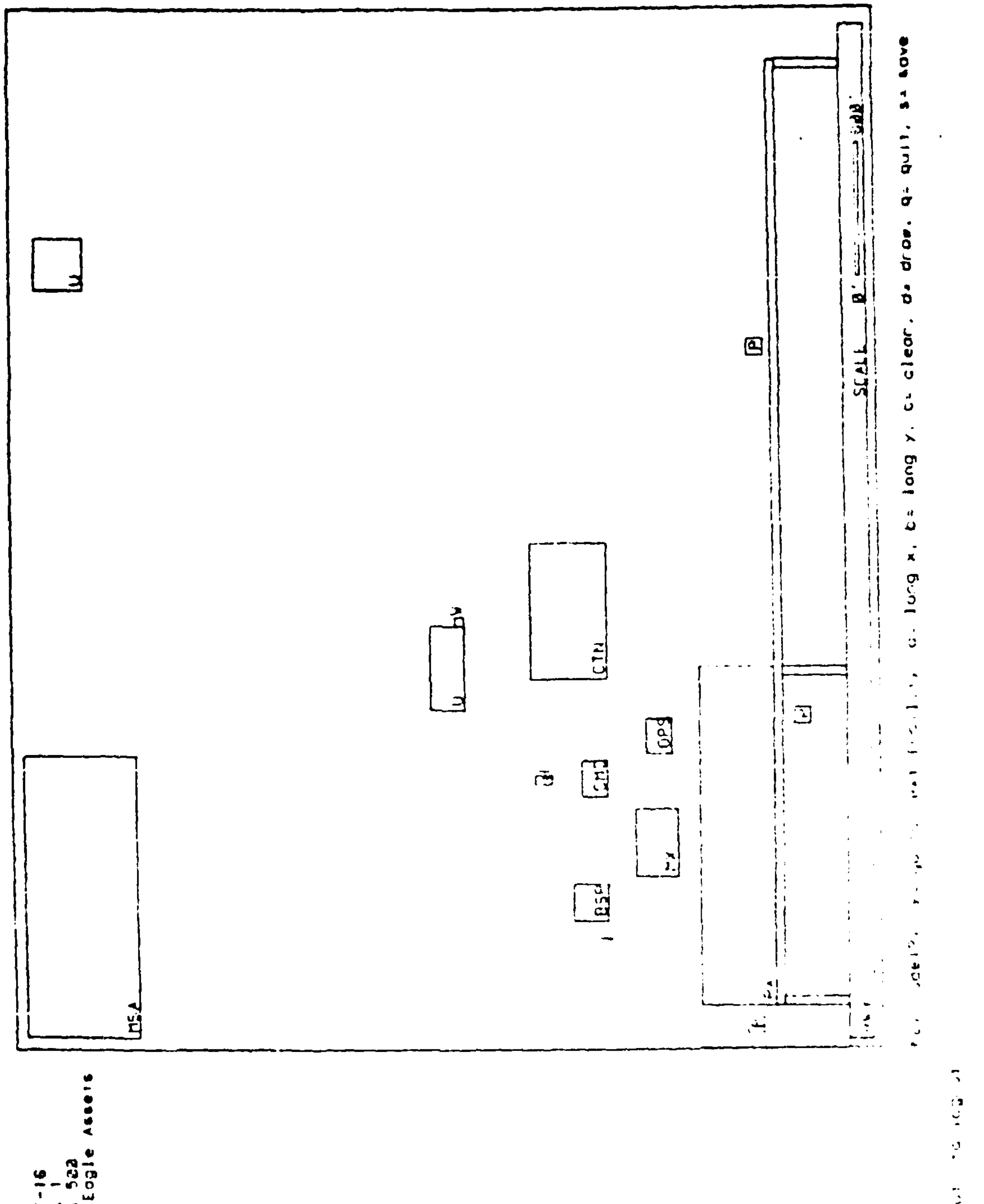

Fig. 4. Base X with Smallest Facility Groups (Harvest Eagle)

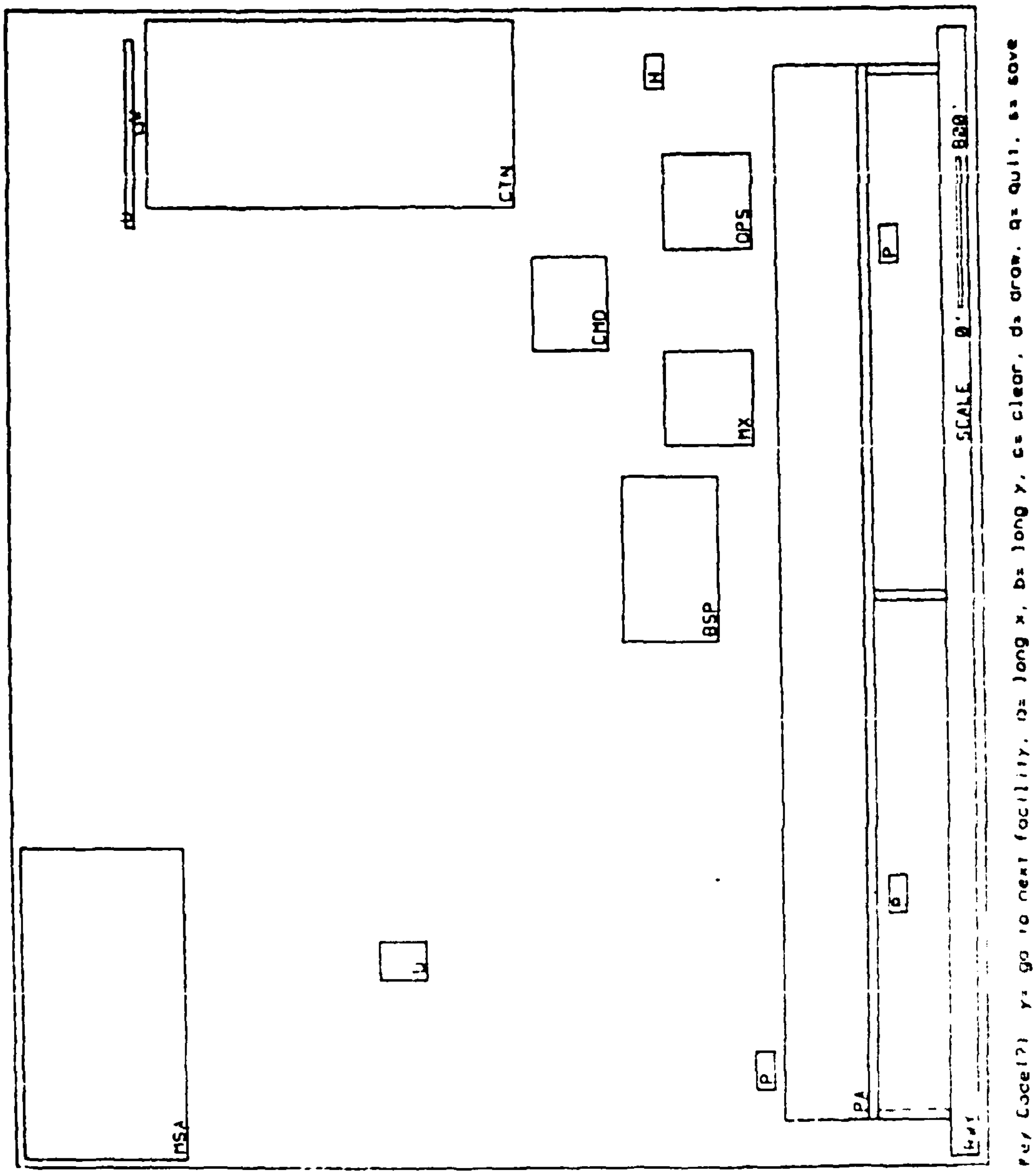

Fig. 5. Base Y with Largest Facility Groups (Harvest Bare)

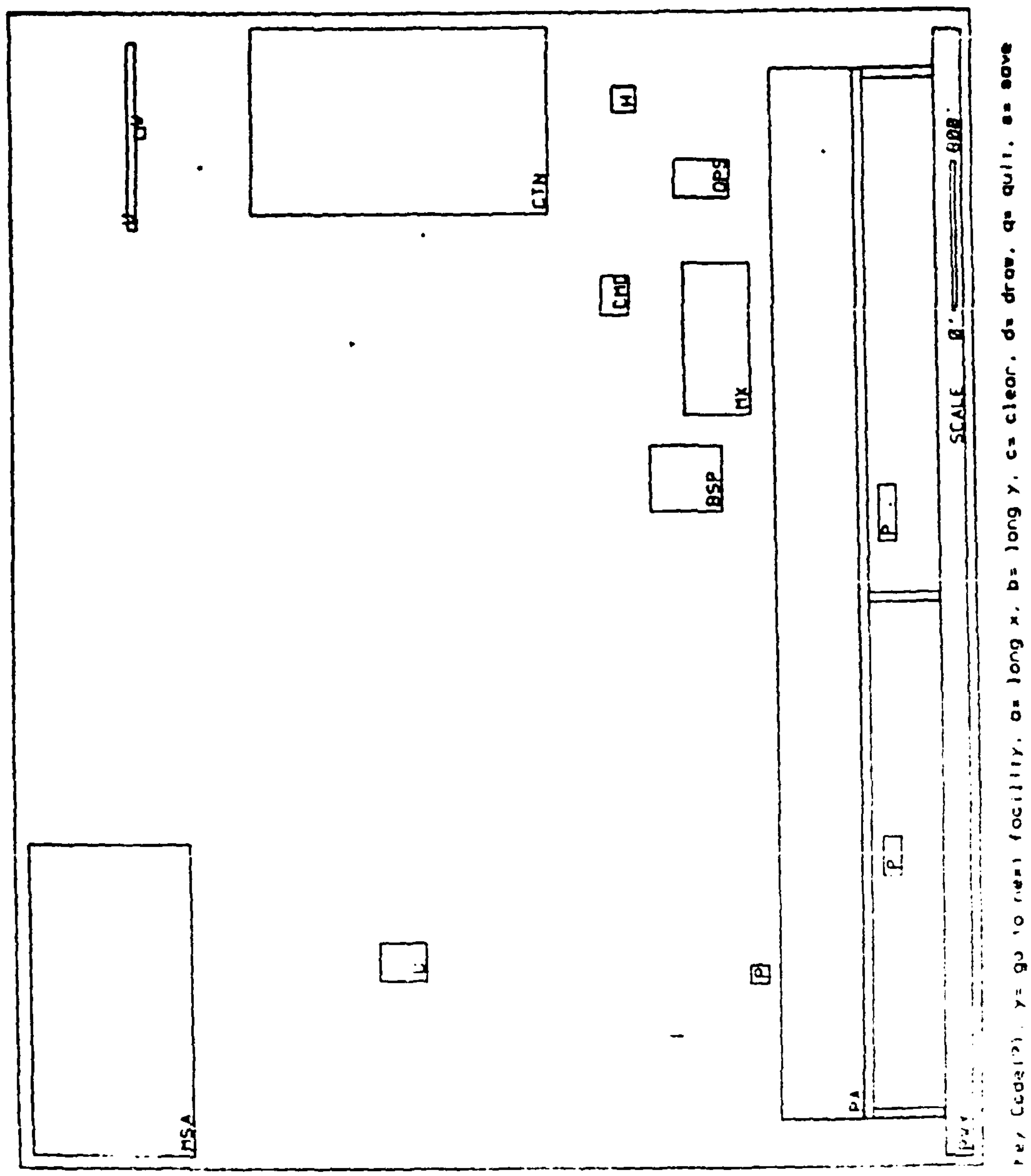

Fig. 6. Base Y with Largest Facility Groups (Harvest Eagle)

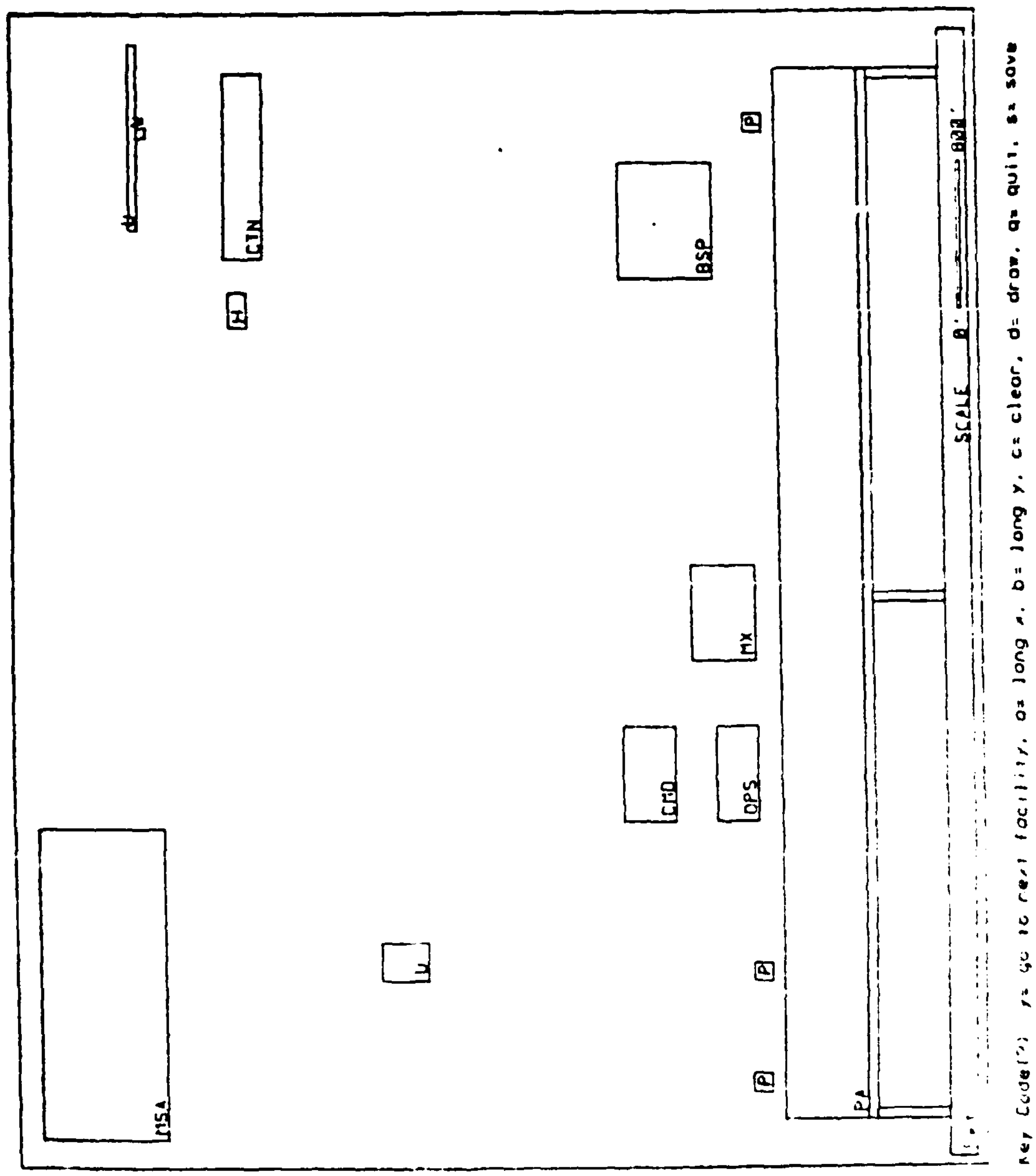

Fig. 7. Base Y with Smallest Facility Groups (Harvest Bare)

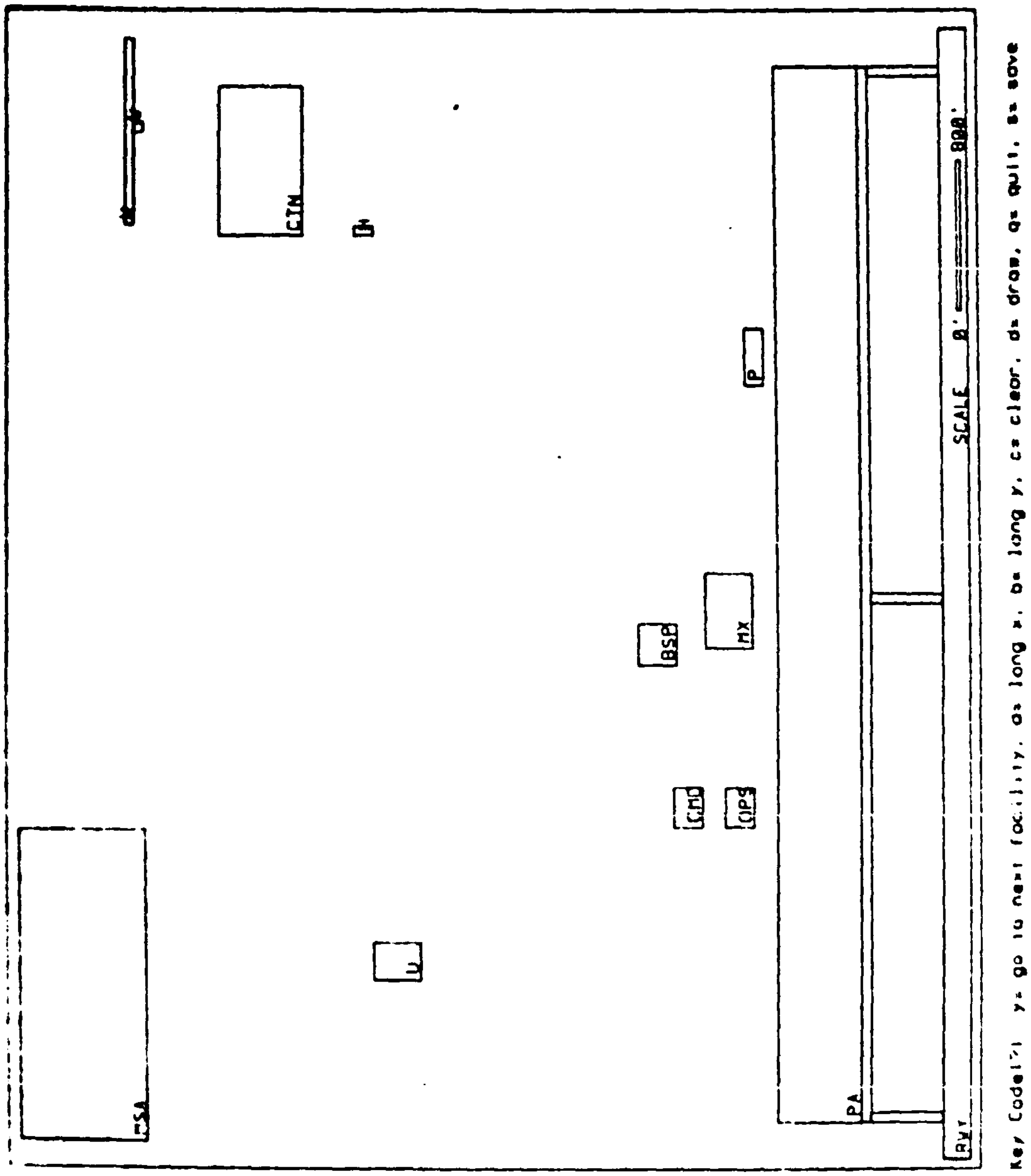

Fig. 8. Base Y with Smallest Facility Groups (Harvest Eagle)

Figures 3, 4, 7, and 8 show one squadron and 500 personnel deployed. This is the smallest deployment programmed. The bases depicted are realistic representations of minimum bare bases containing a single runway, taxiways, parking apron, and a water source. Two areas are marked unuseable (U). These two areas are provided by the program to increase master planning flexibility. The master plans conform to airfield, fire, and safety criteria as programmed. If safety constraints must be overridden by operational needs, the program has the capability to do so and produce the necessary changed master plan.

A graphic scale is shown in the figures. The scale is an 800 foot increment of the total runway length. Layouts with set (1 inch equals 800 feet) scales become inaccurate as they are reproduced with the drawings to different sizes. The graphic scale will be accurate if different size drawings are reproduced.

Research objectives of saving time, providing information, master planning, effectiveness, and efficiency were judged completed by TAC Contingency Planners (38).

Discussion

General

This thesis, a compilation of contingency information automated in a computer graphics program, contains a structure to formulate an efficient and effective master layout plan for each bare base being planned. When prepared by an experienced user or operational planner the plan can be of a very high quality. The computer program presently indicates when minimum safety requirements are violated. But it is the experience and knowledge of the planner that is the key factor in optimizing the base, by keeping it to a minimum size consistent with equipment utilization, etc. This program can greatly reduce the time needed to plan a base or it can provide comparative information on the effects that different numbers or types of aircraft would have on a base layout. It can be a valuable tool to the operational planner who must meet a short suspense date for planning to get an effective fighting force to a part of the world where critical events are occurring.

Description of the Program

This computer graphics program has been developed to facilitate force beddown planning and decision making. It develops a general layout for a contingency operation at a bare base site. It can be used to prepare the initial plans for a particular bare base, by outlining the effects of deploying different types of aircraft, or varying the numbers of aircraft or personnel deployed to the site. It prepares layouts according to the type of facilities available, and it also provides the initial data for planning what materials and equipment will be needed to support the deployment. The program is useful as a decision support system.

Evaluation of Variables

Many variables have an effect on a bare base master plan. The most influential ones, to include the type of aircraft, the number of squadrons, the number of personnel, and the type of asset to be used, were selected. Why these were chosen will be discussed later in this chapter (61; 62; 65; 71).

Fire, explosive and airfield safety criteria were all employed to identify when a facility group was placed too closely to another group or a previously existing component of the bare base site. Either JCS size requirements, or the spacing required between tents, shelters, and equipment was used to determine each facility group size. Using areas at least 10 percent larger than that initially calculated for each facility group was deemed sufficient to allow for small unuseable areas, dispersement, and facility spacing. Because of the criticality of effective barriers around high explosive munitions, a 25 percent increase in the area containing the munitions storage modules was used in the munitions storage area.

The formulation of a contingency base development plan at a bare base location is dependent on many factors. The first problem is "Does the bare base meet the airfield safety criteria outlined in AFM 86-3" (55)? Civil engineers do not make the decisions of whether or not a particular potential bare base site is acceptable. This computer program will accept any base loaded into an external file. The assumption is made that each of these bases meets minimum airfield criteria.

The operational mission that will be accomplished from an airfield greatly affects the location and size of the site facilities. Since the mission determines the type and number of aircraft needed, aircraft type and the number of squadrons were used as the primary computer controlling factors of the munitions storage, aircraft maintenance, aircraft refueling, operations, command, and base support area dimensions (65; 71). The mission and resupply capability have an impact on how many STAMPs would need to be stored in a given munitions area (20; 22; 60). This affects MSA size. To facilitate this research, it was assumed that resupply was responsive and that only one STAMP per squadron would be stored in the MSA.

Although some contingency bare bases may be used as resupply bases, the majority will be used to support aircraft near the FEBA (Forward Edge of the Battle Area). This computer program is limited to supporting tactical fighter aircraft near the FEBA. Locating strategic aircraft near the FEBA is unnecessary since these aircraft possess the range to operate from rear bases, which can be better protected from enemy activity. The greater ranges of strategic aircraft also permit considering a greater number of bases for new or additional missions. Strategic offensive aircraft, assigned to the Strategic Projection Force (SPF), and strategic airlift aircraft were not considered for assignment to the contingency bare base. It is probable that cargo aircraft would be offloaded, possibly refuel, and depart as quickly as possible; minimizing ground time and consequently minimizing exposure to enemy activity. Rotary wing aircraft assigned for search and rescue to a bare base unit were not considered at this time. Facility group and layout changes necessary to support them were not expected to significantly alter the layouts already prepared, and would not affect whether or not the computer system is feasible. As was stated in Chapter II, aircraft of other U.S. Services are not considered. These aircraft can be incorporated into the computer program with additional research effort.

Under normal circumstances the number of people deployed is a function of the mission. However, the country-to-country status of forces agreements between the United States and other nations limits the number of personnel allowed in each country (37). To make adjustment for this possible limitation, the variable "number of people" was used to size the cantonment area. Other base areas are sized by mission requirements as well as personnel (65; 71).

Such facility group sizes should not be decreased for manpower reduction, so that the normal mission sizes are used in the computer program.

Either Harvest Bare or Harvest Eagle type facilities can be used for deployment, so facility group sizes were developed and established for both types. There are differences in facility group sizes between the two facility types. Harvest Bare facility groups are composed of hardwall structures and the group sizes are computed using the Harvest Bare manual (65; 66). Harvest Eagle facilities are softwall structures (tents), and sizes are computed using AFM 86-3 (61; 67). The Air Force is now conceptually planning the combined use of Harvest Bare and Harvest Eagle facilities (31). The decision on how to combine these assets has not been determined and incorporated into Air Force manuals. For this reason, combined facility groups were not developed for this program.

Climate (desert, arctic, temperate) has an effect on what equipment would be taken on a deployment. For example, there is an arctic supplement to a standard Harvest Eagle kit (13). Since these additions are such items as tent liners and insulation, facility group sizings would not be appreciably changed. Therefore, climate was not considered a significant variable to add to the computer program at this level.

Terrain has been considered a major obstacle to constructing a contingency bare base, especially for Harvest Bare facilities which have small elevation tolerances (66). The large number of potential siting and elevation problems, such as rock outcroppings, cliffs, swamp areas, lakes, or even man-made obstacles (such as minefields), has led to the establishment of the unuseable area designation in the computer program. The user has two areas he can designate as unuseable. These are rectangular and can be of any size. The unuseable designation can be a tool for the planner, to identify existing building facilities to which the host nation will not allow U.S. occupancy. If occupancy is permitted, the facilities can be incorporated into facility group areas as supplements to the Harvest Bare or Harvest Eagle assets.

Wind direction was also considered as a potentially important varible in master planning. Although prevailing winds must be considered when locating sanitary facilities, such as latrines and garbage dumps, this is a lower level decision than this computer program considers (12). Specific latrine spacing was incorporated in sizing the cantonment area and the "padding factor" used in other functional areas is sufficient to permit latrine sitings. The exact location of any latrine is not specified. The wind direction becomes important if a more detailed program is developed, or in the actual siting of latrines by the on-site civil engineer.

The level of construction planned for a deployment depends on the length of deployment. Harvest Bare or Harvest Eagle assets are planned for the initial (0 to 6 months) time frame. Under intermediate (6 to 24 months) or temporary (greater than 24 months) standards, facilities are made more permanent. For example, under intermediate standards Harvest Eagle tents would be hardbacked. This difference does not alter the size of the individual facilities or facility groupings. If the operation is to exceed 24 months, permanent construction is planned. This is beyond the scope of this thesis (63; 73).

This master plan is feasible, although not necessarily optimal. The optimal plan would evaluate all possible facility group sitings against not only minimum safety requirements, but also against criteria that would need to be developed by evaluating the effects of equipment utilization, travel time between facility groups, and enemy air or ground threat, etc.

Program Macro View

The computer program was developed to provide a visual representation of the bare base deployment site. It was organized so that the facility groupings with the greatest impact on the site (for mission requirements and to meet safety criteria), and the least flexibility in being located, were sited first. The groupings were prioritized as follows:

1. Munitions Storage Area
2. Aircraft Maintenance Area
3. Aircraft Refueling Areas (up to 3 locations)
4. Flight Operations Area
5. Command Area
6. Base Support Area
7. Cantonment Area
8. Medical Area

<u>Interactive Features</u>

An interactive mode, rather than a batch mode, was developed that allows the planner to view the master layout plan as he develops it. Batch techniques are inflexible, since the entire program must be rerun to alter facility group sitings. The interactive mode facilitates identifying to the planner when fire, explosive, or airfield safety criteria have been violated. Corrections can be made immediately. In this mode the planner/user also has the capability to override distance criteria if the situation requires it. The situation could be an operational requirement where the mission commander determines some safety criteria may be waivered. The program informs the user of possible errors, but the user makes the final decision as to whether or not those errors need to be disregarded.

To facilitate the interaction between the computer program and the user, the program was designed to be "user friendly." The standard set of responses that the user has available to him are listed below the screen. In this way the user is always aware of the options open to him. Computer comments and directives are cryptic, to minimize the time needed by an experienced user to complete a layout plan. In those cases where the response is not standard (as listed under the screen), the available options are listed by the computer. Minimizing the length of computer printed directives allows the experienced user to proceed rapidly. The directives were not shortened to the extent that the novice user is confused on what action to take next.

As shown in the preceding paragraphs, the results of this thesis include not only the compilation of data and the computer program, but the analysis of potential variables, their applicability to automation, and the production of a feasible bare base master plan.

CHAPTER IV

SUMMARY AND RECOMMENDATIONS

Summary

The most recent literature concerning civil engineering contingency planning for bare bases, and military civil engineering application of computer graphics, has been reviewed in this thesis. Contingency planning has been researched from both an historical and a topical viewpoint. Air Force Civil Engineering force beddown efforts have been traced from World War II to the present, and current deployable facilities have been described. The key offices of functional expertise have been identified and the pertinent information gathered.

The consolidated information has provided the basis for the algorithms of the eight facility groups for bare base force beddown. In analyzing this information and formulating these algorithms, decisions were made concerning how various variables that impact on facility siting could be presented.

The successful development of the computer program, with its data files, affirmatively answers the research questions. The questions were:

1. Can a computer graphics program be developed as a decision support system for force beddown planning?

2. What are the variables that determine the number, size, and type of facilities to be used in force beddown planning?

3. Can essential variables such as spacing, equipment, etc. be quantified adequately for computer manipulation?

Computer graphics can have an effective application to force beddown planning. Although the research questions have been answered positively, the program requires expansion and refinement to maximize its potential as an analytic tool. This effort is needed to provide a readily useable automated product for civil engineering contingency planners, and on-site commanders. Two types of improvements are needed. The first type, category I improvements, concerns program refinements of a practical nature. These improvements will be time-consuming but do not require a research effort of thesis proportions. The second type of improvements, category II improvements, concern recommendations for future thesis teams. This will require advancing the theoretical approach used to develop the current program. Categories I and II improvements follow in outline form.

This thesis and its suggested improvements are recommended for Air Force Engineering and Services Center validation.

Recommendations

1. Category II Improvements

a. Develop an automated self-teaching or "help" feature to allow the novice user to access information on both facility group definitions as they relate to the computer program, and program operation.

b. Add the capability to locate more than three aircraft refueling areas, for greater "hot pit" refueling capability (26).

c. Add the capability to locate aircraft refueling fabric tank storage areas (bulk storage facilities) (27).

d. Add additional aircraft types (Air Reserve and National Guard fighters) (2).

e. Add more potential bare base sites, by increasing the external file list (Southwest Asia locations, Central American locations, etc.).

f. Add the capability to have variable numbers of aircraft other than by squadron.

g. Add the capability to use AM-2 matting to increase the size of the parking apron.

h. Separate the cryogenic facility (LOX) from the aircraft maintenance facility group (32).

i. Provide for establishing facility groups in any order.

j. Provide for use of a Harvest Bare/Harvest Eagle mix of facilities (31).

k. Provide for airfield facilities such as the tower, TACAN, etc.

2. Category II Improvements

a. Develop the capability for the user to designate save files by name so that multiple layouts of the same base can be stored.

b. Provide for layout of existing and contingency generated roads.

c. Develop the capability to add utility systems (electrical, mechanical, water and waste) to the layout.

d. Develop the capability to automatically derive complete Bills of Materials for the entire base from the layouts (31).

e. Improve the spacing criteria measurement system so that the program measures the closest distance between two facility groups or a facility group and an existing base component. The current program measures vertical and horizontal distance only.

f. Develop the capability to move from the macro view of the entire base to the micro view of an individual facility group. This capability develops the individual facilities within a facility group. This would be a "zoom" capability.

g. Develop a scale driven layout so that the standard engineering scales of 1:800, 1:400, 1:100, and 1:50 can be used.

h. Develop the computer software to operate the program on the Worldwide Military Command and Control System (WWMCCS), as requested by HQ USAF/LEEPP (31).

i. Develop the capability to expand up to a 9000 man, 2 wing base.

j. Develop the capability for use of local assets rather than only Harvest Eagle and Harvest Bare (13).

k. Provide for labeling and drawing by line at any time during the program.

l. Provide for rectangles at orientations other than parallel to the runway and for shapes other than rectangular.

m. Provide for the Strategic Projection Force (SPF), strategic and tactical airlift, and rotary wing aircraft. The SPF consists of strategic bombers, tankers, and command and control aircraft. This action requires additional facilities such as a demineralized water capability, and broadens the scope of the project from a forward operating location to any bare base used to expand airpower.

n. Provide for dispersed layouts.

o. Provide for use of new facility types (TEMPER tents, Reverse Osmosis Water Purification Units, etc.) (54).

p. Provide for a mix of squadrons of different types of aircraft at a particular bare base (airlift, reconnaissance, etc.).

q. Provide for air base defense (security) constraints.

r. Provide for differing climates. For example, in Southwest Asia air conditioning requirements will require an expanded electrical power production capability. This concept relates items c, d, and f (54).

s. Provide for wind direction constraints. This effort is important at both the macro and micro levels. For example, the base support area contains dust producing activities and should not be upwind of the medical area.

t. Develop through interview, survey, or other research techniques a consensus of opinion from functional experts that will allow for maximum distance constraints and still provide an effective base. Provide for medical facility group constraints as listed in the Tactical Air Command 400 series regulation (68).

u. Investigate using computer techniques in master planning of permanent bases.

v. Provide a program that will teach the individual about base development in the contingency environment through the use of the existing computer program.

w. Develop a three-dimensional viewing capability. This capability would enhance analysis of the base in regard to passive measures of air defense.

x. Develop a color capability to determine the effects of camouflage in reducing visibility of the base to hostile aircraft.

APPENDICES

APPENDIX A

CONSTRAINTS AND SIZING FOR MUNITIONS STORAGE AREAS (MSA)

I. Sources

A. AFM 127-100.

B. T.O. 11A-1-65.

C. Interviews with Mr. Adams, Major Fayl, Major Fontana.

D. AFM 86-8.

II. Constraints

A. MSA > 1600 FT from PA.

B. MSA > 240 FT from Runway.

C. MSA > 240 FT from Taxiways.

III. Background

From T.O.

Munitions Pallet Loading by Aircraft

Pallet	F-16	F-4	F-4G	F-15	A-10
1	156,672	156,672	-	-	-
2	46,400	46,400	-	-	-
3	18,472	18,472	-	-	36,944
4	516	516	-	-	60
5	448	448	-	-	-
6	-	-	-	-	-
7	56,700	56,700	-	-	-
8	64	64	-	-	-
9	2,631	2,631	-	-	2,631
10	2,631	2,631	-	-	1,754
11	1,898	1,898	5,694	-	1,898
12	1,898	1,898	-	-	2,847
13	16,644	16,644	-	-	9,636
14	19,908	19,908	24,648	-	10,428
15	5,100	5,100	1,020	-	65,790
16	81	81	-	-	-
17	6,096	6,096	-	-	-
18	-	-	-	12,954	-
19	-	-	-	-	1,840
20	-	-	-	-	920
21	-	-	-	-	7,376
22	-	-	-	-	-
23	-	-	-	-	-
24	-	-	-	-	-
25	-	-	-	-	-
26	320	320	-	320	320
27	-	-	-	-	-
28	-	-	-	-	-
29	-	-	-	-	-
30	-	-	-	-	-
31	-	-	-	-	-
32	1,820	1,820	1,820	-	-
33	-	-	-	-	-
34	-	-	-	-	-
35	-	-	-	-	-
36	-	-	-	-	-
37	-	-	-	-	-
38	-	-	-	-	-
39	-	-	-	-	-
40	-	-	-	-	-
41	-	-	-	-	-
42	-	-	-	-	-
43	-	-	-	-	-
44	-	-	-	-	-
45	2,280	2,280	-	3,192	-

Pallet	F-16	F-4	F-4G	F-15	A-10
46	-	-	-	-	57,129
47	-	-	-	-	-
48	-	-	-	4,992	-
49	-	-	42,462	-	-
50	-	-	405	-	-
51	-	-	-	-	-
52	-	-	13,536	-	-
53	-	-	18,216	-	-
54	-	-	11,248	-	-
55	-	-	-	-	868
56	-	-	-	-	-
57	-	-	-	-	-

D = K(cube root of W), where D is the separation in feet, K is the protection factor (draft AFM 127-100), and W is the weight of explosives in pounds. W is found in T.O. 11A-1-65.

Use the modular concept of AFM 127-100.

IB = Inhabited Building distance (FT)

PTR = Public Traffic Route distance (FT) = .6(IB)

IL = Intra Line distance (FT)

IM = Intermagazine distance (FT), between 2 storage locations, from stack face to stack face

NEW = Net Explosive Weight

STAMP Net Explosive Weights

Aircraft	New (lbs.)
F-15	21,458
F-4	340,984
F-4G	118,844
F-16	340,984
A-10	200,441

Check Compatibility (AFM 127-100(c-1), p.4-11)

Pad 30' square minimum

Open barricaded munitions storage

Berms--earth covered arch igloo or Butler

Use K6, oneway traffic, no square corners

F-15:

192 AIM 7s

192 AIM 9s

Demo

20 mm HE

Separation Distances for MSA (AFR 127-100)

K Factors

1.	To combat, aircraft parking	K30	1600 FT
2.	To runway	K30	1600 FT
3.	To taxiways	K24/30	1410 FT
4.	To POL	K40	2130 FT
5.	To PTR	K24/30	1410 FT
6.	To IB	K40/50	2350 FT

Note: Runway and taxiway distances can be waived overseas to K4.5 (240 FT).

Combat aircraft to POL K40 2130 FT

IV. Assumptions

A. One STAMP per squadron stationed at the Bare Base.

B. 150,000 lbs is the maximum Net Explosive Weight per cell.

C. Barricades must be 10' high.

D. The MSA security fence will be 50' from all buildings or barricades.

E. All cell pads will be square, 50' by 50'.

F. There will be a minimum of three cells for explosive compatibility requirements.

G. There are sufficient numbers of modules to separate explosives by type.

H. Using a max NEW of 150,000 lbs. and a Kl.1 the Intermagazine (IM) distance is 60'.

I. Using a max NEW of 150,000 lbs. and a K of 18 the Intraline distance is 960'.

J. The assembly building is 60' by 60', but can be expanded in one direction without changing the clearances previously calculated.

K. After the munitions areas were calculated the module areas were increased by 25 percent to allow for terrain problems and to permit minimal dispersion.

V. Algorithm Development

Harvest Bare and Harvest Eagle MSAs are calculated and designed in the same fashion. Based on the size relationships and explosive weights, a rough estimate of overall size was prepared.

VI. Padding Factors and Dimensions

Aircraft	No. of SQs	No. of Arcrft	No. of Modules	No. of Cell/Md	No. of Ttl Cell	MSA (+25% ModA) Area Size
F-4,F-16	3	72	3 + 2S	4	14	1650' x 900'
F-4,F-16	2	48	2 + 2S	4	10	1650' x 700'
F-4,F-16	1	24	1 + 2S	4	6	1650' x 700'
F-4G	3	72	3 + 1S	3	10	1550' x 900'
F-4G	2	48	3 + 1S	2	7	1400' x 900'
F-4G	1	24	4	1	4	1350' x 900'
A-10	3	72	5 + 2D	6	34	1750' x 1200'
A-10	2	48	4 + 2D	5	24	1700' x 1200'
A-10	1	24	2 + 2S	5	12	1700' x 700'
F-15	3	72	1 + 2D	3	7	1550' x 700'
F-15	2	48	2 + 1S	2	5	1400' x 700'
F-15	1	24	3	1	3	1350' x 700'

(S = Single cell; D = Double cell)

X. Tables

Tables 1 and 2 show the Harvest Bare and Harvest Eagle arrays, respectively. Each array is three-dimensional, aircraft type by number of squadrons by number of personnel (5 x 3 x 6). The aircraft order is F-4, F-15, F-16, A-10, F-4G. The squadron order is 1, 2, 3. The personnel order is 500, 1000, 1500, 2000, 2500, 3000. For example, the first six rows of the tables refer to the facility group dimensions for an F-4 aircraft, one squadron, 500 to 3000 personnel. The last six rows of the tables refer to an F-4G aircraft, 3 squadrons, 500 to 3000 personnel.

1650.	700.
1650.	700.
1650.	700.
1650.	700.
1650.	700.
1650.	700.
1650.	700.
1650.	700.
1650.	700.
1650.	700.
1650.	700.
1650.	700.
1650.	900.
1650.	900.
1650.	900.
1650.	900.
1650.	900.
1650.	900.
1350.	700.
1350.	700.
1350.	700.
1350.	700.
1350.	700.
1350.	700.
1400.	700.
1400.	700.
1400.	700.
1400.	700.
1400.	700.
1400.	700.
1550.	700.
1550.	700.
1550.	700.
1550.	700.
1550.	700.
1550.	700.
1650.	700.
1650.	700.
1650.	700.
1650.	700.
1650.	700.
1650.	700.
1650.	700.
1650.	700.
1650.	700.
1650.	700.
1650.	700.
1650.	700.
1650.	900.
1650.	900.

TABLE 1

MUNITIONS STORAGE AREA ARRAY
(HARVEST BARE)

TABLE 1--Continued

1650.	900.
1650.	900.
1650.	900.
1650.	900.
1700.	700.
1700.	700.
1700.	700.
1700.	700.
1700.	700.
1700.	700.
1700.	1200.
1700.	1200.
1700.	1200.
1700.	1200.
1700.	1200.
1700.	1200.
1750.	1200.
1750.	1200.
1750.	1200.
1750.	1200.
1750.	1200.
1750.	1200.
1350.	900.
1350.	900.
1350.	900.
1350.	900.
1350.	900.
1350.	900.
1400.	900.
1400.	900.
1400.	900.
1400.	900.
1400.	900.
1400.	900.
1550.	900.
1550.	900.
1550.	900.
1550.	900.
1550.	900.
1550.	900.

1650.	700.
1650.	700.
1650.	700.
1650.	700.
1650.	700.
1650.	700.
1650.	700.
1650.	700.
1650.	700.
1650.	700.
1650.	700.
1650.	700.
1650.	900.
1650.	900.
1650.	900.
1650.	900.
1650.	900.
1650.	900.
1350.	700.
1350.	700.
1350.	700.
1350.	700.
1350.	700.
1350.	700.
1400.	700.
1400.	700.
1400.	700.
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1400.	700.
1400.	700.
1550.	700.
1550.	700.
1550.	700.
1550.	700.
1550.	700.
1550.	700.
1650.	700.
1650.	700.
1650.	700.
1650.	700.
1650.	700.
1650.	700.
1650.	700.
1650.	700.
1650.	700.
1650.	700.
1650.	700.
1650.	700.
1650.	900.
1650.	900.

TABLE 2

MUNITIONS STORAGE AREA ARRAY
(HARVEST EAGLE)

TABLE 2--Continued

1650.	900.
1650.	900.
1650.	900.
1650.	900.
1700.	700.
1700.	700.
1700.	700.
1700.	700.
1700.	700.
1700.	700.
1700.	1200.
1700.	1200.
1700.	1200.
1700.	1200.
1700.	1200.
1700.	1200.
1750.	1200.
1750.	1200.
1750.	1200.
1750.	1200.
1750.	1200.
1750.	1200.
1350.	900.
1350.	900.
1350.	900.
1350.	900.
1350.	900.
1350.	900.
1400.	900.
1400.	900.
1400.	900.
1400.	900.
1400.	900.
1400.	900.
1550.	900.
1550.	900.
1550.	900.
1550.	900.
1550.	900.
1550.	900.

APPENDIX B

CONSTRAINTS AND SIZING FOR AIRCRAFT MAINTENANCE (MX) AREAS

I. Sources

A. MJCS 201-81.

B. Tactical Air Command Conceptual Plan--System 437A (Harvest Bare), prepared by HQ TAC/DERX, 15 Feb 1974 (drawings).

C. AFM 127-100.

D. McNickle, Major Paul. ACSC Paper.

E. AFM 86-8.

II. Discussion

A. The aircraft maintenance area consists of the facilities used by the Aircraft Generation, Equipment, and Component Repair Squadrons. Most sources facilities by the older AMS - OMS - FMS - MMS terms. Using these sources to generate facility group sizes results in approximations only. Facility groups for both types of assets are sized sufficiently larger than required to allow for site specific modifications.

B. Cryogenic facilities are located with aircraft maintenance in this program, since only R-14s are located by the fuels portion of the program.

C. Harvest Bare facilities are drawing takeoffs (B).

D. Harvest Eagle is used here as a designation for non-Harvest Bare facilities, since Harvest Eagle itself does not include maintenance facilities. With the Harvest Eagle designation, maintenance facilities would be either tents or relocatable buildings.

III. Constraints

A. MX > 2350 FT from MSA.

B. MX > 125 FT from PA.

C. MX < 200 FT from PA (authors' assumption not used in program).

D. MX > 1000 FT from RWY (reduced to 500 FT for this program).

E. MX > 250 FT from farside of taxiway.

IV. Assumptions

A. Main Operating Base support is minimal.

B. The space allocated for a Weapons Calibration Shop can be used by other aircraft. Normally, only F-4s require such a shop.

V. Facility Definitions and Sizes

A. The maintenance area consists of space for:

1. Aircraft Hangars
2. Reclamation Shop
3. Aircraft Weapons Calibration Shop
4. Aircraft Organizational Maintenance Squadron
5. Aircraft Engine Repair Shop
6. Aircraft General Purpose Maintenance Shop
7. Weapons Maintenance

8. Avionics Shop

9. Ground Support Equipment Shop

10. Parachute/Dinghy Maintenance Shop

11. Cryogenic Facility (LOX)

B. Internal Requirements: (Harvest Eagle)

1. A/C Mx Hangar - SF per A/C

   F-4 = 1,562

   F-15 = 1,779

   F-16 = 1,240

   A-10 = 1,337

2. Reclamation Shop - 1,000 SF

3. A/C Weapons Calibration Shop - 6000 SF

4. A/C OMS - 238 SF per A/C

5. A/C Engine Repair Shop - 7,500 SF

6. General Purpose A/C Mx Shop - 472 SF per A/C

7. Weapons Maintenance - 5,520 SF

8. Avionics Shop - 236 SF per A/C

9. Ground Support Equipment Shop - 125 SF per A/C + 3,880 SF per MOB

10. Parachute/Dinghy Mx Shop - 6,065 SF

11. Cryogenic Facility - 2,400 SF

C. Facilities: (Harvest Bare)

1. Avionics Maintenance Squadron

2. Field Maintenance Squadron

3. Organizational Maintenance Squadron

4. Cryogenic Facility (LOX)

Support Type	Area Sizing for Personnel Deployed (FT)	
Squadrons	1500 Personnel	3000 Personnel
AMS	500 x 113	500 x 113
FMS	240 x 283	240 x 308
OMS	1SQ-150x275, 2SQ-225x275	3SQ-353x275
LOX	121 x 30	121 x 30
	Square Footage	
AMS	56,500	56,500
FMS	67,920	73,920
OMS	1SQ-41,250, 2SQ-61,875	97,075
LOX	3,630	3,630

VI. Algorithm Development

A. No hangars deployed with Harvest Eagle.

B. X = number of A/C.

C. Total SF = (1071)X + 32,365.

VII. Padding Factors and Dimensions

A. Harv[illegible] Eagle

1SQ - 250'x250'	+ 150' per SQ in one	400' x 250'
2SQ - 300'x300'	dimension to allow for	600' x 300'
3SQ - 350'x350'	facility spacing and usable terrain	800' x 350'

B. Harvest Bare

Total Square Footage and Areas (FT)

1SQ, 1500 personnel - 169,300 = 500 x 339

2SQ, 1500 personnel - 189,925 = 500 x 380

3SQ, 1500 personnel - 195,925 = 500 x 392

3SQ, 3000 personnel - 231,125 = 500 x 463

VIII. Tables

Tables 3 and 4 show the Harvest Bare and Harvest Eagle arrays, respectively. Each array is three dimensional, aircraft type by number of squadrons by number of personnel (5 x 3 x 6). The aircraft order is F-4, F-15, F-16, A-10, F-4G. The squadron order is 1, 2, 3. The personnel order is 500, 1000, 1500, 2000, 2500, 3000. For example, the first six rows of the tables refer to the facility group dimensions for an F-4 aircraft, one squadron, 500 to 3000 personnel. The last six rows of the tables refer to an F-4G aircraft, 3 squadrons, 500 to 3000 personnel.

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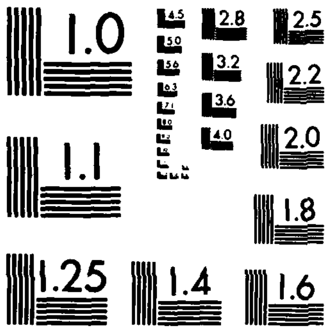

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

500.	339.
500.	339.
500.	339.
500.	339.
500.	339.
500.	339.
500.	380.
500.	380.
500.	380.
500.	380.
500.	380.
500.	380.
500.	463.
500.	463.
500.	463.
500.	463.
500.	463.
500.	463.
500.	339.
500.	339.
500.	339.
500.	339.
500.	339.
500.	339.
500.	380.
500.	380.
500.	380.
500.	380.
500.	380.
500.	380.
500.	463.
500.	463.
500.	463.
500.	463.
500.	463.
500.	463.
500.	339.
500.	339.
500.	339.
500.	339.
500.	339.
500.	339.
500.	380.
500.	380.
500.	380.
500.	380.
500.	380.
500.	380.
500.	463.
500.	463.

TABLE 3

AIRCRAFT MAINTENANCE AREA ARRAY
(HARVEST BARE)

TABLE 3--Continued

500.	463.
500.	463.
500.	463.
500.	463.
500.	339.
500.	339.
500.	339.
500.	339.
500.	339.
500.	339.
500.	380.
500.	380.
500.	380.
500.	380.
500.	380.
500.	380.
500.	463.
500.	463.
500.	463.
500.	463.
500.	463.
500.	463.
500.	339.
500.	339.
500.	339.
500.	339.
500.	339.
500.	339.
500.	380.
500.	380.
500.	380.
500.	380.
500.	380.
500.	380.
500.	463.
500.	463.
500.	463.
500.	463.
500.	463.
500.	463.

400.	250.
400.	250.
400.	250.
400.	250.
400.	250.
400,	250
600.	300.
600.	300.
600.	300.
600.	300.
600.	300.
600.	300.
800.	350.
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600.	300.
800.	350.
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800.	350.
800.	350.
800.	350.
800.	350.
400.	250.
400.	250.
400.	250.
400.	250.
400.	250.
400.	250.
600.	300.
600.	300.
600.	300.
600.	300.
600.	300.
600.	300.
800.	350.
800.	350.

TABLE 4

AIRCRAFT MAINTENANCE AREA ARRAY
(HARVEST EAGLE)

TABLE 4--<u>Continued</u>

800.	350.
800.	350.
800.	350.
800.	350.
400.	250.
400.	250.
400.	250.
400.	250.
400.	250.
400.	250.
600.	300.
600.	300.
600.	300.
600.	300.
600.	300.
600.	300.
800.	350.
800.	350.
800.	350.
800.	350.
800.	350.
800.	350.
400.	250.
400.	250.
400.	250.
400.	250.
400.	250.
400.	250.
600.	300.
600.	300.
600.	300.
600.	300.
600.	300.
600.	300.
800.	350.
800.	350.
800.	350.
800.	350.
800.	350.
800.	350.

APPENDIX C

CONSTRAINTS AND SIZING FOR AIRCRAFT REFUELING (P) AREAS

I. Sources

A. AFM 144-1.

B. AFM 127-100.

C. McNickle, Major Paul. ACSC Paper.

D. Interviews with Mr. Cliff Heath, HQ TAC.

II. Discussion

POL fuel bladder sizes are the same regardless of Harvest Bare or Harvest Eagle deployment.

III. Constraints

A. POL > 2130 FT from MSA.

B. POL > 50 FT from taxiway (nearside).

C. POL > 200 FT from runway.

D. POL < 150 FT from taxiway (authors' judgement--not in program).

E. R-14s should be located in two places at least, preferably three or four.

F. Bladders are located 100-125 FT from refueling pit (taxiway).

G. Refueling pits minimum 50 FT apart, prefer 100 FT apart.

IV. Assumptions

Only JP-4 jet fuel required.

V. Facility Definitions and Sizes

POL Support Requirements

No. of Sqds	No. of R-14s (250K bladders each)	No. of 450K bladder units
1	3	1
2	4	2
3	6	3

VI. Padding Factors and Dimensions

R-14 space = 90' x 100', round to 100' x 100'.

VII. Tables

Tables 5 and 6, respectively, show the Harvest Bare and Harvest Eagle systems. The number of R-14s is listed.

3.
4.
6.

TABLE 5

AIRCRAFT REFUELING AREA ARRAY
(HARVEST BARE)

3.
4.
6.

TABLE 6

AIRCRAFT REFUELING AREA ARRAY
(HARVEST EAGLE)

APPENDIX D

CONSTRAINTS AND SIZING FOR OPERATIONS (OPS) AREAS

I. Sources

A. AFM 127-100.

B. MJCS 201-81 (used for Harvest Eagle).

C. Tactical Air Command Conceptual Plan--System 437A (Harvest Bare), prepared by HQ TAC/DERX, 15 Feb 1974.

II. Constraints

A. OPS > 2350 FT from MSA.

B. OPS > 125 FT from PA.

C. OPS > 250 FT from farside of taxiway.

D. OPS > 1000 FT from runway (program waivers to 500 FT).

III. Assumptions

A. Harvest Eagle facilities will be tents or relocatable buildings.

B. Harvest Bare facilities will be sized by direct takeoffs from the plan.

IV. Facility Definitions and Sizes

A. The operations area consists of space for:

1. Fire Station

2. Base Operations

3. Weather

4. Squadron Operations

B. Internal Spacing Requirements:

1. Fire Station - 6,000 FT

2. Base Operations - 5,055 FT

3. Weather - Assume included with Base Operations

4. Squadron Operations - SF per A/C

F-4 = 458

F-15,16 = 375

A-10 = 242

V. Algorithm Development

A. X = Total number of A/C

B. Total amount of SF = X() + 11,055

VI. Dimensions with Padding Factors

A. Harvest Eagle

Add 50, 75, 100 FT in orde_ to each SQ to allow for spacing and unknown site conditions.

SQs	F-4,F-4G,F-15,F-16	A-10
Number of Squadrons		
1	200' x 150'	200' x 150'
2	275' x 200'	225' x 150'
3	300' x 200'	300' x 200'

B. Harvest Bare

	1SQ	2SQ	3SQ
	36,704	36,704	36,704
	70,965	70,965	70,965
Totals	107,669	169,919	232,169
	500 x 216	500 x 340	500 x 465

VII. Tables

Tables 7 and 8 show the Harvest Bare and Harvest Eagle arrays, respectively. Each array is three-dimensional, aircraft type, number of squadrons, number of personnel (5 x 3 x 6). The aircraft order is 1, 2, 3. The personnel order is 500, 1000, 1500, 2000, 2500, and 3000. For example, the first six rows of the tables refer to the facility group dimensions for an F-4 aircraft, one squadron, 500 to 3000 personnel. The last six rows of the tables refer to an F-4G aircraft, three squadrons, 500 to 3000 personnel.

TABLE 7

FLIGHT OPERATIONS AREA ARRAY
(HARVEST BARE)

500.	216.
500.	216.
500.	216.
500.	216.
500.	216.
500.	216.
500.	340.
500.	340.
500.	340.
500.	340.
500.	340.
500.	340.
500.	465.
500.	465.
500.	465.
500.	465.
500.	465.
500.	465.
500.	216.
500.	216.
500.	216.
500.	216.
500.	216.
500.	216.
500.	340.
500.	340.
500.	340.
500.	340.
500.	340.
500.	340.
500.	465.
500.	465.
500.	465.
500.	465.
500.	465.
500.	465.
500.	216.
500.	216.
500.	216.
500.	216.
500.	216.
500.	216.
500.	340.
500.	340.
500.	340.
500.	340.
500.	340.
500.	340.
500.	465.
500.	465.

TABLE 7--Continued

500.	465.
500.	465.
500.	465.
500.	465.
500.	216.
500.	216.
500.	216.
500.	216.
500.	216.
500.	216.
500.	340.
500.	340.
500.	340.
500.	340.
500.	340.
500.	340.
500.	465.
500.	465.
500.	465.
500.	465.
500.	465.
500.	465.
500.	216.
500.	216.
500.	216.
500.	216.
500.	216.
500.	216.
500.	340.
500.	340.
500.	340.
500.	340.
500.	340.
500.	340.
500.	465.
500.	465.
500.	465.
500.	465.
500.	465.
500.	465.

TABLE 8

FLIGHT OPERATIONS AREA ARRAY
(HARVEST EAGLE)

200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
275.	200.
275.	200.
275.	200.
275.	200.
275.	200.
275.	200.
300.	200.
300.	200.
300.	200.
300.	200.
300.	200.
300.	200.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
275.	200.
275.	200.
275.	200.
275.	200.
275.	200.
275.	200.
300.	200.
300.	200.
300.	200.
300.	200.
300.	200.
300.	200.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
275.	200.
275.	200.
275.	200.
275.	200.
275.	200.
275.	200.
300.	200.
300.	200.

TABLE 8--Continued

300.	200.
300.	200.
300.	200.
300.	200.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
225.	150.
225.	150.
225.	150.
225.	150.
225.	150.
225.	150.
300.	200.
300.	200.
300.	200.
300.	200.
300.	200.
300.	200.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
275.	200.
275.	200.
275.	200.
275.	200.
275.	200.
275.	200.
300.	200.
300.	200.
300.	200.
300.	200.
300.	200.
300.	200.

APPENDIX E

CONSTRAINTS AND SIZING FOR COMMAND (CMD) AREAS

I. Sources

A. MJCS 201-81.

B. Harvest Bare Plan.

C. AFM 127-100.

D. AFM 86-8.

II. Constraints

A. CMD > 2350 FT from MSA.

B. CMD > 1000 FT from runway (reduced to 500 FT in program).

C. CMD > 250 FT from taxiways.

D. CMD > 125 FT from PA.

III. Facility Definitions and Sizes

A. The command area consists of space for:

1. Security Police
2. Wing Command Post
3. Communications
4. Intelligence

B. Internal Requirements:

1. Security Police - 9,695 SF
2. WCP - Unknown, assume 1,000 SF
3. Communications - 8,100 SF
4. Intelligence - Unknown, use photo lab - 3,000 SF

IV. Padding Factors and Dimensions

A. Harvest Eagle

150' x 150'

Add 50' in one dimension to allow for unknown site conditions.

200' x 150'

B. Harvest Bare

Harvest Bare facilities are direct takeoffs from drawings.

V. Tables

Tables 9 and 10 show the Harvest Bare and Harvest Eagle arrays, respectively. Each array is three-dimensional, aircraft type by number of squadrons by number of personnel (5 x 3 x 6). The aircraft order is F-4, F-15, F-16, A-10, F-4G. The squadron order is 1, 2, 3. The personnel order is 500, 1000, 1500, 2000, 2500, 3000. For example, the first six rows of the tables refer to the facility group dimensions for an F-4 aircraft, one squadron, 500 to 3000 personnel. The last six rows of the tables refer to an F-4G aircraft, 3 squadrons, 500 to 3000 personnel.

TABLE 9

COMMAND AREA ARRAY (HARVEST BARE)

500.	276.
500.	276.
500.	276.
500.	395.
500.	395.
500.	395.
500.	276.
500.	276.
500.	276.
500.	395.
500.	395.
500.	395.
500.	276.
500.	276.
500.	276.
500.	395.
500.	395.
500.	395.
500.	276.
500.	276.
500.	276.
500.	395.
500.	395.
500.	395.
500.	276.
500.	276.
500.	276.
500.	395.
500.	395.
500.	395.
500.	276.
500.	276.
500.	276.
500.	395.
500.	395.
500.	395.
500.	276.
500.	276.
500.	276.
500.	395.
500.	395.
500.	395.
500.	276.
500.	276.
500.	276.
500.	395.
500.	395.
500.	395.
500.	276.
500.	276.

TABLE 9--*Continued*

500.	276.
500.	395.
500.	395.
500.	395.
500.	276.
500.	276.
500.	276.
500.	395.
500.	395.
500.	395.
500.	276.
500.	276.
500.	276.
500.	395.
500.	395.
500.	395.
500.	276.
500.	276.
500.	276.
500.	395.
500.	395.
500.	395.
500.	276.
500.	276.
500.	276.
500.	395.
500.	395.
500.	395.
500.	276.
500.	276.
500.	276.
500.	395.
500.	395.
500.	395.
500.	276.
500.	276.
500.	276.
500.	395.
500.	395.
500.	395.

TABLE 10

COMMAND AREA ARRAY (HARVEST EAGLE)

200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.

TABLE 10--Continued

200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.
200.	150.

APPENDIX F

CONSTRAINTS AND SIZING FOR BASE SUPPORT (BSP) AREAS

I. Sources

A. MJCS 201-81.

B. Harvest Bare Plan.

C. AFM 127-100.

D. AFM 86-8.

II. Constraints

A. BSP > 2350 FT from MSA.

B. BSP > 1000 FT from Runway (500 FT used in program).

C. BSP > 250 FT from Taxiways.

D. BSP > 125 FT from PA.

III. Facility Definitions and Sizes

A. The base support area consists of space for:

1. Civil Engineering

2. Transportation

3. Supply

B. Internal Requirements

1. Civil Engineering - 3.25 SF/man

2. Transportation - 12,000 FT

3. Supply - 12.83 SF/man + 488 SF/aircraft + 13,500 SF

IV. Algorithm Development

Total amount of SF = 16.08 SF/man + 488 SF/aircraft + 25,500 SF

V. Padding Factors and Dimensions

A. Harvest Eagle

Add 10 percent in one dimension to account for unuseable terrain.

Personnel	A/C	Size
500	24(1SQ)	220' x 200'
1000	24	275' x 250'
1500	24	275' x 250'
1000	48(2SQ)	300' x 300'
1500	48	330' x 300'
2000	48	330' x 300'
2500	48	330' x 300'
2000	72(3SQ)	385' x 350'
2500	72	385' x 350'
3000	72	385' x 350'

B. Harvest Bare

Harvest Bare facilities are direct drawing takeoffs.

VI. Tables

Tables 11 and 12 show the Harvest Bare and Harvest Eagle arrays, respectively. Each array is three-dimensional, aircraft type by number of squadrons by number of personnel (5 x 3 x 6). The aircraft order is F-4, F-15, F-16, A-10, F-4G. The squadron order is 1, 2, 3. The personnel order is 500, 1000, 1500, 2000, 2500, 3000. For example, the first six rows of the tables refer to the facility group dimensions for an F-4 aircraft, one squadron, 500 to 3000 personnel. The last six rows of the tables refer to an F-4G aircraft, 3 squadrons, 500 to 3000 personnel.

625.	500.
625.	500.
625.	500.
882.	500.
882.	500.
882.	500.
625.	500.
625.	500.
625.	500.
882.	500.
882.	500.
882.	500.
625.	500.
625.	500.
625.	500.
882.	500.
882.	500.
882.	500.
625.	500.
625.	500.
625.	500.
882.	500.
882.	500.
882.	500.
625.	500.
625.	500.
625.	500.
882.	500.
882.	500.
882.	500.
625.	500.
625.	500.
625.	500.
882.	500.
882.	500.
882.	500.
625.	500.
625.	500.
625.	500.
882.	500.
882.	500.
882.	500.
625.	500.
625.	500.
625.	500.
882.	500.
882.	500.
882.	500.
625.	500.
625.	500.

TABLE 11

BASE SUPPORT AREA ARRAY (HARVEST BARE)

TABLE 11--Continued

625.	500.
882.	500.
882.	500.
882.	500.
625.	500.
625.	500.
625.	500.
882.	500.
882.	500.
882.	500.
625.	500.
625.	500.
625.	500.
882.	500.
882.	500.
882.	500.
625.	500.
625.	500.
625.	500.
882.	500.
882.	500.
882.	500.
625.	500.
625.	500.
625.	500.
882.	500.
882.	500.
882.	500.
625.	500.
625.	500.
625.	500.
882.	500.
882.	500.
882.	500.
625.	500.
625.	500.
625.	500.
882.	500.
882.	500.
882.	500.

220.	200.
275.	250.
275.	250.
275.	250.
275.	250.
275.	250.
330.	300.
330.	300.
330.	300.
330.	300.
330.	300.
330.	300.
330.	300.
330.	300.
330.	300.
385.	350.
385.	350.
385.	350.
220.	200.
275.	250.
275.	250.
275.	250.
275.	250.
275.	250.
330.	300.
330.	300.
330.	300.
330.	300.
330.	300.
330.	300.
330.	300.
330.	300.
330.	300.
385.	350.
385.	350.
385.	350.
220.	200.
275.	250.
275.	250.
275.	250.
275.	250.
275.	250.
330.	300.
330.	300.
330.	300.
330.	300.
330.	300.
330.	300.
330.	300.
330.	300.

TABLE 12

BASE SUPPORT AREA ARRAY
(HARVEST EAGLE)

TABLE 12--Continued

330.	300.
385.	350.
385.	350.
385.	350.
220.	200.
275.	250.
275.	250.
275.	250.
275.	250.
275.	250.
330.	300.
330.	300.
330.	300.
330.	300.
330.	300.
330.	300.
330.	300.
330.	300.
330.	300.
385.	350.
385.	350.
385.	350.
220.	200.
275.	250.
275.	250.
275.	250.
275.	250.
275.	250.
330.	300.
330.	300.
330.	300.
330.	300.
330.	300.
330.	300.
330.	300.
330.	300.
330.	300.
385.	350.
385.	350.
385.	350.

APPENDIX G

CONSTRAINTS AND SIZING FOR CANTONMENT (CTN) AREAS

I. Sources

A. Tactical Air Command Conceptual Plan - System 437A (Harvest Bare), prepared by HQ TAC/DERX, 15 Feb 1974.

B. MJCS 201-81.

C. Air Force Engineering and Services Quarterly.

D. Tent City Tips.

E. PACAF Tent City Support Plan.

F. AFM 86-3.

G. AFM 127-100.

H. AFM 86-8.

I. Notes from "Contingency Engineering."

II. Contraints

A. CTN > 2350 FT from MSA.

B. CTN > 1000 FT from runway (reduced to 500 FT in program).

C. CTN > 250 FT from taxiways.

D. CTN > 125 FT from PA.

E. CTN < 1500 FT from water source (author judgement not used in program).

III. Facility Definitions and Sizes

A. The cantonment area consists of space for:

1. Regular Billets

2. Mess Facilities

3. Latrines

4. Shave/Shower units

5. A Chapel

6. A Post Office with packaging facilities

7. A Barber

8. A BX

9. An Officer's Club

10. An NCO Club

11. A Recreation Center

12. A Theater

13. A Laundry

14. A Billeting Office

15. A Flagpole

16. Interior roads

17. VIP Billets

B. Internal Spacing requirements: (nondispersed)

1. 8' between tents

2. 30' between tent rows

3. 100' latrine to billet

4. 30' latrine to latrine

5. 30' latrine to shower

6. 150' firebreaks every 1,000'

7. Every fourth space vacant

8. 300' latrine to messing

IV. Algorithm Development

A. External Spacing requirements: (nondispersed)

No requirement.

B. Internal Requirements:

1. Billeting - 6 officers/tent, 10 enlisted/tent, 10 percent pad.

   18 percent officer, 82 percent enlisted.

   P = Total Number of Personnel.

   Billeting Tents = 1.1((0.18P/6) + (0.82P/10))

   = 0.1232P.

   - 500 = 62 billeting tents.
   - 1000 = 124
   - 1500 = 185
   - 2000 = 247
   - 2500 = 308
   - 3000 = 370

2. Messing - 4 kitchens/1000 people, 9 SF per man.

   Assume 4 30-min feedings per 2 hr meal period, 72 seats per GPL tent.

   - 500 = 2 kitchen + 2 GPLs for seating.
   - 1000 = 4 + 4
   - 1500 = 6 + 6

3. Latrines - Seat 8 percent of personnel, 16 seats per GPM tent.

   Latrine tents = .005P

- 500 = 3 latrine tents
- 1000 = 6 latrine tents
- 1500 = 9 latrine tents

4. Shave/shower units - 2 tents per unit, 8 shower heads per shower tent, assume 5 min. shower/man, 30 men/shower head.

   Shave/shower units = P/240

   S/S tents = 2(units).

   - 500 = 4 tents
   - 1000 = 8 tents
   - 1500 = 12 tents

5. Chapel - 1 GPL tent, 18' by 52'
6. Post Office - 1 GPM tent, 16' by 32'
7. Barber - 1 GPM
8. BX - 1 GPM
9. Officers Club - 1 GPM/1000
10. NCO Club - 1 GPM/1000
11. Recreation Center - 2 GPMs/1000
12. Theater - use Chapel
13. Laundry - 1 GPM/1000
14. Billeting Office - 1 GPM
15. Flagpole - one
16. Interior roads - not considered since non-dispersed layout
17. VIP Billets - 2 GPM tents

C. Tentage

500 - 84 total tents

1000 - 157

1500 - 235

2000 - 308

2500 - 385

3000 - 458

D. Algorithm

1. Plan 2 tent column for every tent row
2. B = total number of billeting tents
3. Number of rows = 1/2 (columns)
4. NR = SQRT(B/2)
5. NC = 2(SQRT(B/2))
6. X Dimension = 30(NC) + 8 + 100(estimate for latrines, etc.)
7. Y Dimension = 62(NR) + 30 + 250(estimate for messing, etc.)

Harvest Bare

Personnel	Facility	Square Footage
500	Chapel	6,750
500	Laundry	2,880
500	Billeting	182,682
500	Services	20,000

Total Square Footage = 212,312 = 1000 x 213

Personnel	Facility	Square Footage
1000	Chapel	6,750
1000	Laundry	2,880
1000	Billeting	425,064
1000	Services	55,000
Total Square Footage = 489,694 = 1000 x 490		
1500	Chapel	6,750
1500	Laundry	2,880
1500	Billeting	1,010,328
1500	Services	79,430
Total Square Footage = 1,099,388 = 1000 x 1100		
2000	Chapel	11,025
2000	Laundry	4,320
2000	Billeting	1,261,860
2000	Services	126,430
Total Square Footage = 1,403,635 = 1000 x 1404		
2500	Chapel	11,025
2500	Laundry	4,320
2500	Billeting	1,513,392
2500	Services	173,430
Total Square Footage = 1,702,167 = 1000 x 1703		

Personnel	Facility	Square Footage
3000	Chapel	11,025
3000	Laundry	4,320
3000	Billeting	1,764,924
3000	Services	205,860

Total Square Footage = 1,986,129 = 1000 x 1987

V. Padding Factors and Dimensions

A. Harvest Eagle

Add 20 percent in long dimension to account for unuseable area.

500 - 450' x 800'

1000 - 600' x 960'

1500 - 700' x 1080'

2000 - 800' x 1200'

2500 - 900' x 1500' (includes 150' fire break)

3000 - 1000' x 1600'

B. Harvest Bare facilities are sized directly from drawings.

VI. Tables

Tables 13 and 14 show the Harvest Bare and Harvest Eagle arrays, respectively. Each array is three-dimensional, aircraft type by number of squadrons by number of personnel (5 x 3 x 6). The aircraft order is F-4, F-15, F-16, A-10, F-4G. The squadron order is 1, 2, 3. The personnel order is 500, 1000, 1500, 2000, 2500, 3000. For example, the first six rows of the tables refer to the facility group dimensions for an F-4 aircraft, one squadron, 500 to 3000 personnel. The last six rows of the tables refer to an F-4G aircraft, 3 squadrons, 500 to 3000 personnel.

1000.	213.
1000.	490.
1100.	1000.
1404.	1000.
1703.	1000.
1987.	1000.
1000.	213.
1000.	490.
1100.	1000.
1404.	1000.
1703.	1000.
1987.	1000.
1000.	213.
1000.	490.
1100.	1000.
1404.	1000.
1703.	1000.
1987.	1000.
1000.	213.
1000.	490.
1100.	1000.
1404.	1000.
1703.	1000.
1987.	1000.
1000.	213.
1000.	490.
1100.	1000.
1404.	1000.
1703.	1000.
1987.	1000.
1000.	213.
1000.	490.
1100.	1000.
1404.	1000.
1703.	1000.
1987.	1000.
1000.	213.
1000.	490.
1100.	1000.
1404.	1000.
1703.	1000.
1987.	1000.
1000.	213.
1000.	490.
1100.	1000.
1404.	1000.
1703.	1000.
1987.	1000.
1000.	213.
1000.	490.

TABLE 13

CANTONMENT AREA ARRAY
(HARVEST BARE)

TABLE 13--Continued

1100.	1000.
1404.	1000.
1703.	1000.
1987.	1000.
1000.	213.
1000.	490.
1100.	1000.
1404.	1000.
1703.	1000.
1987.	1000.
1000.	213.
1000.	490.
1100.	1000.
1404.	1000.
1703.	1000.
1987.	1000.
1000.	213.
1000.	490.
1100.	1000.
1404.	1000.
1703.	1000.
1987.	1000.
1000.	213.
1000.	490.
1100.	1000.
1404.	1000.
1703.	1000.
1987.	1000.
1000.	213.
1000.	490.
1100.	1000.
1404.	1000.
1703.	1000.
1987.	1000.
1000.	213.
1000.	490.
1100.	1000.
1404.	1000.
1703.	1000.
1987.	1000.

800. 450.
960. 600.
1080. 700.
1200. 800.
1500. 900.
1600. 1000.
800. 450.
960. 600.
1080. 700.
1200. 800.
1500. 900.
1600. 1000.
800. 450.
960. 600.
1080. 700.
1200. 800.
1500. 900.
1600. 1000.
800. 450.
960. 600.
1080. 700.
1200. 800.
1500. 900.
1600. 1000.
800. 450.
960. 600.
1080. 700.
1200. 800.
1500. 900.
1600. 1000.
800. 450.
960. 600.
1080. 700.
1200. 800.
1500. 900.
1600. 1000.
800. 450.
960. 600.
1080. 700.
1200. 800.
1500. 900.
1600. 1000.
800. 450.
960. 600.
1080. 700.
1200. 800.
1500. 900.
1600. 1000.
800. 450.
960. 600.

TABLE 14

CANTONMENT AREA ARRAY
(HARVEST EAGLE)

TABLE 14--Continued

1080.	700.
1200.	800.
1500.	900.
1600.	1000.
800.	450.
960.	600.
1080.	700.
1200.	800.
1500.	900.
1600.	1000.
800.	450.
960.	600.
1080.	700.
1200.	800.
1500.	900.
1600.	1000.
800.	450.
960.	600.
1080.	700.
1200.	800.
1500.	900.
1600.	1000.
800.	450.
960.	600.
1080.	700.
1200.	800.
1500.	900.
1600.	1000.
800.	450.
960.	600.
1080.	700.
1200.	800.
1500.	900.
1600.	1000.
800.	450.
960.	600.
1080.	700.
1200.	800.
1500.	900.
1600.	1000.

APPENDIX H

CONSTRAINTS AND SIZING FOR
MEDICAL (H) AREAS

I. Sources

A. Harvest Bare plan.

B. Interview with SMSgt Snyder.

C. TACR 400-10.

D. AFM 127-100.

E. AFR 86-8.

II. Discussion

The siting of a field medical facility must be based on a balance of many factors. Some of the considerations include:

a. The threat to the supported site; e.g., air attack, ground attack.

b. The threat to the medical facility; e.g., looters, enemy observance of the Geneva Convention.

c. Location of the supported population.

d. Terrain.

e. Environmental; e.g., mosquitoes, flies, sewage areas, availability of water.

2. Suggestions for siting/identifying the medical facility in the field include:

a. Stay well away from high priority base target areas; e.g., airplanes, POL facilities.

b. Avoid inbound/exit routes that would be used by enemy aircraft.

c. Site facilities (where prevailing winds are) well upwind of high value targets.

d. Disperse facilities/parking to reduce likelihood of attack/damage.

e. Seek advice from intelligence and the commander on whether to display a Red Cross symbol.

f. If a Red Cross symbol is displayed, insure it or the medical facility is not in a position to be used as an aiming/bombing point.

g. If a Red Cross symbol is not displayed, camouflage the medical facility.

h. Coordinate with security police to insure siting within the defense perimeter whenever possible.

i. Locate in a well drained area, near a good water source and away from the hazards of standing water, sewage, and garbage. Maximize the protective use of the terrain/vegetation, put hills, trees, etc., between the medical facilities, and likely targets.

j. Site field medical facility where it will not be highly accessible to civilian/refugee populations seeking emergency medical treatment. Civilian populations are expected to receive treatment from civilian hopsitals, etc.; if the field medical facility is more accessible than the civilian facility, it is likely to be deluged with civilian casualties. Therefore, avoid major refugee routes from population centers, if possible.

k. For desert environments, the following is recommended:

1. Buildings and tents should be arranged with openings in a north-south configuration so ventilation is better. Primary heat comes from east-west directions and increased insulation on those sides is advantageous.

2. Camps should be located in valleys or dry river beds. These areas are cooler and offer protection from the strong desert winds. Also permits digging holes in hillside for storage, as much of the desert is rocky terrain.

3. Doorways and windows should be shaded to protect from sun and improve ventilation.

4. An additional roof, or flyover shelter provides an airspace, and convection airflow helps cool facility interior.

5. Air conditioned facilities are not recommended and have been associated with a history of lung disorders, including pneumonia. Individual acclimation to desert hardships has been more healthy than creating an artificial environment [67].

III. Constraints

A. MED > 2350 FT from MSA

B. MED > 125 FT from PA

C. MED > 250 FT from taxiway

D. MED > 1000 FT from runway (program waivers to 500 FT)

E. Constraints (subjective) not loaded in program.

1. Not next to CE or Transportation (Dust)

2. Close to but not adjacent to cantonment

3. Flightline access

IV. Padding Factors and Dimensions

A. Harvest Eagle

1. Up to 1000 personnel - ATC - 1 GPM tent area - 32 FT by 92 FT, round to 50 by 100 FT

2. 1000 to 3000 personnel - ATH - 7 tents - area 125 FT by 125 FT

B. Harvest Bare

Use the MATH - area 177 FT by 100 FT

V. Tables

Tables 15 and 16 show the Harvest Bare and Harvest Eagle arrays, respectively. Each array is three-dimensional, aircraft type, number of squadrons, number of personnel (5 x 3 x 6). The aircraft and squadron order match all other arrays. The personnel order is 500, 1000, 1500, 2000, 2500, 3000. For example, the first six rows of the tables refer to the facility group dimensions for an F-4 aircraft, one squadron, 500 to 3000 personnel. The last six rows of the tables refer to an F-4G aircraft, three squadrons, 500 to 3000 personnel.

TABLE 15

MEDICAL AREA ARRAY
(HARVEST BARE)

177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.

TABLE 15--Continued

177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.
177.	100.

TABLE 16

MEDICAL AREA ARRAY
(HARVEST EAGLE)

50.	100.
50.	100.
125.	125.
125.	125.
125.	125.
125.	125.
50.	100.
50.	100.
125.	125.
125.	125.
125.	125.
125.	125.
50.	100.
50.	100.
125.	125.
125.	125.
125.	125.
125.	125.
50.	100.
50.	100.
125.	125.
125.	125.
125.	125.
125.	125.
50.	100.
50.	100.
125.	125.
125.	125.
125.	125.
125.	125.
50.	100.
50.	100.
125.	125.
125.	125.
125.	125.
125.	125.
50.	100.
50.	100.
125.	125.
125.	125.
125.	125.
125.	125.
50.	100.
50.	100.
125.	125.
125.	125.
125.	125.
125.	125.
50.	100.
50.	100.

TABLE 16--Continued

125.	125.
125.	125.
125.	125.
125.	125.
50.	100.
50.	100.
125.	125.
125.	125.
125.	125.
125.	125.
50.	100.
50.	100.
125.	125.
125.	125.
125.	125.
125.	125.
50.	100.
50.	100.
125.	125.
125.	125.
125.	125.
125.	125.
50.	100.
50.	100.
125.	125.
125.	125.
125.	125.
125.	125.
50.	100.
50.	100.
125.	125.
125.	125.
125.	125.
125.	125.
50.	100.
50.	100.
125.	125.
125.	125.
125.	125.
125.	125.

APPENDIX I

COMPUTER PROGRAM USER AND MAINTENANCE GUIDE

User Guide

Examples of Program Operation

To prepare a bare base layout using this computer program, the user must first compile a program and store it in an "a out" file. This file is prepared by using the "f77 carnad.f-lplotl0" command. The VAX 11/780 compiles the file. In order to execute the file, the user must be logged in on a correctly configured Tektronix 4014 terminal.

When the compiling is complete, the user types "a out." This command starts the execution sequence. Figure 9 shows the opening program directives as they appear on the screen. The second carriage return produces the first nine lines of Figure 10. The key code refers to the keyboard keys that will be used to design the facility master plan. The first requirement is for the user to choose the base of interest. Currently, only two bases are loaded into the files, bases X and Y. These are shown in Figures 11 and 12 respectively. Once the user selects a base, the computer checks for a previously prepared file, containing a partial or complete master plan for that base. If none exists, the computer notifies the user and begins the interactive questions. If a file has been previously prepared and stored, the user is asked if he desires to see (work on) it. If the user responds affirmatively, the

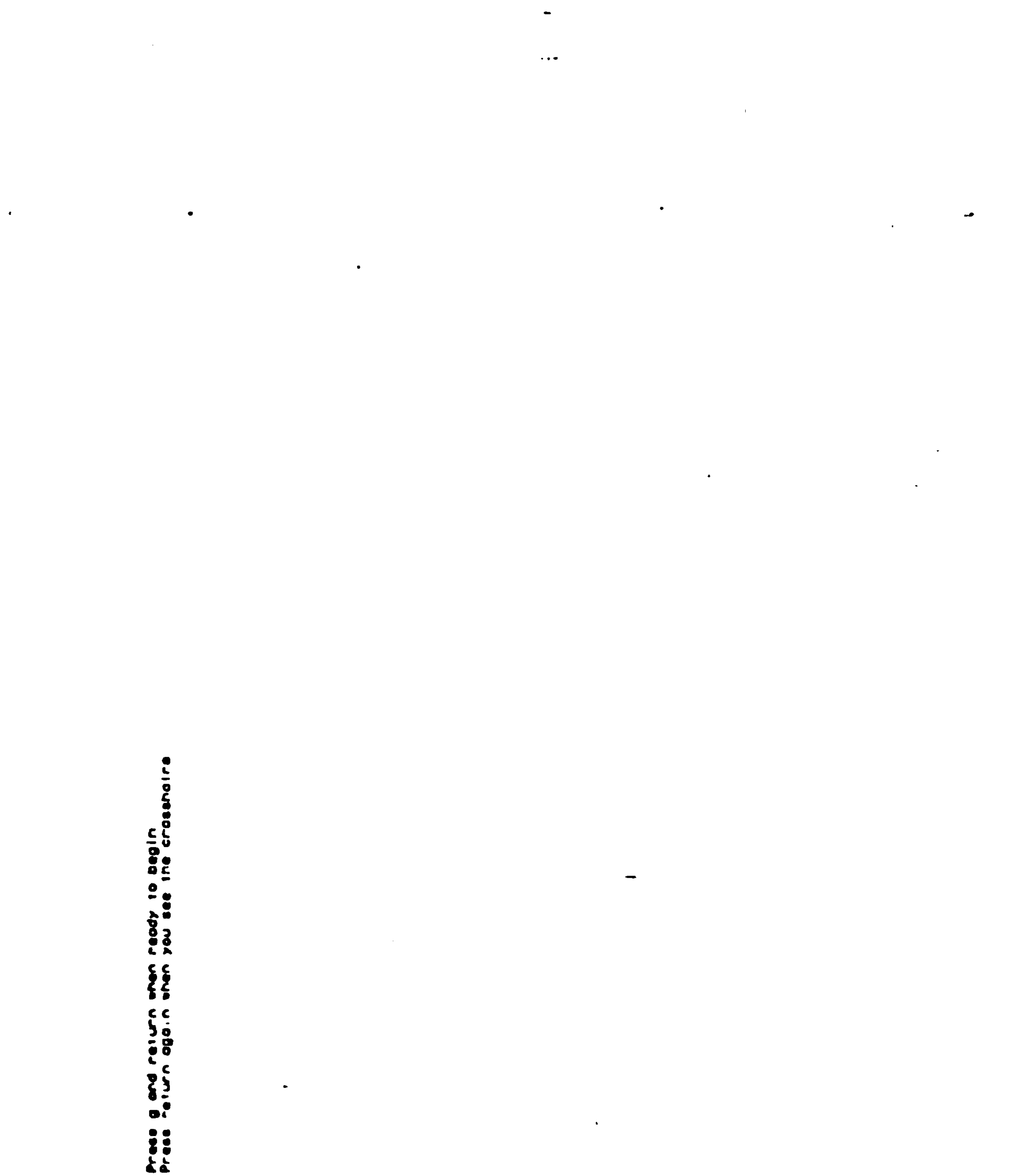

Fig. 9. Opening Directives

```
  Welcome to CARMAD, a systematic computer
program for contingency base master planning

Key Code  c = clear, d = draw, q = quit
s = save, y(yes) = go to next facility.

Keys a and b can be used to change facility
orientation.

Choose the base of interest.
1) Base X
2) Base Y

 Do you wish to
see the file ?
Choose y or n.

  What type of aircraft will be deployed ?
  Choose one
 1) F-4 (G model not included)
 2) F-15
 3) F-16
 4) A-10
 5) F-4G

  How many squadrons will be deployed ?
  Choose one
 1) 1 squadron
 2) 2 squadrons
 3) 3 squadrons

  How many personnel will be deployed ?
  Choose the lowest figure ,greater than
or equal to the actual number of personnel
 1)  500
 2) 1000
 3) 1500
 4) 2000
 5) 2500
 6) 3000

 Choose the type of asset expected to be used.
1) Harvest Bare
2) Harvest Eagle
```

Fig. 10. Interactive Deployment Questions

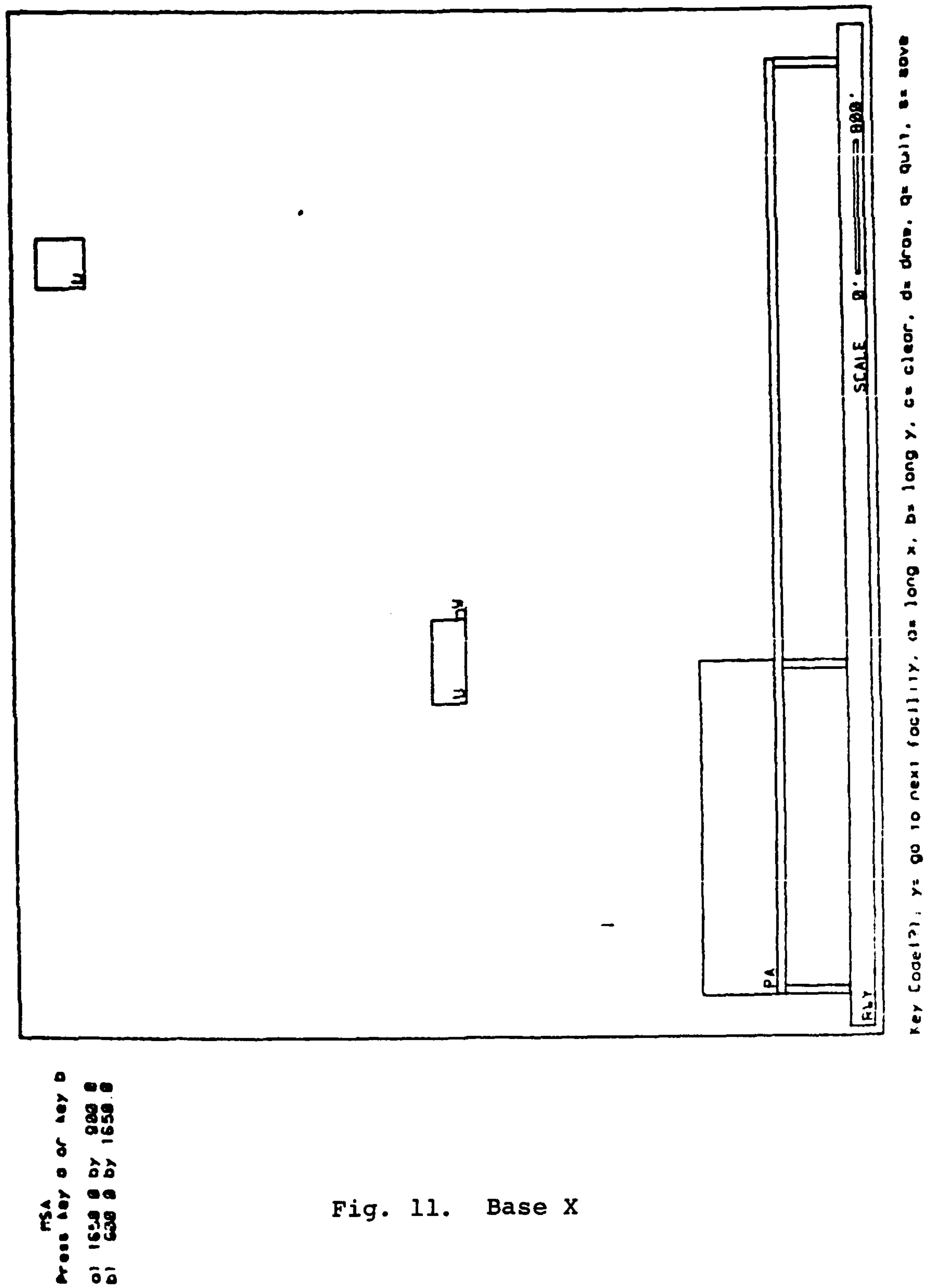

Fig. 11. Base X

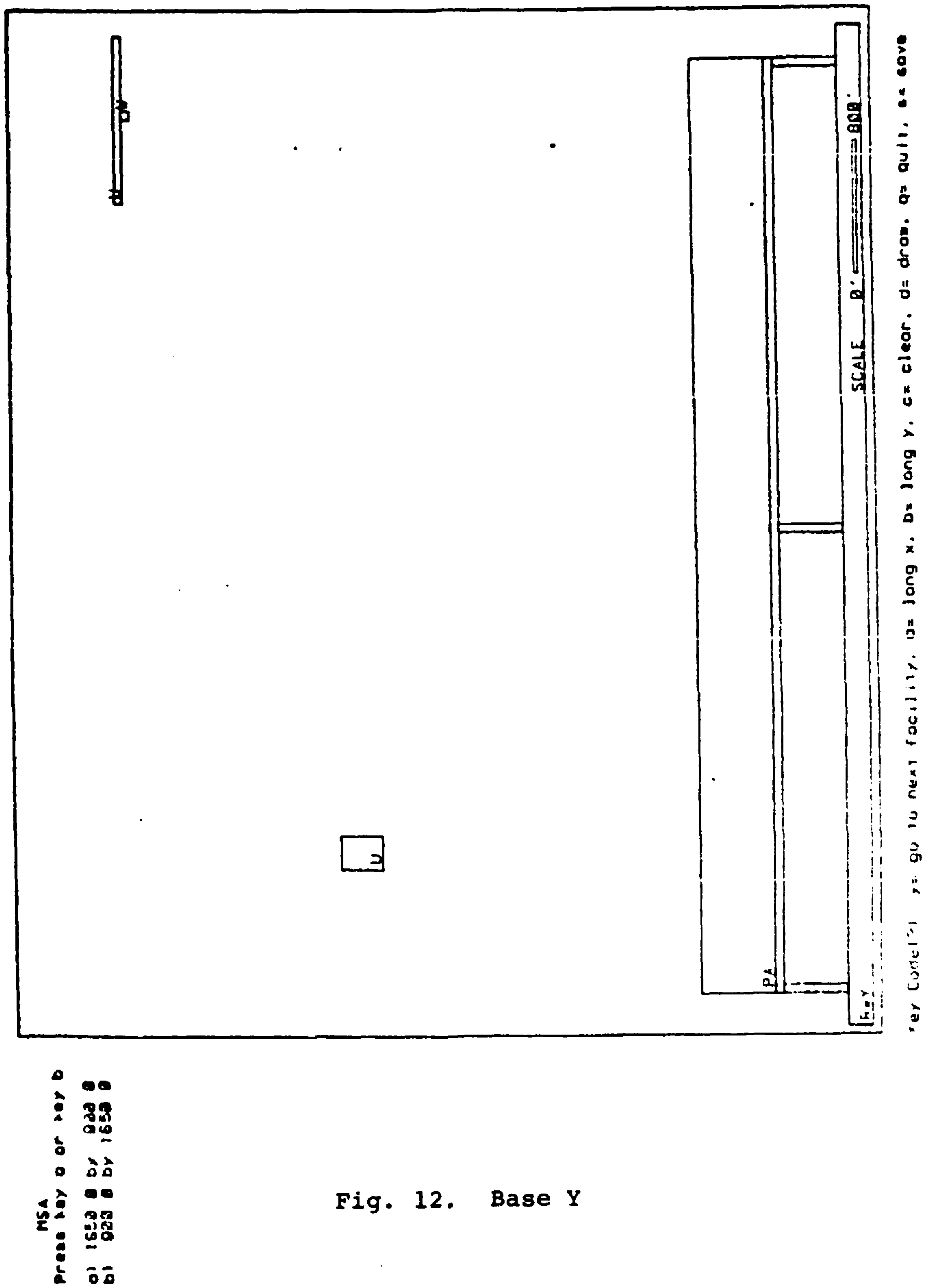

Fig. 12. Base Y

interactive deployment questions are skipped, and the existing plan is displayed. The parameters used to develop it are shown to the left of the master plan (Figures 1-8 in Chapter III).

If the plan is only partially complete, the user can continue the sequence at the next facility grouping. If the user does not want to see the file, the computer begins the interactive deployment questions.

Responses to the questions shown in Figure 10 provide all the data necessary for the computer to locate in the data files the correct rectangle sizes for the eight major facility groups. Figure 13 demonstrates the beginning sequence for locating the MSA at base X. Here the user first chooses key "a" or "b," establishing the orientation of the MSA rectangle. He chose "a," meaning the longest MSA dimension was in the horizontal direction. The computer then instructed the user to locate the cursor and press "d" for draw. If the user forgets the key code, he can look at the bottom of the screen, where the response code for the "?" prompt is printed. The user locates the lower left hand corner of the facility group with the cursor. Pressing "d" draws the facility, and initiates a safety constraint check. Here the user has located the MSA over the runway, two taxiways, and the parking apron. The safety constraint check informs him of the total distance required from each of these base components. In this

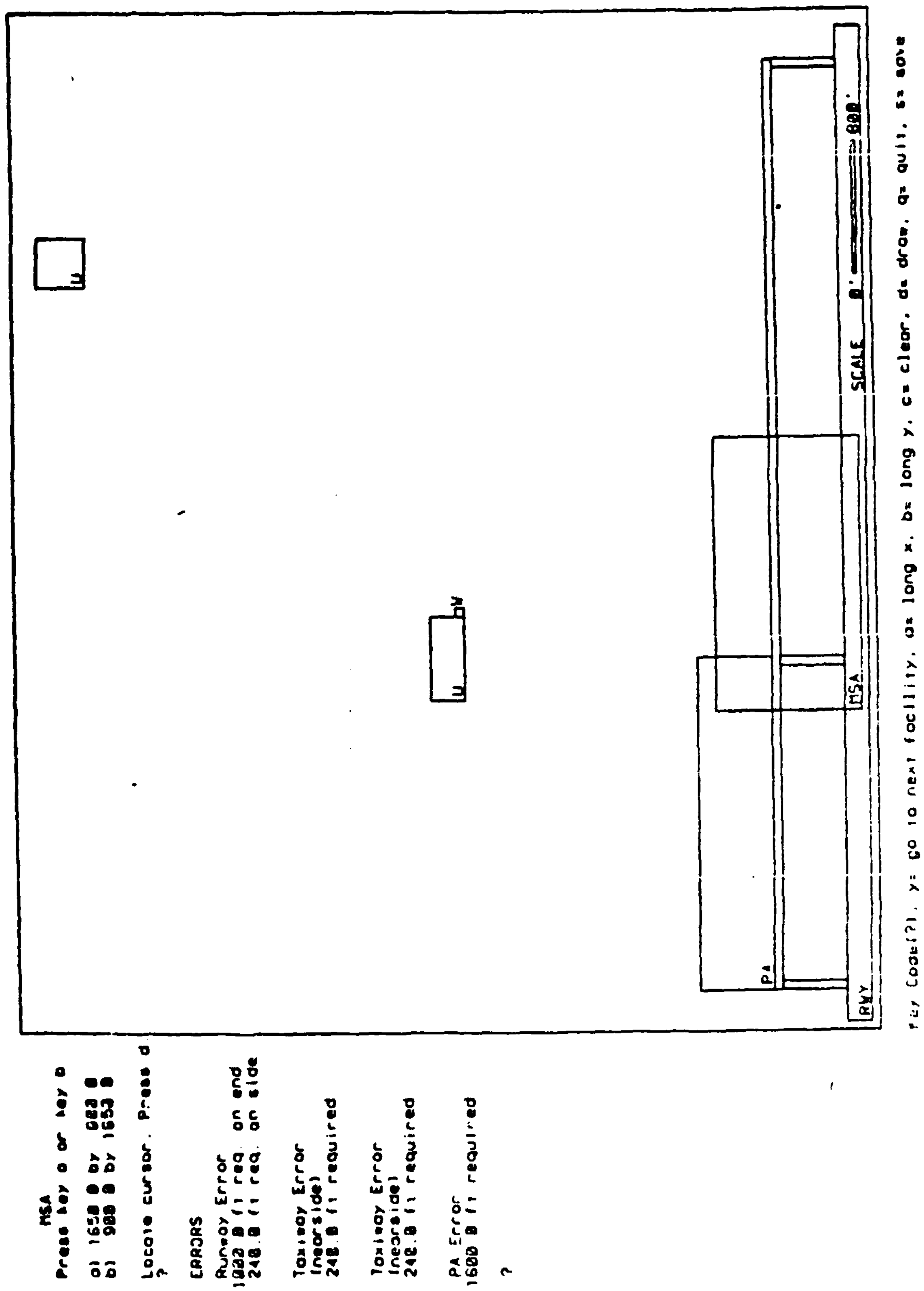

Fig. 13. Demonstrating Constraint Violations for Improper MSA Siting

example, the user obviously would realize his mistake and relocate the MSA. However, the program has the flexibility to override any error message by pressing "y." The program continues to the next facility group. Therefore, the user, not the computer, retains final decision-making control.

Figure 14 shows how the user has corrected his mistake, relocating the MSA to an acceptable (to the safety check routine) location, and clearing the screen with the "c" key. The "c" key can be used to clear unwanted verbiage on the left of the screen or "old" locations of the currently working facility group. This can be done whenever a "?" prompt is given. The "?" prompt appears on the screen to tell the user the computer has processed the last command and the "?" prompt code responses are available to continue the program. Because of the large explosive safety distance constraints imposed on the MSA, the user may find it helpful to locate the MSA as near the top of the screen as possible. Otherwise, the siting of other facilities near the flightline will produce error messages that he may be forced to ignore.

A useful feature for all facility group sitings is shown in Figure 15. By pushing the opposite key, "a" or "b," to the original orientation key, the user changes the long axis orientation as shown. After locating the changed rectangle by the "d" key, the "c" key can erase the

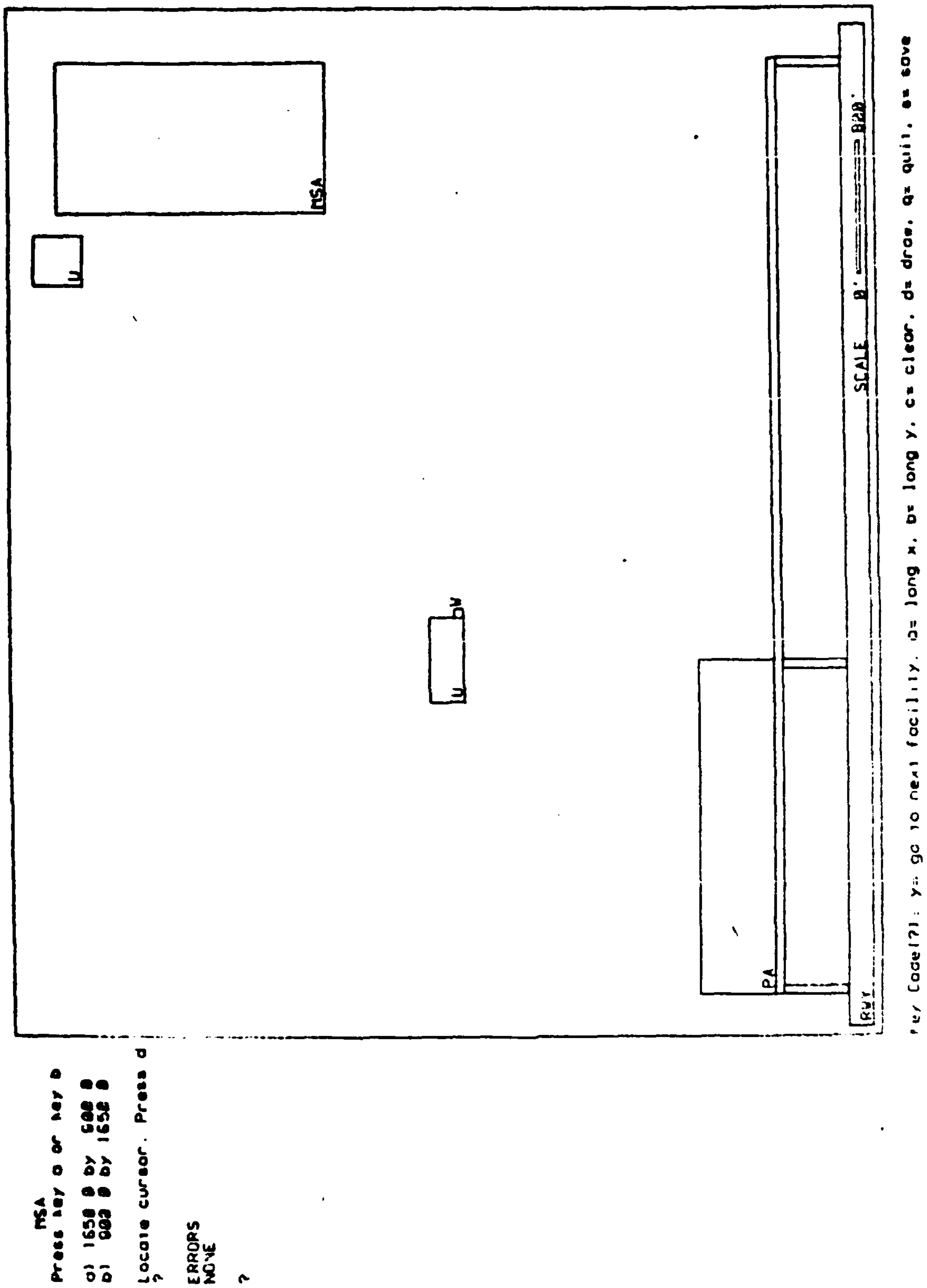

Fig. 14. Locating the MSA Without Errors

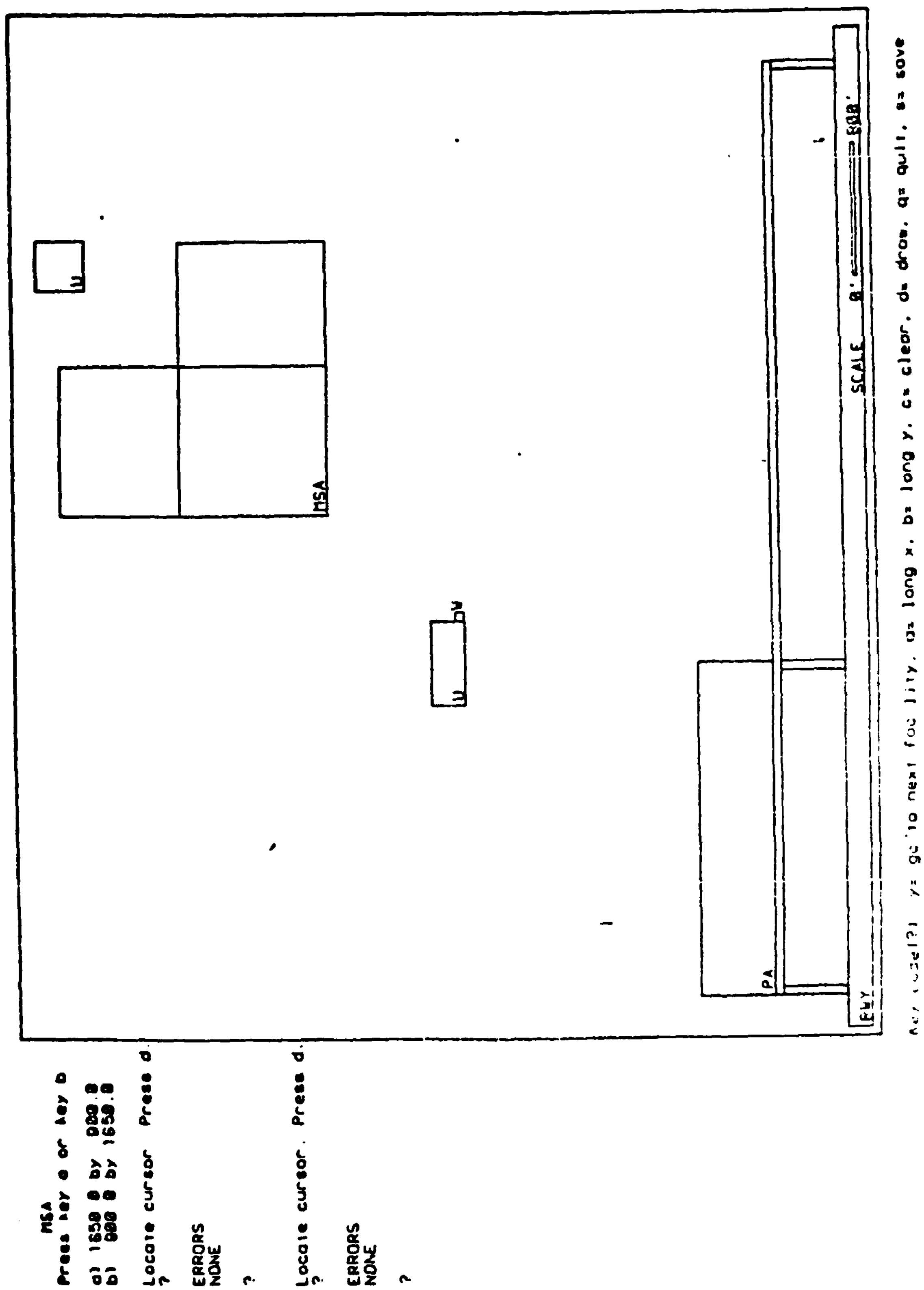

Fig. 15. Using the "a" and "b" Keys to Change MSA Orientation

screen and provides the new facility group orientation alone. When the user is satisfied with the location of the MSA he presses the "y" key. This locks the MSA siting into the master layout and prevents accidental or inadvertent relocation of it. If the user wishes to exit the program at this or at any time the "?" appears, he can press "s" for save to store his work, then "q" for quit, and logout from the computer program. In Figure 16 the user has located the MSA, and also completed the Aircraft Maintenance (MX) siting.

Figure 16 also begins the Aircraft Refueling Area (listed as POL on the left side of the screen or P in the layout) sequence. From the interactive deployment questions, the computer has determined that 6 R-14 ATHRS systems are required for the deployment. The program allows up to three locations for these units. This provides the flexibility to prepare for integrated combat turnaround and/or dispersion. The user selects the number of locations he wishes to use, and begins to work on the first place. He first determines orientation and sites the facility group. The completed POL sequence in Figure 17 shows the siting of 3 POL areas, each siting containing the number of R-14s desired. The computer keeps track of the number of R-14s still to be installed and told the user in each case.

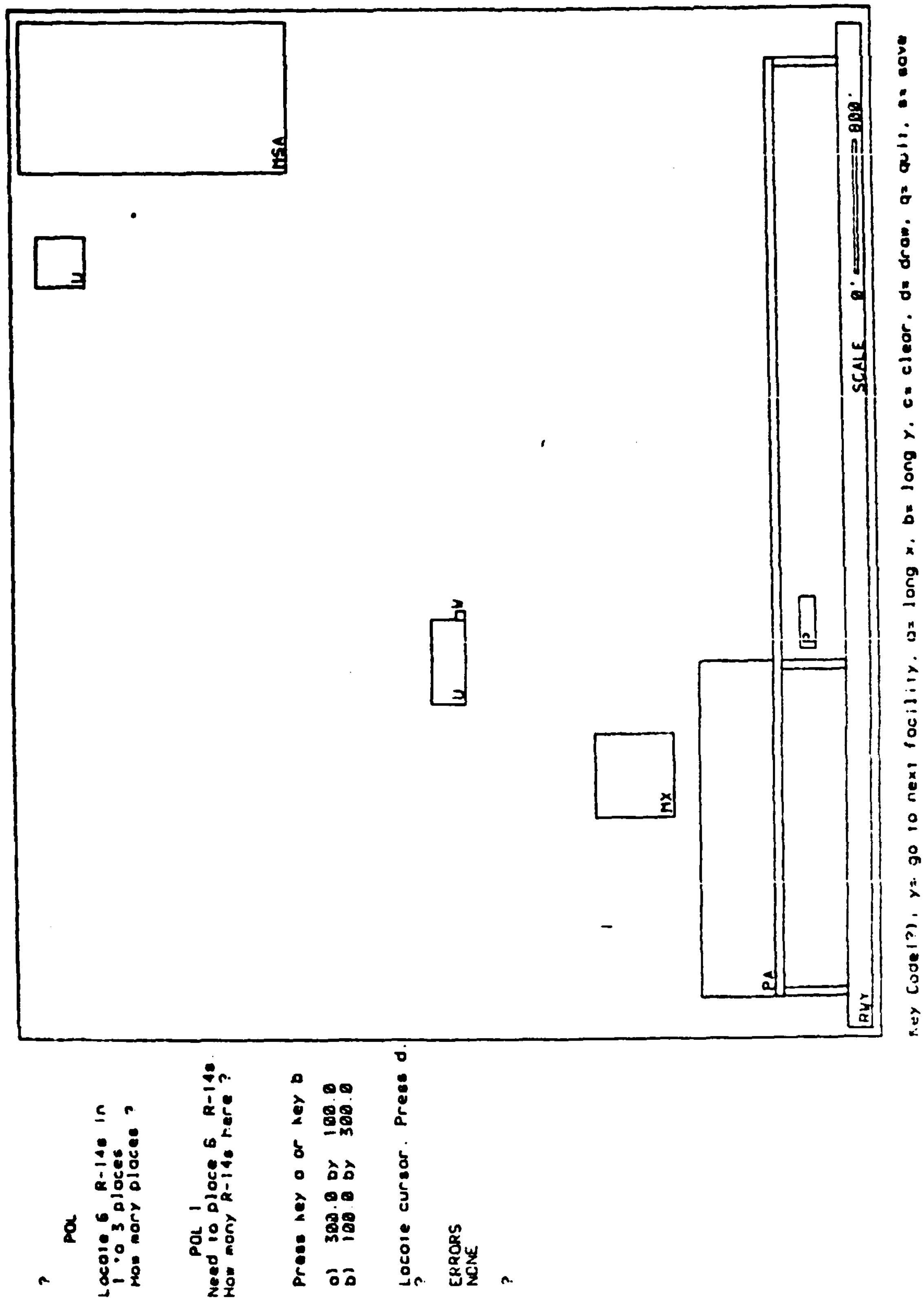

Fig. 16. Beginning POL Sequence

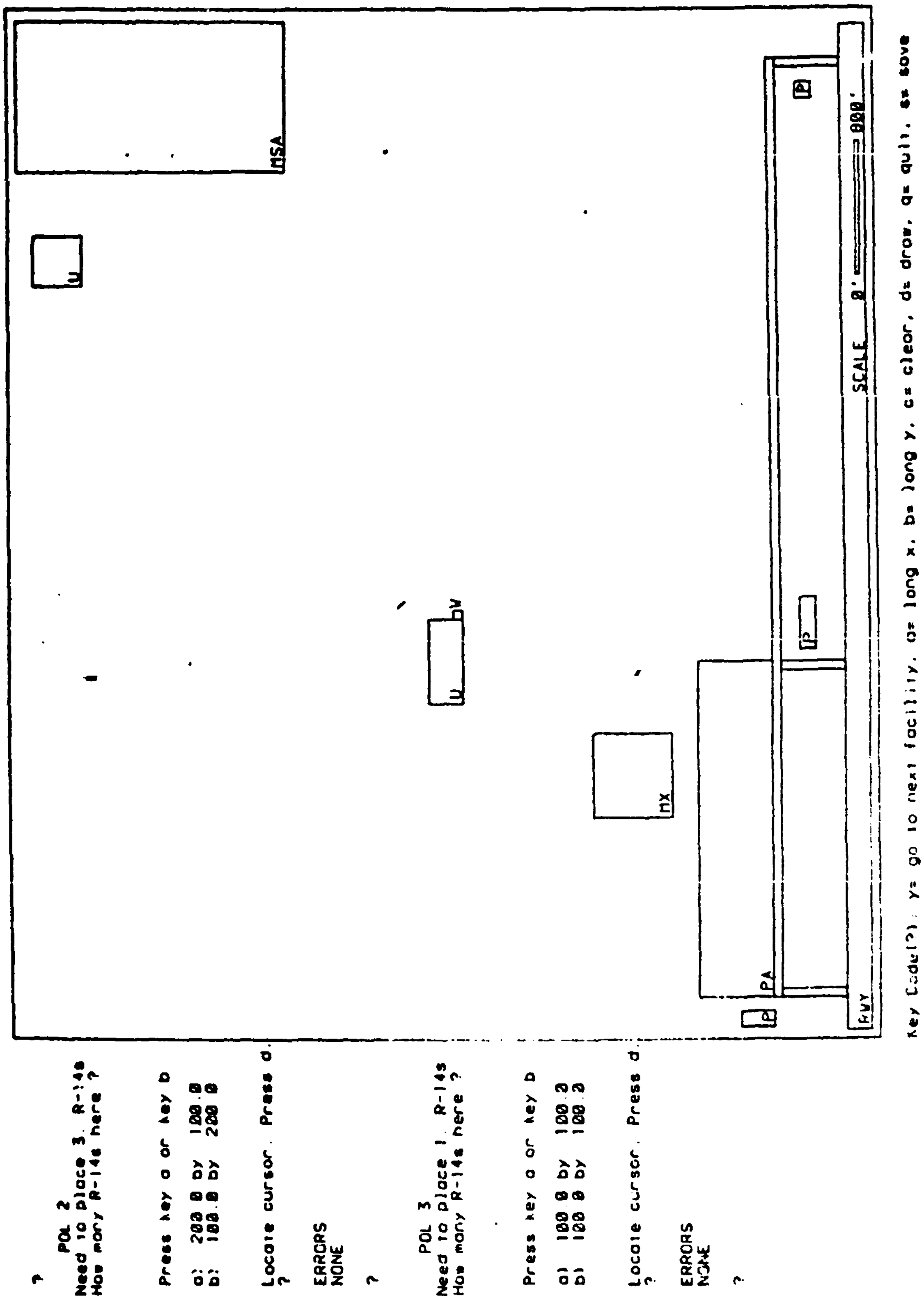

Fig. 17. Completing POL Sequence for Three POL Areas

In like manner, the user proceeds through the Operations, Command, and Base Support facility groups as shown in Figure 18. In each case the user sited facility groups to avoid errors. Each siting was automatically checked against safety constraints, as demonstrated by the "NONE" after the "ERRORS" statement. However, in Figure 19, the Cantonment Area was improperly sited over the water source, one unuseable area, and too close to the MSA. Figure 20 shows a new location with each of these errors corrected. Figure 20 also shows the Medical facility group correctly sited, completing the base master plan.

Although out of sequence, Figure 21 shows a unique feature of interactive programming. While keeping track of the number of located R-14s, the user is negatively prompted if he attempts to site more R-14s than available. An acceptable number reentered continues the sequence.

After master plan completion (Figure 22), the user is prompted to save his layout or simply quit, with his file destroyed. Quitting, without Saving, would be used if the planning has been a learning exercise or if only a print of the layout is required. In this case, the file was saved as demonstrated by the "saved" response. The print button on the 4054 (4014 emulator) console or on the attached printer provides the user with a permanent copy of the finished product.

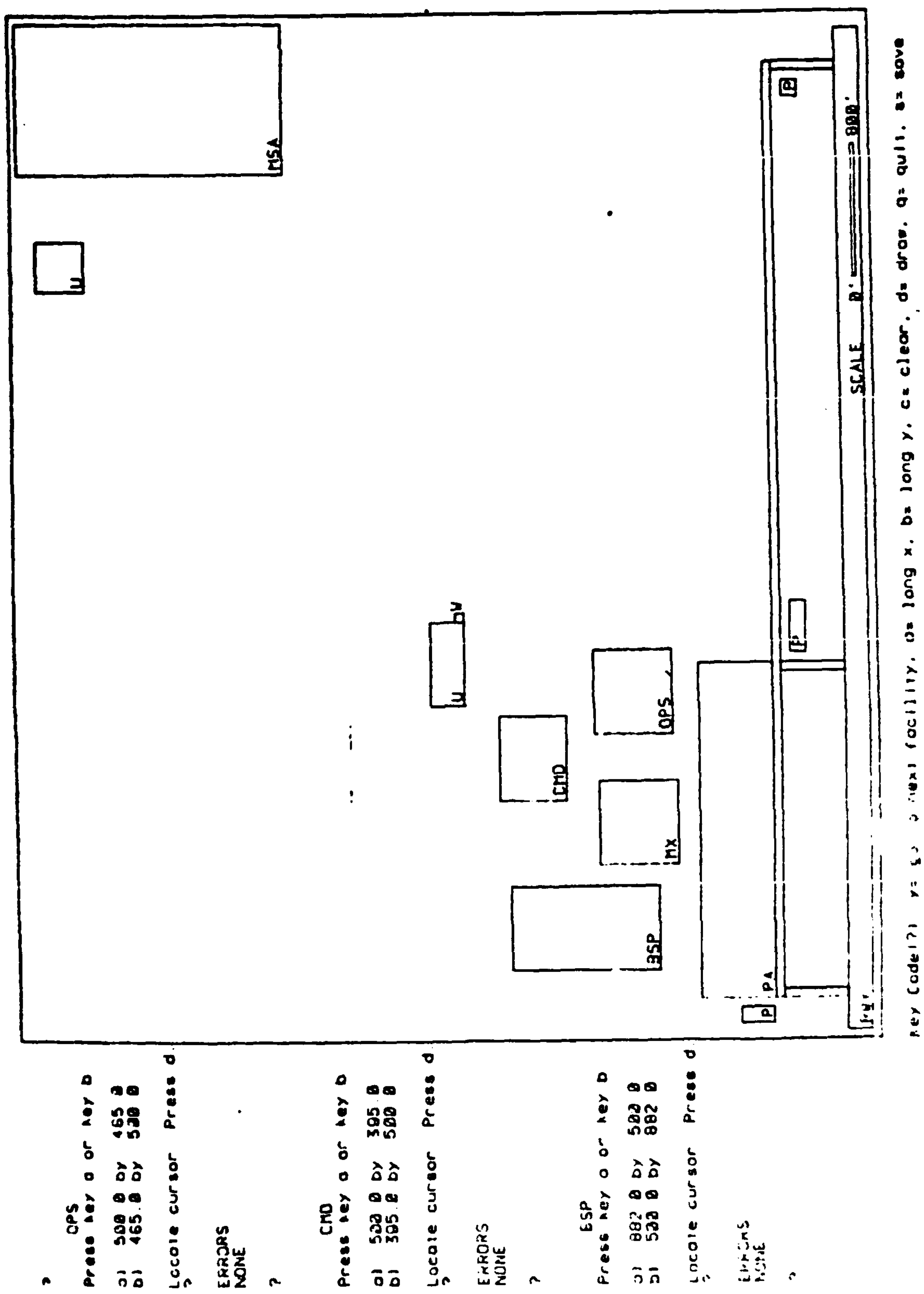

Fig. 18. Locating OPS through BSP

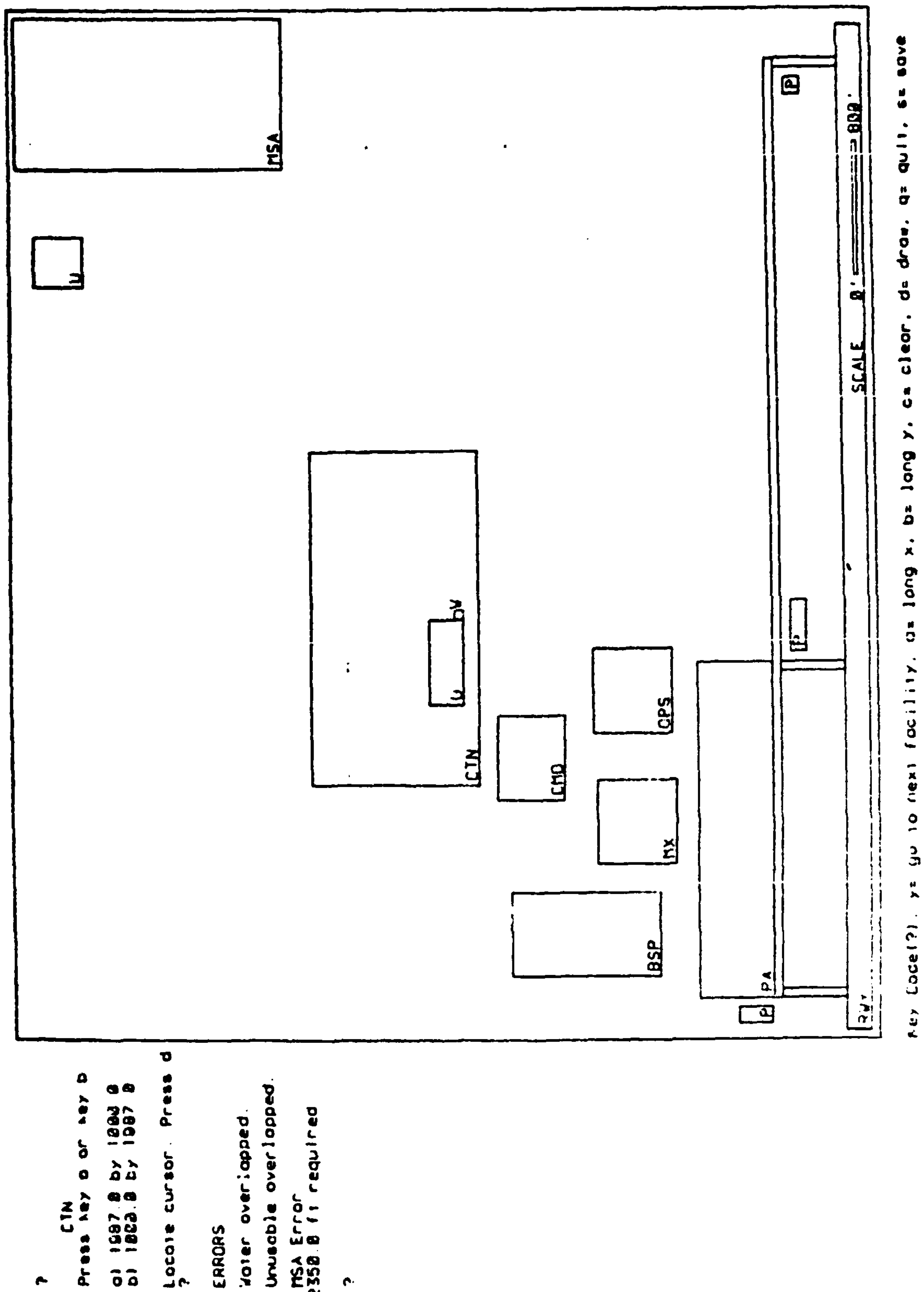

Fig. 19. Errors in Locating CTN

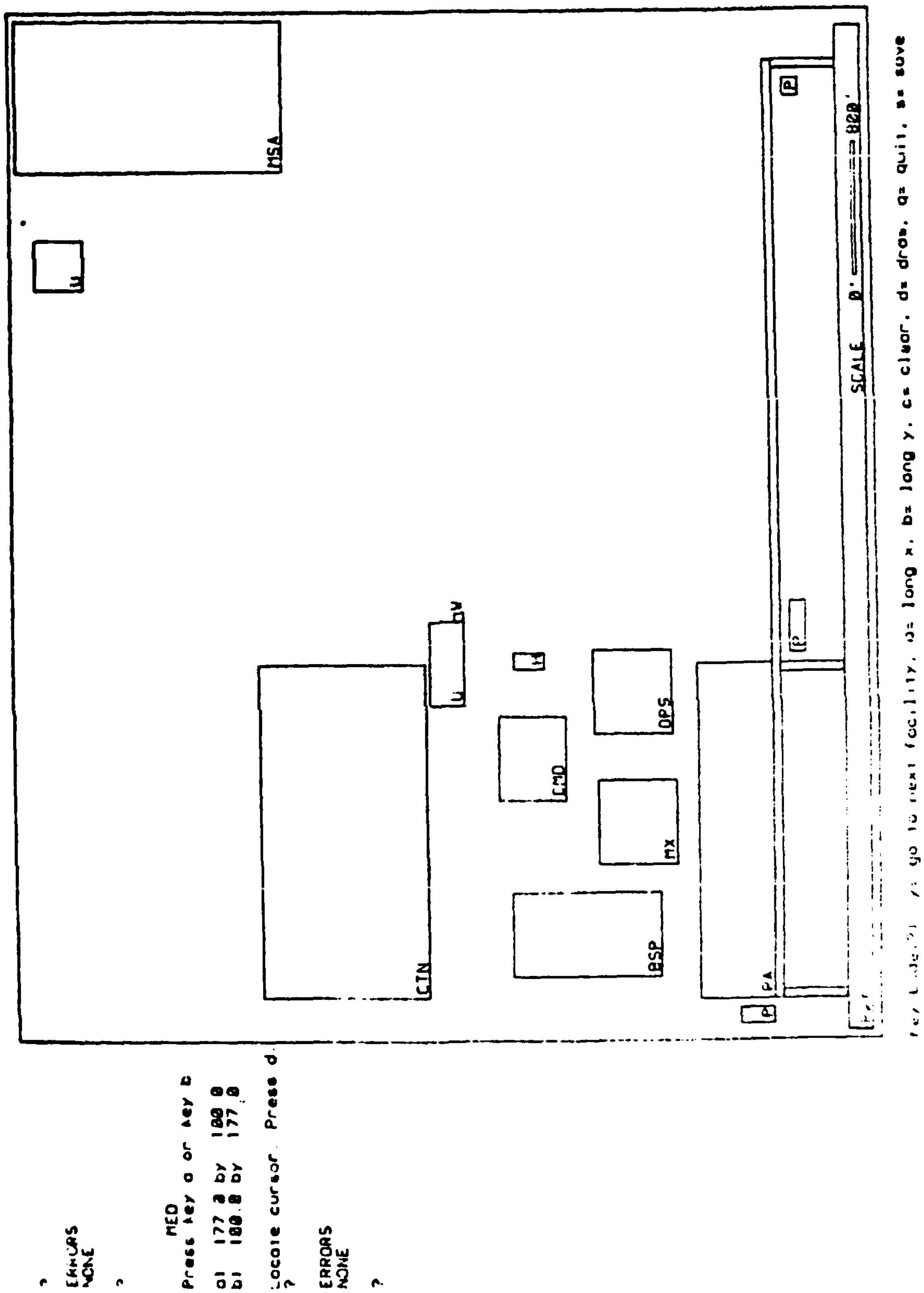

Fig. 20. Locating MED

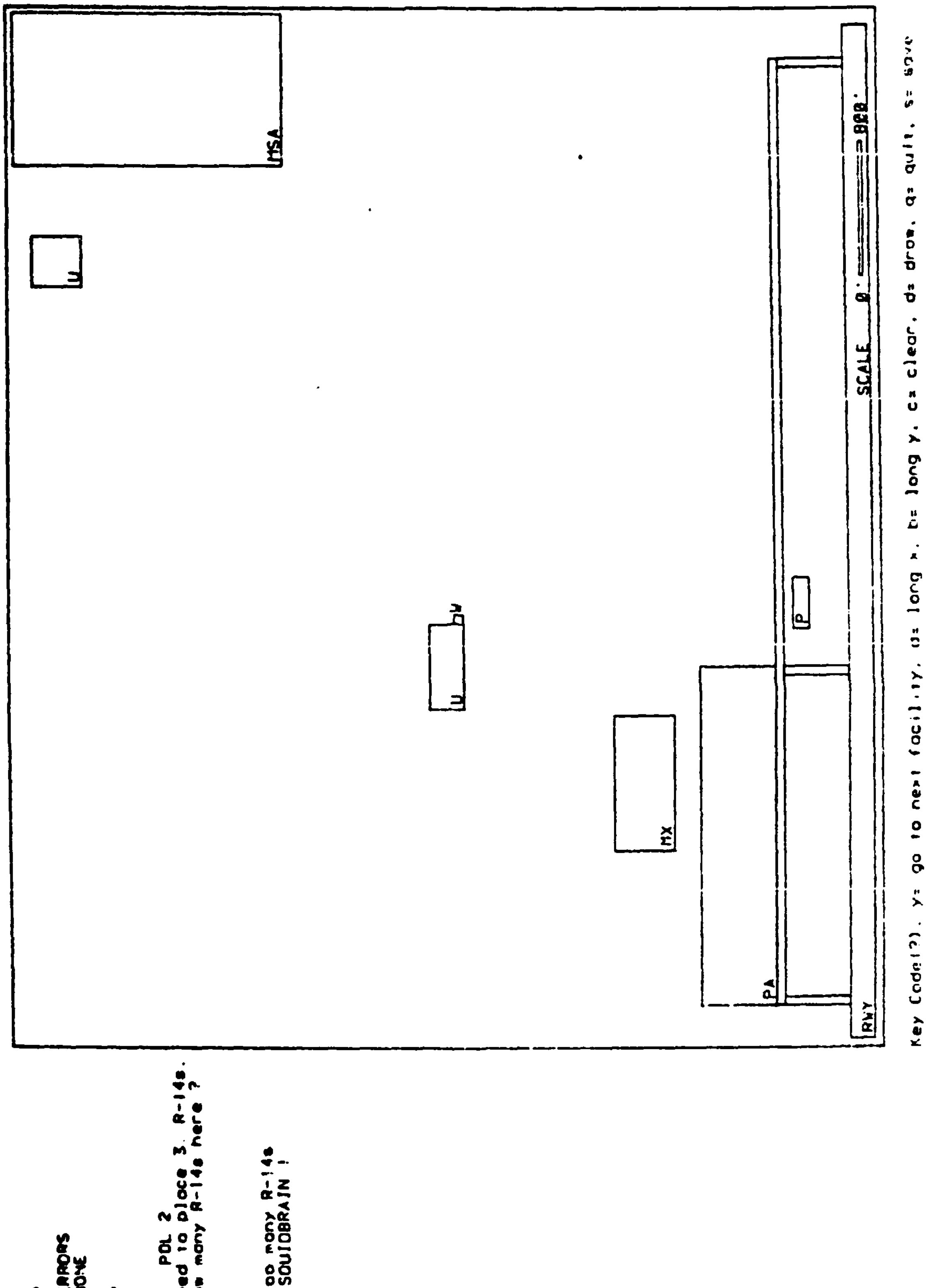

Fig. 21. Attempting to Locate More R-14s than Available

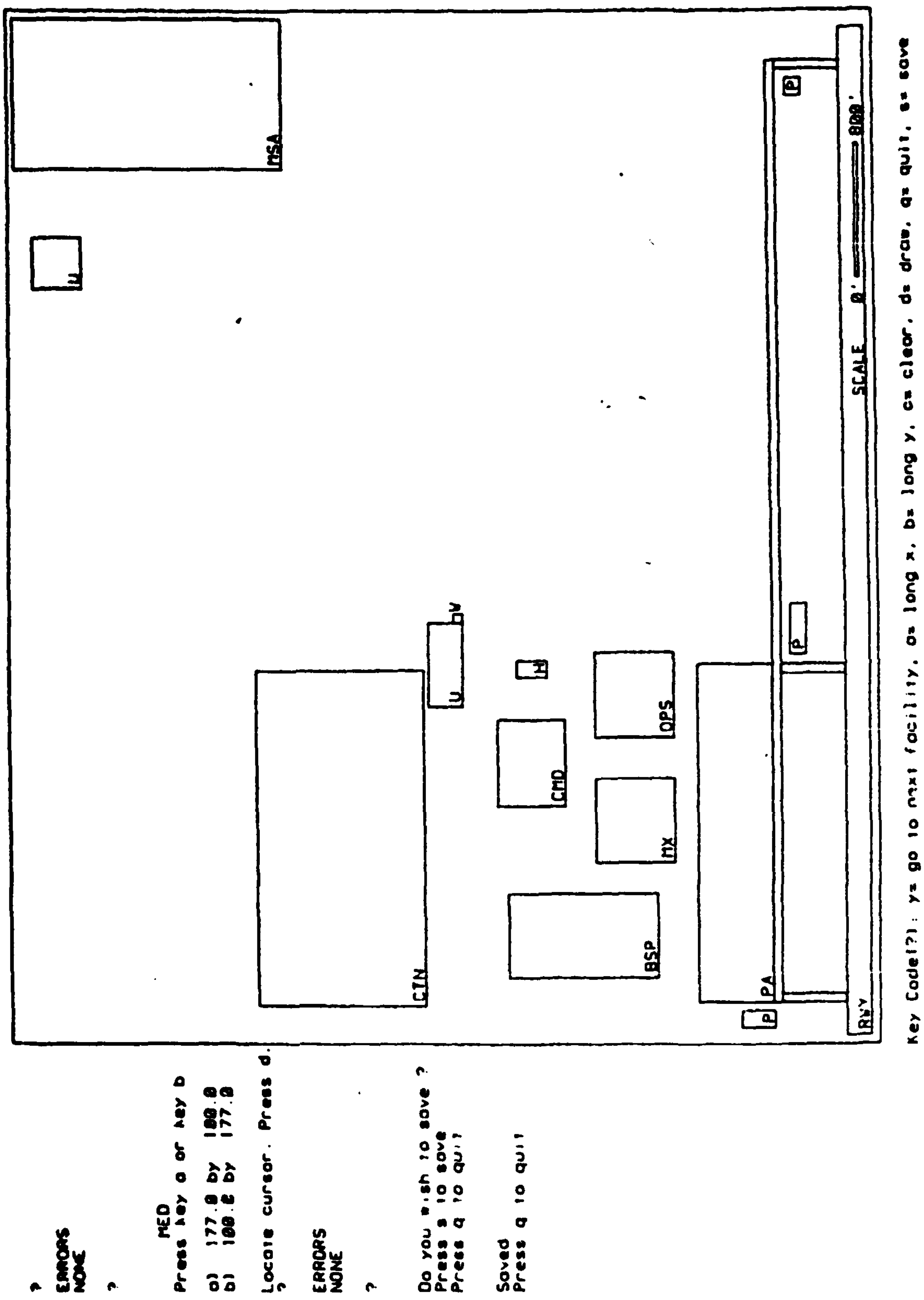

Fig. 22. Save/Quit Commands

Troubleshooting

There are several potential problems that the user may encounter when operating this program:

The terminal "Home Page" key. This key is found on the Tektronix keyboard. The key should not be used for this program, but may be hit inadvertently. When used during the operation of the program the screen is cleared and only the cursor is restored. Pressing "return" restores the crosshairs and if the user remembers his place in the program, he can continue. When he reaches a "?" prompt he can clear the screen with the "c" key. The layout is then redrawn and the user can continue normal operation.

"Y" (YES) key. This key must be pressed while the cursor is still at the correct facility group site. If the cursor is moved before "y" is pressed, the new location of the cursor will provide the X1 and Y1 coordinates of the facility group. These new values are then stored. The change in the size and shape of the affected facility group will not be seen until either the "c" (clear) key is used or the file is reviewed after being saved.

"C" (CLEAR) key. When the user presses the "c" key, the active facility group will be sited wherever the cursor is presently located. Since the "c" key does not activate the CHECK subroutine, the "d" (draw) key should be pushed, activating the CHECK subroutine, and ensuring that no clearance criteria are violated. When the user is satisfied with a location, he should ensure that the cursor is not moved when he presses "c." If it is moved, the location will be changed.

"S" (SAVE) key. The "s" key should not be used, until the active facility group has been sited. The save command stores the X1, X2, Y1, and Y2 values as they are. When the master plan is reviewed this last facility group, if it was not sited, will be improperly sited (if it is sited at all) and the program will continue to the next facility group. The starting of the next facility group eliminates the possibility of correcting the error.

The last possible problem is caused by heavy use of the VAX computer. When the cursor is not visible the computer is responding to the last user input. When the computer has a great deal of activity the response can be quite slow. If other input is made during this time, the computer sometimes stores the input and acts on it after completing the previous responses. Since the computer does not always store the input when the cursor is gone, care should be taken not to make any inputs, thereby avoiding errors of inconsistency.

Maintenance Guide

General

The computer program is made up of a main program, 65 author generated subroutines, and 13 Plot-10 graphics subroutines. The main program establishes the parameters for the screen, initializes contact with the user, and "calls" subroutines to produce a master plan compatible with user directives. The subroutines "read" base component and facility group data from external files, make facility group comparisons using clearance criteria; prompt responses from program users; or facilitate using Plot-10 graphics software. External files were established to contain the data for the bare bases of interest or the facility groups to be sited there. The data establishes the size of the rectangle which will represent each facility group or bare base component. External files are also used to save the siting data for a partially or fully completed base master plan.

Subroutine Interrelationships

Thirteen Plot-10 graphics subroutines are used in the program. A brief description of each subroutine is included in subroutine definitions. Detailed descriptions can be found in the Tektronix users manual (50).

Ten subroutines are involved with gathering facility group data. Subroutine ASSET, which initiates the process, asks the user what assets (Harvest Bare or Harvest Eagle) are to be used and stores the information received. This provides the information to subroutines EAGLE and BARE, to open the appropriate external data files which contain the data to size the facility groups. Subroutines MSA, MX, OPS, CMD, BSP, CTN, and MED read the data from these external files and place the data in 5 x 3 x 6 arrays (referenced by aircraft type, number of squadrons, and number of personnel).

Eighteen subroutines are initiated by or used by the CHECK subroutine in determining if the siting of a facility group breaks any of the clearance criteria. Subroutines CLEARZ, RWYCLR, TWYCLR, PACLR, and MSACLR set the appropriate fire, explosive, and airfield safety clearances into arrays to be utilized by the check subroutine. The facility group sitings are evaluated with respect to the bare base components or the facility groups previously sited. When a clearance is violated the appropriate subroutine RWYERR, TWYERR or ERROR (which initiates either TWYERR, PAERR, H2OERR, UERR, MSAERR, MXERR, POLERR, OPSERR, CMDERR, BSPERR, or CTNERR) is called to notify the planner which criteria has been violated.

Six subroutines are involved with activating the computer keyboard. The subroutines are ASUB, BSUB, DRAWSB, CLRSB, SVSUB, and YESSUB. They are activated by the user responding to the interactive prompt "?."

Individual definitions of these and the other 31 author generated subroutines will be given. This will further clarify why the subroutines were established and what each accomplishes.

Subroutine Definitions

ANCHO(Plot-10)--Allows the printing of a preset alphanumeric character, while staying in the graphic mode.

ANMODE(Plot-10)--Puts the computer into the alphanumeric mode, for interactive communication with the user.

ANSTR(Plot-10)--Allows the printing of a preset string of alphanumeric characters, while staying in the graphic mode.

ASSETS--Asks which asset, Harvest Bare or Harvest Eagle, will be used, and stores the appropriate information for development of the master plan.

ASUB--Provides the directives to establish a facility group rectangle with the longest dimension in the X direction.

BARE--Opens the appropriate external files to properly size facility groupings when Harvest Bare assets are to be used.

BASE--Reads the data from BASEX or BASEY, as appropriate, and stores the corner point of the base components in arrays x1, x2, y1, and y2.

BEGIN--Initializes the program, getting it from the alphanumeric mode to the graphics mode.

BELL(Plot-10)--Provides an audible tone notifying the user that he has finished locating a facility group or has made a mistake in selecting the number of R-14 ATHRS to be located.

BSP--Reads the data from the appropriate external file (BSPDE--Harvest Eagle or BSPDB--Harvest Bare) for the BSP facility group and places it in the a and b arrays (referenced by aircraft type, number of squadrons, number of people).

BSPERR--Notifies the user when the BSP facility group clearance criteria has been violated.

BSUB--Provides the directives to establish a facility group rectangle with the longest dimension in the Y direction.

CHECK--Makes all the calculations to determine if the siting of a facility group breaks any of the clearance criteria from the clear array.

CHOOSE--Reacts interactively to user commands. It establishes the facility group rectangular shape as long in the x-dimension or long in the y-dimension.

CLEARZ--Zeroes out the clear array.

CLRNCS--Initiates the subroutines (RWYCLR, TWYCLR, PACLR, and MSACLR) which establish the nonzero distance criteria.

CLRSB--Clears the screen of interactive dialogue as well as the master plan. It then coordinates the redrawing of the plan with the active facility group shown only at the location of the crosshairs.

CMD--Reads the data from the appropriate external file (CMDDE--Harvest Eagle or CMDDB--Harvest Bare) for the CMD facility group and places it in the a and b arrays (referenced by aircraft type, number of squadrons, number of people).

CMDERR--Notifies the user when the CMD facility group clearance has been violated.

CTN--Reads the data from the appropriate external file (CTNDE--Harvest Eagle or CTNDB--Harvest Bare) for the CTN facility group and places it in the a and b arrays (referenced by aircraft type, number of squadrons, number of people).

CTNERR--Notifies the user when the CTN facility group clearance criteria has been violated.

CURSOR--Tells the user to "Locate the Cursor. Press d." This identifies to the computer where the current facility group is to be located. It also prints the prompt "?," notifying the user that he has available all the options listed under the displayed screen.

DIRECT--Prints the options available to the user when the "?" prompt appears. The options are listed below the displayed screen.

DRAWA(Plot-10)--Draws a line from the present location of the printer beam to its new location. (The movement is done relative to the old position.)

DRAWSB--Coordinates the drawing of the active facility group. The lower left corner of the rectangle is sited by the computer crosshairs.

EAGLE--Opens the appropriate external files to properly size facility groupings when Harvest Eagle assets are to be used.

ERASE(Plot-10)--Clears the terminal screen.

ERROR--Initiates the error subroutines (TWYERR, PAERR, H2OERR, UERR, MSAERR, MXERR, POLERR, OPSERR, CMDERR, BSPERR, and CTNERR), which notify the user when clearance criteria has been violated.

FINITT(Plot-10)--Terminates the program, returns the terminal to the alphanumeric mode and moves the cursor to a point that will not interfere with a previous output.

GRAFIT--Coordinates the drawing of the base components (including the scale) and the facility groups up to the facility group being actively worked. This includes labeling the components and groups, and printing the available options under the display screen.

H2OERR--Notifies the user when the base component "water area" clearance criteria has been violated.

INITT(Plot-10)--Establishes the rate of character transmission at 960 characters per second, which prevents loss of data during screen erasure and copy generation.

INSTRC--Provides the key code responses to the "?" prompt and asks the user what base will be studied.

LABEL--Puts the appropriate labels on the base components (RWY, PA, W, and U) and the facility groups (MSA, MX, P, OPS, CMD, BSP, CTN, and H).

MED--Reads the data from the appropriate external file (MEDDE--Harvest Eagle or MEDDB--Harvest Bare) for the

MED facility group and places it in the a and b arrays (referenced by aircraft type, number of squadrons, number of people).

MOVE--Locates where the labels are to be printed in the base component or facility group rectangles. It also locates and prints the symbols associated with the scale.

MOVEA(Plot-10)--Moves the printer beam on the screen to a new location (relative to its old location).

MSA--Reads the data from the appropriate external file (MSADE--Harvest Eagle or MSADB--Harvest Bare) for the MSA facility group and places it in the a and b arrays (referenced by aircraft type, number of squadrons, number of people).

MSACLR--Sets the applicable portions of the clear array to set proper clearance for the MSA facility group.

MSAERR--Notifies the user when the MSA facility group clearance criteria has been violated.

MVLEFT--Combines Plot-10 subroutines MOVABS and ANMODE to prepare the program for interactive statements with the user. It places the statements on the left side of the terminal screen.

MX--Reads the data from the appropriate external file (MXDE--Harvest Eagle or MXDB--Harvest Bare) for the MX facility group and places it in the a and b arrays (referenced by aircraft type, number of squadrons, number of people).

MXERR--Notifies the user when the MX facility group clearance criteria has been violated.

OPS--Same as MSA for the OPS facility group.

OPSERR--Notifies the user when the OPS facility group clearance criteria has been violated.

PACLR--Sets the applicable portions of the clear array to set proper clearances from the parking apron.

PAERR--Notifies the user when the base component "parking apron" clearance criteria has been violated.

PASSET--Prints for the user which asset (Harvest Bare or Harvest Eagle) was specified for the master plan being reviewed.

PEOPLE--Asks and stores how many people the master plan is being developed for.

POL--Reads the data from the appropriate external file and places it in the e array (referenced by the number of squadrons). It then calculates and inserts values in the a and b arrays (referenced as before).

POLERR--Notifies the user when the BSP facility group clearance criteria has been violated.

PPEOPLE--Prints the number of personnel that can be accommodated by the master plan being reviewed.

PRMTRS--Initiates the four subroutines (TYPEAC, SQ, PEOPL, ASSETS) when a user is developing a master plan.

PRT1--Provides the prompt, asking the user if he wishes to see the existing master plan for the base.

PRT2--Notifies the user that a master plan has not been saved for the subject base.

PSQUAD--Prints the number of squadrons that can be accommodated by the master plan being reviewed.

READDT--Reads the master plan data from the external file for the subject base.

REC--Combines Plot-10 subroutines MOVEA and DRAWA to draw the base component and facility group rectangles.

RWYCLR--Sets the applicable portions of the clear array to set proper clearances from the runway.

RWYERR--Notifies the user when the base component "runway" clearance criteria has been violated.

SAVE--Is used to store the data from the base layout that is actively being worked.

SCALE--Establishes and locates an 800 foot (in the x direction) scale, based on the length of the runway and the location of Y1 and X2.

SCREEN--Establishes the graphic area which will be viewed on the terminal screen. The area will be based on the length of the runway at the base of interest.

SLYDG1--When only one POL site is used, the second site is superimposed on the first. This prevents a "P" from being misprinted near the origin of the visible screen when the clear command is used, or the "saved" file is recalled.

SLYDG2--When the third POL site is not used, the third site is superimposed on the first. This prevents a "P" from being misprinted near the origin of the visible screen when the clear command is used or the "saved" file is recalled.

SQ--Asks and stores how many squadrons the master plan is being developed for.

SVSUB--Coordinates the saving of the facility group and base component arrays (X1, X2, Y1, Y2) in an external file. It then prompts the user to continue the program.

TWINDO(Plot-10)--Defines the portion of the computer terminal screen which will display the portion of the virtual plane defined by VWINDO.

TWYCLR--Sets the applicable portions of the clear array to set proper clearances from taxiways.

TWYERR--Notifies the user when the base component "taxiway" clearance criteria has been violated.

TYPEAC--Asks and stores what type of aircraft the master plan is developed for.

UERR--Notifies the user when the base component "unuseable area" clearance criteria has been violated.

VCURSR(Plot-10)--Is the key to this interactive program. It provides the computer program with the X and Y coordinates of the cursor, and a coded directive, defining what the program should perform.

YESSUB--Notifies the user that the last facility group has been sited and that the decision to save the file must now be made.

VISUAL--Initiates the four subroutines (PTYPE, PSQUAD, PPEOPL, and PASSET) when a user wants to review a saved master plan for a given base. The subroutines define the parameters under which the plan was developed (type of aircraft, number of squadrons, number of people, and type of asset).

VWINDO(Plot-10)--Defines the part of a virtual infinite plane that is to be viewed on the terminal screen.

Establishing a Bare Base File

Each bare base file must contain the rectangle corner points for nine base components. These are (in the order they appear in the file) one runway, four taxiways, one parking apron, one water source, and two unuseable areas. Coordinates are expressed as real numbers in the file and are used by the BASE subroutine to produce the screen layout plan. For each component, the distances relative to the lower left corner of the virtual space (which will be established on the screen), are listed in the file in the following order:

1. Runway--X1, X2, Y1, Y2
2. First Taxiway--X1, X2, Y1, Y2
3. Third Taxiway--X1, X2, Y1, Y2
4. Third Taxiway--X1, X2, Y1, Y2
5. Fourth Taxiway--X1, X2, Y1, Y2
6. Parking Apron--X1, X2, Y1, Y2

7. Water Source--X1, X2, Y1, Y2

8. First Unuseable Area--X1, X2, Y1, Y2

9. Second Unuseable Area--X1, X2, Y1, Y2

The "i" counter in the X1, X2, Y1, Y2 one-dimensional arrays runs from 3 to 11 to establish these numbers. The virtual screen and scale coordinates are established in the 1 and 2 arrays. The facility groups are established in arrays 12 through 21.

Establishing Storage Files

Storage files for each individual bare base file must be prepared prior to program operation. For example, in this thesis, files SAVEX and SAVEY were created for bare base files BASEX and BASEY respectively. The storage files should initially only contain the integer "1." This allows the program to read a value when it attempts to access the storage files. THE PROGRAM WILL FAIL IF "SAVE" FILES ARE NOT CREATED BEFORE OPERATION.

First Level Pseudocode

```
Initialize
Identify base of interest
Does master plan exist?
  Does the user want to see it?
  Initialize parameters
    Type of aircraft
    Number of squadrons
```

```
    Number of personnel
    Type of asset
Establish visual display screen
Draw the base
Loop (master plan)
  Increment to next facility group
    Load data for the ith facility
  Loop (siting)
    Interact with user to site facility groups
  Until (user says stop)
Until (user says stop or last facility)
```

Second Level Pseudocode

```
Initialize
  Establish common blocks
  Declare variables
  Assign values to activate keyboard
  Initialize graphics program (begin)
Identify base of interest
  Initialize interactive questions
  Choose base of interest
    Open appropriate data file
Does master plan exist?
  Look for "save" external file
    Does the user want to see it?
      Yes--display it
```

```
        No--initialize parameters
          Type of aircraft
          Number of squadrons
          Type of asset
            Open facility group data files
Establish visual display screen
  Read base component data
  Set screen parameters
  Establish a scale
Draw the base
  Graph it
Loop (master plan)
  if(i = 12)
    open MSA data file
  else if(i = 13)
    open MX data file
  else if(i = 14)
    open POL data file
  else if(i = 15)
    Open POL data file
  else if(i = 16)
    open POL data file
  else if(i = 17)
    open OPS data file
  else if(i = 18)
    open CMD data file
```

```
else if(i = 19)
  open BSP data file
else if(i = 20)
  open CTN data file
else if(i = 21)
  open MED data file
else
  end program
end if
Loop (siting) interactive
  if(a)
    long x rectangle
  else if(b)
    long y rectangle
  else if(d)
    draw the facility
  else if(c)
    clear the screen of extraneous material
  else if(s)
    save the master plan
  else if(y or q)
    yes--raise the "i" counter, return to start of plan loop
    quit--end of program
  end if
Until (user says stop)
```

```
  "i" counter raised
Until (user says stop or last facility group)
```

<u>Third Level Pseudocode for POL (i = 15 or 16) from the Master Plan Loop</u>

If the second or third POL areas are not used, the X1, X2, Y1, Y2 arrays still need to be filled. Completing the arrays provides a correct master plan after the clear command is used or the plan is recalled from the external saved file.

```
Else if(i = 15)
  if second area is not used
    overprint first POL location
    go to end of loop and up "i" counter
  else
    call POL
  endif
Else if(i = 16)
  if third area is not used
    overprint first POL location
    go to end of loop and up "i" counter
  else
    call POL
  endif
```

APPENDIX J

COMPUTER PROGRAM

```
      program CARNAD
c
c  DEFINITIONS:
c
c     1.  a = one dimension of the rectangle , selected from the
c             appropriate facility group data array .
c
c     2.  asset = variable used to identify which asset
c                 (Harvest Bare or Harvest Eagle) is being
c                 used to determine the design of the facility
c                 master plan .
c
c     3.  b = the second dimension of the rectangle , selected from
c             the appropriate facility group data array .
c
c     4.  basex = one of the two bare base layouts on which a facility
c                 master plan is developed . An external file under
c                 this name has the cordinates (x1,x2,y1,and y2) for
c                 the bare base components .
c
c     5.  basey = one of the two bare base layouts on which a facility
c                 master plan is developed . An external file under
c                 this name has the cordinates (x1,x2,y1,and y2) for
c                 the bare base components .
c
c     6.  c = a counter variable .
c
c     7.  clear = an array containing the clearance requirements for
c                 all base components (except the runway) and all
c                 facility groups .
c
c     8.  clearx = an array containing the clearance requirements for
c                  the end of the runway .
c
c     9.  cleary = an array containing the clearance requirements for
c                  the sides of the runway .
c
c     10. e = an array (based on the number of aircraft squadrons to be
c             located at the bare base) that has the total number of
c             R-14's that must be sited .
c
c     11. f = variable used to determine how many R-14 sitings will
c             be used .
c
c     12. g = variable defining how many R-14's will be located at
c             each site .
c
c     13. g1 = a running count of how many R-14's,total,have been
c              sited .
c
```

AD-A134 432 CONSOLIDATION OF CONTINGENCY DATA AND ITS USE IN COMPUTER GRAPHICS TO PLA..(U) AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL OF SYST.. 3/3

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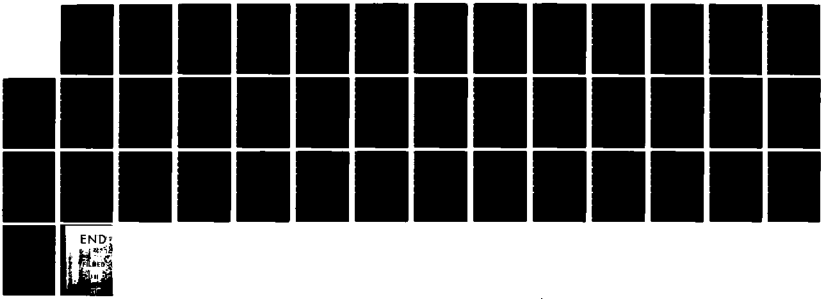

1.0 2.8 2.5 4.5 5.0 3.2 2.2 5.6 6.3 3.6 7.1 8.0 4.0 2.0 1.1 1.8 1.25 1.4 1.6

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

```
c     14. h = variable that defines how many R-14 units still need
c             to be located .
c
c     15. i = a counter variable .
c
c     16. ia = variable 'Keyed' by the user to specify that an x-long
c              oriented rectangle is required for siting .
c              Available when the '?' prompt is given.
c
c     17. ib = variable 'Keyed' by the user to specify that a y-long
c              oriented rectangle is required for siting .
c              Available when the '?' prompt is given.
c
c     18. iclear = variable 'Keyed' by the user to erase from the
c                  screen any extraneous information . The information
c                  can be verbage on the left side of the screen , or
c                  old (unwanted) sitings of facility groups .
c                  Available when the '?' prompt is given.
c
c     19. idraw = variable 'Keyed' by the user to draw the active
c                 facility group where the crosshairs are located .
c                 Available when the '?' prompt is given.
c
c     20. ifive = variable 'Keyed' by the user to select the fifth
c                 item in a series of alternatives .
c
c     21. ifour = variable 'Keyed' by the user to select the fourth
c                 item in a series of alternatives .
c
c     22. ione = variable 'Keyed' by the user to select the first
c                item in a series of alternatives .
c
c     23. iquit = variable 'Keyed' by the user to end the program .
c                 Available when the '?' prompt is given.
c
c     24. isave = variable 'Keyed' by the user to store the cordinates
c                 (x1,x2,y1, and y2) of the base components and the
c                 facility groups in an external file .
c                 Available when the '?' prompt is given.
c
c     25. isix = variable 'Keyed' by the user to select the sixth
c                item in a series of alternatives .
c
c     26. ithree = variable 'Keyed' by the user to select the third
c                  item in a series of alternatives .
c
c     27. itwo = variable 'Keyed' by the user to select the second
c                item in a series of alternatives .
c
c     28. iyes = variable 'Keyed' by the user to signal the computer
c                that the user is satisified with the present location
```

```
c              of the active facility group and to begin the sequence
c              of siting the next facility group .
c              Available when the '?' prompt is given.
c
c     29. j = a counter variable .
c
c     30. k = a counter variable .
c
c     31. l = a counter variable .
c
c     32. linen = integer line counter used to prevent
c                 overprinting.
c
c     33. m = a counter variable .
c
c     34. n = a counter variable .
c
c     35. people = variable used to identify the number of
c                  people for which the facility master plan
c                  is being designed .
c
c     36. s = a variable used to define if an external 'save'
c             file has a master plan saved in it .
c
c     37. squads = variable used to identify the number of
c                  squadrons (1,2,or 3) for which the facility
c                  master plan is being designed .
c
c     38. t = a counter variable .
c
c     39. type = variable used to identify which of five
c                possible types of aircraft is being used
c                as the basis for designing the facility
c                master plan .
c
c     40. x = variable that takes on the value of 'a' if an x-long
c             rectangle is desired , the value of 'b' if a y-long
c             rectangle is desired .
c
c     41. y = variable that takes on the value of 'b' if an x-long
c             rectangle is desired , the value of 'a' if a y-long
c             rectangle is desired .
c
c     42. x1,x2,y1,y2 = real corner points of all
c                       rectangular facilities (base component
c                       or facility group) .
c
c     43. z = a counter variable .
c
c   INITIALIZE
c   ----------
```

```
c
c  ESTABLISH COMMON BLOCKS
      common/block1/i,x1,x2,y1,y2,c
      common/block2/linen,z
      common/block3/type,squads,people
      common/block4/x,y
      common/block5/h
      common/block6/asset
      common/block7/clear
      common/block8/n,clearx,cleary
      common/block9/a,b
c
c  VARIABLE DECLARATIONS
      integer type,squads,people
      integer asset
      integer i,linen,z
      integer c
      integer n
      integer s
      real x1(25),x2(25),y1(25),y2(25)
      real x(25),y(25)
      real clear(4:21,12:21)
      real clearx(12:21),cleary(12:21)
      real a(5,3,6),b(5,3,6)
      real h
c
c
c  ASSIGN VALUES TO ACTIVATE KEYS FOR INTERACTIVE PROGRAMMING
c
      data ia/97/,ib/98/,iclear/99/,idraw/100/
      data iyes/121/,ino/110/,isave/115/,iquit/113/
      data ione/49/,itwo/50/,ithree/51/,ifour/52/
      data ifive/53/,isix/54/
c
c  START PROGRAM
      call begin
c
c
c  IDENTIFY BASE OF INTEREST
c  ------------------------
      call instrc
23    call vcursr(key,xz,yz)
      if (key .eq. ione) then
        open (10,file = 'basex')
        open (19,file = 'savex')
      else if (key .eq. itwo) then
        open (10,file = 'basey')
        open (19,file = 'savey')
      else
        go to 23
      end if
```

```
      rewind 10
      rewind 19
      read (19,*,end = 900)s
900   continue
c
c
c  DOES MASTER PLAN EXIST ?
c  -------------------- -
c
      if (s .eq. 2) then
        call prt1
c
c     DOES THE USER WANT TO SEE IT ?
c     ------------------------- -
c
63      call vcursr(key,xz,yz)
          if (key .eq. iyes) then
            call readdt
          else if (key .eq. ino) then
            call prmtrs
          else
            go to 63
          end if
      else
c
c      INITIALIZE PARAMETERS
c      ---------------------
c
        call prt2
      end if
      if (asset .eq. 1) then
        call bare
      else
        call eagle
      end if
c
c  ZERO OUT THE ARRAY NAMED CLEAR
      call clearz _
c
c  SET NON-ZERO CLEARANCES
      call clrncs
c
c  READ FILE BASEX
      call base
c
c  ESTABLISH THE BOUNDARY LINE
      call screen
c
c  ESTABLISH THE SCALE
      call scale
c
```

```
c  SET THE VIRTUAL AND SCREEN WINDOWS
      call vwindo(0.,x2(1),0.,y2(1))
      call twindo(203,1023,80,780)
c
c  DRAW THE BASE
      call grafit
c
c  BEGIN INTERACTIVE FOR THE MAJOR NEW FACILITIES
c  THE i COUNTER DEFINITIONS ARE:
c    12 = MSA (MUNITIONS STORAGE AREA)
c    13 = MX (AIRCRAFT MAINTENANCE AREA)
c    14 = P (1ST FUEL AREA)
c    15 = P (2ND FUEL AREA)
c    16 = P (3RD FUFL AREA)
c    17 = OPS (FLIGHT OPERATIONS AREA)
c    18 = CMD (COMMAND SUPPORT AREA)
c    19 = BSP (BASE SUPPORT AREA)
c    20 = CTN (CANTONMFNT AREA)
c    21 = H (MEDICAL AREA)
c
       i = z + 1
c
c ************************************************************
c ************************************************************
c
c  LOOP (MASTER PLAN)
c  -----------------
c ************************************************************
c
c   INCREMFNT TO NEXT FACILITY
c   -------------------------
c
198    if (i .eq. 12) then
        call MSA
       else if (i .eq. 13) then
        call MX
       else if (i .eq. 14) then
        call POL
       else if (i .eq. 15) then
         if(h .lt. 1) then
           call slydg1
           go to 199
         else
           call POL
         end if
       else if (i .eq. 16) then
         if(h .lt. 1)then
           call slydg2
           go to 199
         else
           call POL
```

```
          end if
        else if (i .eq. 17) then
         call OPS
        else if (i .eq. 18) then
         call CMD
        else if (i .eq. 19) then
         call BSP
        else if (i .eq. 20) then
         call CTN
        else if (i .eq. 21) then
         call MED
        else
         call finitt(0,30)
         go to 333
        end if
c
c *****************************************************
c
c   LOOP (INTERACTIVE SITING)
c   -------------------------
c
c      VCURSR BRINGS THE CURSOR TO THE SCREEN
c       a KEY ACTIVATES AN X-LONG RECTANGLE
c       b KEY ACTIVATES A Y-LONG RECTANGLE
c       d KEY PRESSED (DRAW) DRAW THE FACILITY
c       c KEY PRESSED (CLEAR)
c     ERASE THE SCREEN, REDRAW THE BASE, REDRAW FACILITIES
c     FROM PAST SUBROUTINES, REDRAW THE CURRENT FACILITIES
c     AT THE LAST CURSOR LOCATION, PROMPT THE USER
c       y KEY PRESSED (YES)
c     GO TO NEXT FACILITY SUBROUTINE OR TERMINATE THE PROGRAM
c     IF ON LAST FACILITY SUBROUTINE.
c       s KEY PRESSED (SAVE)
c     STORES THE COORDINATES (x1,x2,y1,y2) OF THE BASE
c     COMPONENTS AND THE FACILITY GROUPS IN AN EXTERNAL FILE
c       q KEY PRESSED (QUIT)
c     ENDS THE INTERACTIVE SITING LOOP
c
101    call vcursr(Key,x1(i),y1(i))
        if (Key .eq. ia) then
          call asub
        else if (Key .eq. ib) then
          call bsub
        else if (Key .eq. idraw) then
          call drawsb
        else if (Key .eq. iclear) then
          call clrsb
        else if (Key .eq. isave) then
          call svsub
        else if (Key .eq. iyes .or. Key .eq. iquit) then
          if(Key .eq. iyes .and. i .ge. 21) then
```

```
            call yessub
          else
            go to 197
          end if
        end if
        go to 101
c
197     if (key .eq. iquit) then
         call finitt(0,30)
         go to 333
        else
         call bell
         call bell
         call bell
        end if
c
c   UNTIL (END OF INTERACTIVE SITING LOOP)
c **************************************************************
199     i = i + 1
       go to 198
c
c  UNTIL (END OF INTERACTIVE SITING LOOP)
c **************************************************************
c **************************************************************
c
c  TERMINATE THE PROGRAM
c
333    stop
       end
c
c
       subroutine begin
       common/block2/linen,z
       integer linen,z
       print*,'Press g and return when ready to begin.'
       print*,'Press return again when you see the crosshairs.'
       read*,g
       call initt(960)
       call vwindo(0.,200.,0.,780.)
       call twindo(803,1023,0,780)
       linen = 0
       call vcursr(key,xz,yz)
       call erase
       call mvleft
       return
       end
c
c
       subroutine instrc
       common/block2/linen,z
       integer linen,z
```

```
      print *,'  Welcome to CARNAD, a systematic computer'
      print *,'program for contingency base master planning.'
      print *
      print *,'Key Code: c = clear, d = draw, q = quit'
      print *,'s = save, y(yes) = go to next facility.'
      print *
      print *,'Keys a and b can be used to change facility'
      print *,'orientation.'
      print *
      print *,'Choose the base of interest.'
      print *,'1) Base X'
      print *,'2) Base Y'
      linen = 8
      return
      end
c
c
      subroutine prt1
      common/block2/linen,z
      integer linen,z
        call mvleft
        print *,' Do you wish to'
        print *,'see the file ?'
        print*,'Choose y or n. '
        linen = linen + 3
      return
      end
c
c
      subroutine prt2
      common/block2/linen,z
      integer linen,z
        call mvleft
        print*,' No previous layouts '
        print*,' have been saved '
        linen = linen + 3
        call prmtrs
      return
      end
c
c
      subroutine readdt
      common/block1/i,x1,x2,y1,y2,c
      common/block2/linen,z
      common/block3/type,squads,people
      common/block6/asset
      integer type,squads,people
      integer asset
      integer i,linen,z
      real x1(25),x2(25),y1(25),y2(25)
        linen = 0
```

```
      call erase
      read (19,*) z,type,squads,people,asset
      call mvleft
      call visual
      linen = 3
      do 124 i = 1,z
        read(19,*)x1(i),x2(i),y1(i),y2(i)
124   continue
      return
      end
c
c
      subroutine eagle
      open (11,file = 'msade')
      open (12,file = 'mxde')
      open (13,file = 'polde')
      open (14,file = 'opsde')
      open (15,file = 'cmdde')
      open (16,file = 'bspde')
      open (17,file = 'ctnde')
      open (18,file = 'medde')
      return
      end
c
c
      subroutine bare
      open (11,file = 'msadb')
      open (12,file = 'mxdb')
      open (13,file = 'poldb')
      open (14,file = 'opsdb')
      open (15,file = 'cmddb')
      open (16,file = 'bspdb')
      open (17,file = 'ctndb')
      open (18,file = 'meddb')
      return
      end
c
c
      subroutine clrncs
      call rwyclr
      call twyclr
      call paclr
      call MSAclr
      return
      end
c
c
      subroutine visual
      common/block3/type,squads,people
      common/block6/asset
      integer type,squads,people
```

```
      integer asset
      call ptype
      call psquad
      call ppeopl
      call passet
      linen = linen + 4
      return
      end
c
c
      subroutine ptype
      common/block3/type,squads,people
      integer type,squads,people
      if (type .eq. 1) then
        print *,' Type = F-4(not G)'
      else if (type .eq. 2) then
        print *,' Type = F-15'
      else if (type .eq. 3) then
        print *,' Type = F-16'
      else if (type .eq. 4) then
        print *,' Type = A-10'
      else
        print *,' Type = F-4G'
      end if
      return
      end
c
c
      subroutine psquad
      common/block3/type,squads,people
      integer type,squads,people
      if (squads .eq. 1) then
        print *,' Squads = 1'
      else if (squads .eq. 2) then
        print *,' Squads = 2'
      else
        print *,' Squads = 3'
      end if
      return
      end
c
c
      subroutine ppeopl
      common/block3/type,squads,people
      integer type,squads,people
      if (people .eq. 1) then
        print *,' People = 500'
      else if (people .eq. 2) then
        print *,' People = 1000'
      else if (people .eq. 3) then
        print *,' People = 1500'
```

```
      else if (people .eq. 4) then
        print *,' People = 2000'
      else if (people .eq. 5) then
        print *,' People = 2500'
      else
        print *,' People = 3000'
      end if
      return
      end
c
c
      subroutine passet
      common/block6/asset
      integer asset
      if (asset .eq. 1) then
        print *,' Harvest Bare Assets'
      else
        print *,' Harvest Eagle Assets'
      end if
      return
      end
c
c
      subroutine prmtrs
      common/block2/linen,z
      common/block3/type,squads,people
      common/block6/asset
      integer linen,z
      integer type,squads,people
      integer asset
      z = 11
      call typeac
      call sq
      call peopl
      call assets
      return
      end
c
c
      subroutine typeac
      common/block2/linen,z
      common/block3/type,squads,people
      integer type
      integer linen,z
      data ione/49/,itwo/50/,ithree/51/,ifour/52/
      data ifive/53/
      call mvleft
      print *,'  What type of aircraft will be deployed ?'
      print *,'  Choose one .'
      print *,' 1) F-4 (G model not included)'
      print *,' 2) F-15'
```

```
      print *,' 3) F-16'
      print *,' 4) A-10'
      print *,' 5) F-4G'
      linen = linen + 5
99    call vcursr(Key,xz,yz)
      if (Key .eq. ione) then
        type = 1
      else if (Key .eq. itwo) then
        type = 2
      else if (Key .eq. ithree) then
        type = 3
      else if (Key .eq. ifour) then
        type = 4
      else if (Key .eq. ifive) then
        type = 5
      else
        go to 99
      end if
      return
      end
c
c
      subroutine sq
      common/block2/linen,z
      common/block3/type,squads,people
      integer linen,z
      integer squads
      data ione/49/,itwo/50/,ithree/51/
      call mvleft
      print *,'  How many squadrons will be deployed ?'
      print *,'  Choose one .'
      print *,' 1) 1 squadron'
      print *,' 2) 2 squadrons'
      print *,' 3) 3 squadrons'
      linen = linen + 4
99    call vcursr(Key,xz,yz)
      if (Key .eq. ione) then
        squads = 1
      else if (Key .eq. itwo) then
        squads = 2
      else if (Key .eq. ithree) then
        squads = 3
      else
        go to 99
      end if
      return
      end
c
c
      subroutine peopl
      common/block2/linen,z
```

```
      common/block3/type,squads,people
      integer linen,z
      integer people
      data ione/49/,itwo/50/,ithree/51/,ifour/52/
      data ifive/53/,isix/54/
      call mvleft
      print *,'  How many personnel will be deployed ?'
      print *,'  Choose the lowest figure ,greater than'
      print *,'or equal to the actual number of personnel .'
      print *,' 1)  500'
      print *,' 2) 1000'
      print *,' 3) 1500'
      print *,' 4) 2000'
      print *,' 5) 2500'
      print *,' 6) 3000'
      linen = linen + 6
99    call vcursr(Key,xz,yz)
      if (Key .eq. ione) then
        people = 1
      else if (Key .eq. itwo) then
        people = 2
      else if (Key .eq. ithree) then
        people = 3
      else if (Key .eq. ifour) then
        people = 4
      else if (Key .eq. ifive) then
        people = 5
      else if (Key .eq. isix) then
        people = 6
      else
        go to 99
      end if
      return
      end
c
c
      subroutine assets
      common/block2/linen,z
      common/block6/asset
      integer linen,z
      integer asset
      data ione/49/,itwo/50/
      call mvleft
      print *,'  Choose the type of asset expected to be used.'
      print *,' 1) Harvest Bare'
      print *,' 2) Harvest Eagle'
      linen = 0
99    call vcursr(Key,xz,yz)
      if (Key .eq. ione) then
        asset = 1
      else if (Key .eq. itwo) then
```

```
        asset = 2
      else
        go to 99
      end if
      call erase
      return
      end
c
c
      subroutine clearz
      common/block7/clear
      real clear(4:21,12:21)
      integer m,n
      do 26 m = 4,21
       do 25 n = 12,21
        clear(m,n) = 0.
25     continue
26    continue
      return
      end
c
c
      subroutine rwyclr
      common/block8/n,clearx,cleary
      real clearx(12:21),cleary(12:21)
      integer n
      do 25 n = 12,21
       if (n .eq. 12) then
        clearx(n) = 1000.
        cleary(n) = 240.
       else if (n .eq. 14 .or. n .eq. 15 .or.
     * n .eq. 16) then
        clearx(n) = 1000.
        cleary(n) = 200.
       else
        clearx(n) = 1000.
        cleary(n) = 500.
       end if
25    continue
      return
      end
c
c
      subroutine twyclr
      common/block7/clear
      real clear(4:21,12:21)
      integer m,n
      do 26 m = 4,7
       do 25 n = 12,21
        if (n .eq. 12) then
         clear(m,n) = 240.
```

```
        else if (n .eq. 14 .or. n .eq. 15
     * .or. n .eq. 16) then
         clear(m,n) = 50.
        else
         clear(m,n) = 250.
        end if
 25    continue
 26   continue
      return
      end
c
c
      subroutine paclr
      common/block7/clear
      real clear(4:21,12:21)
      integer n
      do 25 n = 12,21
       if (n .eq. 12) then
        clear(8,n) = 1600.
       else if (n .eq. 14 .or. n .eq. 15
     * .or. n .eq. 16) then
        clear(8,n) = 50.
       else
        clear(8,n) = 125.
       end if
 25   continue
      return
      end
c
c
      subroutine MSAclr
      common/block7/clear
      real clear(4:21,12:21)
      integer n
      do 25 n = 13,21
       if (n .eq. 14 .or. n .eq. 15
     * .or. n .eq. 16) then
        clear(12,n) = 2130.
       else
        clear(12,n) = 2350.
       end if
 25   continue
      return
      end
c
c
      subroutine base
      common/block1/i,x1,x2,y1,y2,c
      real x1(25),x2(25),y1(25),y2(25)
      integer i,c
      rewind 10
```

```
      do 200 i = 3,11
      read (10,*) x1(i),x2(i),y1(i),y2(i)
200   continue
      i = 11
      return
      end
c
c
      subroutine rec
      real x1(25),x2(25),y1(25),y2(25)
      integer i,c
      common/block1/i,x1,x2,y1,y2,c
      call movea(x1(c),y1(c))
      call drawa(x2(c),y1(c))
      call drawa(x2(c),y2(c))
      call drawa(x1(c),y2(c))
      call drawa(x1(c),y1(c))
      return
      end
c
c
      subroutine cursor
      common/block2/linen,z
      integer linen,z
      print *,'Locate cursor. Press d.'
      print *,'?'
      linen = linen + 2
      return
      end
c
c
      subroutine screen
c  (Establishes graphic area)
      common/block1/i,x1,x2,y1,y2,c
      real x1(25),x2(25),y1(25),y2(25)
      integer i,c
      x1(1) = 0.
      x2(1) = x2(3) - x1(3) + 150.
      y1(1) = 0.
      y2(1) = x2(1) * 700. / 820.
      return
      end
c
c
      subroutine scale
      common/block1/i,x1,x2,y1,y2,c
      real x1(25),x2(25),y1(25),y2(25)
      integer i,c
      x1(2) = x2(3) - 1500.
      x2(2) = x2(3) - 700.
      y1(2) = y1(3) + 40.
```

```
      y2(2) = y1(3) + 60.
      return
      end
c
c
      subroutine grafit
      common/block1/i,x1,x2,y1,y2,c
      common/block2/linen,z
      integer i,linen,z,c
      real x1(25),x2(25),y1(25),y2(25)
      do 300 c = 1,z
      call rec
      if (c .eq. 1 .or. c .eq. 4 .or. c .eq. 5 .or.
     * c .eq. 6 .or. c .eq. 7) then
       go to 300
      else
       call move
       call label
      end if
300   continue
      call direct
      return
      end
c
c
      subroutine direct
      integer car1(94)
      data car1/75,101,121,9,67,111,100,101,40,63,41,58,
     *9,121,61,9,103,111,9,116,111,9,110,101,120,116,9,102,
     *97,99,105,108,105,116,121,44,9,97,61,9,108,111,110,103
     *,9,120,44,9,98,61,9,108,111,110,103,9,121,44,9,99,61,
     *9,99,108,101,97,114,44,9,100,61,9,100,114,97,119,44,9,
     *113,61,9,113,117,105,116,44,9,115,61,9,115,97,118,101/
      call movabs(203,50)
      call anstr(94,car1)
      return
      end
c
c
      subroutine move
      common/block1/i,x1,x2,y1,y2,c
      real x1(25),x2(25),y1(25),y2(25)
      integer i,c
      integer nad2a(5),nad2b(2),nad2c(4)
      data nad2a/83,67,65,76,69/,nad2b/48,39/
      data nad2c/56,48,48,39/
      if (c .eq. 2) then
       call movea(x1(2) - 700.,y1(3) + 15.)
       call anstr(5,nad2a)
       call movea(x1(2) - 150.,y1(3) + 15.)
       call anstr(2,nad2b)
```

```
        call movea(x1(2) + 850.,y1(3) +15.)
        call anstr(4,nad2c)
       else if (c .eq. 9) then
        call movea(x1(c) + 70.,y1(c) + 15.)
       else
        call movea(x1(c) + 40.,y1(c) + 15.)
       end if
       return
       end
c
c
       subroutine mvleft
       common/block2/linen,z
       integer linen,z
       call movabs(0,(780 - ((linen + 1)*21)))
       call anmode
       return
       end
c
c
       subroutine MSA
       common/block9/a,b
       integer j,k,l
       real a(5,3,6),b(5,3,6)
       rewind 11
       do 401 j = 1,5
        do 400 k = 1,3
         do 399 l = 1,6
           read (11,*) a(j,k,l),b(j,k,l)
399      continue
400     continue
401    continue
       call mvleft
       print *,'     MSA'
       call choose
       return
       end
c
c
       subroutine MX
       common/block9/a,b
       integer j,k,l
       real a(5,3,6),b(5,3,6)
       rewind 12
       do 401 j = 1,5
        do 400 k = 1,3
         do 399 l = 1,6
           read (12,*) a(j,k,l),b(j,k,l)
399      continue
400     continue
401    continue
```

```
      call mvleft
      print *,'     Mx'
      call choose
      return
      end
c
c
      subroutine POL
      common/block1/i,x1,x2,y1,y2,c
      common/block2/linen,z
      common/block3/type,squads,people
      common/block5/h
      common/block9/a,b
      integer i
      integer type,squads,people
      integer f,j,k
      real a(5,3,6),b(5,3,6)
      real x1(25),x2(25),y1(25),y2(25)
      real g,g1,h,e(3)
      data ione/49/,itwo/50/,ithree/51/,ifour/52/,ifive/53/
      data isix/54/
      g1 = g1 + g
      if (i .eq. 14) then
       g1 = 0.
       f = 0
       g = 0.
       rewind 13
       do 601 j = 1,3
        read (13,*) e(j)
601    continue
       call mvleft
       print *,'    POL'
       print*
       print 650, e(squads)
650    format('Locate ',f2.0,' R-14s in',/,' 1 to 3 places ')
       print*,'How many places ?'
       linen = linen + 5
651    call vcursr(key,xz,yx)
        if(key .eq. ione) then
         f = 1
        else if(key .eq. itwo) then
         f = 2
        else if(key .eq. ithree) then
         f = 3
        else
         go to 651
        end if
       call mvleft
       print*,'   POL 1'
       linen = linen + 2
      else if(i .eq. 15) then
```

```
         call mvleft
         print*,'   POL 2'
         linen = linen + 2
        else
         call mvleft
         print*,'   POL 3'
         linen = linen + 2
        endif
        h = e(squads) - g1
        print 655, h
655     format('Need to place ',f2.0,' R-14s.')
        print 656
656     format('How many R-14s here ?')
        linen = linen + 1
661     call vcursr(Key,xz,yz)
         if(Key .eq. ione) then
          g = 1.
         else if(Key .eq. itwo) then
          g = 2.
         else if(Key .eq. ithree) then
          g = 3.
         else if(Key .eq. ifour) then
          g = 4.
         else if(Key .eq. ifive) then
          g = 5.
         else if(Key .eq. isix) then
          g = 6.
         else
          call mvleft
          print*, 'Select Keys 1 to 6'
          linen = linen + 1
          go to 661
         endif
         if (g .gt. h) then
             call bell
             call bell
             call bell
             call bell
             call bell
             call bell
             call mvleft
             print*, 'Too many R-14s'
             print *,' SQUIDBRAIN !'
             call bell
             call bell
             call bell
             call bell
             call bell
             call bell
             linen = linen + 2
             go to 661
```

```
        endif
       do 623 j = 1,5
        do 622 k = 1,3
         do 621 l = 1,6
          a(j,k,l) = 100. * g
          b(j,k,l) = 100.
621      continue
622     continue
623    continue
       call mvleft
       call choose
       h = e(squads) - g1 - g
699    return
       end
c
c
       subroutine slydg1
       common/block1/i,x1,x2,y1,y2,c
       real x1(25),x2(25),y1(25),y2(25)
           x1(15) = x1(14)
           x2(15) = x1(14)
           y1(15) = y1(14)
           y2(15) = y1(14)
       return
       end
c
c
       subroutine slydg2
       common/block1/i,x1,x2,y1,y2,c
       integer i
       integer c
       real x1(25),x2(25),y1(25),y2(25)
           x1(16) = x1(14)
           x2(16) = x1(14)
           y1(16) = y1(14)
           y2(16) = y1(14)
       return
       end
c
c
       subroutine OPS
       common/block9/a,b
       integer j,k,l
       real a(5,3,6),b(5,3,6)
       rewind 14
       do 401 j = 1,5
        do 400 k = 1,3
         do 399 l = 1,6
          read (14,*) a(j,k,l),b(j,k,l)
399      continue
400     continue
```

```
 401   continue
       call mvleft
       print *,'     OPS'
       call choose
       return
       end
c
c
       subroutine CMD
       common/block9/a,b
       integer j,k,l
       real a(5,3,6),b(5,3,6)
       rewind 15
       do 401 j = 1,5
        do 400 k = 1,3
         do 399 l = 1,6
          read (15,*) a(j,k,l),b(j,k,l)
 399     continue
 400    continue
 401   continue
       call mvleft
       print *,'     CMD'
       call choose
       return
       end
c
c
       subroutine BSP
       common/block9/a,b
       integer j,k,l
       real a(5,3,6),b(5,3,6)
       rewind 16
       do 401 j = 1,5
        do 400 k = 1,3
         do 399 l = 1,6
          read (16,*) a(j,k,l),b(j,k,l)
 399     continue
 400    continue
 401   continue
       call mvleft
       print *,'     BSP'
       call choose
       return
       end
c
c
       subroutine CTN
       common/block9/a,b
       integer j,k,l
       real a(5,3,6),b(5,3,6)
       rewind 17
```

```
      do 401 j = 1,5
       do 400 K = 1,3
        do 399 l = 1,6
         read (17,*) a(j,K,l),b(j,K,l)
399     continue
400    continue
401   continue
      call mvleft
      print *,'     CTN'
      call choose
      return
      end
c
c
      subroutine MED
      common/blocK9/a,b
      integer j,k,l
      real a(5,3,6),b(5,3,6)
      rewind 18
      do 401 j = 1,5
       do 400 K = 1,3
        do 399 l = 1,6
         read (18,*) a(j,K,l),b(j,K,l)
399     continue
400    continue
401   continue
      call mvleft
      print *,'     MED'
      call choose
      return
      end
c
c
      subroutine label
      common/blocK1/i,x1,x2,y1,y2,c
      integer i,c
      integer nad12(3),nad13(2),nad17(3),nad18(3),nad19(3)
      integer nad20(3),nad3(3),nad8(2)
      real x1(25),x2(25),y1(25),y2(25)
      data nad3/82,87,89/,nad8/80,65/
      data nad12/77,83,65/,nad13/77,88/,nad17/79,80,83/
      data nad18/67,77,68/,nad19/66,83,80/,nad20/67,84,78/
      if (c .eq. 3) then
       call anstr(3,nad3)
      else if (c .eq. 8) then
       call anstr(2,nad8)
      else if (c .eq. 9) then
       call ancho(87)
      else if(c .eq. 10 .or. c .eq. 11) then
       call ancho(85)
      else if (c .eq. 12) then
```

```
        call anstr(3,nad12)
       else if (c .eq. 13) then
        call anstr(2,nad13)
       else if (c .eq. 14 .or. c .eq. 15 .or. c .eq. 16) then
        call ancho(80)
       else if (c .eq. 17) then
        call anstr(3,nad17)
       else if (c .eq. 18) then
        call anstr(3,nad18)
       else if (c .eq. 19) then
        call anstr(3,nad19)
       else if (c .eq. 20) then
        call anstr(3,nad20)
       else if (c .eq. 21) then
        call ancho(72)
       end if
       return
       end
c
c
       subroutine asub
       common/block1/i,x1,x2,y1,y2,c
       common/block3/type,squads,people
       common/block4/x,y
       common/block9/a,b
       integer type,squads,people
       integer i
       real x1(25),x2(25),y1(25),y2(25)
       real x(25),y(25)
       real a(5,3,6),b(5,3,6)
          x(i) = a(type,squads,people)
          y(i) = b(type,squads,people)
          call mvleft
          call cursor
        return
        end
c
c
       subroutine bsub
       common/block1/i,x1,x2,y1,y2,c
       common/block3/type,squads,people
       common/block4/x,y
       common/block9/a,b
       integer type,squads,people
       integer i
       integer c
       real x1(25),x2(25),y1(25),y2(25)
       real x(25),y(25)
       real a(5,3,6),b(5,3,6)
          x(i) = b(type,squads,people)
          y(i) = a(type,squads,people)
```

```
        call mvleft
        call cursor
      return
      end
c
c
      subroutine drawsb
      common/block1/i,x1,x2,y1,y2,c
      common/block2/linen,z
      common/block4/x,y
      integer i,linen,z
      integer c
      real x1(25),x2(25),y1(25),y2(25)
      real x(25),y(25)
        x2(i) = x1(i) + x(i)
        y2(i) = y1(i) + y(i)
        c = i
        call rec
        call move
        call label
        call check
        call mvleft
        print *,'?'
        linen = linen + 2
      return
      end
c
c
      subroutine clrsb
      common/block1/i,x1,x2,y1,y2,c
      common/block2/linen,z
      common/block4/x,y
      integer i,linen,z
      real x1(25),x2(25),y1(25),y2(25)
      real x(25),y(25)
        x2(i) = x1(i) + x(i)
        y2(i) = y1(i) + y(i)
        call erase
        linen = 0
        z = i
        call grafit
        call mvleft
        print *,'?'
        linen = 1
      return
      end
c
c
      subroutine svsub
      common/block1/i,x1,x2,y1,y2,c
      common/block2/linen,z
```

```
      integer i,linen,z
      integer c
      real x1(25),x2(25),y1(25),y2(25)
         z = i
         call save
         call mvleft
         print *,'Saved'
         if (i .lt. 21) then
           print*,'?'
         else
           print *,'Press q to quit'
         end if
         linen = linen + 2
      return
      end
c
c
      subroutine yessub
      common/block2/linen,z
      integer linen,z
      call bell
      call bell
      call bell
      call mvleft
      print *,'Do you wish to save ?'
      print *,'Press s to save'
      print *,'Press q to quit'
      linen = linen + 3
      return
      end
c
c
      subroutine check
      common/block1/i,x1,x2,y1,y2,c
      common/block2/linen,z
      integer linen,z
      common/block7/clear
      common/block8/n,clearx,cleary
      common/blocka/k
      real x1(25),x2(25),y1(25),y2(25)
      real clear(4:21,12:21)
      real clearx(12:21),cleary(12:21)
      integer j
      j = 0
      call mvleft
      print *,'ERRORS'
      linen = linen + 1
      q = i - 1
      do 700 k = 3,q
       if (k .eq. 3) then
        if (x2(i) .le. x1(k) - clearx(i)) go to 700
```

```
      if (x1(i) .ge. x2(K) + clearx(i)) go to 700
      if (y2(i) .le. (y1(K) + y2(K))/2. - cleary(i)) go to 700
      if (y1(i) .ge. (y1(K) + y2(K))/2. + cleary(i)) go to 700
      j = 1
      call rwyerr
     else if ((i .ne. 12 .and. i .ne. 14 .and. i .ne. 15 .and.
    * i .ne. 16) .and. (K .eq. 4 .or. K .eq. 5 .or.
    * K .eq. 6 .or. K .eq. 7))then
      if (x2(K) - x1(K) .gt. y2(K) - y1(K)) then
       if (x2(i) .le. x1(K)) go to 700
       if (x1(i) .ge. x2(K)) go to 700
       if (y2(i) .le. y2(K) - clear(K,i)) go to 700
       if (y1(i) .ge. y1(K) + clear(K,i)) go to 700
      else
       if (x2(i) .le. x2(K) - clear(K,i)) go to 700
       if (x1(i) .ge. x1(K) + clear(K,i)) go to 700
       if (y1(i) .ge. y2(K)) go to 700
       if (y2(i) .le. y1(K)) go to 700
      endif
      j = 1
      call twyerr
     else
      if (x2(i) .le. x1(K) - clear(K,i)) go to 700
      if (x1(i) .ge. x2(K) + clear(K,i)) go to 700
      if (y2(i) .le. y1(K) - clear(K,i)) go to 700
      if (y1(i) .ge. y2(K) + clear(K,i)) go to 700
      j = 1
      call error
     end if
700  continue
     if (j .eq. 0) then
      print *,'NONE'
      linen = linen + 1
     end if
     return
     end
c
c
     subroutine rwyerr
     common/block1/i,x1,x2,y1,y2,c
     common/block2/linen,z
     common/block8/n,clearx,cleary
     integer i,linen,z,c
     integer n
     real x1(25),x2(25),y1(25),y2(25)
     real clearx(12:21),cleary(12:21)
     call mvleft
     print *,'Runway Error'
     print'(F6.1,' ft req. on end ',/,F6.1,' ft req. on side ')',
    *clearx(i),cleary(i)
     linen = linen + 3
```

```
      return
      end
c
c
      subroutine twyerr
      common/block1/i,x1,x2,y1,y2,c
      common/block2/linen,z
      common/block7/clear
      integer i,linen,z,c
      real x1(25),x2(25),y1(25),y2(25)
      real clear(4:21,12:21)
      call mvleft
      print *,'Taxiway Error'
      if (i .eq. 12 .or. i .eq. 14 .or. i .eq. 15 .or.
     *i .eq. 16) then
         print*,'(nearside)'
      else
         print*,'(farside)'
      endif
      print'(F6.1,' ft required ')',clear(4,i)
      linen = linen + 3
      return
      end
c
c
      subroutine error
      common/blocka/k
      integer k
      if (k .eq. 4 .or. k .eq. 5 .or. k .eq. 6 .or.
     *k .eq. 7) then
        call twyerr
      elseif (k .eq. 8) then
       call PAerr
      else if (k .eq. 9) then
       call H2Oerr
      else if (k .eq. 10 .or. k .eq. 11) then
       call Uerr
      else if (k .eq. 12) then
       call MSAerr
      else if (k .eq. 13) then
       call MXerr
      else if (k .eq. 14 .or. k .eq. 15 .or. k .eq. 16) then
       call POLerr
      else if (k .eq. 17) then
       call OPSerr
      else if (k .eq. 18) then
       call CMDerr
      else if (k .eq. 19) then
       call BSPerr
      else
       call CTNerr
```

```
      end if
      return
      end
c
c
      subroutine PAerr
      common/block1/i,x1,x2,y1,y2,c
      common/block2/linen,z
      common/block7/clear
      integer i,linen,z,c
      real x1(25),x2(25),y1(25),y2(25)
      real clear(4:21,12:21)
      call mvleft
      print *,'PA Error'
      print'(F6.1," ft required ")',clear(8,i)
      linen = linen + 2
      return
      end
c
c
      subroutine H2Oerr
      common/block2/linen,z
      integer linen,z
      call mvleft
      print *,'Water overlapped.'
      linen = linen + 1
      return
      end
c
c
      subroutine MSAerr
      common/block1/i,x1,x2,y1,y2,c
      common/block2/linen,z
      common/block7/clear
      integer i,linen,z,c
      real x1(25),x2(25),y1(25),y2(25)
      real clear(4:21,12:21)
      call mvleft
      print *,'MSA Error'
      print'(F6.1," ft required ")',clear(12,i)
      linen = linen + 2
      return
      end
c
c
      subroutine Uerr
      common/block2/linen,z
      integer linen,z
      call mvleft
      print *,'Unusable overlapped.'
      linen = linen + 1
```

```
      return
      end
c
c
      subroutine MXerr
      common/block2/linen,z
      integer linen,z
      call mvleft
      print *,'MX overlapped.'
      linen = linen + 1
      return
      end
c
c
      subroutine POLerr
      common/block2/linen,z
      integer linen,z
      call mvleft
      print *,'POL overlapped.'
      linen = linen + 1
      return
      end
c
c
      subroutine OPSerr
      common/block2/linen,z
      integer linen,z
      call mvleft
      print *,'OPS overlapped.'
      linen = linen + 1
      return
      end
c
c
      subroutine CMDerr
      common/block2/linen,z
      integer linen,z
      call mvleft
      print *,'CMD overlapped.'
      linen = linen + 1
      return
      end
c
c
      subroutine BSPerr
      common/block2/linen,z
      integer linen,z
      call mvleft
      print *,'BSP overlapped.'
      linen = linen + 1
      return
```

```
      end
c
c
      subroutine CTNerr
      common/block2/linen,z
      integer linen,z
      call mvleft
      print *,'CTN overlapped.'
      linen = linen + 1
      return
      end
c
c
      subroutine save
      common/block1/i,x1,x2,y1,y2,c
      common/block2/linen,z
      common/block3/type,squads,people
      common/block6/asset
      integer i,linen,z,c
      integer type,squads,people
      integer asset
      integer s,t
      real x1(25),x2(25),y1(25),y2(25)
      s = 2
      rewind 19
      write(19,*) s
      write(19,*) z,type,squads,people,asset
      do 127 t = 1,z
       write(19,*) x1(t),x2(t),y1(t),y2(t)
127   continue
      return
      end
c
c
      subroutine choose
      common/block1/i,x1,x2,y1,y2,c
      common/block2/linen,z
      common/block3/type,squads,people
      common/block4/x,y
      common/block9/a,b
      integer type,squads,people
      integer i,linen,z,c
      real x1(25),x2(25),y1(25),y2(25)
      real a(5,3,6),b(5,3,6)
      real x(25),y(25)
      data ia/97/,ib/98/
      print *,'Press key a or key b'
      print *
      print 460,a(type,squads,people),b(type,squads,people)
460   format(' a) ',f6.1,' by ',f6.1)
      print 470,b(type,squads,people),a(type,squads,people)
```

```
470   format(' b) ',f6.1,' by ',f6.1)
      linen = linen + 4
471   call vcursr(key,xz,yz)
        if (key .eq. ia) then
          x(i) = a(type,squads,people)
          y(i) = b(type,squads,people)
        else if (key .eq. ib) then
          x(i) = b(type,squads,people)
          y(i) = a(type,squads,people)
        else
          go to 471
        end if
      call mvleft
      call cursor
      return
      end
%
```

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