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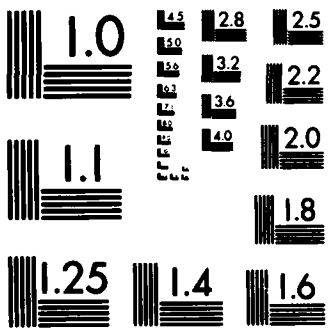

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APPS-IV civil works data extraction/database application study (Phase II)

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September 1983

Prepared for

**U.S. ARMY CORPS OF ENGINEERS
ENGINEER TOPOGRAPHIC LABORATORIES
FORT BELVOIR, VIRGINIA 22060**

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ETL-0336	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) APPS-IV CIVIL WORKS DATA EXTRACTION/DATABASE APPLICATION STUDY (PHASE II)		5. TYPE OF REPORT & PERIOD COVERED Nov. 1982 - Sept. 1983 Final Report
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) James D. Peroutky		8. CONTRACT OR GRANT NUMBER(s) DAAK70-81-C-0261
9. PERFORMING ORGANIZATION NAME AND ADDRESS Autometric, Incorporated 5205 Leesburg Pike/Suite 1308/Skyline One Falls Church, Virginia 22041		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Engineer Topographic Laboratories Fort Belvoir, Virginia 22060		12. REPORT DATE September 1983
		13. NUMBER OF PAGES 114
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Computer-Assisted Photointerpretation, Analytical Stereoplotters, Aerotriangulation Graphics Superposition, Geographic Information Systems, Digital Data Collection, AMS, MOSS, Master Planning, Wetlands Mapping

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report describes Phase II of the APPS-IV Civil Works Data Extraction/Database Application Study. A Master Planning Demonstration Project was performed under military funding for the Seattle District COE, and a Wetlands Mapping Demonstration was performed as a Civil Works project for the Portland District COE. Both demonstration projects involved the use of AMS for aerotriangulation and digitizing, and MOSS for statistical analysis and output preparation.

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Preface

This report was generated under Contract DAAK70-81-C-0261 for the U.S. Army Engineer Topographic Laboratories, Fort Belvoir, Virginia, by Autometric, Incorporated, Falls Church, Virginia. The Contracting Officer's Technical Representative was Mr. Laslo Greczy. The Contract Program Manager was Mr. Alan Smith. A major contribution to this report was made by Mr. Smith.

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1.0 INTRODUCTION

1.1 Background

During the past few years many Federal agencies have turned to the computer for storing, retrieving, analyzing, manipulating and displaying map information. This trend is especially true of such agencies as the Corps of Engineers (COE) that use remotely sensed imagery to collect land use data, to display information, and to carry out various planning, land management, and other applications. Many new techniques and technologies have resulted. A few years ago, recognizing the value of these technological developments, the COE developed the Computer-Assisted Photo-Interpretation Research (CAPIR) facility at the U.S. Army Engineer Topographic Laboratories (USAETL), Fort Belvoir, Virginia.

The CAPIR System consists of an APPS-IV (Analytical Photogrammetric Processing System-IV) stereoplotter interfaced to a host computer and AUTOGIS (Automated Geographic Information System). The APPS-IV, when linked to a digital computer and AUTOGIS, enables the photo analyst to view images in stereo, to accurately measure feature dimensions, to accurately locate these features on the earth's surface, and to record desired data in a digital format. Photointerpretation, mensuration, and digitization can be carried out simultaneously, thereby reducing the number of individual steps and time required to complete a project.

AUTOGIS software was originally developed for the U.S. Fish and Wildlife Service by Autometric, Inc. and the Federation of Rocky Mountain States. It controls all system set up, digitization and data manipulation. It enables the user to integrate and synthesize multiple data sets automatically by means of scale change, digital overlay, and other functions. These manipulations allow the development of correlations among data sets not readily determined by manual methods. Together the APPS-IV and AUTOGIS form the nucleus of CAPIR.

With the advent of CAPIR-type systems, it has become possible for analysts with no formal photogrammetric training (e.g., biologists, foresters, planners) to be directly involved in developing and exploiting digital databases.

1.2 Demonstration Project Summaries

Based on experience gained during previous efforts, USAETL is performing work under the COE Surveying and Satellite Applications/Remote Sensing Research Program to evaluate, demonstrate, and document the potential of CAPIR technology for Civil Works and Military data extraction, database development and database updating applications. As part of this effort, a contract was awarded to Autometric, Inc. to assess potential Civil Works and Military applications and to plan and conduct experiments to demonstrate possible uses of this technology.

Since 1979 USAETL has carried out a number of CAPIR projects to further exploit the rapidly developing areas of analytical photogrammetry, computer-assisted photointerpretation, and geographic information systems. Three demonstration projects have been undertaken in the USAETL APPS-IV Civil Works Data Extraction/ Database Application Study efforts. Two projects - Clinton River/Detroit District and Columbia River/Portland District - were recently conducted to demonstrate CAPIR's utility in supporting Civil Works activities. A third project (Fort Lewis/Seattle District) was conducted to assess CAPIR's utility in supporting the COE's Military Program efforts.

The Columbia River and Fort Lewis demonstrations were conducted as Phase II of the study and are the purpose of this report.

1.2.1 Detroit District (Clinton River) Demonstration (Phase I)

The Clinton River Phase I demonstration, which was completed in September 1982, was conducted in conjunction with the COE Detroit District in order to demonstrate how state-of-the-art analytical photogrammetric equipment and computer-assisted photointerpretation techniques could be used by the Corps to extract and manipulate data required to perform flood damage assessments. Structures (building types) and land use information were interpreted using stereo aerial photography and entered into a digital GIS for comparison and processing with ancillary, raster-formatted information. These data were then analyzed for their suitability for input to such COE tasks as SID (Structure Inventory for Damage) and DAMCAL (Damage Calculation Program).

1.2.2 Seattle District (Fort Lewis) Demonstration (Phase I)

The Fort Lewis demonstration was a Military-funded project showing the use of a CAPIR-type system for COE Master Planning. This demonstration consisted of the digitizing of 1967 Master Plan Base Maps, with additional data derived from photography flown in the fall of 1982.

Preliminary work was needed before any digitizing could take place. First, a coordinate transformation was performed to transform the Washington State Plane coordinate system (used on the maps) to a geographic system for use in AUTOGIS. Secondly, the aerial photography was aerotriangulated using the aerotriangulation subroutine in AMS.

Digitizing was performed using an X-Y digitizing table for all 1967 Master Plan map data. This included buildings, pavement areas, water, and sewer facilities and contour data. The updates to the buildings and pavement areas were accomplished using the APPS-IV stereoplotter. Only the additions to the 1967 Master Plan were digitized except in the case of building data. All buildings (including those shown on the 1967 maps) were digitized from photo data.

Outputs for this project included 1967 and 1982 Master Plan maps, separate building and pavement data for 1967 and 1982, sewer and water facilities, and contour data at 1:4,800 scale. These maps and a magnetic tape of the generated files were provided to ETL with this report.

1.2.3 Portland District (Columbia River) Demonstration (Phase II)

The Columbia River demonstration was a COE civil works project to show the capability of a CAPIR-type system in interpretation and digitization of wetland data. Three target years (1957, 1974, and 1981) were used for the evaluation of dredging effects on Columbia River wetland habitats. (Originally, five years of photography were to be used, but problems caused the elimination of two of these years.)

Only photographic data were used in this demonstration, so only the APPS-IV was used for digitizing. An aerotriangulation procedure was performed for each set of photography available for each of the three years.

Digitizing for this project consisted of the identification and recording of five major wetland classifications pertinent to COE activities. These classifications were permanently inundated areas, regularly inundated areas, occasionally inundated areas, above ordinary high water areas, and significantly above (+10 feet) ordinary high water areas. Sub classifications included vegetated and unvegetated areas.

During the analysis phase these areas were evaluated from many different aspects to determine the best scheme for displaying these data. This analysis included the use of a color CRT (with cursor capability) for creating a special map of the project area. The outputs for this project included demonstration maps for each year at 1:24,000 scale. Maps at 1:5,000 scale were prepared for the three years covering three islands of interest to Portland District personnel. A final set of maps covering one island was prepared at 1:5,000 scale showing an overlay of the individual classification schemes for each year. These maps, along with a magnetic tape of the data files created, were provided to ETL with this report.

2.0 COMPUTER-ASSISTED PHOTOINTERPRETATION RESEARCH (CAPIR) SYSTEM

2.1 System Overview

A basic CAPIR-type system needs the various components shown in Figure 1 to be practical and useful for the types of data collection, analyses, and displays for which it is designed. Most of the work conducted for the Fort Lewis and Columbia River demonstrations was performed at the Greenhorne and O'Mara, Inc. (G&O) facility in Greenbelt, Maryland. G&O is a multidisciplinary Engineering and Planning corporation, and is involved with many environmental analysis, land use, and planning projects. G&O is using AUTOGIS in a production capacity for many of these projects, and special arrangements were made for Autometric, Inc. to use their facility for the duration of the Fort Lewis and Columbia River demonstrations. The ETL CAPIR system configuration is shown in Figure 1; the G&O CAPIR-type system configuration closely resembled the ETL system.

2.1.1 Greenhorne and O'Mara Hardware

The G&O system hardware consists of a host computer with storage and display peripheral components and an X-Y digitizing table. An APPS-IV with graphics superposition was temporarily installed at the G&O facility by Autometric, Inc. for the purpose of aerotriangulation, digitizing, and photointerpretation.

This facility is supported by a Data General Eclipse MV/8000 minicomputer with an integral array processor. Standard peripherals include 800 and 1600 bpi magnetic tape drives, a 192 mega byte disk, a system console, a printer and a Calcomp drum plotter.

The monoscopic workstation is a commercial 36" x 48" table-mounted, back-lighted, digital tablet. An alphanumeric CRT and a graphics CRT allow for the input of commands and data displays. A special purpose "black-box" has been interposed between the RS-232c output of the table and the RS-232c port of the host computer so that signals originating from the X-Y digitizing table can be reformatted, buffered, and transmitted, to mimic the signals generated by the APPS-IV.

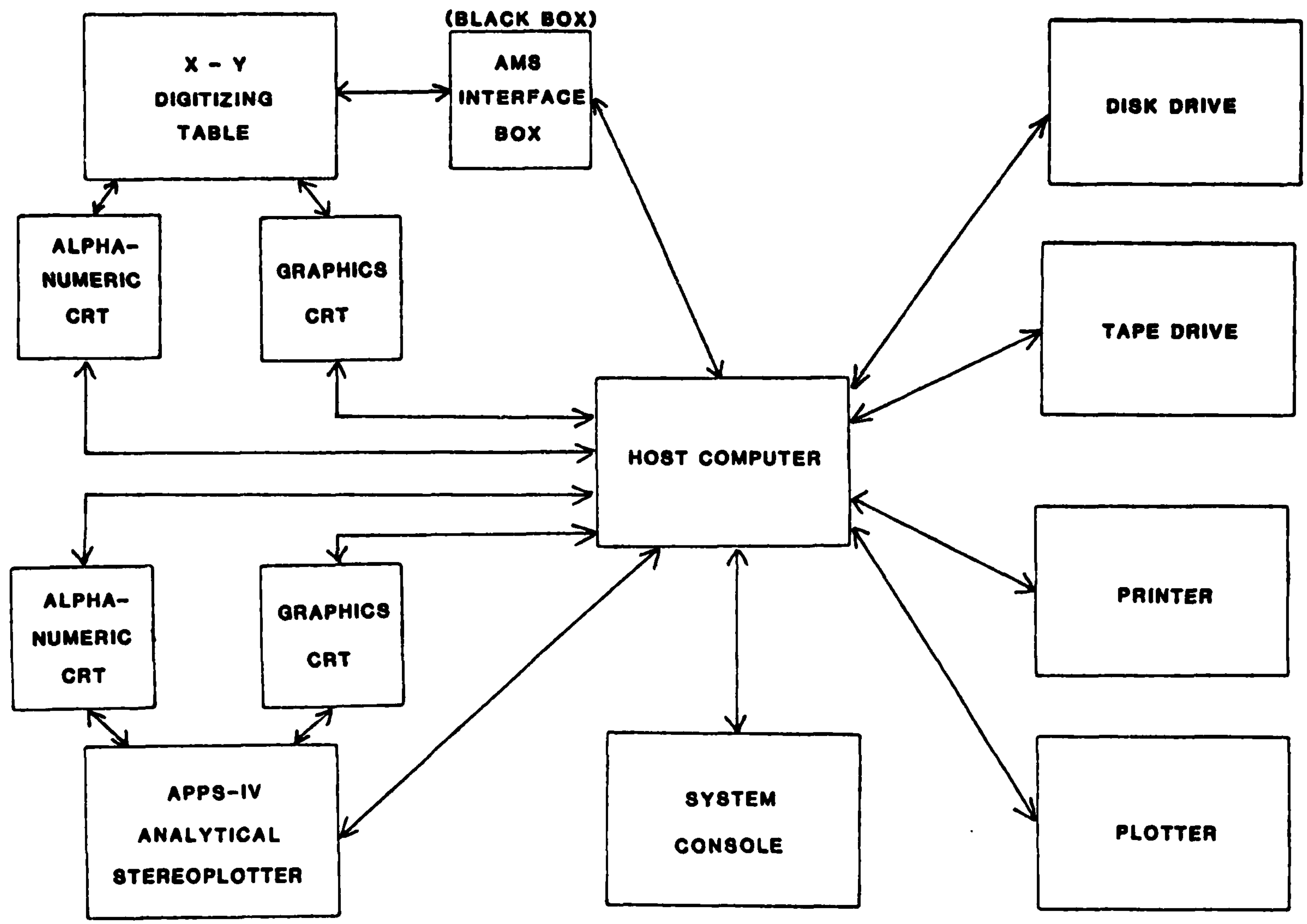


Figure 1 - Basic CAPIR System Components

The stereoscopic workstation consists of the APPS-IV analytical stereoplotter manufactured by Autometric, Inc. This station also had an alphanumeric CRT for command inputs and a graphics CRT for display of digitized features. Graphics superposition was installed midway through the project.

2.1.2 G&O Software

The relevant software on the G&O system consists of the host computer's software and Autometric's geographic information system software (AUTOGIS). The host software operates under the Data General Advanced Operating System (AOS), providing a multi-user, multi-tasking environment. System libraries consist of the International Mathematical and Statistics Library (IMSL), high-level array processing software, and graphics routines for Calcomp, Imlac, and Tektronix devices. Supported compilers include FORTRAN V, Pascal, and assembly language.

2.2 The Analytical Photogrammetric Processing System-IV (APPS-IV)

The APPS-IV (Figure 2) is a medium accuracy (± 10 microns) analytical stereoplotter consisting of an optical system for viewing stereo photographs, an electronics system of microprocessors, and a mechanical system with a unique stage-on-stage design. This design permits significant compactness as compared to other instruments of similar accuracy. The accuracy specification on the stage positon is 10 microns after conversion using an affine transformation. However, actual calibration tests have shown the RMS error seldom exceeds 7 microns. Thirteen microprocessors perform all servo motor functions for stage positioning, communications with the host computer, and stereo model maintenance (loop-close). The instrument accommodates imagery with formats up to 9 by 9 inches and provides controls for manual positioning of the stages, for collecting measurements, and for changing system functions.

2.2.1 APPS-IV Controls

There are three ways of effecting stage movements using the APPS-IV. A disengage switch (or declutch button) allows gross common stage movement. Fine common stage movements are accomplished by use of the trackball. Neither of these controls affect stereo maintenance of the model. The X and Y thumbwheels are used

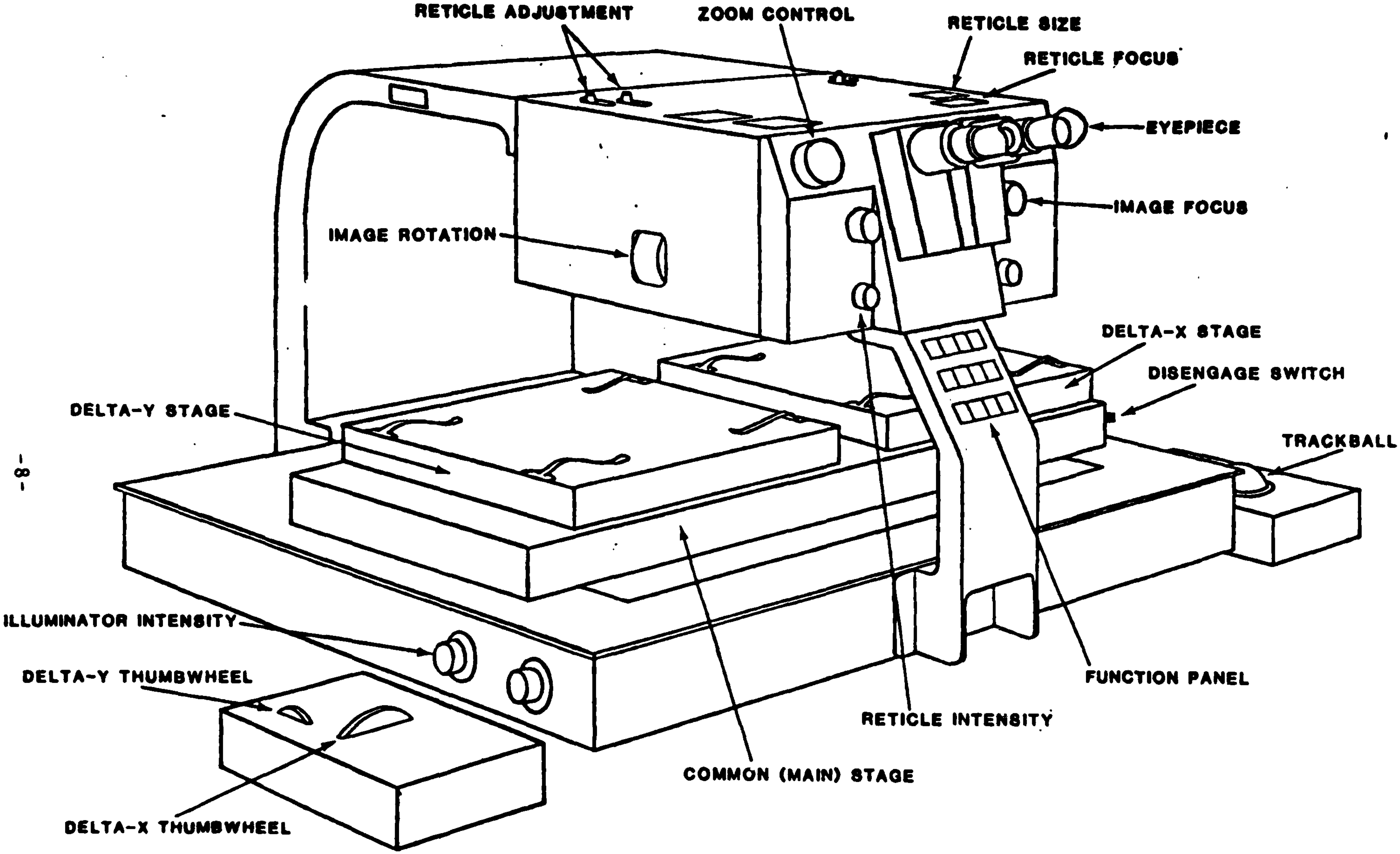


Figure 2 - APPS-IV Analytical Stereoplotter

for removing X and Y parallax in the stereo model and independently move only the upper stages. Data collection is accomplished through the use of a foot pedal.

The function panel controls the major digitizing functions (digitizing mode, node selection, and certain edit capabilities) and informs the operator of system error status. The on-line/off-line capabilities are also controlled through the function panel.

2.2.2 Optical System

One of the more notable features of the APPS-IV is its optical system. The Model 3500 OEM Zoom Stereoscope serves as standard optics (Figure 3). This system's 6-to-36-power zoom range is capable of high contrast resolution in excess of 250 line pairs per millimeter at 36 power. Controls are provided for image rotation and y-phoria correction, as well as an illuminated reticle projection system with 10-, 25-, 50-, and 100-micron dot sizes included for measurement purposes. As an option the Model 3500 optics may be equipped with one-half power parfocal demagnifiers on the objective to decrease the zoom range to 3-to-18-power. This range may be more suitable for many photointerpretation purposes. The field of view is 30 mm or 180 mm divided by the mangification, whichever is smallest. The field of view is doubled when the one-half power demagnifiers are installed.

2.2.3 Graphics Superposition

The most significant enhancement made to the APPS-IV instrument for the CAPIR system is the development of graphics superposition. Both single and dual optical path superpositions are now available. Graphics superposition provides the capability to view graphics from a stroke-refresh type of CRT optically superimposed onto a stereo model. Graphics superposition is accomplished through a second input channel at the objective end of the Model 3500 stereoscope. The digitized information is beam split into the optical path of the 3500 stereoscope (see Figure 3) and optically displayed on top of the stereo model.

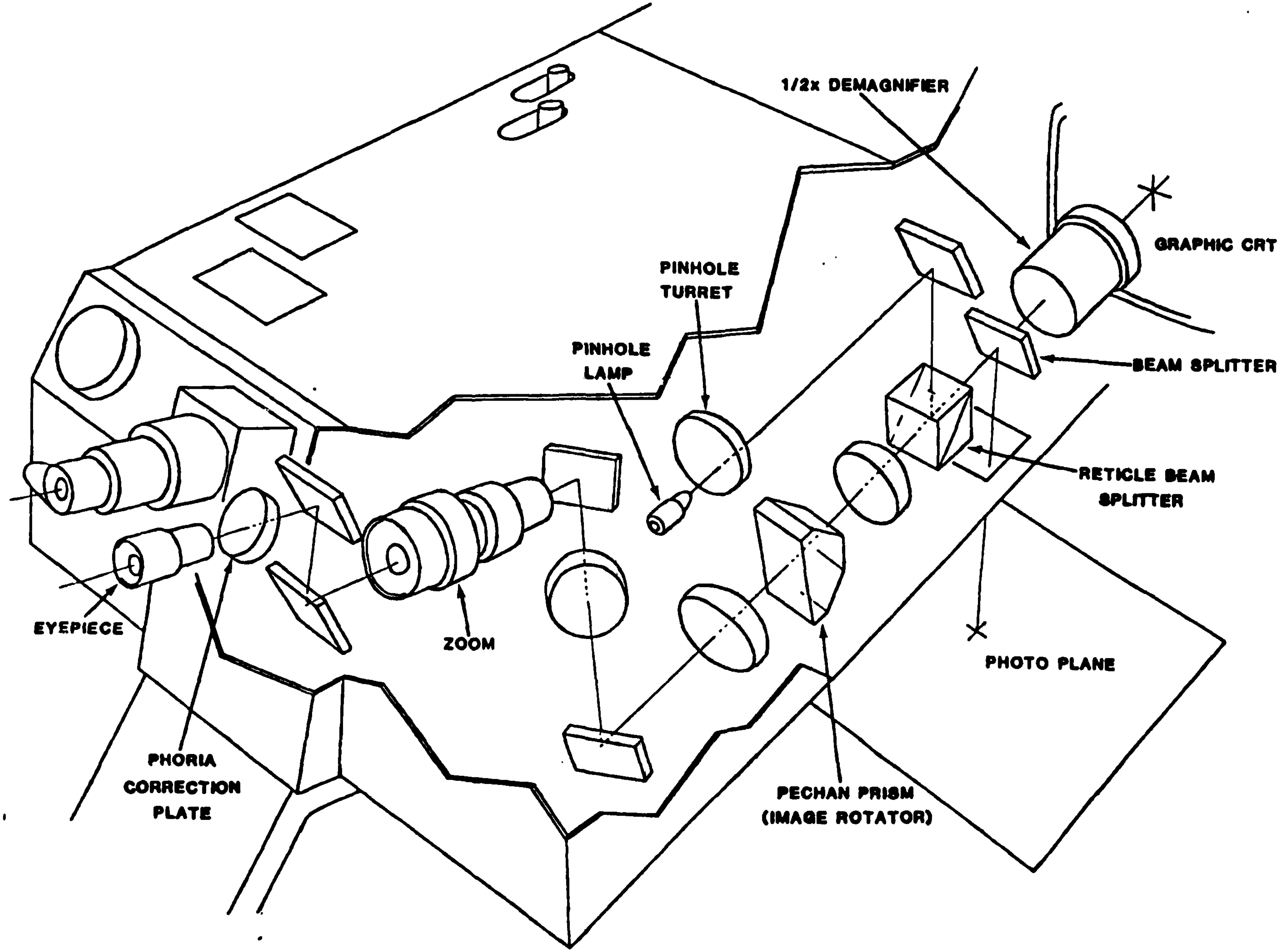


Figure 3 - APPS-IV Optics With Graphics Superposition

An additional microprocessor is added to the APPS-IV electronics package for each optical axis equipped with graphics superposition. These microprocessors constantly monitor the stage positions and translate the image of the graphics to match the current position of the stage, thus keeping the graphics registered at all times with the imagery. The geographic coordinates are transformed into image coordinates as they are downloaded from the host computer to the APPS-IV.

An option with graphics superposition is the one-half power demagnifier which essentially doubles the resolution of the graphics display. When superimposed on the imagery, these lines yield a higher resolution graphic display than would normally be possible by viewing the CRT one-to-one with the imagery.

2.3 Automated Geographic Information System (AUTOGIS)

AUTOGIS is a software system designed and developed by Autometric for the input, storage, retrieval, manipulation, and display of map information. Data can be input to the system via the APPS-IV, an X-Y digitizing table, or from digital tape. Once entered, data can be edited, verified, corrected, and stored for further manipulation, analysis, and output. Maps or photographs at almost any scale or projection can be measured using AUTOGIS software, and thematic data can be developed using photointerpretation techniques.

Digitized areas can be assigned attributes pertaining to the users needs, and multiple maps can be overlaid to form one composite manuscript. Many types of hardcopy and softcopy plots can be output. Since information is stored in a digital format, the database is readily accessible and the information is easily edited.

AUTOGIS is divided into two major sections: the Analytical Mapping System (AMS), which handles the initial map/photo set up and digitization procedures; and the Map Overlay and Statistical System (MOSS), which handles statistics generation, data manipulation, and output.

2.3.1 The Analytical Mapping System (AMS)

AMS represents the data entry and data edit sub-system of AUTOGIS. AMS is a completely interactive general purpose digitizing and editing software system which permits data entry from either maps or photos. AMS provides a full map data base capability in a structured, menu-driven format. This system is used for aerotriangulation purposes (using the APPS-IV), photointerpretation, and digitization The four primary capabilities of AMS include analytical aerotriangulation, digitization (from the APPS-IV or an X-Y table), spatial verification, and database management.

2.3.1.1 The Aerotriangulation Subsystem

Analytical aerotriangulation is the process by which the optical centers and the photographic images are mathematically modeled (Figure 4). AMS utilizes an interactive aerotriangulation package, employing many of the principles of photogrammetry (collinearity), to compute the camera station parameters for aerial photographs used in digitizing.

Using ground control points derived from geodetic files or topographic map sheets, and photo coordinates measured on the APPS-IV, a rigorous bundle adjustment program solves for camera station parameters, position and orientation for as many as ten frames. The inputs to this triangulation package are:

1) Camera parameters
2) Ground control measurements
3) Image measurements
4) Frame estimates
5) Pass point estimates

Outputs from this package are:

1) Final frame position and attitude
2) Final control point positions and residuals
3) Final pass point positions and residuals
4) Error propagation results

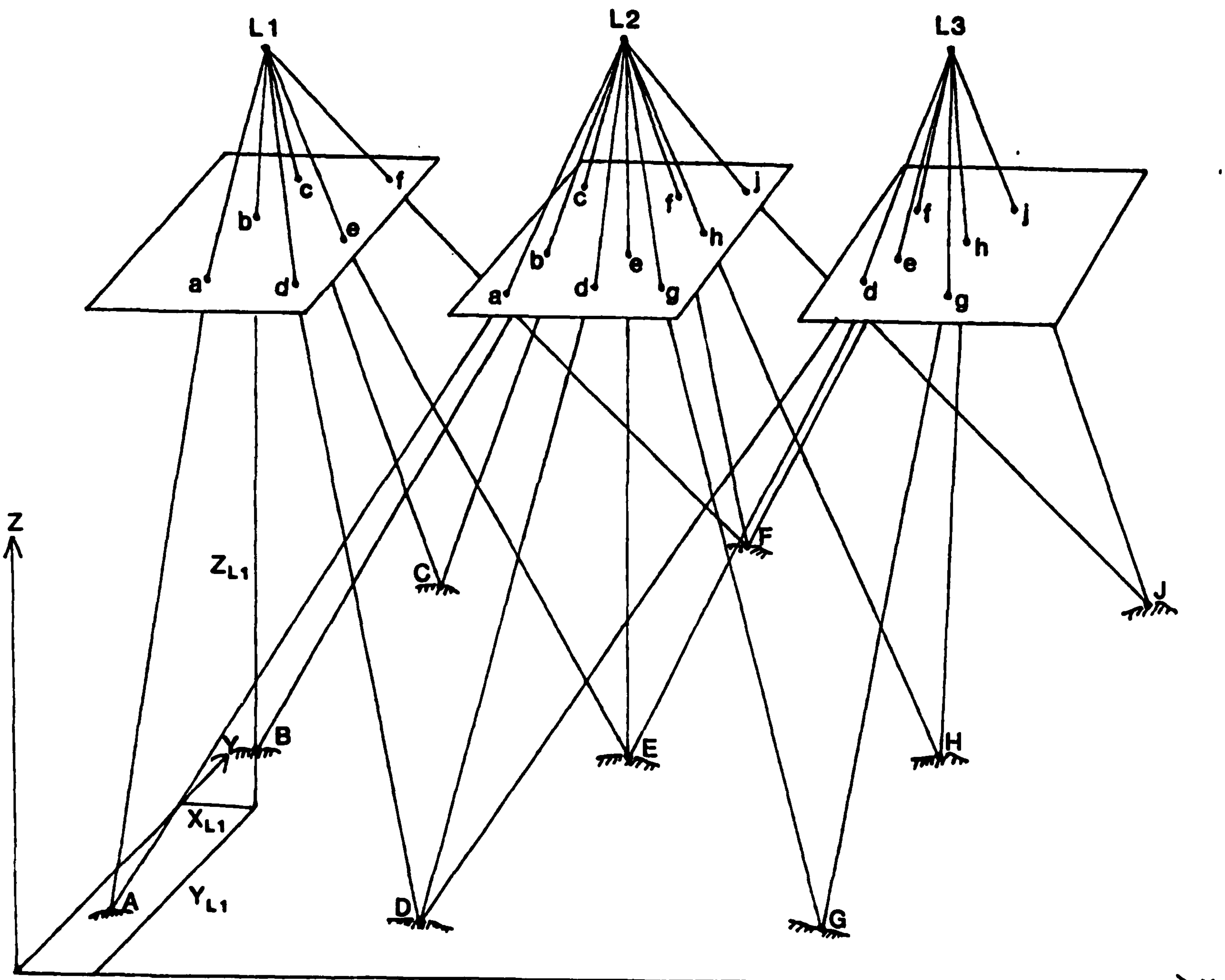


Figure 4 - The Collinearity Condition
(Adapted from Moffitt and Mikhail, 1981)

The operator is led through the triangulation procedure by a sequence of menus that feature capabilities for model set up (interior orientation), measurement of points, on-line data inspections and editing, analysis of triangulation results, and process control.

AMS set up procedures require three unique identifiers for all aerotriangulation jobs: the mission ID, the frame IDs, and the camera ID. The mission ID is used to identify all frames (and/or strip(s) of photography) in one mission . This identifier is stored in the frame database and is used later in support of the digitizing subsystem.

The frame ID's, which are unique to each frame within a mission (or strip), are used to identify each particular model. This information is stored in the frame database and is also used later in support of the digitizing subsystem. Normally, a unique number is exposed on the edges of a frame photography at imaging time as an aid in tracking separate frames.

The camera ID is also unique because it relates to the camera database. The camera parameters (calibrated focal length, fiducial measurements, principle point offsets, and lens distortions) are used when setting up models for aerotriangulation or digitizing. These parameters, which are contained in the camera calibration reports, are entered into the camera database.

A checkpoint is selected during image point measurement. This check- point is a clearly identifiable point that is used throughout the digitizing process for controlling stereo maintenance (loop-close) and checking digitizing accuracy.

The triangulation solution package of the aerotriangulation subsystem allows the operator almost complete control over the solution process. The operator may select the local tangent system origin, the number of iterations desired, and the points to be removed from the solution. Points removed from the solution process are still contained in the triangulation data file, but are not used in that particular solution. The unwanted points are removed by changing their status code. Both image points and ground control points may be removed from the solution in this manner.

2.3.1.2 The Digitizing Subsystem

The digitizing subsystem in AMS enables the operator to digitize from aerial photographs (using the APPS-IV) and map sheets (using an X-Y digitizing table). Photographs and maps at virtually any scale or orientation can be digitized. This subsystem is menu driven and guides the operator through the digitizing process.

AMS produces three basic elements of information during the digitizing process: arcs, nodes, and attributes. The three different feature types formed by these elements are polygons, lines, and points (Figure 5). Polygons A and B are delineated on the outside by arcs 1 and 3 for A and B, respectively. Arc 2 (which is also lineal feature C) represents the common boundary. Feature D is a point feature. Nodes a, b, and c represent the beginning and ending points of the arcs. All arcs must intersect at nodes. Attributes are the unique identifiers attached to features during the digitizing process. Each unique feature or group of features should be defined by a different attribute. This will enable plotting of features by individual attributes later on in MOSS. To illustrate the significance of attributes, consider that arc 3 is digitized from node a to b to c. In this case, feature A is on the right and B is on the left. Therefore, arc 3 has a left attribute of B, a right attribute of A, and a center attribute of C. Feature Z is a polygon and is the background feature for the manuscript.

There are three different modes of digitizing in AMS: point, curve, and stream. In point mode, the discrete points that delineate the feature are identified by the operator. This procedure is generally used for straight lines or individual point features. Curve mode is similar to point mode in the manner in which points are chosen. However, cubic curves instead of straight lines are fitted between the points. This mode is useful when the features being digitized are characterized by gently breaking curving lines. Stream mode is used for digitizing intricate or irregular features. In this mode, points are recorded automatically at a specific distance interval as the feature is traced.

The editing of data can occur at two different times during the digitizing process. If a mistake is made while an arc is being digitized, the operator can deleted the entire arc from the data set and digitize it again or, the end portion of that arc can be "clipped off" and digitizing continued normally. Secondly, if a completed data set contains errors, the operator can identify a specific arc, node, or polygon by its ID number and perform the required edits to correct that data set.

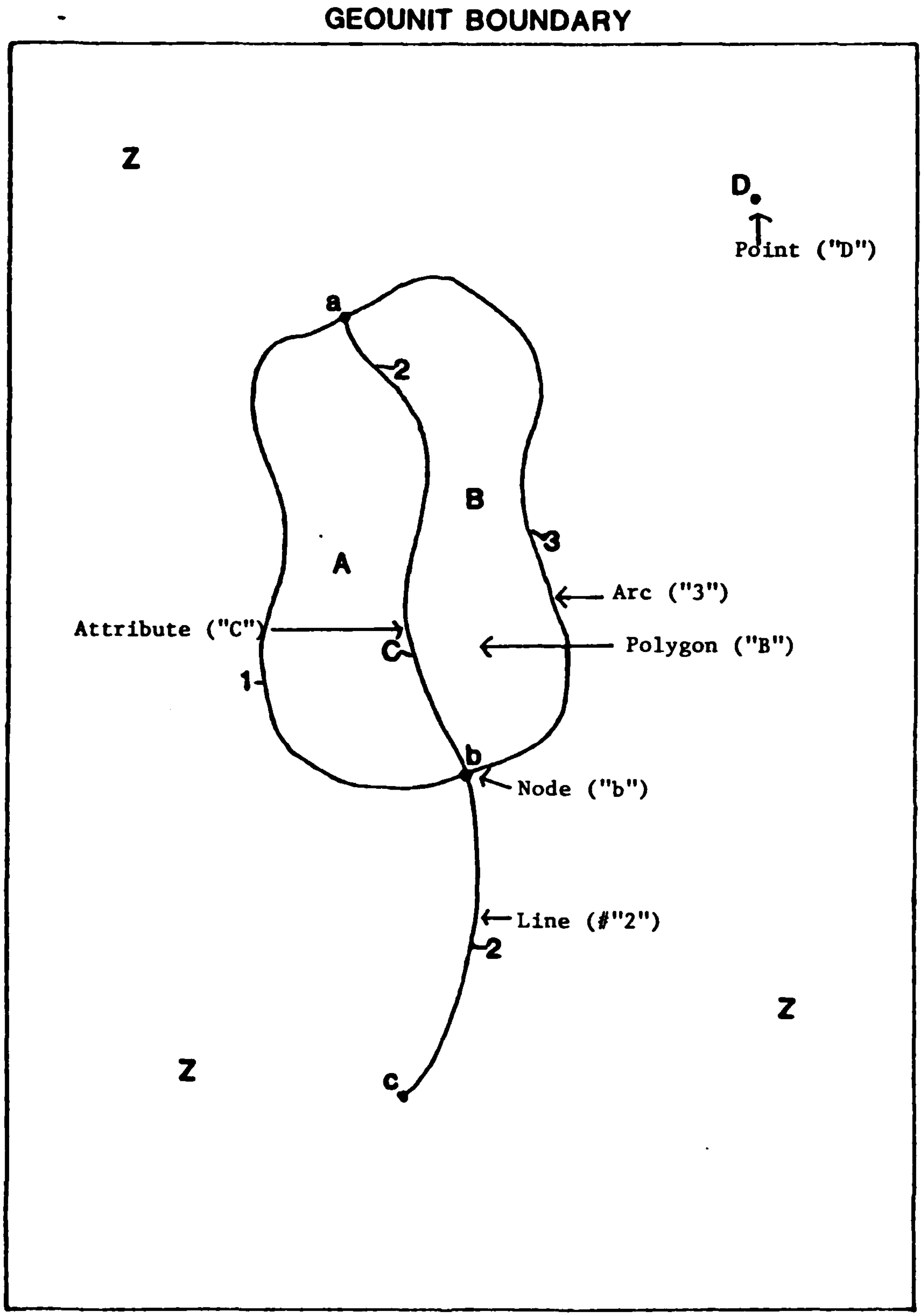


Figure 5 - AMS Feature Types

2.3.1.3 Spatial Verification

Geo-encoded and digitally recorded features are formed during the digitizing process. Thus, the information needed to form a topologically valid data structure exists upon completion of a digitization task. In this process the data are checked automatically for any digitizing errors. A data verification process can be performed either upon completion of each digitizing effort or after completion of the entire digitizing effort. The main purpose of the verification process is to determine whether all polygons are closed. Some of the other conditions checked during this procedure include:

1) Illegal attributes
2) Missing attributes
3) Missing nodes
4) Illegal arcs
5) Missing arcs
6) Duplicate arcs
7) Kinks within an arc
8) Spikes (overshoots)
9) Gaps

When completed successfully, the verification process will confirm that the database is topologically valid.

2.3.1.4 Database Management

The geographic database in AMS has a simple structure due to the use of the "geounit" as the functional division of information. The geounit structure is formatted in the same manner as the U.S. Geological Survey (U.S.G.S.) topographic map series index; that is, individual quadrangle maps are equivalent to geounits.

The database subsystem includes two types of database structures: national and project. The national database covers the conterminous United States and consists of four geounit sizes equivalent to the four standard U.S.G.S. quadrangle sizes:

1) 7.5 minutes x 7.5 minutes (1:24,000)
2) 15 minutes x 15 minutes (1:62,500)
3) 0.5 degrees x 1 degree (1:100,000)
4) 1 degree x 2 degrees (1:250,000)

The project database can cover an area as small as 2 seconds by 2 seconds or as large as one quadrant of the earth's surface. This project database is designed completely to user specifications through the use of an interactive program. To select a user-specified geounit, the operator defines the corner coordinates of the project area.

Any geounit stored in the database can be queried or plotted. The queries provide statistical summaries describing the type, quantity, and area of features on a geounit basis. Features may be automatically labeled on hardcopy plots if desired. This database subsystem enables the creation of projects, themes, and classification schemes needed for digitizing. The database subsystem also serves as the bookkeeping section of AMS.

2.3.2 The Map Overlay and Statistical System (MOSS)

Once a map or photograph has been interpreted and digitized using AMS, it is transferred to the MOSS database in a form suitable for quick and efficient retrieval, analysis, and display. During the transfer process, the coordinate data are transformed from latitude-longitude to UTM, Lambert Conformal, Polyconic, or Albers coordinates for the actual data analysis. This transformation makes computational tasks more efficient by converting arc-second coordinate data to metric units.

MOSS is an extensive, completely interactive software system that enables the user to execute over 70 different functions (Appendix A). Each function is finite and performs a particular task, such as plotting a map on the CRT. MOSS is not a model and makes no a priori assumptions about what the user wishes to do. These different functions are subdivided into five main groups (Table 1):

Table 1 - MOSS Functions/Commands

NOTE: A description of these functions and commands can be found in Appendix (A).

General Purpose	Database	Analysis	Display	Spatial Retrieval
AUDIT	ACTIVE	AREA	ASSIGN	CONTIGUITY
BAUD	ADD	ASPECT	BLOWUP	EDGE
CLI	ATTRIBUTE	BUFFER	CALCOMP	PROXIMITY
COST	BSEARCH	CBUFFER	CELLPLOT	SIZE
DEBUG	DELETE	COMPOSITE	ERASE	
FINISH	DUMP	CONTOUR	LEGEND	
HELP	EDITATT	DISTANCE	LINE	
LOCATE	EXPORT	FREQUENCY	NUMBER	
NEWS	FREE	GRID	PLOT	
QUERY	LIST	LENGTH	PROJECTION	
	MERGE	LPOVER	RESET	
	MULTIVAL	MODELG	SHAPE	
	OPEN	OVERLAY	SYMBOL	
	POLYCELL	PERIMETER	TESTGRID	
	RASTER	POINTOVER	THREED	
	REPORT	PROFILE	WINDOW	
	SAMPLE	SLOPE	WRITE	
	SAVE	STATISTICS		
	SELECT			
	SNGVAL			
	SPSS			
	STATUS			
	STUDYAREA			
	TEXT			
	TRANSLATE			
	WEED			

1) General purpose functions
2) Database functions
3) Analysis functions
4) Display functions
5) Spatial retrieval functions

The user uses a simple, English-type command language to execute these functions. Because MOSS is interactive, the user executes these functions while seated in front of a terminal.

2.3.2.1 General Purpose Functions

General Purpose Functions perform no data manipulation. These functions enable the user to erase the screen, print a table showing the cost of a MOSS session, or terminate a MOSS session. These functions are easily understood and require no technical or analytical training.

2.3.2.2 Database Functions

Database Functions enable the user to manipulate data stored in the MOSS map database. The user can be connected to three map databases simultaneously. One of these databases is called the master map database and contains all the original digitized map data. A second database stores raster (cell) data (three-dimensional data), and a third stores point, line, and polygon data (two-dimensional data). These "work" databases usually contain the results of some map analysis or manipulation. Users may retrieve, store, and/or delete maps from their "work" databases, as needed.

A map database can contain up to 2,000 maps. Each map can have up to 16,000 polygons stored and each polygon can have up to 32,000 coordinate pairs and 225 islands. Each map can also have up to 800 attribute types. In addition, up to 200 minor attributes can be assigned to any point, line, or polygon.

Once map data are stored in the database, any of the following database manipulations can be performed:

1) Obtain a list of maps
2) Obtain a list of legends for a map
3) Obtain a list of subjects for a map
4) Obtain a list of polygons for a map
5) Select data from a map
6) Save a map in the user work database
7) Merge maps
8) Archive and de-archive maps to and from magnetic tape
9) Determine the status of a map

In addition to these functions, there is a set of database functions that only the database administrator can use. These provide for the insertion, deletion, and update of maps in the master map database.

2.3.2.3 Analysis Functions

The Analysis Functions represent the workhorse functions of MOSS. These functions enable the user to manipulate map data, create new maps, and perform mensuration and statistical analyses. Perhaps the most powerful of the analysis commands is polygon overlay, which enables the user to generate the logical intersection between two maps and create a new map which would be stored in the user's "work" database (Figure 6). Some of the other analysis functions are:

AREA: Produces a table showing areas by polygon type.
DISTANCE: Determines the distance between two points.
QUERY: Determines an attribute by pointing to a point, line or polygon with the cursor.
POLYCELL: Performs polygon to cell conversion.
BUFFER: Puts a buffer zone around a point, line, or polygon.

2.3.2.4 Display Functions

Display Functions enable the user to display, on either a CRT or hard copy plotter, any map or part of a map stored in any one of the map databases at any one of twenty-one different projections (Table 2). These output displays can often be the final product in a long sequence of analysis steps. Described below are four of the display options:

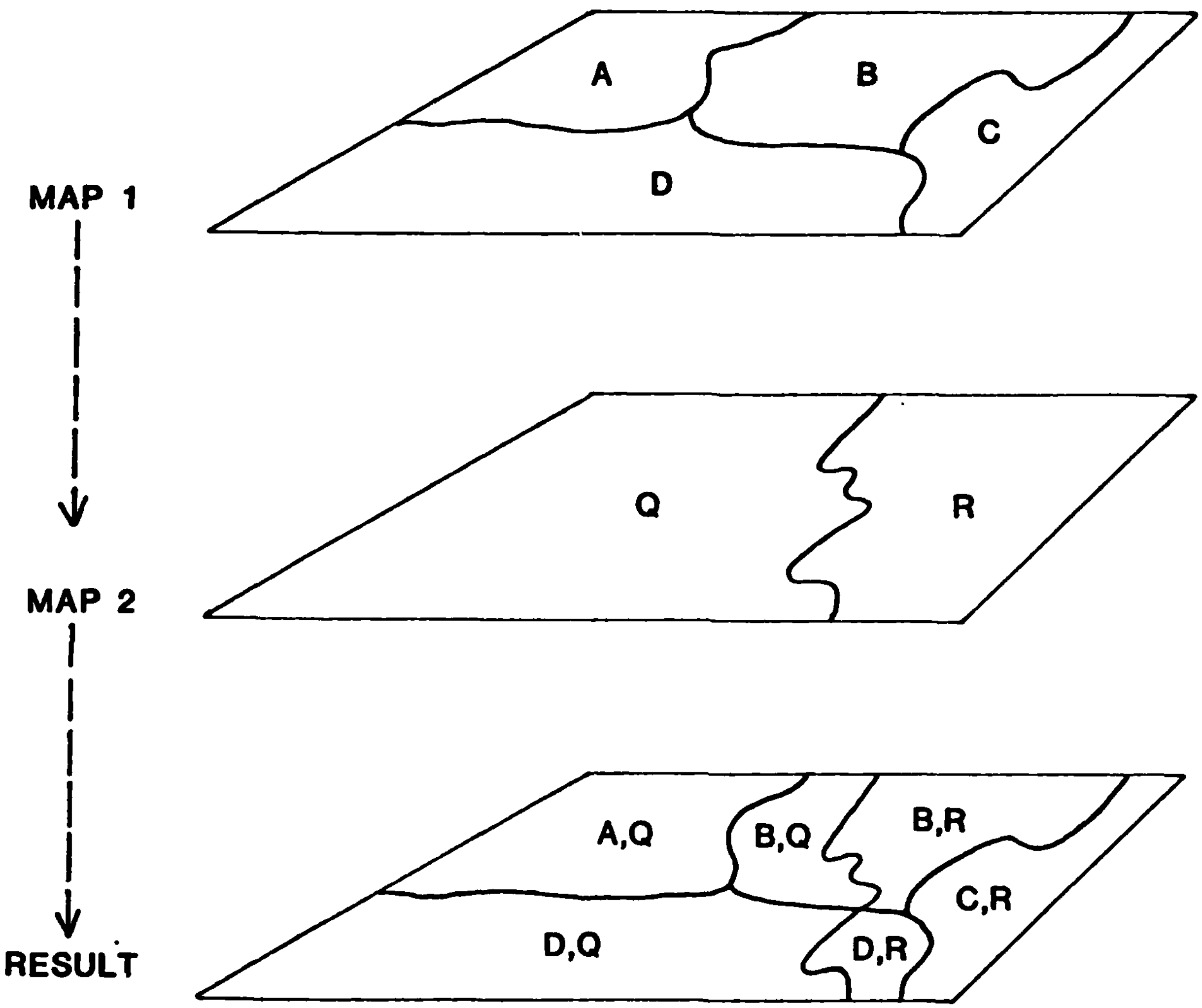


Figure 6 - Polygon Overlay Process

Table 2 AUTOGIS Projections

Projection No.	AUTOGIS Code	Projection
1)	0	GEOGRAPHIC LATITUDE/LONGITUDE
2)	1	UNIVERSAL TRANSVERSE MERCATOR
3)	2	STATE PLANE
4)	3	ALBERS CONICAL EQUAL AREA
5)	4	LAMBERT CONFORMAL CONIC
6)	5	MERCATOR
7)	6	POLAR STEREOGRAPHIC
8)	7	POLYCONIC
9)	8	EQUIDISTANCE CONIC
10)	9	TRANSVESE MERCATOR
11)	10	STEREOGRAPHIC
12)	11	LAMBERT AZIMUTHAL
13)	12	AZIMUTHAL EQUIDISTANCE
14)	13	GNOMONIC
15)	14	ORTHOGRAPIC
16)	15	VERTICAL NEAR SIDE PERSPECTIVE
17)	16	SINUSOIDAL
18)	17	EQUIRECTANGULAR
19)	18	MILLER CYLINDRICAL
20)	19	VAN DER GRINTEN 1
21)	20	OBLIQUE MERCATOR

PLOT: Produces a simple plot of a map.

SHADE: Produces a simple shaded map.

THREED: Produces a three-dimensional display of either raster or digital elevation data.

CALCOMP: Produces a color map on a plotter.

2.3.2.5 Spatial Retrieval Functions

The Spatial Retrieval Functions are uniquely geographic in nature. They analyze map data on the basis of size and distance criteria. Examples of the four spatial retrieval functions are:

SIZE:	Selects data by size criteria (e.g., all areas larger than 50 acres)
EDGE:	Selects common boundaries between areas
CONTINGUITY:	Identifies specific areas adjacent to each other (e.g., all areas of attribute A adjacent to areas of attribute B).
PROXIMITY:	Selects data by distance criteria (e.g., all areas with one mile of a specific feature).

3.0 FORT LEWIS DEMONSTRATION - SEATTLE DISTRICT

3.1 Purpose

The purpose of this demonstration project was to show how CAPIR technology could be used to efficiently and accurately create and revise digital data files of information contained in U.S. Army Corps of Engineers (COE) Master Plans. The CAPIR system was used to create a digital database from the 1967 Fort Lewis Master Plan. This plan was then revised using recently acquired photography covering an area where significant changes had occurred.

3.2 Background

The survey/photogrammetry section of COE's Seattle District is responsible for preparing and updating Master Plans of Army installations in their operating area. These Master Plans generally contain information regarding general site plans, road and railroad networks, water and sewer facilities, electrical lines, topography, etc., and are usually in the form of paper maps and/or mylar overlays. In areas undergoing rapid development, the updating of these maps can become a major undertaking since supplementary inputs can vary significantly in scale, format, and complexity. Maps and overlays can also become cumbersome to use and store.

3.3 Current Practice

The current Fort Lewis Master Plan, which was compiled in 1967, consists of maps and graphics at a scale of 1:4,800, and orthophotos with overprinted topographic information at scales of 1:2,400 and 1:1,200. Since certain areas of Fort Lewis have experienced considerable development since the last Master Plan update, the Seattle District is currently recompiling all of the map sheets in the database, using 1:1,200 scale black-and-white photography flown in 1979.

The Seattle District currently prepares Master Plans using a combination of traditional photogrammetric, ground survey, and cartographic techniques. The final product is a set of overlays/thematic maps containing the types of information described in Section 3.5.2.

3.4 Applicability of CAPIR

By the use of CAPIR technology, digital databases of Master Plan data can be rapidly developed and updated. Once in digital form, various data types can be analyzed and merged, regardless of input formats. The system provides analytical tools for the extraction and manipulation of these data and can produce hardcopy outputs at virtually any scale, format, projection, and design.

3.5 Demonstration Project Methodology

3.5.1 Test Site Selection

Site selection for the Fort Lewis demonstration was based on discussions with Seattle District personnel. The area selected was a portion of Fort Lewis that has undergone rapid development in recent years. The test site was contained entirely within map sheet number seven of the 1967 Fort Lewis Master Plan (Figure 7). The site was bounded by the following Washington State Plane coordinates (Washington Lambert Coordinate System, South Zone):

North	649,000
North	640,000
East	1,487,000
East	1,482,000

The site covered an area of 45,000,000 square feet, or slightly more than 1033 acres.

3.5.2 Resource Collection

The Seattle District provided USAETL with the following 1967 Master Plan maps:

- General Site Map (1:4,800)
- General Road and Railroad Map (1:4,800)
- General Sanitary Sewer Map (1:4,800)
- General Water Map (1:4,800)
- Orthophoto Contour Maps (1:1,200) (total of six)

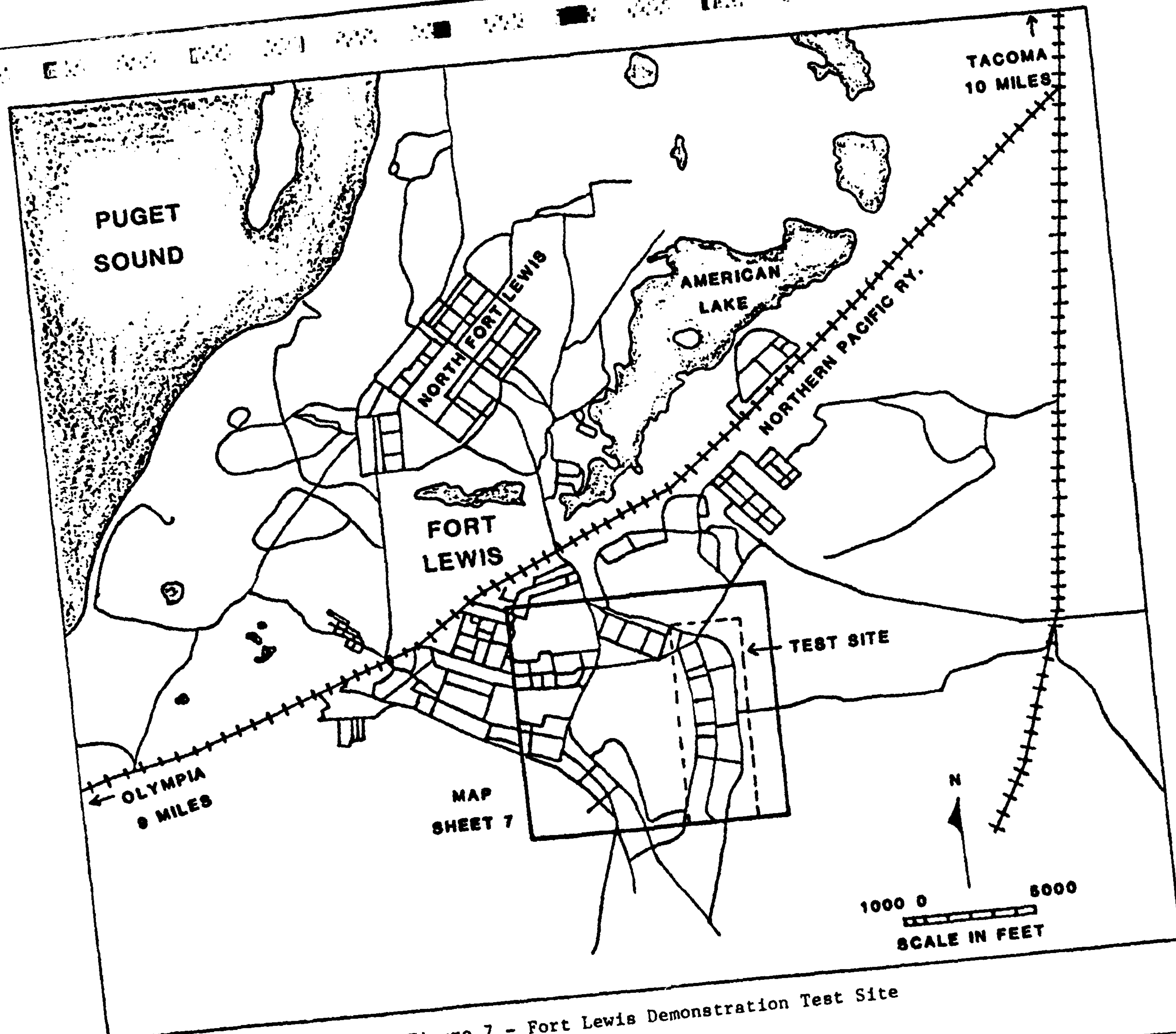


Figure 7 - Fort Lewis Demonstration Test Site

USAETL supplied Autometric with the above maps along with the U.S.G.S quadrangle map (Fort Lewis, Washington) covering the area. All maps were provided in paper print (ozalid) format.

The Seattle District also flew new black-and-white photography at 1:4,800 scale over the demonstration area in the fall of 1982. The photographs were supplied in the form of film positives and paper prints. The Seattle District also provided an aerotriangulation run (performed by the District) and a camera calibration report.

3.5.3 Project Definition

Once all the materials had been collected, the geounit was selected and the project initiated. The geounit selected was the same as the U.S.G.S 1:24,000 scale quadrangle sheet that covered the area. The center coordinates of this geounit were 47°03'45" north latitude and 122°33'45" west longitude.

3.5.4 Aerotriangulation

Only one strip of the 1982 photography was needed to cover the Fort Lewis demonstration area. This strip consisted of six stereo models (seven photographs). The aerotriangulation process, which consisted of selecting control points, creating triangulation files, and carrying the mensuration task itself, is discussed below.

3.5.4.1 Control Selection

3.5.4.1.1 Photo Control

Very little effort was required for selection of photo control points since all necessary information was supplied by the Seattle District. As part of the project, the Seattle District flew the needed photography, selected the control, points and performed a preliminary triangulation solution. This solution, along with the solution performed by Autometric for this project, is included under separate cover for comparison.

The selected ground control was derived from ground survey data, with the points "pugged" (marked) on the photography. Because of the assumed accuracy of the ground control and the large scale of the photography, the following "sigma" allowances were selected for this demonstration:

1)	Horizontal points	- latitude	-	5 feet
		longitude	-	5 feet
		elevation	-	5 feet
2)	Vertical points	- latitude	-	50,000 feet
		longitude	-	50,000 feet
		elevation	-	2 feet

3.5.4.1.2 Map Control

The 1967 Master Plan maps were supplied by the Seattle District COE. Superimposed on these maps was a control grid based on the Washington Lambert Coordinate System, South Zone. This 10,000-foot grid system had to be transformed into a geographic coordinate system for use in AUTOGIS. The coordinate transformation was performed at Autometric's Fort Collins, Colorado, office using the U.S. Geological Survey coordinate transformation package. Although no triangulation solution was needed for the map set up, eight control points and a checkpoint (latitude and longitude) were selected surrounding the demonstration area.

3.5.4.2 Initial Set Up for Aerotriangulation

Before the aerotriangulation procedure was performed, triangulation information sheets were created (Figures 8A and 8B). These sheets included all the necessary information to be entered into the "SEATTLE" triangulation data file. Because only one strip of photography was used, the mission ID was classified as "1". The individual frame numbers as marked on the photography were used for the frame IDs. The photography was assigned a camera ID of "KAREN".

3.5.4.3 Aerostriangulation Procedures and Problems

After all the information from the triangulation information sheets was entered into the triangulation data file, each model was set up on the APPS-IV for measurement of image points. Model setup included an "interior orientation," which used the principal point offsets and calibrated fiducial measurements parameters contained in the camera database.

TRIANGULATION INFORMATION SHEET

MODEL NUMBER 23

	LEFT FRAME		RIGHT FRAME
MISSION ID	Ft. Lewis Washington	20 Oct. 82	S82047-1
FRAME ID	2		3
CAMERA ID	Zeiss RMK A 15/23	No. 116202	"KAREN"
LATITUDE	47°5'37"N		47°5'22"N
LONGITUDE	122°33'58"W		122°33'59"W
ELEVATION	2627 FT.		2610 FT.
KAPPA	-90°		-90°
PHI	0°		0°
OMEGA	0°		0°

MODEL DIAGRAM

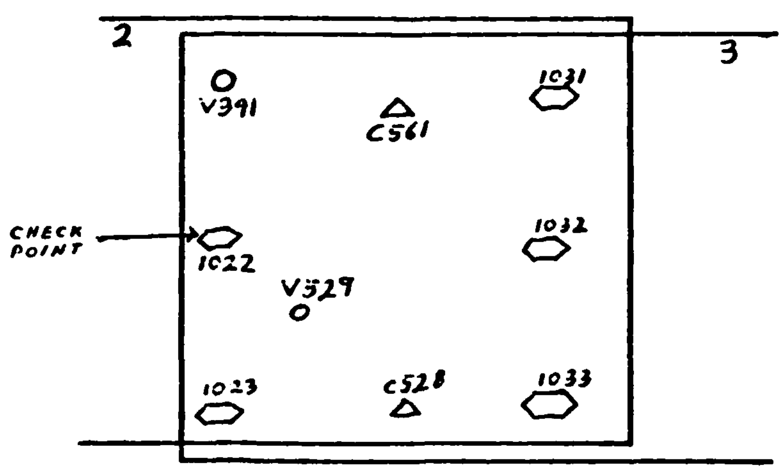


Figure 8A - Triangulation Information Sheet

TRIANGULATION INFORMATION SHEET

MODEL NUMBER 23

POINT ID - V341

LATITUDE - 47°6'0"N

LONGITUDE - 122°33'40"W

ELEVATION - 305.86 FT.

HORIZONTAL SIGMA - 50,000 FT.

VERTICAL SIGMA - 2 FT.

POINT ID - V529

LATITUDE - 47°5'30"N

LONGITUDE - 122°34'0"W

ELEVATION - 288.96 FT.

HORIZONTAL SIGMA - 50,000 FT.

VERTICAL SIGMA - 2 FT.

POINT ID - C528

LATITUDE - 47°5'29.332"N

LONGITUDE - 122°34'15.675"W

ELEVATION - 285.54 FT.

HORIZONTAL SIGMA - 5 FT.

VERTICAL SIGMA - 5 FT.

POINT ID - C562

LATITUDE - 47°5'27.634" N

LONGITUDE - 122°33'43.984"W

HORIZONTAL SIGMA - 5 FT.

VERTICAL SIGMA - 5 FT.

PASS POINTS - 1022, 1023, 1031, 1032, 1033

Figure 8B - Triangulation Information Sheet (Cont'd)

An "interior orientation" was performed each time a model was set up and used on the APPS-IV. This was a simple procedure and normally took about two minutes. The operator measured the four fiducial marks monoscopically in a certain order. When the fiducial measurements for the first stage were completed, residuals (in microns) were printed out on the CRT. The operator was given the choice of accepting the "current" residuals or remeasuring the fiducials. Micron readings of 10 or less were acceptable, as this approaches the accuracy of the instrument. The model was ready for image measurements after both stages were measured.

All points were measured on the first model and then an aerotriangulation solution was performed. The second model was set up, and image points were measured and added to the previous model data. This procedure was continued until a final solution was performed which included all model data. Since undesirable points were eliminated as the solution progressed, a final solution was easily obtained.

3.5.4.4 Triangulation Solution Results

Five pass points (1032, 1052, 1062, 1072, and 1082) were eliminated because all caused nonconvergence of the final solution. One vertical point (V372) was changed to pass point status by changing its ground status from "1" to "0". Since the photo measurement residuals of this particular point were very large (probably due to operator blunder), its status was changed to produce a better solution. The final solution produced "excellent stereo" throughout all models and was considered quite accurate. The final control distribution is shown in Figure 9.

3.5.5 The Photointerpretation and Digitizing Process

The themes to be developed for this Master Plan project (Table 3) were provided to USAETL by the Seattle District. All of the themes listed were to be developed utilizing the 1967 Master Plan maps provided by the District. The APPS-IV was used to update these maps. The themes developed were: (1) new buildings; and (2) new pavement. The process is described below.

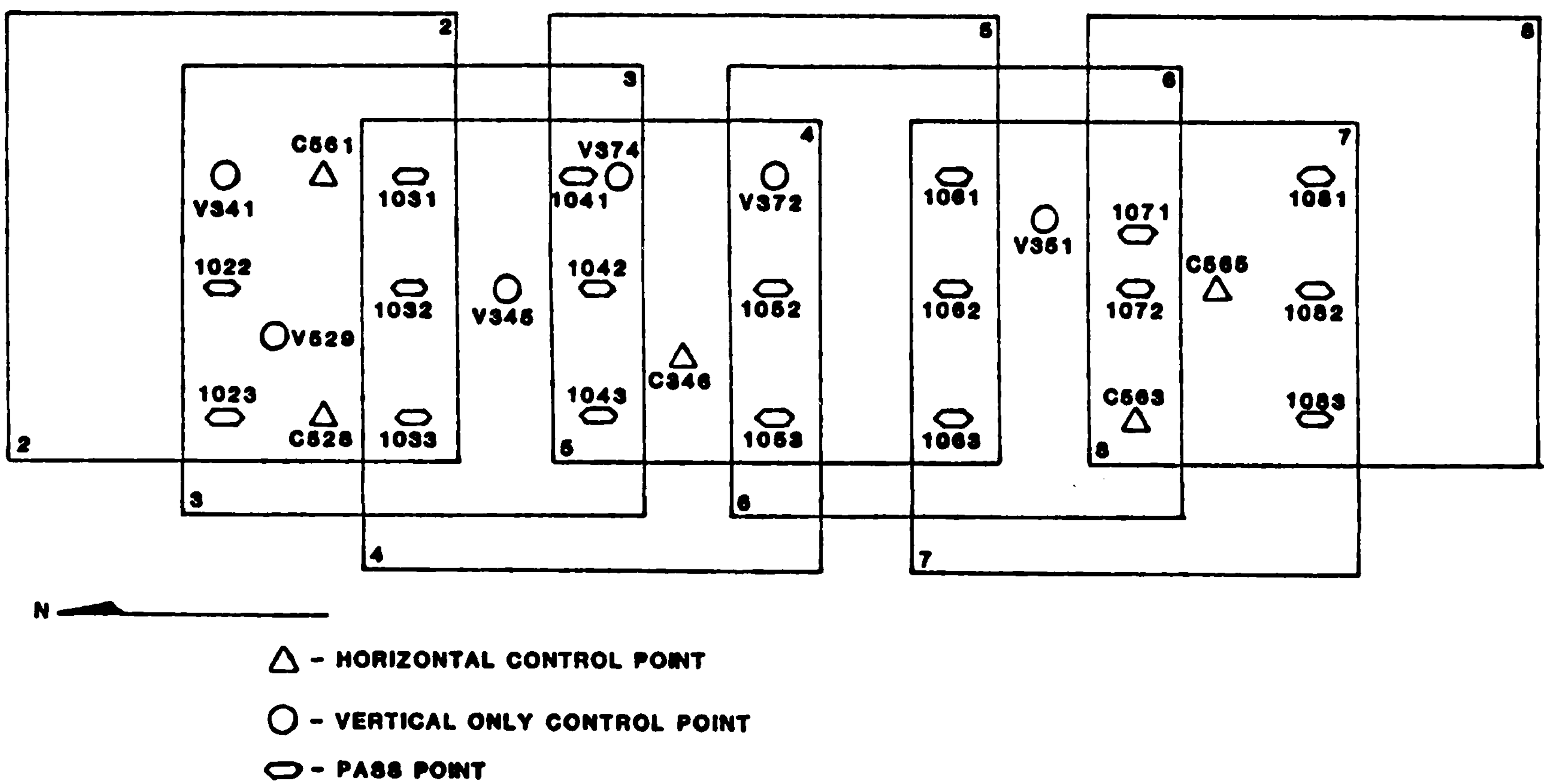


Figure 9 - Control Point Distribution for Aerial Photos

Table 3 - Classification Schemes

<u>Buildings</u>

a. permanent

b. semi-permanent

c. temporary

<u>Pavement</u>

a. primary roads

b. secondary roads

c. tertiary roads

d. parking areas

<u>Water Facilities</u>

a. mains

b. valves

c. hydrants

<u>Sewer Facilities</u>

a. mains

b. manholes

<u>Contours</u>

3.5.5.1 APPS-IV Setup

The initial set up of the photographs for digitizing was the same as the set up for aerotriangulation (i.e., interior orientation). After the interior orientation was completed, the APPS-IV software computed the loop-close tables and adjusted the stages accordingly for stereo maintenance. The operator was then instructed to measure the checkpoint chosen during the aerotriangulation procedure. Once the computer accepted the checkpoint measurement, the operator was ready for digitizing. The main digitizing menu is shown in Figure 10.

3.5.5.2 X-Y Table Setup for Map Digitization

In setting up the maps for digitizing, the eight surrounding control points were measured using the X-Y table cursor. These points were tic marks based on the Washington State Plane 10,000-foot grid system. Each of the control point coordinates was input into the system, using the CRT keyboard, and then measured. When the set up was considered acceptable (i.e., $\pm$ 15 micron residuals), the checkpoint coordinates were input into the system. The checkpoint was then measured and, if accepted, the setup was complete and the operator was ready for digitizing.

3.5.5.3 Digitizing Procedures Using X-Y Table

Digitizing the Fort Lewis information was a very straightforward procedure. The buildings were digitized from the General Site Map as polygons, in point mode, by digitizing a point at each building corner. The top of each building corner was digitized, since the bottom of the building was not evident on the photos. The inside of the building was assigned the appropriate attribute (i.e., permanent, semi-permanent, or temporary). These buildings were classified as "old" buildings because they were digitized from the 1967 Master Plan maps. The number for each building (as shown on the map) was also input to the AMS database during this phase.

Pavement areas were digitized as lines and polygons. All roads were digitized as line features in point mode with the center attribute designating their classification (i.e., primary, secondary, or tertiary). Parking areas were digitized in the same manner as buildings, in point mode with the inside attribute as their classification. Roads were digitized down the centerline, with nodes set at the centers of

*** DIGITIZING CONTROL TEST MODULE ***

Enter Option No.

1. Enter Digitizing Mode
2. Enter Edit Mode
3. Ineriom Wrap-up
4. Final Wrap-up/Polygon Verification
5. Checkpoint Test
6. Change Graphics
7. Anayze Problem from Verification
8. Enable Loop-Close
9. Disable Loop-Close
10. Assign Attribute Values
11. Label Map Features

Figure 10 - AMS Digitizing Menu

intersections. The curve mode was used in a few places where there were long curves in the road.

The remaining categories (water facilities, sewer facilities, and contours) were digitized from the map sheets only. Since water and sewer facilities were underground, they could not be seen on the photographs and hence were not digitized from that source. Water and sewer mains were digitized from the General Water and Sanitary Sewer Maps in point mode in the same manner as were the roads. Manholes, valves, and hydrants were digitized as individual point features having only a center attribute.

Contours were digitized as a planimetric map from the 1:4,800 scale Aerial Photo Contour Map at 5-foot contour intervals. Originally the contours were to be digitized from the 1:1,200 scale Orthophoto Contour Maps at a 2-foot contour interval. However, problems arose when measuring the control points during map set up, thus preventing successful digitizing. Probable causes were scale change during printing and inaccuracies of tic-mark locations used for control on these large-scale map sheets. Two solutions (changing control points and carrying coordinate data out to thousandths of a second) were attempted, but neither was successful, thus contours were digitized from the 1:4,800 scale map instead. When the 5-foot contours were finally displayed in MOSS, it was evident that in many areas the 2-foot contours would have proved unreadable at the 1:4,800 scale. Contours were digitized in point mode, and it was necessary to record numerous points in order to describe the curves in the contours.

3.5.5.4 Digitizing and Photointerpretation of Aerial Photography Using APPS-IV

Digitizing from the APPS-IV (for new building and new pavement areas) was carried out in the same manner as map digitizing. The only difference here was that data were being digitized with three-dimensional (X,Y,Z) coordinates instead of just two-dimensional (X,Y) data. Since graphics superposition was not operational for this part of the demonstration, it was difficult to determine whether the "new" parking areas overlapped with the "old" parking areas. This was because the dividing line could not be seen on the photography. By overlaying the "old" data onto the photography with graphics superposition, the operator would have been able to see these dividing lines and more effectively "join" these two areas together.

All of the buildings (both "old" and "new") were digitized from the photographs and given different attributes for differentiation purposes. This was done to allow a comparison between data digitized from maps and photos. Only "new" pavement areas were digitized from the photography.

No significant problems were encountered in digitizing the Fort Lewis data. The buildings and roads were easily identified and digitized. The only problem encountered was in settingup the Orthophoto Contour Maps for digitizing.

3.5.5.5 Themes Produced

Table 4 shows the themes developed by digitization/interpretation of the photos and map data. Note that all the 1967 Master Plan thematic data were digitized, but that the aerial photos were interpreted for new data only (with one exception).

3.5.6 AMS to MOSS Data Transfer

After all digitized data had been verified, they were transferred to MOSS using the EXPORT function of AMS. During this process coordinate data were transformed from geographic coordinates (latitude-longitude) to UTM coordinates (meters). The UTM zone for this demonstration was 10. The data were also separated into unique point, line, or polygon maps for each classification scheme.

3.6 MOSS Analysis

In the Fort Lewis demonstration very little actual "analysis" was conducted. The primary focus of this task was to present all the digitized data in a format that was easily understandable for anyone viewing the data. The basic problem was determining the symbols and color/shading patterns to be used for differentiating features, updates, and Master Plan data.

3.6.1 Translation of Data

During the initial viewing of the Fort Lewis data, a slight offset between photo-digitized data and map-digitized data was encountered. This problem

Table 4 - Themes Compiled

Theme	Source: Photo	Source: Maps
Old Buildings:		
Permanent	x	x
Semi-permanent	x	x
Temporary	x	x
New Buildings:		
Permanent	x	-
Semi-permanent	x	-
Temporary	x	-
Old Pavement:		
Primary	-	x
Secondary	-	x
Tertiary	-	x
Parking Areas	-	x
New Pavement:		
Primary	x	-
Secondary	x	-
Tertiary	x	-
Parking Areas	x	-
Water Facilities:		
Mains	-	x
Valves	-	x
Hydrants	-	x
Sewer Facilities:		
Mains	-	x
Manholes	-	x
Contours	-	x

probably occurred because the maps were essentially digitized at "zero" elevation (control for X and Y only) while the photographs were digitized at "actual" elevation (control for X, Y, Z). The average elevation of the test area was approximately 300 feet, which resulted in an approximate data offset of 10 feet north and 30 feet west. By use of the TRANSLATE function in MOSS, all photo data were shifted to the "old" pavement data digitized from the maps. These map data were used as the "base" because there were not enough "new" data for use as control. In reality the photo data are probably more reliable than map data, and all data should have been shifted using the photography as the base.

Another source of the problem stems from the maps utilized in the project. While the 1967 Master Plan maps were defined in terms of Washington State Plane (WSP) coordinates, AUTOGIS geounits are defined in terms of geographic coordinates (latitude, longitude). The WSP grid was overlaid onto the maps in the form of tic marks. These tic marks were used as control points for map set up. Because ozalid copy maps were used for digitizing, scale changes were introduced, and tic marks measurement were somewhat off the calculated latitude and longitude coordinates. Accuracy of tic mark placement was also questionable.

Ideally, the maps to be utilized should contain at least 8 readily identifiable latitude/longitude control points (points evident on the U.S.G.S. quad sheets). These points could be such features as road intersections, buildings, bridges, fence lines, etc.

3.6.2 WINDOW Command

The first step in the Fort Lewis MOSS analysis was determining the coordinates of the scene area as shown on the CRT. By use of the WINDOW command, UTM coordinates were chosen surrounding the area of interest. This command created a border around the desired area and ignored any extraneous data outside the border. The UTM coordinates for this demonstration were

5219470 North
5212850 North
533350 East
532350 East

Once the window was set, maps could be merged to produce the desired outputs.

3.6.3 ASSIGN Command

The ASSIGN command was used to create most of the symbology used on the plots for the Fort Lewis data. ASSIGN enables the selection of 60 different point symbols, 30 different line fonts, and line width and shading pattern selection. Since this command overrides all other plot commands, font data are saved with the map as a permanent output file. Manholes, valves, and hydrants were all assigned unique point symbols. Road classifications were designated by using varying line widths. Other features were self exlanatory and left unchanged or were shaded to show "new" (1982) data. A portion of a plot (enlarged to 1:1,800 scale) is shown in Figure 11.

The font and line symbols and shading patterm currently available on AUTOGIS are shown in Appendix B. The symbols and line widths used for the Seattle project were as follows:

Theme	Symbol	Type of Symbol
Water Facilities:		
Mains	———	Line
Valves	Y	Point
Hydrants	✖	Point
Sewer Facilities		
Mains	———	Line
Manholes	○	Point
Contours Pavement:		
Primary Roads	━━━	Line
Secondary Roads	———	Line
Tertiary Roads	———	Line
Parking Areas	▭	Polygon

3.6.4 CALCOMP Command

After all assignments were completed, the "CALCOMP" command was used to format the map data prior to output. Final plots (maps) had color and shading patterns depicting different feature types.

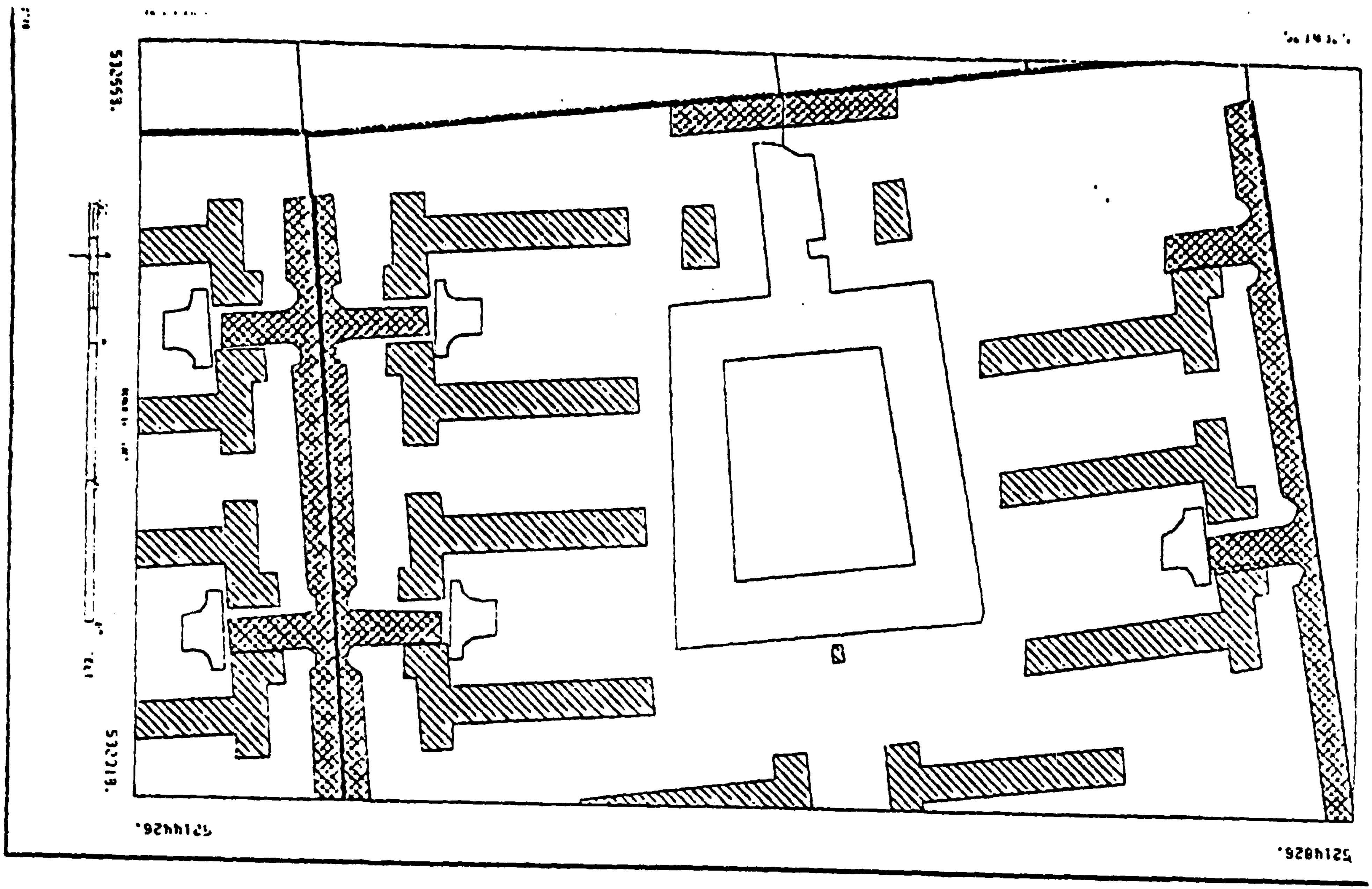


Figure 11 - Enlargement of a Portion of the Fort Lewis Master Plan

The CALCOMP command consisted of a series of menu instructions that enabled the operator to develop a desired single theme or multiple thematic map. By using the "SELECT" command, each MOSS map file or portion thereof is stored in the "active" data file for further processing. The SELECT command enabled the operator to select the entire map and all or only some of its attributes. Multiple composite maps were constructed using the CALCOMP command to plot specific "active" maps. For example, a map could be developed rather quickly (in few minutes) containing the following data: (1) old buildings (from maps); (2) new buildings (from photos); (3) hydrants; (4) new parking areas; (5) contours; and (6) old building numbers.

Another series of CALCOMP commands enabled the operator to shade polygons in various colors and patterns. Shading patterns could be vertical, horizontal or angled lines, etc., in any of 4 colors (depending on the plotter).

Next, other questions enabled the operator to select the desired map scale (and bar scale format). The size of the resultant maps was indicated on the CRT to insure the map width was not larger than the maximum width of the plotter (which was approximately 36 inches wide).

After all questions were answered, the CALCOMP command processed and stored the data in a format that was ready for plotting on the plotter. The desired map theme data were then plotted on a CALCOMP plotter using an operating system (AOS) command.

Note that the exact symbology for point features was selected through the "ASSIGN" command and was permanetly stored in MOSS.

3.7 Output Products Preparation

3.7.1 Hardcopy Maps

The final maps output plots produced by this demonstration were prepared at a scale of 1:4,800 depicting the following data:

1) 1967 Master Plan
2) 1982 Master Plan
3) A Composite Plan
4) Water Facilities
5) Sewer Facilities
6) Building Data (old and new)
7) Pavement Data (old and new)
8) Building Numbers
9) Contour Data

A precise list of each map prepared for the Seattle project is shown in Table 5.

3.7.2 Digital Data Files (on Magnetic Tape)

A copy of each AMS and MOSS file prepared for the Seattle project was also stored on magnetic tape for delivery to USAETL. Since all thematic data were first digitized in an AMS phase, and then reformatted and "exported" to MOSS for further processing, two data files actually exist on disk. The exact name of each file (in AMS and MOSS), its source, its content, etc., is shown in Appendix C.

To accomplish preparation of these digital files, the digital files were transferred from disk to tape (at G&O). These files were also transferred from tape to disk for use on the CAPIR Data General Eclipse system at USAETL.

3.8 Summary and Conclusions

This project has successfully demonstrated that CAPIR techology can be utilized to create and update a digital geographic database suitable for conducting Master Planning efforts.

By utilizing 1967 Master Plan maps, a digital database was created for the following categories: (1) existing buildings, with building numbers assigned to each building; (2) existing pavement; (3) sewer and water facilities; and (4) contours. This database was created by digitizing paper copies of Master Plan maps using an X-Y digitizing tablet. The AUTOGIS geographic information system was used for preparation of an efficient and highly accurate geographic database.

Table 5 - List of Maps Prepared (Fort Lewis Demonstration)

MAP TITLE	MOSS FILES*	MAP SCALE	MAP SIZE
Fort Lewis Demonstration - COMPOSITE	SEA.MBLD1, SEA.TBLDS SEA.OPAVEP, SEA.OPAVEL POR.TPVP, POR.TPVL	1:4,800	10"x25"
" " - 1981 MASTER PLAN	SEA.MBLD1, SEA.TBLDS SEA.OPAVEP, SEA.OPAVEL POR.TPVP, POR.TVPL SEA.MBLD1	"	"
" " - 1967 MASTER PLAN	SEA.OPAVEP, SEA.OPAVEL SEA.TBLDS	"	"
" " - ADDITIONS SINCE 1967	POR.TPVP, POR.TPVL SEA.MBLD1, SEA.TBLDS	"	"
" " - BUILDING DATA	SEA.OPAVEP, SEA.OPAVEL SEA.MBLD1	"	"
" " - BUILDING NUMBERS	SEA.OPAVEP, SEA.OPAVEL SEA.OPAVEP, SEA.OPAVEL	"	"
" " - PAVEMENT DATA	POR.TPVP, POR.TPVL SEA.SEWEL	"	"
" " - SEWER FACILITIES	SEA.SEWERP, SEA.WATERL	"	"
" " - WATER FACILITIES	SEA.WATERP	"	"
" " - CONTOURS	SEA.CONTUR	"	"
" " - COMPOSITE BLOWUP (Color)	SEA.MBLD1, SEA.TBLDS SEA.OPAVEP, SEA.OPAVEL POR.TPVP, POR.TPVL	1:2,400	8"x9"
" " - COMPOSITE BLOWUP (B&W)	SEA.MBLD1, SEA.TBLDS SEA.OPAVEP, SEA.OPAVEL POR.TPVP, POR.TPVL	1:1,800	6"x10"

*NOTE: See Appendix C for Explanation of MOSS File Codes.

An APPS-IV stereo analytical plotter was utilized to update this database for selected land cover fetaures. Photography flown in 1982 was aerotriangulated, digitized and photointerpreted, and geographic data were entered directly into a digital database in the same format as the map database. Thematic information created were as follows: (1) new buildings; (2) new roads; (3) new parking areas; and (4) old buildings.

The development of these permanent databases enabled the preparation of a number of single and multiple thematic maps, such as old plus new buildings, old and new roads, etc. Maps and plots at a number of scales were generated. Using AUTOGIS, the digital data could be output at virtually any scale, at any projection (choice of 21 projections in avaiable), showing any number of themes.

By use of a color graphic CRT with a cursor capability, it is possible to create special softcopy display that would be useful for geographic displays, presentations, and reports.

By use of the APPS-IV graphics superposition capability, it is possible to display any desired 1967 map data on top of the new photography for updating and comparison purposes.

Now that the aerotriangulation effort is accomplished, it would be very simple to set up the steromodel again (using the same photography) within a matter of a few minutes for additional analysis, updating and superposition efforts.

Some concluding observations regarding the project and their significance to any subsequent project work are as follows:

Pre-planning: As with any CAPIR project, a considerable amount of pre-planning would prove very effective in insuring that all desired data are entered, and that they are entered in the appropriate format for future work. Involvement by District personnel is highly recommended.

Input Maps: Some problems (with stretching and shrinkage) were encountered with the paper copies of the 1967 Master Plan maps. In general, the use of more mylar-based map inputs would insure that a high level of geometric accuracy is maintained.

Map Format: Although a software program existed to convert Washington State Plane coordinates to geographic coordinates, it is more desirable to have latitude/longitude geographic coordinates superimposed on the same map. Since AUTOGIS software is based on geographic coordinates, this would eliminate certain problems encountered with registering the older maps with the newer photography.

Ground Control Points: Related to the above comments, it would also have been desirable to digitize a number of permanently-located ground control points easily identifiable on both the photographs and the maps. This would enable the operator to compare map/photo registration characteristics and to make any minor adjustmenets.

4.0 COLUMBIA RIVER DEMONSTRATION - PORTLAND DISTRICT

4.1 Purpose

The purpose of the Columbia River demonstration project was to show how CAPIR technology could be used to create digital data files for monitoring accretion/erosion rates and mapping historical changes in wetland areas. The Portland District possessed aerial photography and other historical data dating back to the 1940's which were used to create a database for monitoring these changes.

4.2 Background

The Regulatory Functions Branch and Waterways Maintenance Group of the U.S. Army Corps of Engineers (COE), Portland District, has had a continued interest in monitoring historical changes in wetland areas along the lower Columbia River. During the past few years, COE has been conducting regular dredging operations along the lower Columbia and has been depositing the dredged materials at various sites along the river. The combined effect of dredging operations and natural sedimentation processes has created land areas which did not exist previously. Through the years, natural vegetative processes have produced significant wetland habitats. The COE is interested in studying the types of changes that have occurred and determining their rates. With large areas of change, and their potential significance to wildlife habitats, CAPIR technology appeared to have a potential for accurately recording and monitoring these changes.

4.3 Current Practice

Current techniques used in the Portland District for monitoring wetland creation and destruction involves conventional photointerpretation techniques. Skilled photogrammetrists delineate shorelines on historical photography and use a zoom transfer scope to overlay these boundaries onto recent, unrectified photography.

Analysis of the overlays is limited to visual estimates of gains and losses of shoreline areas. These visual estimates are then correlated with vegetation studies performed by COE biologists to assess the effects of COE waterways maintenance activities.

4.4 Applicability of CAPIR

Use of the CAPIR system for wetland digitization has already been demonstrated by the U.S. Fish and Wildlife Service in Fort Collins, Colorado. Advantages of this technology include the ability of non-photogrammetrists to perform accurate three dimensional photointerpretation and mensuration tasks. Once the photography is aerotriangulated, biologists can digitize wetland, vegetation and/or wildlife habitat boundaries directly from the photos. This eliminates the need for a zoom transfer scope and also enables a quantitative analysis of changes in wetland area. Scale change problems are handled very easily and multiple overlay inaccuracies can be eliminated.

4.5 Demonstration Project Methodology

4.5.1 Test Site Selection

Following discussions with personnel from the Survey (photogrammetry) and Regulatory Branches of the Portland District, USAETL and Autometric, Inc. selected an area of the Columbia River (Figure 12) stretching from Rice Island to Tenasillahe Island as the site for this demonstration. The demonstration area covered Miller Sands, Snag Islands, Jim Crow Sands, Woody Island, and Grassy Island. This area has undergone considerable accretion and erosion, due partially to COE waterways maintenance activities, and was selected for this reason.

4.5.2 Resource Collection

The Portland District provided Autometric, Inc. with a complete set of U.S. Geological Survey quadrangle maps covering the demonstration area. These included the following two 7.5-minute and four 15-minute quad sheets:

- Cathlamet Bay (7.5')
- Rosburg (7.5')
- Cathlamet (15')
- Grays River (15')
- Skamokawa (15')
- Svensen (15')

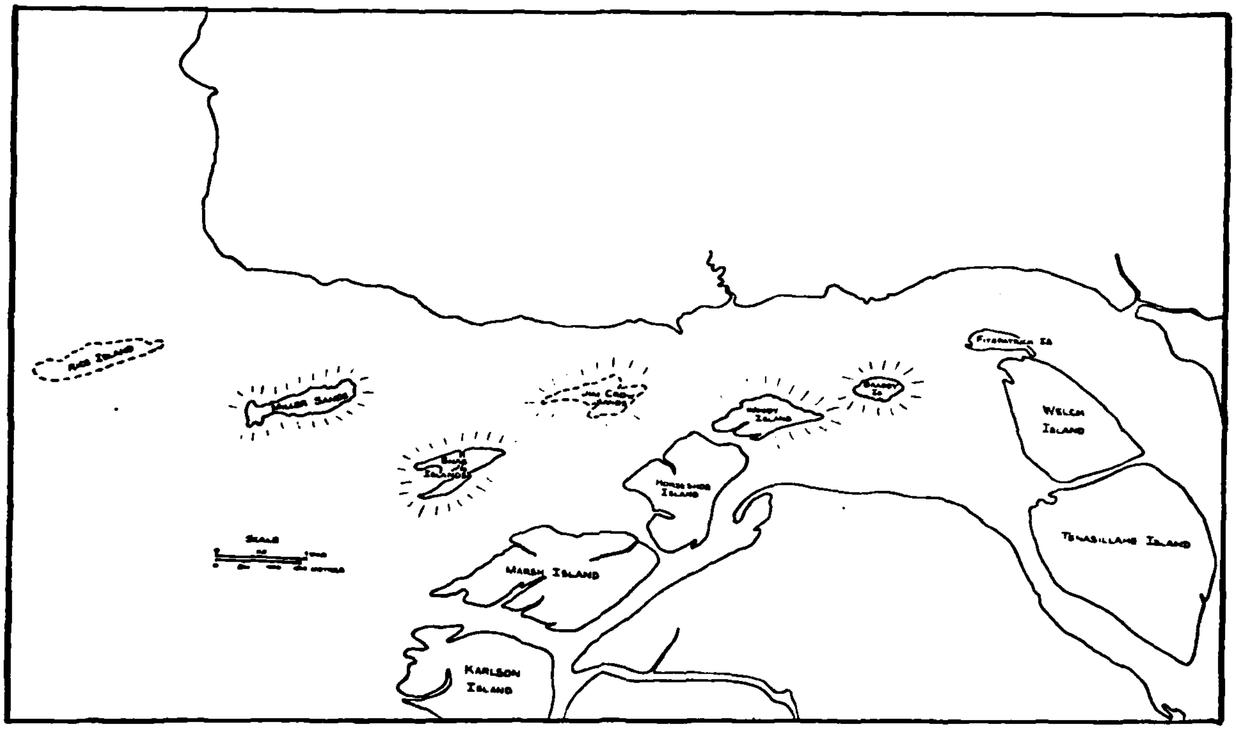


Figure 12 - Columbia River Demonstration Project Area

NOAA nautical charts #18521 (50th edition) and #18523 (38th edition) were not acquired but were reviewed at the NOAA facility in Rockville, Maryland. The Portland District also provided Autometric, Inc. with the following aerial photography (in film positive format):

DATE	TYPE	SCALE	FRAMES
1948	B&W	1:24,000	3558-3560, 3566-3568, 3575-3583
1957	B&W	1:16,800	4864-4868, 4901-4904, 4920-4922, 5031-5037
1966	B&W	1:23,000	674-684, 1027-1029, 1034-1036
1974	B&W	1:24,000	915-921, 939-952, 960-961
1981	CIR	1:48,000	1460-1461, 1463-1466, 1481-1485

Camera calibration reports for the above photography were also provided by COE personnel. However, certain problems were encountered with some of these data. These problems are discussed in Section 4.5.4.1.

The U.S. Fish and Wildlife Service, Western Energy and Land Use Team, Fort Collins, Colorado, supplied Autometric, Inc. with digital files covering a large section of the lower Columbia River. These files had been compiled as an "interim project" in support of the National Wetlands Inventory by digitizing "rough" copies of the NWI quadrangle sheet; hence, they were not totally error free. However, these data were to be used for comparison with the data made available in the demonstration effort.

During the initial meeting between Autometric, Inc., USAETL and Portland District personnel, sample "training sets" (keys) for each of the wetland categories discussed in Section 4.5.3 were defined (by Portland District personnel) as an aid in wetlands identification during the photointerpretation effort.

Mr. Laslo Greczy of USAETL collected and calculated tidal data acquired at the Astoria, Oregon station for possible use in this demonstration (Table 6).

Table 6 - Columbia River Demonstration Tide Data

DATE OF FLIGHT	TIME OF FLIGHT	PREDICTED TIDE AT ASTORIA, OREGON				ESTIMATED TIDE AT HARRINGTON POINT, WASH.				TIME FROM NEAREST TIDE	CORRECTION - HIGH + LOW	ESTIMATED WATER LEVEL HARRINGTON POINT AT TIME OF FLIGHT (FEET)
		HIGH		LOW		HIGH		LOW				
		TIME	HEIGHT (FEET)	TIME	HEIGHT (FEET)	TIME	HEIGHT (FEET)	TIME	HEIGHT (FEET)			
9 SEPT '48	15:45	20:04	7.7	13:56	3.1	20:23	7.2	14:35	2.9	1:07 LOW	+0.4	3.3
5 NOV '57	12:15	11:41	8.1	18:24	0.0	12:00	7.6	19:06	-0.2	0:15 HIGH	0.0	7.6
25 MAR '66	?	15:42	6.9	09:36	0.3	16:01	6.4	10:18	0.1	?	?	?
3 APR '66	12:08	11:48	8.4	18:18	-0.5	12:07	7.9	19:00	-0.7	0.01 HIGH	0.0	8.6
6 SEPT '74	13:55	15:46	7.9	09:34	1.4	16:05	7.4	10:16	1.2	-2:10 HIGH	-1.8	5.6
24 JUNE '81	11:15	05:42	7.1	12:19	0.4	06:01	6.6	13:01	0.2	-1:56 LOW	+1.1	1.3

NOTES: TIDE GAGE LOCATED AT ASTORIA, OREGON.
HARRINGTON POINT, WASHINGTON IS LOCATED WITHIN DEMONSTRATION AREA NEAR PRIMARY CONTROL POINT 1.

4.5.3 Project Definition

Once all the materials had been obtained, the demonstration area (the geounit) was set up. Since this demonstration area covered four U.S.G.S. 15-minute quadrangle maps, difficulties would have been encountered if each map was set up as a separate geounit. Because of this, a single "project" geounit was set up with the following coordinates:

Scene Center:	46° 15' 00" North
	123° 35' 00" West
Scene Boundaries:	46° 10' 00" North
	46° 20' 00" North
	123° 25' 00" West
	123° 45' 00" West

The digitization categories shown in Table 7 were chosen by Portland District personnel as their most important wetland categories.

4.5.4 Aerotriangulation

Aerial photography acquired for five different years (1948, 1957, 1966, 1974, and 1981) was selected for the Columbia River demonstration. All photo sets covered essentially the same area, and the original plan called for the analysis of each set for comparisons. However, problems with insufficiently detailed camera calibration reports resulted in the elimination of the 1948 and 1966 photography. The remaining years (1957, 1974, and 1981) were triangulated successfully. The aerotriangulation process is described in the following discussion.

4.5.4.1 Control Selection

Two problems were encountered during ground control selection for this demonstration. The major problem was that little ground control existed in the area. The few structures that were evident in the earlier years did not exist in later years. also, the structures that could be found on the photographs could not be positively identified on the maps, and vice versa. Because of the dynamic nature of the area, major landscape features (such as islands and shorelines) could not be used, as they were

Table 7 -Wetland Themes

AMS CLASSIFICATION SCHEMES

- Shallow, permanently inundated areas
  a. sand
  b. mud
- Shallow, regulary inundated flats
  a. unvegetated
  b. herbaceously vegetated
- Ocassionally inundated below ordinary high water line
  a. unvegetated
  b. herbaceously vegetated
  c. woody vegetation
- Above ordinary high water
  a. unvegetated
  b. herbaceously vegetated
  c. woody vegetation
- Significantly above ordinary high water (10' and above)
  a. unvegetated
  b. herbaceously vegetated
  c. woody vegetation

continually moving over the years.

The second problem encountered was that, with the exception of the 1981 photography, only one river shoreline was imaged for each target year. This made it impossible to establish ground control points on both the north shore and the south shore of the river.

After considerable study, eight points (all were navigation lights or beacons located in the river or on the shore) were identified and used as primary control for the five target years. The one point that could be identified for all years (except for 1948) was also used as a primary control point. Using the AMS point measurement routine, primary control points were measured from the U.S.G.S. quadrangle maps provided in order to derive the latitude and longitude of each point. Elevation data were interpolated from the maps. The control points were also checked using NOAA charts #18521 and #18523. It was also observed that the lights and beacons selected as primary control were permanent and had not been moved over the years. Since latitude and longitude measurements on the NOAA charts were listed only to the nearest tenth of a minute, the latitude and longitude values as measured from the U.S.G.S. quadrangles were used instead.

Secondary control points were those points identifiable on only one or two target years. Coordinates for these points were also determined from the maps using the point measurement routine of AMS. These control points consisted of buildings, docks, bridges, and road intersections.

All control points (both primary and secondary) were originally considered to be accurate both horizontally and vertically. However, during the various triangulation solutions some of the points were changed to "vertical only" control. Sigma values for the Columbia River demonstration were chosen to conform to National Map Accuracy Standards and were as follows:

1)	Horizontal Points -	latitude	- 80 feet
		longitude	- 80 feet
		elevation	- 15 or 25 feet
2)	Vertical Points -	latitude	- 5,000 feet
		longitude	- 5,000 feet
		elevation	- 15 or 25 feet

Two different elevation sigmas were chosen owing to the nature of the control points. All lights and beacons in the river with known height data (from NOAA charts) were assigned elevation sigmas of 15 feet. All other control points (on land or in the water) were assigned elevation sigmas of one-half the contour interval of the quadrangle maps (25 feet).

4.5.4.2 Initial Setup for Aerotrinagulation

The triangulation information sheets for the Columbia River demonstration were created in the same format as those for the Fort Lewis demonstration (see Figure 10). The information from these sheets was entered into the "PORTLAND" triangulation data file.

The 1981 photography consisted of a block format of two strips, with four photographs in each strip. The assigned mission ID's were "1" and "2" for the north and south strips, respectively. This photography was flown in a general east-west direction and assigned a camera ID of "ZELDA".

The 1974 photography consisted of one strip of seven photographs and was assigned a mission ID of 1. This photography was also flown in an east-west direction and was assigned a camera ID of "WENDY".

The 1957 photography consisted of three independent strips, with a total of 11 photographs. Since this photography was flown in a northeast-southwest direction, mission ID's were assigned as 1, 2, and 3, starting with the northwesternmost strip. The camera ID assigned to the 1957 photography was "FANNY".

All frame ID's were identical to the frame numbers printed on the photographs; this was the Portland District's numbering system also.

4.5.4.3 Procedures and Problems

Photomodel setup and interior orientation procedures were the same as described for the Fort Lewis demonstration. The 1981 photography was triangulated first, followed by the 1957 photography, and then the 1974 photography. The 1948 and 1966 photography were triangulated last.

Two major problems presented themselves during the aerotriangulation process. The first problem was with the original camera calibration reports. The initial camera calibration data supplied to Autometric, Inc. was not useable. The reason was that the data provided were "camera data" but were not camera calibration data. After some searching the Portland District acquired the appropriate camera calibration reports (Appendix D). However, because of the age of the photography (dating back to the 1940's), these reports were little better than the original data supplied. Only the 1981 report contained all necessary information (calibrated focal lengths, fiducial measurements and principal point offsets). All the other reports showed only calibrated focal lengths and a measurement of the distance between fiducial marks. This proved a major problem in processing the 1948 and 1966 photography.

The second major problem encountered with the 1948, 1957 and 1966 photography was that the fiducial marks were not specifically marked. Fiducial marks must be exactly labeled on the photography in order for the aerotriangulation process to operate. The fiducials for the 1948, 1957 and 1966 photography were simply curved lines ("tic mark-type") with no exact intersection shown. Even though an effort was made to estimate the approximate location of these intersection points, the resultant residual measurements proved too large for acceptable aerotriangulation.

There were few problems encountered with the 1981 aerotriangulation process, although the smaller scale of the photography did increase the photo and ground control residuals. One strip was successfully triangulated first, then the other strip, and then the block was triangulated as a whole. Two points were added (one pass point and one secondary vertical-only control point) before conducting the final block solution. This was done to establish control for one corner of the block. This appeared to help, as the final residuals were acceptable.

The major problem with the 1957 photography (other than the above problems) was that it was flown only over specific islands, thus allowing almost no possible control between the individual strips. Only one pass point was found linking strips 2 and 3. The overlap area between strips 1 and 2 was water; thus no control could be selected. Even so, since there were 11 photos in this procedure, a complete block could not have been triangulated using AMS (aerotriangulation in AMS is limited to a maximum of 10 photos). Two new pass points were added to strip 1 to enable a solution (the solution would not converge without the addition of these points). The previously mentioned problems with the camera calibration data and fiducial marks, which caused the elimination of the 1948 and 1966 photography, did not seem to affect the 1957 photography. No explanation could be found for this, and the 1957 photography was successfully triangulated in two parts. Part one was strip 1 and part two was strips 2 and 3.

Few problems were encountered with the 1974 triangulation. Although the camera calibration report lacked some essential data, the fact that the fiducials were well marked appeared to offset this problem. This strip was triangulated by adding new model data to previous solutions (in the same manner as was done for the Fort Lewis strip) and continuing the procedure until the whole strip was successfully triangulated.

Problems with the 1948 photography were previously mentioned. The combination of these two problems prevented set up of a single model on the APPS-IV. The 1948 photography was the "worst" for not having fiducial marks. Although an attempt was made to "scribe" in fiducials in the logical place, this only seemed to make matters worse, thus the 1948 photography was eliminated from the demonstration. Attempted set up results are shown in Table 8.

In addition to the previously mentioned problems, the 1966 photography had some unique problems of its own. These problems stemmed from the fact that the 1966 photography was flown at two different times of year, with two different cameras. This fact was not initially documented and tracking down the "other" camera calibration report proved difficult. It was found that the camera had been calibrated after the photography was flown, and this raised questions as to whether the camera calibration reports were correct for the 1966 cameras. One strip of photography (April, 1966) was set up by adding artificial principal point offsets of approximately 50 microns in both X and Y. This allowed model set up and convergence of the triangulation solution.

Table 8 - Attempted Setup of the 1948 Photography

MODEL 3757 - 3756 (WITHOUT SCRIBED FIDUCIAL MARKS)					
SET-UP ATTEMPT NO.	FIDUCIAL NO.	LEFT PHOTO		RIGHT PHOTO	
		X RESIDUAL	Y RESIDUAL	X RESIDUAL	Y RESIDUAL
1	1	-88.3	-119.2	-89.5	-119.5
	3	88.6	119.6	89.9	119.8
	5	-88.7	-119.8	-90.0	-119.9
	7	88.3	119.3	89.3	119.6
2	1	-112.3	-152.9	-77.4	-118.2
	3	112.9	153.7	77.7	118.7
	5	-112.9	-153.8	-77.7	-118.8
	7	112.3	153.0	77.4	118.3

MODEL 3757 - 3756 (WITH SCRIBED FIDUCIAL MARKS)					
SET-UP ATTEMPT NO.	FIDUCIAL NO.	LEFT PHOTO		RIGHT PHOTO	
		X RESIDUAL	Y RESIDUAL	X RESIDUAL	Y RESIDUAL
1	1	-86.3	-142.1	-113.7	-127.6
	3	86.7	142.7	114.2	128.2
	5	-86.7	-142.9	-114.2	-128.3
	7	86.4	142.3	113.6	127.7
2	1	-91.2	-141.6	-108.5	-127.1
	3	91.7	142.1	109.0	127.6
	5	-91.7	-142.2	-109.0	-127.7
	7	91.3	141.6	108.6	127.1

However, rather large residuals resulted, and set up of the model in loop-close (for digitization) produced Y-parallax distortions that were unacceptable for successful digitizing. One other minor problem noted was that correlation of data between the two dates of photography would have been difficult even if digitization could have been performed, because the photography was flown at different tidal heights. The 1966 photography was thus elimimated from the demonstration.

4.5.4.4 Triangulation Solutions Results

The three years (1981, 1974, and 1957) were successfully triangulated despite various problems that forced the elimination of the other two years of data (1948 and 1966). Various points were "removed" from the solutions and the status of others was changed, but all solutions produced good stereo and presented no digitizing problems. The various photo coverage and primary control point distributions are shown in Figures 13, 14, and 15.

4.5.5 The Photointerpretation and Digitizing Process

Columbia River photographs were set up in the same manner as the Fort Lewis photographs (i.e., by performing an interior orientation). Only the APPS-IV was used for digitizing in this demonstration because only photographic data were involved. The final digitizing categories are shown in Table 9.

The 1981 photography was digitized first for two reasons. One, it was flown at nearly low tide, therefore the greatest amount of land area was exposed. Two, the preliminary identification key was largely based on this photography. An advantage of this photography is that it is color infrared. Since vegetation appeared as a bright red on these color infrared photos, it was easy to distinguish vegetation types from other features. Vegetation areas were more difficult to distinguish from each other on the black-and-white photography. A possible disadvantage might have been that too much information was available, thus making interpretation difficult and time consuming.

The first step in digitizing was the identification of the individual wetland categories. A sample key had been discussed and prepared during the November meeting with Portland District personnel. This key was used as a base for identifying the individual categories, but was modified slightly when the photographs were viewed in stereo and under magnification.

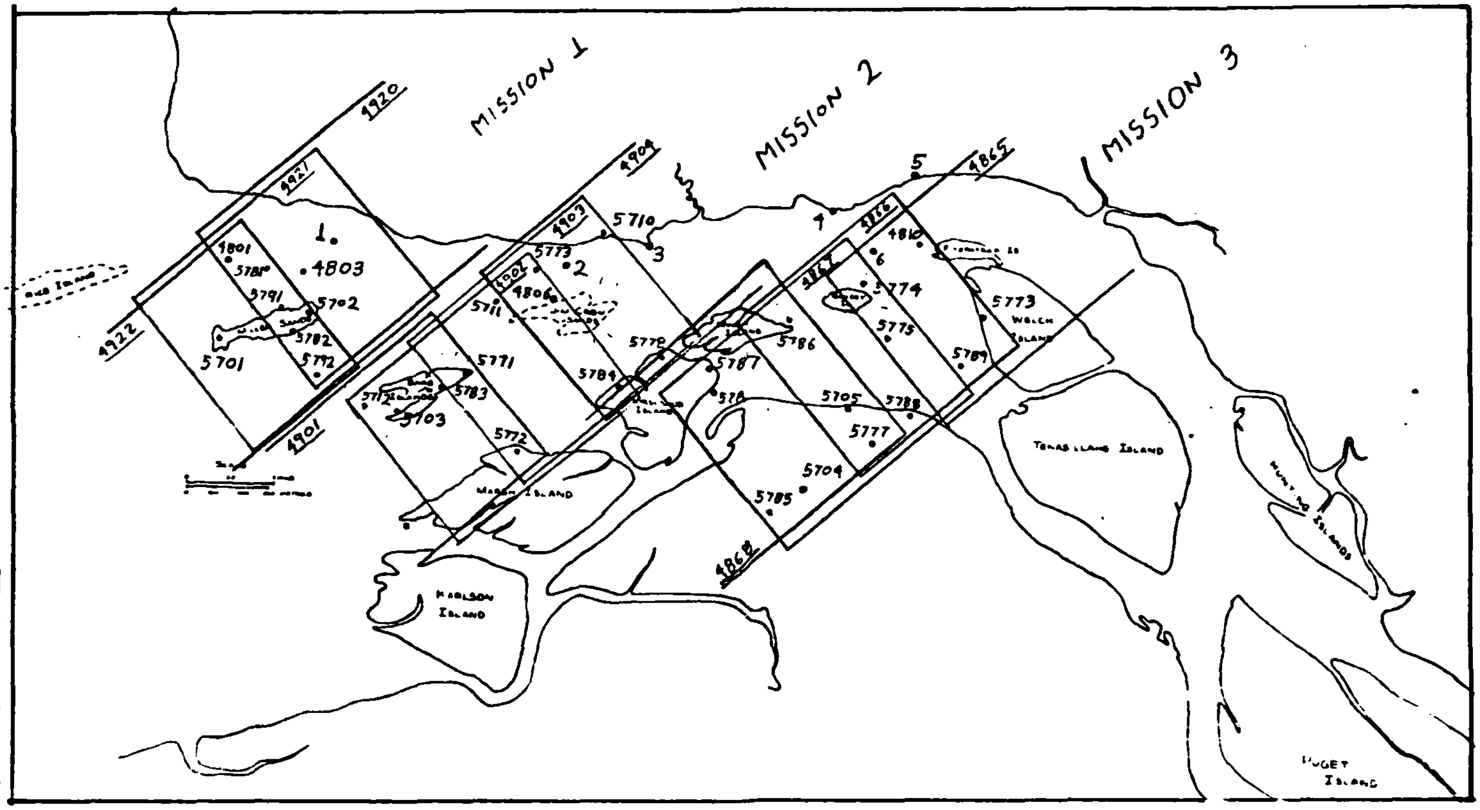


Figure 13 - 1981 Photo Control Points

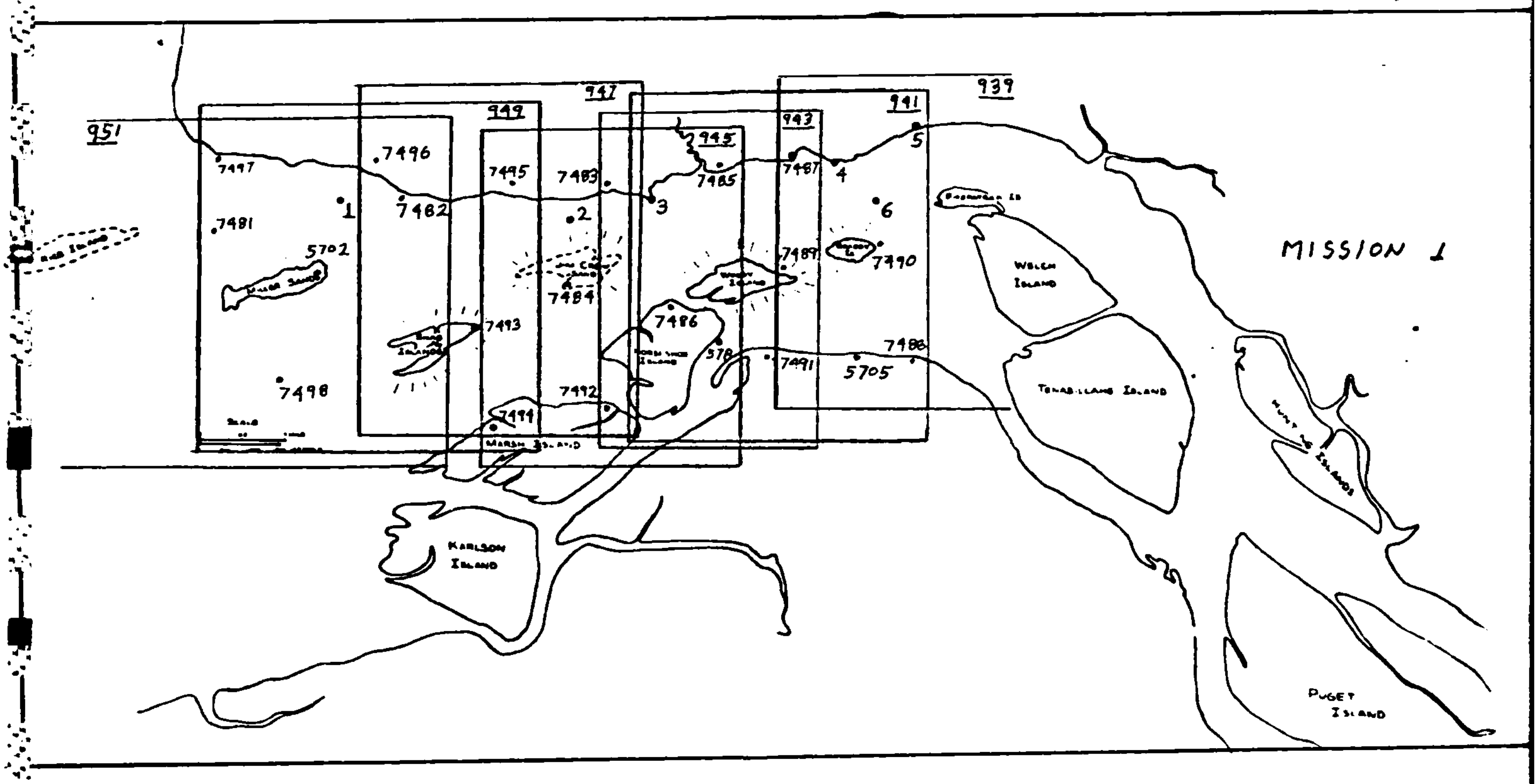


Figure 14 - 1957 Photo Control Points

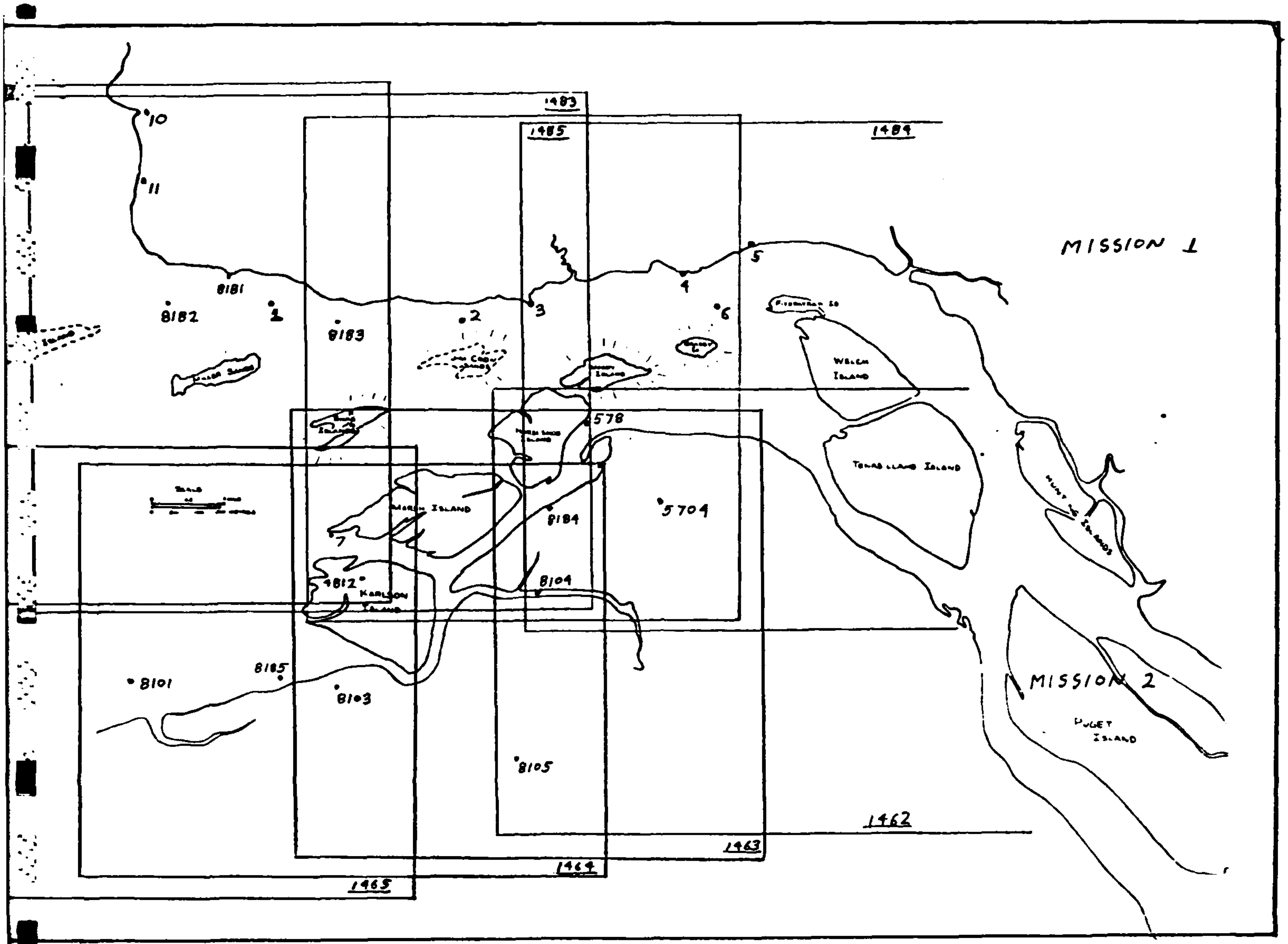


Figure 15 - 1974 Photo Control Points

Table 9 - Wetland Themes

<u>AMS CLASSIFICATION SCHEMES</u>

- o Shallow, permanently inundated areas
  - a. sand
  - b. mud
- o Shallow, regulary inundated flats
  - a. unvegetated
  - b. herbaceously vegetated
- o Ocassionally inundated below ordinary high water line
  - a. unvegetated
  - b. herbaceously vegetated
  - c. woody vegetation
- o *Above ordinary high water*
  - a. unvegetated
  - b. herbaceously vegetated
  - c. woody vegetation
- o Significantly above ordinary high water (10' and above)
  - a. unvegetated
  - b. herbaceously vegetated
  - c. woody vegetation

NOTES:

1) Unvegetated areas show less than thirty percent vegetation.

2) Difference between herbaceous and woody vegetation areas is greater than fifty percent of one category.

3) 1981 Information taken at nearly low tide.
1974 Information taken at nearly high tide.
1957 Information taken at nearly high tide.

Once the individual categories in an area were identified, a digitizing plan was formulated. This included a consideration of the placement of arcs and nodes. This planning was carried out by the operator while viewing the model on the APPS-IV. The digitizing of the area was undertaken when the operator felt confident with the identification and digitizing plan.

All the relevant wetland features on each set of photographs for each year were digitized as polygons in point mode. No line or point data were collected. Points were recorded as the operator traced the outline of the specific feature being digitized. The lines forming the polygons were given left and right attributes. Very small areas (in the judgement of the operator) that could not be easily digitized were incorporated into a larger area with the most similar classification (i.e., a very small regularly inundated-unvegetated area may have been incorporated into a regularly inundated-herbacious vegetation area if, in the opinion of the operator, it was too small to easily digitize).

Various problems were encountered during digitizing. The major problem was with the tidal changes in the area. Tide tables (see Figure 6) indicated that the photographs were flown at different tide heights, with none being flown at low or high tide. This proved a problem when trying to digitize the permanently inundated, regularly inundated and occasionally inundated areas, because these areas are affected by the tide height.

Since the 1981 photography was flown at nearly low tide, most of the regularly inundated areas were exposed. These areas were digitized as such for this year. Since the 1974 and 1957 photography was flown at nearly high tide, most of the regularly inundated areas seen on the 1981 photography were inundated. These areas were digitized as far out from the shore as possible. The permanently inundated areas that were identified and digitized on the 1981 photography could not be identified on the 1974 or 1957 photography and thus were not digitized.

Another digitizing problem was differentiating the "above ordinary high water" areas from the "significantly above ordinary high water" areas. No accurate method of differentiating the 10-foot elevation cutoff could be found, (i.e., there was no reference "zero" elevation). To conform to this designed accuracy, larger scale photography would have been needed. An attempt was made to separate the two classification schemes based on visual estimates, but the accuracy of these data is in doubt.

4.5.6 AMS to MOSS Data Transfer

The EXPORT function of AMS was used to transfer these data to MOSS in the same manner as was used in the Fort Lewis demonstration. The Columbia River data were also contained within UTM zone 10. Since only polygon data were involved, each theme was transferred directly.

4.6 MOSS Analysis

The MOSS analysis for the Columbia River demonstration was somewhat more complicated than for Fort Lewis. This was because three years of data were input, and the data itself were relatively complex. The problem was to present the data in a readable yet technically useful manner.

4.6.1 Setting the Window

The first step in this analysis was setting the window. By use of the WINDOW command the entire study area was outlined, along with three specific island areas of interest. The main window was set for the 1:24,000-scale maps and had the following UTM coordinates:

- o 5126000 North
- o 5115000 North
- o 464000 East
- o 443000 East

Three other windows were developed for the 1:5000-scale maps for the three individual islands areas. The UTM coordinates for these islands are shown in Table 10.

4.6.2 Data Analysis

Commands and functions used in this analysis included OVERLAY, POLYCELL, STATISTICS, GENERATE, and PLOT. All possible variations of data display

Table 10 - UTM Coordinates for Islands

ISLAND	COORDINATES	
Miller Sands	5122550	North
	5120550	North
	451800	East
	446800	East
Snag Islands	5120900	North
	5118100	North
	453600	East
	449100	East
Jim Crow Sands	5122350	North
	5120850	North
	456050	East
	452850	East

were analyzed before the final output information was determined. This analysis consisted of manipulating the data using various commands. POLYCELL created an artificial three-dimensional model from polygon data. Unfortunately, each classification scheme was arbitrarily assigned a "cell level" (which could not be changed), thus the output from this command was of little value.

A color graphics CRT (LEXIDATA) was very helpful in the analysis portion of this project. Outlines and shading were produced in different colors to determine the most pleasing and understandable output. This CRT (with cursor capability) enabled the creation of a label overlay showing background features. This "map" was created using the TEXT command to position labels and choose letter fonts.

4.6.3 Analysis of FWS Digital Data

A magnetic tape of the U.S. Fish and Wildlife Service, Western Energy and Land Use Team, Fort Collins, Colorado lower Columbia River wetlands database was provided for comparison with the demonstration data. These files had been compiled as an "interim project" in support of the National Wetlands Inventory; these were of raw data. This factor may have account for the problem in displaying the tape data on a CRT at USAETL. Much effort wad undertaken to display these data but, as all efforts failed, no comparisons could be made. These data contained wetland classifications by vegetation type and could have been very useful for this demonstration.

4.7 Output Product Preparation

4.7.1 Statistics

A number of statistics were generated for this demonstration. Data for these tables were generated using the AREA command. This command produced a table showing area in acres, percentage of total area, and the frequency (number of occurrences) of each feature type in an active MOSS Master Map file. The table produced by the AREA command, is set up in a random order depending on the order the features were digitized (Table 11).

Table 11 - MOSS Area Statistics Using Area Command

AREA SUMMARY FOR MAP POR.31 ACTIVE MAP NO. 13

SUBJECT	AREA	FREQUENCY	PERCENT
3A	1[illegible]1.25	19	9.04
2A	741.28	45	36.99
1A	287.85	20	14.37
2B	109.11	34	5.44
3B	259.23	16	12.94
3C	18.14	10	.91
5B	88.16	2	4.40
4B	49.24	10	2.46
4A	24.35	3	1.22
4C	164.46	8	8.21
5C	7.71	2	.38
1B	73.11	15	3.65
TOTAL (IN ACRES)	2004.0	184	100.00

These data were manually recompiled into another table showing the entire project area broken down into individual area statistics by year. Tables 12-17 represent the results of recompiling the basic area statistical data. Table 12 shows the area statistics for each theme per year (1957, 1974, and 1981) for the entire project area. The area of each major theme (such as "regularly inundated") and each sub-theme (such as "unvegetated") is shown. The percent of area covered is shown (relative to the total area for that particular major theme), along with the number of polygons mapped with that classification. Table 13 shows the change in wetland land cover between the years 1957 and 1974, 1974 and 1981, and 1957 and 1981. The area (in acres), the change in acres for that theme, and percent of change is shown for each major wetland theme (subdivided into "unvegetated," herbaceous vegetation," and "woody vegetation"). Table 14 shows the extent of change between vegetated and unvegetated areas for the project area.

Also, at the request of the Portland District, another set of tables were prepared for Miller Sands. The tables for Miller Sands were prepared in the same fashion as those for the entire project (except that it shows Miller Sands data only). Table 15 shows the wetland area statistics (by acre, percent, and frequency). Table 16 shows the changes in wetland area between the three time periods. Table 17 shows the change between vegetated and unvegetated areas for each year.

4.7.2 Output Plots (Maps) Preparation

In analyzing the Columbia River data the primary emphasis was on presenting the information in a fashion both informative and readable to the viewer. The resulting output plots and statistical tables when used together show the general trend of the changes taking place. For the Columbia River demonstration the outputs were divided into two categories. First, the 1:24,000 and 1:5000 maps were produced showing individual years with all wetland data separated by color and shading patterns. Second, individual classification categories for all three years were shown (for Miller Sands only) with different shading patterns and the years separated by different colors. These maps illustrated the changes in each zone very well and could be very useful in analysis of the study area. All the final plots were prepared using the CALCOMP command. The resulting plots include Columbia River data for:

Table 12 - Wetland Area Statistics
(For Entire Project Area)

CLASSIFICATION SCHEMES		1957 DATA			1974 DATA			1981 DATA		
		AREA (ACRES)	PERCENT	NUMBER OF AREAS	AREA (ACRES)	PERCENT	NUMBER OF AREAS	AREA (ACRES)	PERCENT	NUMBER OF AREAS
REGULARLY INUNDATED	UNVEGETATED	144.34	19.98	19	130.45	17.79	11	741.28	45.12	45
	HERBACEOUS VEGETATION	136.92	18.95	27	44.28	6.04	15	109.11	6.64	34
OCCASIONALLY INUNDATED	UNVEGETATED	49.65	6.87	22	87.77	11.97	10	181.25	11.03	19
	HERBACEOUS VEGETATION	130.20	18.02	23	150.83	20.57	16	259.23	15.78	16
	WOODY VEGETATION	12.18	1.69	7	23.14	3.16	14	18.14	1.10	10
ABOVE ORDINARY HIGH WATER	UNVEGETATED	15.04	2.08	2	48.35	6.60	5	24.35	1.48	3
	HERBACEOUS VEGETATION	115.76	16.02	6	82.51	11.25	10	49.24	3.00	10
	WOODY VEGETATION	75.65	10.47	6	124.50	16.98	6	164.46	10.01	8
SIGNIFICANTLY ABOVE ORDINARY HIGH WATER (+10')	UNVEGETATED	0.00	0.00	0	4.80	0.66	2	0.00	0.00	0
	HERBACEOUS VEGETATION	33.48	4.63	4	35.65	3.50	4	88.18	5.37	2
	WOODY VEGETATION	9.31	1.29	1	10.85	1.48	2	7.71	0.47	2
TOTALS		722.53	100.00	117	733.13	100.00	95	1642.95	100.00	149
PERMANENTLY INUNDATED		—	—	—	—	—	—	360.99	—	35
(TOTALS)		—	—	—	—	—	—	2003.94	—	184

Table 13 - Statistics Showing Changes in Wetland Areas (For Entire Project Area)

CLASSIFICATION SCHEMES		1957 TO 1974			1974 TO 1981			1957 TO 1981		
		1957 AREA IN ACRES	CHANGE IN ACRES	PERCENT	1974 AREA IN ACRES	CHANGE IN ACRES	PERCENT	1957 AREA IN ACRES	CHANGE IN ACRES	PERCENT
REGULARLY INUNDATED	UNVEGETATED	144.34	-13.89	-9.62	130.45	+610.83	+468.25	144.34	+596.94	+413.57
	HERBACEOUS VEGETATION	136.92	-92.64	-67.66	44.78	+64.83	+146.41	136.92	-27.81	-20.31
OCCASIONALLY INUNDATED	UNVEGETATED	49.65	+38.12	+76.78	87.77	+93.48	+106.51	49.65	+131.60	+265.06
	HERBACEOUS VEGETATION	130.20	+20.63	+15.84	150.83	+108.40	+71.87	130.20	+129.03	+99.10
	WOODY VEGETATION	12.18	+10.96	+89.98	23.14	-5.00	-21.61	12.18	+5.96	+48.93
ABOVE ORDINARY HIGH WATER	UNVEGETATED	15.04	+33.31	+221.48	48.35	-24.00	-49.64	15.04	+9.31	+61.90
	HERBACEOUS VEGETATION	115.76	-33.25	-28.72	82.51	-33.27	-40.32	115.76	-66.52	-57.46
	WOODY VEGETATION	75.65	+48.85	+64.22	124.50	+39.96	+32.[illegible]0	75.65	+88.81	-117.40
SIGNIFICANTLY ABOVE ORDINARY HIGH WATER (+10')	UNVEGETATED	0.00	+4.80	——	4.80	-4.80	-100.00	0.00	0.00	0.00
	HERBACEOUS VEGETATION	33.48	-7.83	-23.39	25.65	+62.53	+243.78	33.48	+54.70	+163.38
	WOODY VEGETATION	9.31	+1.54	+16.54	10.85	-3.14	-28.94	9.31	-1.60	-17.19
TOTALS		722.53	+10.60	+1.47	733.13	+909.82	+124.10	722.53	+920.42	+127.39

Table 14 - Area Statistics: Vegetated and Unvegetated Wetlands (For Entire Project Area)

CLASSIFICATION SCHEMES		1957 DATA AREA (ACRES)	1957 DATA PERCENT	1957 DATA NUMBER OF AREAS	1974 DATA AREA (ACRES)	1974 DATA PERCENT	1974 DATA NUMBER OF AREAS	1981 DATA AREA (ACRES)	1981 DATA PERCENT	1981 DATA NUMBER OF AREAS
REGULARLY INUNDATED	UNVEGETATED	144.34	51.32	19	130.95	74.66	11	741.28	87.17	45
	VEGETATED	136.92	48.68	27	44.28	25.34	15	109.11	12.83	34
	TOTAL	281.26	100.00	46	174.73	100.00	26	850.39	100.00	79
OCCASIONALLY INUNDATED	UNVEGETATED	49.65	25.86	22	87.77	33.53	10	181.25	39.52	19
	VEGETATED	142.38	74.14	30	173.97	66.47	30	277.37	60.48	26
	TOTAL	192.03	100.00	52	261.74	100.00	40	458.62	100.00	45
TOTAL (INUNDATED AREAS)	UNVEGETATED	193.99	40.99	41	218.22	50.00	21	422.53	70.48	64
	VEGETATED	279.30	59.01	57	218.25	50.00	45	386.48	29.52	60
	TOTAL	473.29	100.00	98	436.47	100.00	66	1309.01	100.00	124
ABOVE ORDINARY HIGH WATER	UNVEGETATED	15.04	7.29	2	48.35	18.93	5	24.35	10.23	3
	VEGETATED	191.41	92.71	12	207.01	81.07	16	213.70	89.77	18
	TOTAL	206.45	100.00	14	255.36	100.00	21	238.05	100.00	21
SIGNIFICANTLY ABOVE ORDINARY HIGH WATER	UNVEGETATED	0.00	0.00	0	4.80	11.62	2	0.00	0.00	0
	VEGETATED	42.79	100.00	5	36.50	88.38	6	95.89	100.00	4
	TOTAL	42.79	100.00	5	41.30	100.00	8	95.89	100.00	4
TOTAL (ABOVE ORDINARY HIGH WATER AREAS)	UNVEGETATED	15.04	6.03	2	53.15	17.92	7	24.35	7.29	3
	VEGETATED	234.20	93.97	17	243.51	82.08	22	309.59	92.71	22
	TOTAL	249.24	100.00	19	296.66	100.00	29	333.94	100.00	25
TOTALS	UNVEGETATED	209.03	28.93	43	271.37	37.01	28	946.88	57.63	67
	VEGETATED	513.50	71.07	74	461.76	62.99	67	696.07	42.37	82
	TOTAL	722.53	100.00	117	733.13	100.00	95	1642.95	100.00	149

Table 15 - Wetland Areas Statistics
(Miller Sands)

CLASSIFICATION SCHEMES		1957 DATA			1974 DATA			1981 DATA		
		AREA (ACRES)	PERCENT	NUMBER OF AREAS	AREA (ACRES)	PERCENT	NUMBER OF AREAS	AREA (ACRES)	PERCENT	NUMBER OF AREAS
REGULARLY INUNDATED	UNVEGETATED	67.37	23.69	9	94.54	27.72	2	281.19	40.83	12
	HERBACEOUS VEGETATION	40.41	14.21	10	6.43	1.88	2	49.11	7.13	13
OCCASIONALLY INUNDATED	UNVEGETATED	7.38	2.60	17	61.61	18.06	6	111.90	16.25	9
	HERBACEOUS VEGETATION	23.19	8.15	8	23.71	6.95	5	82.21	11.94	5
	WOODY VEGETATION	6.47	2.27	4	15.01	4.40	8	14.97	2.17	8
ABOVE ORDINARY HIGH WATER	UNVEGETATED	15.04	5.29	2	8.99	2.64	2	0.69	0.10	1
	HERBACEOUS VEGETATION	82.26	28.93	2	68.67	20.14	6	5.91	0.86	3
	WOODY VEGETATION	8.78	3.09	3	31.21	9.15	4	54.33	7.89	6
SIGNIFICANTLY ABOVE ORDINARY HIGH WATER (+10')	UNVEGETATED	0.00	0.00	0	4.80	1.41	2	0.00	0.00	0
	HERBACEOUS VEGETATION	33.48	11.77	4	25.65	7.52	4	88.18	12.81	2
	WOODY VEGETATION	0.00	0.00	0	0.43	0.13	1	0.17	0.02	1
TOTAL		284.38	100.00	59	341.05	100.00	42	688.66	100.00	60
PERCENTAGE OF TOTAL DEMONSTRATION AREA		—	39.36	—	—	46.52	—	—	41.92	—

Table 16 - Statistics Showing Changes in Wetland Areas (Miller Sands)

CLASSIFICATION SCHEMES		1957 TO 1974			1974 TO 1981			1957 TO 1981		
		1957 AREA (ACRES)	CHANGE IN ACRES	PERCENT	1974 AREA (ACRES)	CHANGE IN ACRES	PERCENT	1957 AREA (ACRES)	CHANGE IN ACRES	PERCENT
REGULARLY INUNDATED	UNVEGETATED	40.41	+54.13	+133.95	94.54	+186.65	+197.43	40.41	+240.78	+595.84
	HERBACEOUS VEGETATION	67.37	-60.94	-90.46	6.43	+42.68	+663.76	67.37	-18.26	-27.10
OCCASIONALLY INUNDATED	UNVEGETATED	7.38	+54.23	+734.82	61.61	+50.29	+81.63	7.38	+104.52	+1416.26
	HERBACEOUS VEGETATION	23.19	+0.52	+2.24	23.71	+58.50	+246.73	23.19	+59.02	+254.51
	WOODY VEGETATION	6.47	+8.54	+131.99	15.01	-0.04	-0.27	6.47	+8.50	+131.38
ABOVE ORDINARY HIGH WATER	UNVEGETATED	15.04	-6.05	-40.23	8.99	-8.30	-92.32	15.04	-14.35	-95.41
	HERBACEOUS VEGETATION	82.26	-13.59	-16.52	68.67	-62.76	-91.39	82.26	-76.35	-92.82
	WOODY VEGETATION	8.78	+22.43	+255.47	31.21	+23.12	+74.08	8.78	+45.55	+518.79
SIGNIFICANTLY ABOVE ORDINARY HIGH WATER (+10')	UNVEGETATED	0.00	+4.80	—	4.80	-4.80	-100.00	0.00	0.00	0.00
	HERBACEOUS VEGETATION	33.48	-7.83	-23.39	25.65	+62.53	+243.78	33.48	+54.70	+163.38
	WOODY VEGETATION	0.00	+0.43	—	0.43	-0.26	-60.47	0.00	+0.17	—
TOTALS		284.38	+56.67	+19.93	341.05	347.61	+101.92	284.38	+404.28	+142.16
PERCENT OF TOTAL DEMONSTRATION CHANGES		—	—	34.62	—	—	38.21	—	—	43.92

Table 17 - Area Statistics:
Vegetated and Unvegetated Wetlands
(Miller Sands)

CLASSIFICATION SCHEMES		1957 DATA			1974 DATA			1981 DATA		
		AREA (ACRES)	PERCENT	NUMBER OF AREAS	AREA (ACRES)	PERCENT	NUMBER OF AREAS	AREA (ACRES)	PERCENT	NUMBER OF AREAS
REGULARLY INUNDATED	UNVEGETATED	67.37	62.51	9	94.54	93.63	2	281.19	85.13	12
	VEGETATED	40.41	37.49	10	6.43	6.37	2	49.11	14.87	13
	TOTAL	107.78	100.00	19	100.97	100.00	4	330.30	100.00	25
OCCASIONALLY INUNDATED	UNVEGETATED	7.38	19.92	17	61.61	61.40	6	111.90	53.52	9
	VEGETATED	29.66	80.08	12	38.72	38.60	13	97.18	46.48	13
	TOTAL	37.04	100.00	29	100.33	100.00	19	209.08	100.00	22
TOTAL (INUNDATED AREAS)	UNVEGETATED	74.75	51.62	26	156.15	77.57	8	393.09	72.88	21
	VEGETATED	70.07	48.38	22	45.15	22.43	15	146.29	27.12	26
	TOTAL	144.82	100.00	48	201.30	100.00	23	539.38	100.00	47
ABOVE ORDINARY HIGH WATER	UNVEGETATED	15.04	14.18	2	8.99	8.26	2	0.69	1.13	1
	VEGETATED	91.04	85.82	5	99.88	91.74	10	60.24	98.87	9
	TOTAL	106.08	100.00	7	108.87	100.00	12	60.93	100.00	10
SIGNIFICANTLY ABOVE ORDINARY HIGH WATER	UNVEGETATED	0.00	0.00	0	4.80	15.54	2	0.00	0.00	0
	VEGETATED	33.48	100.00	4	26.08	84.46	5	88.35	100.00	3
	TOTAL	33.48	100.00	4	30.88	100.00	7	88.35	100.00	3
TOTAL (ABOVE ORDINARY HIGH WATER AREAS)	UNVEGETATED	15.04	10.78	2	13.79	9.87	4	0.69	0.46	1
	VEGETATED	124.52	89.22	9	125.96	90.13	15	148.59	99.54	12
	TOTAL	139.56	100.00	11	139.75	100.00	19	149.28	100.00	13
TOTAL	UNVEGETATED	89.79	31.57	28	169.94	49.83	12	393.78	57.18	22
	VEGETATED	194.59	68.43	31	171.11	50.17	30	294.88	42.82	38
	TOTAL	284.38	100.00	59	341.05	100.00	42	688.66	100.00	60

1) 1957 (1:24,000)
2) 1974 (1:24,000)
3) 1981 (1:24,000)

Miller Sands, Snag Islands, and Jim Crow Sands plots were prepared as follows:

1) 1957 (1:5,000)
2) 1974 (1:5,000)
3) 1981 (1:5000)

Specific plots for Miller Sands were prepared as follows:

1) Regularly inundated areas for all years (1:5,000)
2) Occasionally inundated areas for all years (1:5,000)
3) Above ordinary high water areas for all years (1:5,0000)
4) Significantly above ordinary high water areas for all years (1:5,000)

Table 18 lists each of the maps prepared for the Columbia River project area.

4.7.3 Preparation of Digital Files

All of the digital files created during the AMS and MOSS phases were transferred to a digital tape for delivery to USAETL. A complete listing of these files is shown in Appendix C.

4.8 Summary and Conclusions

This demonstration project has successfully demonstrated that CAPIR technology can be utilized to create a multi-year digital geograhic database of wetlands information, in a photogrammetrically accurate format. In this case, different sets of aerial photography covering three years were successfully aerotriangulated, and simultaneously photointerpreted and digitized. Five major and thirteen minor categories of wetlands land cover were digitized, and area statistics were derived for each of the

Table 18 - List of Maps Prepared (Columbia River Demonstration)

MAP TITLE	MOSS FILES*	MAP SCALE	MAP SIZE
ENTIRE PROJECT AREA - 1957 WETLANDS DATA	POR.57	1:24,000	37"x24"
" " " - 1974 " "	POR.74	"	"
" " " - 1981 " "	POR.81	"	"
JIM CROW SANDS AREA - 1957 WETLANDS DATA	POR.57	1:5,000	28"x18"
" " " - 1974 " "	POR.74	"	"
" " " - 1981 " "	POR.81	"	"
SNAG ISLANDS AREA - 1957 WETLANDS DATA	POR.57	1:5,000	38"x28"
" " " - 1974 " "	POR.74	"	"
" " " - 1981 " "	POR.81	"	"
MILLER SANDS AREA - 1957 WETLANDS DATA	POR.57	1:5,000	42"x22"
" " " - 1974 " "	POR.74	"	"
" " " - 1981 " "	POR.81	"	"
" " " - REGULARLY INUNDATED AREAS	POR.MILLER ATTRIB.2A,2B	"	"
" " " - OCCASIONALLY INUNDATED AREAS	POR.MILLER ATTRIB.3A,3B,3C	"	"
" " " - ABOVE ORDINARY HIGH WATER AREAS	POR.MILLER ATTRIB.4A,4B,4C	"	"
" " " - SIGNIFICANTLY ABOVE ORD-INARY HIGH WATER AREAS	POR.MILLER ATTRIB. 5A,5B,5C	"	"

*NOTE: See Appendix C for Explanation of MOSS File Codes.

above wetland themes for the entire project area as well as for selected individual islands.

Once the digital database was created, it was then possible to display and plot any desired wetlands data; both single and multiple year plots were plotted. By combining desired data for the two (or three) years of coverage, it was possible to determine relative accretion/erosion rates and changes in wetland types for specific areas.

Thre results of this project demonstrate that CAPIR utility can be effectively utilized to monitor wetland processes. In the course of this project, numerous lessons have been learned regarding the optimum procedures for conducting such an effort. These observations and suggestions are summarized as follows:

Preplanning: As with the Fort Lewis demonstration, more planning at the beginning probably would have helped the project in the end. This preplanning necessitates the knowledge of the types of outputs desired, so that the appropriate digitizing scheme can be devised. The most significant change in digitizing would have been in the coding of each area or classification scheme. Separate codes could have been inserted to designate classifications by island area, which would have negated the need for the use of the GENERATE command to create individual island statistics. Another change might be to enter a code for designating unvegetated and vegetated areas without breaking the vegetated areas down into herbaceous and woody vegetation, thus eliminating much of calculations done by hand.

Camera Calibration Reports: It is essential that accurate, detailed camera calibration reports be provided along with the respective aerial photography. The data contained within these reports enable the operator to satisfactorily complete the aerotriangulation effort that provides the highly accurate geographic coordinate registration needed for accurate database preparation.

Use of Appropriate Aerial Photography: In this particular project it was necessary to utilize aerial photography flown at different tidal stages; thus, the photointerpretation of tidal-affected areas was not identical in that certain thematic categories were either exposed or not exposed on the photos. Future efforts of this type should consider that aerial photos should be acquired at either high and/or low tide (or both).

Ground Control Points: Because AUTOGIS software is based on a single geographic coordinate system, it is essential that a number of map-identifiable/photo-identifiable ground control points be located and measured. In this project, because of the lack of a sufficient number of ground control points, considerable time was devoted to locating points that enabled the "tying together" of adjacent steremodels and adjacent mission strips.

Data Collection: The above-mentioned preplanning effort should include an analysis of whether black-and-white or color photography should be collected and/or utilized and, if the data are to be collected, the scale at which the photos should be flown. The use of both high altitude color infrared aerial photography and lower altitude black-and-white photos, as was the case in this project, could have had some effect on the significance and accuracy of the wetland categories mapped.

5.0 GENERAL PROBLEMS AND SUGGESTIONS

5.1 Suggestions for Implementing a CAPIR-Type Project

When planning a CAPIR-type project, there are a number of considerations that must be kept in mind. The first consideration should be the type of outputs needed; the digitizing plan must be focused around the eventual outputs needs. This is important in that knowing the output will make analysis and MOSS work much simpler. Control selection is also a major consideration. If there is little control available (as in the Columbia River demonstration), an effort should be made in attempting to create more. This can be done by ground surveys or marking points for aerial photography. The type of analysis or project will determine the type of control needed. If it is to conform to National Map Accuracy, the control network should be extensive and accurate. If only softcopy graphics are needed and only a visual analysis is desired, then a less accurate control network can be used.

The input medium is also of importance in planning a project. If paper-copy maps are to be used one must consider the possibilities of shrinkage and distortion that can be entered into the system. If aerial photos are to be digitized along with the maps, then other problems such as elevation difference offsets (similar to those encountered in the Fort Lewis demonstration) can enter into the system.

Personnel skill is an important consideration when planning a project. One person should know the entire set up (i.e., both AMS and MOSS) and should participate in at least an advisory capacity to help with the initial plans and their implementation. This person should be accessable and available to help with any problems that arise during the duration of the project. Prompt action on problems can save a lot of time and expense. Other necessary personnel should include at least an experienced digitizer, a software manager, and an experienced AUTOGIS user.

In an environment where exclusive use of plotting and CPU time is impossible substantial planning is needed to assure that a project progresses at an acceptable rate. This is especially important during outputs and overlay processes. These operations can consume considerable time and tie up terminals.

5.2 New AUTOGIS Software

Because of the nature of the system and its uses, continual updating is taking place. MOSS has undergone many minor changes and updates, including the addition of new commands and functions. However, AMS is now undergoing a major change. Although the arc-node format is still used, the method of digitizing will be drastically altered. No longer will individual arcs need to be digitized between two nodes with a right, center, and left attribute. The boundaries of areas can now be digitized, with the nodes added after the lines, and the formed polygon attributes can be added at the very end. This will be a significant improvement and will end much of the updating problems that currently exist with adding new data to an existing AMS database.

An example would be the adding of a new road to the existing Master Plan of the Fort Lewis demonstration. No longer will two overlays be needed, because the new road can be digitized, attributes assigned, and nodes added without having to delete and redigitize existing roads.

This new software would have helped also in the digitizing of the Columbia River data. All of the areas could have been outlined first, with nodes and attributes added later. This would have eliminated many crossed line and other attribute problems encountered during the verification process.

The new software is scheduled to be available late in 1983 and should improve the usefulness of AUTOGIS.

APPENDIX A

MOSS FUNCTIONS/COMMANDS

MOSS FUNCTIONAL COMMANDS

ACTIVE produces a table that numbers and describes the data activated by the SELECT command. Data can also be activated using the CONTIGUITY and SIZE commands.

ADD enables the database administrator to add a new map to the master map database.

AREA produces a table of the area (in acres), frequency and percentage of each subject associated with any polygon or raster map referenced in the active map table.

ASPECT enables the user to convert a digital terrain model to an aspect map. The aspect is either degrees from North or one of eight cardinal directions.

ASSIGN enables the user to interactively assign point and line symbologies to point and lineal features. These "font" assigned features may be plotted with the PLOT command.

ATTRIBUTE enables a database administrator to maintain the multiple attributes data files. New attributes may be added, attributes can be updated, and reports can be generated.

AUDIT provides the user with a table containing the number of points, subject ID, item, number, perimeter in miles, area in acres, and number of islands for each individual feature in a vector map.

BAUD enables the user to reset the internal MOSS baud rate setting. The 9600 baud default setting can result in considerable delays when using a 300 baud connection.

BLOWUP magnifies a portion of the display window specified by the WINDOW command. The user should display a map on the screen for orientation. The area to be magnified is indicated by pointing to two diagonal corners of a rectangle that bounds the new area of interest, using the CRT crosshairs (cursor).

BSEARCH enables the user to perform complex boolean retrievals from a MOSS multiple attributes file.

BUFFER computes a user-specified zone around any vector map data referenced in the active map table. The result is a new polygon map which is stored in the polygon workfile.

CALCOMP enables the user to generate a multicolored hardcopy plot on a digital plotter. The user has total control of scale, line type (30 fonts), shade type (angle and density), and labeling. Twenty-two lettering fonts are available. The resulting cartographic product is suitable for meetings analysis or publication.

CBUFFER enables the user to perform raster zone generation.

CELLPLOT enables the user to generate a shaded raster map on a digital plotter. Nine shade patterns are available.

CLI enables the user to "swap in" the AOS CLI, while still running MOSS.

COMPOSITE ARITHMETIC enables the user to manipulate raster data algebraically. Maps may be weighted and added, subtracted, multiplied, or divided. The new map is stored in the user work database.

COMPOSITE LOGICAL enables the user to perform boolean manipulations of raster data using one or more maps. The result of combining data using the COMPOSITE LOGICAL command is a new cell map.

CONTIGUITY helps the user determine "what is next to what?" For example, the user may have a vegetation map and wants to determine how many polygons of ponderosa pine are adjacent or contiguous to polygons of Douglas fir. The result of using CONTIGUITY would be a new map of all Douglas fir polygons that are contiguous to ponderosa pine.

CONTOUR generates a contour map from a digital terrain model.

COST enables the user to find out how much CPU time and how many disk accesses have been made during a MOSS run. If a costing function is available, it will also print out the cost of the current MOSS run.

DEBUG enables the system manager to "turn on" and ""turn off" debug messages. These messages are useful for tracking down software/data problems.

DELETE enables the user to delete a map from the MOSS database.

DISTANCE measures the distance (in miles and kilometers) between two points on the CRT either along a straight line or along a path. The beginning and end points of the DISTANCE measurement are identified using the CRT crosshairs (cursor).

DUMP is a system manager function that prints the contents of a MOSS vector map to the screen. These dumps are useful for tracking data problems.

EDGE activates edges or common boundaries shared by subjects associated with two or more maps referenced in the active map table. The result of the EDGE command is a line map of the common boundaries shared by the input maps.

EDITATT enables the user to interactively edit individual fields for a feature in a MOSS multiple attributes file.

ERASE clears the CRT display screen and resets the crosshairs (cursor) to the upper left-hand corner of the screen.

EXPORT enables the user to generate an ASCII text file from a vector map. This text file is in a suitable format for export to other installations or geoprocessing systems.

FINISH enables the user to terminate the MOSS program. After this command is initiated, the user is returned to the computer operating system. The user can then initate other programs, or type the word BYE and log off the computer operating system.

FREE is used to "deactivate" any map referenced by the ACTIVE command.

FREQUENCY produces a table showing the frequency and percentage of each subject associated with any polygon map referenced in the active map table. Frequency is defined as the number of polygons.

GENERATE enables the user to interactively create a new MOSS map. Interaction is via the terminal cursor. Points, lines, polygons, circles, and rectangles can be created.

GRID performs point to grid interpolation. This command converts (X,Y,Z) point samples to a digital elevation model.

HELP provides either a listing of the MOSS commands or a general description of the capabilities of a specific command.

LEGEND enables the user to label points, lines, and polygons displayed on a CRT.

LENGTH produces a table showing the length (in miles), frequency, and percentage of each subject associated with any line map referenced in the active map table.

LINE plots line data in any one of 18 symbologies.

LIST browses the contents of MOSS map files. The LIST command performs four basic tasks:

1) Lists the names of the maps stored in the master map file and the user's cell or polygon workfile.

2) Lists the subjects for a particular map.

3) Lists the header information for a particular map.

4) Browses through the multiple attributes database for a map.

LOCATE determines the Universal Transverse Mercator (UTM) coordinates of any point on the map being displayed on the graphics display terminal.

LPOVER enables the user to perform an intersection between a polygon data set and a point or line data set. The result is another point or line data set which is stored in the user's polygon workfile.

MERGE combines two or more active maps and creates a new map in the polygon workfile.

MODELG enables the user to perform complex boolean modeling functions against a MOSS multivariable grid file.

MULTIVAL converts a MOSS single variable file to a MOSS multivariable file.

NEWS enables the user to type out the contents of the current MOSS news file. This file contains information on the latest changes to MOSS.

NUMBER enables the user to either print the item number of each feature in a displayed or to asign code numbers to groups of features on a displayed map.

OPEN enables the user to access an alternative master map database.

OVERLAY synthesizes a new map by determining the polygon intersection between two polygon maps referenced in the active map table. OVERLAY uses two active maps as input and creates a new active map as output.

PERIMETER gives the user the length of perimeters (in miles) for each subject of a given polygon map.

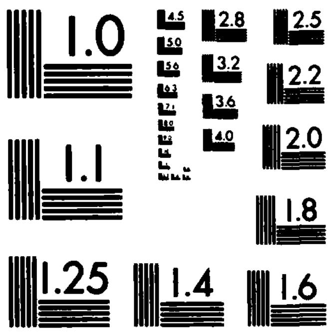
PLOT displays data activated by the SELECT command. Each map set to be plotted is specified by using its unique integer code identifier, which may be found by using the ACTIVE command.

POINTOVER performs a polygon on point overlay (Point in polygon). Typical uses might be to produce a count of water wells by coal lease area or a count of oil wells by section.

POLYCELL converts point, line, or polygon data to raster format.

PROFILE enables the user to point with the CRT crosshairs (cursor) to two locations on a raster map or a digital terrain model and have the surface profile between the two points computed and displayed.

AD-A134 215 APPS-IV CIVIL WORKS DATA EXTRACTION/DATABASE 2/2
APPLICATION STUDY (PHASE II)(U) AUTOMETRIC INC FALLS
CHURCH VA J D PEROUTKY SEP 83 ETL-0336
UNCLASSIFIED DAAK70-81-C-0261 F/G 13/2 NL



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

PROJECTION enables the user to convert coordinate data from one projection or coordinate system to any one of 20 other coordinate projection systems.

PROXIMITY activates data from a map(s) based on its proximity to some point or other map featuare. A typical query for PROXIMITY might be "give me all the ponds within 0.5 miles of a paved road."

QUERY identifies the map name, subject, and item of any point, line or polygon being displayed on the screen. The user uses the CRT crosshairs (cursor) to point to the item of interest.

RASTER is a database utility function that enables the user to:

1) window raster maps
2) apply scalers to cell values
3) change individual cell values
4) recode entire raster maps

REPORT enables the user to generate tables (up to seven columns wide) from data stored in a map's multiple attributes file. There may be up to 200 attributes per map item (point, line, or polygon).

RESET returns the data display window from the BLOWUP window to the window specified by the WINDOW command.

SAMPEL enables the user to select a random sample of features from any MOSS vector map.

SAVE saves a map referenced in the active map table as part of the user's workfile.

SELECT activates all or a specific portion of a map that is stored in a MOSS map file. The SELECT command can be used to activate an entire map based on primary subject, subattributes, or individual map items.

SHADE plots activated polygon map data on the screen and shades the polygons with differential cross-hatching. If more than one active map ID number is entered following the SHADE command, each map can be plotted with different degrees of cross-hatching, as specified by the user.

SIZE activates polygons or lines on an active map based on the size or length of these polygons or lines.

SLOPE enables the user to convert a digital terrain model to a slope map.

SNGVAL converts a single field in a MOSS multivariable file into a MOSS single variable file.

SPSS enables the user to generate a data matrix from a set of raster maps. This data matrix is suitable for input into such statistical packages as SAS, SPSS, and BMD. There is also an option to build a multivariable grid cell file for input into other geoprocessing systems.

STATISTICS CROSS-TABS produces a two-way frequency table of the contents of two cell maps referenced in the active map table.

STATISTICS DESCRIBE computes the following parameters for each subject associated with an active map:

1) the minimum area or length
2) the maximum area or length
3) the total area or length
4) the range, mean, variance, and standard deviation

STATISTICS HISTOGRAM produces a bar graph or histogram of the frequency distribution of the subjects in any active map (vector or raster).

STATUS prints out the number of items and coordinate pairs for:

1) all the maps in the master file
2) a particular map in the master file or
3) any map referenced in the active map table.

STUDYAREA constructs a new boundary around any map or series of maps referenced in the active map table.

SYMBOL enables the user to select any one of 20 symbols and have that symbol plotted for point or polygon data. There are several options of the SYMBOL command.

TESTGRID superimposes a grid over any map displayed on the screen. The grid size is user-specified in acres. TESTGRID is useful for helping the user determine the appropriate cell size when converting a polygon map to a cell map.

TEXT enables the user to create, edit, and display layers of textual information. The text is keyed to ground reference points and is treated as a special type of MOSS map. Twenty text fonts are availble.

THREED enables the user to display any raster map or digital terrain model in a three-dimensional format.

TRANSLATE enables the user to "move" a map from one location on the surface of the earth to another. This command is useful for registering data sets.

WEED culls all unnecessary data points.

WINDOW enables the user to set a virtual display window for one or more vector or raster maps.

WRITE enables the user to generate a line printer map from a discrete raster map.

APPENDIX B
MOSS SYMBOLOGY

Table B-1 - Sample AUTOGIS Shade Patterns

TABLE ONE - SOLID LINE

(The angle and distance between lines are specified by the user.)

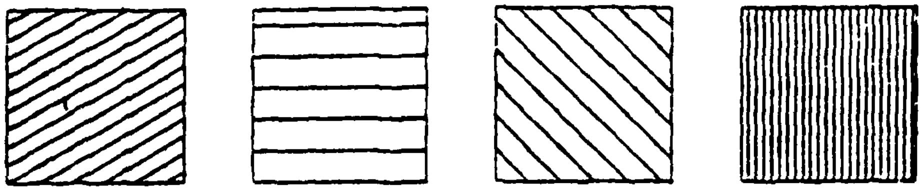


TABLE TWO - CROSS-HATCHED SOLID LINE

(The angle and distance between lines are specified by the user. *Cross-hatched lines are drawn at a perpendicular.*)

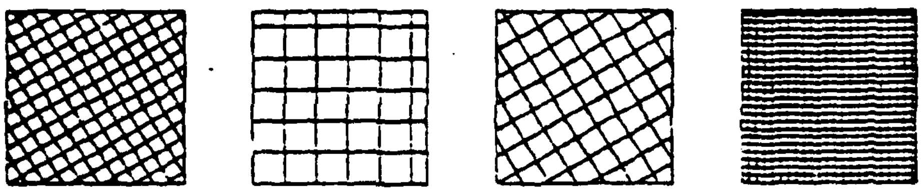


TABLE THREE - DASHED LINE

(The angle and distance between lines are specified by the user Dash style is specified by a four digit dash code.)

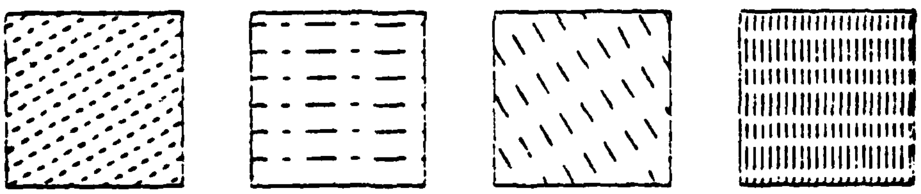


TABLE FOUR - CROSS-HATCHED DASHED LINE

(The angle and distance between lines are specified by the user Dash style is specified by a four digit dash code. Cross-hatched lines are drawn at a perpendicular.)

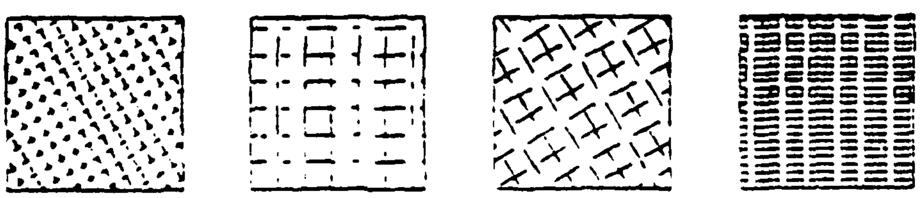
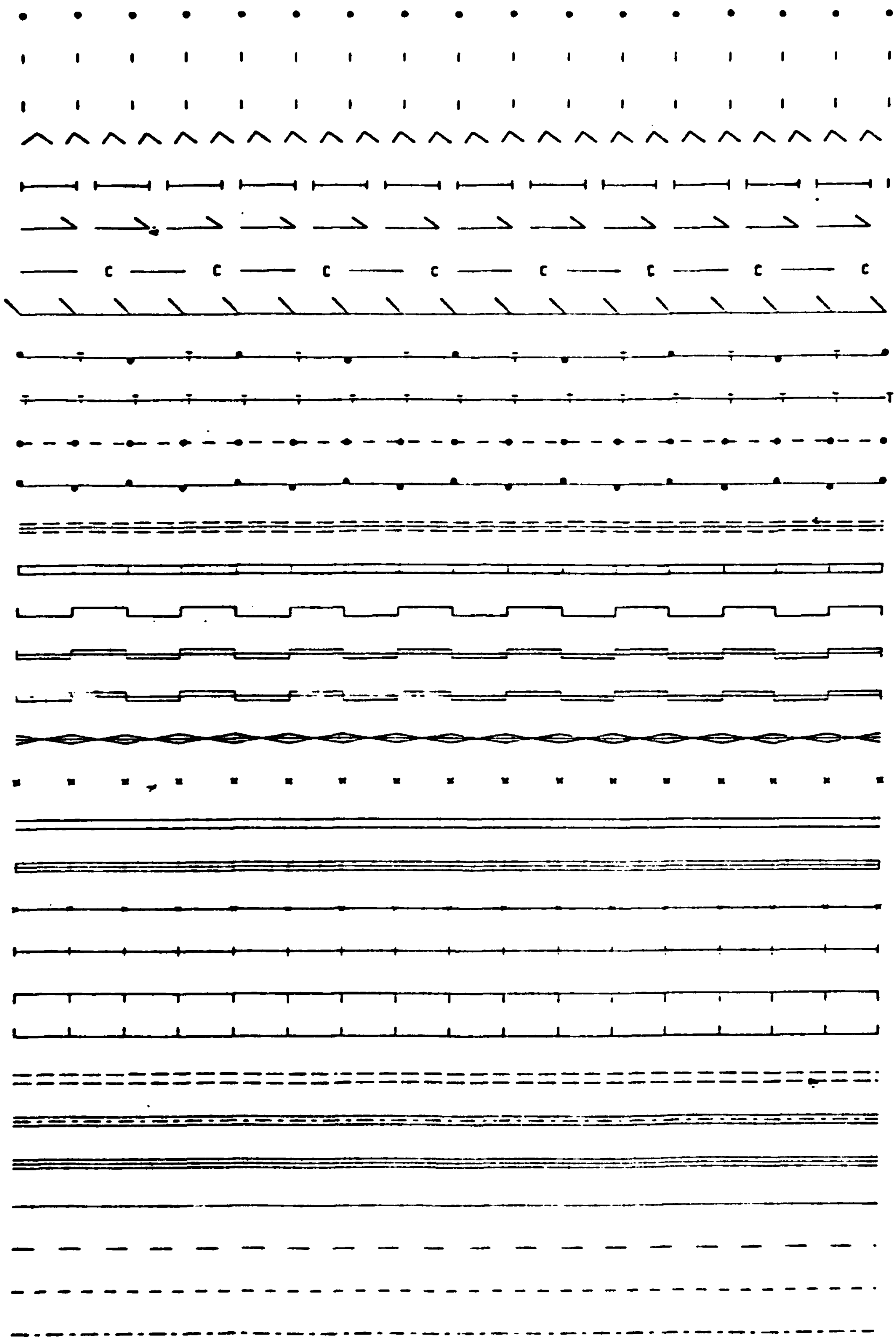


Table B-2 - AUTOGIS Line Fonts



APPENDIX C

Digital File Documentation

Table C-1 - Digital Tape File Description (Portland)

Data Type (Year)	MOSS Map Name	AMS Theme Name	Data Type	Attribute Description	Source
1981 Data	POR.81	W81	Polygon	See Attached Table C-3	1981 Photos
1974 Data	POR.74	W74	Polygon	" "	1974 Photos
1957 Data	POR.57	W57	Polygon	" "	1957 Photos
Background Data	POR.BASE81	BASE	Polygon	WA-Water LA-Land NS-New Spoil Area	1981 Photos " " " "
1981 Miller Sands Window	POR.MIL	---	Polygon	Miller Sands Map Boundary	GENERATE Command
1981 Miller Sands Data	POR.MILLER	---	Polygon	See Attached Table	POR.MIL & POR.81
Text Data	POR.TEXT4	---	---	Text Information	TEXT Command

Table C-2 - Digital Tape File Format (Portland)

File Ø - PORTLAND-AMS Project Database - Contents:

1) Themes
   - W81 (1981)
   - W74 (1974)
   - W57 (1957)
   - BASE

2) Classification Schemes Same as Themes

3) Attributes-See Attached Table C-3

4) Triangulation Data

File 1 - JP-AMS User ID and User File - Contents:

Job No.	Job ID	AMS Theme
Ø1	1,81	W81
Ø2	2,57	W57
Ø3	3,74	W74
Ø4	4615/12335	BASE

File 2 - MOSS DATA - MOSS Master Map and User Work Files - Contents:

Master Map File:
- POR.81
- POR.74
- POR.57
- POR.BASE81

User Work File:
- POR.MIL
- POR.MILLER
- POR.TEXT4

NOTES: Geounit Center: $46^{o}15'00''N$
$123^{o}35'00''W$

Commands To Enter Data Into Computer:	
	AMS Project Database: PORTLAND
	MOSS Project Database: CORPS.DT
	Put File Ø into Project Database Directory
	Put File 1 into User Area
	Put File 2 into MOSS Database Directory
	Move MOSS User Work Files to MOSS User Area

Table C-3 - Wetland Themes

AMS CLASSIFICATION SCHEME	AMS ATTRIBUTE
• Shallow, permanently inundated areas:	
a. sand	1A
b. mud	1B
• Shallow, regularly inundated flats:	
a. unvegetated	2A
b. herbaceously vegetated	2B
• Occasionally inundated below ordinary high water line:	
a. unvegetated	3A
b. herbaceously vegetated	3B
c. woody vegetation	3C
• Above ordinary high water:	
a. unvegetated	4A
b. herbaceously vegetated	4B
c. woody vegetation	4C
• Significantly above ordinary high water line:	
a. unvegetated	5A
b. herbaceously vegetated	5B
c. woody vegetation	5C

Table C-4 - Digital Tape File Description (Seattle)

Fort Lewis Demonstration - Seattle District

Classification Category	MOSS Map Name	AMS Theme Name	Data Type	Attribute Description	Source
Buildings	SEA.BLDS	BUILDINGS	Polygon	1A-Existing Permanent Buildings	Photos
				1C-Existing Temporary Buildings	"
				9A-New Permanent Buildings	"
				9C-New Temporary Buildings	"
Buildings	SEA.MBLD1	MAPBUILD	Polygon	1A-Existing Permanent Buildings	Map
				1C-Existing Temporary Buildings	"
Pavement	SEA.PAVEP	PAVEMENT	Polygon	8D-New Parking Areas	Photos
Pavement	SEA.PAVEL1	PAVEMENT	Line	8C-New Tertiary Roads	"
Pavement	SEA.OPAVEP	OPAVE	Polygon	2D-Existing Parking Areas	Map
Pavement	SEA.OPAVEL	OPAVE	Line	2A-Existing Primary Roads	"
				2B-Existing Secondary Roads	"
				2C-Existing Tertiary Roads	"
Water Facil.	SEA.WATERL	WATER	Line	MAIN - Water Mains	Map
Water Facil.	SEA.WATERP	WATER	Point	HYDR - Hydrants	"
				VALV - Valves	"
Sewer Facil.	SEA.SEWERL	SEWER	Line	MAIN - Sewer Main	Map
Sewer Facil.	SEA.SEWERP	SEWER	Point	MAN - Manholes	"
Contours	SEA.CONTUR	CONTOUR	Line	Elevation Valves	Map
Pavement	POR.TPVP	---	Polygon	New Parking Areas Data Shift	SEA.PAVEP
Pavement	POR.TPVL	---	Line	New Roads Data Shift	SEA.PAVEL1
Buildings	SEA.TBLDS	---	Polygon	New Buildings Data Shift	SEA.BLDS

Table C-5 - Digital Tape File Format (Seattle)

File Ø - SEATTLE - AMS Project Database - Contents:

1) Themes

BUILDINGS	WATER
MAPBUILD	SEWER
PAVEMENT	CONTOUR
OPAVE	

2) Classification Schemes Same as Themes
3) Attributes - See File Description Sheet
4) Triangulation Data

File 1 - JDP - AMS User ID and User File - Contents:

Job No.	Job ID	AMS Theme
Ø1	1,1	BUILDINGS
Ø2	2,2	OPAVE

File 2 - JDPP - AMS User ID and User File - Contents:

Job No.	Job ID	AMS Theme
Ø1	1,1	PAVEMENT
Ø2	4703/12233	MAPBUILD

File 3 - TCC - AMS User ID and User File - Contents:

Job No.	Job ID	AMS Theme
Ø1	1,1	WATER
Ø2	4703/12233	SEWER
Ø3	3,3	CONTOUR

File 4 - MOSS DATA - MOSS Master Map and User Work Files - Contents:

Master Map File:		User Work File:
SEA.BLDS	SEA.WATERL	POR.TPVP
SEA.MBLD1	SEA.WATERP	POR.TPVL
SEA.OPAVEP	SEA.SEWERP	SEA.TBLDS
SEA.OPAVEL	SEA.SEWERL	
SEA.PAVEP	SEA.CONTOUR	
SEA.PAVEL1		

NOTES: Geounit Center: 47°03'45"N
122°33'45"W

Commands To Enter Data Into Computer:

- AMS Project Database: SEATTLE
- MOSS Project Database: CORPS.DT
- Put File Ø into Project Database Directory
- Put Files 1,2,3 into User Area
- Put File 4 into MOSS Database Directory
- Move MOSS User Work Files to MOSS User Area

APPENDIX D

CAMERA CALIBRATION REPORTS

1.0 CAMERA CALIBRATION REPORTS

The following pages show (in full) the camera calibration reports used for the Fort Lewis and Columbia River demonstrations. This information is entered into the camera database for use in the aerotriangulation and interior orientation processes. The important data contained in these reports are the calibrated focal lengths, fiducial measurements, and principal point offsets. Other useful data (which can be used in AMS) are the lens distortion values.

United States Department of the Interior

GEOLOGICAL SURVEY
RESTON, VIRGINIA 22092

REPORT OF CALIBRATION

March 16, 1978

of Aerial Mapping Camera

Camera type Zeiss RMK A 15/23
Camera serial no. 116202
Lens type Zeiss Pleogon A2
Lens serial no. 116257
Nominal focal length 153 mm
Maximum aperture f/5.6
Test aperture f/5.6

Submitted by
Seattle District, Corps of Engineers
Seattle, Washington 98124

Reference: Seattle District Purchase Order No. DACW67-78-0222, dated February 7.

These measurements were made on Kodak micro flat glass plates, 0.25 inch thick with spectroscopic emulsion type V-F Panchromatic, developed in D-19 at 68°F for 3 minutes with continuous agitation. These photographic plates were exposed on a multicollimator camera calibrator using a white light source rated at approximately 3500K.

I. Calibrated Focal Length: 152.940 mm

This measurement is considered accurate within 0.005 mm

II. Radial Distortion:

Field angle (degrees)	$\bar{D}_c$	D_c for azimuth angle 0° A-C	90° A-D	180° B-D	270° B-C
	μm	μm	μm	μm	μm
7.5	-4	-3	-4	-4	-3
15	-4	-5	-5	-6	-3
22.5	-4	-4	-2	-8	-2
30	1	0	1	-1	3
35	4	4	5	2	5
40	0	1	0	3	-1

The radial distortion is measured for each of 4 radii of the focal plane separated by 90° in azimuth. To minimize plotting error due to distortion, a full least-squares solution is used to determine the calibrated focal length. $\bar{D}_c$ is the average distortion for a given field angle. Values of distortion D_c based on the calibrated focal length referred to the calibrated principal point (point of symmetry) are listed for azimuths 0°, 90°, 180°, and 270°. The radial distortion is given in micrometres and indicates the radial displacement of the image from its ideal position for the calibrated focal length. A positive value indicates a displacement away from the center of the field. These measurements are considered accurate within 5 μm.

III. Resolving power in cycles/mm   Area-weighted average resolution 91.6

Field angle:	0°	7.5°	15°	22.5°	30°	35°	40°
Radial lines	113	113	134	113	113	80	67
Tangential lines	113	113	113	113	80	67	57

The resolving power is obtained by photographing a series of test bars and examining the resulting image with appropriate magnification to find the spatial frequency of the finest pattern in which the bars can be counted with reasonable confidence. The series of patterns has spatial frequencies from 5 to 268 cycles/mm in a geometric series having a ratio of the 4th root of 2. Radial lines are parallel to a radius from the center of the field, and tangential lines are perpendicular to a radius.

IV. Filter Parallelism

The two surfaces of the B No. 116357, D No. 116404, FL 12056S and FL-F 1173[illegible] filters accompanying this camera are within ten seconds of being parallel. The B Filter was used for the calibration.

V. Shutter Calibration

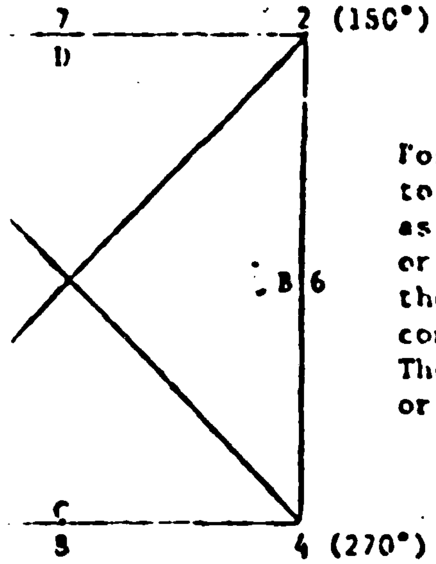
Indicated shutter speed	Effective shutter speed	Efficiency
1/200	4.3 ms = 1/230 s	81%
1/400	2.1 ms = 1/470 s	81%
1/600	1.4 ms = 1/710 s	81%
1/800	1.1 ms = 1/940 s	81%
1/1000	0.9 ms = 1/1170 s	81%

The effective shutter speeds were determined with the lens at aperture f/5.6 The method is considered accurate within 3%. The technique used is Method I described in American National Standard PH3.48-1972.

VI. Magazine Platen

The platen mounted in FK 24/120 film magazine No. 117939 and 117940 does not depart from a true plane by more than 13 µm (0.0005 in).

_and Fiducial Coordinates



Positions of all points are referenced to the principal point of autocollimat as origin. The diagram indicates the orientation of the reference points wh the camera is viewed from the back, or contact positive with the emulsion up. The direction-of-flight fiducial mark or data strip is to the left.

. 117939

ted 40°

5 μm

→

on of
nt

	X coordinate	Y coordinate
point, corner fiducials		
point, midside fiducials	0.004 mm	0.002 mm
utocollimation	0.0	0.0
point (point of symmetry)	-0.007	0.001

l Marks

	---	---
	---	---
	---	---
	---	---
	-112.993 mm	0.002 mm
	113.000	0.002
	0.004	112.998
	0.004	-112.989

flatness
ed on
positives

een Fiducial Marks

agonals) Not Applicable

mm 3-4 mm

markers intersect at an angle of

ion 50.0

mm 7-8 225.986 mm

markers intersect at an angle of 90° 00' 01"

40°

40
34

rimeter) Not Applicable

mm 2-3 mm

mm 2-4 mm

ing these distances is considered accurate within 0.005 mm.

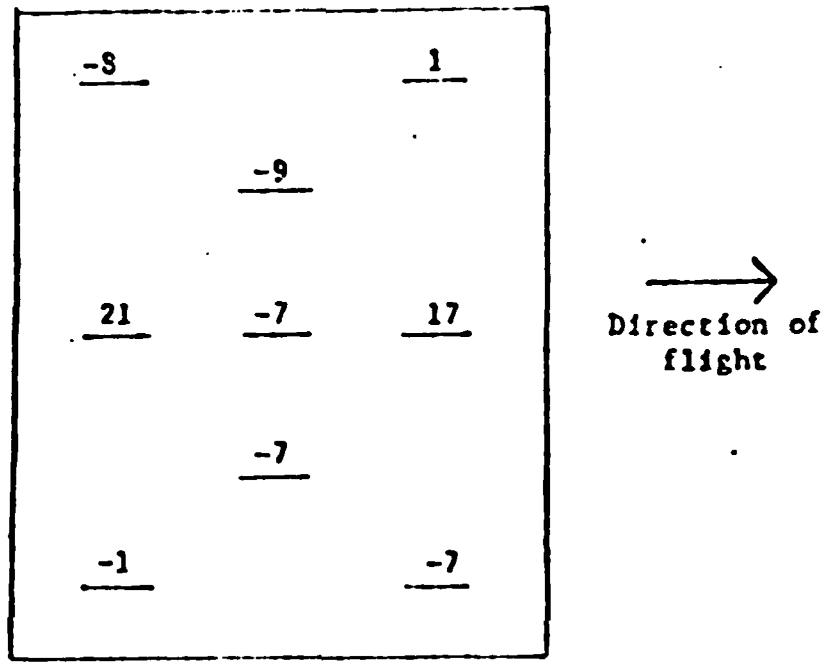
and Design
n

STEREOMODEL FLATNESS TEST AND FILM RESOLUTION

Camera No. 116202 Lens No. 116257 Magazine No. 117939

Focal length 152.940 mm Maximum angle of field tested 40°

Base-height ratio 0.6 Accuracy of determination 5 µm



Stereomodel
Test point array
(values in micrometres)

The values shown on the diagram are the average departures from flatness (at negative scale) for two computer-simulated stereomodels based on comparator measurements on contact glass (Kodak micro flat) diapositives made from Kodak 2405 film exposures.

Resolving Power, in cycles/mm Area-weighted average resolution 50.0
Film: Type 2405

Field angle:	0°	7.5°	15°	22.5°	30°	35°	40°
Radial lines	67	67	67	67	48	40	40
Tangential lines	67	67	67	57	48	40	34

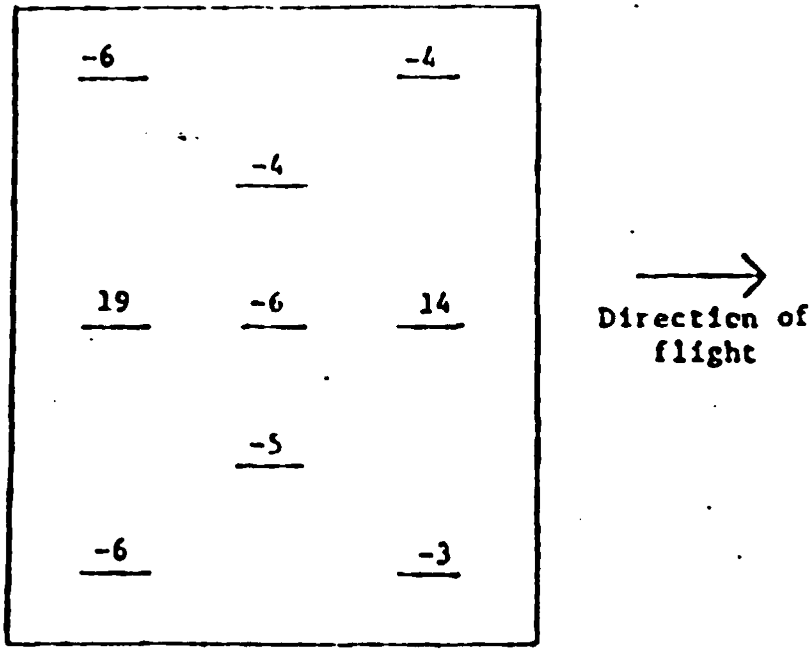
William P. Tayman
Branch of Research and Design
Topographic Division

STEREOMODEL FLATNESS TEST AND FILM RESOLUTION

Camera No. 116[illegible]02　　Lens No. 116257　　Magazine No. 117940

Focal length 152.940 mm　　Maximum angle of field tested 40°

Base-height ratio 0.6　　Accuracy of determination 5 µm



Stereomodel
Test point array
(values in micrometres)

The values shown on the diagram are the average departures from flatness (at negative scale) for two computer-simulated stereomodels based on comparator measurements on contact glass (Kodak micro flat) diapositives made from Kodak 2405 film exposures.

Resolving Power, in cycles/mm　　Area-weighted average resolution 50.0
Film: Type 2405

Field angle:	0°	7.5°	15°	22.5°	30°	35°	40°
Radial lines	67	67	67	67	48	40	40
Tangential lines	67	67	67	57	48	40	34

This report supersedes the previous calibration of this camera contained in NBS Report of Calibration No. 208322, dated March 26, 1973.

William P. Tayman
Branch of Research and Design
Topographic Division

(5 of 5)

United States Department of the Interior

GEOLOGICAL SURVEY
RESTON, VIRGINIA 22092

,11
10

REPORT OF CALIBRATION
of Aerial Mapping Camera

April 10, 1981

Camera type: Zeiss RMK A 15/23
Lens type: Zeiss Pleogon A4
Nominal focal length: 153 mm

Camera serial no.: 124235
Lens serial no.: 124289
Maximum aperture: f/4
Test aperture: f/4

Submitted by: W.A.C. Corporation
Eugene, Oregon 97402

Reference: Letter dated April 3, 1981, from Mr. Richard L. Graville.

These measurements were made on Kodak micro flat glass plates, 0.25 inch thick, with spectroscopic emulsion type V-F Panchromatic, developed in D-19 at 68° F for three minutes with continuous agitation. These photographic plates were exposed on a multicollimator camera calibrator using a white light source rated at approximately 3500K.

I. Calibrated Focal Length: 152.904 mm

This measurement is considered accurate within 0.005 mm

II. Radial Distortion

Field angle	D_c	D_c for azimuth angle 0° A-C	90° A-D	180° B-D	270° B-C
degrees	um	um	um	um	um
7.5	1	2	0	0	1
15	0	1	-1	-2	1
22.5	-1	-3	0	-1	-1
30	2	2	1	2	1
35	1	2	0	0	2
40	-1	-2	-1	0	-2

The radial distortion is measured for each of four radii of the focal plane separated by 90° in azimuth. To minimize plotting error due to distortion, a full least-squares solution is used to determine the calibrated focal length. D_c is the average distortion for a given field angle. Values of distortion D_c based on the calibrated focal length referred to the calibrated principal point (point of symmetry) are listed for azimuths 0°, 90°, 180° and 270°. The radial distortion is given in micrometers and indicates the radial displacement of the image from its ideal position for the calibrated focal length. A positive value indicates a displacement away from the center of the field. These measurements are considered accurate within 5 um.

(1 of 4)

III. Resolving Power in cycles/mm

Area-weighted average resolution: 85.3

Field angle:	0°	7.5°	15°	22.5°	30°	35°	40°
Radial lines	134	134	113	113	95	80	57
Tangential lines	134	134	113	95	80	57	48

The resolving power is obtained by photographing a series of test bars and examining the resultant image with appropriate magnification to find the spatial frequency of the finest pattern in which the bars can be counted with reasonable confidence. The series of patterns has spatial frequencies from 5 to 268 cycles/mm in a geometric series having a ratio of the 4th root of 2. Radial lines are parallel to a radius from the center of the field, and tangential lines are perpendicular to a radius.

IV. Filter Parallelism

The two surfaces of the B No. 124420 filter accompanying this camera are within ten seconds of being parallel. This filter was used for the calibration.

V. Shutter Calibration

Indicated shutter speed	Effective shutter speed	Efficiency
1/200	3.50 ms = 1/290 s	70%
1/400	1.75 ms = 1/570 s	70%
1/600	1.16 ms = 1/860 s	70%
1/800	0.88 ms = 1/1140 s	70%
1/1000	0.70 ms = 1/1430 s	70%

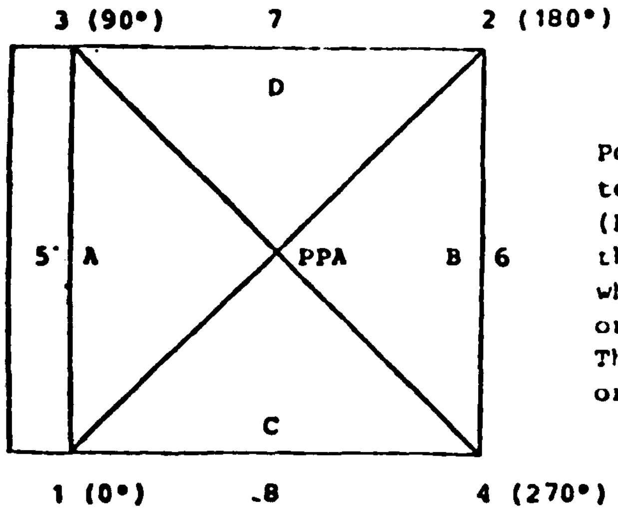
The effective shutter speeds were determined with the lens at aperture f/4. The method is considered accurate within 3%. The technique used is Method I described in American National Standard PH3.48-1972(R1978).

VI. Magazine Platen

The platen mounted in FK 24/120 film magazine No. 124821 does not depart from a true plane by more than 13 um (0.0005 in.).

The platen for this film magazine is equipped with an identification marker that will register "CZ025" in the data strip area for each exposure.

VII. Principal Point and Fiducial Coordinates



Positions of all points are referenced to the principal point of autocollimation (PPA) as origin. The diagram indicates the orientation of the reference points when the camera is viewed from the back, or a contact positive with the emulsion up. The direction-of-flight fiducial marker or data strip is to the left.

	X coordinate	Y coordinate
Indicated Principal point, corner fiducials	-0.002 mm	0.018 mm
Indicated principal point, midside fiducials	0.009	0.001
Principal point of autocollimation	0.0	0.0
Calibrated principal point (point of symmetry)	-0.019	0.002

Fiducial Marks		
1	-103.955 mm	-103.937 mm
2	103.932	103.954
3	-103.938	103.958
4	103.950	-103.937
5	-112.996	0.009
6	112.958	-0.006
7	0.021	112.986
8	-0.003	-112.993

VIII. Distances Between Fiducial Marks

Corner fiducials (diagonals)

1-2: 293.999 mm   3-4: 294.003 mm

Lines joining these markers intersect at an angle of 89° 59' 55"

Midside fiducials

5-6: 225.955 mm   7-8: 225.979 mm

Lines joining these markers intersect at an angle of 89° 59' 52"

Corner fiducials (perimeter)

1-3: 207.895 mm   2-3: 207.871 mm

1-4: 207.905 mm   2-4: 207.891 mm

The method of measuring these distances is considered accurate within 0.005 mm.

(3 of 4)

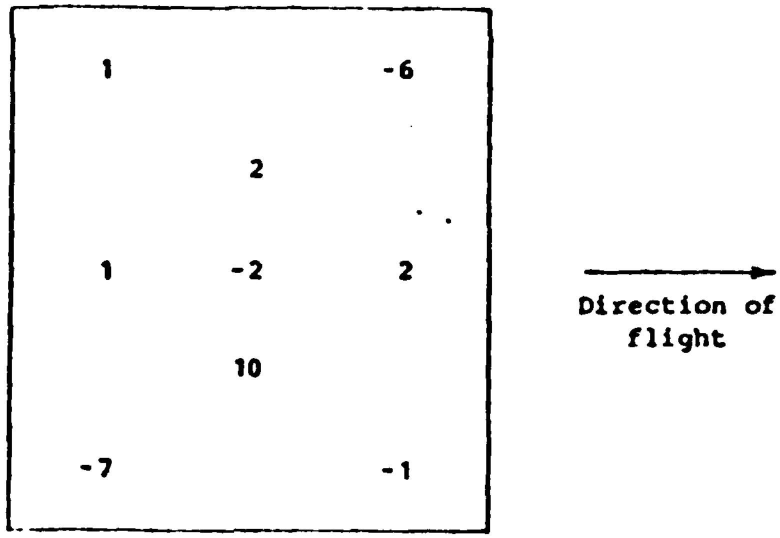
STEREOMODEL FLATNESS TEST AND FILM RESOLUTION

Camera No.: 124235 Lens No.: 124289 Magazine No.: 124821

Focal Length: 152.904 mm Maximum angle of field tested: 40°

Base/Height ratio: 0.6 Accuracy of determination: 5 um

Platen ID: CZ025



Stereomodel
Test point array
(values in micrometers)

The values shown on the diagram are the average departures from flatness (at negative scale) for two computer-simulated stereomodels based on comparator measurements on contact glass (Kodak micro flat) diapositives made from Kodak 2405 film exposures.

Resolving Power in cycles/mm

Film: Type 2405 Area-weighted average resolution: 49.5

Field angle:	0°	7.5°	15°	22.5°	30°	35°	40°
Radial lines	80	80	67	57	57	40	34
Tangential lines	80	67	57	57	48	40	34

This report supersedes the previous calibration of this camera contained in USGS Report of Calibration No. RT-R/393, dated March 28, 1978.

William P. Tayman
Chief, Optical Science Section
National Mapping Division

For 6 Sep 1977

U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS
WASHINGTON, D.C.

REPORT OF CALIBRATION

of Aerial Mapping Camera

Camera Type Wild Aerotrum RC8 | Camera Serial No. [illegible]
Lens Type Wild Universal Aviogon | Lens Serial No. [illegible]
Nominal Focal Length [illegible] | Maximum Aperture [illegible]
Test Aperture [illegible]

Submitted by
Western Aerial Contractors, Inc.
Eugene, Oregon 97401

Reference: Mr. R. S. Daniels' letter dated March 3, 1969.

These measurements were made using Kodak Micro Flat Glass plates, 0.25 inch thick with Spectroscopic emulsion type V-F Panchromatic, developed in D-19 at 68°F for three minutes, with continuous agitation. These photographic plates were exposed on a multicollimator camera calibrator using [illegible] filters and an incandescent tungsten light source.

I. Calibrated Focal Length: 152.22 mm

This measurement is considered accurate within 0.02 mm.

II. Radial Distortion

Field Angle	$\bar{D}_c$	D_c for azimuth angle 1 B-C	2 A-C	3 A-D	4 B-D
Degrees	µm	µm	µm	µm	µm
7.5	5	4	4	5	5
15	7	8	5	8	8
22.5	5	6	2	7	3
30	2	0	1	3	2
37.5	-5	-6	-8	0	-5
45	*	*	*	*	*

* Fiducial marks in the corners prevented measurements at 45°.

The radial distortion is measured for each of four radii of the focal plane separated by 90° in azimuth. The calibrated focal length is derived to minimize the average radial distortion over the field. $\bar{D}_c$ is the average distortion for a given field angle. Values of distortion D_c based on the calibrated focal length are listed for azimuth angles 0, 90, 180, and 270 degrees. The radial distortion is given in micrometers and indicates the radial displacement of the image from its ideal position for the calibrated focal length. A positive value indicates a displacement away from the center of the field. These measurements are considered accurate within 5 µm.

III. Tangential Distortion

Field Angle	22.5°	30°	37.5°
Displacement in µm	1	2	1

The values reported are displacements from the center image point of a straight line connecting corresponding image points at equal field angles along opposite radii of the focal plane. The method of measurement is considered accurate within 5 µm.

IV. Resolving Power, in cycles/mm Area Weighted Average Resolution 58.8

Field Angle:	0°	7.5°	15°	22.5°	30°	37.5°	45°
Tangential lines	76	76	63	53	53	53	*
Radial lines	76	76	76	76	76	53	*

The resolving power is obtained by photographing a series of test bars and examining the resulting image with appropriate magnification to find the spatial frequency of the finest pattern in which the bars can be counted with reasonable assurance. The series of patterns has spatial frequencies in a geometric series having a ratio of the fourth root of two. Tangential lines are those perpendicular to the radius from the center of the field. Radial lines are those lying parallel to the radius.

V. Principal Point of Autocollimation

The lines joining opposite pairs of collimation index markers intersect at an angle within 1 minute of 90° and their intersection indicates the location of the principal point of autocollimation within 0.03 mm.

VI. Collimation Marker Separation

A - B	219.99 mm	1 - 3	299.81 mm
C - D	219.99 mm	2 - 4	299.81 mm

Markers A and B lie in the line of flight. The method of measuring these separations is considered accurate within 0.01 mm.

VII. Filter Parallelism

The two surfaces of the Wild 500 Pan 2X filter No. 391 accompanying this camera are within ten seconds of being parallel. This filter was used for the calibration.

VIII. Magazine Platen

The platen mounted in Wild RC8 film magazine, No. 995 does not depart from a true plane by more than 13 micrometers (0.0005 inch).

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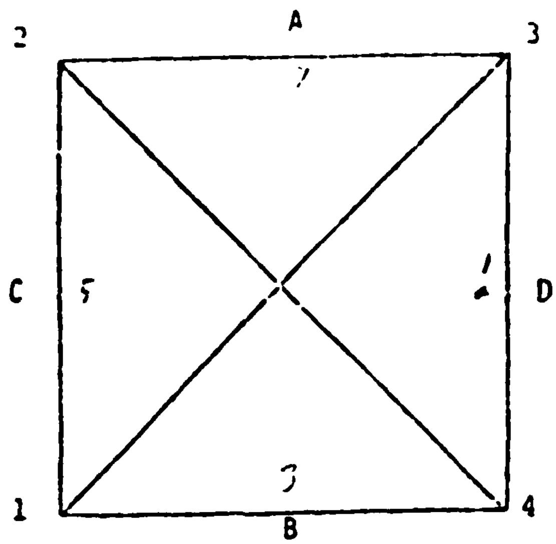

The diagram indicates the orientation of the reference points when the camera is viewed from the back. The direction of flight fiducial marker or data strip is at the top.

For the Director,

C. S. McCamy, Chief
Image Optics & Photography Section
Metrology Division
Institute for Basic Standards

For S... 195...

UNITED STATES DEPARTMENT OF COMMERCE
WASHINGTON

National Bureau of Standards

REPORT 2.2/132962
on

FAIRCHILD CAMERA MODEL K-17B (modified) BODY NO. 43-1143
Cone No. 44-68
Bausch and Lomb Metrogon Lens No. MS8810
Submitted by

Kargl Company, Inc.
Post Office Box 6563
San Antonio 9, Texas

on
July 17, 1952

6" 6/7/57 After Delano 6/17/57 Cougar 2.S.

This report applies to the Fairchild Type K-17B camera, body No. 43-1143, cone No. 44-68, which has been modified to meet the requirements of a precision camera. It is equipped with Bausch and Lomb Metrogon lens No. MS8810, nominal focal length 6 inches, maximum aperture f/6.3. It was tested at an aperture of approximately f/8. All measurements were made with parallel light incident on the lens. The effective wave-length was approximately 575 millimicrons.

I. Focal Length

Equivalent focal length	Calibrated focal length
mm	mm
153.69	153.69

The probable errors of these determinations of focal length do not exceed ±0.10 mm.

II. Distortion

1. Distortion referred to the equivalent focal length

5°	10°	15°	20°	25°	30°	35°	40°	45°
0.00	0.00	0.01	0.03	0.06	0.10	0.12	0.12	-0.12

2. Distortion referred to the calibrated focal length

5°	10°	15°	20°	25°	30°	35°	40°	45°
0.00	0.00	0.01	0.03	0.06	0.10	0.12	0.12	-0.12

The values of the distortion are measured in millimeters and indicate the displacement of the image from its distortion-free position. A positive value indicates a displacement from the center of the plate. The probable error is approximately ±0.02 mm.

III. Resolving Power

	0°	7.5°	15°	22.5°	30°	37.5°	45°
Tangential	39	32	27	23	16	16	16
Radial	39	32	27	27	32	32	27

The values of the resolving power are given at 7.5° intervals from the center of the field and are obtained by photographing suitable test charts comprised of patterns of parallel lines. The series of patterns of the test chart are imaged on the negative with the lines spaced in a geometric series of the fourth root of two lines to the millimeter. The row marked "tangential" gives the number of lines per millimeter in the image on the negative of the finest pattern of the test chart that is distinctly resolved into separate lines when the lines lie perpendicular to the radius drawn from the center of the field. The row marked "radial" gives similar values for the pattern of test lines lying parallel to the radius.

IV. Principal Point

The lines joining opposite pairs of collimation index markers intersect at an angle of 90° ±1 minute, and their intersection indicates the location of the principal point, with a probable error not exceeding ±0.03 mm.

V. Collimation Marker Separation

A-B 222.37 ±0.02 mm
C-D 222.42 ±0.02 mm

Markers A and B lie in the line of flight.

VI. Tangential Distortion

The tangential distortion caused by the effective prism does not exceed ±0.013 mm. The probable error of this determination is approximately ±0.005 mm.

As viewed from the back of the camera with the direction-of-flight collimation index marker A up, the maximum tangential distortion occurs along a diameter at approximately 12° in a clockwise direction to the diameter including A.

The tangential distortion was determined by measuring the departure from a straight line of the images of infinite collinear points formed along the diagonals in the focal plane, when the infinite points lie in a plane perpendicular to the focal plane.

The two surfaces of the filter submitted with this camera are parallel to within 10 seconds of arc.

The platen of the Fairchild magazine type A-5, No. 41-380 complies with the requirements contained in U. S. Department of Agriculture Specification No. A-APC-1102 for a precision airplane mapping camera as approved March 12, 1940.

For the Director
by

Irvine C. Gardner
Chief, Optical Instruments Section
Optics and Metrology Division

NBS Test No. 2.2/132962
Washington, D.C.
July 30, 1952

END

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