

D R A F T  
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SPECIFICATIONS FOR AN AUTOMATED GRAPHICS SYSTEM

1. INTRODUCTION

1.1. Purpose - This development objective contains the background, concept and goals of a Government sponsored program for the design and fabrication of an Automated Graphics System.

1.2. General - Equipment and techniques are available for transforming the information contained on oblique photographic images into orthogonal views. Procedures are also known that enable orthogonal drawings or vertical photographs to be made into oblique or perspective illustrations. However, these procedures are time consuming and require highly skilled personnel to perform them..

2. CONCEPT

2.1. Background - An in-house study disclosed various techniques for partially automating the production of graphics. Plotters, cathode ray tubes, computers and other pieces of equipment have been coupled with sophisticated software to produce various systems for assisting in the production of graphics. None of the systems found were capable of performing the desired task, i.e., of producing a variety of graphics (orthographics, perspectives, isometrics, etc.) in a rapid manner using both photographs and orthographic drawings as inputs, with reasonable accuracies, utilizing semi-skilled personnel.

2.2. Discussion - A graphics system is required that can use either photographs or line drawings as inputs. It must be able to convert the information contained on perspective images to orthographic images and vice-versa.

It must be extremely flexible, capable of using transparencies, translucent materials or opaque photographic prints or other opaque drawings as inputs. The system, while designed primarily as an aid in producing a variety of graphics rapidly and economically, must also be developed with as high accuracies as practical within the limits of these primary goals. It should contain as many proven components as possible.

### 2.3 PHASING

~~2.2 CONCEPT~~ - This program will be divided into two phases. The first phase will consist of the design of the system and the construction of a full scale mock-up of the system. The second phase will consist of the fabrication, development, delivery, training and test of the system.

<sup>3</sup>  
2.2.1 Phase I During the first phase the contractor will design the system. All drawings and specifications will be reviewed with the Contracting Officers Technical Representative (see paragraph 8.4). During this phase a full scale mock-up of all system components will be made and shipped to the destination located in the Washington, D. C. area. The exact destination is to be supplied by the Government. Provisions are also to be made by the contractor for removing the mock-up from the delivered location after it has served its purpose. The purpose of the mock-up is to resolve problems as to movement, placement and man-machine relationships before ~~construction~~<sup>fabrication</sup> begins. The mock-up can be made from wood, plywood, heavy cardboard or other reasonably durable materials. Sharp edges, splinters, etc. should be eliminated and the system components should be painted with similar colors to the real components. The location and color coding of all controls should be provided on the mock-up. Movable components, such as doors, etc. that are used by

2.2.2 Phase II The second phase will be begun only after the approval of Phase I by the Government. If long term delivery items must be ordered before Phase I is completed, details concerning the cost of these items will be furnished to the Government and authorization for the purchase must be made by the Government. Phase II will consist of the remaining work on the contract, i.e. the fabrication, development, delivery and test of the equipment.

### 3. ITEMS REQUIRED

3.1. The following deliverable items are desired by the Government under this program.

- 3.1.1. <sup>1</sup> One (1) Automated Graphics System Mock-up.
- 3.1.2. <sup>2</sup> One (1) Automated Graphics System
- 3.1.2. <sup>3</sup> One (1) set Spare Parts
- 3.1.3. <sup>4</sup> Six (6) copies Operators Instruction Manual in accordance with DB-1003 (attached).
- 3.1.4. <sup>5</sup> Two (2) copies Maintenance Manual in accordance with DB-1003.
- 3.1.5. <sup>6</sup> Four (4) copies Monthly Reports in accordance with DB-1001 (attached).
- 3.1.6. <sup>7</sup> Four (4) copies Engineering Installation Data in accordance with DB-1001.

3.2. Other tasks to be accomplished by the Contractor include:

- 3.2.1. Participation in pre-delivery test at Contractor's plant.
- 3.2.2. Installation of system at Government location(s).
- 3.2.3. Participation in test at installation.
- 3.2.4. Provision of at least 80 hours of operator training for the system at the installation. Approximately 40 hours is to be provided immediately after installation of the system and another 40 hours within three months after installation.

3.2.5. Maintenance of the equipment for a period of six months after installation at no cost to the Government for parts, labor, travel or other expenses.

3.2.6. Maintenance of the equipment for a period of at least three years after the free maintenance period with all expenses paid by the Government.

#### 4. GENERAL SYSTEM DESCRIPTION

The Automated Graphics System will consist of the following components:

4.1. Rear Projection Viewer - This component will be capable of projecting an enlarged image onto either one of two screens. These two screens will be used alternately as input and output surfaces for the system. When an orthographic drawing or vertical photo is used as input material it will be projected onto the horizontal screen if a transparency is available or will be affixed to the surface if the drawing or photo is opaque. The horizontal surface will then be used as a digitizing plane where point and line information can be obtained. The plotting output plane in this case will be the vertical screen. Drafting film will be affixed to the vertical screen and the output line and point information will be plotted thereon.

When an oblique photo is the input source, it will be projected onto the vertical screen if a transparency is available or will be affixed to the surface if the photo is opaque. The vertical surface will then be the input plane where point and line information is read. The plotting output plane in this case is the horizontal surface. Detailed requirements for the Rear Projection Viewer are found in Paragraph 5.1.

4.2. XYZ Digitizer - This component will be capable of extracting X, Y and Z point and line information from the Rear Projection Viewer. It will consist of two styluses. One stylus will be capable of freely moving in the XY plane represented by a vertical photo or the plan or top view of an orthogonal drawing.

The other stylus will be capable of freely moving in the YZ plane of a side view of an orthogonal drawing. The styluses will be interchangeable with pen or pencil working devices. Detailed requirements for this component are found in Paragraph 5.2.

4.3. X-Y Digital Plotter - The Plotter will be capable of plotting lines or points on the vertical screen of the Rear Projection Viewer. It will also be capable of acting as an input device when the vertical screen is used as an input plane. It will have one stylus which can be interchanged with pen or pencil marking devices. The Plotter will also be used when locating the vanishing points of oblique photography. Detailed requirements for the Plotter are contained in Paragraph 5.3.

4.4. Calculator - The Calculator will have the ability to determine the vanishing points in oblique photography and thus complete the proper trigonometric functions to convert oblique photo information into orthographic drawings. It will also be able to furnish calculations to convert orthogonal drawings or vertical photographs to perspective drawings. It will also possess the capability of scaling independently or in any combination, the XY and Z input information from one-tenth to ten times in increments of one-thousandths, i.e., 0.256, 4.782, etc. Detailed requirements for this component are found in Paragraph 5.4.

4.5. Memory - The incorporation of a memory will be optional and will be quoted separately by the Contractor. The memory will be capable of storing line and point information as input by the XYZ Digitizer. It will then be able to play back this digitized information through the Calculator and allow the information to be plotted on the Plotter as a plan view or perspective view in any degree of rotation, tilt and viewing distance. Detailed requirements for the Memory are found in Paragraph 5.5.

4.6. Control Module - The control module shall contain most of the controls for the entire system. It shall contain all of the controls necessary for any of the manual input operations of the operator with the exception of the styluses and foot controlled switches. Other controls used for initial set up operations that are not changed during the actual input operations may be placed at other convenient locations. Detailed specifications for this component are contained in Paragraph 5.6.

4.7. The system may consist of one integrated unit or separate components. However, the system configuration will depend in part on space and weight considerations as outlined in Paragraph 5.7. In general, it is felt that the XYZ Digitizer and Plotter should be affixed permanently or readily attached to the Rear Projection Viewer. The Memory, Calculator and Control Module will probably best be made as separate components to reduce the size and weight of the largest piece of equipment. The separate Control Module would also have the advantage of being moveable and thus locateable in an area most convenient to the operator. Preferably, all components will be provided with castors for ease of movement.

## 5. DETAILED REQUIREMENTS

5.1. Rear Projection Viewer - See Paragraph 4.1. for a general description of this component.

5.1.1. The Viewer shall contain two viewing surfaces. One surface shall be vertical and 30 inches by 30 inches in size. The other surface shall be horizontal and 30 inches wide by 24 inches deep. Both surfaces will be aligned to within  $\pm 0.5$  inches in the 30 inch direction. The image projected on either screen shall align within  $\pm 1.0$  inches. The bottom edge of the vertical screen shall be no more than four inches higher than the horizontal screen and be displaced no more than three inches to the rear of the rear most edge of the horizontal screen.

✓ 5.1.2. The top surface of the horizontal screen shall be mounted flush with the top surface of the XYZ digitizing plane.

✓ 5.1.3. The XYZ digitizing plane shall extend 30 inches to the right of the horizontal screen.

✓ 5.1.4. The unit will be capable of projecting transparencies from 70mm to 9 1/2 inches wide in chip form or in roll form up to 500 feet in length.

✓ 5.1.5. The film gate should be at least 9 1/2 inches deep by 6" wide.

✓ 5.1.6. The projector will have an enlargement capability of 15, 30 and 50X. It preferably should also have a 5X enlargement. The enlargements must be met to within  $\pm 2$  percent of the 30 and 50X requirements and  $\pm 4$  percent of the 5 and 15X requirements. The time required to change from one magnification to the other will be less than five seconds.

✓ 5.1.7. The resolution measured at the output platens using a high contrast target must be at least 8 lines per millimeter at 5X, 6 lines per millimeter at 15X, 4 lines per millimeter at 30X and 3 lines per millimeter at 50X measured and computed by Area Weighted Average Resolution as specified in MIL-STD-150A.

✓ 5.1.8. The screen brightness shall be continuously variable with a minimum range of from 75 to 1200 foot-lamberts. Preferably the brightness should extend to 1800 foot lamberts.

✓ 5.1.9. Broad-band white illumination will be used where the radiation below 380 nanometers and above 750 nanometers is minimized.

✓ 5.1.10. Flicker frequency shall be at least 60 cycles per second and preferably at least 80 cycles per second.

✓ 5.1.11. Film loading will be easy to accomplish and shall not consume more than two minutes. Film loading shall be from the front or side of the viewer but not from the back of the viewer.

✓ 5.1.12. Caution labels should be displayed if special cleaning techniques or solvents are needed for cleaning the screen or other components.

✓ 5.1.13. Lamp replacement shall not require more than three minutes unless average lamp life exceeds 80 hours in which case five minutes will be allowable.

✓ 5.1.14. Lamp life shall average at least 20 hours. Longer lamp life is preferred. Lamp replacement cost shall not average more than \$0.25 per hour of operation.

✓ 5.1.15. Construction shall be such to minimize dust and other matter from reaching optical components. All optical components shall be easily accessible for cleaning.

✓ 5.1.16. The screens shall be clear glass. The image shall be formed on polyester based drafting film of from .002 to .010 inch thickness. Provisions shall be made to mount rolls of 30 inch wide drafting film on both screens so that film can readily be unrolled to cover the screen and then cut upon completion of the drawing. Provisions shall be made to hold the film down onto a flat plane so as not to distort the image projected thereon.

✓ 5.1.17. Variation in illumination level between any two points on the viewing screens shall not exceed 20 percent.

✓ 5.1.18. The Viewer shall contain means for fine focus of any of the magnifications.

✓ 5.1.19. Controls shall be provided for turning power on and off, for fine focusing, for light intensity, changing magnification, moving film in both X and Y directions, rotating the image, and for changing the image projection from the vertical to horizontal screens. These controls need not be elaborate or completely automatic. The viewer will not be used for scanning or interpreting. Once the image magnification is selected the image rotated and focused, these controls should not be adjusted for perhaps several hours or until the illustration has been drawn. Therefore, effort should be devoted to designing simple, inexpensive, low



maintenance controls providing they are easy to use.

✓ 5.1.20. The image shall be rotatable by 360 degrees. (Rotation of the film is allowable).

✓ 5.1.21. The image shall be relatively distortion free. When a calibrated grid is projected; geometric distortion of the images at the screen shall not exceed 1.5 percent across the screen.

5.1.22. The film shall not exceed 115° F.

5.1.23. When the image is in sharp focus there will be no apparent color <sup>f</sup>fringing on the screen.

5.1.24. Design of the film transport shall insure no scratching, stretching, frilled edges, etc. at all film speeds.

5.1.25. Film advance shall be variable from 0.5 to 20 inches per second in the film direction and approximately 0.2 inches per second in the transverse direction.

5.1.26. Film transport logic will be constructed to make it impossible for the operator to damage film by improper sequencing of the film transport controls.

5.1.27. Where necessary, interior surfaces shall be coated with a non-reflecting black coating to minimize reflected light from entering the optical system.

5.1.28. Film tension will be automatic.

5.2. XYZ Digitizer - See Paragraph 4.2. for a general description of this component.

5.2.1. The XYZ Digitizer will be affixed to a horizontal input plane of 24 inches deep by 60 inches wide. The left half of this plane will consist of a 24 inch deep by 30 inch wide rear projection screen (see description of Rear Projection Viewer, paragraph 5.1.). The Digitizer must be able to input X information to within one inch of the left most edge of the projection screen to within

eleven inches of the right most edge of the input plane (48 inches total travel). The Digitizer must be able to input Z information to within one inch of the right most edge of the input plane to within eleven inches of the left most edge of the projection screen (48 inches total travel). The Digitizer must be able to input Y information to within one inch of the rear most and front most edges of the input plane (28 inches total travel).

5.2.2. The left stylus will be used for inputting X and Y information (ground distances in a vertical photograph) and the right stylus will be used to input Z information (height of objects in a vertical photograph) as well as Y information.

5.2.3. The styluses must be easy to move, requiring between a two pound and a six pound force to move them. The resistance to movement should be relatively constant.

5.2.4. The styluses must be capable of straight line movement in the X, Y and Z directions without requiring a locking operation by the operator. In other words, a force in the X direction should move the stylus in a straight line only in the X direction.

5.2.5. The XY stylus and the ZY stylus must have quick setting and releasing locks to prevent their movement when the operator so desires.

5.2.6. The styluses must be easily replaced by a fine point mechanical pencil and a variety of ball point pens from one-eighth to one-quarter inch in diameter and up to four inches long. Styluses, several mechanical pencils and several pens will be supplied with the digitizer.

5.3. X-Y Digital Plotter - See paragraph 4.3. for a general description of this component.

5.3.1. The X-Y Digital Plotter will be affixed<sup>X</sup> to the vertical projection screen of the Rear Projection Viewer. The dimensions of this screen of

are 30 by 30 inches. The Plotter stylus shall be capable of outputting or inputting (depending on mode of operation) to within one-half of an inch or less from any edge of the viewer surface (29 inches by 29 inches total travel).

5.3.2. Plotting speed shall be at least 4 inches per second when operating in a continuous line mode. Plotting speed for point plotting will be at least 4 points per second where the points are up to 1/2 inch apart. Plotting speeds for points farther apart can take longer but the stylus speed between points must be at least 4 inches per second.

5.3.3. The stylus must be easily replaced by a fine point mechanical pencil and a variety of ball point pens from one-eighth to one-quarter inch in diameter and up to four inches long. A stylus several mechanical pencils and several pens will be supplied with the digitizer.

5.3.4. The plotter must respond instantaneously (as measured by the operator's senses) to the inputs of the XYZ Digitizer.

5.4. Calculator - See paragraph 4.4. for a general description of this contract.

5.4.1. The calculator may be a free standing unit or may be incorporated into the XYZ Digitizer as long as requirements specified in Paragraph 5.7. are maintained.

5.4.2. The calculator must be capable of transforming XYZ information input on the XYZ Digitizer to XY information as output on the XY plotter. It must also transform XY information on the XY plotter surface to XYZ information on the XYZ Digitizer surface. It must be capable of calculating vanishing points and tilt, rotation and viewing distance when provided with twelve points of information (2 points on each of six lines) on the XY plotter.

5.4.3. Calculations must be performed at such speeds that appear instantaneous to the senses of the operator.

5.5. Memory - See paragraph 4.5. for a general description of this component.

5.5.1. The memory shall be a free standing unit.

5.5.2. The memory shall be capable of storing XYZ information in point or continuous line form.

5.5.3. The memory shall contribute no more than  $\pm$  0.1 percent to overall system inaccuracies.

5.5.4. The memory shall use magnetic tape for the storage of digital information. The tapes should be as small <sup>as</sup> ~~or~~ practical. It is preferable that one tape should be capable of storing only one complex image so that each taped image can be stored on the shelf independently.

5.6. Control Module - See paragraph 5.5. for a general description of this component.

5.6.1. The Control Module shall contain all controls that are necessary for the manual input operations of the operator with the exception of the styluses and foot controlled switches. Controls used for initial set up operations that are not changed during the actual operations may be placed at other convenient locations.

5.6.2. The following types of controls shall be used.

<u>CONTROL</u>	<u>RECOMMENDED TYPE</u>
power	push button, toggle switch
luminance level	knob, thumbwheel
film drag	knob, lever, thumbwheel
film speed	knob, joystick
film direction	toggle switch, joystick
shade or mask	lever, knobs
magnification	knob, lever, thumbwheel
image rotation	knob
focus	knob, lever, thumbwheel

5.6.3. Display and control placement shall be governed by the attached information on pages (4-26, 4-30, and 4-31.)

5.7. Other Systems Requirements

5.7.1. Overall width of any one section of the system components shall not exceed 34.5 inches which will allow movement through a 36 inch office door. Overall height shall not exceed 78 inches and depth shall be no greater than 88 inches.

5.7.2. Maximum weight of any single component shall not exceed 2400 pounds.

5.7.3. All components shall be of sufficient rigidity to insure that movement of the machine within a building (through elevators, doorways, etc.) will not affect optical alignment or in any way degrade the functions of ~~the~~<sup>any</sup> component.

5.7.4. All components weighing over 100 pounds shall be equipped with 5 inch diameter casters for easy relocation within an office building. Leveling jacks will be provided where necessary.

5.7.5. All surfaces are to be of a corrosion resistant type. Pointed surfaces shall be provided with a suitable undercoat.

5.7.6. Company name plates, if used, shall be of modest size.

5.7.7. The system shall be capable of inputting information from all types of photography (including oblique photography, vertical photography, aerial photography, and slit photography), perspective drawings and orthogonal drawings. Full frames of panoramic photography and other photography presenting a grossly distorted image will not be required as input materials. However, small areas of such photography that present no appreciable distortion shall be used as input material.

5.7.8. The system shall be able to <sup>6</sup>scale the information from one-tenth to ten times the original scale in increments of one-thousandth of a decimal place, i.e., 4.526, 0.788, etc.

5.7.9. The system shall be capable of outputting orthographic and isometric drawings from orthogonal inputs or rectified plan and side view drawings from inputs of oblique photography or perspective drawings.

5.7.10. The overall system accuracy, excluding operator error shall be no greater than plus or minus  $\pm .006$  inch at no change in scale from input to output. If the scale is enlarged, an additional thousandth of an inch error will be allowable for each increment of scale enlargement, i.e.,  $.007$  inch error will be allowable at 2X magnification,  $.015$  inch error at 10X magnification.

5.7.11. The system must have no appreciable lag. When the operator moves a stylus on the XYZ Digitizer it must cause an immediate reaction by the XY Plotter (immediate in the sense that a human observer can detect no delay).

5.7.12. Mounting of equipment shall be governed by the information provided on attached pages 4-32.

5.7.13. Other human factors considerations shall be governed by information provided on attached pages 4-32, 4-33, 4-34 and 4-35.

5.7.14. All test equipment and tools (except those normally found in a small shop equipped for electrical and mechanical maintenance) necessary for complete maintenance and repair will be provided by the Contractor.

## 5.8. Safety Requirements

5.8.1. The noise level of the system shall not exceed 40 db at the operator's normal position or at any other position four feet or more from the equipment.

5.8.2. There shall be no sharp edges, shock hazards or other unsafe conditions presented to the operator during the normal operation of the machine including film loading and lamp replacement. Warning signs will not be acceptable substitutes as all operators cannot be relied upon to read and observe them.

Parts of the equipment accessible only for maintenance should not present undue safety hazards to maintenance personnel. However, warning signs, if prominently displayed are permissible to warn of possible hazards.

5.8.3. Circuits operating with an open circuit potential of 30 volts or more and a capability of delivering 2.5 peak milliamperes or more into a short circuit shall be considered hazardous.

5.8.4. Temperature of areas accessible during normal operation, and during film loading should not exceed 110°F. If the lamp or other components accessible during lamp replacement exceed this temperature, then warning signs should alert personnel to this potential hazard.

5.8.5. Fire hazards should be minimized. A failure of the system to keep the film below safe temperatures shall cause the lamp power to be shut off.

5.8.6. If high energy light sources such as Xenon lamps are used, enclosures shall be provided to protect against lamp explosion. If such light sources are used only trained authorized personnel shall replace them and a warning sign to this effect shall be prominently displayed.

5.8.7. Personnel must be prevented from directly viewing the arc of high energy lamps.

## 6. ACCEPTANCE INSPECTION AND TEST

6.1. Contractor's Inspection - The contractor is responsible for the performance of all inspection requirements. The Technical Representative reserves the right to perform any of the inspections which are deemed necessary to validate the equipment.

6.2. Proposed Test Methods - A comprehensive test procedure including methods, procedures, equipment, and tentative test data forms which the contractor proposes to use in conducting the tests, will be submitted by the contractor for approval

at least 30 days prior to the date of initial testing. The contractor is not to proceed with the proposed test methods until approval has been obtained from the Technical Representative.

6.3. Test Location - Tests and inspection will be conducted at the contractor's plant. Final acceptance will be at destination.

6.4. Test Damage - Any damage to the equipment resulting from the specified tests will be repaired and the equipment will be returned as nearly as possible to "like new" condition before shipment.

## 7. SHIPMENT AND DELIVERY

7.1. The equipment will be suitably packaged and packed for shipment by commercial carrier. Packing shall be such as to insure arrival at the destination specified in the contract in an undamaged and workable condition. *The contractor will be responsible for repairing any damage due to shipment.*

## 8. GENERAL

8.1. Proposals - The proposal should be comprehensive, well organized, explicit, clear, concise, and be limited in content to that information required to qualify the prospective bidder. It should demonstrate ability to perform satisfactorily within the scope of this document. Considerable importance will be placed on the citation of technical facts that support the proposal. The format should be arranged to separate company and personnel qualification sheets from the main body of the proposal. The proposal should also recommend the type of contractual arrangement believed most suitable to the work required herein.

8.2. Administration - The Government will retain overall control of this program. Written approval from the Contracting Officer must be obtained before any changes in objectives, costs, or priorities are effected or before a sub-contractor or consultant is employed.

8.3. Contractor Responsibility - The contractor is expected to provide competent and cooperative administrative service. He will be vested with certain



authority to control the direction and degree of technical effort within the bounds of the estimated costs. As a part of his overall responsibility, the contractor will be responsible for the work performed by all of his sub-contractors and consultants. The fact that the Government has granted approval for use of a specific sub-contractor or consultant (see Paragraph 8.2.) in no way relieves the contractor of this responsibility.

8.4. Technical Representative - The contracting officer will designate a Technical Representative to authorize specific development efforts of the contractor. Such authorization shall be given in writing in its original form or in confirmation of an oral authorization. The contractor will accept no other authorization than that of the Technical Representative or Contracting Officer.

*The Technical Representative will be allowed access to all drawings, specifications and areas of the contractor's facilities that pertain to the ~~system~~ Automated Graphics System.*