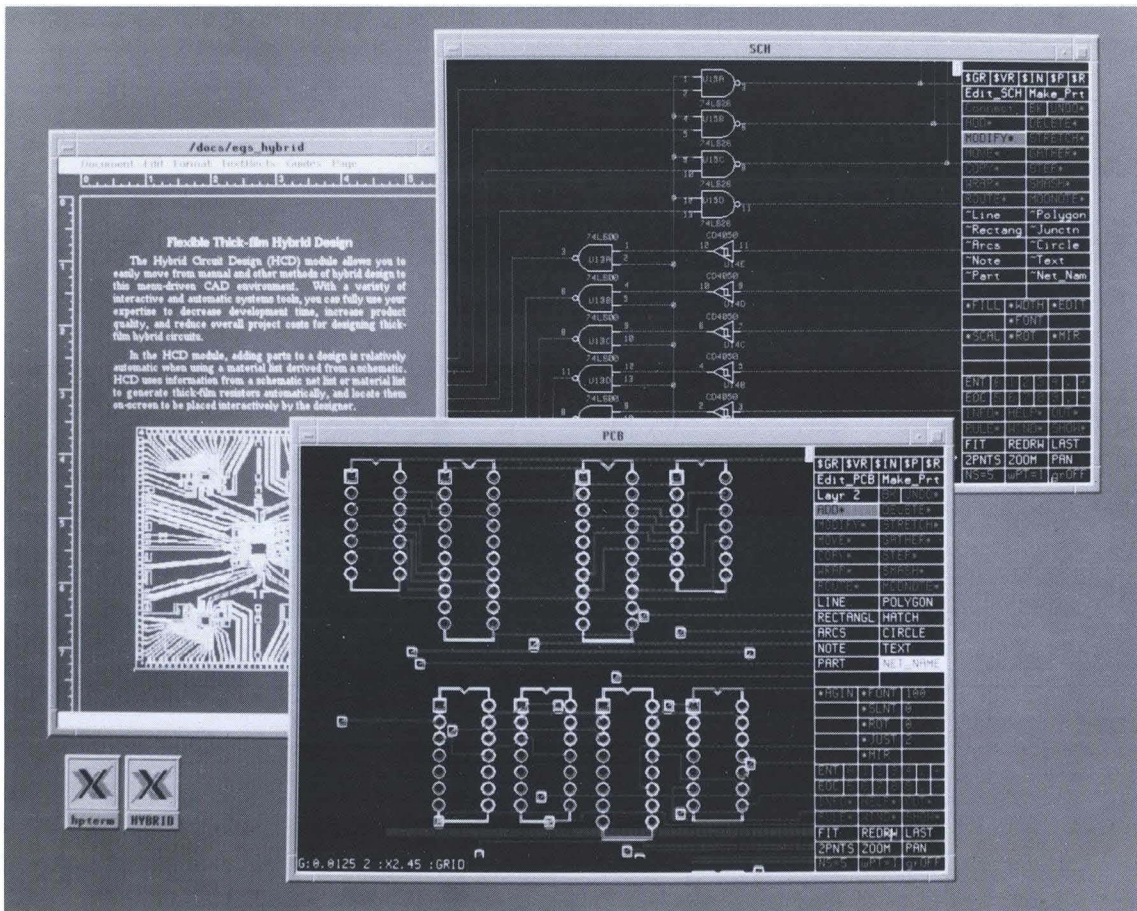# HP Engineering Graphics System for HP Pascal and HP-UX Operating Systems

## Technical Data



## Introduction

The HP Engineering Graphics System (HP EGS) is a customizable, two-dimensional graphics software product for multi-discipline engineering design, including electronic, mechanical, and general engineering applications.

The modular product structure of HP EGS allows users to dedicate a workstation to a single application such as hybrid circuit design or use a workstation as a multipurpose design system providing several applications for a project.

Because all HP EGS modules share a common data structure and user interface, they are automatically linked together.

HP EGS modules include schematic drawing, hybrid circuit design, printed circuit board layout, mechanical drafting, and a general engineering module that designers can use for applications ranging from floor plan layouts to block diagrams and artwork for technical manuals.

HP EGS provides several built-in productivity tools including on-line help, customizable screen and tablet menus, and user-definable macros, or "super commands." Users can even develop entire custom modules for their own applications.

Designers can plot two-dimensional artwork directly from designs on HP EGS. A powerful tool kit includes a rat's nest generator, a connection lister, a material lister, and a connection list compare program. HP EGS options include a photoplotter and N/C drill post-processor, documentation tools, and an IGES (Initial Graphics Exchange Specification) translator (Pascal version only). Designers can also move designs from HP EGS to more automatic CAD systems. Links are available between HP EGS and HP Printed Circuit Design System, HP Electronic Design System, and HP Mechanical Engineering Series 10 (Pascal version only). In addition, links to industry-standard EDIF (Electronic Design Interchange Format) and IGES

(Pascal version only) let designers move HP EGS artwork to non-HP systems.

HP EGS was developed for use on HP 9000 Series 300 workstations, first on the Pascal Application Workstation (PAWS) and now under the HP-UX operating system and X Window environment. Running on the HP-UX operating system in the X Window environment, the user can invoke several applications and interact simultaneously with HP EGS modules, run diskless and network over Local Area Network (LAN) and Wide Area Network (WAN).

HP EGS running on a workstation can be used as a

standalone system or in a networked environment. A network improves productivity by letting HP EGS users easily share data such as drawings and library parts. A network also dramatically reduces system costs by allowing multiple workstations to share disk drives, printers and plotters.
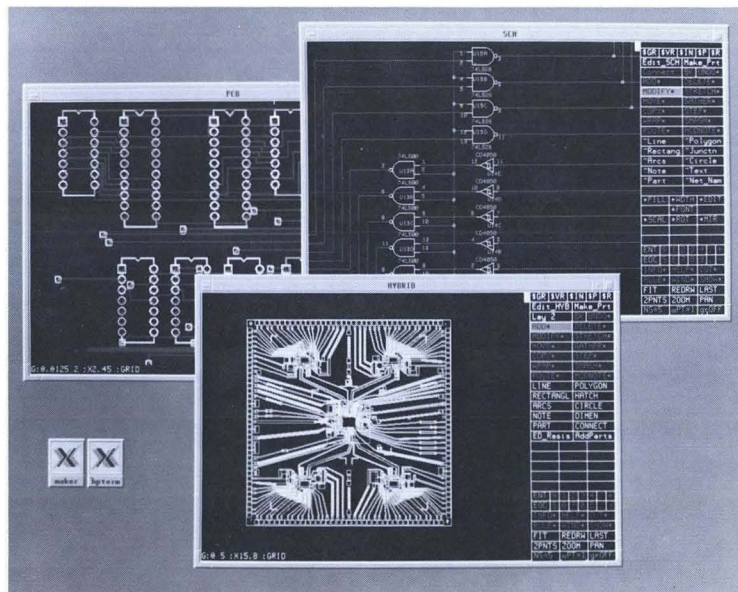


**Figure 1. HP EGS/UX in X Window environment**

## System Overview

HP EGS provides five specialized work environments, or modules. At the heart of each HP EGS module is the graphics editor, a command-driven tool used to generate drawings on the screen. Because these specialized modules are based on the same graphics editor, data sharing between the modules is automatic.

The *Schematic Drawing Module* is the vehicle for initiating electronic designs in HP EGS. This module includes a sample library of common electronic schematic symbols. Users can create additional parts, or modify existing parts as needed.

The *Hybrid Circuit Design Module* combines interactive and automatic features for designing thick-film hybrid circuits. Designers can easily move from manual and other methods of hybrid circuit layout to this menu-driven CAD environment. It fully employs a designer's expertise while reducing errors and speeding changes.

The *Printed Circuit Board Layout Module* includes capabilities for creating board blanks, for interactively placing a variety of components including surface-mounted devices (SMDs), and for laying out a grid or gridless design.

The *Mechanical Drafting Module* lets engineers and drafters use an isometric drawing capability to easily create two-dimensional representations of three-dimensional objects.

The *Engineering Graphics Module* can be used for a multitude of applications: floor plans, overhead slides, project scheduling diagrams, complex artwork for technical manuals, and many other general artwork applications.

HP EGS automatically controls all of these modules. When designers select a module from the manager menu, HP EGS loads all the specialized files and system commands. The specialized files, which can be customized, are:

• **Process**—Definition of 1 to 255 layers. Includes color, line type, and plotter pen number associated with each layer

• **Macro**—Collection of all defined macros for a particular module

• **Library Parts**—Collection of symbols which represent parts

• **Text Font**—Descriptions of text fonts

• **Note Font**—Descriptions of note fonts

• **Screen Menu**—Names of macros pickable from screen-displayed menu

• **Tablet Menu**—Drawings of a tablet menu, including icons and macro names in several tablet sizes

• **Start**—Commands executed to start a particular module

HP EGS allows users to plot complete drawings, or plot only selected layers and sections of drawings. Designers can scale and plot the drawings in a variety of sizes, from A- to E-size. High quality, fast hardcopy is available in several forms with HP EGS. Many printers are supported on HP EGS from the inexpensive HP *ThinkJet* printer to the HP *LaserJet* printer for documentation quality output of text and graphics.

In addition to the specialized work environments, HP EGS features a powerful tool kit that includes a rat's nest generator, a connection lister, a material lister, and a connection list compare program. HP EGS options include a Photoplotter and N/C Drill post-processor, and an IGES translator (Pascal version only).

HP EGS runs on either the HP-UX or Pascal operating system.

## The Graphics Editor

All of the HP EGS modules, including the five specialized work environments available with HP EGS, and user-customized work environments, are based on the graphics editor. The graphics editor provides the basic environment, artwork components, and commands for HP EGS.

The graphics editor offers the ability to work in two viewports at once. Each of the viewports can independently display any portion of the current drawing. A common use of the two viewport system is to use the small viewport as a global view of the entire drawing, and the main viewport as the work space where the designer can zoom and pan to display the portion being worked on.

HP EGS provides an extremely fine grid resolution for creating very large, accurate drawings. System resolution is determined by the two billion system points in both the X and Y direction. Designers can use any of the following units to specify the amount of resolution for a particular application:

- micrometer
- millimeter
- centimeter
- meter
- kilometer
- micro-inch
- mil
- inch
- foot
- yard
- mile

Most applications do not use all the available resolution. To appreciate what can be done with such accuracy, consider the following example.

Printed circuit board designs may require two traces between the legs of a small outline integrated circuit chip. Designers can easily handle this with HP EGS by setting the grid to 10 mils, assuming pads of 58 mils and 5 mil traces and spaces. In fact, designers could set the grid as fine as 0.00001 mil!

So that users do not have to be precise when selecting a point on the screen, HP EGS will "snap" to a point as defined by the current snapping mode. The system supports five snapping modes: grid, vertex, primitive, intersection, and raw (system) point. The grid displayed on the screen can be defined to have a grid point displayed at every system point or a specified set of system points, such as a point displayed at every 1000th system point.

The location of a component on a drawing can be specified by giving X,Y coordinates from the keyboard, by selecting X, Y coordinates with a stylus or mouse, or by selecting a mode which adds the component relative to other components. For example, a component can be added parallel or perpendicular to a line, or at a tangent to other components. Components also can be hatched and filled, and sizes changed after being added to the screen.

HP EGS provides the following basic artwork components that can be combined to create complex shapes:

- arc
- hatch
- marker
- rectangle
- circle
- line
- polygon
- dimension
- oval (or ellipse)
- instance (drawing or part of a drawing)
- note (stock letter)
- text (block letter)

Designers can alter all of these basic elements and more complex shapes by selecting editing commands such as copy, delete, modify, or stretch from the menus. Designers can store complex, frequently-used shapes as library parts to be used in other drawings. New drawings can be created by modifying existing ones.

HP EGS provides 255 layers for each drawing. Layers can be displayed or plotted one at a time, or in any combination. For example, a printed circuit board designer may draw a board blank on one layer, place components on another layer, and route traces on yet another layer. Then, the entire board or some phase of the design can be plotted as needed.

By assigning a different line type and color to each layer, designers can display several layers at one time, yet easily visualize each layer. Eight line types are available: solid, dashed, dotted, phantom, long dash, dot center, dash center, and long dotted. Either seven or fifteen colors are available, depending upon the hardware that HP EGS is running on.

Designers can assign textual information to label components or drawings and then assign a numerical tag value with the textual information. These tag values are useful to post-processors. For example, a particular number can be used to identify drill information for a printed circuit board post-processor. Over 65,000 different tag values are possible.

Figure 2.
A display from
the Schematic
Drawing Module
showing the two
viewports and
easy-to-use HP
EGS menu

HP EGS allows users to create new commands (called macros) for the graphics editor. A command macro simply combines commands and other macros, much like shorthand notation provides a simple way of representing words and phrases.

Macros can speed command entry for commands that are often entered together. And they can reduce the number of commands a user needs to know. In fact, most users create macros to make commands and options more intuitive, by simply renaming commands and options or adding prompts (screen messages).

## Schematic Drawing Module

The Schematic Drawing Module has been tuned to improve the productivity of schematic drawing. Specialized tools address:

• schematic symbol representation (any size or shape)

• assigning attribute information to components

• material list generation

• connection list (netlist) generation

• connection list merge

• links to documentation packages

• customization for unique requirements

A library file containing a representative set of symbols for schematic drawing includes over 50 symbols:

• *active devices*—transistors, diodes, and opamps

• *passive devices*—resistors, capacitors, and inductors

• *digital devices*—NAND/NOR gates, inverters, latches, flip-flops, and buffers

• *packaged chips*—decoders, four-bit decade counters, octal bus, and buffers/drivers

• *miscellaneous symbols*—system ground, chassis ground, and plugs/jacks

## Hybrid Circuit Design Module

The Hybrid Circuit Design Module tunes the extensive HP EGS feature set to the needs of hybrid circuit designers, offering the following:

• automatic input of parts from material lists

• links from the Schematic Drawing Module of HP EGS and the HP Design Capture System

• design in English or metric units

• automatic thick-film resistor generation

• online access to resistor-paste curve data

• a parts library containing more than 100 parts and subparts including dual in-line packages, flatpacks, chip carriers, chip capacitors, transistors, diodes, chips, and edge connectors

• chip and wire bond capability

• design aids for creating custom parts

• connection information (airlines) to aid interactive routing

• support of irregularly-shaped conductors

• material usage estimator for product costing

• access to photoplotter and N/C drill post-processor

Adding parts to a design is relatively automatic when using a material list derived from a schematic. The material list can be derived either automatically from a schematic created with the HP EGS Schematic Drawing Module or entered from the keyboard.

Using a material list, the system displays reference designators and component values for all parts except resistors, and prompts the designer to specify an appropriate library part. Each part is added to the drawing as it is selected. When all parts have been specified, the

designer can use the Rat's Nest Generator to add connectivity information (airlines).

Resistor generation begins with a library of resistor-paste curves that are created and maintained by entering a set of values based on manufacturer-supplied data or measurements unique to a manufacturing process. The system stores the information for future access. From this point designers may create resistors either automatically or interactively.
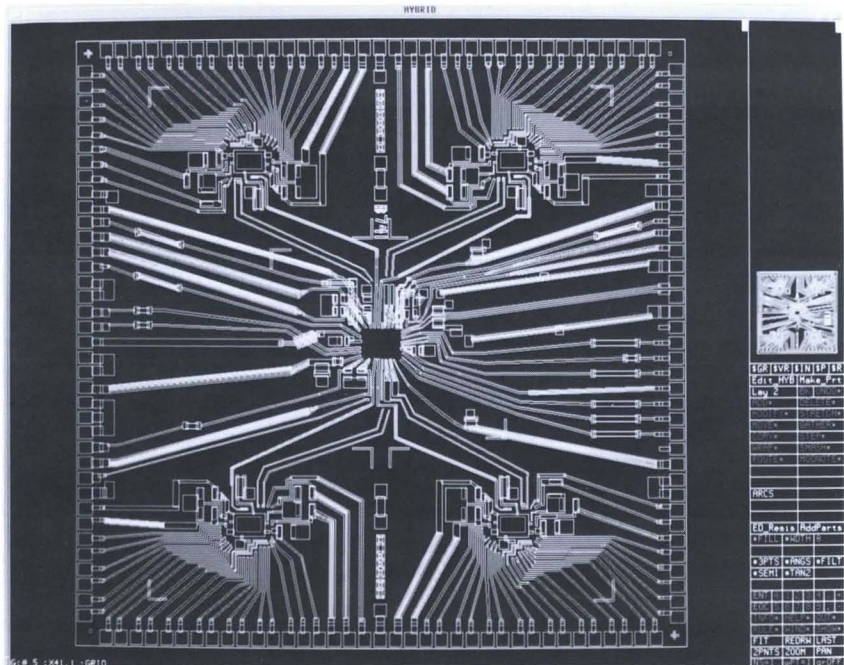


**Figure 3. The full-screen X Window showing Hybrid Circuit Design Module combines interactive and automatic features specifically tuned for the needs of thick-film, hybrid circuit designers.**

For automatic resistor design, the Hybrid Circuit Design Module uses the resistor value and reference designators from the Schematic Drawing Module. The Hybrid Circuit Design Module selects the optimum paste from the resistor paste curves, determines the required active resistor surface size, generates the resistor, and places it in the drawing. If schematic data is not available from the material list, designers can create the resistors interactively by entering resistor information from the keyboard. Once a designer selects a resistor paste curve and specifies the resistor value, the module will make the necessary calculations and generate an appropriate resistor.

The easy-to-use, flexible editing features of HP EGS are used next to place parts and route conductors. Designers can move, rotate, stretch, and mirror one or several parts at a time on a grid with resolution to .00001 mil. Five placement snapping modes assure that components and conductors are precisely placed.

Conductor width can vary along individual conductors and from conductor to conductor, and dielectric layers can be added with a single menu selection. System prompts help designers easily route multi-layer conductors. After the hybrid layout is complete, designers can generate a connection list based on the design. The Connection List Compare program compares the connection list to the one obtained from the schematic to verify that the two agree.

The Hybrid Circuit Design Module can extract data to produce a manufacturing material list including up to 20 fields for information such as part numbers and prices. To help estimate material usage, designers can use an area-calculating utility that measures the paste area on each layer (resistive, conductive, and insulating) and then generates information for calculating how much ink will be needed.

## Printed Circuit Board Layout Module

The powerful interactive tools of the Printed Circuit Board Layout Module give designers direct control over layout drawings, and the ability to easily handle engineering changes. Features to help prepare PCB artwork include:

• grid or gridless design

• rat's nest generation from a schematic connection list

• handling of surface-mount devices

• material list generation

• connection list generation

• connection list compare to verify that physical design matches schematic design

• link to photoplot-drill post-processors

• links to the HP Design Capture System

• customization for unique requirements

**Figure 4.
The HP EGS menu
as used for
printed circuit
board design**
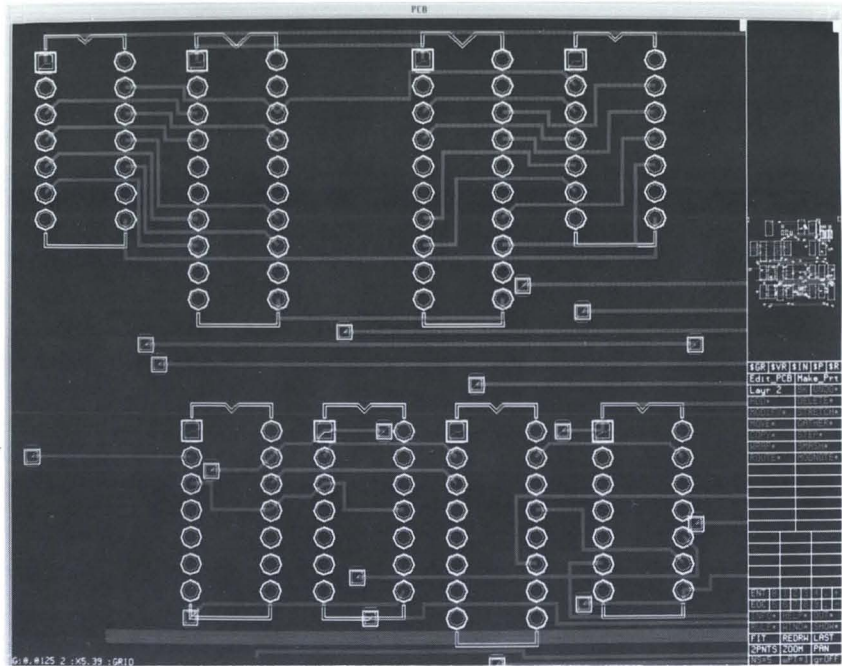


If part of a design (either schematic or printed circuit board) is done on another system, links are necessary to move the design between HP EGS and the other system. Users who want to simulate schematics before laying out a physical design may want to use the HP Design Capture System (HP DCS), a design capture and simulation system. HP DCS will generate a netlist in HP EGS format for users who want to use HP EGS for physical design.

The Printed Circuit Board Layout module supports a set of macros that allow designers to make and save new parts without leaving the layout being worked on. If a new part is needed while the designer is editing the layout, the Make Part mode is accessed simply by picking "Make Prt" from the menu block. Then, after the part is made, the designer returns to the Edit PCB mode by picking "Edit PCB." The new part will be in memory, ready to be added to the board.

Another useful macro in the PCB Layout module is the ROUTE macro. ROUTE allows users to select a point-to-point straight line connection (airline) between two components and then route it. In the process of routing the line, users can change layers or the trace width as necessary to complete the connection.

A helpful command while routing a trace is LOCK ANGLE. It allows the designer to force the system to accept traces only at a specified angle or multiples of the angle. For example, if the LOCK ANGLE is set to 45 degrees, the system will only accept traces at 45, 90, 135, 180, 225, 270, 315, or 360 degrees. Lock angle enforcement can easily be over-ridden for those traces which cannot be routed following the lock angle rules.

The part library in the PCB Layout module contains over 40 representative PCB parts classified as follows:

- primary pads
- primitive pads
- reference parts
- inner layer parts
- IC DIP patterns
- edge connectors
- analog parts

## Mechanical Drafting Module

The library file for the Mechanical Drafting module has four sections. The first three are based on ANSI-standard specifications:

• *Drawing paper templates:* A- to E-size drawing paper that specifies standard border, title blocks, and revisions blocks. Users may place company name and logo within the title block.

• *Geometric tolerancing symbols:* eighteen symbols to indicate such attributes as parallelism, symmetry, diameter specification, and concentricity

• *Surface texture symbols:* five symbols to specify surface finish

• *Macro instances:* simple screws and bolts as macro instances

Macro instances are a specialized macro form that allows the user to define a part in parametric form. For example, a hexhead bolt can be described by diameter, bolt length, and thread length. Once such a macro is defined, it is possible to design a family of such parts merely by specifying a different set of parameter values for each member of the family.

Other features of this module include:

• fillets
• chamfers
• polar step and repeat
• matrix step and repeat
• construction lines of infinite length
• isometric grids
• three tolerance options (single, plus/minus, and HILO)
• material list on drawing
• dimensioning in feet, inches and fractional feet/inches

An isometric grid, obtained by doing a spatial transformation of X, Y coordinates, makes it possible to draw isometric views of three-dimensional objects. This is especially helpful for doing assembly drawings.

## Engineering Graphics Module

The Engineering Graphics Module is where many new users begin to learn how to use HP EGS, and where many sophisticated users create their own applications. Because it has all the power of the other modules, the Engineering Graphics Module lends its flexibility and range of capabilities to a multitude of applications. The tutorial manual and training files lead users through several drawing examples to familiarize them with the step-through menu structure of HP EGS.

## Tool Kit

### Material Lister

HP EGS includes a powerful, versatile Material List Generator. It enables the user to extract part information from a drawing and merge that information with data in a user-defined parts file. The resulting file can be formatted to fit specific requirements and can be sent to a printer or stored in a file. Stored files can be placed on a drawing; for example, in the material specification block on a mechanical drawing.

### Connection Lister

Connection lists can be created based on two types of connections: physical and logical. An example of physical connections would be the numbered pins on a dual in-line package (DIP). These same pins could be given logical connection names such as IN1, OUT2, and GND.

A powerful system feature is the ability to handle connection lists for hierarchical designs. For example, the individual transistors, resistors, and diodes, and the connections between them for making a NAND gate, may be on one logical level. Two resulting NAND gates packaged together in one package may be the next logical level, and the resultant package connected to other components in a schematic

drawing may be a third level. It is possible to generate a connection (net) list at each of these logic levels or to "smash" the hierarchy and get a connection list for the resultant flat file.

HP EGS also will merge connection lists. For example, if several designers are working on the same drawing, or if a single designer wants to break up a complex schematic to make it more manageable, the system can automatically merge the individual connection lists.

The flexible connection lister can also handle general applications to provide, for example, a list of terminals connected to a mainframe computer in an office environment or a list of registers connected to a boiler in a heating system.

### Rat's Nest Generator

From a schematic connection list, the Rat's Nest Generator produces "airline" connections between placed printed circuit board components. The "gather" feature allows the user to move components to eliminate trace congestion. As components are moved, the connections remain intact. Trace placement is accomplished by picking an "airline" and routing it to conform to the user's design rules. In the placement press, a trace can easily be moved from layer to layer as necessary.

## Optional Tools

### Photoplotter and N/C Drill Post-processor

Printed circuit board designers often need to convert designs into a format suitable for a photoplotter or an N/C drill machine. An optional photoplotter/drill post-processor converts boards designed on HP EGS into Gerber photoplotter or Excellon drill format. The resulting ASCII formatted files can be transferred to those machines in compatible magnetic tape or paper tape form. Standard data communications (via terminal emulators) can also be used to move the files.

### IGES Translator

Occasionally, users will want to move mechanical designs between CAD systems. The Initial Graphics Exchange Specification (IGES) is a world-wide standard which is used by many systems for this purpose. An optional bidirectional IGES translator is available for the Pascal version of HP EGS.

### HP EGS Plotfile Capability

HP EGS plotfile (HPGL) capability allows HP EGS graphics to be merged with a variety of automated publishing tools, such as FrameMaker®, Interleaf, and Alis.
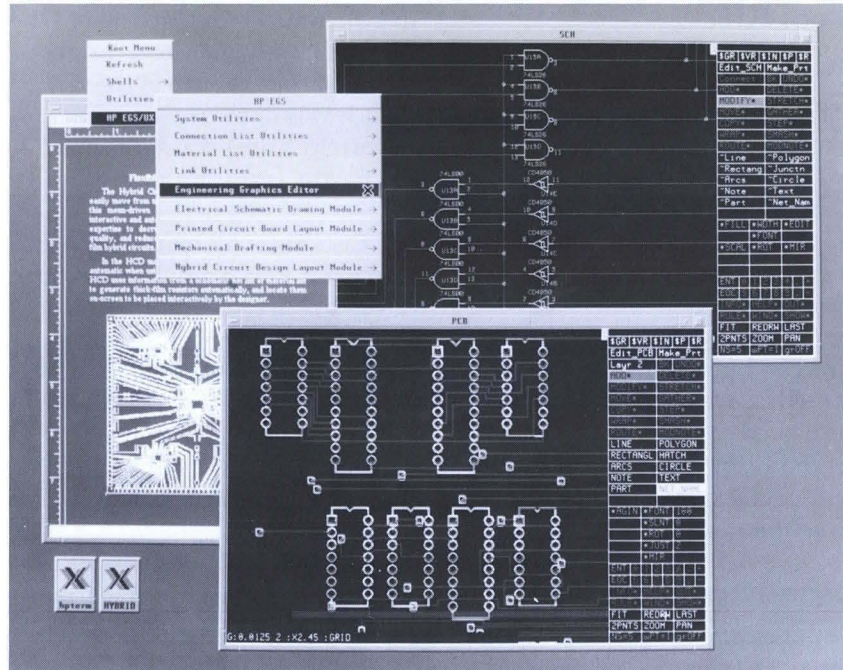


**Figure 5. X Window environment with HP EGS Manager Menu inside X11 pull-down menus**

## Hardware Platform

Hewlett-Packard offers the advantage of a single-vendor solution, with a full line of computer equipment ranging from high-performance computers to industry-leading printers and plotters.

Users can order a bundled system or build a system to suit exact needs by choosing from the complete line of HP 9000 Model 300 workstations, plus a variety of displays, disks, input devices, printers and plotters. Because Series 300 hardware is modular, it can be upgraded easily.

Hewlett-Packard sales representatives are available to help users configure the right system for specific applications.

## Operating System

HP EGS runs on top of the HP Pascal Workstation (PAWS) or the HP-UX operating system. The HP EGS PAWS version is shipped with a Pascal operating system. It can serve as a complete, standalone dedicated workstation or can be connected via the HP Shared Resource Manager (SRM) to networked peripherals.

HP EGS on the HP-UX operating system provides access to a wide variety of engineering applications, all from one workstation. HP EGS can be run directly on the HP-UX operating system or under the X Windows environment. Both standalone and X Windows environments support diskless clusters and powerful local area network (LAN) and wide area network (WAN). Under X Windows the user can invoke and interact simultaneously with several applications of HP EGS. For example, the X Windows environment allows the user to view and modify the schematic and layout of a printed circuit board simultaneously.

## Networking

Whether users select HP 9000 Pascal or HP-UX system workstations, the computers can be linked together by optional network software. HP 9000 Pascal workstations can be linked by SRM. HP-UX system workstations can be linked by Hewlett-Packard's standards-based LAN.

Either network lets users share peripherals such as disks, plotters, and printers. More importantly, networking allows users to share files. With this capability, one person in a design group could have responsibility for designing and maintaining the parts library that will be used by the other people in the group, ensuring uniform, standardized designs.

## Documentation and Support

A multi-level support strategy is available for HP EGS, including manuals, training, and telephone support. A set of manuals available for each core product. They are:

### HP EGS Pascal:

- *Installing HP EGS*
- *Learning HP EGS*
- *Understanding HP EGS*
- *Managing and Editing Files with HP EGS*
- *HP EGS Syntax Reference*

### HP EGS/UX:

- *Installing HP EGS / UX*
- *Learning HP EGS / UX*
- *Understanding HP EGS / UX*
- *HP EGS / UX Reference*
- *HP EGS / UX Master Index*

As the name suggests, the *Learning HP EGS* manuals are tutorials which lead the first-time user through the steps required to complete several drawing tasks. In the process, the user is introduced to most of the commands and the flow of the design process. Using this approach, a novice can begin productive work in about two days.

The *HP EGS Reference* and the *HP EGS / UX Reference* manuals are handy for users who have become reasonably familiar with HP EGS, but occasionally need help remembering the proper syntax for a command. In addition, an online help file provides a brief description of each command.

Training classes can help users get maximum benefit from a system, especially if their unique situation requires customization. Classes may be taught at a Hewlett-Packard site or at the customer's site, depending on customer preference.

Occasionally, a customer finds it helpful to talk to an HP systems engineer. Several levels of support are available, from telephone support through a Regional Response Center to personal contact with an HP systems engineer from a local HP office.

## Ordering Information

HP EGS can be ordered for use on an HP Pascal workstation or an HP-UX system workstation and X Window environment. The software security system requires the inclusion of an HP 46084A HP-HIL ID module in the hardware set. A minimum of 10 Mbytes of online mass storage is required for system installation and updates.

**HP EGS on the HP-UX operating system:**

• **B1646A—HP Engineering Graphics System on HP-UX operating system**
  Option 0AN—Single User License
  Option 103—Adds Schematic, Printed Circuit Board Layout and
        Mechanical Engineering Design Modules
  Option 203—Adds Hybrid Circuit Design Module and related
        manual
  Option 303—Adds HP EGS Photoplotter and N/C Drill Utilities
        and related manual. Allows HP EGS to interface with
        Gerber Photoplotters and Excellon Drill machines.
  Option 0B1—Adds manual set for HP EGS base product.
        Includes *Install*, *Learning*, *Understanding*, *Reference*,
        and *Master Index* manuals.
  Option AEQ—Software on 1/4" cartridge tape for use on
        HP 9000 Series 300 HP-UX system workstations

**HP EGS on the Pascal operating system:**

• **74305A Standard, 74308A High-performance versions of HP EGS: includes the Graphics Editor, Engineering Graphics Module, Material Lister, and Connection Lister, as well as the manual set for the standard product.**
  Option 042—5 1/4-inch media (except high-performance version)
  Option 044—3 1/2-inch media
  Option 102—Schematic Drawing, 5 1/4-inch media (except
        high-performance version)
  Option 104—Schematic Drawing, 3 1/2-inch media
  Option 202—Printed Circuit Board Layout, 5 1/4-inch media
        (except high-performance version)
  Option 204—Printed Circuit Board Layout, 3 1/2-inch media

• **74305R Standard, 74308R High-performance, and HP EGS Right-to-copy**
  Option 101—Delete manuals
  Option 100—Right-to-copy Schematic Drawing Module
  Option 200—Right-to-copy Printed Circuit Board Layout Module

• **74307A Hybrid Circuit Design Module**
  Option 042—5 1/4-inch media
  Option 044—3 1/2-inch media

• **74307R Right-to-copy Hybrid Circuit Design Module**

• **98305A Bundled version of standard HP EGS**
  (Equivalent to 74305A Option 042 or 044, 102 or 104, 202 or 204)

## Utilities

- 98310A Photoplotter and N/C Drill
- 98310R Photoplotter and N/C Drill Right-to-copy
- 98311A IGES Translator
- 98311R IGES Translator Right-to-copy

## Training Courses

- *Introduction to HP EGS* (HP 74300A)
- *Printed Circuit Board Design with HP EGS* (HP 74301A)
- *Customizing HP EGS* (HP 74302A)

**HEWLETT PACKARD**

**HEWLETT PACKARD**

**Field Training Manual**
**November 1989**
**For Internal Use Only**



# HP EGS on HP-UX

# Contents

# HP EGS on HP-UX
# Sales Guide

## 1.0 Introduction

This sales guide will introduce you to the HP Engineering Graphics System (HP EGS), HP's customizable, two-dimensional graphics software product for multi-discipline engineering design, and the newest release of the product on the HP-UX operating system—HP EGS/UX. The product structure has been revised and some product enhancements added to extend the competitiveness of HP EGS and HP EGS/UX. By reading this guide you will be able to:

• understand the features and benefits of HP EGS

• understand the new HP EGS/UX product structure

• understand the links to other HP DesignCenter products

• position HP EGS relative to other HP DesignCenter products

• recognize customers who can benefit from HP EGS

### 1.1 One-minute Sale

HP EGS is a customizable, two-dimensional graphics software product for multi-discipline engineering design. HP EGS consists of a family of artwork-based design modules for complete product design. This includes schematic entry and printed circuit board (PCB) layout, hybrid circuit design, mechanical drafting, and general engineering drawing. The open data structure, user-customizable macro commands, and screen and tablet menus provide the user the capability to customize and adapt HP EGS design modules to meet current design processes.

The market for HP EGS consists of customers doing entry-level EE, ME or general engineering designs. The user-definable model capability makes the product a good fit for customers involved in state-of-the-art or low-volume design activities which require the customization for individual needs that more automatic tools cannot support or which cannot be justified economically. This includes hybrid circuit design and design of very high frequency circuits.

**Advantages of HP EGS to sell to your customers:**

• *Versatility and customizability.* HP EGS is a versatile and customizable graphics system that conforms to the customer's design methods. The macro language and definable menus of HP EGS allow the user the freedom to customize a design module to fit the user's process.

• *Easy-to-use interface.* There is a common interface for all HP EGS design modules—EE schematic, PCB layout, hybrid design, and ME drafting. The menu structure of HP EGS allows the user to arrange the most important or most frequently used commands at the menu level that is most convenient for a specific process.

• *Ready-to-use application design modules.* The modules do not require configuration which reduces learning times and improves productivity.

• *Connective and user-definable data structure.* The data in HP EGS is connected, or associated, which allows the use of semi-automatic tools (such as connection listing and rat's nest generation). The data structure is user-definable to allow the expansion and tailorability of items such as manufacturing information in the design files.

• *Flexible and easy-to-use graphics.* The power of the HP-UX operating system and HP workstations enhance the graphics capabilities of HP EGS and provide access to a wide variety of additional engineering applications, all from one workstation.

• *Global HP sales and support.* HP EGS is sold and supported worldwide. HP EGS has been localized in German and Japanese, making it available for use in primary design markets.

**Additional advantages include:**

• powerful graphics manipulation

• links to automatic tools

• runs on HP 9000 Series 300 workstations

• supports industry standards with the HP-UX operating system and X Window system

• supports HP-UX system peripherals

## 1.2 What's New with HP EGS?
## HP EGS on the HP-UX Operating System!

Thanks to your sales efforts, HP EGS is a resounding success. There are now over 6000 HP EGS systems installed worldwide. External customers number 3000; the remainder are internal customers.

And now HP EGS is available on the HP-UX operating system. This combination provides the flexibility and adaptability of HP EGS with the power of the HP-UX operating system. HP EGS supports diskless clusters, and can be run in full-screen mode or under the X Window environment. HP EGS/UX provides improved networking with the addition of local area network (LAN) and wide-area network (WAN) capabilities. In full-screen mode, the HP EGS program can be suspended and a remote shell can be started to take advantage of background processes such as connection listing, plot spooling, or design post processing. Under X Windows, multiple HP EGS modules or multiple applications of HP EGS or other X Window engineering applications can be invoked and interacted with simultaneously. For example, parts may be created and used simultaneously in designs in multiple windows. The X Window environment affords the use of low-cost display servers, and industry-standard windowing systems with OSF Motif. The HP EGS/UX release also allows the user to:

• easily put the HP EGS Manager menu selections into X Window pop-up command menus

• organize HP EGS component libraries around the HP-UX system directory organization

• invoke and enter any module from the HP-UX command line or X Window environment

• invoke and enter each module multiple times

Data migration from HP EGS/Pascal to HP EGS/UX is easy. HP EGS/Pascal design files, macros, menu files, and process files are forward compatible with HP EGS/UX. HP EGS/UX workstations can be networked as nodes on the Pascal SRM, and design data transferred using HP-UX SRM utilities.

## 2.0 Market

### 2.1 PCB Layout Overview

A 1988 market share survey by Dataquest reveals HP EGS to be a major player in the EE workstation market, especially the PCB layout tools market. (HP EGS is used for electrical engineering by 75% of external HP EGS customers.) With HP EGS and the more fully automated HP Printed Circuit Design System (HP PCDS), HP now ranks 6th in the PCB layout market share with 6.1% of the market. (See Figure 1, following page.)
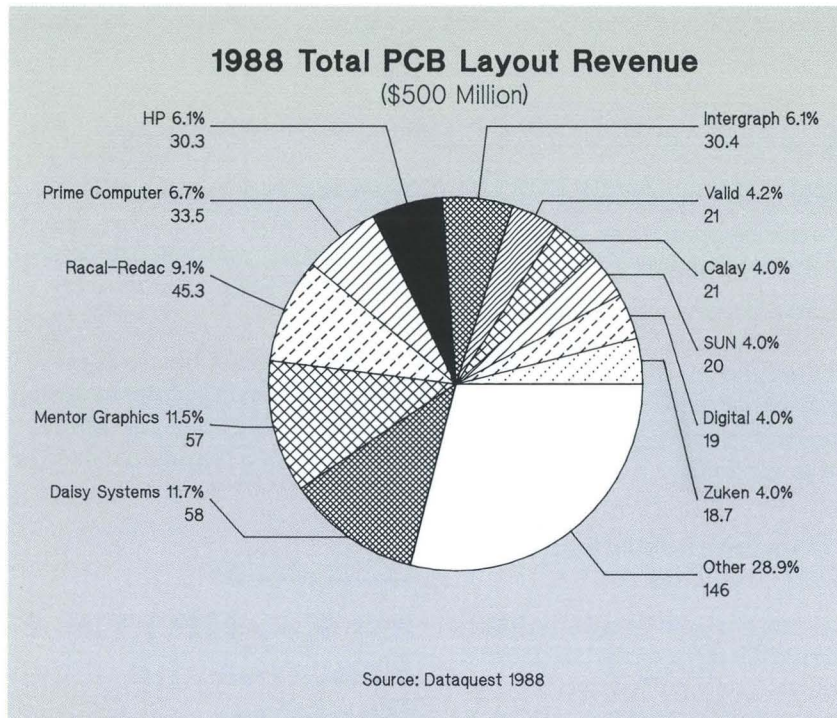
Figure 1.
1988 Total PCB
layout revenue

**1988 Total PCB Layout Revenue**
($500 Million)

HP 6.1%
30.3

Prime Computer 6.7%
33.5

Racal–Redac 9.1%
45.3

Mentor Graphics 11.5%
57

Daisy Systems 11.7%
58

Intergraph 6.1%
30.4

Valid 4.2%
21

Calay 4.0%
21

SUN 4.0%
20

Digital 4.0%
19

Zuken 4.0%
18.7

Other 28.9%
146

Source: Dataquest 1988

The good news continues! Industry analysts agree that the PCB CAD market is a growing market. The penetration (ratio of CPUs per designer) has been only 5% and is expected to grow. With projected growth rate for the PCB CAD market in 1990 at 33%, HP has a tremendous opportunity. With the continuing success of HP EGS and HP PCDS, as well as a growing list of software suppliers, you have an exciting combination of products to provide solutions for your customers. (See Appendix A for an overview of HP PCDS.)

## 2.2 HP EGS Positioning and Customer Profile

As stated in the One-minute Sale, HP EGS is a customizable, two-dimensional graphics software product for multi-discipline engineering design. HP EGS consists of a family of artwork-based design modules for complete product design. This includes schematic entry and printed circuit board layout, hybrid circuit design, mechancial drafting and general engineering drawing. The open data structure, user-cutomizable macro commands, and screen and tablet menus provide the user the capability to customize and adapt HP EGS design modules to meet current design processes.

The market for HP EGS consists of customers doing entry-level EE, ME or general engineering designs. The user-definable model capability makes the product a good fit for customers involved in state-of-the-art or low-volume design activities which require the customization for individual needs that more automatic tools cannot support or which cannot be justified economically. This includes hybrid circuit design and design of very high-frequency circuits.

HP EGS fills the gap between manual drafting methods and fully automatic CAE/CAD systems. More than a drafting tool, HP EGS offers features such as:

• connection list generator

• rat's nest generator

• connection list compare

• links to Gerber Photoplotter and Excellon N/C Drill machines

HP EGS is not a fully automatic CAE/CAD system because it lacks:

• logic simulation or timing verification (found in the HP Design Capture System)

• autoplacement, autopacking, autorouting or design rule checking (found in the HP Printed Circuit Design System)

HP EGS should be positioned as an entry-level CAD tool with the following benefits:

• workstation and HP-UX operating system power (most computer-aided drafting systems use personal computers)

• lower cost than full-function CAE/CAD

• extremely interactive

• short learning curve

• links to full-function CAE/CAD systems

• versatile and customizable

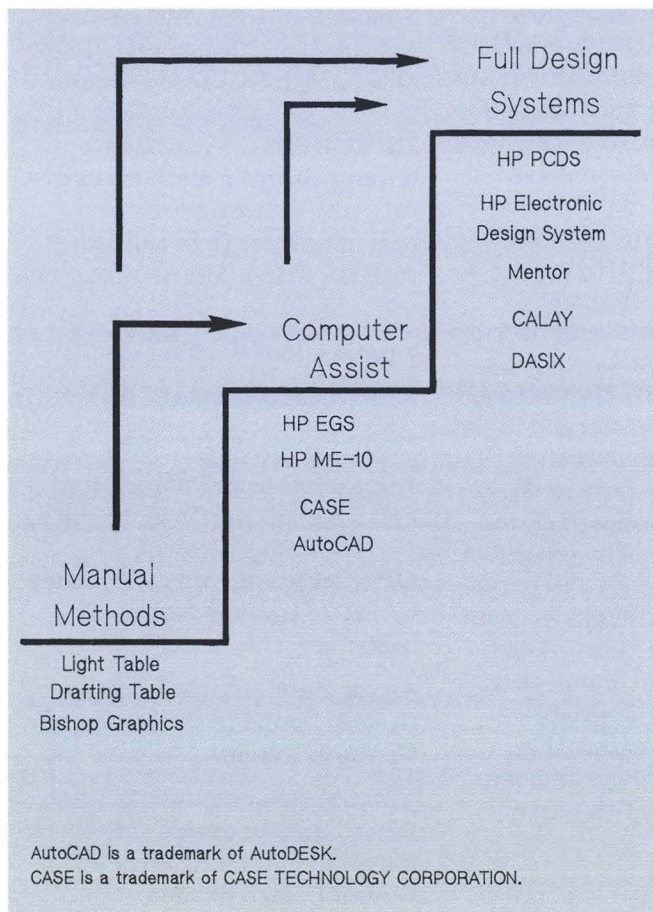Figure 2 illustrates HP EGS positioning relative to other HP DesignCenter products, as well as other products.

Ideal customers for HP EGS are:

• small companies or small groups within large companies

• companies where design may be done by separate groups such as engineering services, R & D, or drafting departments, or companies with a single group that performs many engineering design functions

• companies looking for a highly customizable system

• companies needing some ME or general drafting capabilities in addition to their EE needs

• companies that are price-sensitive and want to automate with minimal disruption

• companies doing manual artwork or hand-taping their printed circuit boards

• companies designing a relatively small number of low density printed circuit boards, and having limited manufacturing output needs

• companies that need a highly-interactive CAD system to design high-technology designs where automatic tools cannot be used or are not cost-effective

# 3.0 Key HP EGS Features and Benefits

## 3.1 Product Structure

In addition to a general drawing module, HP EGS contains four other drawing modules and several post-processors for added design functionality:

**Engineering Graphics Drawing Module (General Drawing Module)**

• large and small viewports

• two billion system points

• unitless system

• five snap modes

• multiple ways to add most components

• multiple ways to enter data

• customizable



Full Design Systems

HP PCDS

HP Electronic Design System

Mentor

CALAY

DASIX

Computer Assist

HP EGS

HP ME–10

CASE

AutoCAD

Manual Methods

Light Table
Drafting Table
Bishop Graphics

AutoCAD is a trademark of AutoDESK.
CASE is a trademark of CASE TECHNOLOGY CORPORATION.

**Figure 2.
Steps to
CAE/CAD**

### Schematic Drawing Module

- English or metric units
- 1,000+ gate design
- connection list (netlist) generation
- connection list merge
- material list generation
- link to General Drawing and PCB Layout modules
- EDIF translator
- customizable

### Printed Circuit Board Layout Module

- EE parts file editor
- EE material lister
- PCB connection lister
- connection list compare
- rat's nest generator

### Hybrid Circuit Design Module

- automatic input of parts from material lists
- design in English or metric units
- automatic thick-film resistor generation
- online access to resistor-paste curve data
- material usage estimator for product costing
- access to photoplotter and N/C drill post-processor

### Mechanical Engineering Drafting Module

- ME parts file editor
- ME material lister

Two separate products are available in addition to the primary HP EGS modules:

- IGES Bidirectional Translator (Pascal version only, not available with HP EGS/UX)
- Gerber photoplotter and Excellon N/C drill output

## 3.2 Features and Benefits

Table 1 below, which targets the economic buyer, highlights some of the features and benefits that make HP EGS a strong contender in the CAD marketplace. The features and benefits shown in Table 2 on the following pag- target the technical user/buyer.

| The Economic Buyer | |
|---|---|
| **Feature** | **Benefit** |
| HP EGS is a multi-purpose CAD tool: schematic drawing, printed circuit board layout, and mechanical drawing. | The customer buys only one CAD system for complete product design (EE and ME). Minimum investment required. |
| HP EGS has links to full-function CAE and PCB CAD systems (HP Design Capture System—HP DCS and HP Printed Circuit Design System) | Provides a growth path. As designs become more complex and as the company grows, a change can be made to HP's full-function systems without loss of data. |
| HP EGS can be purchased as a modular product. | Customer can choose to buy and build a system to meet immediate needs. As needs change, additional modules can be purchased. |
| HP EGS has a short learning curve (73% of our customers surveyed say they learned the system in less than 2 months; 56% in less than 3 weeks). | Users become productive fast. Customers realize a return on investment much sooner. |
| HP EGS has complete drawing compatibility with its predecessors. (HP EGS is now a 5th generation, 11th revision product that has run on three hardware sets. With ARCHIVE, drawings have been upward-compatible.) | Customers are assured that, as new revisions and new computers become available, their costly investment in designs will be protected. |

Table 1.

| The Technical User/Buyer | |
|---|---|
| **Feature** | **Benefit** |
| HP EGS is customizable. | Customer can customize HP EGS to fit needs and mode of operation. Doesn't have to force-fit a system to match unique needs. |
| HP EGS has links to manufacturing outputs: Gerber photoplotter and Excellon N/C drill machines. | Eliminates errors. Data is input electronically. No need to input data manually. |
| HP EGS supports industry-standard IGES and EDIF interchange formats. | Customers can integrate HP EGS into existing CAD systems. Customers can mix and match systems to fit their needs. |
| HP EGS supports the merging of text and drawings via FrameMaker. | Eliminates the need for technical professionals to manually "cut and paste" pictures into memos and documents. |
| HP EGS has online help. | Eliminates fumbling through reference manuals. Users remain productive. |
| User interacts with HP EGS through screen menus allowing "heads-up" drawing. (The user can also customize tablet menus.) | Drawing speed increases. User keeps eyes on screen at all times —no back and forth motion between the screen and the tablet. |
| HP EGS has a connection list compare feature which compares the connection list of the schematic with that of the printed circuit board and lists any discrepancies. | Ensures that the electrical design is implemented in the physical design. Finds errors early. Saves costly repair. |
| When a library part in HP EGS is changed, it is automatically updated in all drawings that use that part. | Eliminates the use of different versions of the same part. If a part is changed by a manufacturer, all designs that contain that part can be updated easily. |

**Table 2.**

Other HP EGS graphics productivity features that save time and improve the accuracy of design include:

• GATHER (with "rubber-banding" of lines)

• lock-angle enforcement

• isometric drawing grid

• macro instance (family-of-parts feature)

• free-hand draw

Table 3, at right, shows the available links from HP EGS to other HP design tools.

| Available Links | Part Number |
|---|---|
| EDIF 2.0 Netlist View | Included in HP EGS |
| HP EGS—HP ME-10 | Included in HP EGS and HP ME-10 |
| HP EGS—Calma GDS II | HP P/N 85153 |
| HP EGS—HP Microwave Design System | Included in HP Microwave Design System, HP P/N 85150B |
| HP EGS—HP Design Capture System | HP P/N 74210A |
| HP EGS—HP Electre | HP P/N B1236A |

**Table 3.**

## 3.3 Comparison with HP DCS and HP PCDS

Table 4 below provides a comparison of HP EGS customers with those of HP DCS and HP PCDS.

Although HP EGS is primarily an entry-level PCB CAD tool, in certain applications its highly interactive nature and flexibility make it a good tool for sophisticated designs. For instance, physical layout of one of the complex printed circuit boards in HPPA-RISC was accomplished manually with HP EGS, because circuit speeds of 40-50 MHz prevented the use of automated tools.

Physical layout of some sophisticated designs such as high-speed digital (ECL) or hybrid analog/digital printed circuit boards, as well as some microwave designs and integrated circuits, can be better designed on a flexible, interactive system like HP EGS than on a fully-automatic CAD system.

Customers who implement such designs are innovators who believe that the best CAD solutions come from experienced engineers or designers who use highly interactive drawing tools. These customers will usually have many different CAE/CAD systems, and thus will require open systems. These innovators are prime prospects for HP EGS because it is versatile, highly-interactive, and customizable.

| HP Engineering Graphics System customer | HP Design Capture System<br>HP Printed Circuit Design System customer |
|---|---|
| Price-sensitive. (HP EGS 19" Color PCB/Schematic Drawing system = $16,000) | Not price-sensitive. (minimum Electronic Design System/HP PCDS = $60,000) |
| Wants to customize system or has EE and ME needs. | Wants fully automatic, vertical, front-to-back system |
| Needs schematic drawing capability--no need for full-function CAE. | Wants full-function CAE system--simulation, timing analysis, fault simulation, links to Microprocessor Software development (64000). |
| Works well for non-specialized engineering services--PCB layout, ME drafting, schematic drafting, etc. | Suits specialized PCB shop--engineering services. |
| Will do mainly low-density, low-volume designs. | Will do mainly medium-density, high-volume designs. |
| Produces various technology boards (any combination of digital, analog or high-speed digital). | Produces mainly digital or mixed analog/digital boards (ECL, Ultra-fineline done manually). |
| Will perform placement and routing manually. | Wants fully automatic placement, packing and routing. |
| Will create own parts library. | Looking for extensive "pre-built" parts library--TTL, MOS, ECL,&PLD. |
| Output is mainly plotter (artwork), Gerber photoplotter, or Excellon N/C drill. | Needs highly automated manufacturing output. |
| No requirement for automatic tools to increase manufacturability of boards. | Needs automatic tools to increase manufacturability of boards--design rule checking, removing unnecessary vias, breakouts and unconnected traces; adding teardrops; thickening short traces. |

**Table 4.**

### 3.4 Comparison with HP ME-10

HP EGS is not a mechanical engineering system. The HP EGS ME Drafting Module is designed for customers who need a mechanical drafting tool secondary to their EE needs. This module offers no HP links to finite element analysis or numerically controlled manufacturing systems (other than Excellon N/C Drill machines for printed circuit boards). The HP EGS ME Module also has no link to 3D systems. The HP ME-10 system offers the following productivity enhancements not found in HP EGS:

- ruler—a T-square emulator

- hatching—automatic hatch area defined and auto-updated after stretch

- calculation of area properties such as center of gravity and moment of inertia

- semi-automatic generation of isometric views—top, front and sideviews

HP EGS, teamed with HP ME-10, is highly recommended for customers needing a comprehensive ME drafting tool along with an EE CAD tool. Drawings created with the ME Drawing Module of HP EGS can be transferred to HP ME-10 with the ARCHIVE file method. This allows customers to begin their ME drawings with HP EGS, then transfer them to HP ME-10 for complete ME drawing capability, finite element analysis and N/C manufacturing.

# 4.0 Selling Against the Competition

Competition for HP EGS ranges from PC-based, entry-level physical design systems to full-function, workstation-based design systems. HP EGS has such a wide range of competition because it has the flexible CAD capability of PC-based design systems, and it also has the element connectivity and associated text capability of the most powerful CAE tools. In this generic, flexible CAD market, the most pronounced competition comes from the widely distributed AutoCAD product from Auto-DESK. HP EGS/UX is price competitive with AutoCAD. HP EGS/UX delivers a performance edge because it provides a superior, open, extensible, customizable system on the powerful HP-UX operating system.

### 4.1 AutoCAD

With increased frequency, HP EGS encounters AutoCAD in the marketplace. AutoCAD can be a tough competitor for HP EGS when the only criteria is absolute system cost. Otherwise, HP EGS can easily prove its added value over the $2,995 drawing editor.

**AutoCAD Product Focus**

AutoCAD, introduced in 1982 for $500 (U.S.), is a general-purpose, 2D/3D wireframe software package. Since its introduction, design modules have been added and the price increased to $2,995 (U.S.) for the latest product, Release 10. The markets in which AutoCAD excels are mechanical drafting and architectural engineering. Although it has many of the drawing entry capabilities of HP EGS, its simple data structures and limited macro capabilities limits its capability to modify and document drawings.

**AutoCAD Market Penetration and Sales Channels**

With an installed base of 82,000 units as of January 1 1989, AutoCAD is the leader in PC-based CAD. Daratech estimates that this gives AutoCAD a 44% share of all PC-CAD installations. AutoCAD's success story continues with shipments averaging 2,200 per month. AutoCAD is sold by over 1000 computer dealers such as ComputerLand. Frequently, these dealers provide free hardware and software installation.

## Selling Against AutoCAD

The following are points to remember when selling against AutoCAD. AutoCAD's strengths (+) and weaknesses (-) are relative to HP EGS/UX:

• AutoCAD is designed to run on low-end PC's:

- monochromatic menus

- available only on MS-DOS platforms (not a player in more powerful UNIX® platforms)

- 3D is just a projection of 2D image

• AutoCAD is a general-purpose CAD software package:

- organization of commands is alphabetical as opposed to frequency of use

- no easy-to-use macro language;. AutoLisp, AutoCAD's macro language is high-level programming language designed for use by software suppliers but not for the casual user

- AutoLisp is complicated and has no debugging capability

• AutoCAD is widely distributed but limited support is available:

- systems sold on price and availability

- many customers are left without post-sales training and support

- over-distributed, black market copies available for as little as $995 (U.S.)

• Menu system is complicated to use:

- no general-purpose macro language to build new commands

- many levels in menus

- menus are not arranged for frequency of use

- need to go back up several menu levels to quit commands. Limited command interrupt capability.

- does not accept input if still in command

- complicated to add geometry; regularly requires pull-down tools, menus and special characters

- faster to type in commands than use menus

• Data structure is designed for general-purpose CAD software:

- hatch is not associated to surrounding geometry

- hatch is made up of single lines

- dimensions on text and lines cannot be calculated during resize operation

+ dynamic zoom

+ large set of hatch styles

- large set of hatch styles require increasing size of data files and affects systems performance

# 5.0 Sales Support

## 5.1 Sales Tools

Sales tools are available to aid you in your selling efforts. Following is a list and brief description of these tools. You can order literature with a part number directly from the Literature Distribution Center. If you need any of the other items listed below, contact your EDD Regional Support Engineer.

### • HP EGS Sales Brochure (5954-9411)

An 8-page, full-color overview brochure that features HP EGS and briefly mentions links to other HP DesignCenter products. A label announcing HP EGS on HP-UX has been added to the front cover of the existing brochure.

### • HP EGS Data Sheet (5952-0864)

A comprehensive, black and white, features-oriented description of HP EGS. Content has been revised to include HP EGS/UX features.

### • EDD Configuration and Performance Guide

A thorough, step-by-step configuration guide which includes information on software ordering, workstation and system configurations, support, customer training and helpful guidelines.

### • HP Electronic Design Automation (EDA) Sales Brochure (5952-0867)

A 16-page, full-color overview brochure that highlights HP DesignCenter products and includes brief application stories.

### • EDD Update

EDD Update is an electronic newsletter that contains sales and technical information related to HP's EDA programs and products. It is distributed monthly via HPDESK. If you have not been receiving a copy and are interested, send an HPDESK request to SALES/HP4006/00.

### • HP EGS Online Support

An online support team is ready and willing to answer your questions. The technical support team handles technical issues such as configuration and hot site support. Sales support handles inquiries regarding issues such as ordering, reference accounts, major account programs and customer visits.

The telephone number is (303) 229-2222 or Telnet 229-2222; ask for HP EGS support. Or send an HPDESK message to EESE/HP4006/00.

## 5.2 System Requirements

The system requirements for HP EGS/UX are:

• CPU: all HP 9000 Series 300 (except the 310 and 318); Models 340/360/370 recommended

• RAM: 4 Mbytes minimum (8 Mbytes with X Windows)

• display: 1024 x 768 pixel monitor (C+) minimum

• disk space requirements in addition to X Windows and HP-UX requirements:

  - 10 Mbytes static disk space

  - 20 Mbytes swap space per simultaneous execution of HP EGS

  - 130 Mbytes of disk space for user files

• diskless operation supported

• ID module and input devices supported by the HP-UX system

• HP-UX Application Execution Environment (AXE) 7.0 or above

In case of a server-client configuration, all of the previous requirements for a standalone system apply.

HP EGS/UX is designed to support all peripherals supported on the HP-UX operating system.

## 5.3 Ordering Information

### HP EGS on the HP-UX Operating System

• B1646A: HP Engineering Graphics System on HP-UX operating system

  - Option 0AN: Single User License

  - Option 103: Adds Schematic, Printed Circuit Board Layout and Mechanical Engineering Design Modules

  - Option 203: Adds Hybrid Circuit Design Module

  - Option 303: Adds HP EGS Photoplotter and N/C Drill Utilities. Allows HP EGS to interface with Gerber Photoplotters and Excellon Drill machines.

  - Option 0B1: Adds manual set for HP EGS base product. Includes *Installing*, *Learning*, *Understanding*, *Reference,* and *Master Index* manuals.

  - Option AEQ: Software on 1/4" cartridge tape for use on HP 9000 Series 300 HP-UX system workstations.

### Training Courses

• Introduction to HP EGS (HP 74300A)

• Printed Circuit Board Design with HP EGS (HP 74301A)

• Customizing HP EGS (HP 74302A)

## 5.4 Software Support Services

Hewlett-Packard provides quality products and backs them up with a range of services to help ensure maximum system uptime and productivity. HP delivers comprehensive support—from planning to implementation, operation, and future enhancements. For EGS/UX (B1646A), the following services are available:

• **HP TeamLine**—HP TeamLine software support service provides an HP support consultant to help maximize the productivity of your customers' systems. HP TeamLine includes:

  - account-assigned support consultant

  - personalized technical assistance and services

  - problem-solving and product-usage assistance

  - proactive support planning

  - right-to-use software updates

  - added service for HP applications software

• **HP ResponseLine**—HP ResponseLine software support service provides comprehensive software maintenance, including unlimited telephone assistance to resolve software problems. This service also provides access to HP electronic support information services. HP ResponseLine software support service includes:

  - phone-in problem-solving and product usage assistance

  - electronic access to support and product information through HP SupportLine

  - well-defined escalation management procedures for critical software problems

  - right-to-use software enhancements

• **HP BasicLine Software**—HP BasicLine software support service delivers current, comprehensive support information by providing electronic access to support information and the right-to-use updates to HP software.

Software questions or problems can be quickly researched in its electronic databases. HP BasicLine includes:

  - right-to-use software updates for licensed products

  - online access to comprehensive problem-solving information

  - online access to training schedules, product and support news.

# Appendix A: HP PCDS Overview

The HP Printed Circuit Design System (HP PCDS) is a full-function computer-aided design solution that links printed circuit board layout to electrical engineering design, manufacturing, and test. HP PCDS is a printed circuit board design system that runs on HP 9000 Series 300s with the HP-UX operating system.

HP PCDS is positioned as a system that ensures error-free design and increased manufacturability of printed circuit boards. Among the HP PCDS features:

• workstation power

• links to CAE systems, including the HP Electronic Design System and HP Engineering Graphics System

• links to manufacturing test

• automatic tools for packing, placing, routing

• design rule checking: batch and interactive

• automated reports to manufacturing

• automated board finishing ("tidy") function

Ideal customers for the HP Printed Circuit Design System are:

• those ready to change their current design process

• those with CAD systems that are more than three years old

• engineering services and PCB layout groups

• those with HP Electronic Design System

• those with HP EGS who are ready to upgrade

• those doing digital and mixed digital/analog boards

The HP PCDS Library Module and Parts Library is the central repository for component information. A forms editor allows the designer to perform part entry and data validation for each part. Within this module resides a database composed of more than 9500 parts. Library parts from HP EGS and the HP Electronic Design System are a subset of the HP PCDS Library.

The HP PCDS Design Module comprises powerful automated tools to aid the designer in the PC board layout process, yet contains all the tools necessary for manual layout. Gates are automatically assigned or partially packaged, as desired. Component placement can be done automatically or manually on both sides of the board. An "improve" routine automatically swaps gates, pins, and packages, thus improving routability, minimizing copper, and reducing the cost of manufacturing the board.

The Autorouter Module uses a proprietary algorithm that pre-plans before laying any traces. It decides where these traces should be, then quickly finishes the selected route. This multipass, intelligent autorouter is both fast and complete. The designer retains the option of routing automatically, interactively, or a combination of both.

For further information on HP PCDS functionality, features, benefits, and configurations, see the HP PCDS data sheet (5954-6638) available from the Literature Distribution Center, the *EDD Configuration and Performance Guide* (HPDESK message to EDDSALES/HP4006/00), and the HP PCDS sales guide (HPDESK to EDDSALES/HP4006/00).

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