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# Introduction

WinBench Version 3.1, November 5, 1992

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WinBench(tm) is the PC Magazine Windows Benchmark suite. It provides comprehensive graphics benchmark tests using the Windows Graphical Device Interface (GDI) and selected high-level user interface functions. Version 3.1 is the fourth major release of WinBench(tm). Version 3.1 adds tests of hard disk subsystems.

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The Compaq 386/25m used as a reference PC for the WINMARKs was configured with the Compaq QVision EISA graphic board. The reference PC was tested with the Compaq QVISION.DRV driver at 800x600x256 colors under Windows 3.1.

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# What You Need to Run WinBench

To run WinBench, you need to have the following hardware and software.

**WinBench requires:**

A PC that runs Windows 3.0 or 3.1

About 250,000 bytes available on your hard disk for the WinBench software itself

About 9 million bytes of available space on your hard disk for a temporary file to run the WinBench disk tests, and to save the results of any WinBench tests that you run. If your hard disk does not have enough space for the work file, WinBench will not run the hard disk tests.

MS-DOS Release 3.1 or later (Release 5.0 recommended)

Microsoft Windows 3.0 or later (Release 3.1 or later recommended)

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## Background

WinBench 3.1 and the Graphics WINMARK reflect how the leading Windows applications use the Windows environment. We used Microsoft Test to capture repeatable scripts that represent typical use of eight Windows applications which are market leaders in their respective product categories. Then, we ran the scripts on standard configurations using Microsoft's Logger and Profiler tools to record information about the Windows functions used by these applications. Finally, we analyzed the log and profile data to construct a composite picture of the most frequently used GDI functions and the characteristics of these functions.

Ziff-Davis Publishing Company is committed to provide the PC industry with high quality state-of-the-art benchmark software. PC Labs and Ziff-Davis Labs carry out the on-going mission to develop the benchmarks by instrumenting and analyzing how major Windows applications use the Windows environment, using the best profiling and instrumentation tools available. Subsequent releases of WinBench may reflect adjustments in both the functions used and their weights, depending on the results of the analysis.

---

## Installing WinBench

WinBench is distributed as single self-extracting executable file, WINB31.EXE, on a single diskette. WINBENCH.EXE is the benchmark program itself. WINBENCH.HLP is this file, the on-line help for WinBench. README.TXT is an ASCII text file that describes how to install WinBench.

You will probably want to create a directory that contains the WinBench files, and that will contain all of the report files generated by WinBench. For example, you could use the following DOS commands to create the WINBENCH directory on your C: drive, and to change to that directory:

```
MD C:\WINBENCH
```

```
CD C:\WINBENCH
```

Then, execute the self-extracting WINB31 program to install all of the files from the WinBench diskette. If the WinBench diskette is in the A: drive of your PC, and you created the WINBENCH directory as shown above, do the following command:

```
A:\WINB31
```

---

# How to Use WinBench

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## Launching WinBench

You launch WinBench just like you would any other Windows application:

1. After installing WinBench as shown above, you may execute the DOS command:

**WIN WINBENCH**

2. You may open up the file manager, go to the WINBENCH directory on your C: drive, and double-click on WINBENCH.EXE.



## **The First Time You Run WinBench**

The first time that you run WinBench, it displays the Ziff-Davis License Agreement, and prompts you for your name and the name of the company or organization where you use WinBench. Once you have registered WinBench, it no longer requests this information from you.

## **The Initial WinBench Dialog Box**

The initial WinBench dialog box identifies the release of WinBench. Version 3.1 of WinBench offers you three choices in this dialog box: Run Tests, Advanced, and Exit.

Choosing the Run Tests button runs the Graphics WINMARK tests, and displays the results in a dialog box. You may also run the Graphics WINMARK tests and/or display the Graphics WINMARK results by selecting Options | WINMARK from the main WinBench menu at any time.

Clicking on the Advanced button displays the main WinBench menu, from which you can run any of the benchmark tests.

Picking the Exit button exits from WinBench.

## **The WinBench Menu Bar**

The WinBench menu bar makes the following choices available to you: Options, Bitblt, Curves, Lines, Polygons, Rectangles, Text, Misc, User Interface, Clipping, Disk, and Help.

## **Options**

The Options menu allows you to select different options and to view test information.

## System Information

If you choose System Information, WinBench displays information about the hardware configuration being tested:

### System Information

- Test Description
- Test Date and Time
- Processor Speed
- Processor Type
- Windows Version
- Windows Mode (Enhanced, Standard, or Real)
- Driver File Name
- Driver Description (from SYSTEM.INI)
- Driver Version
- Driver Date Stamp
- Width of Screen
- Height of Screen
- Number of Colors
- Number of Planes
- Number of Bits/Pixel
- Width of Window
- Height of Window
- Width of Icons
- Height of Icons
- X Aspect Ratio
- Y Aspect Ratio
- XY Aspect Ratio
- System Font Height
- System Font Average Width

WinBench reports the information which the Windows kernel and graphics device driver provide to it.

The Number of Colors reported by the Windows driver is not always an accurate indicator of the color depth available with the driver. Due to historical Windows issues in managing more than 16 colors, the driver often reports fewer than the actual number of colors that it has available. You can more accurately determine the number of colors supported by the driver by examining the data shown for Number of Planes and Number of Bits/Pixel. Typically, sixteen color drivers report that they have four planes and one bit per pixel. Drivers that support more colors report that they have one plane and usually eight, fifteen, sixteen, or twenty-four bits per pixel. If the Number of Planes reported by a driver is one, raise two (2) to the power equal to the Number of Bits/Pixel reported. As examples, a driver with 8 bits per pixel supports up to 256 (2 to the 8th power) colors, and a driver with 16 bits per pixel supports up to 65536 (2 to the 16th power) colors. A Windows graphics driver may choose to reserve some of these colors for its own dedicated use.

Also, the width of the window reported to WinBench by Windows 3.1 is sometimes two pixels wider than the width of the screen, a physical impossibility. WinBench compensates by always reporting the width of the window as being no wider than the width of the screen.

## Modify Options

Clicking the Modify Options menu choice displays the Modify Options dialog box with the following selections:

### *Test Description Edit Box*

You may enter some descriptive text about your test into the Test Description edit box .

### *Display Results Radio Buttons*

The Display Results radio buttons permit you to enable or disable the display of dialog boxes that display the results of each set of tests .

### *File Output Radio Buttons*

The File Output radio buttons allow you to enable or disable a results file, which contains the results for all of the tests that you run, and to change the format of the results.

If you do enable File Output, then you may enter the name of the file to which the results are written. You may also elect the default file name. If you use the same file name for different runs of WinBench, results from the current test are appended to the results of preceding tests.

### *Disk Benchmark Options Group*

The Disk Benchmark Options group contains a pair of radio buttons marked Apparent and Real. The settings for these buttons determine how WinBench runs its disk tests. The Apparent button tells WinBench to measure the apparent time spent running each test. The Apparent time is the time that a test appears to run, and does not take into account the time spent by disk cache software or hardware to flush data to disk from its cache in the background while you go on to do something else with your PC. The Real button tells WinBench to measure the entire time spent to run each test, including the time to flush the disk cache. Choosing Apparent or Real has no effect on the Disk Read tests. If the software disk cache that you are using does not support delayed writing of data from its cache, or if you have not set it up to do so, then Apparent and Real produce essentially the same test results. Microsoft's SMARTDRV (Version 4.0 or later) and PC-Kwik's Super PC-Kwik are two disk cache software packages that permit delayed flushing of data to hard disk as a background operation, and they both have command line options to suppress delayed flushing.

### *Save Checkbox*

The Save checkbox tells WinBench to remember your current option settings, and automatically use these settings each time WinBench runs. WinBench 3.1 saves the option settings in the [Version.3.1] section of the WINBENCH.INI file in your Windows directory. Remember that if you no longer want to use the saved options, you must uncheck the save checkbox.

### *The OK Button and the Esc Key*

Click the OK button when you are satisfied with the options you have chosen. Press the Esc key if you decide you no longer want to modify options.

## **Run All Tests**

The Run All Tests menu choice runs all of the tests using the current options.

## **Run All WINMARK Tests**

The Run All WINMARK Tests menu choice runs the tests used to calculate the Graphics and Disk WINMARKs, the weighted harmonic means for graphics adapter and disk subsystem, respectively, installed in the PC system on which the tests are run.



## **Run Graphics WINMARK Tests**

The Run Graphics WINMARK Tests menu choice runs the tests used to calculate the Graphics WINMARK value, the weighted harmonic mean for the combination of graphics adapter and PC system on which the tests are run.

## **Demo Mode**

The Demo Mode runs all of the tests but neither displays test results nor produces a file containing test results.

## **Compare Results**

The Compare Results menu choice allows you to select another set of test results to compare with the results run to date as stored on the current test configuration. You may select test results only from files written in XLS format by WinBench into the directory from which you have launched WinBench. Until you run at least one test, Compare Results is grayed out and you cannot select it.

## Suggested Usage

If this is the first time you've used the WinBench benchmark, you may wish to experiment with it. You can select and run any individual test via the menus.

If you are timing the performance of a display card, you should run all of the detailed tests. The fastest way to run all of the tests is to disable the display of results, and then enable the file options. Running in this mode allows the benchmark to proceed without intervention, and to record its results in a file.

### **To run all detailed tests automatically:**

Select "Modify Options" from the OPTIONS menu.

Enter a description into the Test Description edit box.

Select "No" for Display Results.

Select "Yes" for File Output.

Enter a name for the results file.

Select OK.

Select "Run All Tests" from the OPTIONS menu.

You may interrupt any sequence of tests by pressing ESC. If ESC is pressed, the test currently running will complete, and you will be asked if you wish to cancel or continue.

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# The Graphics WINMARK

Version 3.1 of WinBench computes the Graphics WINMARK(tm), the weighted harmonic mean of twelve Windows graphics operations that are the most frequently used by leading Windows applications. The specific operations used to compute the Graphics WINMARK are tabulated below.

## Graphics WINMARK Tests

- Memory to Screen Source Copy
- Memory to Screen Pattern Copy
- Memory to Screen Pattern Invert
- Draw Horizontal Single Lines
- Draw Vertical Single Lines
- Draw Diagonal Single Lines
- Draw Horizontal Polylines
- Draw Vertical Polylines
- Draw Diagonal Polylines
- Extended TextOut using System (bitmapped) fonts
- Extended TextOut using True Type (rasterized) fonts
- Polygon Alternating Fill

Here is a brief description of each test included in the Graphics WINMARK(tm):

Memory to Screen Source Copy (MS SRCCOPY) copies bitmaps of the PC Magazine logo from PC memory to the screen using the BitBlt function. As a group, Bit Block Transfers (BitBlts) and Pattern Block Transfers (PatBlts) are the most frequently used graphics operations done within Windows.

Memory to Screen Pattern Copy (MS PATCOPY) copies a cross-hatched pattern object to the screen using the BitBlt function.

Memory to Screen Pattern Invert (MS PATINVERT) copies an inverted cross-hatched pattern object to the screen using the BitBlt function. Inverting a pattern object means that all ones are replaced by zeroes and vice-versa.

Draw Horizontal Single Lines draws lines horizontally across the screen using the MoveTo and LineTo functions. The lines are slightly less than the width of the screen. Line drawing functions are used extensively by vector-oriented graphics software and by spreadsheets and other packages to draw grids on screen.

Draw Vertical Single Lines draws lines vertically down the screen using the MoveTo and LineTo functions. The lines are slightly shorter than the height of the screen.

Draw Diagonal Single Lines draws lines diagonally on the screen using the MoveTo and LineTo functions. The lines are slightly shorter than the height and width of the screen.

Draw Horizontal Polylines uses the PolyLine function to draw a series of horizontal lines across the screen. The lines are slightly shorter than the width of the screen.

Draw Vertical Polylines uses the PolyLine function to draw a series of vertical lines down the screen. The lines are slightly shorter than the height of the screen.

Draw Diagonal Polylines uses the PolyLine function to draw a series of diagonal lines on the screen. The lines are slightly shorter than the height and width of the screen.

Extended TextOut (ExtTextOut) using System fonts writes text to the screen using the bitmapped System font. All applications make extensive use of the system font when displaying menus, and dialog boxes and to serve other purposes. ExtTextOut provides great flexibility in displaying text because it allows a

program to do its own kerning calculations.

Extended TextOut using True Type fonts writes text to the screen using the 21-point New Times font, after the text has been rasterized by the True Type font engine. This test is representative of applications that use various True Type fonts to display text.

Polygon Alternating Fill draws and fills a polygon on screen using the Polygon function, which is used extensively by vector-oriented drawing software packages.

---

## The Disk WINMARK

Version 3.1 adds the Disk WINMARK(tm) to WinBench, based on the hard disk performance tests now included in WinBench. The Disk WINMARK is the harmonic mean of the sixteen disk test results. The WinBench disk tests are comparable to the DOS Access Tests in PC Magazine Labs PCBench DOS benchmark suite.

---

# BitBlt Tests

The BIT BLock Transfer operation (BITBLT) with all of its variations is the single graphics operation most used within the Windows environment.

## Related Topics:

[BitBlt Alignment Tests](#)

[BitBlt Overlap Tests](#)

[BitBlt ROPS Tests](#)

[BitBlt Screen/Memory Tests](#)

[BitBlt Image Blit Test](#)



## **BitBlt Alignment Tests**

The BitBlt Alignment tests perform a set of BitBlt copy operations of various sizes from one area of the client window to another. Aligned and unaligned areas show the differences in throughput for graphics cards that perform best when the data is aligned on an eight-pixel horizontal boundary. In general, 16-color Windows graphics drivers show the greatest performance bias toward aligned areas.

## **BitBlt Overlap Tests**

The BitBlt Overlap tests exercise the ability of a graphics card and Windows driver to perform BitBlt copy operations where the source and destination overlap in the window.

## **BitBlt ROPS Tests**

The BitBlt ROPS tests are a series of 45 tests of the most frequently used BitBlt operations for three combinations of source and destination: memory to screen, screen to screen, and memory to memory. The Bitblt ROP tests use the ROP codes to which Microsoft has assigned mnemonics.

## **BitBlt Screen/Memory Tests**

The BitBlt Screen/Memory tests copy source images in memory and on screen to random destinations in the client window.

## **BitBlt Image Blit Test**

The BitBlt Image Blit test displays large bitmapped images in the client window. It provides an accurate measure of throughput from PC memory across the bus to the graphics subsystem.

---

# Curves Tests

The Curves tests show the difference in performance between graphics cards that have hardware curve drawing operations and those cards that do not.

## Related Topics:

[Curves Partial Arcs Tests](#)

[Curves Ellipses Tests](#)

## **Curves Partial Arcs Tests**

The Curves Partial Arcs tests draw arc shaped lines using the Windows Arc function.

## **Curves Ellipses Tests**

The Curves Ellipses tests draw and fill ellipses with the Windows Ellipse function.



---

# Lines Tests

The Lines tests are the second most frequently used group Windows graphics operations. They show the difference in performance between graphics cards that have hardware line drawing operations and those cards that do not.

## Related Topics:

[Single Lines Tests](#)

[PolyLines Tests](#)

[Lines All Directions Test](#)

[Wide Lines Tests](#)

## Single Lines Tests

The Single Lines tests draw single horizontal, vertical, and diagonal lines across the window using combinations of Windows MoveTo and LineTo functions. Drawing lines in different directions shows that various graphics cards and drivers draw lines faster in one direction than another. With most graphics cards, horizontal line drawing is fastest, followed by vertical, then diagonal.

## **PolyLines Tests**

The PolyLines tests draw many horizontal, vertical, diagonal and mixed lines in the client window using the Windows Polyline function. Interpretation of results is similar to the Single Lines tests.

## **Lines All Directions Test**

The All Directions test draws lines at all possible angles using the Windows MoveTo and LineTo functions. The results represent a composite of the line drawing capabilities of a graphics card and driver.

## **Wide Lines Tests**

The Wide Lines tests draw lines of varying width in random directions and random lengths using the Windows MoveTo and LineTo functions.

---

# Polygons Tests

The Polygons tests exercise polygon filling operations used by business graphics and drawing software.

## Related Topics:

[Alternate Fill Test](#)

[Winding Fill Test](#)

## **Alternate Fill Test**

The Alternate Fill test fills the area between the odd-numbered and the even-numbered sides of a polygon. It uses the Windows Polygon function in the ALTERNATE fill mode.

## **Winding Fill Test**

The Winding Fill test draws a border that encloses a polygon but does not overlap, then fills the shape defined by the border. It uses the Windows Polygon function in the WINDING fill mode.



---

# Rectangles Tests

The Rectangles tests are the third most frequently used group Windows graphics operations. They show the difference in performance between graphics cards that have rectangular area filling operations and those cards that do not.

## Related Topics:

[Boxes Tests](#)

[Random Rectangles Test](#)

[Pattern Rectangles Tests](#)

## **Boxes Tests**

The Boxes tests fill concentric rectangles of various sizes. One test fills square rectangles with the Windows Rectangle function and the other fills rectangles with rounded corners using the Windows RoundRect function..

## **Random Rectangles Test**

The Random Rectangles test draws and fills rectangles of random size and placement on the screen using the Windows Rectangle function. It uses different colors and fill patterns for each rectangle.

## **Pattern Rectangles Tests**

The Pattern Rectangles tests fill the entire client window with rectangles using various shaded brush patterns from black to white, and then using the standard Windows cross-hatching brush patterns. The tests use the Windows FillRect function.

---

# Text Tests

The Text tests exercise Windows operations that are used by Windows itself and by word processors, desktop publishing software, spreadsheets, and other software that makes extensive use of different fonts in different sizes.

## Related Topics:

[Display Text Tests](#)

[Scroll Text Tests](#)

[Display ExtTextOut Tests](#)

[Background Mix Tests](#)

[Greyed Text Test](#)

[Mixed Text Test](#)

## **Display Text Tests**

The Display Text tests repeatedly fill the client window with different fonts: System font (either 16 or 20 point), 21 and 27 point New Times Roman, and 20 and 24 point Arial fonts using the TextOut function. When this test is run under Windows 3.0, Roman and Helvetica fonts are used.

## **Scroll Text Tests**

The Scroll Text tests repeatedly scroll the client window upward and fill the bottom of the screen with text. The five tests in this group use the same fonts as the Display Text tests. These tests are implemented with the Windows ScrollWindow, UpdateWindow and TextOut functions. They are comparable to the scrolling operations done by word processors and desktop publishing software.

## **Display ExtTextOut Tests**

The Display ExtTextOut tests repeatedly fill the client window with the system font and two sizes each of the Roman and Helvetica fonts using the ExtTextOut function. They use the same fonts as the Display Text tests.



## **Background Mix Tests**

The Background Mix tests display the system font against opaque and transparent backgrounds.

## **Greyed Text Test**

The Greyed Text test displays the system font in grey at random positions and angles on the screen. Greyed text is displayed for menu choices which are disabled.

## **Mixed Text Test**

The Mixed Text test displays the New Courier font in a mixture of normal, italic, underline, and bold faces. When this test is run under Windows 3.0, Courier fonts are used.

---

# Misc Tests

The Misc tests perform miscellaneous graphics operations done by Windows.

## Related Topics:

[Stretch Tests](#)

[Image Data Test](#)

## **Stretch Tests**

The Stretch tests use the StretchBlt function to stretch or shrink the PC Magazine logo and display it with eleven different dimensions.

## **Image Data Test**

The Image Data test displays the PC Magazine logo in 256 combinations of foreground and background colors. It uses the Windows SetBkColor function to set the background color, SetTextColor to set the foreground color, and a SRCCOPY BitBlt to display the bitmap in the client window.

---

# User Interface Tests

The User Interface tests exercise high-level functions that are part of the Windows user interface.

## Related Topics:

- [Dialogue Boxes Test](#)
- [Rubber Banding Test](#)
- [Scroll Window Tests](#)
- [Clear Window Test](#)

## **Dialogue Boxes Test**

The Dialogue Boxes test repeatedly draws a dialogue box on screen with a Windows DialogBox function, then exits from the dialog box function, causing Windows to restore the part of the client window covered by the dialog box.



## **Rubber Banding Test**

The Rubber Banding test varies the size of a rectangle with Windows Rectangle functions. Rubber Banding is an operation used in drawing packages and by software that supports the Windows clipboard.

## Scroll Window Tests

The Scroll Window tests scroll text inside a window, an operation used by list boxes and combo boxes. These tests are built upon the Windows TextOut, ScrollWindow, UpdateWindow, and BitBlt functions. One test scrolls with the window aligned on an eight-pixel horizontal boundary, and the other uses an unaligned boundary. Aligned and unaligned scrolling show the differences in throughput for graphics cards that perform best when the data is aligned on an eight-pixel horizontal boundary.

## **Clear Window Test**

The Clear Window test clears the client window using the Windows Rectangle function with a gray brush.

---

# Clipping Tests

The Clipping tests show the effect of clipping on graphics operations performed through a single logical clipping area consisting of four rectangles.

## Related Topics:

[BitBlt Clipping Test](#)

[Line Clipping Test](#)

[Text Clipping Test](#)

## **BitBlt Clipping Test**

The BitBlt Clipping test displays the PC Magazine logo at random points in the client window.

## Line Clipping Test

The Line Clipping test draws lines in all directions.

## **Text Clipping Test**

The Text Clipping test repeatedly fills the client window with text.

---

## Disk Tests

The Disk tests show the effect of hard disk configuration on the performance of disk-intensive applications.

The hard disk configuration parameters that influence the results of the disk tests are disk controller type (SCSI, IDE, ESDI, RLL, or MFM), effective transfer rate from disk to controller, controller bus type (EISA, MicroChannel, or ISA), disk seek times (track-to-track, average, and maximum), disk rotational speed in RPM, number of sectors per track, number of heads per disk.

If you use a software disk cache, its publisher, its size, the algorithms it uses to manage cached disk data, and its mechanisms for sharing memory with Windows may also enable Windows and DOS to manage hard disk accesses effectively. The Disk tests are analogous to the DOS Access Tests in Ziff-Davis Labs' PCBENCH 2.0 DOS benchmarks. They show the throughput for file read and write operations, both random and sequential, for block sizes of 200, 512, 2048, and 4096 bytes.

Without the time unselfishly contributed by many people and the software and hardware resources made available by many different companies, WinBench 3.1 could not have been done.



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## People

The Ziff-Davis WinBench project team included the following people. Each person's organization and primary WinBench responsibility is shown below. Every team member contributed the analysis of results of hundreds of test hardware configurations and ideas to improve WinBench.

Name	Organization	Responsibility
Jim Galley	PC Magazine Labs	PC Testing and Analysis
Edward Henning	PC Magazine (UK)	WINMARK Metrics
Jon Hill	PC Magazine Labs	Microsoft Test Script Project Leader
Bob Kane	Ziff-Davis Labs	PC Testing and Analysis
Jeff Mace	PC Magazine Labs	Graphics Testing and Analysis
Ben Myers	Spirit of Performance, Inc.	Software Design and Development
Thomas Siering	Ziff-Davis Labs	Random number algorithms
Nick Stam	PC Magazine Labs	PC Testing and Analysis
Mike Zulich	PC Magazine Labs	PC and Graphics Testing and Analysis

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## Software

The following software products played key roles in the overall WinBench development process.

Microsoft Test 1.0 was the tool used to capture, edit, and play back scripts that represent typical use of the leading Windows applications.

Microsoft provides a set of tools to developers of software drivers and other interested parties through its ISV relations organization. The Microsoft Profiler profile function calls, reporting the frequency of each call and the time spent executing each call. The Microsoft Logger tools log all of the details of individual function calls for subsequent analysis. There are profilers and loggers for both the Device Driver Interface (DDI) and the Windows Application Programmatic Interface (API) used by developers of Windows applications.

Borland C++ 3.1 was the primary compiler used during WinBench development. The Borland Resource Workshop was used to add and change the Windows resources in an application such as dialog boxes, bitmaps, icons, and other graphic objects.

The Microsoft C/C++7.0 and Watcom C9.0 compilers provided additional syntax checking for the WinBench source code, and helped assure that the code generated by a compiler was not a major factor in influencing the benchmark results.

Doc-To-Help from WexTech Systems, Inc. was the tool used to create a context-sensitive Windows help file.

Graphics Workshop from Alchemy Mindworks, Inc. was the tool used to convert bitmaps from one format to another and to resize them.

Michael Brennan's mawk, a DOS-based Free Software Foundation public domain version of the UNIX awk program compiled with Borland C++3.1 to use 80386 and 80387 instructions was the awk interpreter used to run awk scripts, the tool of choice for analyzing the data generated by the Microsoft logger software.

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## Hardware

The following hardware was used to build PCs used to analyze Logger files, to compile and test WinBench, and to test WinBench with a broad range of graphics adapters.

Intel provided a 33/66MHz 80486 OverDrive processor.

Micronics made available a 33MHz 80486 VESA local bus (VL-bus) motherboard.

Seagate's 42400N, a 2GB full-height 5 1/2" SCSI-2 Fast SCSI hard disk, paired with a BusLogic 747 EISA SCSI host adapter allowed timely access to hundreds of megabytes of Logger data.

All of the leading players in the PC graphics industry made their latest hardware technology available for testing with WinBench.

