

# Windows CE for Industrial Computing

*Windows CE is smashing industrial process control applications. The strength of Microsoft in Marketing is proven but the reliability may be questionable. The question is "Will system engineers jump on this operating system when designing industrial systems?"*

*Microsoft products have already been used in industrial applications, for example the telecom or process control systems. Windows CE offers more interesting features coupling an embeddable real-time kernel and a graphical user interface using a subset of the Win32 API. The development tools are known by all the developers, thus reducing the time to market, maintenance and upgrades cost.*

*This article details the advantage of Windows CE for industrial application. A real life example is also described.*

## WINDOWS CE PRODUCT INFORMATION

**W**indows CE is a 32-bit Windows-compatible operating system (OS) designed to fill the need for a small, scalable OS that can work in a wide range of products, including mobile computers, terminals, industrial controllers, medical devices, testing instrumentation, and many others. Windows CE is a pre-emptive, multitasking, multithreaded operating system specifically designed to support embedded systems. Standard communications support is built into Windows CE, enabling access to the Internet. In addition, a graphical user interface, incorporating many elements of the familiar Windows 95 user interface, is available, facilitating ease of use for end users.

Windows CE provides users the best of two worlds: the Wintel world with its "standard" graphic & network API from Windows and the RTOS world with its real time, deterministic and small footprint features. It also provides many other features like described in figure 1.

### Windows CE Features

- Minimal system requirements: 32-bit CPU, Memory (from 150KB ROM/32KB RAM to 2MB ROM/1MB RAM), and a real time clock
- Multitasking, multithreaded OS with pre-emptive, 8 priority levels-based scheduling
- Win32 API compatible programming (subset of over 500 Win32® APIs)
- Execute from ROM or RAM
- Integrated power management
- Low ISR and thread latency (however no nested interrupt in actual version)
- Instant-on power-up
- Standard communications support
- Standard desktop development tools with x86 emulation mode
- Supports application storage in ROM
- International language support
- Processor independent (x86, PowerPC (800 family), MIPS family ...)

### Customisable Size

Selecting from a set of available software modules can customise Windows CE. In addition, selecting from a subset of available components for that module can further customise some of the modules. Componentisation of Windows CE enables you to design embedded system platforms using the minimum set of software modules and components needed to support the platform's system requirements, which minimises the memory footprint and maximises performance of the OS. For example, using componentisation, you can build a Windows CE embedded operating system that contains the kernel and a selected set of communications modules but does not provide any graphical user interface. All of the components of Windows CE can execute in place in ROM, reducing the amount of RAM required. There is no requirement for additional resident or removable storage, although both are supported. For example, a low end system with just the kernel, the communications stacks, and a single non-display application would require less than 500KB of ROM and 350KB of RAM, depending on the application's needs. The Windows CE components in the Handheld PC, a full-fledged Windows CE-based device using all of the components of the architecture, take up about 2MB of ROM.

### Hardware requirement

The hardware requirements to support a Windows CE-based device are a supported processor, memory, and an internal timer for scheduling. No other hardware is technically required by the operating system, but obviously most devices will have a number of peripherals. Windows CE 2.0 supports the NEC 4100 MIPS family, the Philips 3900 MIPS family, Intel 486 and Pentium®, Power PC 821, and the Hitachi SH3 family of processors.

Windows CE is adapted for a specific hardware platform by creating a thin layer of code that resides between the kernel and the hardware platform: the OEM Adaptation Layer (OAL). The OAL isolates device-specific hardware features from the kernel. This includes managing the hardware's timers and device interrupts, and implementing power management

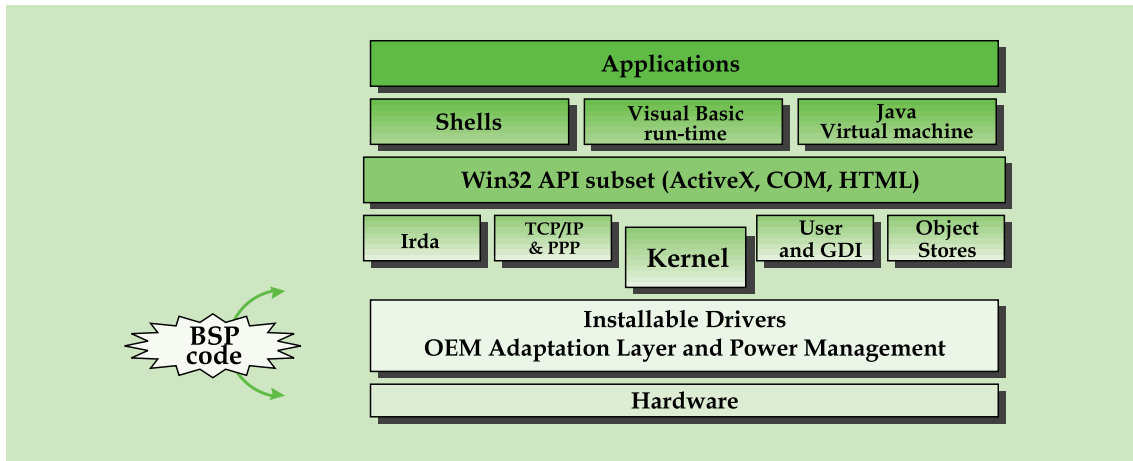


Figure 1. Windows CE Architecture

across the device's peripherals. Windows CE handles interrupts by associating each hardware interrupt request line (IRQ) with one interrupt service routine (ISR). When interrupts are enabled and an interrupt occurs, the kernel calls the registered ISR for that interrupt. The ISR, the kernel-mode portion of interrupt processing, is kept as short as possible. Its responsibility is primarily to direct the kernel to schedule and launch the appropriate interrupt service thread (IST). The IST, implemented in the device driver software module, gets or sends data and control codes to the hardware and acknowledges the device interrupt.

The Windows CE kernel, in turn, contains processor-specific code to handle processor core functions. The OAL is specific for a particular CPU and hardware platform.

Windows CE drivers are not compatible with Windows NT drivers. CE driver model has a different design. Therefore, board level manufacturers have to re-compile specific function driver for this OS.

## WINDOWS CE MARKET POSITIONING

Bill Gates vision was "a PC in every house" when he started MS-DOS design. Now the goal of Bill Gates is a "PC in every pocket"!

Windows CE has been designed from scratch for a large number of applications. Embedded computers are more and more running a day-to-day life. Hand held devices such as integrated mobile computers, personal organiser; smart cellular phone, require an advanced graphical user interface and an Internet access.

This is not the only market targeted by Windows CE. The emerging AutoPC concept is key in the product strategy. The PC desktop is slowing down due to market saturation. Intel and Microsoft are searching for new market opportunities for example the car industry. Millions of cars are sold every year. A PC in every car. Intelligent radio units, GPS positioning system, smart sensors, car diagnostic features will all be coupled via Windows CE according to Bill Gates vision.

The Third market targeted by Windows CE is the vertical market opened to any hardware manufacturer that

have another project idea based on this operating system.

The industrial market is an existing vertical market. For years industrial controllers have been used in production lines, transport vehicle, test and instrumentation equipment. Windows CE, due to its real-time and embedded capabilities, and the standard Windows API, offers an excellent alternative for new industrial controllers.

On the paper, Windows CE is ideal for PC/PLC controllers, data acquisition units, and large spectrum of embedded controllers. But market acceptance is key for the success of Windows CE. Limiting factors are reliability, product stability, development documentation and hard real-time performance.

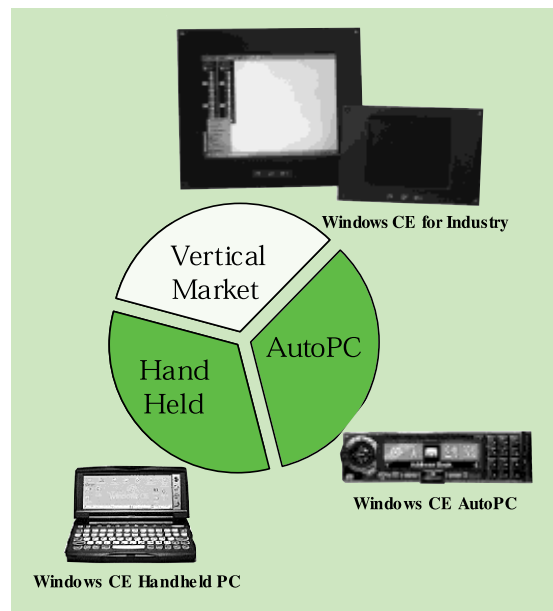


Figure 2. Windows CE Market Positioning

## BENEFITS TO INDUSTRIAL PROJECTS

As described previously, the Windows CE features meet the requirement of most industrial controller projects.

The Windows CE development environment supports

# WINDOWS CE

a comprehensive, expandable subset of Win32 APIs and uses familiar off-the-shelf tools, ensuring faster time to market and a ready supply of trained engineers.

You can build Windows CE applications within the existing Integrated Development Environment (IDE) by using the Windows CE Toolkit for Visual Basic 5.0, Visual C++@5.0 and Visual J++@1.1. These tools are add-on to the respective Windows NT parent tool. Each add-on supplies Windows CE-specific functionality so you can build applications on your PC and easily download, monitor, and debug the applications on a remote device.

User can build his own Windows CE image depending on modules that are required by the project. This Windows CE image will be the system core where C++ applications will be downloaded and executed.

Prices are also an important feature of Windows CE. Like other Windows family development tools, Windows CE development tools have low prices. The Visual C++ for Windows CE and Visual Basic for Windows CE are priced approximately \$200 each. The Embedded Toolkit for Windows CE permits to create a new Windows CE image with desired components. This toolkit is useful for hardware manufacturer in order to port Windows CE to a new hardware architecture. The Embedded Toolkit for Windows CE is priced approximately \$500. The Windows CE run-time license has a very good price compared to traditional RTOS license prices.

## EXAMINING LIMITING FACTORS

### Stability

Windows CE has been designed, without compromises, from scratch for embedded applications. Furthermore, its small size, the modular component approach and the large customer base are excellent basis for a stable and reliable product. Now the version 2.1 is here, the product has been a lot improved and many bugs have been corrected.

### OAL Documentation is poor

Gespac experience has shown that the OEM Adaptation Layer documentation was poor. Hardware Manufacturers will have to provide a Windows CE expertise in order to help new developers.

### Real-time features

Today, the number of threads priority levels is limited to 8. This is too much low in comparison with traditional real-time OS where 256 priority levels is a usual number. When applications become complex and needs hierarchical parallel processes, a 8 priority levels-based scheduling might be a limitation.

Windows CE has a good Interrupt Service mechanics. However it does not (yet) support the nested interrupt. That means that when an ISR starts, no other ISR can occur until the first one is terminated. Windows CE developers are informed that their ISR must be the shortest possible. Real-time performance will improve in the future versions of the product. Today, Windows CE is ideally suited for Soft real-time applications, that

means applications where a dead line may be delayed. It is difficult to speak about response time figures as it depends on a lot of factors like processor speed and number of parallel interrupts. We could however say that "100ms real-time deterministic" type of applications can be written on Windows CE. Today Windows CE is not suited for mission critical systems.

### Compatibility with Windows NT

Windows CE uses a subset of the widely accepted Win32 API. Applications developed for Windows NT must be re-compiled in order to run on a Windows CE platform. But Windows CE uses the same development tools (Visual Studio), therefore it minimises the burden of porting an application.

Modifications on the original code may be necessary for Windows CE because Windows CE has a limited support for graphic functions. For example, the display size is limited to small resolution (640x480 or less) and thus graphical user interface must be modified for this limited space. Windows CE is really designed to operate without a standard PC keyboard. Therefore, existing Windows applications must be modified to cope with touchscreen or function key operator input.

## WINDOWS CE TOOLKIT FOR INDUSTRIAL COMPUTING

Industrial market will accept a WindowsCE solution only if it is well packaged. Know-how of the OS, good documentation, additional programming tools, and a good hardware support is all what an industrial customer will ask.

GESPAC has prepared such a package and named it a Windows CE Board Support Package. See figure 4. It includes the following features:

- Windows CE, ported to x86 based industrial PCs (new OAL)
- Manages CPU, timers, memory and peripherals
- Graphic drivers for Chips&Technology 655xx family in 640x480x256 or less
- Serial/TCPIP/PPP communication drivers
- COM1: Download & Debug line between Host and Target
- COM2: local debugging display

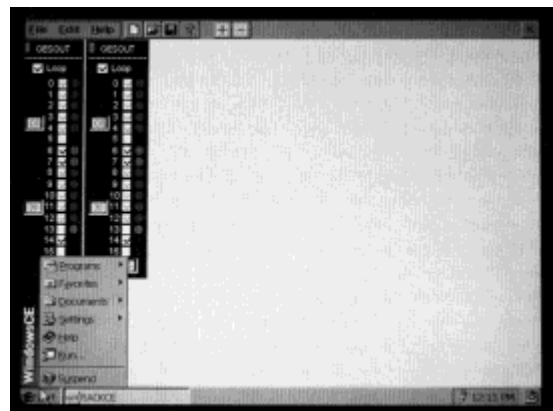


Figure 3. Windows CE Toolkit for Industrial Computing

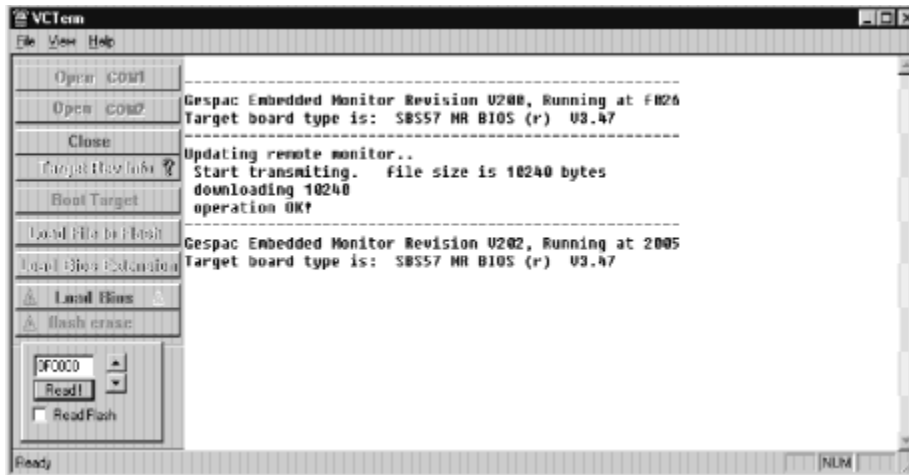


Figure 4. VCTERM tool from GESPAC

- PS/2 mouse
- Flash EPROM support and Flash File System (use Flash as a normal disk)
- CAN fieldbus driver and libraries
- COM3/COM4 serial drivers
- Some applications: BlocNotes, Reversi, Solitaire, Regedi ... (source code of these applications is included in Visual C++ for Windows CE)
- VCTERM tool: a GESPAC programming tool running on Windows NT Host system, to generate a new Boot, download new program and files into Flash, communicate with Windows CE GESPAC target, download new Windows CE images. See figure 5.
- Additionally, GESPAC has implemented a PCMCIA driver for COTS (Commercial-Off-The-Shelf) plug-in PC cards
- Touch Screen
- Further support depending on custom requirements

## AN INDUSTRIAL END-USER APPLICATION

The real life application example we are speaking about is the process control of an industrial robotic machine. This system must control position, move and manipulation of the robotic machine.

### Requirements of the customer

The requirements specified by the customer were the following:

- Multitasking, multithreading OS
- Soft real-time capability
- CAN interface for I/Os
- Embeddable Graphical User Interface
- Standard development tools
- No disk
- Low price
- Good hardware manufacturer support
- Complete solution provider
- Long term availability

### Windows CE was the best suited

Several Operating Systems have been proposed and compared. In many traditional real-time systems, the embeddable GUI was missing or not created from standard development tools. The recognised hard real-time features of most traditional real-time systems were not necessary. The Windows CE Operating System was the best suited for this kind of application. Customer chose the "Windows CE Toolkit for Industrial Computing" from GESPAC to base his application on. See figure 6 showing a view of the complete PanelPC system.

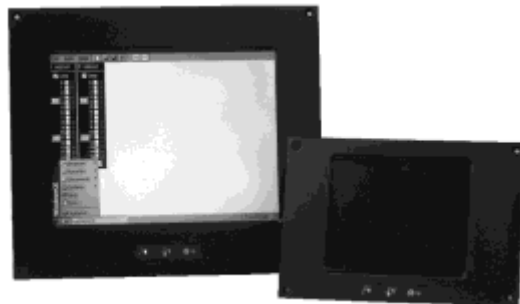


Figure 5. PanelPC running Windows CE

## THE WINDOWS CE PANELPC

This Panel PC is designed for OEMs equipment used in the most severe industrial environments. This system is the only PanelPC available on the market fully qualified for operation from -25 Celsius to +70 Celsius. The 486 CPU, chipset, memory controller, FLASH EPROM Solid State Disk, serial ports, keyboard controller and IDE interface are all certified for industrial temperatures.

The system is ideally suited for severe industrial environment such as train equipment, embedded computers systems, real time controllers, mobile equipment, crane electronic controllers, remote data acquisition systems, aircraft, and military command systems.

GESPAC's Panel PC is based on a custom design core CPU board fully certified for extended temperature operation. This board includes a 486-DX2 or DX4 CPU,

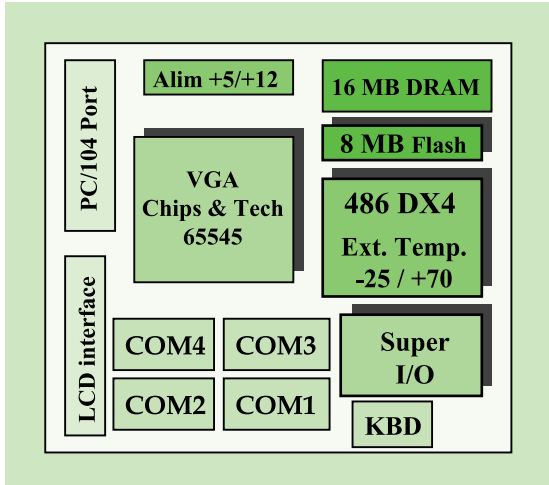


Figure 6. PanelPC diagram

up to 16 MB of DRAM and FLASH EPROM combined. The user interface includes a 10.4-inch TFT display with a resolution of 640x480 at 256 colours using the Chips & Technology 65545 VGA controller. A fully sealed keyboard or an optional touch-screen is also mounted onto the system. Various power supply options can be installed (DC/DC or AC/DC units ranging from 24VDC to 220 VAC). The enclosure is based on a small, compact and rugged mechanical form factor ideally suited for applications with limited space available (L: 300mm H: 280mm W: 70mm).

Using this platform, Windows CE can boot directly from the on-board FLASH EPROM disk. This feature is very interesting for rugged applications where rotating elements, such as hard disk, cannot be used due to severe shocks and vibrations conditions.

A PC/104 port is available for inexpensive plug-in functions such as PCMCIA, Ethernet, fieldbus controller or local I/O interfaces. The PC/104 port provides the flexibility to implement any of these or other specific functions, for example industrial I/Os.

The CPU board has been designed for the most severe operating environment. Not only it is fully certified for extended temperature operations. This board has also been certified for shocks & vibrations, humidity levels, moisture, EMC levels according to the EN 50155 railway specifications.



Figure 7. Panel PC from GESPAC

GESPAC offers a complete support for all the peripheral devices implemented on the PanelPC. System designers can focus on developing their applications without worrying on the availability of the driver for their applications.

### Extended Temperature Functions

The PanelPC hardware uses special features to control the temperature. For example, LCD displays are not designed for -25 Celsius operation. No LCD is available on the market for extended temperature operation. For these applications, the PanelPC is designed to remain operational but with not all its functionality. This degraded operational mode guarantees predictable behaviour of the system under the most severe environment.

For example, GESPAC has implemented a special function so that the display is disabled for sub-zero temperature but the system still operates at extreme temperature. An I2C bus is also available in the system for connecting temperature sensors in order to control the different devices.

Additionally, a day / night switch is available to control the luminosity of the display.

To control all these operations, a monitoring application running under Windows CE is available with the PanelPC kit. This feature allows to control, at the software level, all the devices of the PanelPC.

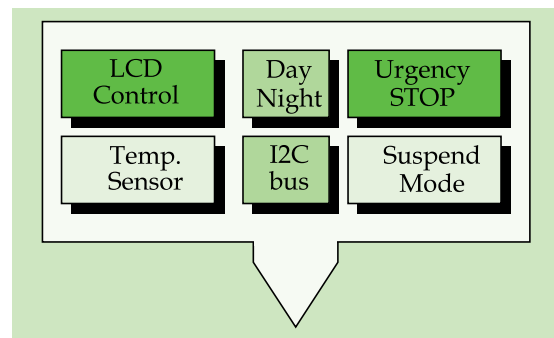


Figure 9: extended temperature functions

### CONCLUSION

Windows CE is going to be THE Operating System of the next millennium. Industrial applications will take benefit from this new technology. It is really suited for embedded & soft real-time industrial PCs. It also makes life easier for embedded system designers. GESPAC commitment is to be a complete solution provider. GESPAC is one of the first OEM providers with such a good experience in this market. ■

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