

# Special Report: Choosing an RTOS

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**[In the market for a commercial RTOS? This article provides an overview of RTOSes and how you can select the one for your project. You'll also find a list of vendors and their products and tips on comparing the products in the Embedded.com Buyer's Guide.](#)**

Engineers often use the term real-time to describe computing problems for which a late answer is as bad as a wrong one. These problems are said to have deadlines, and embedded systems frequently operate under such constraints. For example, if the embedded software that controls your anti-lock brakes misses one of its deadlines you might find yourself in an accident. So it's extremely important that the designers of real-time embedded systems know everything they can about the behavior and performance of their hardware and software.

The designers of real-time systems spend a large portion of their time worrying about worst-case performance. They must constantly ask themselves questions like: what is the worst-case time between the human operator pressing the brake pedal and an interrupt signal arriving at the processor? What is the worst-case interrupt latency? And what is the worst-case time for the software to respond by triggering the braking mechanism? Average or expected-case analysis simply will not suffice.

Most of the commercial embedded operating systems available today are designed for possible inclusion in real-time systems. In the ideal case, their worst-case performance is well understood and documented. To earn the distinctive title "Real-Time Operating System" (RTOS), an operating system should be deterministic and have guaranteed worst-case interrupt latency and context-switch times. Given these characteristics and the relative priorities of the tasks and interrupts in your system, it is possible to analyze the worst-case performance of the software using a technique such as rate monotonic analysis (see "Rate Monotonic Scheduling" by David Stewart and Michael Barr, March 2002, p.79).

An operating system is said to be deterministic if the worst-case execution time of each of its system calls is calculable. An operating system vendor that takes the real-time behavior of its product seriously will usually publish a datasheet providing the minimum, average, and maximum number of clock cycles required by each system call. These numbers may be different for different processors, but it is reasonable to expect that if the algorithm is deterministic on one processor it will be so on any other. (The actual times may differ, however.)

Interrupt latency is the total length of time from an interrupt signal arriving at the processor to the start of the associated interrupt service routine (ISR). When an interrupt occurs, the processor must take several steps before executing the ISR. First, the processor must finish executing the current instruction. Next, the interrupt type must be recognized. This is done by the hardware and does not slow or suspend the running task. Finally, and only if interrupts are enabled, the CPU's context is saved and the ISR associated with the interrupt is started.

Of course, if interrupts are ever disabled (say within a system call), the worst-case interrupt latency increases by the maximum amount of time that they are turned off. Each operating

system will internally disable interrupts in several places and for different lengths of time, so it is important that you know what your system's requirements are. One real-time project might require a guaranteed interrupt response time as short as 1 $\mu$ s, while another may require only 100 $\mu$ s.

The third real-time characteristic of an operating system is the amount of time required to perform a context switch. This is important because it represents overhead across your entire system. For example, imagine if the average execution time of any task before it blocks is 100ms but that the context-switch time is also 100ms. In that case, fully one half of the processor's time is spent within the context-switch routine!

Again, there is no magic number and the actual times are usually processor-specific, since they are dependent on the number of registers that must be saved and where. Be sure to get these numbers from any operating system vendor you are thinking of using. That way, there won't be any last minute surprises.

### **Selection process**

Considering the cost of engineering time these days, a few thousand dollars is a bargain for a commercial RTOS. A wide variety of operating systems are available to suit most projects and pocketbooks. See the vendor listings following this article or go to [www.embedded.com/bg](http://www.embedded.com/bg) for more detailed product information.

Commercial operating systems form a continuum of functionality, performance, and price. Those at the lower end of the spectrum offer just a basic preemptive scheduler and a few other key system calls. These operating systems are usually inexpensive, come with source code that you can modify, and do not require payment of any royalties.

Operating systems at the other end of the spectrum typically include a lot of functionality beyond the basic scheduler. These operating systems can be quite expensive, though, with startup costs ranging from \$10,000 to \$50,000 and royalties due on every copy shipped in ROM. However, this price often includes free technical support and training and a set of integrated development tools.

Between these two extremes are the operating systems that have modest up-front costs and/or royalties, but do not include source code; technical support may cost extra. Most commercial operating systems fall in this category.

With such a variety of operating systems and features to choose from, it can be difficult to decide which is the best for your project. Try putting your processor, real-time performance, and budgetary requirements first. These are criteria that you cannot change, so you can use them to narrow the possible choices to a smaller set of products. Then contact all of the vendors of the remaining operating systems for more detailed technical information.

At this point, many people make their decision based on compatibility with their choice of cross-compiler, debugger, and other development tools. But it's really up to you to decide what additional features are most important for your project. No matter what you decide to buy, the basic kernel will be about the same. The differences will most likely be measured in processor support, minimum and maximum memory requirements, availability of add-on software modules (for example, networking protocol stacks, device drivers, and flash filesystems), and compatibility with third-party development tools.

The best reason to choose a commercial operating system is the advantage of using something that is better tested and, therefore, more reliable than a kernel you have

developed inhouse. So one of the most important things you should be looking for from your OS vendor is experience.

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### RTOS Product Names

- AMX (KADAK)
- AvSYS Real-Time (Avocet Systems)
- Blackhawk OS (Blackhawk)
- BlueCat Linux (LynuxWorks)
- BSD/OS (Wind River)
- C Executive (JMI Software)
- CMX-RTX, CMX-Tiny+, CMX-RTXS (CMX Systems)
- Diamond (3L)
- DR-DOS 7.03 (The SCO Group)
- eCos (Red Hat)
- Embedix RT (Lineo)
- embOS (SEGGGER)
- ERCOSEK (ETAS)
- eRTOS (JK Microsystems)
- EUROS (EUROS Embedded Systems)
- Eyrx (Eyring)
- Fusion RTOS (DSP OS)
- icWORKSHOP (Integrated Chipware)
- INTEGRITY (Green Hills Software)
- iRMX III, iRMX/INtime for Windows (TenAsys)
- Jbed (esmertec)
- Linux for Real-Time (OnCore Systems)
- LynxOS (LynuxWorks)
- mC/OS-II (Micrium)
- Microwave OS-9 (RadiSys)
- MontaVista Linux (MontaVista Software)
- NetBSD Embedded (Wasabi Systems)
- Neutrino (QNX Software Systems)
- Nucleus uiPLUS, Nucleus OSEK, Nucleus PLUS (Accelerated Technology/Mentor Graphics)
- On Time RTOS-32 (On Time Software)
- OnCore OS (OnCore Systems)
- OSE RTOS (OSE Systems)
- OSEKturbo (Metrowerks/Motorola)
- OSEKWorks (Wind River)
- PDOS (Eyring)
- pF/x (FORTH)
- PharLap Real-time ETS Kernel (VenturCom)
- pmDOS (Micro Digital)
- Precise/MQX (ARC International)
- PSMX Portable smx (Micro Digital)
- pSOSystem 2.5/3 (Wind River)
- PSX (JMI Software Systems)
- PXROS (HighTec EDV-Systeme)

- QNX (QNX Software Systems)
- Quadros (RTXC)
- QuickTask (Softtools)
- RAVEN (Aonix)
- REAL/IX PX (MODCOMP)
- Realogy Real-Time Architect (LiveDevices)
- REALOS (Fujitsu Microelectronics)
- Real-Time OS: DSP/BIOS (Texas Instruments)
- Red Hat Embedded (Red Hat)
- REDICE-Linux (REDSonic)
- ROM-DOS (Datalight)
- RTexec (Applied Dynamics International)
- RTEMS (OAR)
- RTKernel (On Time Software)
- RTKernel-RISC (EBSnet)
- RTX for Windows (VenturCom)
- RTX51/RTX51 Tiny, RTX166/RTX166 Tiny (Keil)
- Salvo (Pumpkin)
- SKYmpx (SKY Computers)
- smx/smx++ (Micro Digital)
- Spartos (Ardro Engineering)
- Starlight Linux (Auriga)
- SuperTask (Lantronix)
- TargetOS (Blunk Microsystems)
- ThreadX (Express Logic)
- Tics (TICS Realtime)
- TimeSys Linux/RT, Real-Time Mach (TimeSys)
- TronTask3.0 (Lantronix)
- TTPos (TTTech Computertechnik)
- TurboTask (Softtools)
- TxOS - Titanic (Incantation Systems)
- VRTX (Mentor Graphics)
- VSPWorks (Wind River)
- VxWorks, VxWorks AE (Wind River)
- Windows CE .NET, Windows XP Embedded (Microsoft)

## RTOS Vendor List

The following vendors make commercial real-time operating systems (RTOSes). Product names are included directly below the vendor URLs and also are listed alphabetically in the sidebar. For detailed information about these RTOSes, visit the Embedded.com online Buyer's Guide. You'll find the real-time operating systems category under software.

### 3L

104 (2F3) Spring Gardens  
Edinburgh EH8 8EY  
Scotland  
United Kingdom  
44-131-662-4333  
<http://www.shen.myby.co.uk/three/>  
Diamond

### Applied Dynamics International

3800 Stone School Rd.  
Ann Arbor, MI 48108  
United States  
(734) 973-1300  
<http://www.adi.com/>  
RTexec

### Auriga

1 Overlook Dr., Unit 2  
Amherst, NH 03031  
United States  
(603) 673-2300  
<http://www.auriga.com/>  
Starlight Linux

### Blunk Microsystems

6576 Leyland Park Dr.  
San Jose, CA 95120  
United States  
(408) 323-1758  
<http://www.blunkmicro.com/>  
TargetOS

### DSP OS

327 Dahlonga Rd., Ste. 1801A  
Cumming, GA 30040  
United States  
(678) 208-2250  
<http://www.dspos.com/>  
Fusion RTOS

### ETAS

3021 Miller Rd.  
Ann Arbor, MI 48103  
United States  
(888) 382-7462  
<http://www.etasinc.com/>  
ERCOSEK

### Accelerated Technology (Embedded Division of Mentor Graphics)

720 Oak Circle Dr. E.  
Mobile, AL 36609  
United States  
(800) 468-6853  
<http://www.acceleratedtechnology.com/>  
Nucleus uiPLUS, Nucleus OSEK,  
Nucleus PLUS

### ARC International

2025 Gateway Place, Ste. 140  
San Jose, CA 95110  
United States  
(408) 437-3400  
<http://www.arc.com/>  
Precise/MQX

### Avocet Systems

P.O. Box 490  
Rockport, ME 04856  
United States  
(800) 448-8500  
<http://www.avocetsystems.com/>  
AvSYS Real-Time

### CMX Systems,

12276 San Jose Blvd., Ste. 119  
Jacksonville, FL 32223  
United States  
(904) 880-1840  
<http://www.cmx.com/>  
CMX-RTX, CMX-Tiny+, CMX-RTXS

### EBSnet

39 Court St.  
Groton, MA 01450  
United States  
(800) 428-9340  
<http://www.ebsnetinc.com/>  
RTKernel-RISC

### Express Logic

11423 W. Bernardo Ct.  
San Diego, CA 92127  
United States  
(888) THREADX  
<http://www.expresslogic.com/>  
ThreadX

### Aonix

5040 Shoreham Place  
San Diego, CA 92122  
United States  
(800) 97-AONIX  
<http://www.aonix.com/>  
RAVEN

### Ardro Engineering

431 Ohio Pike, Ste. 210N  
Cincinnati, OH 45255  
United States  
(800) 369-1009  
<http://www.ardro.com/>  
Spartos

### Blackhawk

3 Eves Dr., Ste. 316  
Marlton, NJ 08053  
United States  
(877) 983-4514  
<http://www.blackhawk-dsp.com/>  
Blackhawk OS

### Datalight

21520 30th Dr. SE, M/S 110  
Bothell, WA 98021  
United States  
(800) 221-6630  
<http://www.datalight.com/>  
ROM-DOS

### esmertec

Lagerstrasse 14  
Duebendorf, 8600  
Switzerland  
+41 1 823 89 00  
<http://www.esmertec.com/>  
Jbed

### Eyring

6912 S. 185 W.  
Midvale, UT 84047  
United States  
(800) 937-7367  
<http://www.eyring.com/>  
Eyrx, PDOS

**EUROS Embedded Systems**

Campestrasse 12  
Nuremberg D-90419  
Germany  
+49-911-300328-0  
<http://www.kaneff.de/>  
EUROS

**Green Hills Software**

30 W. Sola St.  
Santa Barbara, CA 93101  
United States  
(805) 965-6044  
<http://www.ghs.com/>  
INTEGRITY

**Integrated Chipware**

1861 Wiehle Ave., Ste 300  
Reston, VA 20190  
United States  
(888) 430--2447  
<http://www.chipware.com/>  
icWORKSHOP

**KADAK**

206 - 1847 West Broadway Ave.  
Vancouver, BC V6J1Y5, Canada  
(604) 734-2796  
<http://www.kadak.com/>  
AMX

**Lineo**

390 S. 400 W.  
Lindon, UT 84042  
United States  
(800) 490-9448  
<http://www.lineo.com/>  
Embedix RT

**Mentor Graphics**

8005 SW Boeckman Rd.  
Wilsonville, OR 97070  
United States  
(800) 547-3000  
<http://www.mentor.com/>  
VRTX  
See also Accelerated Technology

**Micro Digital**

2900 Bristol St. #G-204  
Costa Mesa, CA 92626  
United States  
(800) 366-2491  
<http://www.smxinfo.com/>  
pmDOS, smx/smx++, PSMX Portable  
smx

**FORTH**

5155 W. Rosecrans Ave., Ste.1018  
Hawthorne, CA 90250  
United States  
(800) 55-FORTH  
<http://www.forth.com/>  
pF/x

**HighTec EDV-Systeme**

Feldmannstr. 98  
Saarbruecken, 66119  
Germany  
+49 (0)681 92613-0  
<http://www.hightec-rt.com/>  
PXROS

**JK microsystems**

1403 Fifth St., Ste. D  
Davis, CA 95616  
United States  
(530) 297-6073  
<http://www.jkmicro.com/>  
eRTOS

**Keil Software**

1501 10th St., Ste. 110  
Plano, TX 75074  
United States  
(800) 348-8051  
<http://www.keil.com/>  
RTX51, RTX51 Tiny, RTX166, RTX166  
Tiny

**LiveDevices**

The Innovation Centre  
York Science Park  
York, England YO10 5DG  
United Kingdom  
+44 1904 562580  
<http://www.livedevices.com/>  
Realogy Real-Time Architect

**Metrowerks/Motorola**

9801 Metric Blvd.  
Austin, TX 78758  
United States  
(512) 997-4700  
<http://www.metrowerks.com/>  
OSEKturbo

**Microsoft**

One Microsoft Way  
Redmond, WA 98052  
United States  
(425) 882-8080  
<http://www.microsoft.com/>  
Windows CE .NET, Windows XP  
Embedded

**Fujitsu Microelectronics**

3545 N. First St.  
San Jose, CA 95134  
United States  
(800) 866-8608  
<http://www.fujitsumicro.com/>  
REALOS

**Incantation Systems**

Northern Ireland Science Park,  
Queen's Rd., Queen's Island,  
Belfast, Ireland  
United Kingdom  
+44 (0)28 90534560  
<http://www.incantationsystems.com/>  
TxOS -- Titanic

**JMI Software Systems**

Box 237  
Dover, NH 03821  
United States  
(408) 287-7090  
<http://www.jmi.com/>  
PSX, C Executive

**Lantronix**

15353 Barranca Pkwy.  
Irvine, CA 92618  
United States  
(949) 453-3990  
<http://www.lantronix.com/>  
SuperTask, TronTask3.0

**LynuxWorks**

2239 Samaritan Dr.  
San Jose, CA 95124  
United States  
(800) 255-5969  
<http://www.lynuxworks.com/>  
LynxOS, BlueCat Linux

**Micrium**

949 Crestview Circle  
Weston, FL 33327-1848  
United States  
(954) 217-2036  
<http://www.micrium.com/>  
mC/OS-II

**MODCOMP**

1650 W. McNab Rd.  
Ft. Lauderdale, FL 33309 U.S.A.  
(954) 974-1380  
<http://www.modcomp.com/>  
REAL/IX PX

**MontaVista Software**  
1237 East Arques Ave.  
Sunnyvale, CA 94085  
United States  
(408) 328-9200  
<http://www.mvista.com/>  
MontaVista Linux

**OSE Systems**  
1731 Technology Dr.  
San Jose, CA 95110  
United States  
(866) 844-RTOS  
<http://www.ose.com/>  
OSE RTOS

**Quadros**  
275 Grove St., Ste. 2-400  
Newton, MA 02466  
United States  
(866) 879-QUAD  
<http://www.quadros.com/>  
RTXC

**REDSonics**  
1740 E. Garry Ave., #212  
Santa Ana, CA 92705  
United States  
(866) 899-1688  
<http://www.redsonic.com/>  
REDICE-Linux

**The SCO Group**  
355 S. 520 W., Ste. 100  
Lindon, UT 84042  
United States  
(801) 426-5001  
<http://www.sco.com/>  
DR-DOS 7.03

**Texas Instruments**  
12500 TI Blvd.  
Dallas, TX 75243  
United States  
(800) 477-8924  
<http://www.ti.com/>  
Real-Time OS: DSP/BIOS

**TTTech Computertechnik**  
Schoenbrunnerstrasse 7  
Vienna, A-1040  
Austria  
+43 1 585 34 34 0  
<http://www.tttech.com/>  
TTPos

**On Time Software**  
88 Christian Ave.  
Setauket, NY 11733  
United States  
(888) 667-8200  
<http://www.on-time.com/>  
On Time RTOS-32, RTKernel

**Pumpkin**  
750 Naples St.  
San Francisco, CA 94112  
United States  
(415) 584-6360  
<http://www.pumpkininc.com/>  
Salvo

**RadiSys**  
5445 NE Dawson Creek Dr.  
Hillsboro, OR 97124  
United States  
(800) 950-0044  
<http://www.radisys.com/>  
Microwave OS-9

**SEGGER Microcontroller System**  
Kleinhülsen 4  
Hilden, NRW 40721  
Germany  
+49-2103-8958-99  
<http://www.segger.com/>  
embOS

**Softools**  
81 Norwood Rd.  
West Hartford, CT 06117  
United States  
(860) 236-4201  
<http://www.softools.com/>  
TurboTask, QuickTask

**TICS Realtime**  
3333 Bowers Ave., Ste. 130  
Santa Clara, CA 95054  
United States  
(408) 727-3100  
<http://www.cris.com/~Tics/>  
Tics

**VenturCom**  
5 Cambridge Center  
Cambridge, MA 02142  
United States  
(617) 661-1230  
<http://www.vci.com/>  
PharLap Real-time ETS Kernel, RTX  
for Windows

**OnCore Systems**  
795 Main St.  
Half Moon Bay, CA 94019  
United States  
(866) 4-ONCORE  
<http://www.oncoresystems.com/>  
Linux for Real-Time, OnCore OS

**QNX Software Systems**  
175 Terence Matthews Crescent  
Kanata, ON K2M 1W8  
Canada  
(800) 676-0566  
<http://www.qnx.com/>  
QNX, Neutrino

**Red Hat**  
2600 Meridian Pkwy.  
Durham, CA 27713  
United States  
(866)-2REDHAT, x3004  
<http://www.redhat.com/>  
eCos, Red Hat Embedded

**SKY Computers**  
27 Industrial Ave.  
Chelmsford, MA 01824  
United States  
(800) 486-3400  
<http://www.skycomputers.com/>  
SKYmpx

**TenAsys**  
1600 NW Compton Dr., Ste. 104  
Beaverton, OR 97006  
United States  
(877) 277-9189  
<http://www.tenasys.com/>  
iRMX III, iRMX for Windows, INtime  
for Windows

**TimeSys**  
4516 Henry St., Ste. 401  
Pittsburgh, PA 15213  
United States  
(888) 432-TIME  
<http://www.timesys.com/>  
TimeSys Linux/RT, Real-Time Mach

**Wasabi Systems**  
104 W. 14th St., 4th Flr.  
New York, NY 10011  
United States  
(646) 638-2424  
<http://www.wasabisystems.com/>  
NetBSD Embedded

**Wind River**

500 Wind River Wy.

Alameda, CA 94501

United States

(800) 545-WIND

<http://www.windriver.com/>

BSD/OS, OSEKWorks, pSOSystem

2.5, pSOSystem 3, VSPWorks,

VxWorks, VxWorks AE

**OAR**

4910-L Corporate Dr.

Huntsville, AL 35805

United States

(256) 722-9985

<http://www.rtems.com/>

RTEMS