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# Evolution of MODCOMP's Single Board Computers

***This article provides insight into the Single Board Computers produced by MODCOMP. This includes SBC Development Background (Description of VMEbus SBC's, Description of PICMG SBC's, Operating System Information), Benchmark Comparisons and Typical Applications.***

In the late 1980's MODCOMP® began to migrate away from proprietary computer hardware and operating systems with the vision of being the premier supplier of open hardware and software systems for the real-time market and process control environment.

During the product planning, evaluation and implementation phase, MODCOMP engineers evaluated several available system bus architectures and processor families and decided to base MODCOMP's open system technology upon the VMEbus combined with Motorola processor based Single Board Computers. The design engineers rejected the other bus technologies because of their lack of wide spread use in the real-time market. MODCOMP did, however, make the REAL/IX® operating system available on Multibus II platforms for limited use only.

While one team of engineers worked on the next generation hardware, a second team of real-time operating system engineers began the complex task of creating the first real-time UNIX® operating system. Using AT&T System V.3, the engineers began the task of making the base kernel fully preemptive and deterministic. The result of the software effort was the world's first real-time UNIX operating system that was fully compliant with the System V Interface Definition (SVID) and passed the System V Verification Suite (SVVS) and POSIX (FIPS 151.1) conformance. Rounding out the product set was the REAL/STAR® family of high performance VMEbus open systems. The REAL/IX operating system is a fully preemptive, deterministic, priority based real-time operating system. The REAL/IX operating system supports dynamic load balancing, symmetric multiprocessing (SMP), the ability to queue I/O and to bypass system calls to write directly to a physical device. Major kernel changes were implemented, while still maintaining compliance with the System V Verification Suite, providing optimized performance with single board computers (SBCs) based upon the Motorola 68030, 88100 (single, dual or quad) and 88110 (single or dual) processor.

With Motorola's announcement that they were discontinuing support and development on the 88K series of RISC computers and reassigning their engineering staff to the Power PC development effort, MODCOMP began to reevaluate the processor strategy. The first consideration was the porting of REAL/IX to the Power PC as there appeared to be many similarities in the underlying chip design and MODCOMP shared a strong alliance with Motorola. With further investigation, MODCOMP engineers finally selected the Intel Pentium family of processors. A detailed analysis of the industry showed that the Intel Pentium processor family was gaining much greater market acceptance and had a greater market share than all the other processors combined. Concurrent with this realization, several single board computer manufacturers (General Micro Systems, Xycom, VMIC, and Trenton to name a few) began producing SBCs based upon the Pentium family (Pentium, Pentium Pro, Pentium MMX and Pentium II.)

Since MODCOMP already had the REAL/IX operating system available on the Intel 386/486 processors in a Multibus II environment, the migration from 68K and 88K REAL/IX was simplified because it was only necessary to merge the VMEbus support with the existing Intel processor support. It became apparent that this base kernel could be improved and enhanced to support all the features of the Pentium family of processors in the VMEbus environment. During 1994 and 1995, MODCOMP shipped a number of beta copies of the REAL/IX PX™ operating system kernel to existing MODCOMP users for evaluation and comment. With positive feedback from our user base, MODCOMP continued to enhance and improve the kernel and in 1997 announced and released the REAL/IX PX operating system. The REAL/IX PX operating system supports the latest SBC features, including ultra SCSI, auto sensing 10/100Base Ethernet, PCI Mezzanine Card (PMC), PC-104 and Card Bus (PCMCIA). For customers upgrading systems from the Motorola based REAL/STAR to the Intel Pentium based REAL/STAR II, MODCOMP offers REAL/IX PX drivers that support the previous generation of I/O cards (IEEE-488, DR-11W, MIL-1553, HSD, REAL/MAX™ bridge and MODCOMP's MODACS™ and MODACS 90 products). This continued support is in keeping with MODCOMP's long standing tradition of evolution and reuse of existing hardware and applications, not revolution where everything is scrapped for something new. Supporting the existing hardware with appropriate driver's eases the migration of existing REAL/STAR system from Motorola to Intel based SBCs.

Several of the old I/O interfaces are no longer supported because the technology is dated and current products provide superior performance. The previous devices that are no longer supported are the Motorola MVME327 SCSI interface which gave way to the Ultra SCSI interface, the VLAN-E2 Intelligent Ethernet which has been replaced by several 10/100Base devices in PMC, PC-104, PCMCIA, PCI and ISA formats and the Motorola MVME332 Intelligent Communications

Interface which has been replaced by 2, 4, 8 and 16 port interfaces available in PMC, PCMCIA, PCI and ISA formats.

The REAL/STAR II family of single board computers is available for upgrades to existing REAL/STAR VMEbus systems or as new VMEbus systems. In addition to offering continued support for the VMEbus systems, MODCOMP also offers several PCI Industrial Computer Manufactures Group (PICMG) compliant systems as well as stand-alone PCIbus Server and Workstation computers. REAL/IX PX is delivered with all single board computers (new applications or upgrades) and complete systems. REAL/IX PX is also available for use on existing PCIbus systems where a more robust real-time operating system is required.

## VMEBUS SINGLE BOARD COMPUTERS

MODCOMP presently offers a variety of VMEbus single board computers that are used to build complete systems or to upgrade the processor in an existing VMEbus system. This wide range of offerings allows MODCOMP to tailor systems to meet the exacting requirements (processor speed, multiple processors, memory and built-in I/O features) of the end user while providing continued support of and offering very high performance VMEbus systems. The boards offered provide a range of features to meet any user's performance specifications and monetary requirements.

The Model 7100-1-064 SBC provides one 200 MHz Pentium with 64 MB (maximum, using two 72-pin, 32MB SIMMs) of memory. The SBC is a double wide 6U VME card set that provides the basic PC/AT features (2 serial, parallel, keyboard, mouse floppy disk controller and EIDE interface) and two proprietary option boards that plug into an onboard option site. The first option module, Model 7201-1, supports 10BaseT or 10Base2. The second option module, Model 7203, supports 10BaseT/100BaseTx and Ultra SCSI. Additionally, the Model 7100 supports a modular I/O carrier module, Model 7001, providing one PMC and one PC/104 expansion site. Adding the I/O carrier option makes the SBC into a triple wide VME card set. Options for the I/O carrier module include Model 7201-2 a PC-104 secondary 10BaseCombo (RJ-45, BNC and AUI) Ethernet module; Model 7204 PMC 10BaseT/100BaseTX (auto sensing) Ethernet module; Model 7220-1 or 7220-2 PMC Ultra SCSI; and 7250 PMC eight channel asynchronous interface board. The 200 MHz Pentium processor and the limited 64 MB memory feature provides a high performance, low cost SBC that is ideal for use in a remote terminal unit (RTU) as the support for multiple Ethernet interfaces makes it easy to configure network redundancy. At the same time, this SBC provides very robust performance with either EIDE or SCSI devices allowing the user to create a full distributed RTU capable of withstanding a network loss and by storing data on the local disk, it minimizes network activity.

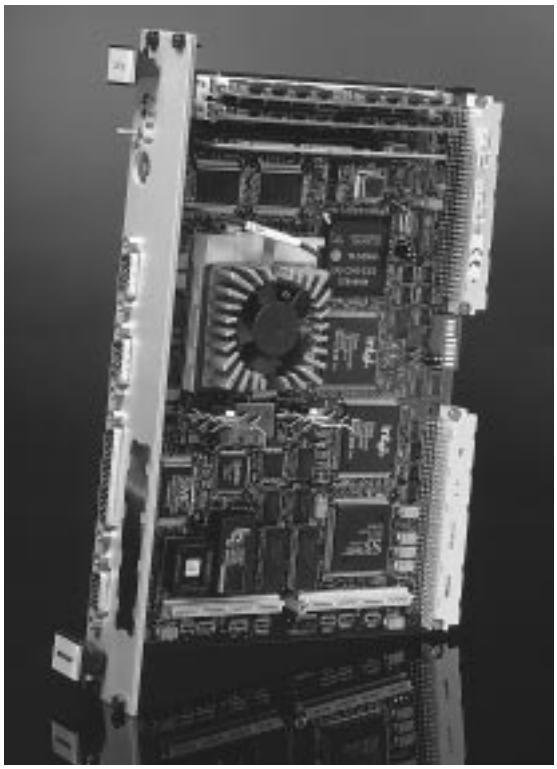

*Figure 1. Model 7100 Intel Pentium Upgrade Kit for REAL/STAR Computers*

The next VME offering is the Model 7102-X-200-XXX SBC. This SBC is available in six configurations with either one or two 200 MHz Pentium® processors and either 64 MB, 128 MB or 256 MB of EDO memory. The SBC is a double wide 6U VME format card set which provides all the PC/AT features (2 serial, parallel, keyboard, mouse floppy disk controller and EIDE interface), an integrated Ultra SCSI interface (Adaptec), 10BaseT/100BaseTx Ethernet (auto sensing Tulip Chip) and two PMC expansion sites. PMC options include: a model 7220-X secondary Ultra SCSI interface; a model 7204 auto detect 10BaseT/100BaseTx Ethernet; a model 7250-X 4, 8, or 16 port asynchronous communications interface, and a Model 7290 PCMCIA adapter for type I, II, and III cards. This SBC supports two 200 MHz Pentium processors and is an excellent replacement for the Motorola MVME188 25 MHz single, dual or quad 88100 processor SBC and the Motorola MVME197 50 MHz single or dual 88110 processor. It can also be used to design new VMEbus systems that must meet the demanding requirements of the real-time process control and simulation market.

Another VME SBC is the Model 7103-1-XXX-XXX. This SBC is available in four configurations with either a 180 or 200 MHz Pentium Pro processor and either 32 or 64 MB EDO parity memory dual ported to the VMEbus. This SBC is also a double wide 6U VME format card set which provides all the PC/AT features (PCI SVGA controller, 2 serial, parallel, keyboard, mouse floppy disk controller and EIDE interface), integrated PCI fast/wide SCSI-II controller with front panel interface, and on-board fast Ethernet with options for 10BaseT, 10Base2, and 100BaseTX interfaces. This SBC also includes one PMC expansion site. The VMEbus interface is based upon the Newbridge/Tundra chip set and includes byte swapping hardware for Little-Endian and Big-Endian data interfacing. This SBC supports the same PMC modules as the Model 7102. This the

only Pentium Pro processor available and is a good choice for users who need more performance than that offered by the single 200 MHz Pentium and less performance than the dual 200 MHz Pentium. The basic features are equivalent to those of Models 7102 and 7105.

The final VME SBC offering is the Model 7105-X-XXX-XXX. This SBC is available in six configurations with either one or two 200 or 233 MHz Pentium MMX processors and either 64, 128 or 256 MB of EDO memory. The SBC is a double wide 6U VME format card set which provides all the PC/AT features (SVGA video, 2 serial, parallel, keyboard, mouse floppy disk controller and EIDE interface). It also includes an Advanced Graphics Display (AGD) port, an integrated Ultra SCSI interface (Symbios), an auto detect 10BaseT/100BaseTx Ethernet interface (Intel Chip) and two PMC expansion sites. This SBC uses the Universe II chip set to interface to the VMEbus and supports the same PMC modules as Models 7102 and 7103. Equipped with the Intel 200/233 MHz Pentium MMX technology, this SBC provide a very high performance solution for users requiring advanced graphics and MMX functionality. The two PMC expansion sites provide several interface options within the SBC bus architecture without involving the VMEbus.

At this time, a fifth VME SBC is being developed and will be released later this year. It will be similar to Models 7102 and 7105 but will provide one or two 266 or 300 MHz Pentium® II processors.

## PICMG COMPLIANT SINGLE BOARD COMPUTERS

With the migration to the Intel processor products and the PCI bus architecture, and the support of VMEbus for process control environments, MODCOMP has entered the PCI Industrial Manufacturers Group (PICMIG) market. PICMG compliant systems are designed for installation in extremely hostile environments (dust, heat, RFI noise, etc.); utilize a passive backplane architecture allowing for abbreviated Mean-Time-To-Repair (MTTR); and are available with redundant, hot swap power supplies for extended Mean-Time-Between-Failures (MTBF). PICMG systems are available as 19-inch rack mounted systems; as desktop systems or as free-standing systems. PICMG systems are available with a variety of backplane options, which provide a mix of PCI and ISA bus slots. MODCOMP offers PICMG Single Board Computers with Pentium and Pentium Pro processors and various memory options.

The Model 7101-X-XXX-XXX is available in four configurations offering 166 or 200 MHz Pentium processor and either 64 or 128 MB of EDO or memory. The SBC is PICMG 2.0 compliant and has the following features: 166 or 200 MHz Pentium processor, Intel Triton-II (430HX) chip set, on-board Super VGA video interface with 2MB display memory, supporting non-interlaced video resolutions up to 1280 x 1024 and 16.8 million colors at 1024 x 768. This SBC also supports 256 MB of ECC EDO DRAM, 512 KB synchronous burst SRAM L2 cache, floppy and dual PCI EIDE drive interface, on-board PCI bus mastering fast SCSI-2 (Symbios) interface, two 16550 compatible serial ports and one ECP/EPP parallel port. The SBC contains a Board Temperature Monitor System (BTMS), a watch dog timer and will support up to a 20-slot passive backplane. This board, coupled with one of the PICMG chassis is an excellent processor for harsh environments where the midrange level of performance is required and the necessary I/O devices are available in either the PCI or ISA format.

The Model 7104-X-XXX-XXX is also available in four configurations offering either single or dual 200 MHz Pentium Pro processors and either 64 or 128 MB of EDO memory. This SBC is also PICMG 2.0 compliant and has the following features: 180 or 200 MHz Pentium Pro processor, Intel 440FX chip set, up to 256 MB of EDO/Hyper mode memory using 60ns 36-bit wide gold finger SIMM DRAM, and 512 KB of dedicated internal 64-bit wide non-blocking second level (L2) running at full CPU core speed. The SBC has on-board PCI Local Bus Interface (2.1 compliant), floppy and dual PCI EIDE drive interfaces, two 16C550 compatible serial ports, one ECP/EPP parallel port and a Universal Serial Bus (USB). The SBC contains a Board

Temperature Monitor System (BTMS), a watch dog timer and will support up to a 20-slot passive backplane. This board, coupled with one of the PICMG chassis is an excellent processor for harsh environments where a high performance system/server is required and the necessary I/O devices are available in either the PCI or ISA format. Because of the lack of space on this SBC, an optional SVGA interface is required if connecting to a monitor and a SCSI interface is required if other than EIDE support is required.

## OPERATING SYSTEM SUPPORT

All VMEbus and PCI bus SBC are shipped with the REAL/IX PX operating system for those customers requiring robust, deterministic performance in real-time applications. All SBC are Microsoft Windows and Windows NT capable and can also be configured for dual boot where the user can select between REAL/IX PX, Windows or Windows NT.

## BENCHMARK COMPARISONS

When the 68030, 88100 and 88110 SBC's were coupled with the REAL/IX operating system, they provided extremely high performance with very deterministic response with typical interrupt latency in the fractional millisecond range. The 25 MHz 68030 had interrupt latency from 5-105 ms and process dispatch latency from 52-347 ms . If the processor was performing a floating point operation when an interrupt occurred, the FP registers had to be saved resulting in the reported worst case numbers. These values compare to HP-UX at 206-401ms and 655-1991 ms; Harris CX/RT at 5-125 ms and 90-430 ms; and MASSCOMP (Now Concurrent) RTU at 5-1005ms and 1605-11606 ms. The same interrupt latency and process dispatch latency test on the 25 MHz 88110 showed that the interrupt latency was 20-160 ms and the process dispatch latency was 46-560 ms . The increase is the result of the way interrupt and context switches are handled in CISC and RISC processors. Whetstone testing shows that the 25 MHz 68030 executes the single precision benchmark at the rate of 2.19 Mwhets and the double precision benchmark at the rate of 1.90 Mwhets. The same benchmark on a single 25 MHz 88100 yielded a single precision of 21.3 Mwhets and a double precision of 11.2 Mwhets. The dual 25 MHz 88100 yielded a single precision of 4.24 Mwhets and a double precision of 22.0 Mwhets while the quad 25 MHz 88100 SBC yielded a single precision of 85.7 Mwhets and a double precision of 44.0 Mwhets.

With the above information in mind, Diagram 1 shows the relative performance of the various Motorola and Pentium processors tested. The number shown is a composite number generated by the Byte Magazine benchmark test. When viewing the results on the single and dual processors, you will note that the second and/or fourth processor does not significantly change the result. This is the result of an anomaly in the Byte Magazine benchmark. The performance when comparing the SCSI with the EIDE performance is because of the fact that the eight-bit SCSI was being used. The REAL/IX PX operating system now supports SCSI-II Fast and Wide and Ultra SCSI Fast and Wide. We expect that the new SCSI interfaces will exceed the EIDE performance.

MODCOMP will soon conduct further benchmark testing which will compare REAL/IX PX performance with Wind River's VX Works, and other popular real-time operating system and executives.

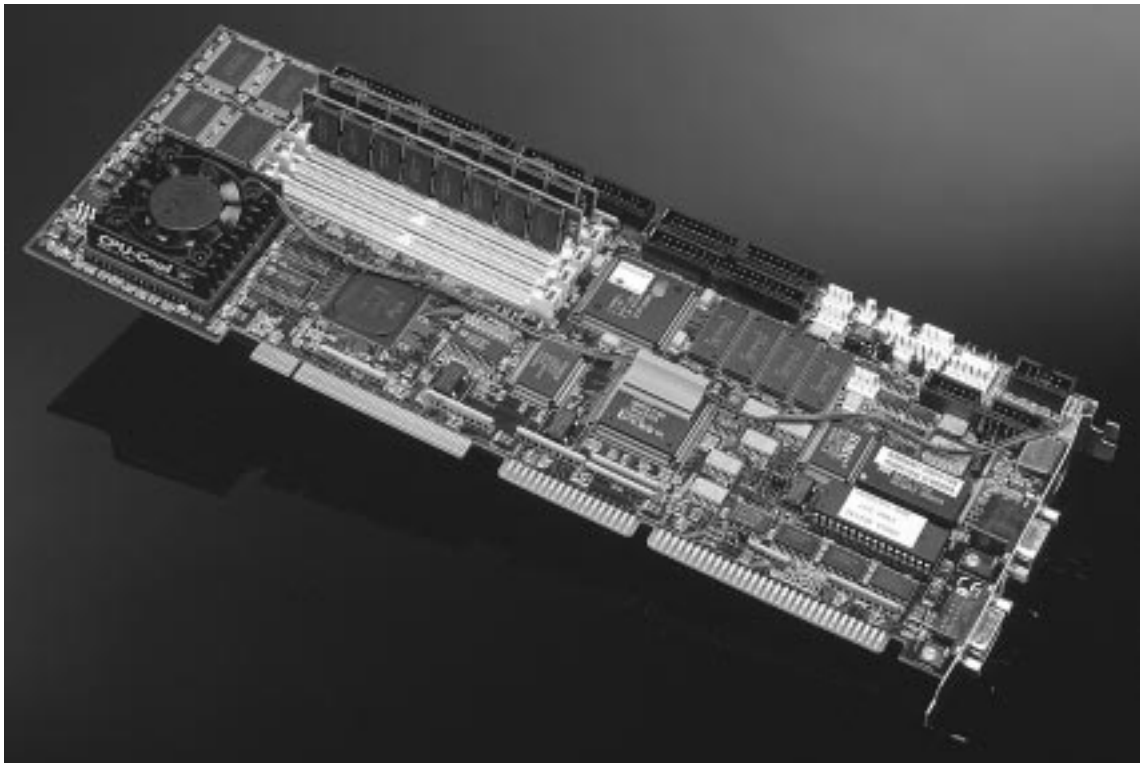

*Figure 2. Model 7101 Intel Pentium Industrial Single Board Computer*

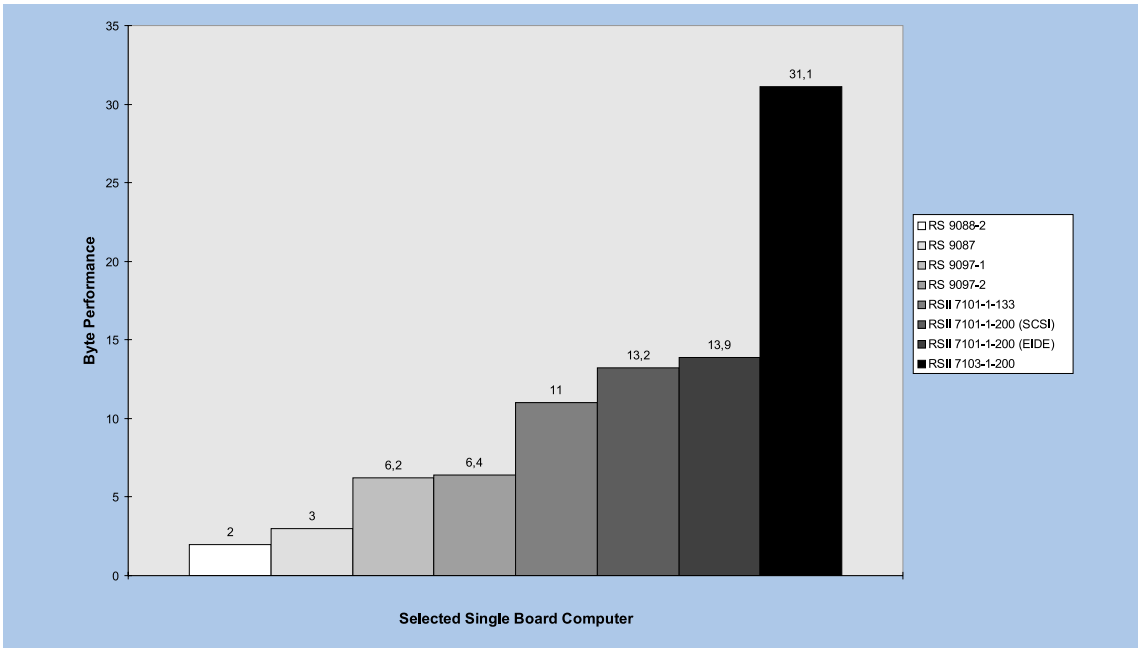


*Figure 3. REAL/IX versus REAL/IX PX*

MODCOMP continues to follow the trends in the single board computer industry and has partnered with General Micro Systems, Inc. a Rancho Cucamonga, California one of the world's leading independent suppliers of high performance embedded single board computers. MODCOMP also has established a relationship with Xycom, Inc., Trenton Technology, Inc. and VMIC and will continue to incorporate COTS products into the MODCOMP product set as demand dictates.

## TYPICAL APPLICATIONS

MODCOMP systems have traditionally been used in demanding hard-real time applications such as those found in steel rolling mills, aluminum rolling mills, aluminum reduction facilities, steel reduction facilities, waste and drinking water plants, hydro-electric generation plants, nuclear power plants, NASA applications and defense applications.

With the migration into open systems, MODCOMP was also able to move into the simulation market as a result of the features of the REAL/IX operating system, which has a fully preemptive real-time kernel. Boeing Defense and Space selected MODCOMP to provide some custom interfaces that would allow a REAL/STAR computer to communicate with the flight computer used on various missiles as a part of the Avionics Obsolescence Activity (AOA). MODCOMP was selected because the kernel could meet the demanding time constraints and MODCOMP Customer Engineering was able to replicate the three critical (non-standard) interfaces.

Jet Propulsion Laboratories also selected MODCOMP, after extensive demonstrations and bench marking, to provide the system that control the Deep Space Network (DSN). In the DSN, REAL/STAR computers retrieve data from the spacecraft, record it at the tracking station and transmit it back to Pasadena, California for processing. REAL/STAR computers also position the antenna to the correct coordinates and track the spacecraft when it is within range of the spacecraft. These systems also send command data back to the spacecraft.

A recent application was the upgrade of a hydroelectric facility. The facility, Virginia Electric Power Company's Bath County works, is unique in that using a dual reservoirs, power is generated during the day when demand is high and during the night, when low demand forces a surplus of nuclear power, the turbines are reversed and pump the water from the lower reservoir to the upper reservoir for use the next day.

REAL/STAR computers were selected for control of rocket engine testing at NASA, White Sands Test Facility, Las Cruces, New Mexico and for fusion testing at DOE contractor, General Atomics in San Diego, California. In addition to Boeing, Lockheed Martin, Orlando, Florida is using REAL/IX as the operating system of choice in the flight simulators because of the robustness of REAL/IX.

With the advent of faster and faster microprocessors, it is now possible to support soft-real time applications with a number of operating system, but our experience is that a real-time operating system is required for hard real-time applications. MODCOMP welcomes the opportunity to evaluate any customer's requirements and can offer either a hard real-time or soft real-time solution. MODCOMP the Idea Integration Company. ■

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*Ronald E. Beers, Senior Sales Analyst, has been with MODCOMP since 1984. Mr. Beers has over 24 years experience with hard real-time applications. Prior to joining MODCOMP, Mr. Beers managed the implementation of the California Highway Patrol's first Computer Aided Dispatch operation in Los Angeles, CA. Mr. Beers was the task leader for the team that developed the computer systems for tracking Highway Patrol equipment and resources during the 1984 Los Angeles Olympic Games.*