Volume 5
Number 1
Spring 2001

PC/104 Embedded Solutions

The Journal of Modular Embedded Computing

www.pc104-embedded-solns.com

An OpenSystems Publication

CEO Challenge

The duality of Microsoft's position on Linux

PC/104 flat panel products

PRESORTED
STANDARD
US POSTAGE PAID
COLUMBUS WI
PERMIT NO 73

Coming of age:

A trinity of technology PC/104 – Linux – GPS

By Doug Stead

Figure 1. MZ104 board in the hand – One of the first five original beta test MZ104 boards. This unit was designed, built, and tested in less than 60 days. Shown without the SO_DIMM memory module, main memory can be added in sizes 2 to 64 Mbytes using fast SDRAM. Heat is not a problem as the MachZ chip consumes less than 0.5 Watts of saving battery power, or engineering additional heat dissipation in sealed enclosures.

What the world needs now, aside from love, sweet love, are more reliability, efficiency, and ubiquity. Over the last decade, our company has been a witness and a participant in the maturation of not only our own technology of embedded x86 PC/104 single-board computers and peripherals, but also the acceptance and widespread adoption of Linux, a freely available x86 open-source-code operating system, and the development of a military navigation system called the Global Positioning System. Together these three technologies have converged providing the critical mass for the development and deployment of reliable and inexpensive solutions to numerous vexing problems. Only a few years ago, solutions to these problems would have been beyond the average engineer or scientist. Today, first-year engineering students take all three for granted and happily use them without a second thought.

PC/104 has become the de facto standard for embedding x86 hardware. It defines both a physical board size (3.6 inches x 3.8 inches) with predetermined connector locations, and an electrical specification for using the standard ISA BUS signal technology optimized for embedded applications.

In today's world of rapidly opening and closing windows of opportunity, system integrators, solution providers, university laboratories, and inventors are using PC/104. PC/104 is an ideal solution due to its cost effectiveness, high reliability, and reduced development time. These advantages combined with its ease of development, testing, and post deployment service support makes it the ideal hardware package for many applications. As luck would have it, my company, Tri-M Engineering, has just released the MZ104, a brand new sibling to the world of PC/104 products. (See Figure 1.)

The MZ104 is a 486+ PC/104 single-board computer, which is a fully compliant PC/104 CPU engine. It embodies all standard I/O most often required in the typical black-box embedded solution. It will be of particular interest to those looking to embed moderate performance x86 technology into hostile, mobile, industrial, military, medical, and telecom environments, or where a desktop system is not suitable.

At the heart of the MZ104 is a 133 MHz 486 processor buried within the MachZ silicon. This PC-on-a-chip, measuring 35mm x 35mm, contains all the transistors and logic gates to produce the functionality of a multi-card solution (See Figure 2). The MachZ chip uses 0.25-micron technology and is packaged in a 388-pin Ball Grid Array (BGA). When operating at top speed of 133 MHz, it consumes less than 0.5 Watts of power. It can also be throttled down to a low 33 MHz and achieve considerably greater power efficiency. This is very desirable in applications where the unit is powered by battery or solar panels.

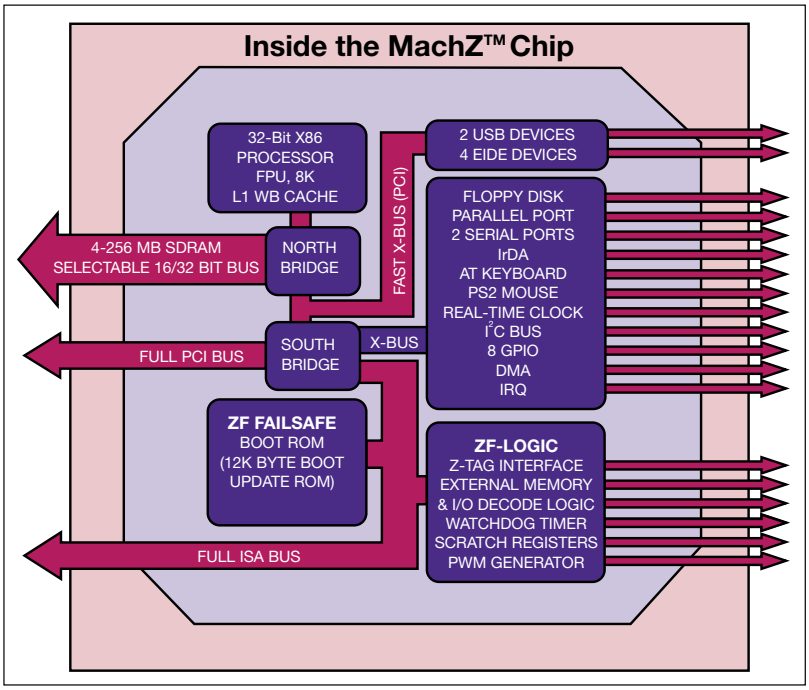

Figure 2. What's inside the MachZ – The MachZ PC-on-a-Chip is the first auto-booting PC-on-a-Chip containing the full functionality of a single-board computer in a 388BGA package. Its FailSafe system architecture is crash immune and is the only System-on-a-Chip that comes bundled with a full Phoenix BIOS and Linux O/S or WindRiver VxWorks RTOS. The MachZ silicon is made up of a number of different core logic masks, which when combined into one chip costing less the 50.00 USD, make it incredibly attractive to even small production run projects.

Copyright ©2001 CompactPCI Systems. All rights reserved.

The MZ104 was designed using a six-layer circuit board, nothing special in that. On closer inspection, one finds this generation of single-board computer has all the components mounted on the topside, thereby reducing production expenses. The MZ104 goes through the robotic chip shooter only once and then directly into the re-flow ovens and out to the quality assurance department. The consequent reduction in manufacturing time results in lower costs and thus translates to a more cost-effective solution for the end user. The ability to install all the silicon on one side also translates into a much-reduced component count. When viewed from an overall cost of ownership perspective, this reduction in components gives the end user additional advantages, such as a corresponding increase in reliability and reduced post deployment maintenance expenses. Another advantage is a much longer in-service life, as failure rates for all electronics can be directly related to the number of discrete components, and as a general rule of thumb, fewer components translates into increased longevity and reduced infant mortality.

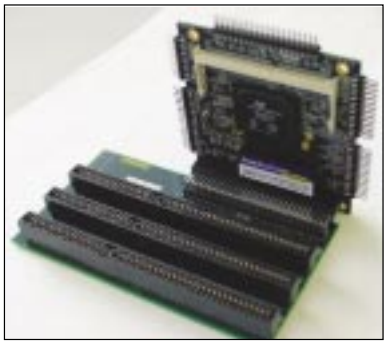

Figure 3. ISA Passive Backplane – PC/104 uses the same ISA signals found in the standard desktop PC. The one minor difference is a low 4mA current on the PC/104 data bus whereas the desktop environment specifies 20mA. The MZ104 pictured here is coupled with the Tri-M ISA104IO bus extender card allowing for quick and easy hardware prototyping with up to three ISA cards.

The MZ104 is currently one of the most cost effective PC/104 boards in the world with a single unit price of $249.00 USD without RAM. Moderate volumes of 1,000 units per year substantially decrease the price below the $200.00 level. It is mind boggling to contemplate the economies of scale for an annual usage between 10,000 – 100,000 units. The MZ104 is available with a 1, 2, or 4 Mbytes/sec BIOS flash device. The Phoenix BIOS takes up the first 256K. The balance of this flash is usable for program storage and as a boot device. Also supported are the 8 to 288 Mbytes/sec DiskOnChip (DOC) devices from M-Systems Inc. The DOC can also be used as the boot device, and has, in my opinion, the best Flash File Systems (FFS) in the world. The secret of M-Systems technology lies in their "wear leveling" and "data management" algorithms. This intellectual property essentially resolves the problems associated with using flash devices in applications that write data frequently and in high volumes.

Figure 4. 64 Mbytes/sec DiskOnChip with support floppy disk – A 64 Mbytes/sec DiskOnChip and its support software. The DOC is by far the most widely supported bootable flash device on the market today with almost every manufacturer of single-board computers offering support for this family of products. Due to its ease of use, scalability, and reliability, the M-Systems product line makes an ideal digital storage device for new advanced set-top box and other embedded applications.

Main memory (RAM) is provided using a 144-pin SO_DIMM module. The MZ104 can be configured to operate with RAM memory in sizes 2 to 64 Mbytes/sec of fast SDRAM. Developers and system integrators are thus able to mix and match various sizes of Flash, DOC, and RAM. These configuration options provide a flexible and scalable environment in which to develop and test products. When it comes time to build a production version for deployment into the real world, the hardware platform can be reduced in cost to meet the minimum requirements, no more and no less than needed. The circuit and gerbber files required to construct SO_DIMM modules are obtainable at www.Tri-M.com.

Most, if not all, "black boxes" operate somewhere in the real world collecting and storing data and sometimes acting on this data, even if nothing more than uploading is required. These devices exist because they can be cost justified. When dealing with mid-size to larger production projects, it is imperative to only embed the necessary resources. Business abhors paying for a Rolls Royce when a Chevy will do the job just as reliably and just as well.

Figure 5. Black Box solution: Three views – Tri-M's Can-Tainer was designed specifically to protect PC/104 hardware solutions from G-force shock and continuous vibration found in mobile applications such as helicopters, planes, trains, and automobiles. The electronic package is dual isolated with both corner and external rubber mounts. By the time you read this, a new larger version of this product line jointly developed by Versa Logic Corporation and Tri-M will be in development. Hopefully, this "Versa-Tainer" will be ready to show you at this spring Embedded System Conference in San Francisco.

As an x86 platform, the MZ104 can run thousands of applications with perhaps hundreds of the operating systems developed over the last twenty years. The MZ104 hardware features include:

- Adjustable 486+ CPU clock from 33 ~ 133 MHz, including an FPU
- Standard Phoenix BIOS with extensions for additional embedded features
- 1, 2, or 4 Mbytes/sec of onboard Flash memory, of which the first 256K is used for the BIOS with the remainder available for OS and application software
- 2 ~ 64 Mbytes/sec of SDRAM memory using SODIMM modules
- 8 ~ 288 Mbytes Flash disk support using M-Systems' DiskOnChip Millennium
- Two standard IDE drives and two floppy drives
- Two RS232 serial ports supporting data rates to 1.5 Mbytes/sec
- One parallel port, EPP, ECC, and IEEE 1248 support
- One USB port
- One Infrared (I/R) port
- One I^2C bus
- 8- and 16-bit PC/104 self-stacking expansion bus

Due to the use of the ZF Linux Devices "MachZ" chip, the MZ104 also allows the OEM access to a plethora of useful utilities and extensions to the standard Phoenix BIOS, including:

- Advanced system resource management
- Advanced power management, including 1.2 functions
- Plug-N-Play (Win98)
- A FailSafe boot recovery system
- Dual Watchdog timers
- ZFlash allows user software to be loaded above BIOS in Flash device
- ZFlash OS Loader
- Universal Serial BUS Host Controller
- Infrared support
- Remote Management from PC Host

Estimates by industry insiders predict that the expanding market for embedded x86 devices will be many times greater than the total number of desktop systems currently in use. A very substantial number of these embedded solutions will use PC/104 as the hardware foundation layer. Yes, I know there are millions of desktops in the world, but stop and consider for a moment what is happening in certain segments of the embedded market. Market segments such

Copyright ©2001 CompactPCI Systems. All rights reserved.

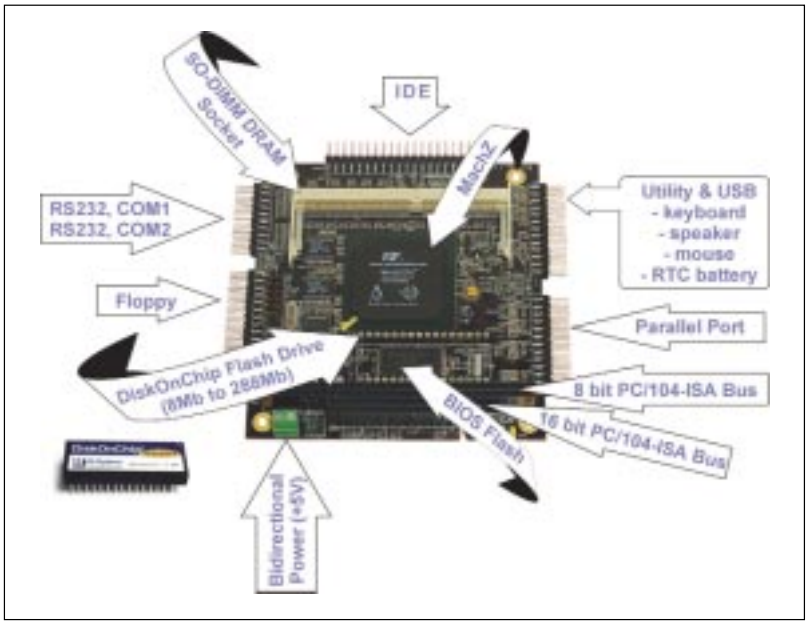

Figure 6. MZ104 annotated – For those of you who aren't familiar with the PC/104 standard, this 3.6 inch x 3.8 inch single-board computer has all the standard functionality need for most embedded applications. You may be wondering why there is no video, very few black box solutions require a screen and if one is needed it is simple and inexpensive to add an LCD or SVGA controller card on top or below the CPU.

as Internet appliances and wireless communications technology will invariably bring an endless stream of cyber-connected devices.

The question now is, why use an x86 platform, let alone PC/104? The answer is simple. With the number of PC-on-a-chip devices, like the MachZ, coming to the market, the era of priced-right PC/104, full functionality modules is here. Fuse these modules with a Real-Time Linux or a Plain Jane Linux kernel that is known to be scalable, stable, reliable, supportable, and cost effective. Add in twenty years of legacy development software tools with a fast flowing river of skilled and talented people (a mile wide and a mile deep) who wouldn't seriously consider using x86 and PC/104 as their recipe for success.

Embedding Linux – Open Source alternative

Linux is a clone of the venerable but costly UNIX operating system. Linus Torvalds, a guru and one of the founding fathers of the open source movement, developed Linux from scratch. As a freely distributable operating system, it has all the features and more that one would expect in an expensive full-fledged UNIX. Linux has evolved to include true multitasking, virtual memory, shared libraries, demand loading, shared copy-on-write executables, efficient memory management, X Windows and TCP/IP networking, to name only a few of its desirable and useful features.

Torvalds originally developed Linux to run on an 80386 CPU, the first true 32-bit x86-based PC. Today it also runs on Compaq Alpha AXP, Sun SPARC, UltraSPARC, the entire Motorola family of 68000 CPUs, the PowerPC, ARM, Hitachi SuperH, Mips, DEC VAX, and the Intel IA-65 just to name a few. What a long journey for an operating system with such humble beginnings. This journey proves Linux is portable, scalable, reliable, and in great demand by the consumer.

Figure 7. MZ104 with Penguin – The MZ104 is capable of booting Linux or any of a host of other operating systems. As with standard desktop hardware, the MZ104 can boot and run programs from a floppy disk, or an IDE hard disk drive, in addition to supporting a boot from DiskOnChip or easily booting your code embedded in Flash memory above and within the BIOS Flash device.

Linux in its purest form refers specifically to the free-release kernel(s). It can also be correctly thought of as an entire operating system. From an embedded point of view, Linux is a kernel and most likely the entire operating system code that a PC/104 CPU module runs. It controls hardware, manages files, separates processes, and controls what other tasks need to be managed in any particular device. This is also the part that is free, providing you have the knowledge to roll your own kernel to support your particular hardware configuration. There are also numerous commercial "distributions" on the market. These distributions offer we lowly hardware types, added enhancements to the standard free release, including utilities and applications, which make life a lot easier. These enhancements also include installation tools, and a Graphical User Interface (GUI), which facilitates customizing individual "ports" of the kernel to match the hardware and software requirements.

The latest open source kernel is version 2.4, which was released in January of this year. It replaces the highly successful 2.2 kernel, which was released in January 1999. OEMs and other vendors of critical service applications such as firewalls, SCADA, robotics, and communication devices have avidly embraced Linux en masse. All mainstream manufacturers of enterprise level servers and desktop providers offer and support Linux on their hardware. Although the 2.4 release has focused primarily on improving performance on larger machines such as IBM's S/390, Linux 2.4 has also expanded support in areas important to the embedded x86 community. Features such as Universal Serial Bus hardware and files larger than 2 GB are now incorporated in the 2.4 kernel release. For the hard core Linux "bit-heads," you may be interested to know that at www.tummy.com/kernelpool/ you can enter your guess as to when the 2.6 kernel will be released.

For those interested in a great Linux reference site containing the latest news and information, I highly recommend you visit www.linuxdevices.com, founded by Rick Lehrbaum, who is certainly no stranger to the world of embedded PC/104. Rick and I had a chance to meet and renew our acquaintance at the Linux World Trade Show in New York this past January. Rick cofounded Ampro Computers with Dave Feldman, now President of ZFLinux Devices Inc., (the company that makes the MachZ). Both of these gentlemen are credited with the creation of the PC/104 standard, but perhaps more importantly, made it an open architecture and thereby created an entire industry. My staff and I gratefully

Copyright ©2001 CompactPCI Systems. All rights reserved.

thank them for creating the industry that puts bread on our tables.

Real Time Linux

Linux is not inherently a real-time operating system. Although from my perspective, a real-time operating system is defined by its ability to run the application software within the envelope of hardware resources. Hence, Linux in many cases may be the appropriate OS in a particular project. If you find your solution is unable to keep up reliably and perform the required task, there are three main areas you need to investigate for performance improvements. They are: hardware, application software, and the operating system. The solution may be to throw faster hardware at it ($$), or perhaps a re-write of the application software ($$), or to invest in one of many enhanced real-time Linux distributions ($$). Most of the real-time Linux distributions offer the system integrator the ability to control their software environment. This control includes the ability of the operating system to monitor and change individual tasks, with schedulers and pre-emptive function enhancements, thereby allowing jobs of lower priority to be deferred and the reallocation of CPU resources to functions that are more critical. These processes minimize the latency delays from an "event" to "response," while keeping throughput consistent with the product's objective.

As with most things in life, there are many ways to add "real-time" Linux OS functionality and capabilities to your embedded x86 project. Your solution will probably be some combination of the hardware, operating systems, or application software. The final deciding factors will take into account numerous variables, but when the project goes beyond the beta and proof of concept stage, cost effectiveness will be a major criterion in the decision-making process.

So how does one go about using a Linux distribution such as BlueCat, Redhat, RedSonic, Embedix, TurboLinux, or VxWorks into DRAM at boot time on our much-touted MZ104? The steps to install an Image (a Linux kernel tuned to the specific hardware) are straightforward but do require a moderate knowledge of embedded hardware and software. The process is as follows:

Install the image(s) into the available space above the BIOS in the onboard Flash device. To do this, one need only run the utility AMDFLASH.EXE, available from ZFLinux Devices, and the job is done automatically.

Write small loaders in the style of an option ROM, using examples provided by ZF Linux Devices. The loader finds the image, loads it into DRAM, and executes the image code.

In the BIOS setup, specify where your small loader is located in the Flash. If you specify no loader, then the INT 19H occurs and a normal boot results. If you specify a loader, a transfer is made to that loader.

The image loaded will invariably construct its own file system in the DRAM, or you can use the DiskOnChip with its own file system.

The GPS (Global Positioning System)

The U.S. Department of Defense owns the GPS infrastructure but its output signals are available for the publics' use. Briefly, here's how it works.

Figure 8. Current state of GPS technology – A collection of readily available commercial-off-the-shelf GPS hardware, this assortment of handheld receivers from Garmin and Lorance are shown together with a collection of Tri-M magnetic and bulkhead mounting Mighty-Mouse 1 & II and SkyMaster active antennas. Also shown are two OEM GPS receivers, an electronic compass, a DGPS, and Coast Guard data correction beacon receiver. Note: the center middle antenna was adopted by US Marine Corps Warfighting Labs, which deployed more then 900 of these units to collect tracking data on individual soldiers involved in large scale training exercises.

There are 24 GPS satellites, plus three spare satellites, orbiting the Earth at 10,600 miles above the surface. These satellites have been placed in orbit so that from any given point on the Earth's surface, a minimum of four satellites will be in view above the local horizon. Each of these satellites is really an extremely accurate atomic clock together with a computer and a radio. Each satellite keeps track of its own orbit and position and continually broadcasts its position, ID, and time signal. A GPS receiver, such as the Royaltek REB2100, computes its location by triangulation using the position and bearing information from a minimum of three to as many as twelve satellites. This setup makes it possible for anyone with a GPS receiver to pinpoint his or her geographic location. The location accuracy ranges from 10 to 100 meters for most off-the-shelf equipment. With little difficulty, one can increase accuracy by using various types of signal data correction hardware. The two major accuracy improvements are Differential GPS (DGPS) and the Wide Area Augmentation System (WAAS), the latest correction technology. If you are willing to pay the price, there is an abundance of software correction methods for post processing GPS data, which can yield accuracy down to the sub-centimeter level. Keep in mind that the standard GPS output from the least expensive receiver is still much more accurate than most maps you can purchase.

When a GPS receiver locks onto a minimum of three satellite signals, it can calculate a two-dimensional latitude and longitude location. With four or more satellite signals, the GPS receiver can also calculate altitude. If the GPS receiver is operating in a mobile application, it can also provide ground speed and direction of travel information. With storage and manipulation of this GPS data, the user can calculate a myriad of other useful information; things like cross winds, tides, flows, drift, acceleration, and deceleration to name just a few. Added to other known Geographic Information Systems (GIS), a wide variety of future events such as ETA, point of no return, and time to alternate, now become predictable.

Most OEM GPS devices and the better handheld receivers provide useable data output in the form of a once-per-second serial data stream. These 1 Hz serial data messages are usually provided in one of two protocols, an industry standard called NMEA-0183 and the manufacturer's specific binary interface. The National Marine Electronics Association (NMEA) sets the standard for electrical and data protocol interfacing for marine instrumentation. All GPS manufacturers support the NMEA standard.

Under the NMEA-0183 Standard, all characters are ASCII text, except the carriage

Figure 9. GPS receivers circa 1999 and 2000 – Two GPS receivers in the hand show the progress made during the last 18 months in this arena. The larger unit, an REB12R (71 x 41 x 7mm), is a 12-channel receiver, DGPS-ready, and the smaller unit is an REB2100 (40 x 31.5 x 6.5 mm) DGPS- and WAAS-ready receiver and weighs a minuscule 8.6 grams. Both receivers will reacquire satellite signal lost due to the effects of urban canyon or foliage environments in an incredible 0.1-second. Both of these OEM receivers are priced below 100.00 USD in small quantities.

Copyright ©2001 CompactPCI Systems. All rights reserved.

return and line feed. NMEA-0183 data is sent at 4800 baud, 8 bits, 2 stop bits, and no parity. The data is transmitted in the form of sentences. Each sentence starts with a $, a two-letter talker ID, a three letter sentence ID, and is followed by a number of data fields separated by commas, and terminated by an optional checksum and a carriage return/line feed. A sentence may contain up to 82 characters including the $ and CR/LF.

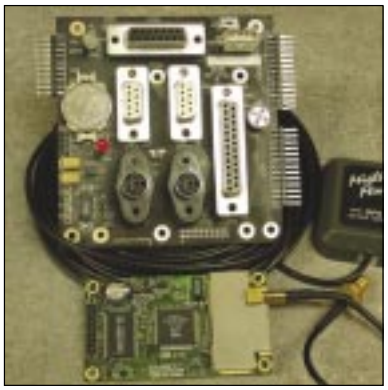

Figure 10. MZ104 I/O board with PlugNplay REB12R GPS and antenna – In addition to hosting either the REB12R or REB2100 GPS receivers with all the TTL level signal conversion and DGPS signal input, MZ1041O solves one of the most vexing problems in building black box solutions. Cabling and connectors for I/O are by far the bane of most embedded projects. The MZ1041O card shown here accommodates connector support for dual serial, parallel, PS2 keyboard and mouse, speaker, reset, battery backup, and USB output from the MZ014.

Global Positioning System Fix Data (GGA) is a common GPS sentence. A typical GGA may look like the following: GGA,123519,4807.038,N,01131.324,E,1, 08,0.9,545.4,M,46.9,M, , ,

GPS equipment is widely used by the military, business, science, and industrial fields to say nothing of its acceptance by the general public for recreational uses. With the demand for this kind of accurate data in so many applications, GPS receiver technology has become so inexpensive that most people can afford to purchase a GPS receiver. This is a new and developing area of technology that will make a significant impact on the world in which we live. Geodesy and Geomatics Engineering is now a red-hot university degree in a red-hot market. Two Canadian Universities are at the cutting edge of this emerging discipline.

The universities are The University of New Brunswick, Faculty of Engineering, www.unb.ca/GGE/, headed by a friend, Dr. Richard Langley, Professor of Geodesy & Precision Navigation; the University of Calgary, headed by Dr. K.P. Schwarz, Professor of the Department of Geomatics Engineering, www.ensu.ucalgary.ca/. For those of us no longer able to party, study, and earn a degree, a practical source of valuable information is at www.joe.mehaffey.com/, run by another friend, Joe Mehaffey, and his pal Jack Yeazel.

Data	Descriptive field meaning
GGA,	Sentence name in this case = Global Positioning System Fix Data
123519,	Fix taken at 12:35:19 UTC
4807038,N,	Latitude 48 deg 07.038' North
01131324,E,	Longitude 11 deg 31.324' East
1	Fix quality: 0 = invalid
	1 = GPS fix
	2 = DGPS fix
08,	Number of satellites being tracked
0.9,	Horizontal dilution of position
545.4,M,	Altitude, Meters, above mean sea level
46.9,M,	Height of geoid (mean sea level) above WGS84 ellipsoid
(empty field),	Time in seconds since last DGPS update
(empty field),	DGPS station ID number

Figure 11. 2001 GPS technology soon to be released – Shortly after this article is published, Tri-M will release the REB2200 from Royaltek. This is an amazingly small, 23mm x 23mm, 3.3VDC 12-channel GPS receiver. Using the SirfStar-II chip set, it supports both DGPS and WAAS demodulation for greater output accuracy. Tri-m's Micro Sykmaster shown on top, is an active ceramic patch GPS antenna built around a 24Db gain, low-noise amplifier that consumes a mere 11mA.

So what will this trinity of technology bring?

This trinity of technology brings the promise of unlimited opportunity. The embedding of x86 using PC/104 technology provides the launch pad for new product development and growth. Individuals and companies involved with embedded PC/104 are unquestionably in one of the most challenging and fast paced areas within the high tech arena. Tri-M Engineering and Tri-M Systems Inc. have invested eighteen years in building long-term relationships with our clients, suppliers, and yes, even our competitors. The embedded market is expanding so rapidly that success is within the grasp of anyone who can provide reliability, efficiency, and ubiquity.

Our clients, and the clients of our clients, are willing to pay for practical, reliable, and effective solutions that address issues such as monitoring and controlling usage levels and load sharing/shedding. This trinity of technology is ideally suited to take advantage of the ever-increasing cyber connectivity. Historically, the hardware and dedicated communication links used in remote applications were often very expensive Micro VAX, or other mini computers. Not only was the capital cost of this hardware and the monthly communication expense a major consideration; but also the OS and application software, custom application modifications, and ongoing maintenance often exceeded the capital cost many times over.

It is now possible to achieve the same or often a better level of reliability using the MZ104, Linux, and less expensive application software. With the ever-increasing pressure on all businesses to become more efficient and to maintain or improve the bottom line, companies are more willing to

Copyright ©2001 CompactPCI Systems. All rights reserved.

Figure 12. A typical black box solution: an embedded router – A typical black-box solution, these embedded routers are used in a mobile mining application, where available power is noisy with occasional spikes of several hundred jewels to say nothing of the constant shock and vibration the unit is subjected to day in and day out. Inside each is a PC/104 stack of cards consisting of a Tri-M vehicle DC to DC power supply, UPS battery backup, and an Ethernet card and CPU, which boots a Linux kernel and application. This is the quintessential black-box solution collecting serial data, packaging this data, and passing it along via the Ethernet port to a wireless communication system. Perhaps there is a place for white-box solutions in a black-box world.

look outside the box for alternative embedded solutions. This is true not only for new projects, but also for the replacement and upgrading of older systems, which can no longer be economically justified in light of the alternatives we now have to offer.

Think telecommunications, medical devices, robotics, Internet appliances, data loggers, Supervisory Control, and Data Acquisition (SCADA), and you have barely scratched the surface of embedded PC/104 potential. Anywhere there is a need to transform raw data into useful information, and to do it at the right price, someone will be happy to use your products and services. As I started this article with the words paraphrased from an old song, and as you have endured my musings to this point, you deserve to know the connection. Love is the foundation on which all successful marriages are built. The successful marriage of different technologies, companies, and people will provide the foundation needed for a healthy and prosperous future.

As I was writing this article, fragments of a forgotten quotation kept intruding into my thoughts. I had to leave my desk and track that elusive fragment to its source. The result is the quotation below from *The Tragedy of Julius Caesar* by William Shakespeare.

There is a tide in the affairs of men,
Which taken at the flood, leads on to fortune;…
… On such a full sea are we now afloat,
And we must take the current when it serves,
Or lose our ventures.

I believe Shakespeare's words summarize the theme of this article very succinctly; yet leave open the question – Am I still on the shore, or am I riding the crest of the wave?

Doug Stead *(dstead@Tri-M.com) is the President and founder of Tri-M Systems Inc. and Tri-M Engineering, (www.Tri-M.com). For the last eighteen years these companies have engineered designs and marketed high tech embedded boards and related products, specializing in their deployment into mobile, hostile environments. Doug was awarded a Queens Commission as an Officer in the Canadian Armed Forces Reserve (Air) and retired after serving eleven years, the last five as Commanding Officer 519 RCACS, part of a national aviation and leadership training program for adolescents between twelve and nineteen years of age. He is still involved in community betterment, contributing his time and corporate resources working to protect children from digital criminals. Doug is a member of the Board of Directors in the following non-profit organizations: Anti Child Pornography Organization, USA – www.antichildporn.org, The International Society for the Policing Of Cyberspace – www.polcyb.org, Entrepreneurs Against Pedophiles, Canada – www.eap.ca, and the Protect Your Family Organization, International at www.protectyourfamily.net.*

Copyright ©2001 CompactPCI Systems. All rights reserved.