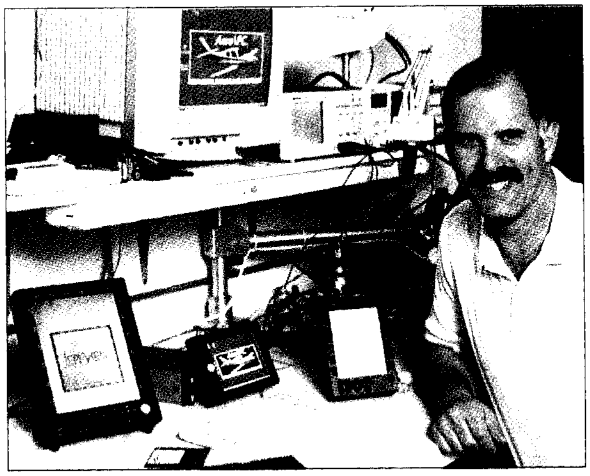
Computing module takes pilot's charts to the air

For a long time, Rick Ellerbroch was a frustrated man. As a representative of Jeppesen (Englewood, Colo.), a firm that supplies all the air route charts for North America on a single CD-ROM, he was searching for a tiny PC based platform that would run his software. The CD-ROM replaced many pounds of paper charts, but pilots couldn't fit existing display systems into an already crowded 747's cockpit—to say nothing of a small private airplane.

Ellerbroch found his solution when he met Brent Regan at an experimental aircraft show. Regan, a private pilot and principal of Regan Designs (Davis, Calif.), an electro-mechanical design house, had designed a cockpit display system based on a single board computer that was small enough to fit easily in a private airplane's cockpit, but still delivered notebook-like performance.



Designer-pilot Brent Regan shows off the Junior family of cockpit navigation displays. Regan's first prototype (center), connected to an external single board computer, is flanked by a Cell Computing based Junior (right). A mock up (left) was abandoned because of its large size.

Wish list requirements

If it could be built, the product would have to be more reliable than a notebook, though, and have a high-resolution display that would be daylight readable. The system would also have to be rugged enough to travel anywhere a pilot would typically go.

Jeppesen envisioned a computer that would work with standard personal computer peripherals and would include a large number of function keys. His wish list also called for a pen interface. Of course, the system would have to be shielded from RF interference (RFI) and electromagnetic interference (EMI), operate in unpressurized cockpits, and resist shock, vibration, and the inevitable cup of spilled coffee.

Just in time design

There was one other requirement. The design had to be working within six weeks so it could be shown at an upcoming trade show. Regan accepted the challenge, and the project, code named Junior, was launched.

At the Embedded Systems Conference, Regan saw Cell Computing's (San Jose, Calif.) CardPC, a so-called micro-motherboard single board computer module. "It was just what the Junior needed," remembers Regan. "With it, a large part of the system could be integrated immediately."

Regan enlisted fellow pilot Hamid Wasti, a principal of the Wasti Consulting Group (Rancho Murieta, Calif.), to help design and build the paperback book size system's motherboard. "We considered standard packaged chips versus ASICs," says Wasti. "We also looked at CPU modules from Intel and others. We also thought about using a PC/104 form factor single-board computer.

"Standard ICs would take too long to implement. Ditto for spinning a system on a chip. Likewise, we didn't have the time to design an ASIC with a Pentium class core and a high performance video subsystem, not to mention the added complexities of a BIOS and chipset."

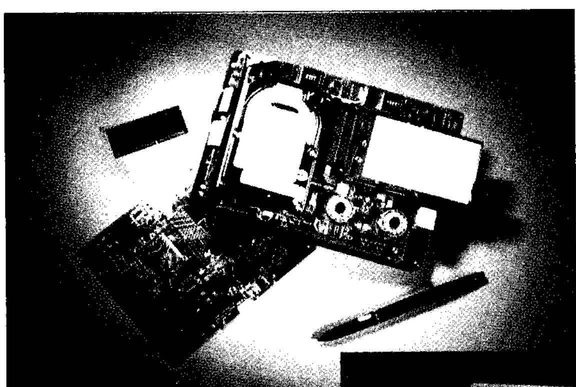
Just the right mix

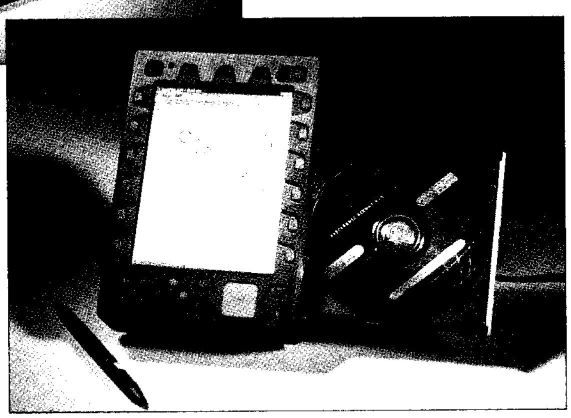
"PC/104 modules and single-board computers were either too big or didn't offer the right mix of features," adds Regan. "On the other hand, the CardPC, with its chip scale packaging (CSP), packed a Pentium processor, a mating chipset, a video controller with an Mbyte of VRAM, and up to 128 Mbytes of DRAM.

"It also included a National Semiconductor (Santa Clara, Calif.) Super I/O chip, and a Phoenix Technologies (San Jose, Calif.) BIOS—all in a credit card size package measuring only 3.4 × 2.2 × 0.52 inches (85.6 × 54 × 12.7 mm).

"What's more, ISA devices, such as Junior's PC Card controller, could be handled by the module's Intel PCI-to-ISA bus bridge chip. The Super I/O chip would also endow the CardPC with two serial ports and a parallel port. The module also included floppy and hard disk controllers, had IDE expansion, and mouse and keyboard interfaces.

"Implementing the CardPC was relatively straightforward," says Wasti. "The CardPC is inserted into a 236-pin con-





In addition to switching power supplies, dual CCFL inverters, and PC Card connectors, one side of Junior's motherboard sports a 2.5-inch format HDD that's just 9.5 mm thick. The other side of the board hosts the CardPC and CD-ROM drive. Pilots can carry Junior, which weighs about three pounds, instead of about 40 pounds of paper charts.

nector. There are very few high speed signals to deal with externally."

Good support

Cell's support resources, as well as its schematics and reference designs, played a key role. "Cell volunteered to do a design review and turned it around with many meaningful suggestions in under 24 hours," says Wasti. "That gave us more time to design the Junior's power supplies, cold cathode fluorescent lamp (CCFL) backlight inverter, keyboard, and PC Card and disk interfaces."

"Jeppesen's initial display requirement drove me to choose a 10-inch diagonal XGA resolution TFT (thin film transistor) display of 1024 × 768 pixels," says Regan. "But the CardPC's graphics controller wouldn't support that because it only has 1 Mbyte of video memory. We thought we might have to do a board level design for this product."

Regan built several prototypes using a 10-inch screen. The physically large Senior version of Junior was more of a mockup than a prototype. "The display was operational," quips Regan, "but it was connected to a PC that was in a briefcase under the table.

"The display, the buttons around it, and a PDA size QWERTY keyboard were all functional. There was even a CD-ROM drive, although it wasn't working, but you could press a button and the CD drawer would pop out."

Regardless of its shortcomings, Jeppesen took the mockup on tour. Everybody loved the display. But even in a large aircraft, there wasn't always enough spare cockpit real estate to host the system. It was just too big.

"We knew we had to shrink the design," explains Regan. "I immediately thought of the very small 600 × 800-pixel SVGA display made by Sharp (Camas, Wash.). It could be driven by the CardPC, letting us put a working system in one box."

3-D to the rescue

CAE tools helped get the Junior's package size down, especially Autodesk's (San Rafael, Calif.) Mechanical Desktop v2.01 modeling package. Its 3-D capability ensured that all the components could be arranged within the enclosure, which was milled from a solid billet of aluminum.

"We milled out an area to make room for the display, shaving every millimeter we could," recalls Regan. "We removed the Sharp display from its housing and used just the raw glass. We were left with an optical subsystem that stood just 4 mm tall.

"The portrait mode LCD is daylight readable thanks to the CCFL backlight. It offers 700+ nit brightness and a 400:1 dimming ratio. Daylight display performance would be key to pilot acceptance of Junior, and the high dimming ratio would enhance night operation."

The Junior's system board wound up occupying a 5.2 × 7.1-inch footprint, using a six layer circuit board. "The first turn of the board worked with only four minor trace cuts and jumpers," tells Wasti. "Everything fit together on the first try."

The CD-ROM and CardPC shared a board layer, followed by a ground plane. Another layer accommodated the unit's hard disk drive and PC Card socket. The entire electronics package was surrounded by a solid aluminum frame.

Mightier than a mouse

Stringent cockpit EMI standards required special consideration. "A cutaway drawing of Junior looks like a layer cake," says Wasti. "The design includes a ground plane beneath the LCD panel backlight and pen input antenna assembly to reduce EMI. Pen I/O was based on components from Mutoh America (Phoenix, Ariz.).

Unfortunately, Mutoh America didn't initially supply a radiometric pen in a form factor Regan could use. But Regan worked with Mutoh's engineers to put together an interface spec and a drawing, and within weeks Mutoh America produced a prototype.

At that point, it was discovered that the TFT display interfered with the pen's operation. The pen's cursor would jitter back and forth whenever it was moved near the edge of the display, making random motions of about 10 to 12 pixels.

To solve that problem, the design teams revised the pen input subsystem so the pen receiver would only look at the pen during the horizontal refresh period of the display. "We used radiometric pens in other designs," adds Regan, "but we're especially pleased with the custom RF based pen Mutoh built for us.

"It operates at 500 kHz and offers a fine degree of control. Moreover, RF pens, unlike touchscreens, don't degrade image quality. That's a meaningful advantage for pilots."—*PG*

Autodesk
San Rafael, CA
(415) 507-5000
www.autodesk.com
Circle 122

Cell Computing
San Jose, CA
(408) 967-8800
www.cellcomputing.com
Circle 123

Intel
Santa Clara, CA
(408) 765-8080
www.intel.com
Circle 124

Jeppesen
Englewood, CO
(303) 799-9090
www.jeppesen.com
Circle 125

Mutoh America
Phoenix, AZ
(602) 276-5533
www.mutoh.com
Circle 126

National Semiconductor
Santa Clara, CA
(800) 272-9959
www.national.com
Circle 127

Phoenix Technologies
San Jose, CA
(408) 570-1000
www.phoenix.com
Circle 128

Regan Designs
Davis, CA
(530) 758-7164
Circle 129

Sharp
Camas, WA
(360) 834-2500
www.sharpsma.com
Circle 130

Wasti Consulting Group
Rancho Murieta, CA
(916) 354-0386
Circle 131

ARC Wizard powers

Continued from page 10

Altera software library. The resultant gate level version is then ready to implement in the hardware prototyping system by programming an Altera FLEX programmable logic device (PLD).

Simultaneously, software developers can write and compile code using MetaWare's C language compiler and assembler. Linkers, debuggers, and optimizers, all available from MetaWare, complete the software development package.

Once the hardware prototyping system has been programmed, you can plug the system into a PC and begin running code through the system. If the results are less than expected, making changes is as simple as reprogramming the PLD.

The hardware prototyping system can typically be reprogrammed in three to four hours, providing the ability to test code in a flexible hardware environment at 3.125 MHz. Altera's FLEX 10k100 PLD can handle a 40,000 to 50,000 gate instantiation. That's ample room for ARC and more.

The hardware prototyping system is available from ARC for $5,000. MetaWare's software development environment is available on PC or Unix and costs between $5,000 and $10,000.

Altera Corporation
San Jose, CA
(408) 544-7000; fax (408) 544-7755
www.altera.com
Circle 132

ARC
Huntsville, AL
(256) 464-9222; fax (256) 772-0908
www.risccores.com
Circle 133

MetaWare
Santa Cruz, CA
(408) 429-6382; fax (408) 429-9273
www.metaware.com
Circle 134

Synopsys
Mountain View, CA
(650) 962-5000
www.synopsys.com
Circle 135