UEI Application Notes:

A Modern Alternative to Reflective Memory and VME

App Note #027

10-Year Availability Guarantee

United Electronic Industries

A Modern Alternative to Reflective Memory and VME:

This white paper is divided into two sections. The first provides a brief description of some of the reasons our customers have switched from Reflective Memory and VME based technology to UEI's Ethernet RACKtangle and Cube I/O chassis. The second part is a case study of the process as well as how and why FlightSafety International, a world leader in the design and manufacture of flight simulators, made the switch to UEI.

Introduction

Reflective Memory, and in particular, Reflective Memory in VME chassis has been the standard for real-time DAQ and embedded control systems for years. However, due to the age of most VME technology, as well as the recent consolidation of vendors in the market, many VME users have, or will soon face "end-of-life" issues with their VME solutions. Reflective Memory itself is an older, proprietary technology and may itself be facing end-of-life in the not too distant future. In the meanwhile, new technology from UEI provides the functionality of Reflective Memory in a simpler, less expensive, and more modern architecture. With a 10+ year availability guarantee, UEI's powerful RACKtangle I/O system is an ideal replacement for VME based I/O systems, whether or not they use Reflective Memory technology.

Reflective Memory History

Developed in the 1980's and popularized for VME systems by VMIC, Reflective Memory is a method for sharing and synchronizing data in multiple chassis. Reflective Memory networks typically provide the deterministic timing required by real-time control systems and at the same time minimize the network load on the chassis CPU. In VME systems, Reflective Memory I/O systems are typically configured with an RM board in each chassis. These Reflective Memory boards are then connected via some type of communications link/network.

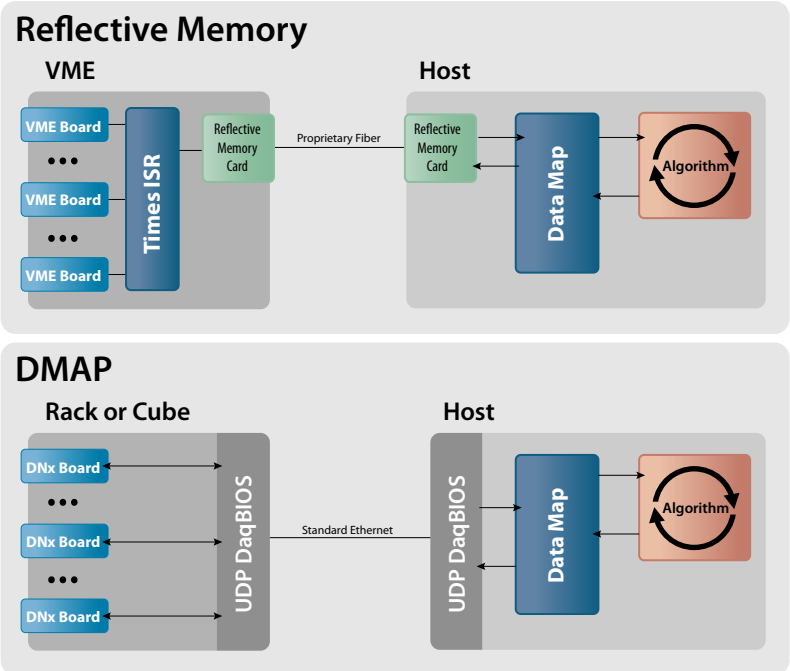
An "image" of the I/O is created in the I/O chassis that describes the state of all the I/O at a given instant in time. A duplicate, Reflective Memory image is created in the CPU chassis. A communications link (typically fiber) is also provided connecting the two boards. The Reflective Memory system takes care of keeping the two memory images synchronized and identical in a time deterministic manor. This synchronization is done in the background automatically for the user.

When the CPU wants to query an input in I/O chassis, it need only read the appropriate memory location in the local RM board. Similarly, when the host CPU wants to write to an output in the I/O chassis, it needs only write to the appropriate memory location in the local RM board. The RM system ensures the I/O images are updated, that current input data is available in the local chassis and that the output data on the RM card in the CPU chassis is written to the RM board in the I/O chassis (which the I/O chassis is then responsible for writing to the appropriate I/O card.).

The BIG disadvantages with Reflective Memory are that it takes up a valuable slot in your VME chassis and more importantly, the boards are quite costly.

A Modern Alternative to Reflective Memory and VME:

Reflective Memory vs. DMAP



The block diagrams above depict both Reflective Memory and UEI's DMAP protocol. The UEI solution eliminates the requirement for two expensive memory cards and communicates over a standard Ethernet link.

UEI's Modern Alternative to Reflective Memory.

UEI's patented DMAP™ alternative to Reflective Memory provides the same functionality, but eliminates the requirement for dedicated memory boards by taking advantage of recent technology and in particular, speed advances in CPU, FPGA, DDR2 memory technologies. DMAP uses a simpler, less expensive architecture and uses a standard Ethernet techology as the communications link. On the host side, instead of keeping the data image in a Reflective Memory board, the UEI system uses a section of the host CPU's standard memory. On the I/O chassis side, as opposed to adding an expensive Reflective Memory board, UEI's solution reads and writes the data from the various I/O boards' actual data registers. This configuration eliminates the requirement for any special memory board as utilized in Reflective Memory systems.

The data image in the host CPU's memory and the image held in the I/O chassis's data registers is kept identical and synchronized using UEI's patented DMAP Ethernet protocol. Like the Reflective Memory system it often replaces, DMAP can operate completely in the background. Once DMAP is launched, the various I/O function calls provided in the API simply read and write the appropriate memory locations in the local I/O image.

As most readers will recognize, the standard TCP/IP based Ethernet network does not offer deterministic timing (not even close) and so is not an appropriate communications link for this type of real-time system. UEI's goal while developing the DMAP protocol was to develop a system that may be deployed on a standard Ethernet network, and at the same time offer the true real-time performance. The basis for the patented DMAP protocol is actually UDP packets. Using UDP as well as patented communications control algorithms UEI can offer deterministic, real-time update rates up to 4 kHz (250 microsecond updates) on GigE networks and up to 1 kHz on 100 Base installations. It's important to note that this guaranteed timing is possible on almost arbitrarily large systems, including systems with well over one thousand (1000) distinct I/O points. It's also important to reiterate that this capability is available using standard Ethernet networks including standard off-the-shelf network swithches/routers.

Introduction to VME

Launched in 1981, based largely on Motorola's VERSAbus technology, the VME bus has been a mainstay technology in both military and industrial I/O for over 25 years. Like the venerable RS-232 interface, people have been predicting the demise of the VME bus for some time. "Borrowing" a line from Mark Twain, it might easily be said "the rumors of VME's death have been greatly exaggerated."

However, time does march on. Though the VME bus has seen modernization including wider data buses (e.g. VME64) and additional instrumentation features (e.g. VXI), the reality is that VME is now seen as a "cash cow" market by many VME suppliers. In today's marketplace, VME is simply not seen as deserving significant investment in new product develoment or maintenance.

The VME market has seen quite a bit of consolidation over the past few years, and it's difficult for the new larger entities to justify manufacturing small quantities of boards from different groups all performing the same function. At the same time, many of the components that have been designed into these products are being discontinued by the semiconductor manufacturers due to ROHS and/or low volume. Finally, as more and more production is moving to the "East", it is difficult to justify transferring the manufacturing fixtures and knowledge for many VME boards to off shore partners, particularly some of the relatively low volume analog and digital I/O boards.

The reality of product obsolescence

All these factors have driven many vendors to discontinue a variety of their VME I/O boards. This regrettable trend (at least if your system is based on boards about to go "End-Of-Life" or EOL) is not likely to change at any time in the future. This leaves many VME users facing obsolete components and last-time buys. Even many VME users who have yet to face an EOL disturbance are certainly looking over their shoulder and wondering when their purchasing department will give them the bad news.

Faced with an EOL issue, a growing number of designers are looking for other alternatives. Though redesigns based upon substitute VME products are sometimes possible, it is not a popular option as there is no telling when the next VME board will bite the proverbial dust. More and more engineers are basing their replacement systems on modern COTS Ethernet I/O products, and computers.

*The long-term solution is guaranteed**

10-Year Availability Guarantee

UEI's Ethernet I/O products are only a few years old and are based upon up to date modern technology. In addition, UEI has an incredible track record for maintaining production of products and not forcing our customers to upgrade to the latest, greatest technology until they want to, not need to. This is a promise backed by a 10- Year availability guarantee*. *(see back panel for details)*

Other key reasons to switch to Ethernet I/O

Once backed into a corner and forced to consider non-VME solutions, designers are delighted to find a host of benefits and advantages a UEI I/O chassis provides over the VME chassis to which they have grown accustomed. Indeed, product obsolescence is often not the primary reason a VME designer switches to a UEI solution. Sometimes the designer simply needs a feature or capability not available on a VME platform. The following section describes the advantages and benefits the UEI Cubes and RACKtangles have relative to VME systems.

A Modern Alternative to Reflective Memory and VME:

Small size / high channel density

The UEI Cube and RACKTangle allow you to pack more I/O into a smaller space than VME racks. A DNA-PPC8 Cube measures just 4.0" by 4.1" by 5.8" and yet allows the installation of up to 150 A/D channels, 192 D/A channels, 288 DIO points, 72 ARINC 429 channels, 12 MIL-1553 ports, 48 Serial ports, 48 counter/timer/quadrature channels or 24 CAN-bus ports. The 12-slot RACKtangle I/O chassis provides double these quantities in a standard 3U rack form factor.

Using our high density chassis, designers have found they no longer need to mount their I/O in remote racks and then run long cables between the I/O rack and the main "product" (e.g. a simulator, a dynamometer, a test stand, etc.). Mounting the I/O right on the product decreases noise pick up in the signal wiring and reduces the cost and complexity of running hundreds and sometimes thousands of wires between the sensors and a remote I/O rack. With the I/O mounted locally, installing your product at a customer or final installation site is as simple as connecting power and Ethernet.

Customers who take advantage of the Programmable Automation Controller versions of UEI's I/O also eliminate the space required by an external host computer. The UEIPAC builds a standard Linux based (with Xenomai RTOS support) operating system directly into the I/O chassis, allowing the units to run full stand-alone.

Flexibility

Flexibility comes both from the unique Cube/RACKtangle form factor and from the extraordinary array of different I/O boards that may be installed in a UEI Ethernet Chassis. With I/O Cubes as small as 4" by 4.1" by 4", you can put a UEI chassis in places you'd never dream of installing a VME rack. Our I/O Cube is rated from -40 °C to +85 °C, 50g shock, 5g vibration, 0-70,000 feet altitude and has been radiation tested for space applications. If that's not enough,

For applications requiring the absolute smallest footprint and/or the ability to survive the in the most rugged environments, UEI's Cube is ideal. For more traditional, rack-based applications, the RACKtangle is a perfect solution.

our fiber optic interface allows the I/O system to be mounted up to 20 kM from the host computer. That's handy when the I/O is located on the ocean floor, 15,000 feet below the host PC mounted on an oil drilling platform.

As for I/O flexibility, UEI offers over 30 different boards. In addition to standard analog and digital I/O, there are CAN-bus, RS-232/422/485, ARINC-429, quadrature encoder inputs and soon there will even be a MIL-STD-1553 board.

Software Support
Like most I/O manufacturers, UEI offers incredible support for all popular Windows Development languages and applications. Unlike many I/O vendors, UEI also provides factory written drivers for all popular Linux and Real-Time operating systems including QNX, VXworks, RT Linux, Windows RTX, RTAI Linux and more.

Price
Our customers find that when they switch from VME to UEI technology, their system price goes down. If you add the cost savings provided by smaller rack sizes, shorter wiring, and the time saved by using our easy-to-use software drivers, the cost savings become even more significant.

Performance
Does Ethernet I/O offer the performance available on the VME platform? The answer is a resounding yes. Our patented DMAP Ethernet protocol ensures systems with thousands of I/O points are monitored and updated, all in less than a millisecond. As you'll see in the case study included later in this paper, FlightSafety International monitors/updates their I/O points at 2 kHz.

COTS production
If you're building your first system, you don't want to wait 6-12 weeks to get a piece of hardware to evaluate. If you're releasing your project to production, you don't want to hear from purchasing that the component you need is 12-16 weeks away. Finally, if your up and running and your system takes a lightning hit, you don't want to find out a replacement board is two months away. All of UEI's Cube and RACKtangle I/O products are standard, off-the-shelf products. Even in the unlikely event we are out of a product you need for an emergency replacement, we will scramble and find something we can get to you to get you back up and running immediately.

Beginning on the next page is a case study on FlightSafety International's successful transition from VME to UEI.

Case Study: FlightSafety International

Piloting an aircraft without training is an inherently dangerous endeavor. Though early aviation pioneers were forced to take this risk or stay on the ground, this is no longer the case. Almost all pilots start their training in single engine, piston powered aircraft accompanied by a flight instructor. Most advanced training, and in particular, training of professional pilots in turbine powered aircraft, is now performed in a simulator.

Flight simulators offer a number of key advantages over training in actual aircraft. First and foremost is safety. It's possible to simulate almost any emergency or system failure in a simulator without risking life or limb. The same is certainly not true in an actual aircraft. It's perfectly safe for a student pilot to experience an engine failure on takeoff in a simulator. If the student is slow to abort the takeoff and the simulator runs off the runway, no damage is done (except to egos).

Another key advantage of flight simulator training is the cost savings of simulated flight versus actual. Though simulators are not inexpensive, it's still much less expensive for a pilot to take his/her "check ride" in a simulator than actually firing up and flying a Boeing, Airbus or other aircraft.

Though there were earlier attempts to build a ground based flight simulator, most consider the Link trainer developed by Edwin Link in 1929 to be the first "real" simulator. Following a number of US Army Air Corps accidents in the early 1930s, the army purchased four of Link's simulators and the flight simulator industry was born.

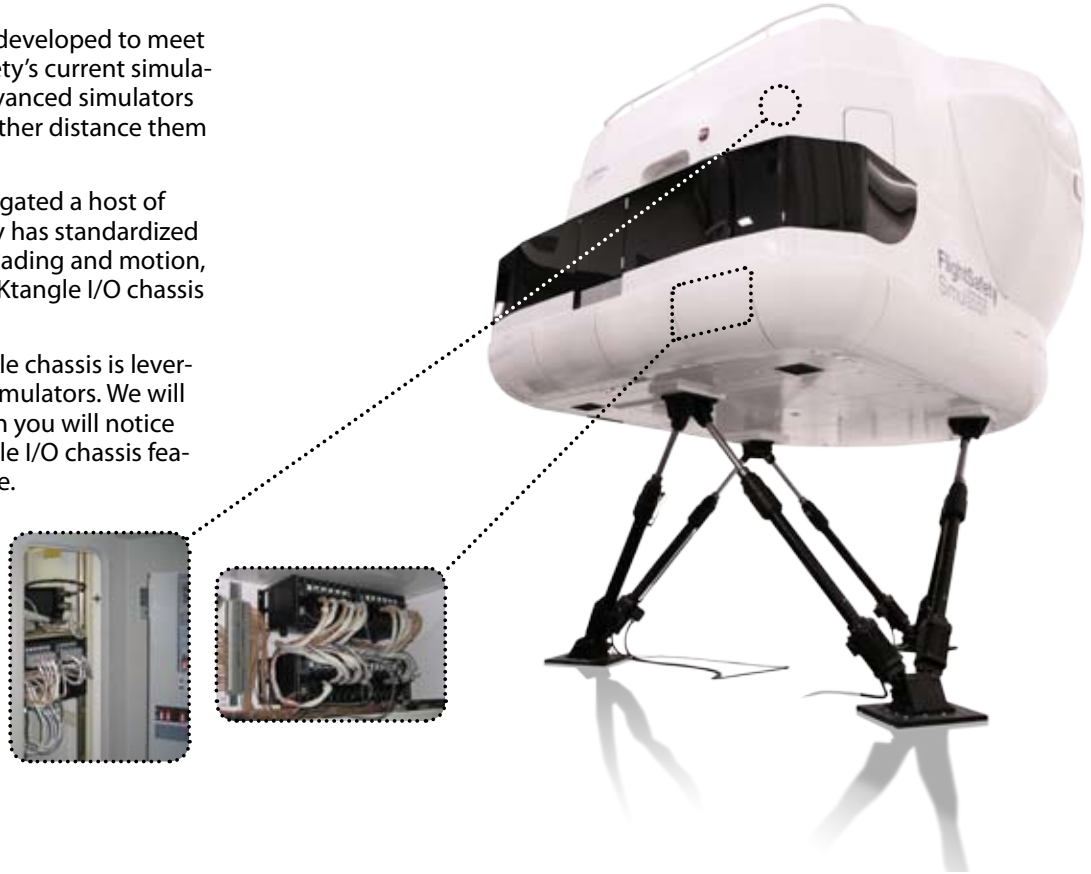
FlightSafety International was founded in 1951, dedicated to the principle that aviation safety is best achieved through training. With a fleet of nearly 400 simulators, FlightSafety is the world's leading supplier of flight simulators. Since the beginning, they have been a leader in developing simulator technology. For simulator training to be economically viable, simulators must:

1. Accurately replicate the "look and feel" of the actual aircraft
2. Provide an extraordinary level of reliability as most simulators are "flown" around the clock and are scheduled out weeks, if not months, in advance.
3. Allow quick repair. Simulators are complex devices and all devices can fail. It is critical to be able to diagnose and repair any failures quickly.
4. Be maintainable. A simulator is an expensive piece of capital equipment. To justify the investment, the simulator must have a long life, and so, must be assembled from components that will be available for many years.
5. Use standardized, well established components so new simulators, and in particular, simulators of new aircraft are developed in a timely manner with a minimum of new "learning curves" to be climbed.
6. Offer attractive pricing. Simulation is a competitive market. In order to prosper, a simulator must be able to offer competitive prices.

FlightSafety's new Sim*I/O* equipped simulators have been developed to meet all of the above requirements and more. Though FlightSafety's current simulators are the highest performance, most technologically advanced simulators available, the new Sim*I/O* equipped simulators serve to further distance them from the competition.

In their development of the new series, FlightSafety investigated a host of different I/O vendors and systems. In the end, the company has standardized all computer based I/O (including flight deck I/O, control loading and motion, and avionics) on the United Electronic Industries (UEI) RACKtangle I/O chassis and its associated I/O boards.

The remainder of this paper will detail how UEI's RACKtangle chassis is leveraged to achieve these goals in the new Sim*I/O* equipped simulators. We will break the discussion down into distinct advantages though you will notice there is frequently an overlap where a particular RACKtangle I/O chassis feature has a positive influence on more than one system issue.



The high density of the RACKtangle allows it to be mounted in cabinets at the base of the simulator (above) or in racks within the simulator (right) rather than in "off-sim" racks.

High performance:

Performance is always an issue on a simulator. Obviously the goal is to make the simulator perform EXACTLY like the real aircraft. The new RACKtangle I/O equipped simulators have helped FlightSafety enhance the performance of the Sim*I/O* equipped simulators in a number of ways.

1. The RACKTangle to computer interface is implemented via 1000base-T, Gigabit Ethernet. The Gigabit implementation ensures communication between inputs, the controlling computer and control/display output is fast and does not become a gating issue. Also, the ability to address 12 I/O boards in a single rack, with a single IP address reduces the overhead required to "talk" to the I/O system. The 12-slot rack provides up to 300 analog input, 384 analog output, 696 digital I/O or 144 ARINC-429 channels. The high Gigabit data transfer rate, combined with the low overhead, enables system scan/update rates of 2000 Hz. This enhances overall system "smoothness" and allows control algorithms to make smaller, more accurate changes and adjustments.

2. Ensuring there are no "hiccups" or uncommanded "bumps" in the simulator requires the use of a computer with an operating system offering deterministic timing. There is no time to stop the control system algorithms while a disk drive is written or a monitor updated. Sim*I/O* equipped simulators utilize the Ardence RTX® – Real-time Extension for Control of Windows operating system. UEI's RACKtangle chassis includes complete support for the RTX real time operating system (RTOS) as well as most other popular RTOS including QNX, VXworks, RT Linux, and RTAI Linux. Though many I/O manufacturers have ignored the Linux/RTOS market or relegated the support to unofficial user forums, UEI drivers are factory written and fully supported.

3. On Sim*I/O* equipped simulators, the I/O chassis are mounted directly on the simulator itself as opposed to previous designs where the actual I/O interfaces where mounted in racks external to the simulator. The on-board location of the Sim*I/O* allows shorter wiring lengths, which decreases noise pickup and increases the system's overall signal to noise ratio.

High reliability

Whether the simulator is operated by an airline, a government agency, or a training division of FlightSafety unscheduled simulator down time is a disaster. Not only does it reduce billable/usable hours, it creates schedule chaos. Most simulators are operated "round the clock" and it is extremely difficult, if not impossible, to "make up" time lost by a down simulator. In particular, pilots of Part 121 airlines have extremely tight schedules, and their training schedules are not flexible. A pilot who misses a check ride because the Sim is down is effectively grounded. This not only causes hardship for the pilot, but also the airline, which is then forced to allocate a reserve pilot as a replacement. FlightSafety's simulators offer a remarkable 99.6% availability. Assuming the simulator is scheduled out 24/7, this represents less than three hours of down time per month. Two key factors determine simulator availability. These are reliability (typically expressed as mean time between failures or MTBF) and

repairability (often referred to as mean time to repair or MTTR). The new RACKtangle I/O solution enhances both MTBF and MTTR. We will discuss the reliability advancements here while repairability topics will be covered in the next section.

The new UEI based simulators are designed to improve on FlightSafety's already extraordinary reliability. Here's how:

1. Historically, simulators have been installed in two "parts"; the actual simulator and the external control station. All I/O connections had to be wired directly from the sim to the control panel. In complex aircraft, this requires a wiring harness containing over one thousand wires. The fact that the simulators move in 6 degrees of motion greatly complicates this connection and requires the use of a "waterfall" wiring scheme. The high I/O density of the UEI RACKtangle I/O chassis has allowed FlightSafety to build the entire control station into the simulator itself. The waterfall wiring harness on a Sim*I/O* equipped simulator now contains little more than power and Ethernet connections. All I/O wiring is fixed in place. The elimination of thousands of moving wires greatly reduces the probability of a broken wire or connector causing a system failure.

2. Today's aircraft cockpits are filled with annunciator lights and indicators. Turn them on at the same time and the cockpit takes on the look of a Christmas tree. Though there is a movement toward the use of high reliability LED indicators, the bulk of the indicators in most aircraft remain incandescent bulbs. Incandescent bulbs left on (or off) are extremely reliable and will last for years. There are reports of a bulb installed at a Texas opera house that has been burning constantly since September of 1908! However, the thermal shock, and corresponding rapid expansion/contraction of bulb filaments as they are turned on/off dramatically reduces bulb life. The Guardian series digital output modules installed in the UEI RACKtangle provide a pulse width modulated (PWM) "soft-start" capability. The soft-start allows the bulb filament to be brought up to temperature (and brightness) gradually enough so thermal shock is greatly reduced, yet quickly enough that there is no noticeable impact on the display. This feature dramatically improves bulb life and reduces down time. *(Note the PWM feature can be set to run at steady state duty cycles. This allows the digital outputs to also serve as a "virtual rheostat" and allows the outputs to offer a "dimmer" capability in addition to simply turning bulbs on or off.)*

Rapid diagnosis and repairs.

FlightSafety simulators are remarkably reliable. However, failures in a device as complex as a simulator are inevitable. A critical design goal of the Sim*I/O* equipped simulators is to reduce the mean time to repair once a system or component has failed. UEI's RACKtangle I/O chassis has allowed FlightSafety to reduce the amount of time required for the repair technician to diagnose problems. It has also enabled the technicians to make many repairs more quickly. Many failures are now diagnosed and repaired in the amount of time it takes the crew to grab a cup of coffee. In fact, many failures can be fully diagnosed while the sim is still running! Also, the simpler and faster repairs made possible by the new Sim*I/O* diagnostics allow the simulation operator to maintain a smaller, less technically advanced repair and maintenance staff.

Here's how the RACKtangle I/O chassis helps accomplish these goals.

1. Each RACKtangle I/O chassis provides two Ethernet connections, at independent IP addresses. One of the IP addresses is used by the simulator host computers to read and write the I/O. The second is available as a diagnostics "snoop in" port and diagnostics software may be run while the simulator is actually operational. Many, if not most, simulator failures do not bring the simulator "down", but merely make certain procedures or functions unavailable. It is often possible for the instructor to move on to a different part of the training syllabus with a "failed" system on board. The ability to run diagnostics concurrently with actual training will make it possible for the repair technician to identify the cause of a failure, determine which component(s) need replacement, acquire the components from stock, and prepare to perform the repair without stopping the training. Of course it's unlikely the repair can be made while the Sim is operating. However, since the technician knows exactly what to replace, how to replace it, and has the items in hand before bringing the sim down, the repairs are often made in minutes, not hours.

2. All Sim*I/O* inputs are connected to an internal switch that allows the input to be disconnected from the live Sim*I/O* and connected to a predefined test signal. Similarly, all Sim*I/O* outputs can be independently monitored. The ability to fully test all I/O automatically dramatically simplifies and speeds up diagnosing any problems identified in the cockpit or via system generated error alarms. This capability also allows complete self-tests and identifies wiring and installation problems without requiring manual wiring and continuity testing. A key aspect of the self diagnostics is the ability for the RACKtangle's digital outputs to monitor their actual output voltage and current, while the digital inputs are able to monitor not only hi and low, but to actually measure the input voltage with 25 mV accuracy. This measurement capability makes it possible not only to detect failures, but also to note changes in system behavior that might be predictive of pending failures.

3. The new Ethernet based "diagnostic IP" system enables a standard wireless interface to the technician's remote, hand-held diagnostic unit. In addition to identifying the problem, the system also provides instant access to any required schematics, user manuals, and/or wiring diagrams.

4. The second diagnostic IP address also supports a Web browser interface allowing a senior technician or engineer to access the system remotely. They can then diagnose and correct any issues beyond the local technician's capability without requiring any travel or travel related down-time.

5. The modular nature of the RACKtangle, combined with the ability to replace any I/O module in a matter of seconds, greatly reduces repair time. The RACKtangle chassis contains no active components. All I/O modules, the CPU/NIC module and power supply modules are all easily replaced. The new Sim*I/O* system is based upon a small number of standard COTS components, reducing the on-site requirement for spares as well as ensuring fast access to replacement components when necessary.

6. Not all simulator features and functions are used in all training sessions. Sim*I/O*'s self test and diagnostic capabilities allow the system to self test between sessions. The engine fire, cabin depressurization, or alternator

failure warning annunciators might be used infrequently, but must work when commanded. The self-test features allow these components to be automatically checked. Should a failure be noted, it is possible for the technician to correct the situation between sessions, during scheduled maintenance, or while another repair is made without causing any down-time and without impacting training efficacy.

Extended simulator life

Though efficient and cost effective, there is no debate that a flight simulator is an expensive piece of capital equipment. As such, a purchaser/operator of a flight simulator needs to know the device will be viable far into the future. UEI's RACKtangle I/O series was the perfect choice as the basis for the I/O requirements in the new Sim I/O equipped simulators. Here's why.

1. Previous versions of FlightSafety's flight simulators have been based upon VME technology. Though many vendors remain committed to supporting the VME bus, many others, and in particular those focusing on I/O products are moving on to other platforms (e.g. Ethernet, LXI, etc.). To ensure long term availability of the hardware required to build new simulators as well as to support those already in the field, it was necessary to switch to a more stable architecture. *(Note: FlightSafety has taken the necessary steps to ensure there will not be any disruption in support for existing simulators. Also, if required, it will be possible to retrofit existing simulators with Sim I/O hardware.)*

2. The Ethernet in its various formats is ubiquitous and has been supported in one form or another since 1980. The Gigabit Ethernet interface currently used in UEI's RACKtangle I/O system is becoming well established in the I/O control environment and will provide a stable communications protocol for many years to come.

3. UEI and FlightSafety are partners in the Sim I/O endeavor. Previous simulators have been based upon I/O systems provided by a large number of different vendors. Though FlightSafety's I/O purchases were significant, they have not always been large enough to justify a vendor's continued production of a given component. This is particularly the case as more and more of the VME based components have been "EOL-end of lifed". In the Sim I/O case, all I/O will be purchased from UEI. The partnership ensures a continued supply of product, now and in the future.

4. UEI serves a large number of OEM customers who depend on the company to provide a long-tem, uninterrupted supply of measurement and control products. UEI's commitment is demonstrated daily by the company's willingness to continue supplying its OEM customers ISA bus boards developed almost 20 years ago. UEI product support has even gone so far as to clone and provide a stable source of I/O boards that have been discontinued by other vendors. UEI is a vendor committed to long term support of its products and its OEM customers.

Timely development of new simulators

Previous simulators have been based on I/O supplied by a variety of vendors. Though this situation was workable, it was not optimal. It mandated developers to use multiple, often dramatically different, software and hardware form factors. In the Sim*I/O* equipped series, all I/O hardware and software, including avionics instrument control (AIC), control loading and motion (CLM) and flight deck I/O (FDK) is based upon the UEI RACKtangle I/O series. Here's how the UEI RACKtangle helps FSI get their new simulators up and running quickly.

1. In the new Sim*I/O* architecture, all I/O is based on the UEI RACKtangle I/O chassis. This chassis allows great flexibility as any of the 25+ available I/O modules may be installed in any of the rack's 12 I/O slots. The standard form factor and footprint allow FlightSafety to standardize on the I/O and control bay on each simulator and yet have an almost limitless ability to configure the I/O to match the particular aircraft. The RACKtangle provides unprecedented I/O density, including up to 300 analog input, 384 analog output, 144 ARINC-429 channels per rack.

2. The software interface to all of the I/O capability is provided in a single, straightforward API. This dramatically reduces the time required by the software developers to actually write the application programs. It provides portability so application code may be shared among different development groups. It dramatically simplifies software documentation and maintenance as all the I/O is based upon a single driver. Finally, when a driver software update is required, it is achieved by updating a single driver,

Lower cost:

Though performance, availability, and supportability are the key issues that drove FlightSafety to standardize on the UEI RACKtangle series, the UEI system also provides all of its advantages and reduces the cost of Sim*I/O* based systems relative to previous configurations. The UEI based system reduces overall cost in a number of ways.

1. The UEI RACKtangle I/O costs less than the previous VME based systems.

2. The advanced diagnostics provided dramatically reduce debugging of a newly built simulator. This reduces the time and labor costs required to get a new simulator up and running.

3. Reduced cost of construction due to the reduction in waterfall wiring required. This offers dramatic cost savings both in "parts" cost and in assembly labor. This is of particular note as almost all simulators are built twice. Once at the factory to prove proper operation, and then again at the simulator's final location, be it a FligthSafety or customer facility.

4. The actual size of "on-simulator" equipment cabinet is reduced by over 50%. This reduces the cost of the structure required to support the I/O system.

5. Common I/O and chassis components reduce the requirement for on-site spare products. The spares requirement is also reduced as all of the RACKtangle components used in the Sim*I/O* equipped sims are standard COTS products at UEI and there are no long delivery schedules that need to be considered when it comes to planning the stock of spare components.

About UEI:

UEI is a leader in Ethernet I/O, Data Logging, Embedded Control, and Simulink I/O. Our "Cube" chassis are compact, rugged and ideal for both flight test and distributed I/O applications. Our RACKtangle chassis are perfect for larger applications. Over 30 I/O boards are available including A/D, ICP/IEPE, LVDT/RVDT, Synchro/Resolver, DIO, ARINC-429, MIL-1553, CAN, Serial and more. All popular operating systems, languages and applications are supported.

* **10-Year Availability Guarantee**

UEI guarantees the availability of all RACKtangle/Cube series products (including DNA, DNR, UEIPAC, UEISIM, UEILogger and UEIModbus chassis and compatible I/O boards) for a minimum of 10 years. Unless you are specifically notified at the time of purchase, all DNA/DNR series products purchased will be available for purchase for at least 10 years. We understand the investment you make by using our products and we ensure long-term product availability. Protecting customers from product obsolescence issues is nothing new at UEI. We still sell ISA bus boards. Now our excellent long-term support is backed up by our written promise. As of the printing date of this catalog, ALL RACK/Cube series products in the catalog will be available for 10+ years!

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