Pilatus PC-21

An Integrated Systems Success Story

Figure 1: Pilatus PC-21: a single-turboprop, monoplane advanced trainer

Imagine a new type of trainer aircraft for the twenty-first century. One that can adapt to a particular student's requirements, transforming its' console to match that of the specific type of aircraft the training calls for. An aircraft that lowers the cost of training for jets, while expanding on functionality and capabilities. Pilatus Aircraft Ltd., with Curtiss-Wright Defense Solutions, has made this ideal new teaching platform a reality. The Pilatus PC-21 is a next-generation turboprop trainer that provides an unmatched level of advanced technology, configuration flexibility, and lifecycle cost savings. With an intelligent avionics system that can be modified to suit the student pilot's phase of training, the PC-21 is significantly less costly than jet aircraft training alternatives. This high performance, aerobatics aircraft uses Curtiss-Wright hardware and subsystems integration expertise to manage and control its sophisticated mission system.

During the earliest stages of the PC-21's development, Pilatus based its' mission system on older, proprietary 6U embedded hardware. As they approached the aircraft's production phase, Pilatus sought a new design to reduce the cost, improve the performance, and significantly reduce the size and weight of the PC-21's mission computer. Curtiss-Wright's compact, high performance 3U CompactPCI® (cPCI) Integrated Systems subsystem hardware and rugged systems integration expertise proved to be their ideal solution.

Curtiss-Wright's unique Integrated Systems subsystems strategy enables customers to leverage all of the benefits of the COTS market ecosystem. These benefits include not only reduced development cost and faster time to market, but also the critical advantages that derive from the increased characterization and real-world data that accrue from the experience of multiple users of a particular COTS technology. By providing Pilatus with an off-the-shelf subsystem product, the customer gains increased reliability and performance through the shared knowledge of all other users of the same platform. Traditionally, these COTS market ecosystems benefits have been viewed and understood from the single board computer (SBC) level. Curtiss-Wright has elevated this strategy to go beyond card-level hardware, to consider the subsystem solution as not simply a discrete chassis and a set of boards, but instead as a coherent COTS product, a common solution, neither custom-spun nor exclusive to a unique program.

Curtiss-Wright has moved the traditional COTS value proposition to the next level of integration. This Integrated Systems strategy understands and treats all users of a particular subsystem to be members of a superset of users, enabling development costs to be shared, and thus lowered, across multiple programs. Even better, it enables lifecycle management costs to be shared, and thus lowered, across multiple programs, while the platform is continually vetted, matured and improved. Additionally, the Integrated Systems strategy simplifies the customer's supply chain burden, because the resultant subsystem has a single part number to be tracked rather than a larger list of numbers, likely from a large variety of different suppliers, for the disparate components (i.e., the boards, cables, chassis, etc.) that comprise the product.

The PC-21

The PC-21 boasts leading-edge aerodynamic performance and is designed to address the full range of training applications, including basic flying, advanced flying, full mission management and embedded simulation and emulation. It delivers an optimal environment to develop the capacity and skills for flying military jets. It features a tandem-seating arrangement (student in-front/instructor behind or vice/versa) in a bird strike resistant glass canopy with excellent all around vision. Its' powerful, integrated training system features a glass cockpit, Hands on Throttle and Stick (HOTAS) controls as well as Zero-Zero ejection seats for both the student and instructor alike. Sophisticated on-board avionics enable the PC-21 to emulate front-line mission systems. It features an open-architecture mission computer driving multi-function displays and separates critical and non-critical software to ensure that successful operation of the aircraft is not affected by failure of non-critical functionality.

Each cockpit is fitted with three 6 x 8" (152 x 203 mm) Active Matrix Liquid Crystal Displays (AMLCD). The central liquid crystal display is the Primary Flight Display (PFD). The bezel-mounted display buttons and Up-Front Control Panel (UFCP) buttons are used to select the navigation, mission, systems and tactical data displayed on the two outer multi-function displays. Two 3ATI secondary back-up displays alongside the UFCP show the primary flight display, systems and essential engine data.

Figure 2: Multi-function Display (MFD)

All of the PC-21 cockpit displays and lighting systems are night vision NVIS class B compatible. The aircraft's forward cockpit is fitted with a HUD that features a HUD symbol generator and the rear cockpit is equipped with a full color HUD repeater display showing the view from the HUD camera, overlaid with HUD symbology information. The front and rear cockpits can be fully decoupled, allowing the instructor access to training modes and sensor data unavailable to the trainee pilot.

Specific Requirements

Formerly, the PC-21 utilized a mission computer subsystem based on older technology integrated with 500 MHz PowerPC G4 processors, each with 512 MB memory for real-time, high refresh rate data processing. For their production model Pilatus required an improved subsystem with the increased processing power capable of driving the PC-21's advanced tandem multi-function displays, packaged in a reduced weight and more compact rugged enclosure.

The Challenge

The PC-21's primary development mission computer, with its' earlier generation processing power, large size and limited roadmap for technology insertion led Pilatus to seek a high performance alternative that would satisfy all of the aircraft's requirements while lowering costs and halving the subsystem chassis space, weight and power (SWaP).

The Right Solution

Pilatus identified the requirements for their Open Systems Mission Computer (OSMC), an integrated rugged mission computer subsystem, and Curtiss-Wright was able to satisfy these requirements with their MPMC-935x Integrated Systems subsystem. Each MPMC-935x integrates up to four Curtiss-Wright conduction-cooled DCP-124/124P Freescale Power Architecture™ MPC7448-based SBCs and four mezzanine cards – an ARINC-429 PMC, a MIL-STD-1553 PMC, and two graphics PMCs – in a rugged, lightweight and environmentally sealed chassis.

Outstanding Benefits for the Customer

The MPMC-935x delivers numerous benefits to Pilatus. Many of these benefits derive from the customer's understanding of the limitations of a "point solution." The Integrated Systems approach enables the superset of customers for a particular COTS subsystem to gain the "genetic" improvement derived from collective knowledge and a wide user base.

Positive Results: Curtiss-Wright's Integrated Systems Approach

Curtiss-Wright's Integrated Systems family of pre-qualified, pre-configured compact rugged subsystems offers the high performance computer power and standard interfaces that today's air and land vehicle mission computers increasingly require. They also deliver the flexibility needed to meet the needs of emerging deployable systems. The Curtiss-Wright Integrated Systems approach significantly lowers acquisition and lifecycle costs.

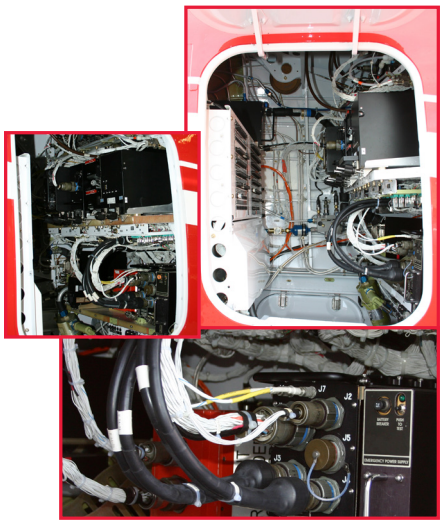

Figure 3: PC-21 Avionics Bay

A Modern Cockpit for Maximum Training Value

Systems integration is at the core of the PC-21 cockpit design philosophy with a specification that includes:

- 3 x Night Vision Goggle (NVG)-compatible 6 x 8" active-matrix liquid crystal display (AMLCD) units comprising
  - + Primary Flight Display (PFD)
  - + 2 x Multi-function Displays (MFD), complemented by
  - + an AMLCD secondary flight display and an AMLCD engine monitoring display in each cockpit
- Head up Display (HUD) with Up-Front Control Panel (UFCP) in the front cockpit and a HUD repeater and UFCP in the rear cockpit
- Flight Management System (FMS) in the front cockpit (standard) and the rear cockpit (optional)
- Autopilot (optional)
- Mission Data Recorder (MDR)
- Inputs to the mission system are made via the MFD soft keys, UFCP and Hands on Throttle and Stick (HOTAS)

Embedded Simulation and Training

The PC-21 cockpit not only provides the student with the appropriate tools to learn and develop relevant skills but also the perfect airborne 'classroom' for the instructor. The Embedded Simulation and Training suite provides:

- Cross-platform cockpit emulation
- Weapons delivery simulation
- Stores management system
- Simulated radar and electronic warfare (EW)
- Datalink
- Tactical situational display

The cockpit avionics can be 'split' so that the instructor can manipulate the student's display data. This allows the following capabilities:

- Simulated non-flight safety critical system failures
- Data degradation
- Synthetic air-to-air radar target generation
- Synthetic EW generation
- Datalink management

Environmental

DO-160E Test

- Temperature/altitude: Category B1
- Temperature variation: Category B
- Humidity: Category B
- Operation shocks: Category B
- Crash safety: Category B
- Vibration: Category: S
- Waterproof-ness: Category W
- Fluid susceptibility: Category F
- Fungus resistance: Category F
- Magnetic effect: Category A
- Power input: Category Z
- Voltage spike: Category A
- Audio frequency conducted susceptibility: Category Z
- Induced signal susceptibility: Category C
- RF susceptibility: Category Y
- Emission of RF energy: Category M
- Lightning induced transient susceptibility: Category A3E3
- Electrostatic discharge: Category A

Curtiss-Wright's MPMC-935x features up to four DCP-124 3U cPCI SBCs and the I/O interface flexibility to exactly meet the needs of today's deployable systems, including Ethernet, RS-232 serial, RS-422 serial and DIO.

Fully Rugged

The MPMC-935x is designed to meet the harsh environments of many military computing applications. Circuit cards installed in the sealed compact chassis (10.72 x 5.11 x 7.62", L x W x H) are completely isolated from external environmental conditions such as humidity, dust and sand. Cooling is accomplished by thermal transfer between the card edge of the conduction-cooled 3U cPCI cards and the side walls of the system enclosure. A rugged integrated fan provides the necessary cooling air across the walls. EMI filters and gaskets are employed for isolation from the effects of external interference and containment of possible emitted noise.

Fully Tested and Qualified

To ensure the highest levels of performance, the MPMC-935x has been designed to meet or surpass DO-160E Environmental Conditions for Airborne Equipment. It has successfully passed numerous intensive environmental tests including temperature, altitude, shock, vibration, fluid susceptibility, voltage spikes, electrostatic discharge and more.

Standard MPMC-935x Configuration Features

Slot 1

3U cPCI system controller slot driving the cPCI bus at 66 MHz/32-bit. It is populated with a Power Architecture based DCP-124 SBC and supports two dual redundant MIL-STD-1553 channels with an optional DPMC-601 PMC module.

Slot 2

PICMG 2.3 compliant slot wired for an ARINC-429 PMC on a processor or PMC carrier. 32 channels of ARINC-429 are provided with each channel individually selectable as in input or output.

Slots 3 & 5

Both are PICMG 2.3 compliant and are wired for a Curtiss-Wright PMC-704/706 video card. Each PMC-704 video card provides two video output channels, either of which can be LVDS, DVI or VGA, and six video input channels that can capture two NTSC or RS-170 simultaneously. The video cards can be mounted on a PMC carrier or on a MPC7448 SBC. (NOTE: the Pilatus variant of the MPMC-935x uses PMC-706 cards and does not support the video inputs.)

Slot 4

Integrated for a generic 64-bit PMC on a PMC carrier or SBC, and supports custom variants The MPMC-935x's DCP-124P SBCs are variants of Curtiss-Wright's standard DCP-124 that have been designed as a PICMG 2.3-compliant peripheral-only processing card, thus providing access to all 64-bits of on-board PMC I/O, a level of I/O bandwidth not provided by many competing 3U systems. In addition to supporting the full PMC I/O, each SBC also features 2 Ethernet channels, one RS-232, two RS-422, and one USB 2.0 ports.

The DCP-124/124P 3U cPCI SBC

Designed for space constrained applications, the DCP-124P is the next generation of 3U cPCI SBC. Based on the Freescale Power Architecture MPC7448 processor, the board runs at clock speeds of 1,000 and 1,200 MHz. At 1.2 GHz, the board executes an impressive 2,773 Dhrystone Millions of Instructions per Second (DMIPS). To pack the greatest functionality into the smallest standard form factor possible, the DCP-124P offers a full-speed on-board PMC site with unshared 64-bits of PMC I/O, 1 or 2 GbE ports, up to three serial channels (one RS-232, two RS-422/485), up to 8-bits Discrete Digital I/O, and a Universal Serial Bus (USB) 2.0 port.

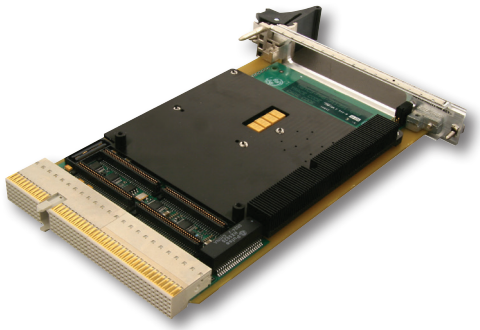

Figure 4: Curtiss-Wright 124/124P 3U cPCI SB

124P Features

- MPC7448 processor
  - 1000 or 1200 MHz
  - 2773 DMIPS
  - 133 MHz CPU bus speed
  - 1024 KB of Internal L2 Cache running at core processor speed with ECC protection
  - DFS support
- cPCI Bus
  - System controller and peripheral controller
  - 3.3 or 5V signaling supported
  - 33 or 66 MHz operation
  - Compliant with PICMG 2.0, Revision 3.0 cPCI specification
  - I/O routed to PICMG 2.3 specification
  - 64-bit, 100 MHz PCI-X PMC expansion site
- Memory
  - 512 MB of DDR1 SDRAM with ECC at 133 MHz, with a growth path to 1 GB
  - 256 MB non-volatile Flash
  - Flash for Permanent Alternate Boot Site (PABS)
  - 128 KB non-volatile RAM
- I/O
  - 2 x 10/100/1000Base-T Ethernet port
  - 1 x RS-232 Serial port
  - 2 x HDLC/SDLC-capable EIA 422/485 serial channels (both synchronous)
  - 1 x USB 2.0
  - 4 x general purpose DMA controllers
  - Up to 8-bits Discrete I/O
  - Up to 8-bits Differential Discrete I/O (4 x inputs, 4 x outputs)
- Comprehensive Foundation Firmware
- BSP Support for VxWorks 6.x/5.5.x support PowerPC, Linux, INTEGRITY®
- Available in both SCP and DCP versions; conduction- and convection-cooled, Level 0 up to Level 200 - fully ruggedized
- Standards based
  - Complies with PICMG 2.0 Rev 3.0, cPCI specification
  - Complies with PICMG 2.3 Jn4 to J2 user I/O mapping

Custom Variations

The MPMC-935x can be ordered as an Modified Commercial Off the Shelf (MCOTS) product with a modified front panel connector set, modified backplane wiring, and/or modified card set designed specifically to meet a customer's exact needs. An Intel® Core™2 Duo-based variant is also available.

The MPMC-935x's Slot 4 has been wired for a generic 64-bit PMC and a PMC carrier or SBC. The SBC I/O is wired to the front panel connectors. The 64-bits of PMC I/O are available from the front panel I/O board and can also be wired to connectors in a custom configuration.

To lower costs for large volume orders the number of MIL-STD-1553 or ARINC-429 channels provided can be reduced. Also, if video input is not required, a non-capture PMC card variant may be used.

Power, I/O and Graphics: All Included

The MPMC-935x family supports a full selection of standard and optional I/O. Standard I/O includes Ethernet, RS-232 serial, RS-422 serial and DIO. Two dual redundant channels of MIL-STD-1553 are supplied via a Curtiss-Wright PMC-601 PMC module. 32 channels of ARINC-429 can be provided via a PMC card with each channel individually selectable as RX or TX.

High Performance 3U cPCI SBCs

The main processing power of the Power Architecture version of the MPMC-935x is provided by up to four Freescale Power Architecture MPC7448 processor based DCP-124 and DCP-124P 3U cPCI SBCs. The DCP-124P peripheral-only processor is a variant of Curtiss-Wright's standard DCP-124 SBC and supports PMC I/O, dual Ethernet channels, and a USB 2.0, RS-232 and dual RS-422 ports.

The Intel Core micro-architecture version of the MPMC-935x features up to four Intel Core 2 Duo-based DCP-1201/P 3U cPCI SBCs. In addition to running Windows, the SCP/DCP-1201 runs both WindRiver® GPP Linux® 2.6 and Solaris™ 10 and operating systems. Support for real-time applications using VxWorks® 6.x OS is planned.

Performance Features

- Freescale Power Architecture
- Optional interfaces
- MIL-STD-1553: up to two dual redundant channels
- ARINC-429: up to 32 channels Individually selectable as RX or TX
- Video
  - Up to 6 input channels (NTSC, PAL, RS-170)
  - Up to 4 outputs (DVI, LVDS or VGA)
- Optional PowerPC video processor
- 3U cPCI backplane
- 5-slot, 66 MHz/32-bit
- Power supply: 28 VDC input per MIL-STD-704E, DO-160E
- Mechanical
  - Volume optimized
  - Weight fully populated:16 lb
  - Dimensions (L x W x H): 10.72 x 5.11 x 7.62”
- Custom variations

In addition to the MPMC-935x, Curtiss-Wright's MPMC-932x/931x/962x/961x Integrated Systems subsystems offer a variety of enclosure configuration, enabling wide-ranging solutions optimized for application requirements. All are high performance, rugged subsystems designed for the most demanding deployed military and aerospace requirements.

About Pilatus

Pilatus Aircraft Ltd., was founded in 1939 and is currently world market leader in the manufacture and sale of single-engine turboprop aircraft. It is the only Swiss company that develops and produces private and training aircraft. Pilatus, which is headquartered in Stans, Switzerland, is licensed to maintain and perform upgrades on a variety of aircraft. This service is complemented by three independent subsidiaries in Altenrhein (Switzerland), in Broomfield (Colorado, USA) and Adelaide (Australia). With over 1,200 employees at its' headquarters, Pilatus is one of the largest employers in Central Switzerland.

About Curtiss-Wright Defense Solutions

Curtiss-Wright Defense Solutions is a long established technology leader in the development of rugged electronic modules and systems for defense applications. Curtiss-Wright serves as a technology and integration partner to its customers, providing a full range of advanced, highly engineered solutions in applications including C4ISR systems, unmanned subsystems, mission computing, fire control, turret stabilization, and recording & storage solutions. Additionally, the company's broad engineering capabilities combine systems, software, electrical, and mechanical design expertise with comprehensive program management and a broad range of life-cycle support services. For more information, visit www.cwdefense.com.