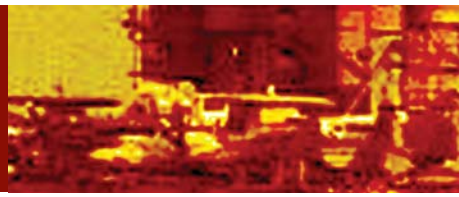
LynuxWorks for Military and Aerospace

LynuxWorks operating systems at the forefront



Today's defense and aerospace system developers trust LynuxWorks™ for the uncompromising security and reliability that their applications require.

For more than 20 years, LynuxWorks has cultivated a well-earned reputation for delivering operating systems and development tools built to handle the most demanding real-time and embedded system projects.

It's no wonder that LynuxWorks operating systems—LynxOS®, LynxOS-178, and BlueCat® Linux®—are at work providing long-term value in more than one million mission-critical embedded applications. LynxOS and LynxOS-178 offer the most inherently secure, reliable design of virtually any commercial off-the-shelf (COTS) embedded operating system, and are the most open, hard real-time operating systems available today.

What's more, only LynxOS and LynxOS-178 combine hard real-time embedded technology with broad conformance to open and de facto standards such as Linux, POSIX®, and UNIX®. As a result, developers can confidently meet stringent requirements for real-time mission-critical applications while benefiting from the time-to-market and investment-protection advantages that open-standards-based development provides.

BlueCat Linux

Linux is perhaps the best-known and most-used open-source platform and can be found today in many military applications.

BlueCat Linux, based on the 2.6 kernel, delivers the flexibility and cost benefits of open-source software. The significant improvements to the real-time capabilities of the Linux 2.6 kernel and the flexibility and cost savings offered by BlueCat Linux have led various military programs to adopt this open standard in mission-critical systems.

The explosive growth of Linux, especially in the military sector, is due to the fact that the native Linux interface is compatible with many open standards. Given the many factors needing consideration when the military plans its future system requirements, embedded Linux has become the logical direction for software selection.

Features of BlueCat Linux include:

Preemptible kernel—allows suspension of an executing process so that another, higher-priority process can be launched

Low-latency scheduler—ensures execution of processes, for increased determinism

Improved POSIX threading support—provides compatibility of applications

POSIX timers—for time and alarm management, and ideal for applications requiring high throughput or fast response time

LynxOS and LynxOS-178: the only POSIX-conformant RTOSes

Fully POSIX-conformant, LynxOS and LynxOS-178 provide optimal interoperability between safety-critical systems. POSIX (Portable Operating System Interface) is the open operating interface standard accepted worldwide. The LynxOS product line is certified POSIX-conformant and also supports the specifications of POSIX.1b and POSIX.1c.

Embedded Linux in the military

Linux from an operational point of view is very similar to other robust OSes such as Solaris, UNIX or LynxOS because it is open, standards-based and POSIX-conformant, and capable of running tens of thousands of different off-the-shelf applications.

The military has painstakingly realized that being tied to a single OS can be cost-prohibitive and lead to long product delays because applications cannot be easily ported among incompatible proprietary OSes. Therefore, the military is trying to reduce costs and improve time to deployment through "spiral development" and the use of open standards. With Linux, the military can choose from multiple vendors whose products are compatible.

Most importantly, since Linux uses open standards and is POSIX-based, it can be used in an EAL-7 environment by having the Linux OS run in a secure partition on an EAL-7-certified kernel.

To achieve this, a Linux application could be isolated from other applications, and data and information control would be managed by the EAL-7-certified kernel. This separation is extremely important because the key element in security is keeping unauthorized people from viewing information that they don't have security privileges to access. If Linux is running in a partition of an EAL-7-certified kernel, it could be completely isolated from all other applications running in other partitions on the same certified kernel.

The military has smartly decided to move away from proprietary solutions and toward open standards so that future hardware and software upgrades can be made seamlessly. Linux will work in a secure network-centric battlefield and LynuxWorks is one of the vendors that will provide the tools to make that happen.

LYNUXWORKS

LynxOS and LynxOS-178 include:

Time and space partitioning: Partitioning applies to computing time, memory space, and resources on a per-partition basis as a way to isolate faults and ensure availability of all resources.

LynxOS-178 provides for multiple hard partitions in both time and space, allowing developers to concentrate on developing applications rather than system partitioning. Each partition is completely isolated to ensure no propagation of faults between partitions.

Hard real-time performance: Predictable performance for safety- and mission-critical embedded applications.

ABI-compatibility with Linux: Application Binary Interface (ABI) refers to the run-time interfaces between an application program and the OS environment in which it is executing.

High availability: For the creation of fault-tolerant embedded systems capable of 99.999 percent uptime, cutting maintenance and support costs and improving the overall performance of mission-critical applications.

DO-178B certifiable software

The only DO-178B-certifiable, POSIX-conformant RTOS, LynxOS-178 is today's answer for companies seeking a low-risk, low-cost path to DO-178B software certification.

The DO-178B standard establishes guidelines for processes and objectives, as well as certain architectural considerations that must be used in the development of safety-critical software.

Designed specifically to satisfy rigorous technical requirements for safety-critical computing in the military and aerospace sectors, LynxOS-178 is the first RTOS proven to accelerate safety-critical products to market while delivering:

- **Reduced costs**—eliminating man-years of effort and significantly lowering the overall expense of software certification
- **Incredible value**—providing the most robust feature set of any DO-178B-certifiable operating system (five times more certified code than comparable packages!)
- **Decreased risk**—fully DO-178B-level-A-certifiable at a predictable, known cost

LynxOS-178 incorporates the advanced technology behind LynxOS, tested and hardened by tens of millions of product deployments since its initial release in 1988.

Both LynxOS and LynxOS-178 serve as foundation software for many DO-178B certified deployments, including military and aerospace systems certified to DO-178B standards, up to and including level A, the most stringent safety-critical requirement.

A framework for intelligent system development: In the commercial, aerospace and military sectors, open standards enable ease of application portability, software reuse and interoperability between systems. By ensuring that all software is open standards-based, hardware and software upgrades can be made seamlessly to reduce costs and development time and support future enhancements to new and unique tactical logistics capabilities on ships, aircrafts, submarines and other platforms.

At the forefront is LynxOS. Both the Navy Open Architecture (OA) initiative and the Weapons Systems Common Operating Environment (WSCOE), which provides a framework for the development of tactical weapons for the Army, rely on the hard, real-time deterministic capabilities of LynxOS to satisfy their rigorous system requirements.

The Navy Open Architecture: The Navy OA is a systems design approach supported by verifiable governmental testing platforms, such as the Open Architecture Computing Environment (OACE), that seeks to implement open specifications for interfaces, services and supporting formats. It enables software components to work across a range of systems and interoperate with other software components on local and remote systems. The Navy OA promotes interaction between designers, suppliers and end users that facilitates portability. Through OA, common standards and products are employed in the areas of frameworks, middleware, resource management and operating systems, utilizing established and evolving industry standards.

OACE is a compatible set of largely standards-based COTS computing infrastructure components (hardware and software) that provides the computational framework upon which tactical and support applications are built under the guidelines of OA. The scope of OACE includes technical architecture, standards and products.

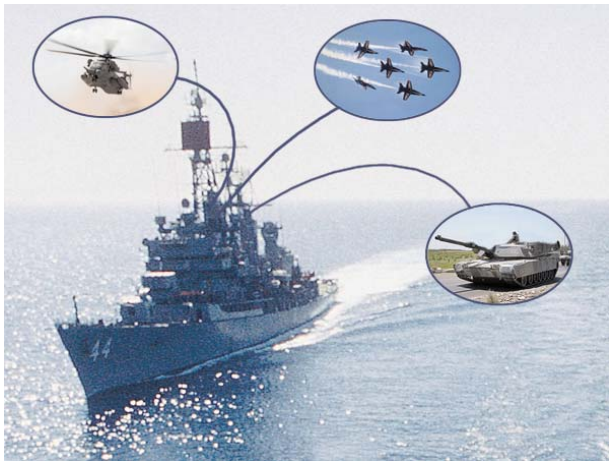
Navy OA guidelines mandate software systems that employ either a POSIX-conformant (not just "POSIX-compliant" (in which only portions of POSIX are implemented) operating system—or a Linux-based, open-systems approach. LynxOS is Navy OACE Category 3-compliant, supporting a full POSIX profile 54.

Weapons Systems Common Operating Environment (WSCOE): The goal of WSCOE is to develop a common environment of "products" to serve as a template for the development of new or upgraded Army manned and unmanned weapon systems. WSCOE provides a framework for developing embedded weapons systems, addressing real-time, safety-critical and resource constraints. It employs a modular, open-systems design that facilitates interoperability through standardized interfaces (APIs) developed to promote functional hardware-software component-based design and reuse, portability/commonality across disparate weapon systems, incorporation and migration of commercially accepted COTS, leveraging of existing weapon systems capabilities, and reduction of system development time and system acquisition cost.

Software-Defined Radio (SDR): LynxOS supports SCA-compliance (v. 2.2.1) and there are several core frameworks that have been ported to LynxOS, in support of software-defined radio (SDR) capabilities.

LynuxWorks' leadership position in the military

The promise of a single integrated air picture



Under development by the Joint SIAP System Engineering Organization (JSSEO), Arlington, Va., the ambitious SIAP (Single Integrated Air Picture) promises to change the rules of warfare. Essentially a networking communications tool, the SIAP will allow U.S. military service personnel and allies to share a single graphical representation of the battlespace. This will be accomplished using data generated by multiple surface and air sensors and broadcast via a sophisticated logistical information distribution system.

The SIAP replaces an earlier endeavor by the Navy to provide the fleet with capabilities similar to those promised by the SIAP. Now, JSSEO and NAVSEA (Naval Sea Systems Command) are designing SIAP to integrate with naval weapons. Originally, the critical nature of the SIAP necessitated the Navy to select an operating system featuring hard-real-time deterministic performance.

It required an environment that would provide reliability, maintainability and availability, along with the interoperability of truly open systems code. POSIX conformance was crucial; in fact, to support system interoperability and software reuse, all Navy OA systems are mandated to employ a POSIX-conformant operating system or a Linux-based, open-systems approach. The only certified POSIX-conformant RTOS, LynxOS was the natural choice and the Navy hasn't looked back since.

At build-out, the SIAP and will help users make better, more informed decisions by linking military forces and their tactical situations. With access to accurate, consistent data, the notion of net-centric warfare and the prospect of transforming information superiority into combat power is one step closer to reality.

A smarter way to communicate

Developed by Innovative Concepts, Inc., IDM Technology® is a powerful suite of products offering tactical wireless data communications systems that can effectively interface between the various communications protocols used in the U.S. Armed Services. A version of the Force XXI Battle Command, Brigade and Below (FBCB2) software called EBC (embedded battlefield command) runs in the IDM V304, which is scheduled for deployment in all Army Aviation platforms, to interconnect the Army's major networks for maneuver and fire support and also provide critical linkage to the military's legacy systems.

Because the VxWorks® RTOS had been originally deployed in the IDM, porting FBCB2 to VxWorks seemed a logical approach. However after spending considerable effort trying to port VxWorks to FBCB2, the earlier project cut its losses and turned to LynxOS. Like many operating systems, VxWorks only implements portions of POSIX, which represented a significant reason why efforts to port to VxWorks ultimately failed—it is not a true POSIX-conformant operating system. Conversely, the company's efforts to port to LynxOS succeeded in just a few months and FBCB2 Air was fielded in Operation Iraqi Freedom to maintain communication between helicopters and ground forces.

Innovative Concepts has since shifted its software baseline from VxWorks to LynxOS to support the continued development and deployment of the Army's standard FBCB2 Air software for its aviation unit. As the standard for airborne Army communications equipment interfacing with the Tactical Internet, LynxOS now plays a critical role in helping Innovative Concepts achieve interoperability, integrated battlespace communications, and seamless data communication requirements.

and aerospace arena is solid and long-standing

'The most high-tech cannon ever built'

The U.S. Army's Future Combat System (FCS) includes a system of manned and unmanned ground and aerial vehicles designed to outmatch and outsmart enemies and increase the effectiveness of the entire ground and joint forces. Included in the FCS is a non-line-of-sight cannon (NLOS-C) under development by United Defense, which will provide combat soldiers with the most advanced howitzer ever built.

NLOS-C incorporates myriad cutting-edge technologies—particularly in the areas of robotics, ammunition handling, projectile tracking, electronics and crew compartment design—in a more lethal, agile and rapidly deployable cannon system that can hit targets as far away as 30 km. In fact, the automation provided by the NLOS-C will enable a two-person crew to achieve what it currently takes five soldiers to accomplish, and will significantly reduce the physical demands and stresses placed on combat soldiers while offering substantially increased firepower faster and more accurately.

Satisfying the need for lighter, more maneuverable artillery, NLOS-C includes increased strategic mobility, networked communication systems, full automation with unmatched rates of fire and an advanced projectile tracking system. It also incorporates MRSI (multiple rounds simultaneous impact) capability for optimum enemy destruction and suppression, built-in active protection systems for optimum crew protection, and a real-time digital operating environment to enhance situational awareness.

The LynxOS RTOS supports required onboard processing of advanced functions such as ballistic calculations, the graphical user interface (GUI) and real-time equipment control systems. "We used LynxOS 4.x on the Army Program's CTD NLOS-C System Demonstrator," says Rick Chaddock, senior staff engineer at United Defense. "We chose LynxOS for its conformance to POSIX standards, scheduling predictability, high-performance device handling mechanisms, and standard UNIX-like application interface. The decision to use LynxOS was one of the factors that strategically helped United Defense successfully achieve and exceed its business goals for the demonstrator."

Next-generation warfare—today

Developed for the Navy, DD(X) is a next-generation warship destined to provide the foundation for all Navy surface combatant ships to be built in the 21st century. DD(X) is a revolutionary multi-mission destroyer and the centerpiece of a family of ships (including destroyers, cruisers and littoral combat ships) that will operate within the construct of the Surface Combatant Navy, providing a range of warfighting capabilities designed to maximize and revolutionize the combat potential of the Navy fleet.

DD(X) is unique in providing a single integrated command center that affords it the ability to operate in a multi-domain perspective: land attack, undersea warfare, anti-air warfare, etc. LynxOS is used extensively by the DD(X) program in areas such as in ships' embedded distribution application processors, which control key interfaces of the ship; for example, the missile launching equipment, the ship's propulsion equipment, and external communications equipment. LynxOS incorporates Navy OA precepts to create a powerful system and software architecture that is easily accessible to team members and customers throughout the DD(X) distributed network.

Ultimately, DD(X) will comprise a complementary, balanced force offering capability across the full spectrum of naval warfare. It will ensure access to littoral regions as well as the ability to defeat the air and missile defense threats the Navy will face in the future.

Intelligent ship self-defense

Shipboard Self-Defense System (SSDS) is a combat system designed to integrate and coordinate all sensor and weapon systems aboard a ship. Incorporating LynxOS and COTS hardware, SSDS employs radar systems with anti-air weapons, both hardkill (missile systems and rapid fire gun systems) and softkill (decoys), to their optimal tactical advantage.

On Navy ships, SSDS defends against the threat of lethal and highly capable Anti-Ship Cruise Missiles (ACSMs), linking and automating standalone sensor and engagement systems for aircraft carriers and amphibious warfare ships to provide quick reaction combat capability and satisfy the concept of full-dimensional ship protection. A fiber optic Local Area Network (LAN) connects ship sensors and weapon systems. The system coordinates sensor integration, identifies and evaluates potential threats, assesses readiness of ship defenses, and executes specific tactical procedures.

SSDS enhances target tracking by integrating the inputs from different sensors to form a composite track. In addition, SSDS expedites the assignment of weapons for threat engagement, and provides a "recommend engage" display for operators, or if in automatic mode, initiate weapons firing, electronic countermeasures (ECM) transmission, chaff or decoy deployment, or any combination of these.

SSDS is a family of systems designed for use in carriers and expeditionary ships. Mk 1 was the first system fielded; Mk 2

systems are designed to interoperate within and beyond the carrier or expeditionary strike group. Paving the way for Navy OA compliance, SSDS is intended to be used for future Navy ship combat systems such as DD(X) destroyers.

Aerial refueling and airlift—the essential tanker comes of age

The primary mission of the KC-135 Stratotanker is air refueling of strategic long-range bombers, and it also provides air refueling support to Air Force, Navy and Marine Corps aircraft as well as aircraft of allied nations. Through the years, this mission-critical jet has been altered to perform as airborne command posts, weather aircraft, and highly specialized electronic reconnaissance aircraft. The KC-135 is equipped with a flying boom for fuel transfer; a special drogue can be attached to the boom on the ground so it can refuel probe-equipped aircraft. During air refueling, the large flyable boom attached to the airplane's belly can offload fuel at 6,500 pounds per minute.

The U.S. Air Force's decision to update its KC-135s to Global Air Traffic Management (GATM) guidelines and the DO-178B standard has provided them with significant benefits in terms of aircraft operation, maintenance and cost of ownership. The Rockwell Collins' Integrated Processing Center (IPC) units provide a processing and data networking system that can host multiple mission, flight management, or display management processing functions while providing extensive functional growth for additional applications. The IPC is interfaced to an avionics-quality Ethernet Local Area Network (LAN). The LynxOS-178 certifiable, safety-critical RTOS powers the IPC Common Computing Module (CCM) and the Input/Output Concentrator Module.

The GATM program is designed to prepare military aircraft to meet changing communication, navigation, surveillance and air-traffic management requirements as the air space transitions to Free Flight operation. The new system provides an open-systems architecture that ensures integration with multiple products, such as weather radar, head-up guidance systems, and flight and situational awareness displays. It increases cockpit efficiency, safety and user-friendliness, while providing a plug-and-play capability that provides growth for evolving requirements.

The KC-767 tanker, also with LynxOS-178 inside, stands ready to provide a quantum leap forward for the U.S. Air Force's air refueling capability, replacing the oldest KC-135E tankers, which have been in service for more than 40 years. Not only will the KC-767 represent a significant improvement in capability, it will also be a more reliable aircraft and, therefore, available for more operations. In fact, the KC-767 is essentially four aircraft in one: while maintaining its tanker capability, its cabin floor can be configured for passenger; freighter; convertible (passenger or freighter); and combination (passenger and freighter), making it highly utilitarian.

LynuxWorks operating systems in military and aerospace

Navy Open Architecture programs

- DD(X)—next-generation warship
- SSDS—Shipboard Self-Defense System
- COTS for AEGIS-equipped cruiser conversion
- SPY radar program
- Weapons Control System (WCS)
- NSWC SGS/AC Shipboard Gridlock System with Automatic Correlation
- TMS UK Navy sonar systems (display and communications)
- Patriot Missile trainer and simulator—long-range, high-altitude, all-weather defense system
- MK 30—anti-submarine warfare training target system
- Raytheon MK 57 vertical launching system—DD(X)
- Joint Tactical Combat Training System (JTCTS)—POD control system
- BSG-1 Program Nuclear Tomahawk Missile Program—U.S. Navy surface- and submarine-launched precision strike standoff weapon
- Naval Undersea Warfare Center (NUWC) submarine trainer

Navy aviation programs

- P3 BMUP upgrade program—sonar processing
- Naval Air Warfare Center (NAWC) large area tracking system (LATR)
- Naval Air Warfare Center (NAWC) P3 ground and air systems
- Naval Air Warfare Center (NAWC) P3 GATM FMS upgrade
- Naval Air Warfare Center (NAWC) aircraft test systems
- Sonar systems
- Radar defense systems
- Radar tracker
- Tomahawk Mach III BSG 1 Patriot trainer systems
- U.S. Coast Guard CN-235 twin turboprop maritime patrol aircraft
- German Navy Sea Lynx MK 88
- U.S. Marine VH-60N presidential helicopter for anti-submarine and anti-surface vessel operation
- U.S. Coast Guard HH-60J rescue helicopter

Air force

- Radar control systems
- BASES program—Eglin AFB and SRI
- Full flight simulator and trainer for military and civil aircraft
- ASAAC—Arinc 429 and 629 test systems—Voice recognition for military aircraft
- Weapons and guidance systems
- Telemetry systems—Radar data acquisition
- Electronic warfare systems
- Electronic warfare and hybrid simulator
- Nuclear applications
- F22 data logger
- Communications server (France)
- 3D/MF radars C3I launch systems
- KC-135 tanker GATM upgrade
- KC-767 tanker
- International C-130 medium-range aircraft—GATM upgrades

NASA programs

- Satellite Laser Ranging SLR—NASA GSFC
- AVIRIS Airborne Visible/Infrared Imaging Spectrometer—JPL, California
- POSIX flight software program—NASA Goddard Space Flight Center
- GPM simulation systems—NASA Goddard Space Flight Center

U.S. Army programs

- ARTS de-mining vehicles
- Tyndall Air Force Base Joint Architecture for Unmanned Ground Systems (JAUG)—common message format for robotics middleware
- Guardian program
- Fire Control-Node Engagement Technology (FC-NET)—modular fire control software architecture
- FBCB2 Air joint situational awareness software used in Operation Iraqi Freedom
- Innovative Concepts improved data modem (IDM)—data communications device incorporated into Longbows, Kiowa Warrior, Chinook and LittleBird U.S. Army helicopters
- PC-IDM—handheld IDM (incorporated in MBITR radios for Landwarrior)
- SIDM (incorporated into the British Harrier program)
- MMKV—Multiple missile kill vehicle
- NLOS—Non-line-of-sight cannon
- CDAS—Computer decision-aided software
- CAAS—Common avionics architecture
- Guardrail program—directional finding logistics system
- Tank turret controls systems
- GPS positioning systems
- Manless tank control systems
- Tactical message handling system
- Halo II artillery missle detection systems
- MH-60—U.S. Army Special Operations helicopter (CAAS)
- MH-47—U.S. Army Special Operations helicopter
- A/MH-6—U.S. Army Special Operations helicopter
- US-60M U.S. Army helicopter—UH-60M multi-function displays
- CH-47F U.S. Army improved cargo helicopter

Joint programs

- MOSAIC waveform development
- SIAP—Single Integrated Air Picture
- Innovative Concepts Joint Tactical Radio Systems (JTRS) waveform development initiative for seamless real-time voice, data, and video communications

FAA/Commercial avionics programs

- ARTS IIIe, Common ARTS
- Airbus navigation system
- Full flight simulator (France)
- Test engines (France)
- AAD SACCS—full flight simulators (France)
- Air traffic control simulation systems
- Bombardier Challenger 300 AFD (adaptive flight display) system
- SIU—Server interface units
- CES—Cabin electronics systems
- IFIS—Integrated flight information

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