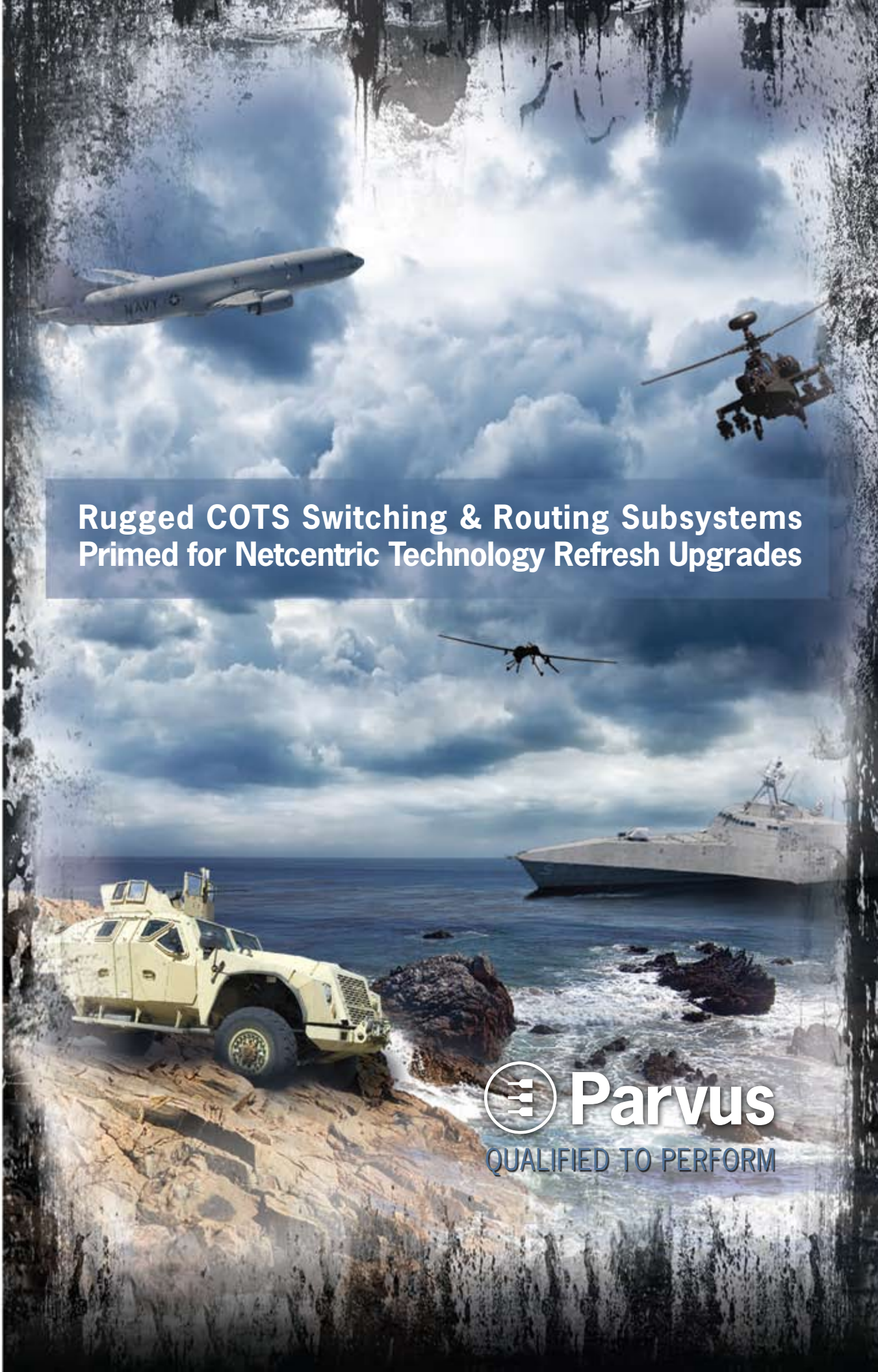
WHITE PAPER

Rugged COTS Switching & Routing Subsystems Primed for Netcentric Technology Refresh Upgrades



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Rugged Switching and Routing Subsystems Optimized for Military Needs

The success of net-centric warfare is dependent on fast, secure communications technology – specifically Ethernet. To meet the military's demands for Ethernet-enabled vehicles and aircraft, there is an increased focus on developing a variety of Ethernet switches and routers that help the military achieve mission success. Currently, there is a rich set of rugged COTS board-level and box-level Ethernet switching and routing LRUs (Line Replaceable Units), which is a clear testament to the demand for vehicle-based networking options. This whitepaper outlines many of the key functional requirements and network management features sets expected today in router and switch subsystem products used by the US Department of Defense, along with a case study on the Expeditionary Fighting Vehicle (EFV)'s Tactical Switch Router (TSR).

Key Concepts: *Network bandwidth, managed versus unmanaged switches, spanning tree redundancy, virtual local area networks (VLANs), zeroization / security, Quality of Service (Qos), OSI Layer 2 versus Layer 3 functionality, Simple Network Management Protocol (SNMP), and MIL-STD environmental requirements.*

Balancing Ethernet Wants vs. Needs

Traditional vehicle data buses such as MIL-STD-1553, CANbus, and RS-232 continue to have an important role in mission-critical military applications. However, due to their limited bandwidth and the growing priority to gather and synthesize information as quickly as possible for situational awareness, Ethernet is becoming the preferred enabler for situational awareness in many battlefield platforms.

Despite the desire for high speed and performance, not every application receives tangible benefits from the faster pipe offered by Gigabit Ethernet or 10 Gigabit Ethernet. In fact, Fast Ethernet often meets current network requirements, since actual Wide Area Network (WAN) backhaul speeds are often slower than 100 Mbps in the field. This is because the speed of inter-vehicle communications can be constrained by the wireless connection, which becomes the bottleneck for speed and performance. However, for intra-vehicle communications not limited by the bottlenecks of a WAN connection, on-board computing devices certainly benefit from 1 Gigabit/second or faster connectivity.

To help the military meet its current need for Ethernet-enabled vehicles and to anticipate future demands, there is increasing pressure on defense contractors to provide rugged Ethernet switches and routers that meet the requirements of SWaP2-C2 (Space, Weight, Power and Performance – Cooling and Cost). Additionally, these network switches and routers must endure the harshest environments to enhance situational awareness in unmanned aircraft, tactical ground vehicles and maritime assets, where standard commercial-grade equipment cannot survive.

Parvus Develops Rugged Routers to Support Military Missions

One of the many significant deployments of Ethernet in the military is with the Expeditionary Fighting Vehicle (EFV) – the Marine Corps' highest priority ground combat modernization program. Designed and developed by prime contractor General Dynamics, the EFV is an armored amphibious vehicle capable of seamlessly transporting Marines from Naval ships located beyond the visual horizon to inland objectives. The new vehicle is a self-deploying, high water-speed, amphibious, armored, tracked vehicle, and is to provide essential Command, Control, Communications, Computers, and Intelligence (C4I) functions for embarked personnel and other EFV units.

To support the EFV's mission, General Dynamics initially selected Fast Ethernet as the main inter-vehicle network protocol for linking various IP-enabled computing and communications devices in the EFV. General Dynamics needed a rugged router that wasn't yet commercially available to sustain its networking requirements. General Dynamics contracted with Parvus Corporation to develop the Tactical Switch Router (TSR)—enabling the deployment of communications-on-the-move and information-sharing capabilities, supporting the Marine Corps' net-centric operations initiatives.

The miniaturization of components allows more functionality to be packaged into communications technology—a key requirement of the USMC for the TSR. Parvus met this challenge by combining the router and Ethernet switch in one stand-alone Line Replaceable Unit (LRU). This engineering development simplified installation and maintenance for the USMC, which ultimately saves time and reduces costs.

By basing the TSR router on Parvus' COTS DuraMAR Mobile IP router product, the EFV benefited from a small form-factor rugged router subsystem that integrated Cisco System's Rugged 3200 Series Integrated Services Router (ISR) and Internetwork Operating System (IOS) together with an isolated military-grade DC/DC converter in a rugged chassis with MIL-C-38999 interfaces. Capable of delivering secure data, voice and video communications to stationary and mobile network nodes across wired and wireless networks, this proven IP networking solution includes Cisco's stackable embedded PC/104-Plus modules, the 3251 Mobile Access Router Card (MARC), 3201 Fast Ethernet Switch Interface (FESMIC) and 3201 Serial Mobile Interface Card (SMIC).

Tactical Switch Router

COTS Technology Critical for Military Operations

The pervasiveness of Cisco technology and its IOS software in the government arena was a critical factor for specifying this routing technology in the TSR. According to industry reports, Cisco has least a 70 percent market share in the US Government's IP network infrastructure. By including network management software that the US Marines has been trained to operate, the learning curve to operating the TSR would be diminished and would improve the EFV's time to deployment.

Cisco IOS software also afforded the USMC with advanced capabilities for network security, manageability, and scalability. Some of the integrated network security features include authorization and authentication, stateful firewall, intrusion detection, and Triple Digital Encryption Standard (3DES) or Advanced Encryption Standard (AES) encryption for VPNs. Remote management capabilities give network managers visibility into and control over the remote network, including devices connected to the router. Powerful debug and troubleshooting commands allow network managers to quickly isolate network problems and securely make changes to network configurations.

In keeping pace with the initiative to "future-proof" the EFV, Parvus' latest revision of the TSR integrates two PC104+ Gigabit Ethernet switch cards into a new chassis to provide a total of 17 Ethernet ports—more than triple the number of available ports on the original TSR configuration or that is normally available from Cisco's standard product. By integrating 3200 series mobile access router technology together with PC/104+ Gigabit Ethernet switch cards, the TSR offers expanded LAN port count and consolidated switch and router functions into a single hardened subsystem designed to MIL-STD-810F and MIL-STD-461E environmental conditions. Sealed MIL-C-38999 connectors bring out an IOS-managed 10/100 WAN port, three IOS-managed 10/100 switch ports, and 13 10/100/1000 Gigabit Ethernet switch ports, as well as two multi-protocol serial ports and a RS-232 management console port. These additions supply the EFV with enough capacity to meet future networking demands.

The latest version of the TSR subsystem helped shape Parvus' other rugged COTS router product offerings. The DuraMAR 3230 will become a standardized version of the TSR for generalized use by the armed forces.

DuraMAR 3230

Unmanaged Switches Serve Important Role

Like routers, switches are an important component of the military's net-centric toolbox. For some military applications, an unmanaged switch could be the ideal solution. Since unmanaged switches require no configuration and are designed for simple plug-and-play operations, in applications when this is all that is required, a managed switch may add a lot of unnecessary complexity and expense to the equation. Unmanaged switches can also be helpful when a Virtual Local Area Network (VLAN) has already been defined and there's a need to merely expand the port count on the edge of the network.

Unmanaged switches are also ideal for scenarios where the network traffic is light and data simply needs to pass from one device to another. Rather than giving the user the ability to configure link parameters, unmanaged switches use a procedure called "auto-negotiation" to agree upon certain communication parameters. One parameter they negotiate is the data rate—generally 10, 100 or 1000 Mbits/s. Another is whether to use half-duplex or full-duplex mode.

DuraNET 1059

Full-duplex allows communications to exist in both directions at the same time, while half-duplex allows for only one way communication at a time. However, in today's networking environments, half-duplex might only be used where older, legacy systems are in place.

Although managed devices are more common now in military usage, unmanaged switches still play an important role as a piece in the overall networking architecture, including within many rotary aircraft modernization programs. The U.S. Army's Aviation Applied Technology Directorate (AATD), for example, specifies an unmanaged Ethernet switch subsystem (DuraNET 1059) into the AH-64 Apache helicopter to improve situational awareness and connect onboard computing devices. Multiple unmanaged Ethernet switch cards in the VME form factor are integrated into the Light Airborne Multi-Purpose System (LAMPS) technology insertion for the U.S. Navy SH-60 Seahawk. Similarly, the UH-60 Blackhawk integrates a combination of unmanaged and managed devices.

Military Applications Demand Managed Switches

By providing users with options for monitoring and configuring networks, managed switches can provide the armed forces with greater control and security over their local area network (LAN) data. There has been an increasing demand of late within military technology refresh programs for "lightly managed" rugged COTS switches. These devices support a core networking feature set and provide some basic management capabilities, which make these switches well suited for many situational awareness upgrade applications. Additionally, the "lightly managed" variety of switch is much less costly than fully managed switches—a very attractive feature for budget sensitive military groups.

DuraNET 1268

The need for a switch that includes many of the functional advantages of a fully-managed switch without the hefty price tag or complexity prompted Parvus to develop the new lightly-managed DuraNET 1268 rugged 10-port Ethernet switch subsystem. By offering powerful Layer 2 features such as IPv6 Class of Service (CoS) prioritization, Simple Network Management Protocol (SNMP), IEEE-802.1Q tagged or port-based VLANs, a Serial Command Line Interface (CLI), and Web management, among others, the DuraNET 1268 is primed for insertion into demanding network-centric manned and unmanned vehicles and aircrafts. A handful of airborne, maritime, and ground vehicle programs have already specified this device since it was recently introduced to the market.

The demand for managed switches, along with Layer 2 data link and Layer 3 network layer support is also becoming a strong preference for many military applications. In the Open Systems Interconnection (OSI) model of computer networking, Layer 2 refers to the node-to-node frame delivery on the same link, whereas Layer 3 refers to the end-to-end (source to destination) packet delivery including routing through intermediate hosts. A Layer 3 switch blurs the line between routing and switching, permitting a more efficient networking architecture while including more optimized protocols – such as Internet Protocol or IP. Additionally, many fully managed switches and routers can now support Layer 3 protocols and beyond.

OSI Model			
	Data Unit	Layer	Function
Host Layers	Data	7) Application	Network Process to Application
		6) Presentation	Data Representation & Encryption
		5) Session	Interhost Communication
	Segment	4) Transport	End-to End Connections & Reliability
Media Layers	Packet	3) Network	Path Determination & Logical Addressing
	Frame	2) Data Link	Physical Addressing
	Bit	1) Physical	Network Process to Application

The need for managed switches, along with Layer 2 data link and Layer 3 network layer support (per the OSI model) is becoming a strong preference for many applications.

Managed Switches Provide Necessary Features for Military's Needs

Maintaining situational awareness through the use of video, maps, radio and satellite technologies requires a networking infrastructure that can manage and prioritize data packets to ensure mission safety and success. With the DuraNET 1268 switch from Parvus, necessary features are included to meet the military's stringent efficiency and security demands.

Such features include Quality of Service (QoS), which allows users to prioritize network traffic by assigning a higher priority to traffic from particular ports, VLANs, IP classes, tags, etc. This helps ensure consistent network performance for critical, time-sensitive data. QoS is especially critical for military users in a mixed-traffic environment where large data files such as map images can delay important voice packets or flash messages that need to reach the vehicle operator. QoS allows the user to tag certain traffic as high priority to ensure delay-sensitive data is delivered in a timely manner.

Similarly, VLANs featured on managed switches allow the device to logically group devices together to isolate traffic between these groups, even when the traffic is passing over the same physical switch. This segmentation and isolation of network traffic helps reduce unnecessary traffic and provides maximum bandwidth to devices that need to communicate to each other. This allows better network performance, and in many cases, provides an additional level of security.

Another common feature of managed switches is support for redundancy. Redundancy provides the ability to safeguard a network in case a connection or cable fails by providing an alternate data path for traffic. Many switches incorporate what is called Spanning Tree Protocol standard (STP), to provide path redundancy in the network. Using the spanning-tree algorithm, STP provides redundant paths while preventing loops that are created by multiple active paths between switches. STP allows for one active path at a time between two network devices, preventing loops and establishing the redundant links as a backup to keep integrated systems available and preventing expensive downtime.

With the IEEE's introduction of a newer protocol called Rapid Spanning Tree Protocol (RSTP), networking devices can now provide for faster spanning tree convergence after a topology change. All the basic concepts of STP are included with RSTP with the main difference being convergence time. While it may take STP 30 to 50 seconds to re-converge, RSTP does it in dramatically less time. Further, Multiple Spanning Tree Protocol (MSTP) extends RSTP for grouping multiple VLANs into a single Spanning-Tree topology. It is not uncommon for redundant flight-critical electronics

onboard manned and unmanned aircraft to be networked by Ethernet switches supporting some form of STP. In this way, onboard mission computers have multiple potential data paths and can quickly recover if critical hardware fails.

Monitoring functions of network switches can provide additional control and efficiency. Through the use of SNMP, a protocol that facilitates the exchange of management information between network devices, users can determine the health of the network or the status of a particular device. This includes the number of bytes and/or frames transmitted and received, errors generated, and port status. By displaying this data over a standard web browser, administrators can monitor the performance of the network and quickly detect and repair network problems without having to physically interact with the switch.

In addition to these key management features, when designing network devices, Parvus often includes a non-destructive zeroization feature to provide additional security for military users. Now a requirement in many military vehicles, zeroize capabilities can sanitize switch or router should the military platform be compromised, clearing out system firmware, as well as network addresses and configuration settings.

Ruggedizing Routers and Switches for the Military

As with most computer hardware destined for military vehicle use, rugged switches and routers must be small and lightweight in form factor, yet robust in mechanical design. Parvus' unique approach to thoroughly test and qualify its products to meet military standards ensure that that its routers and switches rugged routers and switches are ready for a variety of situation awareness and net-centric applications, including in-vehicle wireless Internet access, VoiceOverIP (VoIP), streaming video surveillance, and smart vehicle diagnostics/ maintenance.

The DuraNET 1268 switch, for example, weighs less than 5 lbs and integrates a conduction-cooled, aluminum chassis with sealed MIL-38999 connectors and MIL-STD-1275/704 power supply. This fully immersible subsystem is designed for harsh MIL-STD-461E EMI/EMC and MIL-STD-810F thermal, shock, vibe, humidity, altitude, and ingress conditions with an operating temperature of -40°C to 71°C fanless. These rugged accommodations enable defense contractors to specify such devices into programs to benefit from managed switches without having to compromise reliability and durability.

Additionally, Parvus ensures its DuraMAR router products are designed to MIL-STD-810F and MIL-STD-461E environmental conditions to empower prime defense contractors to provide net-centric communications in even the harshest shock, vibration, thermal, ingress, and EMI environments. Specifically, the DuraMAR 3230 supports military-grade power supply supports aircraft (MIL-STD-704E) and ground/marine (MIL-STD-1275B) vehicle voltage inputs, spikes, and transient levels.

DuraNET 1268

What's Ahead for Switches & Routers

As the military's need for more network management capabilities increase, manufactures must continue to innovate switch and routing technology to meet impending demands. An example of this is the number of ports available on managed switches. Presently, many military vehicle applications require 8-10 ports; however, with the military's "future-proof" stance on acquiring technology, manufacturers need to have roadmaps in place to deliver switches with more port density to support a larger number of devices. Parvus has witnessed programs requirements for as many as 64 ports on rotary aircraft.

Additionally, switches and routers will need to support greater bandwidth requirements. Although bandwidth doesn't currently present much of an issue because few applications require more than 1 Gigabit per second, the military is increasingly requesting 10 Gigabit Ethernet switches in preparation for more bandwidth intensive applications, particularly those associated with signal intelligence, radar, sonar and high-performance communications systems. However, the successful implementation of 10 Gigabit speeds depends on the development of switches and routers to accommodate this technology. As evidenced from Parvus' design and deployment of the DuraMAR and DuraNET routers and switches, government contractors and suppliers are well primed to help the military meet its net-centric objectives.

Appendix: Rugged COTS Router Subsystems

Rugged Routers

DuraMAR® 1000

DESCRIPTION	MIL Rugged Cisco 3230 Mobile IP Router w/ POE
MOBILE ROUTER	Cisco 3230 MARC, FESMIC, SMIC
CISCO IOS FEATURES	Security, Management, QoS, VLAN, Routing Protocols, IPv6
PORTS	1x FE WAN, 4x FE LAN, 4x Serial, 1x Aux, 1x Console
PHYSICAL	7.5 lbs, 8.37" x 5.90" x 4.18" (L x W x H)
POWER	28VDC, MIL-STD-704E, 18W Power Consumption, PoE, PwS
ENVIRONMENTAL	MIL-STD-810F (-40 to +71C, 15G Shock, Random Vibe, Watertight)
EMI/EMC	MIL-STD-461E (CS101, RE102, RS103)

DuraMAR® 3230

DESCRIPTION	MIL Rugged Cisco 3230 Router with Integrated Gigabit Ethernet Switch
MOBILE ROUTER	Cisco 3230 MARC, FESMIC, SMIC + Parvus Gigabit Ethernet Switch
CISCO IOS FEATURES	Advanced Security, Management, QoS, VLAN, Routing Protocols, IPv6
PORTS	1x FE WAN, 3x FE LAN, 13x GigE LAN, 2x Serial, 1x Console, Zeroize
PHYSICAL	<16 lbs, Approx. 6.0" x 6.2" x 10.0" (L x W x H)
POWER	28VDC, MIL-STD-704E, <75W Power Consumption
ENVIRONMENTAL	MIL-STD-810F (-40 to +71C, 20G Shock, Random Vibe, Watertight)
EMI/EMC	MIL-STD-461E (CS101, RE102, RS103)

DuraNET® 3825

DESCRIPTION	Ruggedized Cisco 3825 Integrated Services Router
CISCO ROUTER	Cisco 3825 ISR, HWIC-8A/S-232, NME-16ES-1G, AIM-VPN/SSL-3
CISCO IOS FEATURES	Advanced Security, Management, QoS, VLAN, Routing Protocols, IPv6
PORTS	2x GigE Router, 1x GigE Switch, 16x FE Switch, 8x RS232, Console
PHYSICAL	<28 lbs, Approx. 3.5" x 17.6" x 18.3" (H x W x D)
POWER	100-240VAC, <300W Power Consumption
ENVIRONMENTAL	Designed to MIL-901D, Class 2 Shock, MIL-810F (0 to +40C Temp)
EMI/EMC	Designed to MIL-STD-461E

NOTE: Specifications are Subject to Change without Notice

Appendix: Rugged COTS Switch Subsystems

Rugged Switches

DuraNET® 1268

DESCRIPTION	Rugged 10-Port Gigabit Ethernet Switch, Lightly Managed
PORTS	10x Gigabit Ethernet, 1x Fast Ethernet Console, 1x Serial Console
OPTIONAL FIBER	4x 1000BaseSX Fiber Optic Ethernet Ports (on Rear Panel)
PORT FEATURES	Auto-MDI/MDIX, Auto-Negotiation, Auto-Detect, Speed Auto-Sensing
MANAGEMENT	RS-232 Console, Web Browser, VLAN, QoS, RSTP
PHYSICAL	< 5.0 lbs, Approx. 7.6" x 5.3" x 3.6" (L x W x H)
POWER	28VDC, MIL-STD-704E, MIL-STD-1275D, 25W Power Consumption
ENVIRONMENTAL	MIL-STD-810F (-40 to +71C, 40G Shock, Random Vibe, Watertight)
EMI/EMC	MIL-STD-461E (CE102, CS101, RE102, RS103)

DuraNET® 1059

DESCRIPTION	Rugged 5-Port 10/100 Ethernet Switch, Unmanaged
PORTS	5x Fast Ethernet
NETWORKING	Auto-Detection, Auto-MDI/MDIX, Auto-Sensing, Auto-Negotiation
SWITCHING	Pause Frame-Based Non-Blocking Switch Fabric
	512 Kb Frame Buffer Memory, 1,024 MAC Address Look-Up Engine
PHYSICAL	1.9 lbs, 6.00" x 4.95" x 3.70" (L x W x H)
POWER	28VDC, MIL-STD-704E, <8W Power Consumption
ENVIRONMENTAL	MIL-810F (-40 to +85C, 15G Shock, Random Vibe, Water Resistant)

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