Transforming Military Communications for Network-Centric Warfare

Network Enabled by Lucent Technologies

A white paper on:

• Upgrading military networks for “Everything-over-IP,” while supporting legacy applications
• Providing bandwidth scalability for immediate and future growth
• Preventing service disruptions with resilient connections
• Minimizing operational complexity
Table of Contents

Executive Summary .................................................................................................3
Requirements for Network-Centric Operations ......................................................4
Lucent Solutions – Meeting Military Network Needs .............................................6
Upgrading Networks, While Supporting Legacy Applications ...............................7
Metropolis® WSM DWDM Core Network ...............................................................8
Metropolis® DMX Next-Generation SONET MSPP Infrastructure ......................10
Providing Scalability for Immediate and Future Growth ...............................11
Preventing Service Disruptions with Resilient Connections ............................12
Minimizing Operational Complexity .................................................................13
Lucent Solutions – Enabling Network-Centric Operations ..............................14
Acronyms ............................................................................................................15
Lucent Optical Solutions .....................................................................................16
The Lucent Advantage for the U.S. Military ......................................................18
Executive Summary

To maintain supremacy and transform combat operations in the air, at sea, and on land, the U.S. military is moving to network-centric warfare. With current tactical and theater-wide battle-space data simultaneously available to war fighters, field units, and commanders — regardless of location — the U.S. military can rapidly synchronize forces and multiply combat effectiveness.

Today, new advances in communications technologies provide scalable transport of voice, data, video and sensory traffic as well as data from legacy applications, allowing the Army, Air Force, Navy and Marine Corps to transform existing communications networks to support highly connected and highly visual combat operations. These new technologies can transform communications systems from individual network “silos” supporting discrete users and applications to a multi-application, multi-user network enabling instantaneous communications across all locations. With these new technologies, war fighters, operators, commanders in the field, and headquarters staff can instantly access vital information.

Next-generation optical solutions from Lucent Technologies provide the mission-critical backbone infrastructure for core base, range and pier-side networks, as well as connectivity to the Department of Defense (DoD) Global Information Grid Bandwidth Expansion (GiG-BE) / Defense Information Systems Network (DISN) backbone. Lucent solutions:

- Allow military networks to carry Gigabit Ethernet (GigE) and 10 GigE video, sensory, voice-over-Internet Protocol (VoIP) or other traffic, while supporting legacy applications such as time division multiplexing (TDM) voice.
- Provide bandwidth scalability for existing and future application growth through dense wave division multiplexing (DWDM), SONET, 10G and, in the future, 40G support.
- Minimize complexity from the core to the network edge, while expanding network functionality and capacity.
- Reduce individual application “silos” and help converge all applications and networks onto one core backbone.
- Prevent service disruptions with resilient connections to all sites.
- Minimize operational complexity through intelligent network design, implementation and management.

By working closely with the U.S. military — from deploying early optical networks with the U.S. Army and Air Force to upgrading bases with DWDM for single network transport of multiple-traffic types — Lucent optical solutions, developed at Bell Laboratories, enable the successful implementation of critical DoD initiatives including:

- The U.S. Army Installation Information Infrastructure Modernization and Digital Switched Systems Modernization Programs (I3MP-DSSMP).
- The U.S. Air Force Combat Information Transport Systems (CITS) and Network-Centric Solutions (NETCENTS).
Lucent’s optical solution portfolio includes:

• The Metropolis® Wavelength Services Manager (WSM) DWDM family.
• The Metropolis® DMX Next-Generation SONET MultiService Provisioning Platform (MSPP) family.
• Lucent Optical Management Solutions.
• Lucent Worldwide Services.

This integrated, flexible solution enables consistent high-performance transport for mission-critical applications and allows all branches of the U.S. military to rapidly deploy scalable communications networks to achieve superior battle-space awareness.

Requirements for Network-Centric Operations

The U.S. military is in the process of upgrading base, range and pier-side networks to provide commanders and field personnel with unparalleled battle-space awareness. These continuing improvements create opportunities to transform legacy networks to “Everything-over-Internet Protocol” in order to accommodate enterprise applications, voice, unsecured and secured data, video, and sensory information. Network transformation also provides the opportunity to transform internal processes and operations while increasing reliability and scalability and ensuring connectivity for all users.

Key requirements for network transformation include:

• Design superior networks for outside plant, optical, voice, and data services – Incorporate best practices for network planning, design and implementation to ensure mission-critical networks operate smoothly and reliably, provide ultra-broadband connectivity to other base networks through the DoD GiG-BE backbone, and eliminate or minimize network-wide delays.

• Migrate to an “Everything-over-IP” network, while supporting legacy applications – Move to an all-IP network to allow military usage of enterprise-developed applications, including VoIP, human resource planning, supply chain, instant messaging, email, remote storage, disaster recovery, IP video and video conferencing, while continuing support for existing TDM-based voice applications.

• Maximize network capacity while minimizing costs – Economically optimize core backbones for highly scalable bandwidth to accommodate current and future applications.

• Inventory, upgrade and expand fiber plant – Determine inventory, usage maps, and quality levels of existing fiber plant. Qualify existing fiber plant to current standards for OC-48, OC-192 and DWDM transport. Replace compromised or unusable fiber, augment existing copper drops with fiber, and add connectivity to additional sites.

• Migrate data networks from ATM to GigE or 10 GigE backbone – Upgrade data networks to state-of-the-art data backbones running GigE and/or 10 GigE to support new applications, including VoIP, remote storage and disaster recovery.
• **Boost networking capacity to data centers and critical sites** – Upgrade data networks to connect critical sites together and to the GiG-BE and other military networks. Incorporate deterministic networking through Multi-protocol Label Switching (MPLS) or ring technologies such as Resilient Packet Ring (RPR) for GigE or 10 GigE transport. Upgrade OC-3 or OC-12 rings to OC-48 or OC-192 and provide scalability with DWDM.

• **Optically connect training ranges and sites** – Extend the limited existing fiber networks at ranges and training facilities to support remote sensors and carry video, images, telemetry, and surveillance data to other users via the global military network.

• **Converge discrete networks, while maintaining independence** – Replace discrete data, secured data, voice and sensor networks with a converged network to eliminate “silos.” Provide high reliability, simplify management, enhance scalability, and ensure connectivity for all users in multiple locations, while allowing for independent network administration.

• **Enhance management for full network visibility** – Provide efficient network management tools to enhance network performance, prevent problems before they become disruptive, plan for future growth, and easily implement upgrades.

• **Support on-going evolution** – Extend the capacity of existing network to accommodate new bandwidth and site connectivity requirements, introduce new applications and prepare for the migration of legacy applications to IP.

To meet these requirements and continue the recent success of base upgrades, the military can rely on the expertise of Lucent Technologies and Bell Laboratories to design, engineer, and implement a highly reliable and scalable core network solution.

---

**Lucent Optical Leadership**

Forged from Bell Laboratories, Lucent has a vast heritage of innovation that includes generations of optical products:

• Lucent continues to deploy a wide array of research talent to enable advanced optical solutions. Lucent’s Bell Laboratories has developed over 2500 patents in optical technology.

• As the original innovator in optical networking, Bell Laboratories has pioneered new standards for SONET and 40 Gbps technology to efficiently transport Ethernet, IP and legacy traffic with high reliability and low latency.

• Field-proven in both wide area and carrier metropolitan networks, Lucent metro solutions have over 1,000,000 ports — DS3 and above — installed in North America.

• Benefiting from partnerships with the U.S. military, Lucent solutions are optimized for high-reliability, rapid provisioning, and total service excellence.
Lucent Solutions – Meeting Military Network Needs

With more than 13 years of optical experience building base optical networks for the U.S. Army, Lucent Technologies leads the industry in 40G, non-banded DWDM and TDM-to-packet migration. With engineering, design and implementation expertise provided by Lucent Worldwide Services, Lucent’s integrated solution enables U.S. military planners to deploy base, range and pier-side networks for today’s network-centric operations and warfare, as well as to support near- and long-term growth.

Lucent provides the following critical expertise:

- **Cost-efficient network implementation** – To decrease capital, management and administration costs, Lucent’s solution portfolio provides the foundation for a scalable core network capable of carrying all traffic types while reducing network complexity. With standards compliant and reliable deployments in numerous service provider networks, Lucent ensures high availability and compatibility with industry networking and storage technology. In its standard configuration, the Lucent Metropolis® WSM DWDM family delivers high efficiency and cost savings through an advanced optical add/drop multiplexing (OADM) capability that delivers non-banded wavelengths and automated power management for maximizing bandwidth efficiency and reducing engineering and equipment costs. For high-churn network paths, a full reconfigurable optical add/drop multiplexing (ROADM) solution is also available for minimizing configuration and operating expenses. The Lucent Metropolis® DMX Next-Generation SONET MSPP family offers scalable SONET solutions that provide “right-sized” network deployments and hardened options for outside plant installations.

- **Optical networking leadership with market-leading solutions** – Lucent’s optical leadership is realized in widely deployed, proven solutions that deliver bandwidth flexibility, service reach, and reliability. The Lucent Metropolis® DMX and Lucent Metropolis® WSM families incorporate several advanced innovations, including Generalized Multiprotocol Label Switching (GMPLS) control plane on the WSM for simplified provisioning of wavelength (DWDM) services, Ethernet-over-SONET (EoS) and Ethernet-over-WDM (EoW) for efficient transport of IP traffic. They also provide pluggable optical interfaces on a single line card for maximum flexibility and efficiency. Lucent’s Optical Management Solutions provide the comprehensive performance and service management customers require — a key component of the total solution.
• **Superior network design and implementation capabilities** – Lucent Worldwide Services has engineered, designed and deployed many fiber plants and optical networks. With in-depth experience gained through numerous military and government projects, Lucent Worldwide Services can eliminate or minimize optical backbone management issues as well as provide for future growth without additional fiber plant build-outs. Lucent networks and products are designed for and support 99.999% availability.

• **IP and legacy data and voice networking excellence** – Lucent also has expertise designing, engineering and deploying GigE and 10 GigE solutions and legacy applications so that the combined optical, data, video, voice, wireless and sensory networks operate efficiently and reliably.

• **Solutions flexibility to provide high value networks and scalability** – To help the military fully leverage its infrastructure investment, Lucent's end-to-end, highly flexible optical product portfolio and proven experience enable the military to build highly scalable networks that minimize complexity and provide flexible application transport for current and future bandwidth.

From deploying next-generation MSPPs to implementing DWDM systems, Lucent can enable successful implementation of critical network infrastructure initiatives for all military branches.

**Upgrading Networks While Supporting Legacy Applications**

Many existing military networks support ATM data and TDM-based voice networks with an OC-3, OC-12 or OC-48 SONET backbone. To upgrade these networks and expand connectivity between data centers and core facilities — such as command posts, barracks, communications, offices, medical, logistics and support centers — the military can replace ATM with a GigE or 10 GigE data backbone and upgrade legacy SONET infrastructure with a DWDM optical core network and/or a next-generation SONET network.

Benefits of a next-generation optical core network include high resiliency, scalability, and ultra-high bandwidth as well as transport of legacy TDM-based traffic. It allows an “Everything-over-IP” migration strategy where a single network converges all data, secured data, TDM voice, VoIP, video and sensor traffic while at the same time allowing for expansion of voice and data services to new ranges, training facilities or bases.

With an optical solution from Lucent, the military can successfully upgrade core networks with advanced, flexible SONET and DWDM products consisting of:

• **Metropolis® WSM DWDM Core Network** – Provides advanced OADM capabilities including non-banded wavelength architecture for flexible wavelength add/drop at each node without stranding any capacity; GMPLS control plane for simplified wavelength service provisioning; automated power management for lower engineering costs. A full ROADM solution is also available to address high churn network scenarios.
• **Metropolis® DMX Next-Generation SONET MSPP Infrastructure** – For seamless transport from T1 to 10G, next-generation SONET incorporates data and TDM switching fabrics, 10G optics, 50 ms or less restoration time, Resilient Packet Ring (RPR), Ethernet transport, and efficient aggregation support for multiple traffic types.

Lucent optical solutions allow the military to move to an all-IP network while maintaining legacy voice or private line services.

---

**Metropolis® WSM DWDM**

Lucent’s Metropolis® WSM is an advanced DWDM system enabling converged transport for multiple networks through common and separate, protected wavelengths for each traffic type — data, legacy voice, VoIP, secure data, IP video conferencing, and range sensory systems.

A core DWDM network provides for current applications, future growth and operational simplicity. Lucent Metropolis® WSM solution:

- Supports the GigE and 10 GigE requirements of the I3MP and new CITS architectures.
- Demarcates traffic types by wavelength to serve as a converged network for discrete system networks.
- Minimizes complexity by eliminating expensive fiber plant build outs for additional bandwidth and managing crucial optical functions, including line amplification, automated power equalization and performance monitoring.
- Enable “deterministic” optical protection for all GigE or 10 GigE traffic supported wavelengths regardless of the number of GigE or 10 GigE networks — thereby eliminating non-deterministic, variable restoration times associated with higher-layer routing protocols such as rapid spanning tree protocol (RSTP) or open shortest path first (OSPF).

---

<table>
<thead>
<tr>
<th>Network Type</th>
<th>Typical Bandwidth</th>
<th>No. of Networks / Wavelength</th>
</tr>
</thead>
<tbody>
<tr>
<td>TDM Voice</td>
<td>T1, DS3, OC12, OC48</td>
<td>1344x (T1s) 5376x (T1s) 48x (DS3) 16x (OC12) 1x (OC48)</td>
</tr>
<tr>
<td>VoIP</td>
<td>GigE, 10 GigE</td>
<td>2x 10x (GigE) 1x (10GigE)</td>
</tr>
<tr>
<td>Data</td>
<td>GigE, 10 GigE</td>
<td>2x (GigE) 10x (GigE) 1x (10GigE)</td>
</tr>
<tr>
<td>Range Sensory</td>
<td>GigE</td>
<td>2x 10x</td>
</tr>
</tbody>
</table>

**DWDM transports multiple networks through common or separate wavelengths across a common core for Everything-over-IP with legacy support**
The Lucent Metropolis® WSM core network offers:

- Support for a converged backbone, collapsing discrete networks with mesh, ring and linear topologies with medium-to-short long haul optics to boost capacity to critical sites and data centers.

- Per wavelength scalability from one to 40 wavelengths that can be provisioned through GMPLS to meet existing and future capacity needs.

- Advanced OADM capability providing a non-banded architecture for maximum efficiency and flexibility so that any wavelength can be added or dropped at any node without simultaneously adding or dropping other wavelengths or stranding bandwidth.

- A full ROADM solution where required to eliminate manual engineering changes in high-churn networks.

- Restoration times within 50 milliseconds.

- GigE and 10 GigE interfaces to support high-speed data networks with “deterministic” sub-50 millisecond optical protection for all wavelengths and traffic types.

- 10G and 2.5G optics and C/DWDM in one chassis.

- Ultra-high bandwidth Fiber Channel and Fiber Connection (FICON) and lower-speed Enterprise System Connection (ESCON) storage interfaces for connectivity to Continuity of Operation (COOP) sites.

- Aggregation and transport of legacy traffic through the Metropolis® DMX family which provide OC-3 to OC-48, n x T1 and n x 10/100 Ethernet interfaces.

- Enhanced system management by Lucent Optical Management Solutions for service provisioning and assurance, element management, network planning, and support for northbound interfaces to other management systems. Lucent’s Optical Management Solutions provide full visibility for DWDM, SONET and mixed backbones including support for capacity, service levels, circuit inventory, network planning, and performance.

---

**A Metropolis® WSM network provides converged access for multiple data, secured data, voice, VoIP and range networks. Lucent’s Metropolis® DMX provides cost-efficient aggregation of legacy TDM applications and protected extensions to other facilities and remote sites.**
Real-World Case Study

Home of one of the military’s advanced operation headquarters, this base underwent a transformation of its ATM core backbone, ATM data, and TDM voice networks to support force projection and remote training range connectivity. To achieve Everything-over-IP, the customer requirements were for a highly reliable solution that supported next-generation optical networking and bandwidth; introduction of IP video conferencing for online training and communications; future support for VoIP; boosting of knowledge management through connectivity to war game simulators; and extension of fiber infrastructure to support multiple facilities and remote ranges.

As a solution partner, Lucent Technologies designed and installed an infrastructure that enabled support for network-centric operations. Lucent provided:

- IP Ethernet GigE data network to replace ATM with future MPLS and 10 GigE support.
- Outside plant upgrades, including capacity additions to training ranges and core facilities.
- Lucent Metropolis® WSM for GigE interfaces to GigE data backbones and range facilities as well as support for a converged network of secured data, Voice over IP, IP trunking, IP video conferencing, and range traffic.
- Extensions to the Metropolis® WSM to other facilities and integration of legacy voice services through the Metropolis® DMX.

The network upgrade provided for broad use of IP video conferencing and minimized or eliminated future outside plant builds for bandwidth growth.

Metropolis® DMX Next-Generation SONET MSPP Infrastructure

The Lucent Metropolis® DMX family provides optical transport for legacy TDM-based applications as well as IP traffic over Ethernet and private line interfaces. With a scalable solution that allows for “right size” network deployments and up to four chassis in one rack, the Lucent Metropolis® DMX is ideally suited for:

- Core support for base, range and pier-side backbone infrastructure for GigE data networks as well as TDM voice, VoIP, IP video conferencing, storage, and sensory range networks.
• Network upgrading from OC-3, OC-12 and OC-48 to one or more OC-48 or OC-192 protected rings with 50 millisecond restoration time.

• Extending Lucent Metropolis® WSM networks with protected ring connections to remote ranges, command centers, barracks, medical, support and logistical facilities.

• Cost-efficient aggregation of legacy applications, including transit of TDM voice and private line data.

• Multiplexing n x GigE, Fibre Channel, ESCON and FICON services into a Metropolis® WSM network for high wavelength utilization.

• Resilient Packet Ring and Ethernet-LAN (E-LAN) point-to-multipoint networks.

With planned support for multiple OC-192s and an expanded backplane and switching fabric, the Metropolis® DMX can grow as backbone bandwidth demands increase. It is a crucial network solution for any base, range or pier-side application either as the primary backbone solution or in support of a Metropolis® WSM backbone highlighted above. Its capabilities include:

• Seamless transport from T1 to 10G through chassis options with the Metropolis® DMX for large builds, hardened Metropolis® DMXtend for remote locations needing up to OC-192 capacity, and Metropolis® DMXplore for sites that require up to OC-12 capacity.

• Transit of low speed to high bandwidth TDM traffic through multiple T1s, DS3s and OC-n interfaces with built-in, flexible cross connect.

• Delivery of high bandwidth and ultra-high bandwidth Ethernet interfaces for n x 10/100 Mbps and 1 Gbps services, with up to four GigE interfaces per card.

• Robust Quality of Service (QoS) per Ethernet port with support for committed information rate (CIR), peak information rate (PIR) and multiple virtual concatenated groups (VCG).

• Support for Fibre Channel, GigE, FICON and ESCON storage interfaces for COOP sites.

• Flexible deployment options through ring or point-to-point support — ideally suited to extend capacity of up to OC-192 to remote sites and training ranges.

• System management by Lucent Optical Management Solutions for service provisioning, service assurance, element management, network planning, and availability of northbound interfaces to other management systems.

Providing Scalability for Immediate and Future Growth

To maximize network capacity while minimizing cost, the military requires scalable network solutions that minimize or eliminate outside plant upgrades — reducing a significant infrastructure cost. With an upgraded outside plant to support OC-48, OC-192 and DWDM transport and extended to core and secondary facilities and ranges, U.S. Military IT personnel can minimize the cost for bandwidth expansion. The Lucent Metropolis® WSM and Lucent Metropolis® DMX families support capacity extensions that can scale current networks dramatically. They support small footprints, flexible
interface cards, and bandwidth density that deliver significant capacity while minimizing rack space:

- The Metropolis® WSM can be initially deployed as a small-footprint single shelf to serve up to four protected or eight unprotected wavelengths. As additional capacity is needed, additional wavelengths can be added through additional shelves and line cards with up to 8 shelves in a rack.

- Line side capacity for the Metropolis® WSM can be either 2.5G or 10G with transponder/ transceiver options to fit investment and deployment scenarios.

- The Metropolis® WSM supports several de-multiplexer/multiplexer and serial filters to accommodate low-count and high-count wavelengths and hub, point-to-point, and ring deployments.

- The Metropolis® DMX can support OC-192 (10G) optics with future support for multiple OC-192s. As capacity is needed, additional shelves can be installed — up to four Metropolis® DMXs in a rack — to add more OC-48 or OC-192 protected rings in a core network with available fiber plant.

- Upcoming versions of the Metropolis® DMX will support an upgraded backplane that rapidly expands capacity to a combined 120G of protected traffic.

As base, range and pier-side networks begin to support multiple 1/10 GigE level traffic from range sensors and forward surveillance systems, IP video conferencing for remote learning, training and command and control, and data mining of stored war game and simulation data, U.S. military IT staff can accommodate growth to meet the mission critical needs of its constituents.

Preventing Service Disruptions with Resilient Connections

Since battle-space operations require uninterrupted connectivity to tactical forces, command and control facilities, data centers, and core sites, the U.S. military needs complete reliability from its communications networks. Lucent can engineer base, range and pier-side networks that offer high reliability:

- Lucent Metropolis® DMX and Metropolis® WSM families are built to support Telcordia standards that require reliability of up to 99.999 percent.

- Metropolis® WSM provides deterministic optical protection (within 50 ms) for “Everything-over-IP” networks that surpasses higher-level protocols such as OSPF or RSTP, especially in medium to large GigE and 10 GigE backbones.

- Metropolis® WSM supports optical protection for C/DWDM networks for each wavelength. Protection can be based on surpassing bit error rate (BER) thresholds as well as loss of optical signal (LOS) with restoration within 50 ms.

- Metropolis® DMX supports SONET-ring based protection using BLSR or UPSR and packet-ring based survivability through RPR restoration within 50 ms.

- With expert network design capabilities, Lucent Worldwide Services can deploy diverse fiber routes in an outside plant network to provide the highest level of survivability and redundancy.
• Lucent can implement core optical, 1/10 GigE and voice networks that minimize complexity and operate with very high levels of resiliency.

• Lucent’s Optical Management Solutions offer comprehensive support for fault isolation and pro-active management of services allowing IT staff to increase service availability. They can determine which services may be impacted by network failures, providing IT staff with time to avoid service disruptions. They deliver performance management data that includes alerts when thresholds are crossed to direct network operators for investigating and preventing potential problems from becoming disruptive. Their powerful fault alarm tools identify faults and failures to the circuit and facility level and include an alarm log to help IT staff diagnose problems and restore service quickly. As an available option, Navis® provides high-availability options including disk mirroring and redundant control and probe points to ensure continued management of the optical network.

Minimizing Operational Complexity

Planning, managing and growing an optical network should require little training in optical engineering. Networks should be built with operational flexibility, resiliency and effective management that remove optical complexity. Otherwise, network planning, installation of new services and troubleshooting problems take undue time and resources. Lucent can minimize operational complexities by providing:

• **Enhanced system management for full visibility** – Lucent Optical Management Solutions offer flexible support for a wide range of network deployments and incorporate multiple management domains to assist network operators. With a simple graphical user interface that provides access to configuration, circuit and services inventory, performance management, service assurance, and network planning, operators can enable inventory and monitor all DWDM, SONET, Ethernet, TDM, private line and storage services. As Ethernet services are spread throughout the network, the Optical Management system can provide Ethernet-level provisioning and service activation, including all variants from Ethernet Private Line to Ethernet-LAN. Installed in the carrier networks in North America, Lucent’s Optical Management Solutions provide U.S. military IT personnel with a highly functional management system to keep base, range and pier-side networks operating 24 x 7 in both stable and high-growth environments.

• **Flexible configurations that maximize capacity** – The Metropolis® WSM and Metropolis® DMX platforms support flexible configurations that scale with application growth. In network environments where bandwidth, routing, and traffic changes can be frequent, the Metropolis® WSM ROADM solution provides reconfigurable wavelength services without the need for on-site provisioning of wavelength route changes. With built-in support for non-banded wavelength design, automated power equalization, and multi-function, multi-rate line cards, the Metropolis® WSM simplifies service turn up, network service changes, and line-card inventory. The Metropolis® DMX can provide multi-rate Ethernet support at n x 10 Mbps in its 10/100 Base-T line cards and n x 100 Mbps in its GigE line card allowing for software control of bandwidth-level change. Furthermore, Metropolis® DMX storage line cards use pluggable optics for Fibre Channel and FICON interfaces that eliminate the need for separate cards.
• **Superior network design of fiber plant, optical and IP backbone** – Lucent can design networks using best practices from the physical plant, optical core to IP backbones that support an “Everything-over-IP” implementation. Lucent can engineer networks to ensure survivability, ease of maintenance, and efficient troubleshooting by using the most appropriate optical fiber.

**Lucent Solutions – Enabling Network-Centric Operations**

By leveraging end-to-end optical solution from Lucent Technologies and our proven military base experience, military IT professionals and officers can successfully build and rely on the network and applications required for next generation, network-centric communications and operations.

Our Metropolis® WSM DWDM solution can serve as the optical core of an Everything-over-IP network for converging legacy and new IP. Our Metropolis® DMX next generation SONET product family supports multiple services from T1 to 10G for efficiently carrying high bandwidth and legacy services.

With Lucent as a committed partner, the U.S. military can:

• Rapidly migrate from ATM and TDM networks to highly scalable networks supporting 1/10 GigE data, VoIP, IP video, video conferencing, and enterprise-based IT applications.
• Maximize network capacity through DWDM and SONET and boost services to core sites and data centers.
• Provide resilient connections to data centers, core facilities, and to the DoD GiG-BE and DISN backbones.
• Minimize capital and operating costs through advanced-capability, scalable solutions that allow for “right-sized” networks.
• Minimize complexity through tools that enhance network visibility and provide for problem analysis and fault isolation before they can become disruptive and bandwidth growth capacity through wavelength additions that minimize the need to expand fiber plant.
• Maintain independence for separate range, data/secured data, voice, and video networks while converging their transport over a common, highly resilient optical core.
• Maintain continued connectivity for stay-behind and forward-deployed forces and commanders.

From our early experience in supplying the first SONET solutions for the U.S. Army and Air Force bases to our continued programs for supporting the current and future communication needs of the U.S. military, Lucent Technologies is helping to lead the way for transforming military communication networks.
<table>
<thead>
<tr>
<th>Acronyms</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATM</td>
<td>Asynchronous Transfer Mode</td>
</tr>
<tr>
<td>BER</td>
<td>Bit Error Rate</td>
</tr>
<tr>
<td>BLSR</td>
<td>Bi-Directional Line Switched Ring</td>
</tr>
<tr>
<td>CIR</td>
<td>Committed Information Rate</td>
</tr>
<tr>
<td>CITS</td>
<td>U.S. Air Force Combat Information Transport Systems</td>
</tr>
<tr>
<td>COOP</td>
<td>Continuity of Operation</td>
</tr>
<tr>
<td>CWDM</td>
<td>Coarse Wave Division Multiplexing</td>
</tr>
<tr>
<td>DISN</td>
<td>Defense Information Systems Network</td>
</tr>
<tr>
<td>DoD</td>
<td>U.S. Department of Defense</td>
</tr>
<tr>
<td>DSSMP</td>
<td>U.S. Army Digital Switched Systems Modernization Program</td>
</tr>
<tr>
<td>DWDM</td>
<td>Dense Wave Division Multiplexing</td>
</tr>
<tr>
<td>E-LAN</td>
<td>Ethernet-LAN</td>
</tr>
<tr>
<td>EoS</td>
<td>Ethernet-over-SONET</td>
</tr>
<tr>
<td>EoW</td>
<td>Ethernet-over-Wave Division Multiplexing</td>
</tr>
<tr>
<td>ESCON</td>
<td>Enterprise System Connection</td>
</tr>
<tr>
<td>FICON</td>
<td>Fibre Connection</td>
</tr>
<tr>
<td>GiG-BE</td>
<td>Global Information Grid Bandwidth Expansion</td>
</tr>
<tr>
<td>GigE</td>
<td>Gigabit Ethernet</td>
</tr>
<tr>
<td>GMPLS</td>
<td>Generalized Multiprotocol Label Switching</td>
</tr>
<tr>
<td>I3MP</td>
<td>U.S. Army Installation Information Infrastructure Modernization Program</td>
</tr>
<tr>
<td>LOS</td>
<td>Loss of Signal</td>
</tr>
<tr>
<td>Metropolis® WSM</td>
<td>Metropolis® Wavelength Services Manager</td>
</tr>
<tr>
<td>MPLS</td>
<td>Multiprotocol Label Switching</td>
</tr>
<tr>
<td>MSPP</td>
<td>MultiService Provisioning Platform</td>
</tr>
<tr>
<td>NETCENTS</td>
<td>U.S. Air Force Network-Centric Solutions</td>
</tr>
<tr>
<td>OADM</td>
<td>Optical Add/Drop Multiplexing</td>
</tr>
<tr>
<td>OSPF</td>
<td>Open Shortest Path First</td>
</tr>
<tr>
<td>PIR</td>
<td>Peak Information Rate</td>
</tr>
<tr>
<td>QoS</td>
<td>Quality of Service</td>
</tr>
<tr>
<td>ROADM</td>
<td>Reconfigurable Optical Add/Drop Multiplexing</td>
</tr>
<tr>
<td>RPR</td>
<td>Resilient Packet Ring</td>
</tr>
<tr>
<td>RSTP</td>
<td>Rapid Spanning Tree Protocol</td>
</tr>
<tr>
<td>SDH</td>
<td>Synchronous Digital Hierarchy</td>
</tr>
<tr>
<td>SONET</td>
<td>Synchronous Optical Networking</td>
</tr>
<tr>
<td>TDM</td>
<td>Time Division Multiplexing</td>
</tr>
<tr>
<td>UPSR</td>
<td>Unidirectional Path Switched Ring</td>
</tr>
<tr>
<td>VCG</td>
<td>Virtual Concatenated Group</td>
</tr>
<tr>
<td>VoIP</td>
<td>Voice-over-Internet Protocol</td>
</tr>
</tbody>
</table>
**Lucent Optical Solutions**

Optical networking solutions available from Lucent include:

<table>
<thead>
<tr>
<th>Optical Solution</th>
<th>Description</th>
<th>US Military Application</th>
</tr>
</thead>
</table>
| Dense Wave Division Multiplexing  | • **Enabled by the Metropolis® WSM family solution**  
  • A multi-wavelength backbone that can scale from one to 40 protected wavelengths  
  • Provides advanced OADM with non-banded architecture, where any wavelength can be dropped or added at any node without dropping/adding additional wavelengths  
  • Supports GigE, 10 GigE, OC-n, Fibre Channel and FICON interfaces to serve as a core backbone for a converged network of data, secured data, voice, VoIP, private line, video, sensory and surveillance networks  
  • Available full ROADM solution for network cores in which remote configuration would be required, especially in paths that have heavy churn  
  • Provides demarcation of separate networks through individual wavelengths at 2.5G or 10G  
  • Minimizes complexity by supporting automatic power equalization and optical filter options for low- to high-count wavelength builds                                                                 | • Supports primary optical backbones for bases, ranges and pier-side networks  
  • Provides resilient, scalable connectivity to all sites  
  • Provides transport for high-bandwidth applications like IP video conferencing, range sensory traffic and multiple 1/10 GigE data networks                                                                 |
| Next-Generation SONET MSPP       | • **Enabled by the Metropolis® DMX solution family solution**  
  • Provides multiple TDM, private line and 10/100 Ethernet interfaces over an OC-48/OC-192 protected ring in one chassis  
  • Aggregates multiple services from T1 to 10G into a Metropolis® WSM network for efficient wavelength utilization  
  • Ideally suited for a smaller network core backbone which supports GigE data networks  
  • Complements the Metropolis® WSM by extending Metropolis® WSM core networks with OC-192/48/12 protected rings to deliver services to other critical and remote sites  
  • Provides legacy support for TDM and private line traffic with IP application scattered over Ethernet or OC-n interfaces                                                                 | • For optical core backbones that require GigE data network support  
  • Ideally suited to extend Metropolis® WSM core networks for connecting facilities such as barracks, logistical and medical centers, ranges and training grounds with protected OC-48/192 ring service                                                                 |
<table>
<thead>
<tr>
<th>Optical Solution</th>
<th>Description</th>
<th>US Military Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optical Management</td>
<td>• <strong>Enabled by Lucent Optical Management Solutions</strong></td>
<td>• Provides overall management of all Lucent network networks elements, including the Metropolis® WSM and Metropolis® DMX</td>
</tr>
<tr>
<td></td>
<td>• Provides management of SONET, DWDM, Ethernet and TDM infrastructure network elements through a single system</td>
<td>• Assists network operators to plan, operate, scale and troubleshoot optical core networks</td>
</tr>
<tr>
<td></td>
<td>• Provides network element management, service provisioning, performance management, service assurance, Ethernet provisioning, network planning and fault analysis management</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Ensures continued operations by supporting replication of management servers to remote facilities and redundant network element probe points</td>
<td></td>
</tr>
<tr>
<td>Professional Services</td>
<td>• <strong>Delivered by Lucent Worldwide Services</strong></td>
<td>• Provides expert design, engineering, implementation and operation of all infrastructure builds, including outside plant, core optical backbone, IP data and voice networks</td>
</tr>
<tr>
<td></td>
<td>• Provides capacity planning, quality of service and high availability assessment for a military networks prior to deployment of converged range, TDM, voice and IP data services</td>
<td>• Assesses military networks support of converged voice, video, range, data and secured data transport at high quality of service levels</td>
</tr>
<tr>
<td></td>
<td>• Helps determine best practices to enable trouble-free operation of converged networks</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Design, engineering and installation of optical fiber; IP networking backbones, including 1/10 GigE networks and VoIP systems; and core optical backbones and networks including DWDM, SONET, SDH and Ethernet</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Network assurance for rapid fault recovery</td>
<td></td>
</tr>
</tbody>
</table>
The Lucent Advantage for the Military

With decades of optical networking experience, including deploying the first SONET and DWDM networks, as well as over 13 years of optical base deployment experience with the U.S. Army, Lucent delivers solutions that can help the U.S. military transform how it conducts battle operations and prepare for the future of network-centric war operations. Lucent-enabled solutions can:

- Enable network-centric operations through transport of battle-space data from sensors to commanders and war fighters regardless of location.
- Provide scalable, reliable, converged access for all mission-critical networks from sensory, and secured-data to VoIP, video and legacy applications.
- Provide Continuity of Operations (COOP), high bandwidth connectivity, and scalability for critical sites.
- Minimize network complexity through intelligent optical solutions, network management systems, and comprehensive design, engineering, implementation and operational services from Lucent Worldwide Services.
To learn more about our comprehensive portfolio, please contact your Lucent Technologies Sales Representative or visit our web site at http://www.lucent.com.

This document is for informational or planning purposes only, and is not intended to create, modify or supplement any Lucent Technologies specifications or warranties relating to these products or services. Information and/or technical specifications supplied within this document do not waive (directly or indirectly) any rights or licenses — including but not limited to patents or other protective rights — of Lucent Technologies or others. Specifications are subject to change without notice.