EXECUTIVE SUMMARY

Northrop Grumman is the industry leader in providing live, virtual and constructive (LVC) training to the U.S. Air Force (USAF). In June 2015, Northrop Grumman’s LVC Experimentation, Integration and Operations Suite (LEXIOS) began supporting operational level LVC training at Eielson AFB, Alaska. The training is the most advanced LVC training conducted in the United States and is used to support both small-scale and large-scale training such as Red Flag-Alaska and Northern Edge exercises. An expert in networking and distributed training architectures, Northrop Grumman integrates U.S. operational simulators located throughout the world, with live aircraft and live range threat systems to enable the most dynamic tactical level training, testing and experimentation available. LEXIOS allows virtual and constructive forces to train with and against the Integrated Air Defense Systems (IADS) on live ranges while interacting with live aircraft on those same ranges. LEXIOS routinely supports Red Flag-Alaska exercises where live coalition aircraft from Australia, Canada, Denmark, Japan, Korea, New Zealand, Singapore and the United Kingdom are able to join U.S. forces in conducting LVC operations. Northrop Grumman is installing LEXIOS at Polygone Range in Germany where U.S. and NATO forces will be able to conduct advanced LVC training, testing and experimentation. Pilots of fifth-generation fighters such as the F-22 and F-35 require the use of LVC technologies to adequately train to the aircraft capabilities; LEXIOS meets those needs. The use of a standardized and repeatable approach makes LEXIOS a low-risk, cost-effective approach to enable LVC operations anywhere in the world. Export licenses are in place to accommodate sales to international customers.

NORTHROP GRUMMAN BACKGROUND

Northrop Grumman’s expertise in LVC operations builds on nearly two decades of modeling and simulation successes. Northrop Grumman has a long and sustained history of providing enhanced network capabilities, network services and integration services to a diverse group of customers. We bring a team of advanced and highly experienced industry partners to catapult any customer to the forefront of global LVC training, testing and experimentation technologies. Northrop Grumman has more than 17 years of demonstrated capability delivering high-fidelity interconnected training experiences to warfighters in the form of the Distributed Mission Operations Network (DMON) and the Distributed Training Center Network (DTCN) in the United States. The DMON and DTCN fuel both the U.S. Combat Air Forces (CAF) and the Mobility Air Forces (MAF) simulator training program where U.S. forces conduct distributed simulator
operations at “System High” security levels. At present, Northrop Grumman connects more than 70 different U.S. simulator sites together in those two programs while meeting the strict security requirements necessary to enable advanced tactical training for operations at multiple levels of security. These globally recognized “best programs” are viewed as the “standard bearer” for other LVC programs and provide the background and expertise necessary to lead the way in LVC activities.

LVC DEFINED

Numerous companies claim to accomplish LVC activities in the military modeling and simulation industry; none, however, are as advanced or deliver as much as Northrop Grumman’s LEXIOS. Customers must fully evaluate how each individual company defines LVC activities to truly see the differences. The standard definition for LVC as defined by the U.S. Department of Defense is:

- **LIVE** – Real people who are operating real systems
- **VIRTUAL** – Real people operating simulated systems
- **CONSTRUCTIVE** – Simulated people operating simulated systems

Northrop Grumman uses the definitions above but further clarifies LVC as:

- **LIVE** – Real people operating real aircraft and real threat systems
- **VIRTUAL** – Actual warfighters operating home station simulators at “Systems High” security levels while accomplishing realistic tactical training
- **CONSTRUCTIVE** – Simulated people operating simulated systems/constructive-generated forces suitable for use by all virtual participants

Northrop Grumman is proud to be the only company that has connected live aircraft, live threat systems, constructive entities and actual home station warfighter simulators together in the same LVC environment. Actual home station simulators are not only connected into the LVC event but also connected at “Systems High” security levels enabling the warfighter to fully execute their go-to-war tactical plans. The bi-directional interaction of the simulators with the live aircraft and live range threats truly allow the virtual warfighter to be immersed in the live war.
LVC REQUIREMENTS

To successfully execute advanced LVC operations, the Northrop Grumman team addresses three major requirements associated with every military LVC effort:

- SECURITY
- TECHNOLOGY
- MISSION OPERATIONS

**Security:** The vast majority of military modeling and simulation activities require operations across multiple levels of security. With more than 17 years of experience working across multiple layers of security, Northrop Grumman has developed a Cross Domain Solution that enables forces to operate at various security levels while conducting virtual mission operations. One of the biggest challenges in providing an advanced LVC capability is developing a technical solution that also meets the stringent security requirement necessary to conduct operations across the various military security levels. Northrop Grumman is the only company in the United States that has demonstrated the ability to secure an accredited solution that enables the most secure U.S. simulator sites to connect into an LVC environment where data is passed all the way down to UNCLASSIFIED nodes on a live range.

**Technology:** In addition to meeting strict security requirements, the LVC solution must also provide a sound technical solution for achieving a persistent, distributed LVC training capability. Our technical solution provides an extremely high reliability rate (greater than 99 percent) while also meeting bandwidth and latency requirements as data is transferred between multiple sites that are often separated by thousands of miles. The solution often must translate, integrate and condition data between multiple protocols to include: Distributed Interactive Simulation (DIS), High Level Architecture (HLA), Test and Training Enabling Architecture (TENA), Joint Range Extension Application Protocols (JREAP-C) and others. Each protocol has a well-developed set of standards that must be complied with as the interactive LVC environment is developed. The nature of the military environment also requires the developer to have an in-depth understanding of the military standards required to conduct training among a multitude of different aircraft, surface vessels and sub-surface vessels.

**Mission Operations:** Solving the security and technical challenges means little to the warfighter if the solution does not enable the advanced training, testing and experimentation in the LVC environment which the warfighter desires. While today’s technologies do not enable 100 percent of military systems to be integrated, Northrop Grumman’s LVC solution provides the most extensive integration available in the world. Whether the customer desires small-scale unit-based training using only live-constructive capabilities or advanced large-scale exercise training using diverse live-virtual-constructive capabilities, Northrop Grumman is experienced in delivering a world-class LVC solution suitable for advanced operational training, testing and experimentation for the warfighter.
LEXIOS ENABLES LVC TRAINING

**LVC OPERATIONAL CAPABILITIES**

Northrop Grumman’s LEXIOS enables advanced operational LVC training, testing and experimentation. This section provides a basic overview of those capabilities. The customer can select any or all of the capabilities depending on their requirements.

**Voice Communications:** Bi-directional voice communications between live, virtual and constructive entities is provided. This includes options for UHF, VHF, HF, SATCOM and Have Quick among others.

**Data-Link Communications:** LEXIOS provides bi-directional data-link communications between live, virtual and constructive entities. Link 16 provides the primary link to live aircraft and enables operational training in the LVC environment. LEXIOS also can accommodate other data-link architectures such as those used in fifth-generation fighters.

**Integrated Air Defense Interaction:** Bi-directional interaction with enemy threat systems located on customer ranges enables virtual and constructive entities to detect, engage and kill live range threat systems. Live aircraft training versus an Integrated Air Defense system is more realistic when the range threats are capable of engaging constructive entities such as Miniature Air Launched Decoys (MALDs), air- and ground-launched cruise missiles and other weapons used to attack defense systems. Training, testing and experimentation in an Anti-Access/Area-Denial (A2AD) environment is much more effective when using LVC technologies.

**Constructive Blue Force Interaction:** Small-scale and large-scale live training is enhanced by augmenting the blue team with constructive blue forces to complete the mission package. If a 4-ship of F-35’s are conducting small-scale training, constructive forces can be added to provide a strike package that has bi-directional voice and data-link communications with the live 4-ship of F-35’s.

**Constructive Red Force Augmentation:** Small-scale and large-scale live training is enhanced by augmenting the red team with constructive red forces to provide more robust adversary training for the blue forces. Today’s budgets and force structures do not allow Air Forces to adequately provide adversary air forces for warfighter training. Use of constructive Red Air in an LVC environment enables units to train in a realistic manner that challenges the capabilities inherent in fifth-generation fighters.

**Ground Vehicle GPS Tracking System:** A fully integrated ground vehicle GPS tracking system enables beginning-to-end employment versus moving vehicles with bi-directional interaction between live, virtual and constructive entities.
Operational LVC Event Coordination and Scenario Development: Northrop Grumman is the industry leader in developing and executing small-scale and large-scale LVC training scenarios. With a history of leading LVC at major exercises such as Red Flag-Alaska and Northern Edge and at small-scale training events such as Distant Frontier, Northrop Grumman enables users to safely and effectively integrate virtual and constructive forces into the live environment while maximizing training for the warfighter.

Embedded Cyber-Warfare Capabilities: LEXIOS offers the option to install a fully integrated, on-demand, cyber-warfare system to assist the warfighter in training and employing in a cyber-warfare environment without the risk of actually executing cyber-warfare techniques.

Operational LVC Limitations: While LEXIOS offers the most advanced LVC capabilities available, the software in live aircraft must be modified for live aircraft to consume, process and engage virtual and/or constructive entities. Even so, the LVC training that is enabled by LEXIOS allows users to fill significant training gaps in today’s environment. Live aircraft are expected to begin receiving LVC modified software that will be fully interactive with LEXIOS capabilities in the next five to ten years.

LEXIOS TECHNICAL OVERVIEW

Northrop Grumman’s depth of expertise in military modeling and simulation over the past 17 years directly correlates to the LVC domain, where highly effective, automated event tools provide the baseline for flexible and modifiable capabilities for our customers. We exploit advanced standards for information technology by using industry-leading mesh architectures. This approach enhances telecommunications and information exchange between systems to provide world-class distributed training capabilities. The future for all customers will include not only the very best capabilities on the market today but also the very best technologies being developed and designed by the entire Northrop Grumman team to meet tomorrow’s training requirements, including fifth-generation assets. Northrop Grumman’s technical integration for LVC includes integration of the capabilities listed in the chart to the right. Effective integration of these capabilities is essential to providing warfighters with quality LVC training. The use of a repeatable and standards-based approach makes for seamless LEXIOS installation at any facility.
CONCLUSION

Northrop Grumman’s LEXIOS provides industry leading, world-class LVC training, testing and experimentation to USAF warfighters. LEXIOS is based on a well-developed, repeatable, standards-based solution enabling Northrop Grumman to seamlessly and securely transfer LVC technologies around the world to coalition and allied partners. Although LEXIOS has been built to exploit a full range of advanced large-scale USAF capabilities, the product offering can be tailored and scaled to meet the desired budget and capabilities of any air or naval forces as required. With minimal effort, the Northrop Grumman integration team will provide rapid LVC capabilities in a relatively short period of time on a very small to extremely large-scale effort. This overall offering includes coalition countries acquiring F-35 aircraft or other fifth generation aircraft. Northrop Grumman will professionally and effectively support LVC training, testing and experimentation – a mission-critical need to maintain the edge in fifth-generation capabilities.

Northrop Grumman stands ready to assist our international coalition and allied partners in meeting their warfighter requirements.

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