Achieving Actionable Information in a Complex Operational Environment

Tony Cerri	Cynthia Harrison	John Andrew Landmesser	Ralph O'Connell	Emilie Reitz
TRADOC G27	PEO STRI	PEO C3T	Joint Staff J6	Leidos
Fort Eustis, VA	Orlando, FL	Aberdeen PG, MD	Norfolk, VA	Norfolk, VA
anthony.j.cerri.civ@mail.mil	cynthia.t.harrison.civ@mail.mil	john.a.landmesser.civ@mail.mil	ralph.m.oconnell.civ@mail.mil	emilie.a.reitz.ctr@mail.mil

ABSTRACT

During operations in Iraq, Afghanistan, and elsewhere over the last decade, one significant lesson has been learned: a failure to recognize, acknowledge, and accurately define the operational environment (OE) led to a mismatch between forces, capabilities, missions, and goals. Fortunately, warfighters and senior leaders were able to overcome the information technology (IT) capability shortfalls through materiel and non-materiel solutions -- building relationships with the local population and key leader engagements, creating fusion cells to assimilate operations and intelligence information, and expanding the use of liaison officers. The Afghan Mission Network (AMN) (Serena, Porche, Predd, Osburg, & Lossing, 2014) is one solution which has had long-lasting impacts on how we, as a joint and multinational force, come together to share data. It has led to the NATO Federated Mission Networking (FMN) concepts, and the US contribution to FMN, the Mission Partner Environment (MPE).

Sharing OE information with mission partners in an FMN/MPE promotes unity of effort and effectiveness across interagency, coalition, host-nation partners, think tanks, academia, commercial entities, and non-governmental organizations. Fielding IT data services in an enterprise environment that automates mining and extracting mission-relevant data from vast amounts of restricted and open source repositories is prerequisite to fully understanding a complex OE. This political, military, economic, social, information, and infrastructure (PMESII) data about a specific geospatial location at a point in time must be integrated and transformed into actionable information that considers second-order effects.

This paper will describe the Joint Staff and Army's collaborative approach to leverage and horizontally integrate Combatant Command, military Service, DOD Agency, and multinational capabilities as enterprise solutions that advance a comprehensive understanding of a complex OE; supporting decision making with actionable information, and promote information superiority over trans-regional, multi-domain, and multi-functional adversaries.

ABOUT THE AUTHORS

Tony Cerri is the Data Science, Modeling, Simulation Director for the TRADOC G2. He is responsible for the integration of technologies to facilitate Operational Environment representation. He formerly led the JS J7's Joint Operating Systems Environment, the Experiment Engineering Division for USJFCOM J9 and the M&S Branch Chief for USJFCOM J9. Tony is a graduate of the United States Military Academy. He earned master's degrees from Central Michigan University in Administration and from the Florida Institute of Technology in Management. His military awards include the Legion of Merit and the Bronze Star.

Cynthia Harrison is the Deputy Technical Director/Chief Software Architect at the U.S. Army Program Executive Office for Simulation, Training and Instrumentation (PEO STRI) where she is responsible for enterprise wide system and software engineering standards, policy, and initiatives and Science and Technology (S&T) planning for the PEO. Ms. Harrison holds Bachelor and Master of Science degrees in Computer Science from the University of Central Florida (UCF). She is an Army Acquisition Corps Member and is DAWIA Level III certified in Systems Planning, Research, Development and Engineering - Systems Engineering. Ms. Harrison has over 30 years' experience in acquisition and development of Live, Virtual and Constructive systems for the training and simulation communities.

John Andrew Landmesser, Ph.D., is a computer scientist in Project Manager (PM) Mission Command (MC) serving as Army architect and systems engineer in the Joint Command & Control (C2) community. He has B.S. and M.S. in Computer Science from Drexel University and Villanova University respectively. He obtained his Ph.D. in Information Systems from Nova Southeastern University. He obtained Information Assurance (IA) and Enterprise Architecture (EA) certificates from National Defense University. He is DAWIA Level III certified in Systems Planning, Research, Development and Engineering - Systems Engineering. He retired as a US Army Reserve Major after 25 years of service including deploying to Afghanistan for OEF X. He currently teaches undergraduate Information Systems courses at Valley Forge Military College and Penn State Brandywine. Dr. Landmesser's professional, military, and academic experiences have spanned over 25 years in all system lifecycle aspects for financial, pharmaceutical & healthcare, and military systems.

Ralph O'Connell is a systems engineer with the Joint Staff J6 Deputy Director for Command, Control, Communications, Computers, and Cyber Integration (DDC5I) Data and Services Division (DSD). He has a BSEE from Virginia Tech, a Master in Systems Analysis from the Naval Postgraduate School, and certified DAWIA Level III Systems Planning, Research, Development and Engineering - Systems Engineering. Mr. O'Connell has over 30 years' experience supporting military system acquisition and fielding. He is currently working to extend Service developed data service capabilities and standards as DOD Enterprise solutions.

Emilie A. Reitz, M.A., is a Research Analyst at Leidos, currently supporting the Combined Fire Support Interoperability Division of Joint Staff J6, Deputy Director for C4 and Cyber Integration. In this capacity, she is the data collection and analytical working group lead for Bold Quest, a Joint Staff Coalition Capability Demonstration and Assessment.

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MISSION EFFECTIVENESS DEPENDS ON ACTIONABLE INFORMATION

While General H. Norman Schwarzkopf, USA Commander-in-Chief Central Command stated, "The great military victory we achieved in Desert Storm and the minimal losses sustained by U.S. and Coalition forces can be directly attributed to the excellent intelligence picture we had on the Iraqis," Lieutenant General William M. Keys, USMC Commanding General 2nd Marine Division during Operation Desert Storm clarified, "At the strategic level, [intelligence] was fine. But we did not get enough tactical intelligence - front-line battle intelligence" (Department of Defense, 1992). Despite the intelligence community (IC) having prototyped, implemented and encouraged a way of life structured around data, there are no readily available military leadership quotes about big data or data-centric organizations that we can use to illustrate the importance of detailed, accurate and readily available information about the operational environment (OE).

One significant lesson learned from the last decade of war is that during operations in Iraq, Afghanistan, and elsewhere, a failure to recognize, acknowledge, and accurately define the OE led to a mismatch between forces, capabilities, missions, and goals (JCOA, 2012). Fortunately, warfighters and senior leaders were able to overcome the information technology (IT) and data sharing capability shortfalls through materiel and non-materiel solutions -- building relationships with the local population and key leader engagements, creating fusion cells to assimilate operations and intelligence information, and expanding the use of liaison officers. The Afghanistan Mission Network (AMN) solution, which came from this series of quick win solutions, has had long-lasting impacts on how we as a joint and multinational force come together to share data (Serena, Porche, Predd, Osburg, & Lossing, 2014). The success of the AMN as an enhancement to data sharing and increased network functionality for all mission partners led to the NATO Federated Mission Networking (FMN) concepts, and the US contribution to FMN, the Mission Partner Environment (MPE) (Department of Defense, 2014).

Sharing OE information with mission partners in an FMN/MPE promotes unity of effort and effectiveness across interagency, coalition, host-nation partners, think tanks, academia, commercial entities, and non-governmental organizations. MPE capabilities are the critical enabler for conducting operations with multinational partners. Based on lessons learned from over a decade of war, the MPE enables mission partners to plan and execute operations at a common security level via a common mission network with supporting tools and services

Fielding data services in an enterprise environment that automates mining and extracting mission-relevant data from vast amounts of restricted and open source repositories is prerequisite to fully understanding a complex OE. This political, military, economic, social, information, and infrastructure (PMESII) data about a specific geospatial location at a point in time must be integrated and transformed into actionable information that considers second-order effects; this depth of information must then be integrated and accessed beyond decision support tools, and leveraged to enhance the training and simulation communities (O'Connell, Citizen, Nolan, & Cerri, 2016).

There is a plethora of longstanding and well documented operational requirements, lessons learned, capability gaps, and DOD policy related to understanding, planning, making decisions, and analyzing operations in a dynamic OE (for more information, see: Dempsey, 2012; Dempsey, 2013; DOD, 2013; and Nolan, 2016). Currently, each military service and DoD agency develops capability applications for their specific mission; moreover, they each must discover, access, extract, transform, fuse, and load OE data into their specific visualization and decision support system. Since data integration consumes approximately 35%-65% of a program's IT budget (The Data-Centric Manifesto, 2017), it must be streamlined if we are to maximize long-term outcomes within the Department of Defense. The goal for achieving actionable information from a complex OE is to automate the fusion of PMESII data into near real time OE data repositories. To achieve this outcome, the intent is to shift from an application-centric to a data-

centric paradigm where data is integrated once and used often by many different mission applications. This is driving the need for an enterprise approach.

This paper will describe the Joint Staff and Army's collaborative approach to leverage and horizontally integrate Combatant Command, military Service, and DoD Agency, as well as multinational command and control, simulation, and training capabilities as enterprise solutions to advance a comprehensive understanding of a complex OE; supporting decision making with actionable information, and promote information superiority over trans-regional, multi-domain, and multi-functional adversaries.

BIG DATA - CENTRICITY IS PARAMOUNT

It is easy to see that data-centric organizations are facilitating modern American life: Amazon, Google, Uber, Facebook, American Express, eBay, Starbucks (Liebowitz, 2013). Data-centric organizations also protect our way of life, as in the three-letter agencies (Ferguson, 2015). Interestingly, the comfort level of the average person extends well beyond these organizations and corporations. We are data-citizens.

It is difficult to imagine life without the amenities currently offered by data analytics. There is no way to rewind the clock to a time before Google. The loss of 'simplicity' and privacy have been outweighed by the benefits that are regularly available to the general populace (Tantner, 2014). Navigation systems tap into crowdsourced traffic data, shopping, hotels, prices on medicine. Every time you access a website or an app on your phone to find an answer or use a service, you are tapping into a great pool of data. Everyone who has ever refined a google search with new terms is, at a minimum, a fledgling data scientist (Chen Chiang, Storey, 2012). By adding additional information to a search, you are creating an "analytic". As you go through your daily life, you are building a body of information on your computer; you are, for all intents and purpose, performing a version of Extract, Transform and Load (ETL) (Porter, 2008). By using a computer to solve any of life's problems, one must:

1) Deal with a variety of different data types (e.g. video, text, tables).
2) Marvel at the sheer magnitude of content that seems applicable.
3) Sometimes run against the clock to make a decision as data is changing from various sources (e.g., that reservation is only good for the next 5 minutes.).
4) Look for indicators of trust (e.g. 'likes', stars, order rank).

These are a less formal version of the classic 5 "Vs" used to define Big Data: Variety, Volume, Velocity, Value and Veracity (Normandeau, 2013). Big data is typically described as datasets so large that collecting and analyzing the content cannot be accomplished within a reasonable amount of time. Big Data was originally characterized with 3Vs being generated from various structured and unstructured sources [or Variety], in large size [Volume], and accessed with speed [Velocity] (Laney, 2001). However, big data has to be useful in finding insights from new and emerging types of data and content to improve organizational agility by confidently answering difficult multi-faceted questions leading to two additional Vs. Thus big data also has to provide high Value and establish confidence through comprehension for decision making to be meaningful and provide Veracity. The corporations and organizations mentioned earlier face the same Big Data problems as the average user around the world only multiplied by their wider access to more information.

Despite the prevalence of these systems in civilian life, the Department of Defense (DoD) continues to "discover" and implement late 20th century technology and approaches while our soldiers incessantly ping us about "data" overload and the near exponential battlefield complexity they see hurtling their way (Duggan, Banbury, Howes, Patrick, & Waldron, 2004). As a community, there seems to be an acceptance of a barrier between expectations on the outside and policy environment on the inside. There are no DoD or Service Big Data piles for warfighters to search against, learn from, purchase with, train with, experiment with, or fight wars with. At best, we have "systems" that have aggregated data; these systems and small storage repositories can't run universal analytics and tend to be held by a single staff group, which severely limits utility. Some staffs implement self-taught database and storage techniques to acquire and manipulate the information they need; this is great initiative, but of limited scalability and speed.

A simple definition for data centric: "A data-centric company is an organization in which its people, processes and technologies are designed and implemented with the clear goal of generating and utilizing clean, relevant information

— with the collaborative goal of furthering the business success of the organization" (Lagore, Putnam, and Sciban, 2017). Of note, the word collaborative, with which the DOD still struggles (Gilmore, 2010). Data centric is not a new buzz word. People have been writing about data centricity for the last two decades (Ceri, 1997). Data Centric organizations are also not new, and our own intelligence community is becoming more and more data centric.

Within the networks available, content creators use the best data available to them. When they "publish," it is with the idea that their data will be reused by another author or system. Success is seeing their data reused or providing a puzzle piece that supports decisive action by someone else. Moore's law and the speed of the individual's processor as a recipe for success is replaced by an interpretation of Metcalfe's law; the community value of a network [data source] grows as the square of the number of its users increase (Hendler & Golbeck, 2008). Data value is derived from systems' [users'] ability to access and use the right data for their own purpose. The more systems and people re-using the right data for a task, the more successful the organization. This works in the non-DoD world and one can imagine the utility for DoD as units work to make sense of their Operating Environment to make the best decisions.
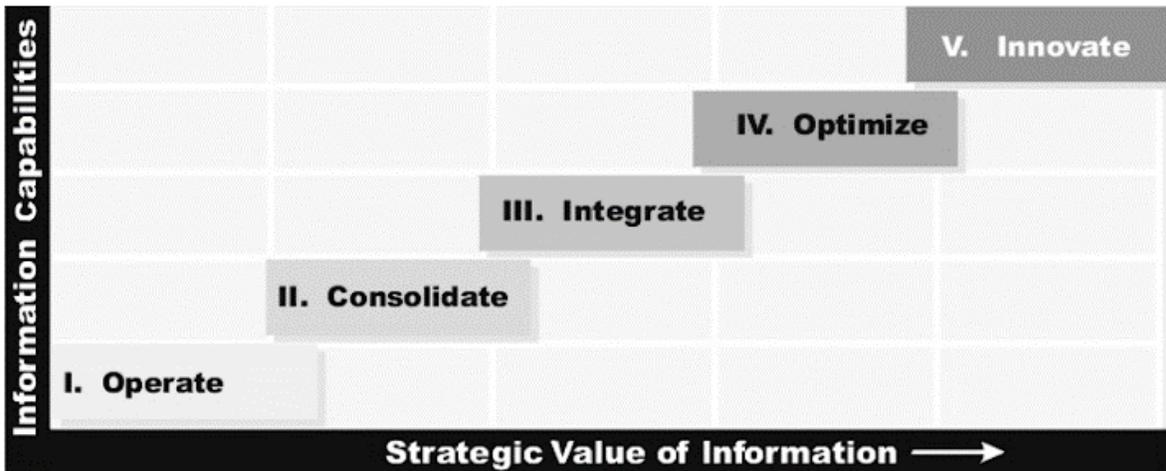

Figure 1. Information Evolution Model. (Lagore, Putnam, and Sciban, 2017).

A loose way ahead is provided in Figure 1. Linked with the following definitions, it provides a framework to plan our migration to a Data Centric organization. These concepts, clearly laid out in Lagore, Putnam, and Sciban, (2017), are summarized below.

Operational Level: At the operational level, data is owned by functionaries who keep their data separate from other data sets. This level epitomizes the phrase "stovepipes of excellence," where duplication of work and data sets with slightly different parameters but the same purposes is rampant.

Consolidation Level: At this level, individual users no longer control the data and set the tone for the use of the information. The data sets are elevated to a departmental (or in our view, higher echelon) level and unification of sets begin.

Integration Level: Consolidation continues with an increasingly widening focus.

Optimization Level: The organizational data-set is now capable of being applied to an operating environment, crossing beyond geographic areas and allowing for predictive insight about the organization itself, allies, and the enemy.

Innovation Level: Optimization can stagnate. The DOD's goal is being innovative enough to grow, change, and expand like Google and other tech companies, not to become Google.

In the sections that follow, we will discuss how the U.S. Army is approaching efforts to follow the above outlined

way ahead from the Mission Command Systems and Simulation Systems perspectives; and how this information can be shared across services and with multinational partners in an unified data environment.

ARMY MISSION COMMAND APPROACH TO ACTIONABLE INFORMATION

To determine how information from big data collections becomes actionable, we should assess the 5Vs of big data within the context of the nine principles of war (Objective, Offensive, Mass, Economy of Force, Maneuver, Unity of Command, Security, Surprise, and Simplicity). Our *objective* in any mission determines the ultimate Value of any information received. These objectives can often be very wide ranging -- joint and multinational operations are coordinated at operational and tactical levels with the activities of participating United States Government (USG) departments and agencies, relevant international organizations, nongovernmental organizations (NGOs), host nation (HN) agencies, and elements of the private sector to achieve a set of agreed upon common objectives (CJCS, 2016).

Often, there is too much data available in the operating environment. Excess information can create noise that can impact the cognitive capability of military decision makers. Military commanders are exposed to semi-structured problems with many unknowns that can only be evaluated with confidence levels in data to help assess risk with the possible payoffs and probabilities associated with decision alternatives (Landmesser, 2014). We cannot simply maintain a posture of the *offensive* in this unfiltered information environment or we will always be in reactionary mode. We need to utilize complete information superiority to influence adversary decision cycles. This should eventually be solved by employment of Command and Control of the Information Environment (C2IE) -- a holistic capability for Command and Control (C2) shaping activities throughout all phases of conflict, targeted to deliver consistent, synchronized, coherent messaging to mission partners, competitors, and adversaries making rapid (i.e., Velocity) and knowledgeable (i.e., Veracity) responses to shape the information environment.

Mass in data comes from processing all available Variety in Volume of big data assets while presenting it in cognitively intuitive mechanisms that enhance mission commanders' comprehension and decision confidence. *Economy of force* ensures resource optimization while processing big data. Just as *maneuver* is critical in the physical battlespace, it is just as important to capitalize and exploit all available opportunities to accomplish stated mission objectives when maneuvering in the current information environment. To maintain *unity of command*, Veracity is important. It focuses information presented on the military problem being analyzed, allowing for easier sorting of the data set and discarding of non-critical information. Operationally, Army Mission Command now expands its view on the Variety of high Veracity data to come from the effective exchange of information with any mission partners Multinational and other Mission Partners (MNMP) C2 information sharing (CJCS, 2016; CSCSI, 2014). A Mission Partner is defined as the breadth of possible DoD partners needing to share information to contribute to mission accomplishment, whether with organizations or national governments including: non-DoD agencies of U.S. Federal, State, local, tribal governments, non-governmental organizations (NGO), first responders, and the private sector within a multinational environment (CJCS, 2016).

Other pieces of legislation and policy are helping the Army proactively shape the information environment. The Intelligence Reform and Terrorism Prevention Act (IRTPA) of 2004 established an Information Sharing Environment (ISE) to plan, oversee, and manage ISE exchanges among these mission partners (Program Manager, Information Sharing Environment (PM, ISE), 2008). The ISE enterprise architecture framework (EAF) additionally provides a strategic roadmap for technology standardization by documenting ISE mission goals, processes, services, data, and technologies in use by Federal, State, and local governments that facilitate information sharing across all ISE communities including defense, foreign affairs, homeland security, intelligence, and law enforcement.

There are organizations within the Army taking steps toward implementing big data sets. U.S. Army Europe (USAREUR) Unclassified Common Operating Picture Working Group (UCOPWG) was established to collect, consolidate, and document mission requirements for working with mission partners at COCOMs, ASCCs, and their lower level echelons (Keith, 2016). The USAREUR initiative to deal with ever changing missions in the current operational environment is called OPSpace. The goal of OPSpace is to ensure interoperability with both standard and non-standard mission partners (Keith, 2016) and address the Variety and Velocity of mission partner data. OPSpace adopted the open source Apache Camel implementation within a new Global Command & Control System-Army (GCCS-A) version to facilitate USAREUR mission partner interoperability. Apache Camel enables dynamic definition of data routing and mediation rules for agility and flexibility with mission partners without rebuilding and deploying entire systems. Army Project Manager (PM) Mission Command (MC) is currently working with JS J6 on

a JCTD proposal that helps expand the system by leveraging and incorporating OPSpace into the Army Command Post Computing Environment (CPCE).

The downside of adding more partners, systems, and data is that any open flexible architecture provides more surface area that must be protected than exists in traditional closed systems operating only on closed networks. In the midst of these Army techniques to increase access to information for mission partners, that same information must be *secured* to maintain our competitive advantage. The integrity of information must be maintained while being transmitted from trustworthy sources to ensure decisions are being made in a timely manner with expedited Velocity. This includes appropriate sharing with mission partners contributing to accomplishment of our objectives. Velocity is also critical for *surprise* in staying ahead of adversaries, while Variety can help confuse adversaries by generating surprise when our actual intentions and actions are ultimately revealed at an appropriate time. *Simplicity* is critical to prevent cognitive overload that can be experienced from the Variety and Volume of available big data. Providing simplicity with human-computer interaction mechanisms that enhance the comprehension of relevant big data is just as important as accessing the big data to begin with.

Problems occur in many different aspects of achieving actionable information with different stakeholder perspectives and goals that influence the success of Army Mission Command solutions. However, the complex nature of hybrid cloud computing architectures using a Variety of data sources generating large Volumes of data to understand meaningfulness or Veracity to the problem being analyzed in solving global computing problems requires multiple technologies to work seamlessly together with Velocity to provide organizational Value. Ultimately, investment in IT to support big data usage in Army Mission Command to provide actionable information must also provide acceptable return on investment (ROI) or Value. As we continue to build towards using big data in a way that can be leveraged by multiple Army systems, its value must be linked to meaningful performance improvement or risk reduction goals of mission for Veracity, and not planned with associated process, manpower, and logistics updates.

ARMY TRAINING APPROACH TO COMMON DATA FOR SIMULATIONS

The U.S. Army Combined Arms Center (USACAC) and Program Executive Office Simulation, Training and Instrumentation (PEO STRI) are teaming to resolve the point to point interface problem between data sources and simulation system consumers where building data sets to support live, virtual, and constructive (LVC) training objectives is expensive and time consuming. The data sets currently available are often unreliable and not interoperable. They require unique conversions for each source of data, and cannot keep pace with the increasing demand for higher fidelity and mission specific simulation supported events within mission critical timelines.

The goal is to significantly reduce the data conversion cost and correlation errors associated with building training databases through common data services that are based on open standards, automated tools, and software reuse that results in improved reliability, interoperability, and integrated capabilities. One current initiative is the Enterprise Data Services (EDS) Common Data Production Environment (CDPE) that is working to provide on demand Order of Battle (OOB), Environmental Representation, and other types of data services to deliver modeling and simulation (M&S) ready data in standard data interchange formats. Following the data centric paradigm, the intent is to integrate source data once so that it can be used by M&S constructive federations, virtual simulations, test and training centers and ranges, and support M&S mission planning and course of action analysis simulations.

PEO STRI is working to integrate the U.S. Army Organization Server with Training and Doctrine Command (TRADOC) opposition force (OPFOR) data into a cloud based OOB server that will feed the Scenario Generation systems at Mission Training Centers (MTCs) to support Multi-Resolution Federation training events. This capability will serve to provide timely, on demand, authoritative data sets to the broad simulation, training and mission command user base and will serve to increase interoperability while reducing the currently time consuming effort to generate and populate simulation scenarios.

Additionally, PEO STRI has identified several key objectives for the I/ITSEC 2017 Operation Blended Warrior (OBW) event and is working closely with industry, DOD, and other Army organizations on the best ways to move toward meeting these objectives. These objectives promote and lead the way for how current and future Army initiatives and Programs of Record (PoR) may pursue LVC interoperability and utilize technologies that may support the Synthetic Training Environment (STE), which brings together the virtual, constructive and gaming training environments into a single environment that will interact with and augment live training. The new focus

areas include: 1) Gaining better insights and improving the Human Dimension/Performance; 2) Integration of dense urban areas into terrain data, and moving towards better database; correlation and interoperability; 3) Emphasizing the importance of a uniform and centralized distribution of authoritative data; 4) Promoting LVC through the use of new and existing network technologies, including use of service/cloud-based capabilities; and, 5) Using LVC in domains beyond traditional Training (e.g., mission command, test, analysis, other). This event will begin to demonstrate these emerging initiatives to provide common and correlated data sets and will provide lessons learned that will influence and shape future big data efforts in the M&S community. It is anticipated the results and findings of these activities will be captured and presented back to the community during I/ITSEC 2017.

ADVANCING ACTIONABLE INFORMATION WITH MISSION PARTNERS

The US Services create the data; the joint environment seeks to make that data easier to move and share within both the operational environment and the training environment. Building joint distributed simulation capabilities requires policy changes to promote interoperability between the Services and mission partners. A joint distributed simulation capability, as was described above, must provide a secure interoperable architecture that supports sharing, accessing, and connecting authorized users to the information they need in order to train effectively. One way of creating a network solution that facilitates sharing was exposed by the Afghan mission network efforts – the Mission Partner Environment (MPE) concept provides a process for establishing multi-Service network standards that can allow inclusion of multinational mission partners.

As demonstrated during a Joint Staff demonstration event, Bold Quest 16.2, a federated MPE has ample capacity to support effective operations among mission partners. During this event, the Joint Staff led the implementation of an MPE that provided connectivity between fourteen participating nations. Denmark, Finland, Italy, Norway, and the Joint Staff all agreed to federate their networks, core services, and certain Command and Control (C2) systems as Network Contributing Mission Partners (NCMP). Other participants – Australia, Belgium, Canada, Germany, Great Britain, France, Netherlands, Poland, Sweden, and New Zealand – did not bring their own networks, but connected their systems directly to and received services from an NCMP, thus participating as Hosted Mission Partners (HMP). As coordinator for all MPE operations, the Joint Staff led the collaborative development of Joining, Membership and Exit Instructions (JMEI) that ensured all mission partners understood how to operate and share data as part of the mission network.

Much in the same way that it enabled data flow for C2 systems and core service interoperability in Bold Quest 16.2, the MPE can be used as a model for improving LVC interoperability. Mission partners can join as NCMP or HMP and, following guidance provided in JMEI tailored to the LVC environment, conduct distributed operations via interconnected simulator systems. As with MPEs supporting operational C2, MPE capabilities offer the option of establishing an LVC mission network that is complementary to – not a replacement for – existing national, alliance, or other multi-national networks. While a way of creating an environment to enhance sharing, data brought to such events are still not explicitly tagged or handled in a way which would facilitate long term data reuse. Even a network that relies on the explicit consent and agreement of all participants to the terms of the network does not mean that the data resident on that network is being handled any more efficiently than if it were sitting static on a non-networked hard drive.

RECOMMENDATION: COLLABORATIVE APPROACH TO HORIZONTAL INTEGRATION

To improve our warfighter decision making effectiveness, many Army, Joint, Defense M&S Coordination Office (DMSCO), Air Force, Navy, Marine Corps, and Intelligence Community OE data stakeholders are coordinating and collaborating to promote reuse and advance the implementation of common shared standards. This informal and evolving Enterprise Data Architecture (EDA) Cross-Functional Team (CFT) includes Joint Interagency Intergovernmental Multinational (JIIM) representatives. Participants are eager to leverage, reuse, synchronize, and horizontally integrate existing and evolving cross-community OE data service capabilities to enable warfighter information superiority. At the time of this writing, a one year demonstration proposal is being drafted to automate the fusion of disparate authoritative source data into OE data repositories that will support 3-D common operational picture (COP) visualization and war gaming courses of action in simulation. Since mission relevant information is often compartmentalized and difficult to share with mission partners in near real time, aggregate data stores will enable

security tagging at the data/cell level to automate multi-domain information exchanges and authorized access adjudication.

What can you do as an individual reader or representative from an organization who is interested in participating in this cross functional team? Help us build on the last two years of programmatic and policy gains by carrying this message home to your own organization.

1. Familiarize yourself with how this data challenge impacts your own organization. Read the Data-Centric Manifesto.
2. Promulgate the Information Evolution Model (figure 1); ask key organizations to self-assess and prognosticate when they might move to the next level. Are you and your organization still dealing with data sets at the Operational Level?
3. Participate in the next EDA CFT Work Group, which will be strategically co-located with large conferences (for example, MODSIM 2018).
4. Focus implementation efforts on earliest adopter in order to prototype for other services and agencies.
5. Normalize Service expectations in the year they are ready to begin work on concepts within the paper.
6. Help structure the OE Repository such that it is capable of providing data as theorized in this paper.

CONCLUSION

The acquisition cycle, the Joint Capabilities Integration and Development System (JCIDS) process, the Federal Acquisition Regulation (FAR), and DoD prioritization processes were all designed before big data. No single organization, department, or country has been granted the responsibility and/or the financial resources to solve the comprehensive OE data service problem. Individual programs develop applications for their specific community and typically derive their own data integration solution to meet their requirements. Cost and complexity for each application is impacted by the relationship of the application to the data. Mission relevant information that could make creation of these applications easier is often compartmentalized; that makes it difficult to share with services or mission partners. Mining and processing OE data for patterns that humans cannot perceive requires big data analytics and machine learning. By seeking unity of effort in pursuing aggregate data stores, communities and mission partners will be afforded the opportunity to focus future resources on algorithm and application development that will lead to big data analytics and machine learning rather than on building databases to feed their systems. This will result in achieving actionable information in a complex OE.

If reading this paper creates a sense of guilt, or causes a reader to think about a data set to which only they have access, take the opportunity to fix the problem. What the above was meant to do was illustrate the need and introduce DOD's first steps on the journey to a Data Centric organization.

ACKNOWLEDGEMENTS

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