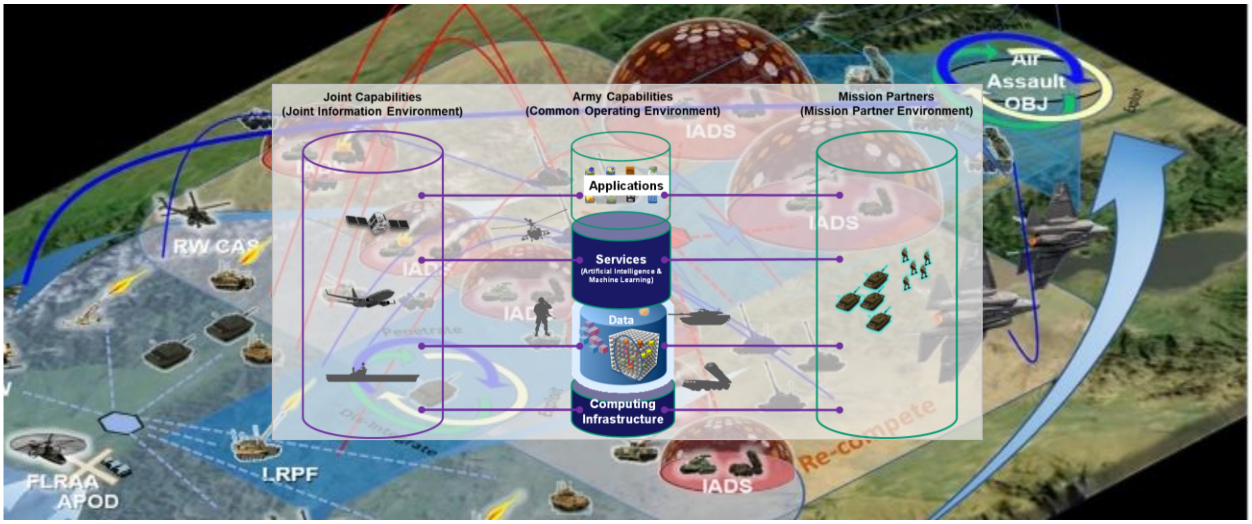
Operational End State for Data Analytics & Computing

A White Paper



MISSION COMMAND
U.S. ARMY
Balancing the Art of Command
With the Science of Control

Mission Command Center of Excellence
Combined Arms Center
Fort Leavenworth, KS 66027

Operational End State for Data Analytics & Computing

Purpose

This Paper describes the operational endstate that should drive technical implementation of data analytics, and the supporting computing infrastructure. The endstate has four components: (1) enable individuals and platform/systems, (2) enable formations internally & externally, (3) enable echelon agnostic capabilities such as JADC2 and STE, and (4) provide resiliency for decentralized / distributed mission command in contested conditions. These components, in combination, drive the technical implementation that ensures the right data analytic and computing capability at a given point of need. The Paper focuses on "decision-driven and warfighting-driven data", the idea that modern warfare requires getting data to the right place, and applying data analytics to achieve timely, high-quality decisions, and desired operational outcomes.

Problem Statement

To enhance operational & tactical decision-making, the US Army requires effective data analytics, with dynamic compute and store capabilities. This includes on-person, on-vehicle, on-premises, and cloud computing, in order to provide operational applications and services under contested and dynamic conditions. *"The right data, to the right people, at the right place, by the right time to inform decision."*[1]

Background

The character of warfare is changing. Automated systems and sensors are proliferating, and multi-domain operations require situational awareness and decision-making aided by both human and machine. Increasingly, human and machine teaming is a central feature of combined arms warfare. Individual soldier, platform, and formation effectiveness now requires human to human, human to machine, and machine-to-machine communications; with increasing emphasis on data analytics. We can expect multi-domain operations requiring an extremely compressed timeline to understand, decide and act.

> ***"Future conflicts will manifest at longer range, across all domains, and at much greater speed, both physical and cognitive".***
> - Chief of Staff Paper #1

These trends demand a decision-driven and warfighting-driven perspective on readiness and warfighting to enable operations at sufficient speed, scale, and tempo. Success will depend on data analytics, with artificial intelligence and machine learning (AI/ML) applied wherever possible to enhance decision making, and speed reaction time. For all practical purposes, data analytics are the foundation for human & machine interaction, and for command & control. Data analytics will speed the actions and interactions so that we have the lethality, survivability, and tempo needed to succeed.

Data is an increasingly valuable asset in competition and conflict. Access to the right data, at the right time, enables superior decision-making. Data enables the Observe –

[1] This problem statement resulted from the September 20 COE / Transport Convergence Summit.

Orient – Decide –- Act cycle, allowing us the ability to be one-step ahead of our adversaries. The right data access, processing, and storage capabilities enable practical artificial intelligence, cloud computing, and machine learning capabilities.

Our Echelon above Brigade (EAB), Multi-Domain Operations (MDO), and Combined Joint All-Domain C2 (CJADC2) concepts require data interoperability across service, interagency, and multinational partners. CJADC2 is the combination of human, procedural, and technical means that underpin convergence and multi-domain formations. This level of interoperability requires a Common Operating Environment (COE), which reduces existing data stovepipes and implements a common data fabric.

For this reason, the Army is moving to a COE featuring a unified data framework. Additionally, Army capabilities in development include manned & unmanned platforms, sensors, and Soldiers; all enabled by AI/ML for maximum effectiveness. Examples include Long Range Precision Fires, Air and Missile Defense, Next Generation Combat Vehicle, Soldier Lethality, and Future Vertical Lift. As a notable addition, the Synthetic Training Environment generates its own demands for computing infrastructure and data flow.

Operational Context

This paper uses the Multi-Domain Operations framework to provide context. It considers the support areas, close and deep maneuver areas, through the operational and strategic fires areas. In addition, it considers the four primary capabilities of the Mission Command Network: Unified Network (consisting of the Integrated Enterprise Network and Integrated Tactical Network), COE, Mission Partner Environment, and Command Posts. As noted above, data analytics has a role across the multi-domain framework. Key considerations for understanding requirements include (1) functional applications and services, (2) categories / types of data (see enclosure 2), (3) processing / artificial intelligence (AI) / computing infrastructure, (4) data storage, and (5) transport. Figure 1 illustrates the operational and data framework interrelationship.

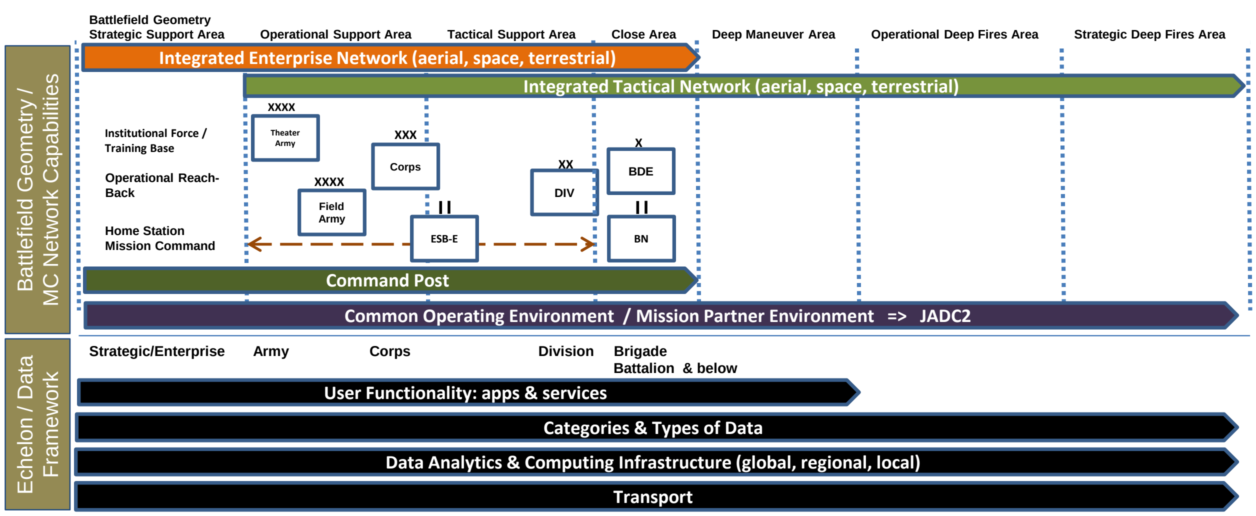


Figure 1. Operational Data Framework

As the Army modernizes to be ‘multi-domain operations – capable’, data analytics requirements will multiply. We will operate in austere and dynamically changing conditions, in the face of peer adversary capabilities that may disrupt or restrict data flow. The underlying application, services, and transport design must mitigate periods of disconnected, disrupted, intermittent, and limited communication. This mitigation will drive some requirements so that users have critical information and services in spite of congested and contested conditions. Data / information needs change as the dynamics of the mission change. Prioritization of data dissemination must support the commander’s critical information requirements. These variables require analysis of mission threads and use cases in combination.

Operational End State Introduction

The operational end state focuses simultaneously on individual soldier/platform effectiveness and collective effectiveness (e.g. formations). An individual capability is not only a ‘stand alone’ effect or solution, rather it is a capability nested within larger, collective capabilities. Overall, effectiveness is the combined result of concepts, doctrine, TTPs, organization, materiel, and other factors. To this must be added the applications, services, data analytics, and computing needed. Also, consider that individuals and formations operate under contested and dynamic conditions, which requires resilient design. The key point to remember is that data analytics and DOTMLPF-P considerations are interrelated. Data analytics & computing serve to enhance the lethality, survivability, and tempo of individuals and organizations, which alters the DOTMLPF-P needed for maximum performance. We must recognize this interrelationship, and work the supporting DOTMLPF-P concurrently.

The goal for data analytics and computing is to provide the appropriate data analytics at the right locations to meet operational needs. Therefore, computing infrastructure design meets operational requirements for nested data / information flow, and effective decision cycles, across echelons and formations. The computing infrastructure provides an overall ecosystem, which is able to scale rapidly at echelon. In this way, it simultaneously enables individual ‘points of need’, formations, and ‘agnostic’ capabilities. This ecosystem extends from individual soldier/platform to theater level, concurrently enabling interaction with other services and mission partners at every level.

Essentially, there are four drivers for data analytics and computing infrastructure: (1) platform and Soldier effectiveness; (2) effective formation performance; (3) collective performance required by Army concepts and the JADC2 framework, which are echelon-, service-, and mission partner-agnostic; and (4) resiliency in a congested &, contested environments. Therefore, the operational end state contains four nested components, which apply to any particular ‘point of need’. Figure 2 offers a visual depiction of four enabling components, and the next section examines each in detail.

- Enable individuals and platform/systems
- Enable formations internally & externally (decision-making; lethality; survivability; tempo; collaboration/interaction with peers, partners, higher, and supporting)

- Enable echelon agnostic capabilities such as JADC2 and STE (sensor grid, multi-echelon collaboration)
- Provide resiliency for decentralized / distributed mission command (independent/disconnected operations)

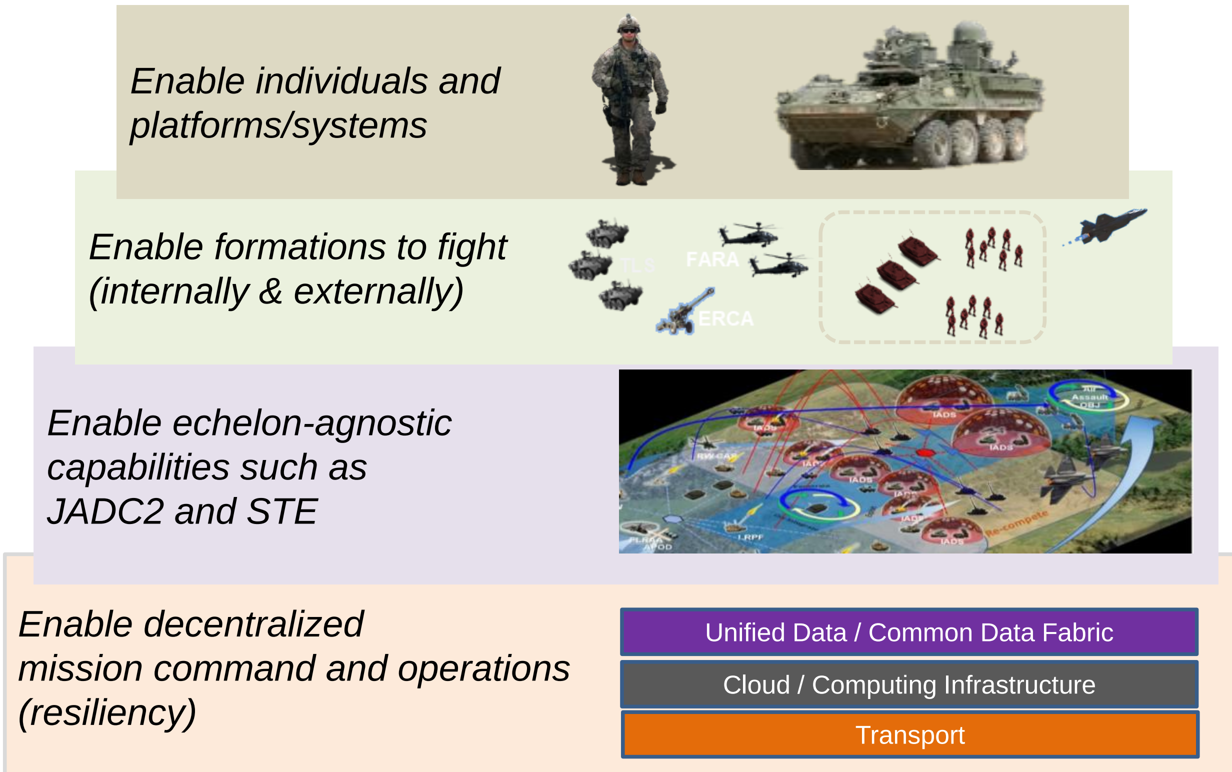


Figure 2. Operational End State Components

Operational End State Components

***Enable individuals and platforms/ systems**.* At the individual level, data analytics and computing enable the performance of an individual soldier/platform in two ways: (1) basic performance of the individual/platform, and (2) ability of the individual to be part of a team. Examples of each type of enhance follow in the table below. Individual soldiers and platforms/systems contribute to their formation's performance.

Individual Enhancements	Team Enhancements
• Individual status • Performance aids (e.g. facial recognition, language translation, speech to text services) • Decision aids / planning tools • Individual training • COP with alerts/cues • Info from soldier-borne sensors	• Team status • On-board processing to facilitate decision making & data sharing • Info from external sensors • Cooperative engagement • Collective training

Enable formations: internally & externally*.* Formations require means for effective decision making, to include situation awareness, a common operational picture, staff collaboration, and C2 nodes. Each formation requires effective human interaction / collaboration – both face-to-face and/or virtualized as needed. The primary need is a flow of information between the commander/leader and subordinates, so the assigned subordinate organizations are effectively improved. At the formation level, internal data flow must enable formation level lethality, survivability, and operational tempo. Data analytics enables warfighting functions, and other key functions such as cyber, within the formation. Certain platforms/systems require a collaborative engagement capability. To varying degrees, formations require high quality, timely collaboration and flow of data across distributed C2 nodes at different echelons. Individually, these C2 nodes may be tactically distributed, and highly mobile, to enable survivability. Because of variability in mission and task organization, a Data 'Arms Room' concept may be required (i.e. units provisioned with the infrastructure they need for the mission at hand).

At the same time, formations seek to act within the higher headquarters mission, and set conditions for subordinate formation success. They continually collaborate and interact with the higher headquarters, peer formations & mission partners, and other supporting capabilities. Warfighting functions reach across echelons, and therefore represent key external interactions. Similar to interactions within a formation, there is both a human and data component to these external interactions. Many of these interactions will be 'secret releasable' and/or 'secure but unclassified' to facilitate operations with mission partners. Data dissemination in particular must support Joint and mission partner interactions. The table below identifies examples of internal and external interactions. Formations may both contribute to, and leverage echelon/formation agnostic capabilities.

Formation-Internal Interactions	Formation-External Interactions
• Status • Sensor information • COP / Situational Awareness • C2: leader – subordinate interaction • Decision aids / planning tools • Warfighting & other key functions • Collaborative engagement • Collective training	• Higher HQ / Peer status • Sensor Information • COP / Situational Awareness • C2: higher HQ / peer interaction • Decision aids / planning tools • Warfighting & other key functions • Collaborative engagement • Collective training

Enable echelon/formation agnostic capabilities**.** Several envisioned capabilities will operate independently of echelon/formation, and require their own consideration of computing infrastructure and data dissemination. JADC2, for example, will employ an intuitive sensing grid (part of the Joint Tactical Grid), and feature a cooperative engagement capability which employs C2 and sensor to shooter capabilities which are echelon, service, and mission partner agnostic. The Synthetic Training Environment is another example of an echelon/formation agnostic capability. These 'agnostic' capabilities impact how formations fight, and therefore require consideration of the additional computing and data dissemination on any unit which is operating within the 'boundaries' of these capabilities.

Enable decentralized mission command and operations. A future fight against a peer enemy requires the ability for leaders and their formations to be able to fight in a highly decentralized, distributed, and disconnected manner. Individuals and formations require a basic capability to continue fighting in spite of a loss of communications. Leaders will require mission command tools, which still enable them in spite of communication interruptions. This requires capability that allows key functions to continue in degraded circumstances, with enough information/tools to allow leaders to continue to lead their units under these conditions. Data analytics and computing must be able to continue to function at some level in highly contested environments. The necessary resiliency results from (1) an emphasis on 'local' computing and data storage, (2) a common data fabric tolerant of limited and/or interrupted communication conditions, and (3) protecting data in transit, at rest, and in use.

Operational End State Synthesis

The desired operational End State for data analytics and computing is to enable lethality, survivability, and operational tempo at any particular 'point of need'. Data analytics and computing enables individual entities (humans and platforms), formation effectiveness (internal and external interactions), and echelon agnostic capabilities. Infrastructure and data fabric design provides resiliency and enables mission command in spite of communications challenges; as individuals and formations still need 'enough' computing and data to continue operations. We will use the Mechanized Infantry Company as an example, the following figure provides a visual representation.

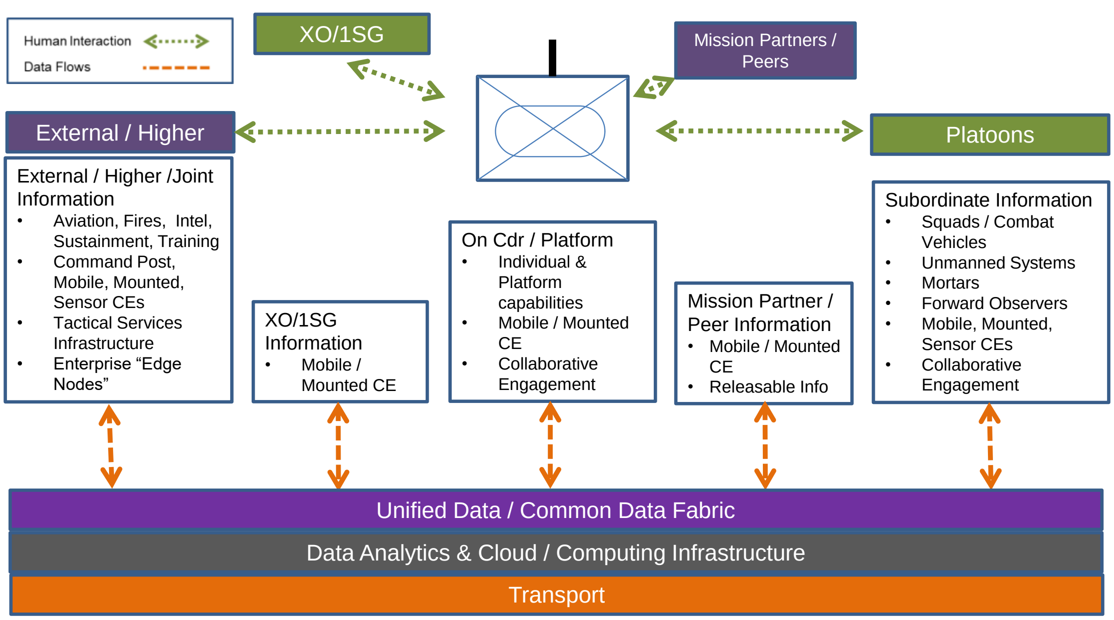


Figure 3. Company 'Point of Need' Example

In this example, the operational endstate is the combined need for data analytics to enable (1) individual soldier and platform/system performance, (2) company collective performance, (3) echelon-agnostic capabilities, and (4) continued mission performance in spite of congested and contested conditions. Since these four components nest, the ‘location’ of data analytics requirements can be defined, be it internal or external to the company’s organic assets. Data analytic capability requires ‘placement’ to meet the full range of requirements, whether with individuals, distributed within the formation, and/or distributed more broadly. For resiliency, the company requires some ‘local’ capability, and access to external capabilities. Upon definition of company data analytic capability (whether internal or external), the design of the supporting infrastructure follows.

Implications for Technical Implementation

A balanced and integrated network architecture will best meet the operational needs and provide the necessary resiliency. The technical implementation includes applications, services, data layer, computing infrastructure, and network transport. At its core, the architecture enables interaction for humans and machines. The better the architecture in terms of disseminating data and providing timely analytics, the better the resulting performance of the individuals and formations. Figure 4 illustrates this relationship.[2]

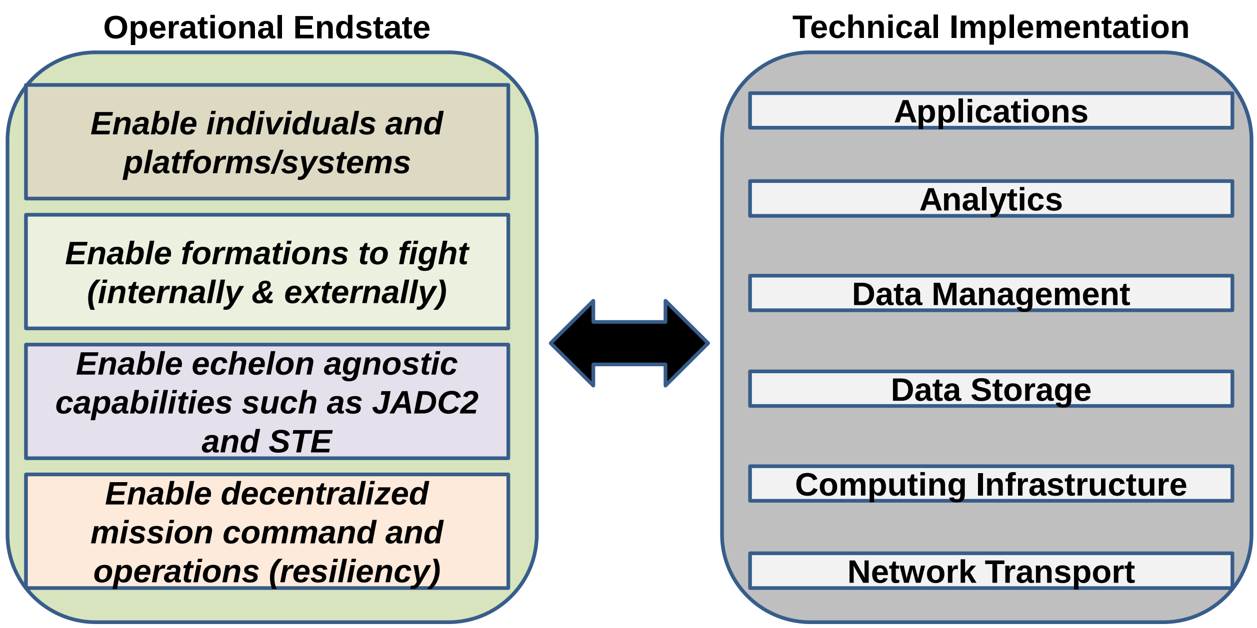


Figure 4. Operational End State Relationship to Technical Implementation

In order to realize the nested requirements at any particular ‘point of need’, the following actions will ensure technical implementation has the necessary design attributes:

- Implement the COE to ensure data standardization within the Army to facilitate computing and data flow during operations.
- Pursue data standardization and interoperability with the other services and mission partners, who will be significant data conduits and sources.

[2] Lee, Scott; Briefing: “A Vision for Future Command & Control (C2) and Network Development”; MITRE Corporation; 28 January 2021

- Implement a common data fabric that provides access to other data sources, and moves data to the right places.
- Design the Mission Partner Environment to ensure mission partners have access to the data we choose in a timely manner during operations.
- Employ security measures to protect data, in order to support mission effectiveness.
- Design the network, and the computing / data infrastructure, to function under congested cyberspace and electromagnetic spectrum conditions.
- Leverage Cloud computing to enable echelon/service/partner agnostic capabilities.
- Mesh enterprise and tactical capabilities to support unit deployment, and fully enable functional data dissemination globally.
- Develop policies and tactics-techniques-procedures to establish data ownership/stewardship across echelons, services, and mission partners.

Conclusion

Modern warfare increasingly compresses the timeline to understand, decide and act. In addition, warfare increasingly features an interweaving of human and machine interaction within the decision cycle. A decision-driven and warfighting-driven perspective on readiness and warfighting best ensures mission accomplishment. Within this context, the operational endstate is the combined need for data analytics to enable (1) individual soldier and platform/system performance, (2) company collective performance, (3) echelon-agnostic capabilities, and (4) continued mission performance in spite of congested and contested conditions. The Army must establish a technical implementation, which facilitates all four components of the operational endstate.