Data Collection, Reduction and Analysis Initiative for Integrating US Army Data Plan into Warfighter Qualifications

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ABSTRACT

The U.S. Army needs a common governing policy, methodology and architecture for generating, collecting, reducing and analyzing the training data available today. As described in the Army's latest Learning Concept for 2030-2040, collecting training data is critical to diagnose, prescribe, and facilitate effective training. Current methods to collect and store training data are disparate and require Army units to manually input data into the Army's current data tracking system. This paper describes a Data Collection, Reduction and Analysis (DCRA) research effort that is working to support the U.S. Army's broader Data Strategy, as well as integrating parallel research on new data strategies for the U.S. Army's Synthetic Training Environment (STE) program. DCRA's research goal is to produce a prototype data architecture and methods that will enable the U.S. Army to automatically collect existing training data that is being "lost" from current training systems. We discuss challenges to collect, reduce, and align different data sources, types, and formats needed to diagnose, prescribe, and support the US Army's warfighter qualifications, and facilitate machine learning algorithms that will support future STE AI-based training and assessment capabilities. We discuss collaborative efforts occurring with active duty Army commands and facilities to baseline current data collection processes and practices. We also provide a high-level description of the DCRA-STE model, and capabilities being applied to a US Army, Integrated Weapons Training Strategy (IWTS) use case. We conclude by discussing best practices and data standards we have found or developed to address existing data challenges, and how they may apply to data collection at scale.

ABOUT THE AUTHORS

Kevin Owens is an Engineering Scientist at the Applied Research Laboratories: The University of Texas at Austin. He has over 40-years practical experience in military, industry and academia engineering new learning systems and evaluating/improving military occupational competence. He has an MS in Instructional Systems Development and a BS in Workforce Education and Development. Kevin is currently working on engineering simulation-based experiential learning models, employing adaptive learning systems, and designing data strategies for improving warfighting competence.

Kevin Gupton is a Systems Architect with over 20-years of experience in data engineering and knowledge management. Currently, he holds the position of Engineering Scientist at the Applied Research Laboratories, The University of Texas at Austin. Kevin has contributed his expertise in system architecture and data management to various notable projects, including the Army Synthetic Training Environment (STE), Joint Federated Common Data Services (JFCDS), Integrated LVC Test Environment (ILTE), and NATO MSG-164 M&S-as-a-Service. He earned a B.S. in Mathematics and an M.S. in Computer Science from Texas A&M University.

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INTRODUCTION

The US Army's Data Plan emphasizes the crucial need for efficient data collection and management. The plan's strategic goal is to significantly improve data management, governance, and analytics capabilities by the year 2030. The data plan aims to enhance the Army's ability to utilize data effectively, leading to improved decision-making, enhanced training, increased operational efficiency, and a more streamlined approach to handling data (US Army CIO, 2022).

In line with the Army's latest Learning Concept (TRADOC 2024) and the development of the Army's future Synthetic Training Environment (STE), data has the potential to revolutionize how the US Army trains, evaluates, and manages the competence and readiness of its Soldiers and units for future battles. However, despite the wealth of training data generated annually from thousands of home-station training events, the Army currently lacks a cohesive training data policy, methodology, and architecture to support training analysis. This hampers the ability of the STE to incorporate and utilize this data effectively. A common framework for generating, collecting, reducing, and analyzing training data is essential to enable the STE to fully leverage the available data and enhance the Army's training capabilities.

The Data Collection, Reduction, and Analysis for the Synthetic Training Environment (DCRA-STE) initiative, financially sponsored by the Army Futures Command's University Technology Development Division, and technically overseen by the US Army Combat Capabilities Development Command, Soldier Center's, Simulation and Training Technology Center (STTC), is focused on addressing these data-related needs. DCRA-STE builds upon the Synthetic Training Environment Experiential Learning for Readiness (STEEL-R) concept to produce a framework for data-driven training and competency management (Goldberg et al., 2021, 2023). DCRA-STE seeks to establish a common interoperability layer for collecting, reducing and managing the raw STEEL-R training data. The research effort's immediate goal is to produce a prototype data model that will enable the U.S. Army to automatically collect existing data being "lost" from current training systems.

In this paper, we discuss progress towards establishing this prototype data model. Specifically, we discuss challenges to collect, reduce, and align different data sources, types, and formats needed to diagnose, prescribe, and support the US Army's warfighter qualifications; including facilitating machine learning algorithms that could support future STE AI-based training and assessment capabilities. We discuss collaborative efforts occurring with commands and facilities at Fort Cavazos, Texas (FCTX) to baseline current data collection processes and practices. We also provide a high-level description of the DCRA-STE model, and capabilities being applied to a US Army, Integrated Weapons Training Strategy (IWTS) use case. We conclude by discussing best practices and data standards we have found or developed to address existing data challenges, and how they may apply to data collection at scale.

BACKGROUND

Integrated Weapon Training Strategy

The training data use-case that DCRA-STE ultimately decided to focus its initial research on was the US Army's Integrated Weapons Training Strategy (IWTS). The IWTS was chosen because it is a standardized training strategy for the US Army's commanders to train, evaluate, and assess a unit's maneuver mission proficiency while at home-station, and because it maximizes the use of training aids, devices, simulators, and simulations (TADSS) within a force-on-force or live-fire training event. The aim of IWTS is to help commanders increase and sustain their Soldiers' weapon and system proficiency and lethality (US Army TRADOC, 2019) using an integrated, standardized, and systematic framework for unit training and "gated" evaluation as shown in Table 1. The IWTS framework establishes a "crawl-walk-run" progression for each unit echelon's training process. Each training event is aligned to a "Table" that prescribes either classroom instruction, virtual, blended, or live-fire methods to support individual, team, crew, or unit-level training.

Table 1. IWTS structure

Echelon	Table 1	Table 2	Table 3	Table 4	Table 5	Table 6
	PREREQ	PREREQ	PREREQ	COLLECTIVE TASK-PROFICIENCY	COORD / REHEARSAL / PRACTICE	LIVE-FIRE PROFICIENCY EXEVAL
	CRAWL	CRAWL	WALK	RUN	RUN	RUN
Battalion / Squadron	TEWT *Live*	STAFFEX *Blended*	CPX *Live*	FTX *TADSS*	FCX *Blended*	CALFEX *Live-Fire*
Company / Troop	TEWT *Live*	V-STX *Virtual*	STX *TADSS*	FTX *TADSS*	FCX *Live-Fire*	CALFEX *Live-Fire*
Platoon	CLASS Local SOP *Live*	V-STX *Virtual*	STX *TADSS*	FTX *TADSS*	FCX *Live-Fire*	LFX *Live-Fire*
Section						
Squad						
Mortar Formation	Gunnery Skills Test *Live*	V-STX *Virtual*	STX *TADSS*	FTX *TADSS*	Practice *Live-Fire*	Qualification *Live-Fire*
Crew Platform				Basic *Live-Fire*		
Special Purpose Weapons	CLASS Marksmanship Instruction *Live*	V-STX *Virtual*	Drills *TADSS*	Basic *Live-Fire*	Practice *Live-Fire*	Qualification *Live-Fire*
Crew Served Weapons						
Individual Weapons						

Legend:

CALFEX	Combined Arms Live Fire Exercise	SOP	Standard Operating Procedures
COORD	Coordinated Exercise	STAFFEX	Staff Exercise
CPX	Command Post Exercise	STX	Situational Training Exercise
EXEVAL	External Evaluation	TADSS	Training Aid Devices, Simulations & Simulators
FCX	Fires Coordination Exercise		
FTX	Field Training Exercise	TEWT	Tactical Exercise Without Troops
PREREQ	Prerequisite Training	V	Virtual (Semi-Immersive)

Training Aids, Devices, Simulators, and Simulations

Many of the Table exercises are enabled by TADSS developed for the primary purpose of providing realistic and effective training while also supporting crawl-walk-run graduated immersive training experiences. TADSS maximize training safety while enabling more repetitions before moving on to the more dangerous, expensive and time-consuming live training modes. TADSS include part-task individual training simulators, crew/team training systems, and collective virtual and constructive simulations (varying based on echelon). As trainees and units progress to higher live-based Tables, instrumentation systems are used to support force on force rehearsal events and live fire practice.

Current Training Data Collection Practice

Although Army units conduct thousands of training events weekly, the data generated from these events are not gathered or used in a systematic manner to support data-driven training management. This oversight hinders the ability to leverage data for informed decision-making in training planning, preparation, execution, and assessment. The training data available from Army TADSS varies by their training function and the platforms they support. Platform simulator systems are more capable of capturing the higher-fidelity training state and activity data from simulations, while live training relies more on instrumentation to capture events like weapon shots, target states, and the times of event activity, and in some cases video and audio capture of the event. Once a training event is complete, and an after-action review (AAR) or evaluation is conducted, any training data logs pertaining to trainee performance during the training event must be manually retrieved and recorded before they are overwritten or erased from the system. Neither the TADSS themselves nor the broad Army training management system include capabilities for automating this process or enabling further analysis, distribution or exploiting of the data beyond the single training event it represents. As a result, insights from performance trends and comparisons cannot be obtained.

The challenges associated with collecting training data from TADSS are underscored by three critical issues:

1. The lack of automation in data transfer during or after training events is a significant hurdle in that it adds workload to the unit, introduces a higher risk of errors, and may or may not contain data that would inform diagnostics of future performance trends or anomalies. This manual approach not only increases the time and effort required but also limits the scalability of data operations, thereby impeding timely decision-making and adaptive responses in training operations.
2. Inconsistencies in data requirements, standards, and practices further complicate the ability to gather data from training systems to derive meaningful insights about trainee performance. Fragmented data systems across different TADSS hinder the integration and analysis of unit-wide training data as a whole. Additionally, data granularity varies significantly among different training modules and scenarios. This variation makes it challenging to derive comparative insights between different units' performance in a single event or a single unit's longitudinal performance over a series of training events.
3. There is not a unified training data strategy, policy or governance structure for acquisition programs and units to follow to ensure data collection, retention, and utilization becomes part of a system's requirements. Without clear training system requirements for common data models and their integration with external training management systems, any future effort to establish a cohesive training data framework will be difficult. Furthermore, without a unifying data architecture each training system can incorporate or integrate into, as well as a user-friendly process with which units can easily collect and playback data across the training enterprise, the Army's ability to effectively employ data to improve warfighter training will be fragmented and inefficient.

Addressing these challenges requires a concerted effort to automate data processes, standardize data practices, and establish a cohesive policy framework and data architecture. These steps are essential for enhancing the accuracy, efficiency, and utility of training data in informing decision-making and optimizing training outcomes across the Army's training ecosystem.

DCRA-STE EFFORT

Objectives of DCRA-STE

Leveraging insights from the Army's Test and Evaluation (T&E) community (US Army 2003), DCRA-STE considers the entire lifecycle of training data. This includes the collection, reduction, and analysis phases, ensuring that data is not only available for immediate assessment but also available for future learning engineering applications such as data science, human-systems analysis, and learning science research (Goodell & Kolodner 2022). The DCRA-STE project's ultimate goal is to implement scalable, repeatable practices for data management that will support the STE program's future training and assessment capabilities, enabling a comprehensive, evidence-based approach to Soldier readiness and operational effectiveness. The objective, approach, and outcomes for each component of DCRA-STE's model are noted in Table 2.

Table 2. Objectives for DCRA-STE Model

Data Collection	• **Objective:** Collect comprehensive data at the point of generation during training exercises. • **Approach:** Implement processes for both real-time streaming and batch processing of data, depending on network and computing capacities. • **Outcome:** Ensure data from all training modalities, whether synthetic or live, is captured for subsequent use.
Data Reduction and Formatting	• **Objective:** Format, align, filter, and aggregate collected data to facilitate its transport, storage, and analysis. • **Approach:** Develop reduction processes that support multiple stakeholders, ensuring that all necessary data is available in a usable format. • **Outcome:** Streamline data handling to reduce complexity and improve efficiency in data usage
Data Analysis and Visualization	• **Objective:** Enable stakeholders to analyze and visualize training data effectively. • **Approach:** Create automated, repeatable analysis processes that manage the volume and velocity of data. • **Outcome:** Provide actionable insights to trainers, soldiers, and commanders during and after exercises, supporting long-term performance tracking.
Assessment and Reporting	• **Objective:** Use collected data to support assessments of unit performance and training outcomes. • **Approach:** Associate data with assessments and reports, creating a comprehensive record that can be replayed and reviewed. • **Outcome:** Establish a robust framework for performance evaluation and accountability over the soldier's career and training cycle.

Prototype DCRA-STE Model

The Prototype DCRA-STE model is designed to streamline the management of training data from collection to analysis and visualization. Rather than specializing data to a particular training capability or TADSS system, this model (Figure 1) integrates seamlessly with the IWTS and STEEL-R framework, organizing and analyzing data in a manner that directly supports unit training evaluation and decision-making.

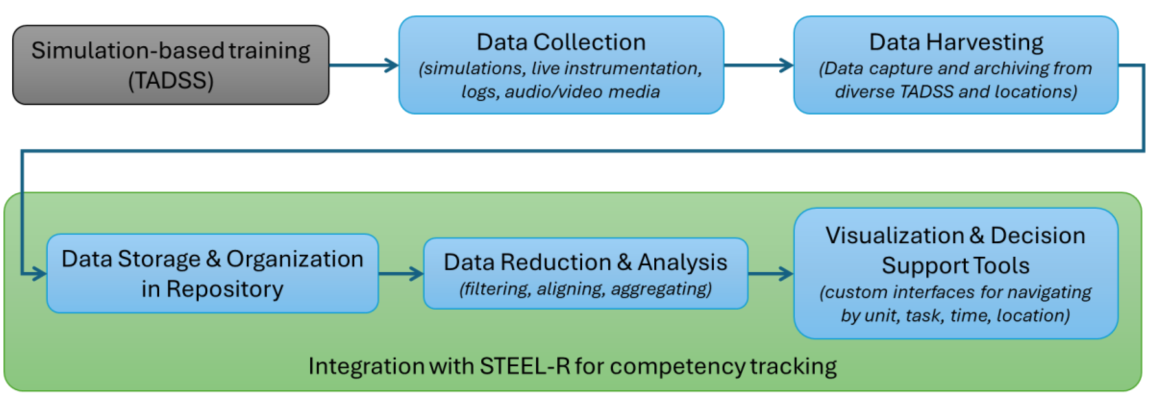


Figure 1. DCRA-STE model

Data collected from TADSS moves through the following stages and steps.

Data Collection. Training data is collected across a spectrum of sources including simulation outputs, live instrumentation data, digital logs, and audio/video recordings—determined by what data is accessible from the training environment. This collection also extends to metadata, which provides context such as the type of training, the units and Soldiers involved, specific tasks, and the conditions under which the training was conducted.

Data Harvesting. Data harvesting mechanisms are needed to capture all data from various training activities. Meanwhile, DCRA architecture development has been limited by the existing admin-based network boundaries, requiring manual data harvesting to move data from training environments into the DCRA common data environment. The ideal approach would be to include real-time data collection and seamless harvesting to DCRA data environment, per the Army Data Plan and long-term STE program objectives; however, that will require a careful design and integration of future STE network architectures into those enterprise-level data collection services.

Data Storage and Organization. Once collected, data is stored in a centralized repository designed for high-volume and complex data structures. This repository must support efficient and user-friendly data retrieval with respect to the IWTS framework, where data is labeled by soldier, unit, task, exercise, time, and location. The organization within the repository is critical for rapidly supporting quick access to relevant data for any given training scenario, facilitating ongoing training assessments and planning. A repository must also be adaptable to different training models and data from different training environments.

Data Reduction and Analysis. Data is processed and reduced to manageable insights through automated scripts that filter, align, and aggregate raw data. This reduction is crucial for transforming voluminous detailed data into actionable insights. Reduction is not a one-size-fits-all capability, but rather a process tailored to fit the analytical needs of data consumers. Analysis: Advanced analytics are applied to the reduced data to extract meaningful patterns and performance metrics. This analysis helps in assessing unit readiness, identifying skill gaps, and optimizing training regimes based on historical performance.

Visualization and Decision Support. The data, once analyzed, can be visualized to allow commanders and trainers to navigate complex datasets easily. These tools enable users to drill down into specific aspects of training, such as individual crew performance or overall unit effectiveness. Similarly, Army science and technology researchers need to access, navigate, and visualize datasets to support learning engineering future training technology and methods. Currently visualization tools are customized around the IWTS framework, enabling decision-makers to view data in formats that align directly with the training gates and echelons outlined in the IWTS.

Integration and Impact. The DCRA model is designed to be fully integrated with other initiatives that will provide a more automated and standardized data management layer. This includes more automated analytics, and interfaces to other learning data storage, and competency management systems. Key is integrating the data-evidence links to performance objectives and performance outcomes in order to clearly demonstrate the overall training value of a training exercise and its operational impact. By providing a data architecture from data collection to decision-making, the DCRA-STE model should improve the Army's ability to use training data strategically, just as the Army Data Plan seeks to make all Army data visible, accessible, understandable, linked, trustworthy, interoperable, and secure in support of decision-making in different mission areas.

DCRA-STE Technical Architecture

To enable the functionality described above we developed and prototyped a technical implementation of the model using open-source platforms. The two primary components of the DCRA-STE repository are the DCRA-STE Dataverse Project based data platform, and an interfacing web application (WebApp) (Figure 2).

The Dataverse Project is an open-source research data repository system developed to catalog data from research initiatives; it is designed specifically to support management of structured and unstructured data files and archive large volumes of such datasets with metadata to support data governance practices. Dataverse is well-suited as a starting point for DCRA-STE because it includes a generic web interface to navigate data holdings and is able to support various AAR, audio/video, scenario, and scoresheet files that may be associated with a training exercise.

The DCRA-STE WebApp is a customized user interface we developed to provide the training-focused view on the IWTS data repository - currently at Technology Readiness Level 4. The DCRA-STE WebApp initially supported upload of data that we collected from training events conducted at FCTX, along with ability to view, navigate and retrieve training data by exercise date (a timeline view), by training unit, by TADSS, or by weapon platform types used in a training event. With these initial views designed into the data repository, we are able to show how increasing volumes of training data can be organized alongside training plans (today often done with PowerPoint slides and Excel documents) and training outcome views (in the form of IWTS score sheets and crew rollup forms).

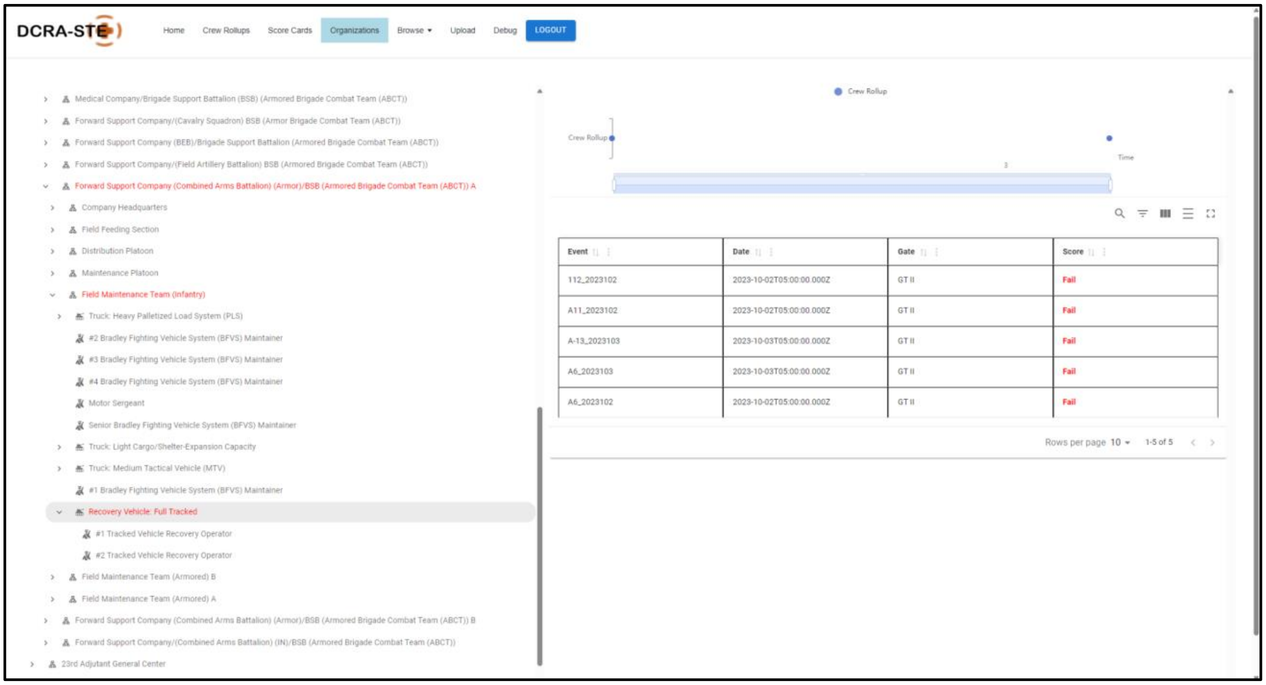


Figure 2. DCRA-STE Data Collection WebApp

DCRA-STE USE CASE

Collaborative Efforts at Fort Cavazos, TX

Over the past year, we have collaborated with the III Armored Corps and the Warrior Skills Training Center (WSTC) at FCTX to identify relevant TADSS and data to inform the DCRA-STE framework. WSTC serves as a typical home-station training facility, providing simulation-based training for the IWTS using the Stryker Virtual Constructive Trainer (SVCT), and the Games for Training (GFT) Virtual Battlespace (VBS) system, as well as offering other customized simulation training environments and TADSS (Figure 3). WSTC provides training services in concert with FCTX facilities that support TADSS like the Abrams Gunnery Training System (AGTS) and Bradley Advanced Training System (BATS).

Through discussions with our partners at WSTC, we identified the Stryker machine gun, and gun-truck non-mounted machine gun crew gunnery events as the optimal use case for DCRA-STE data collection based on the following criteria:

- **Alignment to training priorities:** Focusing on crew gunnery data aligns with the III Armored Corps' strategic priorities and needs.
- **Alignment to technology gaps:** Unlike the AGTS and BATS systems, the Stryker and gun-truck trainer systems lack built-in crew gunnery assessment capabilities, highlighting a significant gap in data analytics that needs addressing.

- **Accessibility of simulation data:** Both the SVCT and the GFT programs, based on the US Army's VBS simulation, allow for data capture through open interfaces and custom scripting.
- **Clearly defined evaluation criteria**. IWTS doctrine offers clearly defined crew gunnery evaluation criteria. Crew gunnery evaluation scores are captured manually by a Vehicle Crew Evaluator on a Scoresheet that records "engagement" metadata, conditions, crew performance, any penalties, and a final score. We were able to use these measures to define our data collection requirements.

Figure 3. Simulation-based trainers at the Fort Cavazos Warrior Skills Training Center

An objective of our use-case was to determine if we could replicate and automate the creation of the Scoresheet data using trace data from the simulation platform and to identify data sources that could be used to automate individual crew member and overall crew performance outcomes over several engagements in different conditions.

Data Collection

Since WSTC uses the VBS simulation system for much of its IWTS training, we were able to collect VBS-AAR data from approximately 152 training events spanning 15 units at FCTX. We created customized scripts to automatically populate Scoresheets for target engagements and to automatically collect fine-grained diagnostic data to assess a team or crew member's distinct individual activities.

We were also able to collect data from the Targetry Range Automated Control and Recording (TRACR) systems on FCTX live-ranges with support from the WSTC but this data source was found to be unreliable due to data transfer obstructions. However, from this data, we were able to characterize the gaps that exist between the data available in early simulation-based training, and the data needed to adjudicate and automate the IWTS final engagement outputs. This included data needed for describing specific crew members and units being trained, as well as the engagement, environment, target, and condition-parameters. Having access to these data sources allowed us to identify metadata that can be used in DCRA-STE to filter and cross reference variables (crew, position, target type) for data analysis. Where gaps exist in the de facto data collection, we established built-in forms and data tagging procedures to attain the necessary engagement metadata.

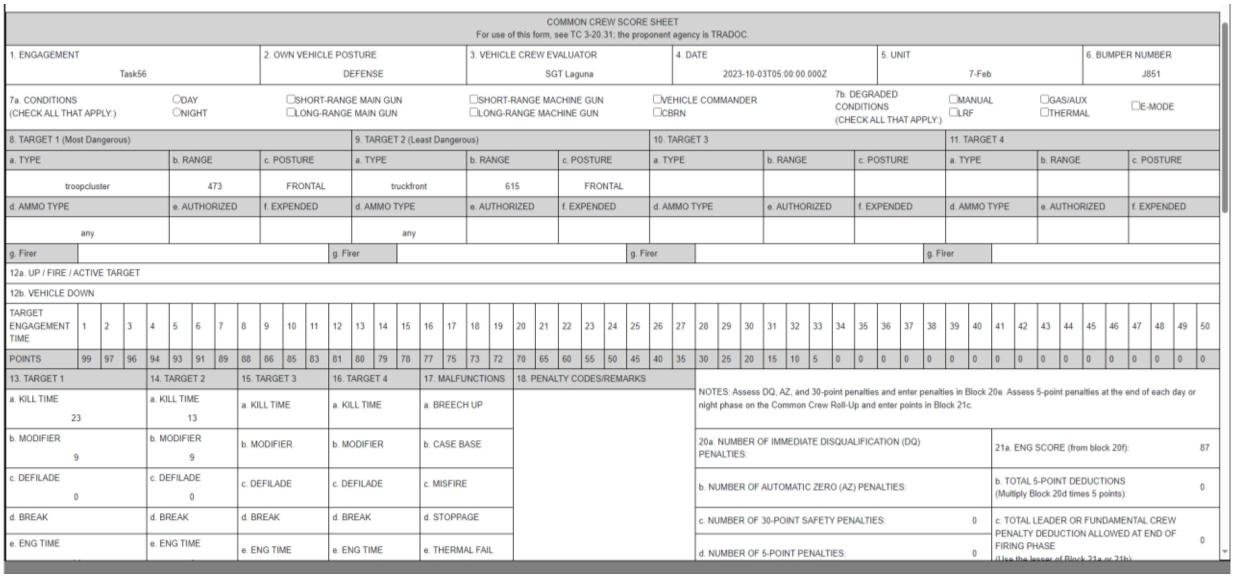
Data Reduction

While much of our effort to date has been focused on collecting training event data, we also identified data reduction requirements and developed an experimental database to help us sort and translate the data we collected. The reduction mappings allowed us to adjudicate and transpose data into the final evaluation products used for IWTS gunnery Table 2 engagements.

In our next steps for DCRA-STE we will work with the STEEL-R project technology and data strategy to employ its ability to inherently reduce the data, label it, and formatting it into IEEE standard activity logs that can then be integrated with more enterprise level training management systems like STE-TMT, and future Army enterprise-wide talent management systems as described in the latest Army Learning Concept (TRADOC 2024).

Data Visualization

As noted, one of DCRA-STE's goals was to have the ability to use the reduced data we stored in our database to automate the creation of the output Scoresheet (Figure 4). Today these standard forms are manually filled out by crew evaluators and master gunners during or after each training engagement is complete using either TADSS data outputs, notebooks, or memory. We have not only reproduced the standardized form information but have experimented with exploiting additional data we can collect to provide new data visualizations that provide more complete reconstruction of an engagement's activities that would not be possible using manual Scoresheet recording without excessive additional time and work.



COMMON CREW SCORE SHEET
For use of this form, see TC 3-20.31; the proponent agency is TRADOC.

1. ENGAGEMENT	2. OWN VEHICLE POSTURE	3. VEHICLE CREW EVALUATOR	4. DATE	5. UNIT	6. BUMPER NUMBER
Task56	DEFENSE	SGT Laguna	2023-10-03T05:00:00.000Z	7-Feb	J851

7a. CONDITIONS (CHECK ALL THAT APPLY:) ○DAY ○NIGHT ☐SHORT-RANGE MAIN GUN ☐LONG-RANGE MAIN GUN ☐SHORT-RANGE MACHINE GUN ☐LONG-RANGE MACHINE GUN ☐VEHICLE COMMANDER ☐CBRN
7b. DEGRADED CONDITIONS (CHECK ALL THAT APPLY:) ☐MANUAL ☐LRF ☐GAS/AUX ☐THERMAL ☐E-MODE

8. TARGET 1 (Most Dangerous)			9. TARGET 2 (Least Dangerous)			10. TARGET 3			11. TARGET 4		
a. TYPE	b. RANGE	c. POSTURE	a. TYPE	b. RANGE	c. POSTURE	a. TYPE	b. RANGE	c. POSTURE	a. TYPE	b. RANGE	c. POSTURE
troopcluster	473	FRONTAL	truckfront	615	FRONTAL						
d. AMMO TYPE	e. AUTHORIZED	f. EXPENDED	d. AMMO TYPE	e. AUTHORIZED	f. EXPENDED	d. AMMO TYPE	e. AUTHORIZED	f. EXPENDED	d. AMMO TYPE	e. AUTHORIZED	f. EXPENDED
any			any								
g. Firer			g. Firer			g. Firer			g. Firer		

12a. UP / FIRE / ACTIVE TARGET
12b. VEHICLE DOWN

TARGET ENGAGEMENT TIME	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
POINTS	99	97	96	94	93	91	89	88	86	85	83	81	80	79	78	77	75	73	72	70	65	60	55	50	45

TARGET ENGAGEMENT TIME	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
POINTS	40	35	30	25	20	15	10	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

13. TARGET 1	14. TARGET 2	15. TARGET 3	16. TARGET 4	17. MALFUNCTIONS	18. PENALTY CODES/REMARKS
a. KILL TIME 23	a. KILL TIME 13	a. KILL TIME	a. KILL TIME	a. BREECH UP	
b. MODIFIER 9	b. MODIFIER 9	b. MODIFIER	b. MODIFIER	b. CASE BASE	
c. DEFILADE 0	c. DEFILADE 0	c. DEFILADE	c. DEFILADE	c. MISFIRE	
d. BREAK	d. BREAK	d. BREAK	d. BREAK	d. STOPPAGE	
e. ENG TIME	e. ENG TIME	e. ENG TIME	e. ENG TIME	e. THERMAL FAIL	

NOTES: Assess DQ, AZ, and 30-point penalties and enter penalties in Block 20e. Assess 5-point penalties at the end of each day or night phase on the Common Crew Roll-Up and enter points in Block 21c.

20a. NUMBER OF IMMEDIATE DISQUALIFICATION (DQ) PENALTIES:	21a. ENG SCORE (from block 20f): 87
b. NUMBER OF AUTOMATIC ZERO (AZ) PENALTIES:	b. TOTAL 5-POINT DEDUCTIONS (Multiply Block 20d times 5 points): 0
c. NUMBER OF 30-POINT SAFETY PENALTIES: 0	c. TOTAL LEADER OR FUNDAMENTAL CREW PENALTY DEDUCTION ALLOWED AT END OF FIRING PHASE (Use the lesser of Block 21a or 21b): 0
d. NUMBER OF 5-POINT PENALTIES: 0	

Figure 4. DCRA-STE Digital IWTS Scoresheet

LESSONS LEARNED AND RECOMMENDATIONS

The DCRA-STE initiative has provided critical insights into the current use and management of training data within the U.S. Army's training environments, including practices, tools, and data formats, leading to conclusions on how to shape the training data *environment* of tomorrow. Accordingly, we present a set of lessons learned and strategic recommendations. Our findings highlight the necessity for improved data standards, models and automated integration requirements to make effective use of training data as well as to incorporate advanced technologies like AI/ML into training management sooner.

Lessons Learned:

- Metadata Integration: Essential metadata linking training data to specific units, tasks, IWTS tables, and conditions is often missing or inaccurate in scenario files and AAR data. To remedy this, future training environments should integrate more closely with units' training plans and range management systems, linking training management data to the simulation data and reduce reliance on manual data entry.
- Contextual Relevance: Understanding the context of the training exercise, including objectives and overall scenarios, is crucial for interpreting exercise playbacks and assessments accurately. Without this context, it becomes challenging to retrospectively determine the goals and effectiveness of the unit's performance during training.
- Configuration Management: The management of simulation assets, including maps, terrain, and 3D models, is critical for accurate data replay. Ensuring that all elements used in an exercise are correctly managed and documented is essential for the future reliability and effectiveness of training data playback and analysis.

Strategic Recommendations:

- Incorporate Army Data Plan Tenets: Align future training environments with the principles of the Army's data plan, emphasizing the creation of a data culture that values and utilizes data for enhanced decision-making and identification of training needs.
- Evolve Observer-Controller Practices: Develop practices that allow observer-controllers to analyze data and provide independent validation of automated outcome products. This includes labeling data to improve future capabilities and ensuring that assessments are both accurate and reliable.
- Establish Data Standards: Standardize data outputs and inputs, including scenario and exercise data formats. Adopt common ontologies and semantic web-based structures to enable interoperability across various systems and training platforms.

FUTURE DIRECTIONS AND CONCLUSION

As we look beyond what data is collected today to what data might be collected in the future with STE, or might be needed for future research, our focus will include exercise voice/intercom and radio audio, in-cab video, and additional live-range instrumentation that can provide more objective digital evidence of how crews perform in live conditions. We also will integrate the more automated data collection, reduction and adjudication capability from the STEEL-R technology and data strategy. Our hope is this will enable the Army to create a more complete and accurate reconstruction of crew or team performance at any echelon, support more objective and insightful assessment of competence, and more accurate (and perhaps automated) diagnosis of training needs in future training events.

Looking beyond the immediate benefits of collecting data and establishing the value of training data for decision making, DCRA-STE has two more *strategic* goals in mind: (1) Feeding training data into AI/ML research and (2) designing a mature data management backbone for the STE Training Management Tools.

Machine Learning and Artificial Intelligence in STE

The DCRA-STE research initiative sets the groundwork for advancements in AI/ML for STE. The collection of large volumes of high-quality training data is essential for developing AI/ML capabilities that support training effectiveness and simulation realism. By leveraging the detailed, structured data produced through the DCRA-STE model, AI-driven techniques can be used to create more adaptive and responsive training environments.

Future applications of AI/ML in STE include the development of automated intelligent tutor systems that provide real-time, personalized feedback to soldiers and trainers. Additionally, AI can be used to dynamically generate synthetic training scenarios, content, and behaviors that adapt to the evolving skill levels and tactical responses of units, making training sessions more effective and engaging. Moreover, ML algorithms can analyze vast datasets to predict training needs and suggest optimal training regimens, ensuring that soldiers are prepared for a wide range of operational scenarios. (Goldberg et al., 2023)

Best Practices and Data Standards

The development and implementation of best practices and data standards are central to the DCRA-STE initiative, particularly in shaping the design of the STE-Training Management Tool TMT. Establishing an architectural framework and data flows for Army-wide training data governance ensures that data collected across various training platforms is consistent, reliable, and secure. This standardization not only facilitates more effective data sharing and interoperability across a unit's crawl-walk-run training cycle, but also supports the scalability of training analytics across the enterprise.

Emphasizing best practices in data management, including the standardization of data collection, storage, and analysis processes, will ensure that training data is utilized to its fullest potential. These practices will help mitigate risks associated with data silos and incompatible systems that can hinder the Army's training and readiness objectives. Furthermore, well-defined data standards will aid in the development of advanced analytics tools and AI applications, enabling a more systematic approach to training management and decision-making.

Through these focused efforts on enhancing low-level training data collection and management, the DCRA-STE initiative is setting the stage for other research of advanced, integrated data solutions within the STEEL-R framework.

This ensures that all training environments within the STE can effectively support soldiers with data-driven analysis and decision-making, paving the way for more informed strategies and optimized training outcomes.

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