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Research on Data Development and Application for Manual Wargaming in Joint Operations

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Abstract

Manual wargaming is an important method for joint operational training, , which is used to support operational simulation, improve command ability, and test tactics and operational methods. The quality of data development directly affects the realism of wargaming and the training effect. However, at present, the data system for manual wargaming in joint operations is still at an early stage of development, and there are some problems, such as weak connection between training and actual operations, limited quantitative description of human factors, and incomplete data accumulation and management mechanisms. These problems reduce the ability of grassroots units to meet routine training and combat-oriented training requirements, and , and also affect the training of operational personnel and the reuse of training results. Based on the practical needs of grassroots wargaming training, this study focuses on the gap between data supply and application needs. It proposes an application framework that includes standardized training, verification of tactics and operational methods, data updating, and training feedback. The framework is developed from three aspects: improving data granularity at different levels, establishing quantitative indicators for human factors, and improving data management standards.

Keywords

Joint operations; manual wargaming; data development; combat-oriented training.

1. INTRODUCTION

Modern joint operations are becoming more complex, with different forces working together across multiple areas and facing system-level competition. Through human interaction, confrontation, and decision-making, manual wargaming allows participants to carry out simulations and reproduce battlefield uncertainty. It has become an important method for grassroots units to conduct combat-oriented joint training, explore tactics and operational methods, and improve command abilities [1]. Data are the basic support for the scientific and accurate implementation of manual wargaming. However, although manual wargaming has been widely used at the grassroots level, current practice pays more attention to the process of wargaming than to the construction of data support. It also focuses more on individual exercises than on the continuous accumulation and reuse of training results. As a result, data development has not fully met the needs of combat-oriented training. This has caused problems such as poor connection between training and actual operations, limited improvement of personnel abilities, and difficulties in updating and applying training results [2]. Based on these problems, this study focuses on the gap between training needs and data support. It analyzes the main problems in the development of data for manual wargaming in joint operations. It further expands multidimensional application scenarios in support of combat-oriented training,

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thereby contributing to improvements in the quality and effectiveness of joint operational training at the grassroots level.

2. CORE CONTRADICTIONS IN DATA DEVELOPMENT FOR MANUAL WARGAMING IN JOINT OPERATIONS

Based on the practical scenarios of manual wargaming training for joint operations at grassroots units, the current data system exhibits multiple mismatches with operational training requirements. These mismatches are further compounded by deficiencies in system interaction and data reuse, which are mainly reflected in three structural contradictions.

(1) Insufficient Integration Between Training and Operations, Limiting the Validation of Joint Operational Tactics

From the perspective of grassroots combat-oriented training requirements, the current manual wargaming data system remains relatively low in hierarchical sophistication and limited in data dimensions, making it difficult to support the demands of joint operational wargaming. With joint training and joint exercises becoming increasingly routine at the grassroots level, the training requirements of officers and soldiers for wargaming are no longer confined to traditional single-service firepower confrontation or linear tactical drills. Instead, wargaming platforms are increasingly needed to support combat-oriented simulations. These simulations should include coordination among different services, interaction between multiple domains, and confrontation between complex systems. They can be used to test joint tactics, improve operational procedures, and develop system-based operational thinking. This can help better represent the characteristics of modern joint battlefields. However, existing manual wargaming systems lack core quantitative data related to joint operations, such as multidomain coordination gains and system-level confrontation and counterbalancing effects. They also lack simulation rules for confrontation among multi-element force groupings, making it difficult to construct system-level confrontation scenarios that closely approximate real combat conditions. As a result, in-depth joint operational wargaming and the validation of emerging coordinated tactics at grassroots units cannot be effectively conducted [3]. Consequently, wargaming training remains largely confined to relatively basic tactical confrontation and is unable to fully realize its core value in studying, training for, and validating joint operations, thereby failing to meet the advanced training requirements for cultivating joint operational capabilities at grassroots units in the new era.

(2) Absence of Human-Factor Data Dimensions, Weakening the Effectiveness of Combat-Oriented Command Personnel Development

Human-centered adversarial interaction and adaptive decision-making are the core strengths of manual wargaming and constitute an important means of developing commanders' tactical thinking, on-the-spot decision-making, psychological resilience, and system-level coordination capabilities. However, the current data system for manual wargaming has some obvious problems. It focuses more on equipment and platforms but pays less attention to personnel factors. Quantitative data related to human factors are still lacking, which does not meet the needs of combat-oriented personnel training [7]. Current wargaming rules often assume that command posts and operational units work under ideal conditions, with no decision errors and no coordination delays. These assumptions ignore important human factors in real battlefields, such as psychological changes under pressure, mistakes in complex decision-making, and coordination problems between different departments. Under this data model, wargaming can only train basic procedures and tactical skills, and cannot fully demonstrate the pressure of real combat situations or the risks of battlefield decision-making. Therefore, it is difficult to improve the adaptive response, emergency management and system coordination ability of officers and soldiers[4]. In addition, there is a lack of standard processes for collecting, storing

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and reviewing human factor data. Repeating important information in the wargaming exercises, such as decision-making patterns, tactical problems and common errors, cannot be effectively saved and reused. This limits the ability to target training and support the development of operational personnel.

(3) Deficiencies in Data Management Mechanisms, Constraining the Long-Term Iterative Development of Wargaming Training

From the perspective of the long-term development of grassroots wargaming training, the imperfect data management system and weak institutional support have become important factors affecting the quality of training and continuous improvement. At present, grassroots manual wargaming training focuses on the implementation of drills and ignores the construction of the support system. There is still a lack of unified methods in data collection, standard setting, data storage and regular updating. The overall process of data management is relatively simple and lacks systematic planning[6]. Grassroots manual wargaming is often carried out in the form of temporary or periodic training activities, and most of the drill information is preserved through oral review and paper records. Due to the lack of clear data storage standards, important training information from wargaming, such as battlefield interaction processes, decision-making experience, and tactical application results, cannot be effectively converted into structured data that can be saved, reused, and updated. Due to the lack of institutionalized data-management mechanism, operational training experience cannot be systematically accumulated, improved and transformed into reusable knowledge, resulting in repetitive and low-level confrontation at the wargaming training, which seriously limits the continuous realization of the value of manual military wargaming deduction combat training.

3. METHODOLOGICAL PATHWAYS FOR DATA DEVELOPMENT IN MANUAL WARGAMING FOR JOINT OPERATIONS

Based on the objectives of combat-oriented training at grassroots units, personnel development, and coordinated system development, a comprehensive, implementable, and iterative pathway for manual wargaming data development should be established from three dimensions: data resource standardization, human-factor system development, and the implementation of unified standards and specifications. This method aims to solve the mismatch between data supply and training demand.

(1) Standardizing Data Resources and Adapting Them Hierarchically to Training Scenario Requirements

In order to solve the problem of mismatch between data supply and combat training requirements in manual wargaming, the following measures can be taken:. First, standardize multi-source data collection. Data sources may include records from live fire troop exercises and training, equipment performance manuals, combat results from actual troop level exercises, and records accumulated from previous combat exercise activities. Second, data cleaning and validation. The collected data shall be checked and standardized. Data based on personal estimates, outliers and outdated or unavailable data should be deleted. Verify the authenticity and applicability of the data against the actual combat exercise results, eliminate the parameters inconsistent with the joint operation mechanism, and establish an accurate, reliable and unified basic database. Third, realize differentiated applications based on data granularity [2]. For advanced joint training requirements such as tactical innovation and system-level confrontation, high-precision indicators, including micro-level parameters, operational differences, and system-level counterbalancing gains, should be extracted to support the modeling of complex joint operational battlefield logic and the validation of emerging tactics and operational methods. For routine grassroots training, overly complex and highly subdivided parameters should be streamlined, while core combat indicators such as firepower-related

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gains and losses should be retained. A lightweight data standard should thereby be established to reduce the operational threshold of wargaming and support high-frequency basic training.

(2) Standardizing Human-Factor Data Development and Improving the Combat-Oriented Personnel Training Mechanism

First, deficiencies in existing rules should be addressed. Closely aligned with grassroots training syllabi and the actual responsibilities of command positions, standardized specifications for human factor data collection should be established around four key areas: battlefield situation assessment, adaptive handling of unexpected situations, high-pressure command decision-making, and cross-domain system coordination. Second, human-factor data should be collected on a routine basis. Drawing on daily wargaming confrontations, tactical exercises, command-skill assessments, and other training scenarios, designated personnel should be assigned to record the actual performance of trainees and command groups throughout the training process, thereby accumulating first-hand human-factor data that closely reflect grassroots operational realities. Third, human-factor data assets should be consolidated. Human-factor data collected from previous wargaming activities should be classified, cleaned, standardized, and organized into traceable, comparable, and reusable training records for individuals and teams. This can effectively address the problem of human-factor training experience being lost after each exercise and failing to accumulate as reusable knowledge. Fourth, data-driven after-action review should be used to support targeted personnel development [7]. Based on standardized human-factor data assets, recurring errors, deficiencies in tactical thinking, decision-making blind spots, and weaknesses in system coordination should be systematically identified. Quantitative review can then be used to accurately locate training deficiencies and establish a targeted training mechanism focused on specialized practice, weakness remediation, and capability enhancement. In this way, a closed-loop personnel development process of "standard unification–data collection–asset accumulation–review and improvement" can be formed, thereby fully realizing the unique training value of manual wargaming in human-versus-human confrontation and combat-oriented capability development.

(3) Improving the Data Governance Standards System to Promote Iterative Enhancement of Training Data

To address problems such as inconsistent data standards, difficulties in retaining training outcomes, and delayed system iteration in manual wargaming, a standardized data governance system should be established to enable the long-term iterative improvement of training data. First, unified standards should be established for all categories of data. Operational parameters of equipment across different services and arms, battlefield environmental correction coefficients, system-level confrontation attrition rules, and statistical criteria for wargaming review should be systematically standardized, thereby enabling the unified, standardized, and interoperable application of manual wargaming data at grassroots units. The second is to establish a structured archiving mechanism. The traditional practice of relying mainly on oral reports and written records should be replaced. On the contrary, the data in the whole process of combat simulation should be structurally retained around five core dimensions: evolution of the operational situation, command decision-making processes, system-level confrontation gains and losses, handling of unexpected situations, and the effectiveness of tactical applications. This can transform scattered personal confrontation experience into standardized data resources that can be tracked, compared and reused. Third, a mechanism for regular data updating and improvement should be established [6]. On the basis of accumulating combat data resources, the system continuously analyzes the confrontation mode, tactical defects and weak links of training organization, and dynamically modifies the combat simulation parameters. In this way, the accumulated data can be fed back to the improvement of training quality, thus

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overcoming the traditional problem of "returning to zero after each exercise and repeatedly operating at the same level", which is conducive to long-term iteration and steadily improving the combat ability of the combat-oriented training capabilities of manual wargaming.

4. MULTIDIMENSIONAL APPLICATION SCENARIOS OF THE DATA SYSTEM FOR MANUAL WARGAMING IN JOINT OPERATIONS

An optimized and improved data system for manual wargaming can support combat-oriented training and personnel development at grassroots units. At the same time, it can bridge the data gap between manual wargaming and computer-based wargaming, enabling complementary advantages and bidirectional iteration between the two forms of wargaming. On this basis, four major application scenarios can be established.

(1) Enabling Routine Wargaming and Establishing a Standardized Training System

With a hierarchical and refined data system, manual wargaming can support the quantitative validation of tactical effectiveness and force organization while accommodating the training requirements of different operational scenarios. For routine basic wargaming and advanced tactical research tasks, lightweight basic data and high-precision system-coupling data can be applied in a differentiated manner. By adjusting core variables such as force organization, coordination strategies, and the timing of firepower employment, the strengths and weaknesses of different tactical approaches and force-grouping patterns can be accurately identified, thereby providing support for the iterative optimization of emerging coordinated tactics at grassroots units.

On this basis, standardized human-factor data collection and after-action review mechanisms can be used to accurately identify deficiencies in command training. Real performance data of trainees in high-pressure confrontation, unexpected battlefield situations, and adaptive decision-making errors can be recorded in detail. By comparing data from different wargaming sessions, common problems in officers' and soldiers' decision-making and weaknesses in commanders' operational thinking can be identified. This can provide support for targeted training and improvement. By using refined system data and human-factor analysis to build more realistic combat scenarios, manual wargaming can develop from a single confrontation activity into a more complete training method that combines operational testing, personnel training, and regular combat-oriented practice.

(2) Supporting Comparative Tactical Wargaming and Enabling Quantitative Validation of Joint Operational Tactics

A comprehensive set of cross-domain system-coupling data and dynamic battlefield correction data provides a scientific and quantitative validation platform for the innovation of emerging joint operational tactics [3]. Grassroots units can rely on high-precision wargaming data systems to conduct multi-scenario, multi-round, and multi-variable comparative simulations focusing on emerging operational approaches such as unmanned-system coordination, cross-domain firepower integration, and electromagnetic offense and defense.

By quantitatively comparing core indicators such as mission completion efficiency and losses of forces and equipment under different tactical models, the applicable conditions and operational risks of emerging tactics can be accurately assessed, thereby supporting the optimization of operational plans. Compared with traditional experience-based assessment, data-driven wargaming makes tactical innovation quantifiable, comparable, and reviewable. It can overcome the limitations of traditional tactical research, which has largely relied on qualitative judgment and practical experience, and promote a transition in joint operational tactical research from experience-based judgment to data supported empirical validation. This

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provides solid support for the practical implementation of frontline tactical innovation and the optimization of tactical systems.

(3) Accumulating Combat-Oriented Data Assets to Support Long-Term Iterative Upgrading of Wargaming Training

A standardized system for data development and archiving can transform fragmented, one-off wargaming exercises into combat-oriented data assets that can be continuously accumulated, analyzed, and iteratively improved, thereby addressing the traditional problem of "returning to zero after training and losing accumulated experience" [6]. In the past, grass-roots combat simulation generally lacked systematic data retention mechanism, which made it difficult to achieve continuous improvement of training quality and effectiveness.

Through the standardized data management system, the dimensions such as the evolution of operational situations, decision-making logic, tactical applicability, and other dimensions generated in continuous combat exercises can be archived structurally, so as to establish a special grass-roots combat database. Through data analysis, hindsight review and pattern recognition, we can find effective tactical choices, common decision-making errors and weak links in system coordination under different battlefield situations. These results can be used to improve combat simulation settings, simulation rules and training content. This process can form a continuous model of "training practice data collection problem identification optimization", and support the steady development of joint operational wargaming training.

(4) Feeding Back into Intelligent Model Iteration and Building an Integrated Human–Machine Collaborative Wargaming System

Manual wargaming has the advantages of flexible scenarios, direct interaction between participants, consideration of human factors, and adaptive decision-making. The operational data, decision data and collaborative data in manual combat simulation are important resources to improve the computer combat simulation system. These data can help connect manual combat simulation and computer-based combat simulation, and support the development of these two methods [5]. The traditional computer-based combat simulation system has some problems, such as fixed model, limited description of human factors, poor scene flexibility and so on. These problems make it difficult to fully reflect the complexity of the real battlefield. The structured data collected by manual combat simulation can be processed through standard data management methods, and used for intelligent models through data conversion methods. These data are helpful to adjust the equipment countermeasure parameters, improve the collaborative models in different fields, and reduce the limitations of intelligent simulation in representing real operational situations.

At the same time, the decision-making experience, interaction mode and coordination method collected from the manual wargaming can also be added to the intelligent simulation system. This can reduce the fixed and mechanical characteristics of current intelligent wargaming. In this way, a combined wargaming system can be developed, where manual wargaming provides combat data, data support intelligent improvement, and human and machine abilities work together.

5. CONCLUSION

Data development for manual wargaming in joint operations is an important part of improving grassroots wargaming training, optimizing the joint operational wargaming system, and supporting tactical development and personnel training. At present, the main problem in manual wargaming data development is the gap between available data and the needs of operational training. This problem is mainly reflected in three areas: existing data systems provide limited support for the development and testing of new tactics and operational methods; insufficient human-factor data affects the effectiveness of combat-oriented personnel

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training; and incomplete data management limits the improvement and updating of the wargaming system.

These problems can be improved by increasing the level of data classification, developing quantitative indicators for human factors, and improving data management methods.

With standardized data systems, manual wargaming can better support conventional training, tactical testing and continuous improvement. At the same time, sharing the use data can make the results of manual wargaming support the development of computer-based wargaming system, and improve the relationship between the two kinds of wargaming. This framework can provide a solid support for the high-quality development of combat-oriented joint operational training in the new era.

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