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COMPARATIVE ANALYSIS OF THE ADVANTAGES AND LIMITATIONS OF SIMULATION TRAINING SYSTEMS USED IN THE ARMED FORCES OF ADVANCED COUNTRIES

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Abstract. This article analyzes the capabilities, advantages, and limitations of modern simulation training systems used in the armed forces of advanced countries. It examines the experience of the United States, the United Kingdom, and NATO member states in military training and discusses the impact of simulation technologies on training effectiveness. The article also considers the prospects for integrating these technologies into the military education system of the Armed Forces of Uzbekistan.
Keywords: simulation training systems, military training, armed forces, virtual technologies, military education, combat readiness.

Аннотация. В статье анализируются возможности, преимущества и недостатки современных симуляционных тренажёров, применяемых в вооружённых силах передовых государств. Рассматривается опыт США, Великобритании и стран НАТО в системе военной подготовки, а также влияние симуляционных технологий на эффективность обучения военнослужащих. Кроме того, изучаются перспективы внедрения данных технологий в систему военного образования Вооружённых Сил Узбекистана.
Ключевые слова: симуляционные тренажёры, военная подготовка, вооружённые силы, виртуальные технологии, военное образование, боевая подготовка.

Annotatsiya. Ushbu maqolada ilg‘or xorijiy davlatlar Qurolli Kuchlarida qo‘llaniladigan zamonaviy simulyatsion trenajyorlarning imkoniyatlari, afzalliklari va kamchiliklari tahlil qilingan. AQSh, Buyuk Britaniya va NATO davlatlarining harbiy tayyorgarlik tizimidagi tajribalari o‘rganilib, simulyatsion texnologiyalarning harbiy xizmatchilarni tayyorlash samaradorligiga ta’siri yoritilgan. Shuningdek, mazkur texnologiyalardan O‘zbekiston Qurolli Kuchlari harbiy ta’lim tizimida foydalanish istiqbollari ko‘rib chiqilgan.
Kalit so‘zlar: simulyatsion trenajyor, harbiy tayyorgarlik, Qurolli Kuchlar, virtual texnologiyalar, harbiy ta’lim, jangovar tayyorgarlik.

Introduction

Armed forces increasingly employ simulation to rehearse complex tasks under controlled conditions. The term encompasses virtual systems in which personnel interact with simulated equipment, constructive systems that represent forces and events computationally, and live exercises supported by instrumentation. The US Army explicitly distinguishes live, virtual and constructive environments and advises commanders to select combinations according to training objectives and

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constraints [1]. Consequently, "simulation trainer" should not be treated as a single uniform technology.

Simulation may permit repeated practice when live training is constrained by time, location, safety, or resources. Nevertheless, the quality of learning cannot be inferred from technical sophistication alone. A visually convincing environment may fail to reproduce the physical, interpersonal, or organisational demands of an actual task. Evidence on transfer of training indicates that simulator fidelity must be evaluated relative to trainee experience and the task being taught [2].

This question is relevant to Uzbekistan, where official publications describe dynamic computer-based trainers in military education and training programmes combining simulation with practical exercises [3, 4]. The present article therefore asks:

1) What benefits and limitations are supported by official international documentation?

2) What common criteria permit a fair comparison?

3) Which implementation principles can be considered for military education in Uzbekistan without presuming that foreign systems are directly transferable?

Materials and Methods

Study design and evidence base

The study uses a structured narrative literature review, not an experiment or a systematic review claiming exhaustive retrieval. Publicly accessible documents were selected for institutional authority and direct relevance: US Army training guidance and Synthetic Training Environment (STE) materials; NATO education and modelling-and-simulation information; UK Ministry of Defence policy (JSP 939); and official Uzbek government and presidential reports [1, 3–9]. Peer-reviewed research was used to assess the general relationship between simulation fidelity and training transfer [2, 10].

Comparison framework

Sources were analysed using six criteria: training purpose and scale; repeatability and access; fidelity and transfer; interoperability and technical integration; costs and sustainment; and assessment and feedback. Statements were coded as (a) directly documented institutional practice, (b) findings of peer-reviewed studies, or (c) analytical implications. This separation prevents a programme description from being misrepresented as proof of effectiveness.

Scope and limitations

The analysis covers unclassified, publicly reported training practices and institutional frameworks. It does not examine classified capabilities, tactical performance or weapons employment procedures. Public sources do not provide standardised head-to-head outcome measures or comparable full lifecycle budgets across the selected systems. Therefore, no ranking, effectiveness percentage, or monetary saving is calculated.

Results

United States: integrated live, virtual and constructive training

US Army guidance presents live, virtual and constructive environments as complementary rather than interchangeable. Virtual environments can allow practice before field exercises, while live training exposes personnel to actual equipment and variable physical conditions. The Army's STE programme aims to improve access to integrated training resources and to reduce the fragmentation of older systems [1, 5]. This offers a plausible advantage in repeated practice and instructional scheduling; however, integration is itself a major engineering and organisational challenge.

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A US Army assessment of sustainment simulation identified limitations in maintenance representation, logistics-system interfaces and other support functions in earlier training architectures [6]. This is important evidence against assuming that complex synthetic environments necessarily reproduce all organisational processes accurately. It also illustrates the need for task-specific validation before simulation outputs are used as indicators of readiness.

NATO: multinational interoperability and exercise support

NATO identifies interoperability as a core purpose of education, collective training and exercises, including computer-assisted simulations [7]. Its Modelling and Simulation Centre of Excellence provides specialist education and supports simulation-related capability development [8]. A central benefit of this model is the use of shared concepts and professional training to facilitate multinational learning. Its likely constraints include aligning data, standards, procedures and exercise objectives across different national systems. These constraints are analytical implications of multinational integration, not measured failure rates.

United Kingdom: policy-led governance of modelling and simulation

The UK Ministry of Defence publishes JSP 939 as guidance for the acquisition, development and use of modelling and simulation across defence [9]. Compared with descriptions focused on individual devices, this framework emphasises governance and technical coherence. Such policy coordination can improve accountability and consistency of procurement decisions. Nevertheless, a policy framework by itself does not establish that every simulator is pedagogically effective; local validation, qualified instructors and periodic reassessment remain necessary.

Table 1. Source-grounded comparison. Limitations described as "evaluation needs" are analytical cautions, not measured shortcomings of a particular country.

System / approach	Documented strengths	Main limitations or evaluation needs
US Army LVC / STE	Complementary training modes; repeatable virtual practice; integration ambition [1, 5]	Legacy integration challenges; incomplete representation of some support processes [6]
NATO simulation-supported exercises	Multinational coordination; specialist education; interoperability focus [7, 8]	Cross-national standards and data alignment; need for shared evaluation criteria
UK JSP 939 governance	Institutional direction for acquisition, development and use [9]	Governance alone cannot demonstrate transfer or educational value
Uzbekistan documented trainers	Domestic use of computer trainers and combined simulation/practical training [3, 4]	Insufficient public comparative outcome and lifecycle-cost data

Uzbekistan: documented domestic experience

An official presidential report described a modern situational centre and dynamic computer trainers at the Armed Forces Academy [3]. A Ministry of Defence publication reported the use of modern simulation and trainer programmes in a course that also included practical unmanned-aircraft

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flights; the report described simulated weather, terrain and training situations [4]. These reports demonstrate that simulation is part of documented national training practice. They do not, however, provide controlled before-and-after results, total costs, or a standardised comparison against foreign systems. It would therefore be inappropriate to infer measured superiority or savings from these accounts.

Discussion

Benefits must be tied to learning objectives

The strongest educational rationale for simulation is not the novelty of the technology but its capacity to support deliberate, repeated practice with feedback. For tasks where errors are costly or hazardous, a controlled environment can allow learners to practise procedures before working with real equipment. Yet the US Army cautions that simulation enhances rather than replaces live training [1]. This distinction should guide curriculum design: use simulation to prepare learners, then verify performance in appropriate practical settings.

Fidelity is multidimensional

Fidelity may refer to appearance, behaviour, task demands, feedback or context. A meta-analysis of troubleshooting simulation reported 25 eligible reports covering 57 experiments and 1,481 participants; no single fidelity level was universally superior, and outcomes varied with prior skill and system type [2]. These findings concern troubleshooting across occupational domains, including military-related applications, and should not be extrapolated as a precise effectiveness estimate for all military simulators. They nevertheless support a key procurement principle: specify the behaviours and decisions that must be reproduced before selecting expensive visual or physical features.

Cost, maintenance and instructor capacity

Potential reductions in travel, consumables or equipment wear must be weighed against acquisition, software updates, hardware replacement, network support, cybersecurity, instructor preparation and scenario maintenance. Because public sources do not report comparable total-cost-of-ownership figures, a general assertion that simulation is always cheaper is unjustified. An appropriate economic evaluation would compare cost per trainee reaching a defined proficiency threshold over the system's full service life.

Assessment and transfer to practice

Simulator scores are useful only when linked to observable competencies. A robust evaluation plan should measure baseline proficiency, performance during practice, delayed retention and subsequent performance in practical exercises. Outcome indicators may include completion of prescribed tasks, error rates, response quality, instructor ratings and trainee safety. Evaluation should also identify negative transfer: habits learned from simplified scenarios that are inappropriate in real settings.

Implications for Uzbekistan

A cautious development pathway would begin with a needs assessment in military education institutions, identify repeatable instructional tasks, and pilot a limited set of trainers with explicit educational objectives. Local-language interfaces, technical support, instructor training and compatibility with existing curricula should be considered early. Comparative pilot evaluation could then establish whether trainees receiving blended instruction perform better on the same practical assessments than trainees receiving conventional instruction alone. These are recommendations

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derived from the review, not claims that such a controlled study has already been conducted in Uzbekistan.

Conclusion

International experience indicates that simulation-based military training can improve access to repeatable exercises, support structured feedback and complement resource-intensive field activities. The US Army illustrates the value and difficulty of integrating live, virtual and constructive environments; NATO demonstrates the importance of multinational interoperability; and the United Kingdom provides an example of governance-oriented simulation policy. Uzbek official publications confirm domestic use of computer-based trainers and blended practical training. However, the reviewed sources do not justify numerical comparisons of effectiveness or cost across countries. The most defensible strategy is to match simulation fidelity to clearly defined tasks, integrate simulation with practical exercises, evaluate transfer using common performance measures and account for full lifecycle requirements.

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