

ENHANCEMENT OF OPERATIONAL READINESS VIA PREDICTIVE MAINTENANCE AND NETWORK OPTIMIZATION

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This article presents a methodological framework aimed at building an agile and resilient logistics system for the material and technical support of the Armed Forces of Azerbaijan through digitization, modeling, and optimization. The problem's relevance is determined by the multifaceted maneuver dynamics of modern warfare, the high intensity of supply, and the impact of information latency in the operational environment on combat readiness. The approach synthesizes three scientific directions. First, Digital Supply Chain principles with near real time tracking, ERP and WMS integration, RFID based warehouse management, and big data analytics (figure). Second, a Predictive Maintenance model that detects failures in advance using vibration, temperature, and load regimes. Third, Resource Optimization delivers multi criteria efficiency for inventory levels and transport networks. The methodology is grounded in systems engineering, operations research, and the digital twin concept. For inventory management the classical (Q, R) policy is applied. The reorder point R is computed according to the service level using a z factor and the mean and dispersion of demand during the lead time L. The average inventory \bar{I} is estimated as Q divided by 2 plus the safety stock, which reduces excess inventory and warehouse capacity while keeping the service level stable. Transportation and distribution processes are modeled as a multi-source, multi objective flow. The objective function is cost minimization, with constraints defined by source capacity and demand satisfaction. The Pareto frontier balances cost, time, and risk. In the predictive maintenance module, the time to failure $\hat{T}_{failure}$ is estimated using regression or deep learning based on vibration, temperature, and duty cycles. Within the digital twin structure, a Plan Do Check Act cycle is established, and KPI indicators are updated automatically.

The discussion of results shows that online monitoring of supply operations via the digital twin significantly shortens the decision cycle, and multi criteria optimization of routes yields a rational compromise between transport cost and risk level. In emulation scenarios the MTBF indicator increases by 15 to 20 percent and the MTTR indicator decreases by 10 to 12 percent. If overall availability A is calculated as MTBF divided by MTBF plus MTTR, it reaches approximately 0.91, which indicates improved operational readiness of the fleet. For risk management a register is created for CBRN effects, cyber risks, and supply delays, and control measures are planned that include alternative routes, decontamination posts, zero trust architecture, journaling, and buffer warehouses. The economic analysis shows that the model reduces logistics costs by 8 to 10 percent, increases service level by 12 to 15 percent, and yields a positive net present value NPV.

The application results are reinforced through normative alignment and standardization in the Azerbaijani context. The adoption of STANAG formats and interface protocols facilitates the integration of heterogeneous systems. The KPI set includes service level, on time order fulfillment, warehouse agility, transport time reliability, OODA loop duration, and resilience

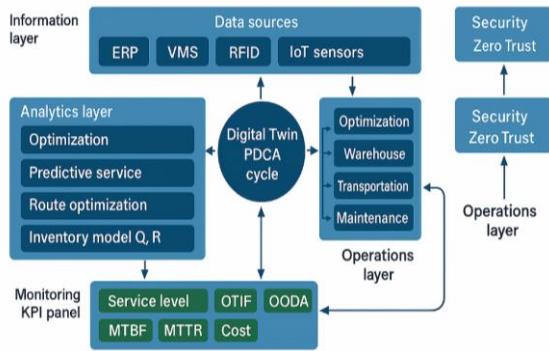


Fig. 1. Digital Twin based military logistics architecture

indicators for CBRN and cyber risks. Sensitivity scenarios consider demand variation, supply delays, fuel price, personnel, and infrastructure constraints, with thresholds adjusted dynamically. In conclusion, a digitized, modeled, and optimized multi-level logistics architecture plays a decisive role in maintaining operational superiority, comparable to weapon systems. The proposed framework integrates modules for inventory management, network optimization, and predictive maintenance within a unified digital twin, which increases decision transparency and speed, ensures rational allocation of resources, and reduces operational risks. Future research should focus on expanding real time telemetry, AI based fault diagnostics, on the fly route updating via edge computing, and the development of simulation ranges for testing digital twin.

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