TECHNICAL UNIVERSITY OF CLUJ-NAPOCA

ACTA TECHNICA NAPOCENSIS

Series: Applied Mathematics, Mechanics, and Engineering
Vol. 69, Issue Special III, July, 2026

AMOS – ACTIVE MANAGEMENT OPERATIONS SYSTEM

Silvia Daniela POHRIB, Nicolae-Bogdan ZVONARU, Vlad-Sebastian ANGHELUȚĂ Adrian PÎSLĂ

Abstract: *Current global crises generate high uncertainty, operational pressure, and resource volatility, affecting Medical Evacuation (MEDEVAC) systems in military missions and civilian emergency response. This study applies a comparative case-based analytical methodology examining combat, peacekeeping, and civilian missions in Afghanistan, Bosnia, Kosovo, Nigeria, Turkey, and Switzerland to identify performance gaps in MEDEVAC governance, interoperability, and decision-making. Based on this analysis, the paper proposes AMOS – Active Management Operations System, a system-of-systems management architecture integrating dynamic resource allocation, secure digital communication, predictive maintenance, and audit-driven feedback loops. Findings show MEDEVAC effectiveness in tactical and joint multinational operations within NATO frameworks depends not only on platform capability but on interoperability, governance maturity, and decision integration, civil–military interoperability and resilience in NATO/EU VUCA environments.*

Keywords: *MEDEVAC systems; active management; AMOS; civil–military interoperability; predictive maintenance; digital communication; crisis operations; resilience*

1. INTRODUCTION

In a global environment increasingly defined by unpredictability, volatility, and crisis-driven constraints, the need for adaptable, efficient, and resilient systems has become critical, particularly in defense and emergency operations such as **Medical Evacuation (MEDEVAC)** systems [1]. In response to the growing complexity of the operational landscape, the development of an integrated **Active Management Operations System (AMOS)** emerges as a strategic necessity, building on prior research in active resource management under crisis conditions. AMOS functions as a real-time digital management platform for monitoring risks, resources, and expenditures, enabling timely and effective decision-making within MEDEVAC operations. The paper proposes a multidisciplinary framework for MEDEVAC systems grounded in active management principles and supported by digital communication and resilient maintenance, facilitating the transformation of MEDEVAC into a dual-use capability aligned with **NATO joint operational requirements**. This study addresses three research questions: What recurrent structural deficiencies affect MEDEVAC performance across combat, peacekeeping, and civilian missions? How do interoperability and governance influence tactical and joint effectiveness in multinational contexts? Can an integrated management architecture improve the planning and conduct of MEDEVAC missions within **NATO or EU-led frameworks**? To answer these questions, a comparative case-based analytical methodology is applied, enabling cross-mission evaluation and conceptual validation of the proposed AMOS framework.

2. ACTIVE RESOURCE MANAGEMENT WITHIN CRISIS

The concept of active resource management represents a paradigm shift from rigid, reactive operational models toward adaptive, forward-

looking frameworks capable of continuously reassessing objectives and reallocating resources in real time [2]. Within MEDEVAC systems, such conditions are inherent, as missions are often initiated in unstable environments, including conflict zones, disaster-affected regions, or remote and inaccessible locations. In these contexts, rapid transport of critically injured individuals must be ensured despite information asymmetry, infrastructural disruption, and operational instability.

An active management approach enables MEDEVAC operators to dynamically adjust mission priorities, medical capabilities, transport resources, patient profiles, and logistical constraints in response to emerging threats. Effective implementation requires several enabling conditions:

• flexible allocation mechanisms for medical assets and transport platforms;
• transparent communication protocols across strategic, operational, and tactical levels;
• data-driven monitoring tools capable of quantifying system stress and performance degradation in real time [3].

Furthermore, MEDEVAC system architecture must accommodate non-linear dynamics, where localized disruptions may escalate into cascading failures if not actively mitigated. Active management supports the development of scenario-resilient resource portfolios anticipating multiple plausible futures and enabling flexible response pathways. The following sections examine how this framework interfaces with digital communication infrastructure and aircraft maintenance strategies, forming a multidisciplinary approach in which active resource management acts as a coordinating layer enhancing adaptability, connectivity, and resilience across civil and military evacuation missions.

3. ENABLING SYSTEMS FOR MEDEVAC OPERATIONS

3.1 Digital Communication Systems in MEDEVAC Operations

In complex and volatile operational environments, communication represents a critical enabler of safe, timely, and coordinated MEDEVAC missions. Effective communication relies on physical infrastructure, trained personnel, and predefined routes, ensuring secure real-time information exchange among medical teams, flight crews, command-and-control centers, and ground control [4]. Operational experience shows that even advanced medical capabilities cannot compensate for the absence of reliable, integrated communication systems.

Beyond technical support, digital communication functions as a strategic management capability enabling real-time decision support, reduction of operational uncertainty, and integration of civil and military actors. Its effectiveness depends not only on bandwidth but also on the capacity to collect, validate, prioritize, and distribute operationally relevant data. At the operational level, communication systems synchronize medical telemetry, aircraft status, environmental data, and command directives securely and in a coordinated manner. Emerging technologies such as **digital twins (DT)** and the **Internet of Medical Things (IoMT)** extend these capabilities toward predictive decision support [5], allowing simulation of mission evolution under changing constraints and continuous transmission of clinical parameters for proactive resource allocation and early risk mitigation.

Cybersecurity constitutes an integral design requirement. Compliance with **NIS2 and NATO cyber guidelines** ensures data integrity, confidentiality, and system resilience, particularly within civil–military interoperability contexts. In MEDEVAC operations, uncertainty manifests as medical, operational, and logistical risks, which structured digital communication transforms into measurable and manageable risks through systematic probability and impact assessment, enabling informed decision-making.

Civil–military interoperability introduces additional complexity due to divergent standards and regulatory frameworks. Effective MEDEVAC communication systems must incorporate governance mechanisms ensuring secure information exchange without

compromising institutional autonomy or data protection. In this context, **AMOS** provides a management-level framework harmonizing technical interoperability with procedural alignment through standardized data structures, prioritized information flows, and audit-enabled traceability, supporting coordinated decision-making across institutional boundaries.

3.2 Conceptual framework for predictive maintenance strategies in MEDEVAC

The reliability and continuity of MEDEVAC operations depend not only on mission planning and digital communication but also on sustained airworthiness, aircraft availability, and technical readiness. In crisis-driven environments, unexpected technical failures may compromise patient safety, delay response times, and disrupt the evacuation chain; therefore, maintenance strategies must be treated as a strategic management component rather than merely technical support. Traditional aviation maintenance approaches—reactive, preventive, and condition-based—have significantly improved safety and reliability; however, their limited capacity to anticipate failures and optimize resource allocation becomes evident in high-tempo MEDEVAC operations. **Predictive maintenance (PdM)** addresses these constraints by integrating historical maintenance records with real-time sensor data to forecast component degradation and anticipate failures before they occur.

The comparative contribution of predictive maintenance to MEDEVAC performance, relative to traditional approaches, is summarized in Table 1.

Table 1

Predictive Maintenance Contribution to MEDEVAC Performance

Aspect	Traditional / Preventive / CBM Maintenance	Predictive Maintenance (PdM)	Relevance for AMOS
Maintenance approach	Reactive, preventive, or condition-based	Predictive, AI- and data-driven	Enables proactive resource management
Data sources	Scheduled inspections, basic monitoring	IoT sensors, historical data, digital twins	Provides real-time decision inputs
System downtime	Unplanned and difficult to anticipate	Reduced by 15–20%	Increases aircraft availability
Maintenance costs	Inefficient resource allocation	Reduced by 12–18%	Optimizes lifecycle cost management
Failure anticipation	Limited, threshold-based	Early prediction of component degradation	Supports mission risk assessment
Decision integration	Isolated technical function	Integrated with planning and audit	Enables audit-driven optimization
Operational impact	Potential mission delays	Improved readiness and reliability	Enhances operational resilience

Advances in **artificial intelligence, machine learning, and the Internet of Things** enable PdM through anomaly detection, degradation pattern recognition, and failure forecasting [6]. Digital twin technology further enhances predictive capabilities by enabling real-time simulation of asset behavior under varying operational conditions, while cloud-based platforms support scalable integration of maintenance and operational data [7]. Empirical evidence indicates that PdM can reduce system downtime by 15–20% and maintenance costs by 12–18%, improving aircraft availability, safety margins, and lifecycle cost efficiency (Table 1). Within the AMOS framework, predictive maintenance is embedded as a core subsystem integrated with digital communication and active resource management layers. Maintenance data feed directly into decision-support processes, enabling real-time visibility over aircraft availability, technical risk levels, and mission feasibility. Audit mechanisms validate predictive models, monitor maintenance outcomes, and ensure traceability, transforming maintenance into an audit-driven decision-support capability.

The evolution of MEDEVAC maintenance strategies is closely linked to broader aerospace developments, including advanced propulsion concepts, new materials, additive manufacturing, and unmanned aerial systems for medical logistics. These trends reinforce the need for

scalable, data-driven predictive maintenance models capable of supporting heterogeneous fleets while ensuring regulatory compliance, workforce readiness, and phased integration with legacy systems.

4. COMPARATIVE CASE STUDY OF MEDEVAC SYSTEMS

4.1 Methodological Approach and Case Selection

To assess the effectiveness of **active resource management** in aeromedical evacuation systems under crisis conditions and operational stress, the paper examines six representative case studies selected from **military, humanitarian, civil protection, and post-conflict contexts**, covering a broad spectrum of critical scenarios, including high-intensity combat operations, major natural disasters, civilian mass-casualty incidents, structural collapses, and peacekeeping missions.

4.2 Case Study Overview

Rather than providing detailed narrative descriptions, the six case studies are synthesized according to their defining operational characteristics and performance outcomes:

Afghanistan (2001–2014) represents a benchmark for high-intensity combat MEDEVAC, characterized by structured ROL 1–4 medical architecture and consistent compliance with the "Golden Hour," yet constrained by limited multinational interoperability and personnel burnout [8,9,10,11].

Nigeria – SCOAN Building Collapse (2014) exemplifies systemic failure in civilian MEDEVAC, where institutional opacity, regulatory deficiencies, and insufficient cooperation resulted in critical delays and avoidable losses [12].

Turkey Earthquake (2023) highlights the vulnerability of civilian medical systems to large-scale disasters, emphasizing international aeromedical evacuation, civil–military cooperation, and rapid coordination mechanisms [13].

Crans-Montana Fire, Switzerland (2025–2026) demonstrates the effectiveness of European interoperability and dual-use platforms through rapid activation of EU civil protection mechanisms [14].

Bosnia and Herzegovina (1992–1996) reflects reactive MEDEVAC operations in a conflict environment, marked by improvised evacuations, fragmented coordination, and reliance on political negotiation [15].

Kosovo (since 1999) illustrates the transition from reactive to routinized MEDEVAC within NATO peacekeeping structures, supported by procedural standardization and bilateral cooperation [16].

4.3 Analysis across Mission Types

Comparative analysis is structured around a common set of operational and managerial indicators summarized in **Table 2**, ensuring methodological consistency across heterogeneous contexts. The indicators capture both **structural dimensions** (mission type, MEDEVAC architecture, medical infrastructure) and **functional dimensions** (coordination and command, response time, operational challenges, and outcomes). The analysis reveals that response time and compliance with the "Golden Hour" are primarily influenced by institutional maturity, governance mechanisms, and interoperability, rather than by platform capability alone. Major challenges recurrently relate to infrastructure limitations, fragmented command-and-control, governance constraints, and human resource sustainability. Lessons learned from each case directly inform the design of adaptive active resource management models.

The synthesized values presented in Table 2 are derived directly from qualitative and quantitative evidence reported in each case and do not constitute speculative generalizations. This approach supports the validity of conclusions regarding the role of interoperability and active management in MEDEVAC effectiveness. The comparative results of this analysis are synthesized in Table 2.

Table 2

Comparative Table – MEDEVAC Systems across Different Operational Contexts

Criterion	Afghanistan (combat)	Bosnia (peace keeping)	Kosovo (peace keeping)	Nigeria (civil)	Turkey (civil)	Switzerland (civil)
Mission type	NATO combat operations (ISAF/OEF), high-intensity asymmetric conflict	Active conflict – humanitarian and military (post-conflict transition)	NATO post-conflict mission (KFOR)	Civil diplomatic crisis	Natural disaster	Civil disaster (fire)
MEDEVAC assets used	Air MEDEVAC (Black Hawk, CH-47, Pave Hawk), MERT teams, fully developed ROL 1–4 structure	High-risk air evacuation, limited local support	Externally organized – NATO air MEDEVAC + bilateral ground transport	Military airlift (RSA C-130)	International air MEDEVAC (C-130, helicopters)	EU air MEDEVAC (C-27J Spartan, medical LAR)
Coordination	Regional PECC + ISAF HQ; fragmented coordination among nations and partially integrated digital platforms	UN coordination + individual nations, no common protocol	NATO HQ + bilateral agreements	Exclusively RSA government; lack of Nigerian institutional support	AFAD (Turkey) + WHO + EU mechanisms	ERCC (EU) + national authorities (Romania–Switzerland)
Response time *(differences driven primarily by institutional and logistical factors)*	< 60 min (Golden Hour achieved in 88–92% of cases); average < 1 h	Variable, frequently delayed	Efficient routine operations, limited synergy	Delayed: >10 h flight, 48–72 h until extraction	Delayed in remote areas; 1–3 days	Rapid: < 24 h from EU mechanism activation
Medical infrastructure	Complete ROL 1–4 structure: NATO hospitals, mobile surgical teams, international strategic evacuation	Destroyed or improvised	KFOR medical facilities + regional hospitals	No local infrastructure; evacuation to South Africa	Local hospitals damaged; lack of centralized triage	Regional hospitals overstretched but functional
Main challenges	Limited STANAG interoperability, national caveats, fragmented C2 coordination, medical staff burnout	Lack of common protocols, slow political decision-making	Minor fragmentation, outdated procedures	Lack of transparency, absence of a civilian MEDEVAC network	Limited road access, restricted communications	Initial logistical overload, followed by effective response
Lessons for AMOS	Decision automation, digital triage, real-time visibility, NATO–national integration	Unified multinational platform	Standardized bilateral cooperation	Diplomatic MEDEVAC protocol + civilian interoperability	Logistics connectivity, data sharing, rapid triage	Effective adaptation of military MEDEVAC for civilian use
Final outcome	Low mortality (<10%), high efficiency under significant personnel pressure	Successful evacuations, but slow and disorganized	Sustainable MEDEVAC, stable coordination	Delayed rescues, preventable fatalities	Major life-saving outcomes through exemplary international mobilization	

The originality of the case study selection lies in the integrated examination of MEDEVAC systems from operational, institutional, and managerial perspectives, by analyzing heterogeneous yet comparable contexts in terms of resource pressure and interinstitutional coordination requirements. This approach identifies distinct performance and vulnerability patterns correlated with mission type: combat, peacekeeping, and civilian.

I. Combat Missions – High Operational Performance, Systemic Vulnerabilities

In military theaters of operation, represented by the Afghanistan case, MEDEVAC systems achieve the highest operational performance levels. Aeromedical evacuation is structurally embedded in tactical planning, supported by NATO-standard medical infrastructure (ROL 1–4), dedicated air fleets, and advanced medical teams. Consistent application of the "Golden Hour" concept resulted in response times below 60 minutes and survival rates exceeding 90%, demonstrating the effectiveness of a pre-positioned and well-funded system.

However, the analysis identifies persistent structural deficiencies in multinational interoperability, digital coordination, and human resource sustainability, affected by burnout and rapid personnel rotations. For AMOS, the combat environment underscores the need for an audit system addressing tactical performance as well as joint C2–medical digital integration and human resource risk monitoring.

II. Peacekeeping Missions – Relative Stability, Uneven Efficiency

In peacekeeping missions, MEDEVAC performance depends largely on post-conflict stability and the existence of common operational protocols. The Bosnia case illustrates a reactive model marked by evacuations under hostile conditions, destroyed medical infrastructure, and fragmented coordination among international actors, where intervention success often relied on diplomatic and media pressure. By contrast, Kosovo represents a more mature model where MEDEVAC is routinized and integrated into NATO joint logistics, supported by bilateral agreements and predictable procedures. Even within this relatively stable context, the analysis identifies risks of procedural stagnation and the need for periodic protocol updates. For AMOS, peacekeeping missions emphasize an audit framework focused on standardization, regional interoperability, and procedural review.

III. Civilian Missions – Extreme Variability and Governance Dependency

Civilian case studies display the greatest variability in MEDEVAC performance. Nigeria illustrates systemic failure, where insufficient institutional cooperation, bureaucratic barriers, and the absence of local infrastructure resulted in critical delays and avoidable losses despite external intervention capabilities.

In Turkey, the natural disaster rapidly exceeded national capacities; however, integration of international teams and EMT networks enabled a partially effective response, though affected by logistical challenges and initial triage shortcomings. At the opposite end, Switzerland demonstrates the effectiveness of a coordinated European model, where civil–military interoperability and rapid activation of EU mechanisms ensured timely evacuations and reduced mortality. For AMOS, the civilian environment highlights the need for an audit system focused on governance, international cooperation, triage standardization, and rapid integration of external resources.

4.4 Recurrent Structural Deficiencies

The cross-cutting analysis reveals **recurrent deficiencies**: limited interoperability, fragmented command-and-control platforms, excessive dependence on aerial assets, the absence of standardized triage, and human resource vulnerability.

Table 3

Recurrent Structural Deficiencies Identified Across MEDEVAC Missions

Issue	Affected Theaters
Lack of interoperability	Afghanistan, Bosnia, Nigeria
Fragmented joint command-and-control (C2) coordination	Afghanistan, Turkey
Prolonged response times	Nigeria (48–72 h), Turkey (1–3 days)
Absence of standardized triage	Nigeria, Bosnia, Turkey
Excessive dependence on aerial assets	Afghanistan (95%), Nigeria, Turkey
Medical personnel burnout	Afghanistan, Turkey
Deficient or collapsed medical infrastructure	Nigeria, Bosnia, Turkey

Table 4

Correlation of case studies with AMOS functionalities

Case study	Key lesson	Relevant AMOS functionality
Afghanistan	Golden Hour compliance, burnout, lack of unified C2	Operational dashboard + AI-optimized personnel rotation
Bosnia	Chaos caused by the absence of common protocols	Interoperability gateway + digital triage
Kosovo	Efficient but outdated routinization	Automated protocol updates + bilateral integration
Nigeria	Absence of civil MEDEVAC, institutional opacity	Continuous operational audit + diplomatic MEDEVAC protocol
Turkey	Destroyed infrastructure, lack of triage	Resource geolocation, rapid triage, predictive analytics
Switzerland	Rapid EU intervention, excellent coordination	ERCC integration + military–civil dual-use modules

The differences in performance identified between combat, peacekeeping, and civilian missions demonstrate that the effectiveness of MEDEVAC systems is not determined exclusively by technological capability, but fundamentally by the quality of governance, interoperability, and decision-making processes. Within this framework, the implementation of an **Active Management Operations System (AMOS)** emerges as a systemic necessity, ensuring continuous audit, optimizing resource flows, and enabling the dynamic adaptation of MEDEVAC systems to the requirements of each mission type.

5. PROPOSED FRAMEWORK

The integrated MEDEVAC architecture is grounded in active resource management principles for aerospace systems operating in (VUCA) environments. Unlike functionally isolated approaches, it adopts a system-of-systems perspective where operational effectiveness results from coordinated interaction among management, digital communication, and maintenance subsystems. Evidence from recent MEDEVAC operations shows that performance is increasingly conditioned by the integration of real-time data flows across these subsystems. Case studies such as Operation Moshtarak in Afghanistan [17] and the mass-casualty MEDEVAC coordinated in Nigeria (2014) [13] illustrate that response time, situational awareness, and patient outcomes depend on digital interoperability and real-time operational insight rather than platform performance alone.

Romania's participation in multinational exercises at **Cincu Training Area** and the **71st Air Base**, together with the acquisition of **MEDEVAC-configured Piranha 5 platforms**, reflects tangible progress toward NATO interoperability [18].

This conclusion derives from recurrent deficiencies identified across the case studies, including fragmented command visibility, delayed logistical coordination, and the absence of standardized performance monitoring:

1. **Active Resource Management as a Joint Operational Coordinating Layer**
2. **Digital Communication and Predictive Maintenance as Strategic Enablers**
3. **Audit-Driven Integration and Feedback Loops**

5.1 Performance Indicators for Validation

Effectiveness validation requires a structured set of Key Performance Indicators (KPIs) (Table 5), addressing operational, clinical, and managerial dimensions and reflecting lessons from the analyzed case studies.

Table 5

Key Performance Indicators (KPIs) for AMOS

Case study	Key lesson identified	Relevant AMOS functionality
Afghanistan	Effective Golden Hour implementation, medical staff burnout, lack of unified C2	Operational dashboard + AI-optimized personnel rotation
Bosnia	Operational chaos due to absence of	Interoperability gateway +

	common protocols	digital triage
Kosovo	Efficient but outdated routinized procedures	Automated protocol updates + bilateral integration
Nigeria	Absence of civilian MEDEVAC, lack of transparency	Continuous operational audit + diplomatic MEDEVAC protocol
Turkey	Collapsed infrastructure, lack of standardized triage	Resource geolocation, rapid triage, predictive analytics
Switzerland	Rapid EU intervention, excellent coordination	ERCC integration + civil–military dual-use modules

5.2 Logic Model for Pilot Implementation

To test and validate AMOS under real conditions, an implementation logic model structures the relationship between inputs, outputs, and impact, enabling coherent evaluation across different operational contexts.

Table 6

Logic Model for AMOS Pilot Implementation

Component	Description
Inputs	MEDEVAC equipment, medical personnel, digital infrastructure, AI algorithms, NATO/EU support, historical data
Activities	Real-time data collection, digital triage, automated resource allocation, predictive maintenance, inter-agency coordination
Outputs	Reduced response time, enhanced logistical visibility, prevention of crew overload, automated operational audit
Immediate Outcomes	Faster evacuations, fewer triage errors, efficient resource utilization, clearer decision-making
Long-Term Impact	Reduced mortality, increased interoperability, transformation of MEDEVAC into a fully dual-use capability

The logic model illustrates the gradual implementation of AMOS and its audit function, reconceptualized as a continuous enabling capability rather than a post-event punitive control mechanism.

5.3 Civil–Military Impact Scenarios

Scenario 1: Urban terrorist incident with multiple casualties

In a dense urban terrorist attack involving approximately 30 casualties, AMOS enables rapid automated digital triage based on injury severity (e.g., traumatic brain injuries versus orthopedic trauma). The system supports automated allocation of available MEDEVAC resources and, for critically injured patients, direct extraction decisions toward ROL 4 facilities according to clinical and logistical criteria.

Scenario 2: Regional-impact major disaster

In a major earthquake affecting the Vrancea region, characterized by damaged medical infrastructure and limited access, AMOS enables automatic victim geolocation, prioritizes MEDEVAC crew allocation and rotation, and supports redistribution of mobile medical resources (e.g., ROL 2 units) from other regions.

5.4 AMOS Implementation Barriers

Implementation is subject to legal, technical, and organizational constraints requiring integrated mitigation. Legal fragmentation and data sovereignty considerations require data collection and exchange mechanisms compliant with NATO standards (NTR, JTTR), as well as GDPR and NIS2. Disparities in IT maturity across states and agencies are addressed through a modular architecture that enables selective deployment of AMOS functionalities aligned with local capabilities.

At the organizational level, resistance to audit practices and procedural change is mitigated through a non-punitive, improvement-oriented audit framework supported by rapid operational feedback.

5.5 Expected Impact and Advantages

Compared with traditional MEDEVAC registries and systems, AMOS offers advantages in automated data collection, multi-level interoperability, and real-time operational visibility. Continuous audit mechanisms enable early dysfunction identification and dynamic

procedural adaptation. Its dual-use nature facilitates civil–military integration and supports efficient resource utilization across diverse crisis environments [13], [15].

6. FUTURE RESEARCH DIRECTIONS

Although the analysis provides a solid foundation for the AMOS architecture, several limitations must be acknowledged. The case studies rely primarily on secondary data and publicly available operational reports, limiting the granularity of quantitative indicators. The framework is validated at a conceptual level and through illustrative scenarios, without full-scale operational deployment. Future research directions include empirical testing of AMOS through pilot programs in multinational exercises or coordinated civil emergency interventions; refinement and calibration of KPIs according to regional specificities and mission types; integration of advanced artificial intelligence modules for system load prediction and operational risk assessment; and extension of the AMOS architecture toward interoperable NATO–EU trauma registries while ensuring cybersecurity and data protection compliance. These directions support the transformation of AMOS into an operational tool with direct impact on MEDEVAC efficiency and resilience.

7. CONCLUSIONS

The paper presents a comparative analysis of six MEDEVAC case studies, highlighting significant performance disparities and recurrent structural deficiencies largely independent of operational context. The findings demonstrate that MEDEVAC effectiveness is determined by the quality of interoperability, digital coordination, and decision-making processes rather than exclusively by technological sophistication or the availability of air assets.

The primary contribution of this paper is the proposal and conceptual substantiation of the **Active Management Operations System (AMOS)** as an integrated audit and active resource management framework for MEDEVAC operations, derived from cross-case lessons. AMOS provides a structured management layer that enhances the planning and conduct of MEDEVAC missions at tactical and joint operational levels within **NATO–EU multinational command structures**. By integrating interoperability and real-time decision support, the framework strengthens operational coherence, civil–military synchronization, and resilience in high-pressure crisis environments.

8.ACKNOWLEDGEMENT

This research was supported by the project New Frontiers in Adaptive Modular Robotics for Patient-centered Medical Rehabilitation—ASKLEPIOS and was funded by the European Union—NextGenerationEU and Romanian Government under the National Recovery and Resilience Plan for Romania, contract no. 760071/23.05.2023 and code CF 121/15.11.2022, with the Romanian Ministry of Research, Innovation, and Digitalization within Component 9, Investment I8.

9. REFERENCES

[1] Selcuk, S., *Predictive maintenance, its implementation and latest trends*, Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture, vol. 231, no. 9, pp. 1670–1679, 2017.

[2] Caricato, A., Ficarella, A., Spada Chiodo, L., *Prognostic techniques for aeroengine health assessment and remaining useful life estimation*, E3S Web of Conferences, vol. 312, 11017, pp. 1–8, 2021.

[3] Pundir, P., Maheshwari, P., Prajapati, P., *Machine learning based predictive maintenance model*, Proceedings of the IEOM Conference, pp. 428–435, 2022.

[4] Romanian Air Force, *Logistica de aviație, între strategie, precizie și responsabilitate națională*, Cer Senin, pp. 1–5, 2023.

[5] Kabashkin, I., Perekrestov, V., *Ecosystem of aviation maintenance*, Applied Sciences, vol. 14, no. 11, art. 4394, pp. 1–19, 2024.

[6] Hasib, A.A., et al., *Systematic review of machine learning models for predictive maintenance of*

aircraft engines, arXiv preprint arXiv:2309.13310, pp. 1–18, 2023.
[7] Chaudhary, A., et al., *Cloud based predictive maintenance technique for aviation system*, IEEE ICACCS, pp. 1–6, 2024.
[8] Eastridge, B.J., et al., *Death on the battlefield (2001–2011): Implications for the future of combat casualty care*, Journal of Trauma and Acute Care Surgery, vol. 73, no. 6, Suppl. 5, pp. S431–S437, 2012.
[9] Shen-Gunther, C., Ellison, R., Kuhens, C., Roach, C.J., Jarrard, S., *Operation Enduring Freedom: Trends in Combat Casualty Care by Forward Surgical Teams Deployed to Afghanistan*, Military Medicine, vol. 176, no. 1, pp. 67–75, 2011.
[10] Clarke, J.E., Davis, P.R., *Medical evacuation and triage of combat casualties in Helmand Province, Afghanistan: October 2010–April 2011*, Military Medicine, vol. 177, no. 11, pp. 1261–1266, 2012.
[11] Munayco Sánchez, A.J., Navarro Suay, R., de Nicolás Álvarez, M.A., *Modelo español de MEDEVAC. Experiencia en Afganistán*, Sanidad Militar, vol. 68, no. 3, pp. 182–184, 2012.
[12] NATO Allied Joint Force Command Naples, *US aviation soldiers and EULEX train on medical evacuation procedures*, KFOR Media Center, 2026.
[13] African Leadership Security Group, *Mass casualty aeromedical evacuation – Nigeria 2014* (MCIF), pp. 1–15, 2014.
[14] World Health Organization, *Emergency Medical Teams and aeromedical evacuation during the Türkiye earthquakes*, Situation Report, pp. 1–10, 2023.
[15] European Commission – Directorate-General for European Civil Protection and Humanitarian Aid Operations, *EU Civil Protection Mechanism*, 2023.
[16] Weekers, J., *Medical evacuations from the region of former Yugoslavia*, European Journal of Public Health, vol. 6, no. 4, pp. 257–262, 1996.
[17] Dressler, J., Operation Moshtarak: *Lessons Learned from Helmand Province*, Institute for the Study of War, Washington, DC, pp. 1–28, 2010
[18] Ministry of National Defence of Romania, Locații de desfășurare și participanți, 2023.

AMOS – Sistem de management activ al operațiunilor

Rezumat: Crizele globale actuale generează un nivel ridicat de incertitudine, presiune operațională și volatilitate a resurselor, afectând sistemele de evacuare medicală (MEDEVAC) atât în misiuni militare, cât și în intervențiile civile de urgență. Acest studiu aplică o metodologie analitică comparativă bazată pe studii de caz, analizând misiuni de luptă, menținere a păcii și intervenție civilă în Afganistan, Bosnia, Kosovo, Nigeria, Turcia și Elveția, pentru a identifica lacune de performanță în guvernanța, interoperabilitatea și procesele decizionale ale sistemelor MEDEVAC. Pe baza acestei analize, lucrarea propune **AMOS – Active Management Operations System**, o arhitectură de management de tip *system-of-systems*, care integrează alocarea dinamică a resurselor, comunicații digitale securizate, mentenanță predictivă și bucle de feedback bazate pe audit. Rezultatele arată că eficiența MEDEVAC în operațiuni multinaționale tactice și întrunite, desfășurate în cadrul NATO, depinde nu doar de capabilitatea platformelor, ci și de interoperabilitate, maturitatea guvernanței și integrarea decizională, precum și de interoperabilitatea civil–militară și reziliența operațională NATO/UE în medii VUCA.

Silvia Daniela POHRIB, Phd. Student, Technical University of Cluj-Napoca, Department of Design Engineering and Robotics , learn.learnex@gmail.com, +40 722 250 904, 28 Memorandului Street, Cluj-Napoca, Romania.
Nicolae-Bogdan ZVONARU, Phd. Student, Technical University of Cluj-Napoca, Department of Design Engineering and Robotics, zvonarubogdan@hotmail.com, +40 722 462 125, 28 Memorandului Street, Cluj-Napoca, Romania.
Vlad-Sebastian ANGHELUȚĂ, Phd. Student, Technical University of Cluj-Napoca, Department of Design Engineering and Robotics, vlad_vlad9999@yahoo.com, 28 Memorandului Street, Cluj-Napoca, Romania.
Adrian PÎSLĂ, Prof.Eng. PhD, Technical University in Cluj-Napoca, Department of Design Engineering and Robotics, Adrian.Pisla@muri.utcluj.ro, 28 Memorandului Street, Cluj-Napoca, Romania.