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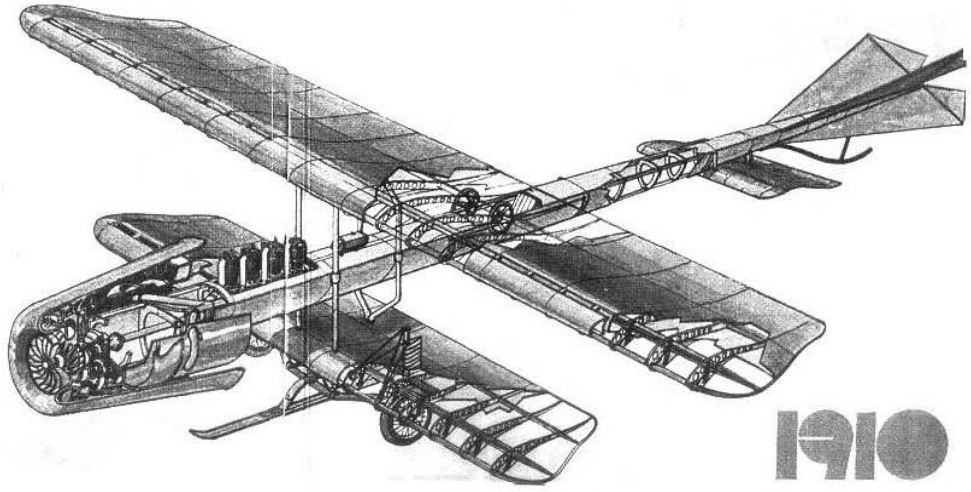

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C O N T E N T S

INTEGRATING LEADERSHIP AND INFORMATION DISSEMINATION - A PROACTIVE FRAMEWORK FOR AVIATION SAFETY CULTURE

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Abstract: *Safety culture is a fundamental aspect of aviation operations, promoting the risk reduction and accidents prevention through proactive measures and open communication. Each individual that takes part to the aviation process has the responsibility to understand it and make the best decisions for the smooth running of things. This article explores the multidimensional nature of safety culture in aviation by focusing on the role of effective information dissemination, but also the critical influence of leadership in shaping and reinforcing these practices. We examine various methods of promoting aeronautical safety, identifying the critical components that contribute to it, and analyze how leaders at every level create an environment where safety information is proactively shared and acted upon. In order to demonstrate the importance of proactive measures and safety information in preventing catastrophic situations, we analyze the Southwest Airlines Flight 1380 as a case study. We show that active leadership, when combined with transparent communication, is essential for preventing catastrophic situations. The lessons learned from this event highlight the necessity of more strict maintenance regulations, updating training protocols, and improving reporting systems. The study concludes with recommendations for fostering a proactive safety culture and optimizing information flow in aviation organizations through the lens of leadership.*

Keywords: *safety, aviation, information dissemination, leadership*

1. INTRODUCTION

The promotion of an aeronautical safety culture represents a mechanism though which lessons learned from the implementation of specific aeronautical safety activities are made available to all personnel involved in aeronautical operations. At the same time, this process helps in developing a positive aeronautical safety culture, which, once established, if followed, can be sustained.

Aviation is often considered as one of the safest industries in the world, due to the constant advancements of cutting-edge safety measures, rigorous training, and strict regulatory oversight. However, the maintenance and improvement of safety remain a challenge in the face of new technological advancements, complex processes, and evolving threat. Also, effective leadership and continuous education sustain and advance this safety culture. The idea of aviation safety culture, which emphasizes a proactive and positive approach to safety at all organizational levels going beyond simple regulatory compliance, is essential in tackling these issues.

According to the International Civil Aviation Organization (ICAO), safety culture is described as more than the sum of its parts.

It refers to "the commitment placed on safety by every individual and every group at every level of the organization", which highlights the need of unified approach, where safety becomes a fundamental organization value, and not just a simple operational requirement [1]. As a general rule, the safety culture refers to how an organization manages and values the safety mentality and procedures.

The study of safety culture has known a great progress from a simple analysis of technological and human errors to an interdisciplinary and systemic approach incorporating organizational, technological and psychological perspectives. Today, safety culture is viewed as a central element of global aviation safety, being a continuous process of identifying and implementing best practices to reduce risks and promote sustainable safety in the industry.

In the issue of professional development and continuous learning, there must also be a side related to monitoring progress, and in the context of this article this can be extrapolated into reference levels. In other words, the level of competence achieved by a given individual in carrying out a specific task will be reflected in the manner of execution approached in fulfilling that task and in the efficiency of achieving the expected results [2].

An organization that successfully implements a positive safety culture, is capable of attaining the goal of maximum attainable operational safety. In this regard, an organization has to focus on the five pillars that together define the safety culture according to Adjekum [3]:

-Informed culture – being aware of the current state of people, technology and relations between them for a good performance overall;

-Reporting culture – the ability to recognize and report errors and shortcomings;

-Just culture – reasoning of what is acceptable and unacceptable behavior regarding safety;

-Flexible culture – the organization needs to adapt continuously based on the evolution of technology or new requirements in the domain;

-Learning culture – the organization needs to rely on lessons learned system.

FIG. 1 Pillars of safety culture according to Adjekum

A safety culture ensures that all stakeholders, from pilots and air traffic controllers to ground crews, prioritize risk management and accident prevention. The five pillars mentioned above are dependent on the way organizations' directorate manages each aspect of its wellbeing. In this regard, leadership is fundamental whether this culture can thrive. Continuous education and progressive leadership competencies play a fundamental role in building organizations that learn from incidents, encourage open disclosure, and adapt in real time to emerging threats. In the same time, as a complementary aspect of air forces development, the continuous learning concept is turning itself into an important factor of one's leader development adaptation[4].In the general aviation context, we can apply the same principle, that well-prepared leaders across the hierarchy of each organization, either civilian or military, enable and sustain robust safety culture.

Aviation organizations with a strong safety culture report fewer incident, develop better teamwork and promote a higher level of trust. Leadership – the way managers, supervisors and officers guide, influence and inspire their crews, significantly shapes whether safety systems are effective and up-to-date.These things can only be achieved if the higher level of aviation organizations leadership has a basic understanding of what constitutes constructive dynamics, team dynamics, and much more that comes from the special quality called professionalism [5].

2. THE IMPORTANCE OF SAFETY CULTURE IN AVIATION

In aviation industry, safety culture went through a complex process, influenced by the technological progress, lessons learned from major accidents, constant changed in regulations and interdisciplinary research on human factors and organizational management. This evolution can be understood through multiple chronological phases, each of them bringing significant contributions to the safety consolidation in aviation.

Initially, aviation safety efforts focused on the development of aircraft and infrastructure in order to guarantee safe flights at all stages, from takeoff to landing. Improvements in hydraulics, avionics, materials, and system integration were all part of these endeavors. By the end of 1960s accidents had drastically decreased due to technological advancements. However, organizational and human factors, officially recognized by ICAO in 1970 and 1990 respectively, have emerged as crucial elements in comprehending and reducing failures [1].

Until the 1970s, aviation accidents were mainly attributed to technical failures, but major incidents, such as the Tenerife runway collision in 1977, radically changed this perspective[6]. This accident, one of the worst in aviation history, involved two Boeing 747 aircraft colliding on the runway, resulting in the loss of 583 lives. One of the main causes, based on the final report after the investigation was human error combined with poor communication between the crew and air traffic controllers.

The fundamentals of safety cultures were not defined very well at this point. The introduction Crew Resources Management (CRM) concept, which is used in every process of organization nowadays, following the analysis of the Tenerife accident, is a training program focused on improving communication, collaboration and decision-making processes in flight crews. This program has become a standard in flight training, being part of the safety culture currently [7]. Also, there was great attention on the awareness of operational pressures and the role of management in aviation processes. Analyses from this period have begun to explore how economic or operational pressures affect safety.Such hasty decisions and strict deadlines without considering operational risks, significantly contributed to incidents [8].

Aviation safety has increased over time as a result of ongoing analysis and integration of these factors, driving to a stronger safety culture and more flights with fewer fatal and non-fatal incidents. Human factors now account for about 80% of the primary causes of aviation accidents, whereas technical factors play a smaller role due to the technological advancements[9]. In order to improve future safety and contribute to a more developed safety culture, this high percentage underscores the necessity of a deeper understanding of the decisions and elements involved in previous accidents to improve future safety.

The 1990s' marked an important transition towards the formalization of safety culture, through the introduction of regulatory standards and structured safety management systems. The adoption of Safety Management Systems (SMS) by ICAO, came with a systematic and proactive approach to identifying and managing risks, which has become mandatory for aviation and its organizations[10]. One of the main concepts that had the attention of aviation organizations was the Just Culture, which promoted the reporting of incidents and errors without the fear of sanctions, aimingto collect and analyze necessary data to prevent future accidents [11].

The latest milestone was the integration of technology which has played a crucial role in improving safety culture, allowing for more precise monitoring of operations and data collection for risk analysis. In this regard, Flight Data Monitoring (FDM) has allowed organizations to proactively identify and prevent risks[12], through detection of deviations from operational standards and implementation of corrective measures.

Depending on the field, organization or operational context, safety culture can be defined and understood from multiple perspectives. In aviation, this concept reflects a collective effort for safety, based on standardized values, behaviors and attitudes that support accident prevention and promote a secured operational environment.

- Organizational perspective – organizations focus on processes that encourage hazard reporting and adapting to emerging risks;
- Individual perspective – each individual, as part of an organization has a commitment to responsible behaviors that support safety;
- Psychological perspective – this culture is shaped by individually of group perceptions, and attitudes that affect the way risks are managed;
- Managerial perspective – safety culture can be treated as a strategic tool in prioritizing safety in decision-making processes;
- Regulatory perspective – ICAO, FAA or EASA are responsible into defining and standardizing safety as a part of aviation, which later must be monitored and enforced;
- Technological perspective – safety is dependent of modern technology to enhance operational safety and communication of critical information.

3. DISSEMINATION OF INFORMATION IN AERONAUTICAL SAFETY CULTURE

The dissemination of information is an essential process in promoting and strengthening the safety culture in aviation. Its role is to ensure that critical information is communicated efficiently and in a timely manner, so that all parties involved can make informed decisions, avoid risks, and contribute to incident prevention. In a complex field such as aviation, where operational conditions can change rapidly, the efficiency of the dissemination process directly influences operational safety.

According to ICAO [1], the efficiency of dissemination depends on 5 main pillars:

- Relevance of the information – messages must be tailored to the target audience and reflect the specifics of their operations. In an environment where the personnel are often overwhelmed, processing a large volume of irrelevant information can lead to the ignoring or misinterpretation of important messages – for example a briefing of alternative routes in case of bad weather becomes essential if it is delivered before the flight, otherwise it might lose its utility;
- Clarity is another essential component of information dissemination. A message that is complex or ambiguous risks being misinterpreted or ignored, which can influence the operational risks. Reason[13] emphasizes that complex information must be simplified to be accessible to all levels of staff, regardless of their training or experience;
- Moment of communication – the time frame to transmit significant information influences the efficiency of dissemination. Information delivered too early can be forgotten or considered irrelevant, while information delivered too late can become useless, especially in critical situations. ICAO emphasizes that timing is crucial for maximizing the impact of the message;
- Means of communication – choosing the right channel to disseminate is essential. Documents can be considered a great method to spread information, whilst online platforms give the opportunity to access information rapidly. In case of urgent and confidential information, briefing is the most suitable way of doing it.
- Feedback – an efficient dissemination process includes mechanisms through which staff can provide feedback on the clarity and usefulness of the information received. This helps organizations improve the process.

These five pillars represent the foundation of effective information flow, but they do not operate in isolation. To apply them, there is a need of capable individuals and an aligned organizational structure. Good leadership is the guiding power that orchestrates how these five elements function effectively in day-to-day settings, ensuring that each step, from choosing the right channel to timing the message release, is executed without flaws. Different processes require different levels of expertise of the same competency to achieve performance, just as not all processes require a maximum level of manifestation of a competency.

In this context, Jim Collins, framework from his book "*Good to Great*," offers valuable insight of how leadership development process is essential for efficient information dissemination. Collins argues that leaders in most large organizations exert influence across five tiers of personal development:[14]

- Level 1 – Highly Capable Individual: Makes productive contributions through talent, knowledge, skills, and good work habits;
- Level 2 – Contributing Team Member: People who support group goals and collaborate effectively;
- Level 3 – Competent Manager: Organizes people and resources toward the effective and efficient pursuit of desired results;
- Level 4 – Effective Leader: Catalyst for a strong vision and drives higher standards of performance;
- Level 5 – Executive: This is the highest level of management in an organization, building sustainable greatness through an unusual blend of personal humility and professional will. Their determination is to do whatever it takes to make the organization "great."

Levels 1 through 4 of Jim Collins' hierarchy can be found in every organization that is made up of more than one person, including airlines, air traffic control units, and maintenance facilities. When new leaders develop in an organization, they tend to become better at what they do. They also help everyone who works with them do the same.

This continuous expansion in leadership capacity equips them to tackle increasing responsibilities, create initiatives, and guide the way information is shared [15].

Achieving a seamless correlation between who is sharing information, when and how they deliver it, requires a high level of leadership insight and precision. Related to the last level of Collins' hierarchy, the personnel at the top of aviation organizations must demonstrate the ability to drive safety measures rigorously. In practical terms, this refers to choosing the right competencies needed for each stage of an operational process, either flight planning, weather briefings, maintenance checks or after mission reports, and matching to the exact level of leadership behavior:

- Clarity and adaptability – Level 2 and 3 leaders, might be in charge of ensuring that all personnel (flight, ground crews) receive relevant updates that can be adapted to local context (ground crew supervisor tailoring maintenance or safety bulletins to a specific aircraft type);
- Strategic oversight – Levels 4 and 5 leaders have the executive authority to change the communication strategy partially or totally, by selecting platforms, allocating resources for staff training or manipulating large-scale feedback loops.

Efficient dissemination of information in a high-stakes environment such as aviation rely on the capacity of an organization to combine the five pillars mentioned by ICAO (relevance, clarity, timing, channel, and feedback) with leaders who can control them. To create this dynamic synergy, where leaders can foster a culture of clear, relevant and on time communication, aviation organizations can integrate leadership training into their safety curriculum, incorporate mentorship and continuous training, assign responsibility accordingly and apply the principles of recognizing and rewarding effective communicators. This way consists of a strong method to achieve a safety culture adapted to modern times.

Even though the dissemination of information has a crucial role in aviation safety culture, this process does not lack challenges. In this dynamic environment there are a few barriers that can affect the clarity, accessibility or applicability of messages to their full meaning. These factors that need to be managed to create a safe medium are:

- Language barrier and cultural differences -Aviation is a global industry where pilots, air traffic controllers, technicians and other professionals from different countries must communicate effectively to maintain operational safety. Differences in language and culture may lead to misinterpretations of critical messages affecting decision-making process and lastly jeopardizing flight safety. That is the reason the standard phraseology was implemented with the help of intensive linguistic courses;
- Cognitive overwhelming - Being a complex work environment, aeronautical personnel is daily exposed to a great amount of information. Depending on other factors, such as fatigue, personal problems, complexity of the mission or experience, this exposure might lead to cognitive overwhelming and ignoring of essential messages.
- Resistance to change -Another obstacle in the dissemination of information is resistance to change, especially when new procedures or technologies impose changes in the daily routine of aviation personnel. Fear of the unknown, lack of trust in the new rules, or the subjective perception that some changes are not necessary, can cause this resistance. In order to combat this, organizations have to involve the personnel in understanding the reasoning behind the changes and receive real feedback from individuals.
- Misinterpretation - A message can be misunderstood depending on the experience, preparation and context of the recipient. Ambiguity in the formulation of instructions can lead to confusion and the incorrect application of safety measures.

- Rhythm of technological and operational changes- Aviation industry knows a continuous evolution in many aspects, where the personnel must adapt to new technologies and regulations. Sometimes, some information is disseminated too quickly, not providing a sufficient foster period. This can be the case of new navigation software, or different new regulations for each airport or aircraft.

- Confidentiality - Information confidentiality and security can be a great barrier, because some safety information contains sensitive details that cannot be divulged. The management of this information must respect a balance between transparency and data protection.

The management of challenges that information dissemination presents is essential to maintain aviation safety. Through the improvement of messages clarity, implementation of new standardized processes, organizations can assure an efficient communication and a safe operational environment.

4. SOUTHWEST AIRLINES FLIGHT 1380 – INFORMATION DISSEMINATION PERSPECTIVE

On April 17 2018, Southwest Airlines Flight 1380, a Boeing 737-7H4, experienced a left engine failure, while climbing to the cruising altitude, 30 minutes after takeoff from LaGuardia airport in New York with Dallas Love Field as the destination airport. The debris from the engine caused significant damage to the aircraft, including fragments that hit the left wing, fuselage and stabilizer. One of the fragments hit the fuselage near a window, which led to an explosive depressurization. The flight crew managed to descend and land safely 17 minutes after the incident on Philadelphia International airport. Out of the 149 souls on board, 1 passenger who sat next to the window, suffered fatal injuries, whilst 8 others were injured. The flight was a regularly scheduled domestic service under Federal Aviation Regulations. The investigation of the case provided valuable lessons on incident management, the impact of effective communication, and the need for proper dissemination of safety information to prevent such events[16].

The role of information dissemination before the incident. Following further investigations, it was discovered that the incident was not an isolated event. The CFM56-7B engine used by the involved aircraft had already experienced similar issues 20 months before the event. In 2016, another Southwest aircraft (Flight 3472), as mentioned in safety data sheets, had a similar incident where a fan blade detached and caused severe damage. As a consequence, the National Transportation Safety Board (NTSB) and the Federal Aviation Administration (FAA) issued recommendations for more rigorous inspections. However, just the recommendations were not sufficiently efficient. If the information from the previous accident was enforced more through safety bulletins and regulations, maybe the Flight 1380 incident could have been avoided. This aspect emphasizes the importance of a proactive information use in the safety culture.

Regarding the relevance of information, operators knew about the engine malfunctions, but the communication of how urgent and critical those risks were remained unclear. Also, FAA made the inspections mandatory only after the second incident (Flight 1380), proving that the necessary dissemination of information after the first one was ineffective. Also, high-level organizational leaders bear the responsibility to interpret and act on hazard reports. And this incident is no exception. Failure to emphasize proactive risk management and to foster a Just culture, not only undermines information dissemination, but also directly affects the readiness to address known technical vulnerabilities.

The role of information dissemination during the incident. A positive aspect of the Flight 1380 incident is represented by the pilots' professionalism, especially the captain Tammie Jo Shults, a former fighter pilot, with great experience in aviation. The way the crew managed the situation demonstrated the efficiency of the training in application of the emergency procedures. The pilots followed the established protocol, by making an emergency descent to bring the cabin back to safe breathing altitude, maintaining clear and efficient communication with air traffic controllers. This demonstrates that efficient information dissemination during training and the use of simulators in emergency scenarios can help drastically any critical situation.

By following protocols and communicating effectively, the crew demonstrated they were involved actively in the safety culture, being flexible, based on the new circumstances. However, the aviation industry as a whole failed to learn from the past experience fast enough. Following the 2016 incident (Flight 3472), which calls into question the effectiveness of the feedback process and organizational learning in the safety culture, the FAA and airlines should have taken more concrete actions more quickly.

The role of information dissemination after the incident. This incident has become a part of safety culture in understanding the process of disseminating information, which improved, prompting the FAA and other regulatory agencies to take measures to prevent similar situations. An important initiative in this matter was the Airworthiness Directive AD 2018.09.10, which mandated frequent inspections of the fan blades of the engines that causes the two incidents. This reactive measure demonstrated the importance of fast and mandatory dissemination of safety information, assuring that the personnel involved in the industry apply stricter inspections to detect critical defects before they can become dangerous for flying.

At the same time, the NTSB published a detailed report on the causes of the incident, creating the opportunity for the aviation industry to become more transparent. As a result, Southwest Airlines and other companies implemented more frequent inspections, disseminate lessons learned, and used safety bulletins, training and simulators to improve responses to similar future situations. While these measures exemplify post-incident learning, it also highlights a missed opportunity for more proactive leadership. As Collins describes, a level 5 executive mindset would have enforced immediate changes following the first incident (Flight 3472) rather than wait for another incident.

The implementation of more stringent inspections programs enhanced the safety culture in aviation industry, encouraging a more proactive dissemination of safety related data across all operators.

Lessons learned. The Flight 1380 incident, demonstrates that information dissemination is important at all stages. All the training required before the flight, the relations between pilots, crew and ground operators, and the technical aspects are necessary for a good flying activity. What makes the difference, though, is the communication and how information gets between them. As long as there are any flaws or misunderstandings, there might be something that can jeopardize the entire activity. The Flight 1380 confirmed that someone along the communication chain has not done their job as they were instructed to. What can be learned from this incident in order to improve aviation safety culture include:

- Future dissemination of critical safety information needs to be more **proactive** and less reactive, where lessons from each incident are disseminated immediately. Rather than waiting for another incident to validate the risk, which could be more devastating, potential hazards should be taken into account and trigger immediate regulatory enforcement.

Each incident or situation should be treated as serious as possible, and all the regulations coming from aviation agencies must be enforced rather than treated as optional recommendations;

- Organizations need to treat all safety warnings with high priority and act on them accordingly. It does not matter the gravity or dimension of a flaw in the system, it might create a domino, increasing catastrophically. This requires **transparent mechanisms of sharing data** at all levels, between regulatory agencies, airline operators and manufacturers, ensuring there are no gaps in this chain of information. Real-time data analytics, continuous monitoring or predictive maintenance technologies allow aviation stakeholders to detect and address actively risks before they escalate into full-scale incidents;

- Improving **Crew Resource Management (CRM) training** is another lesson learned. Although CRM was a strong aspect of the Flight 1380 incident, it needs to be continuously expanded by including more scenario-based simulations, ensuring that crew and other ground personnel can handle any situation, regarding its complexity. By ensuring that communication during emergencies is precise and on subject, airlines can mitigate errors induced by high intensity environments and increase the safety overall;

- Aviation safety culture depends on the **ability to learn from past incidents** and implement lasting changes. To improve just culture and reporting mechanisms, aviation industry must encourage open incident reporting without fear of punitive actions. Pilots, maintenance crew or airline staff should feel comfortable to report safety concerns, such as errors or damages, knowing that their report will lead to proactive measures. Also, the transparency should not stop there, but safety reports and findings should be shared across the industry, in order for other operators to benefit.

5. CONCLUSIONS

The importance of a robust safety culture and an efficient information dissemination in aviation cannot be overstated. The Southwest Flight 1380 shows the important role that proactive communication, regulations and safety practices plays in accident prevention and improvement of operational safety. Safety culture is not a static concept, but a dynamic one where it needs to adapt to knew technologies, operational risks and human factors.

The five pillars of information dissemination (relevance, clarity, timing, appropriate channels and feedback) represent the fundamentals of how safety-related messages reach every individual or group. However, these pillars can be enforced to reach their full potential when guided by leaders who are committed to expand a Just culture and continuously adapt it to new requirements. Drawing on models, such as Jim Collins' framework, it shows clearly the role leaders from Highly Capable Individual to Executive levels contribute harmoniously to building an environment where safety is dominant.In addition to upholding procedural and technical norms, proactive leadership fosters an environment of openness, responsibility and continuous learning. When leaders at each level ensures that safety primates and lessons learned are taken into account as starting points for new changes, organizations are better equipped to diminish risks and adjust to evolving operational challenges.

Ultimately, by combining leadership skills with the core aviation safety initiatives, as improving the dissemination of information systems, organizations can develop resilient systems that prevent incidents, protect lives, support operational efficiency, and drive sustainable safety improvements.

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DESIGN AND EXPERIMENTAL EVALUATION OF AN ION ENGINE PROTOTYPE

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Abstract: *Ion propulsion, traditionally utilized to adjust satellite and space station trajectories, also demonstrates significant potential for aeronautical applications. This paper investigates the feasibility of an ionic motor designed to ionize ambient atmospheric air, eliminating the need for gases such as xenon or argon. The motor features a triangular geometry manufactured using 3D printing technology. Preliminary propulsion calculations are provided, focusing on determining the required voltage to achieve target airspeeds that yield sufficient thrust.*

These studies help to assemble a model that can propel its weight without using fossil fuel, opening up the possibility of giving up kerosene in the future by bringing new forms of propulsion structures simpler and more economical, introducing new possibilities!

Keywords: *Aerospace, Ionic engine, Generative Design, Additive Manufacturing*

1. INTRODUCTION

Ion propulsion, also referred to as electric propulsion, is a system in which electric current is used to ionize a propellant in order to generate thrust through high-velocity exhaust. This process significantly reduces the amount of propellant required compared to conventional chemical propulsion systems that rely on fossil fuels. By minimizing fuel consumption, the total mass of a spacecraft or launch vehicle can be substantially decreased, leading to lower launch costs and improved mission efficiency. [1]

Ion propulsion has been employed in space exploration since the 1960s and is increasingly being adopted for satellite systems and deep-space exploration missions, replacing traditional chemical thrusters in many applications. Among electric propulsion technologies, ion engines are considered top-tier in terms of performance indicators such as thrust efficiency, specific impulse, and operational longevity. These systems typically operate at voltages ranging from hundreds to thousands of volts, achieving specific impulses in the range of several thousand seconds while delivering low thrust. [1]

Common propellants for ion thrusters include inert gases such as xenon or argon. Xenon, in particular, is the preferred choice due to its ease of ionization, chemical inertness, and the practicality of storage in liquefied form, which allows for more efficient transportation into space. [1]

In a typical ion engine, xenon gas is ionized to form plasma, which is then accelerated through an electric field to produce thrust. While the thrust produced is relatively low compared to chemical propulsion systems, the efficiency is significantly higher, enabling spacecraft to operate continuously for thousands of hours using a minimal amount of propellant. [1]

Objective of the Research

The primary objective of this study is the development of a functional prototype and the experimental evaluation of its performance under atmospheric conditions, without the use of fossil fuels or noble gases.

Electric Propulsion General Principle

Electric propulsion achieves high specific impulses by accelerating electrically charged particles to very high velocities. These charged particles are created through the ionization of a gas — in this case, atmospheric air. The ionization process produces both ions and free electrons, forming what is known as plasma. When subjected to a high-voltage electric field, the plasma particles are accelerated toward neutral molecules, transferring momentum and generating what is known as ionic wind (also referred to as electrohydrodynamic thrust). [1,2]

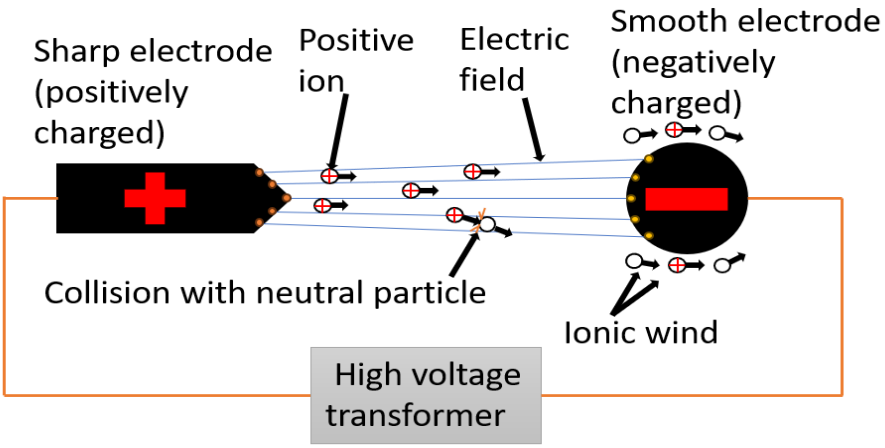

FIG. 1 Schematic representation of the electric propulsion phenomenon

2. CLASSIFICATION OF ELECTRIC PROPULSION SYSTEMS

Electric propulsion systems are generally classified based on the method by which they accelerate particles. The three main categories are:

- Electrostatic
- Electromagnetic
- Electrothermal

2.1 Arcjet Thrusters (Electrothermal)

An arcjet thruster is a type of electrothermal propulsion system that heats the propellant by passing it through a high-voltage electric arc, located upstream of the nozzle. Although plasma is formed in this process, the level of ionization is low, and the resulting plasma contributes minimally to the exhaust velocity. The specific impulse is typically limited to below 700 seconds when using storable propellants. [1]

2.2 Ion Thrusters (Electrostatic)

Ion thrusters utilize various techniques to ionize a significant portion of the propellant gas. These systems use electrostatic grids to extract the positively charged ions from the plasma and accelerate them to very high velocities, often exceeding 10 kV. Ion thrusters are among the most efficient electric propulsion systems, achieving efficiencies of 60% to over 80% and specific impulses ranging from 2,000 to 10,000 seconds. [1]

2.3 Hall Effect Thrusters (Electrostatic)

Hall thrusters use a unique configuration involving a perpendicular electric and magnetic field to create and accelerate plasma.

The electric field accelerates ions, while the magnetic field inhibits electron motion in the direction of the electric field, maintaining charge separation and preventing electrical shorting. Although Hall thrusters typically have lower efficiency and specific impulse than ion thrusters, they produce higher thrust at the same power input and are simpler to construct and operate, requiring fewer power supply systems. [1]

3. PROTOTYPE MANUFACTURING PROCESS

The prototype was manufactured using additive manufacturing, more commonly known as 3D printing, with equipment provided by the faculty laboratory.

Additive manufacturing is a layer-by-layer fabrication technology, where physical components or assemblies are produced from a digital 3D model. This 3D model is created using Computer-Aided Design (CAD) software. Common CAD platforms used for modeling include CATIA, CREO, Fusion 360, and SolidWorks, among others.

During the printing process, the printer deposits successive layers of material, each representing a horizontal cross-section of the final part. The layer thickness can be adjusted: thinner layers result in higher surface quality but increase manufacturing time, while thicker layers reduce printing time at the cost of precision and finish. [3]

Although the additive manufacturing process may seem complex, it generally consists of eight straightforward steps:

1. 3D Model Generation

All parts to be manufactured via 3D printing must first be designed using CAD software. The model must incorporate the exact dimensions required and must fit within the build volume of the chosen 3D printer. Alternatively, existing components can be 3D scanned to generate editable digital models for replication or modification. [3]

2. Saving the File as STL

Once the design is finalized, the model must be exported in STL format or another format compatible with the slicing software used by the 3D printer. [3]

3. Importing the STL File into the Printer Software

The STL file is then loaded into the printer's software interface, where the object is positioned on the print bed. At this stage, the model can be rotated, scaled, or otherwise adjusted to ensure proper orientation and fit. [3]

4. Printer Configuration and Calibration

The next step involves selecting the appropriate printing parameters, including:

- Material type and extrusion temperature
- Bed temperature
- Layer height
- Print speed
- Quality settings
- Support structures (if needed)

If the printer has been moved or unused for an extended period, recalibration is recommended to ensure optimal print quality. [3]

5. Printing the Part

The printing process is automated, with the printer executing the job based on the predefined parameters. Human supervision is recommended to detect any malfunctions or deviations. [3]

6. Removing the Printed Part

After completion, the part is carefully removed from the print bed. In some cases, the print bed may need to be detached from the machine. A spatula or scraper can help detach the part without damage. [3]

7. Post-Processing

Post-processing may include:

- Removal of support structures
- Trimming excess filament residue
- Surface smoothing using sandpaper
- Painting or coating for improved aesthetics or functionality

8. Final Component

The resulting part can be used as-is, or integrated with other 3D-printed components, mechanical parts, or electronic elements for full assembly. [3]

For this prototype, the Zortrax M200 Plus 3D printer was used.

Table 1. Specifications of the Zortrax M200 Plus Printer [4]

Feature	Specification
Build Volume	200 × 200 × 180 mm (heated bed)
Nozzle Diameter	0.4 mm (standard); 0.3 mm; 0.6 mm
Connectivity	Wi-Fi, USB, Ethernet
Display	4” IPS, 800 × 480 resolution
Filament Diameter	1.75 mm
Maximum Temperature	290°C (nozzle), 105°C (heated bed)
Power Supply	110 V / 240 V

FIG. 2 Zortrax M200 Plus 3D Printer

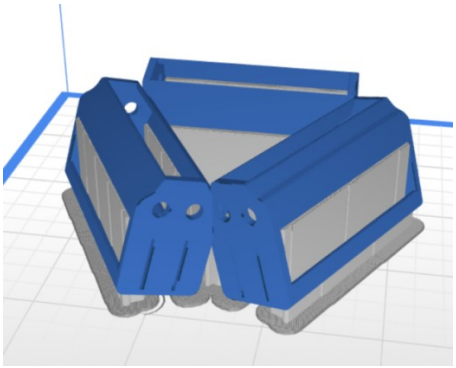

FIG. 3 Fully Printed 3D Model (100%)

After removing the printed model from the 3D printer, the support structures must be detached. For this operation, we used a pair of pliers to carefully remove the supports without damaging the model.

FIG. 4 Printed 3D Model (with supports)

FIG. 5 Cleaned Model (supports removed)

Electrode Preparation

For the anode components, we selected copper tubes with a 6 mm outer diameter. Since the design requires six pieces, we purchased a 1-meter-long tube, and cut it into 6 segments of 8.5 cm each using a standard pipe cutter.

FIG. 6 Marking the copper tube for cutting

FIG. 7 Final copper anode segments

For the cathode, we used a sheet of aluminum measuring 120 × 1000 × 0.8 mm. We cut six strips from this sheet, each 9 cm long and 1 cm wide. To improve ionization efficiency, small teeth were cut on one side of each strip using metal shears.

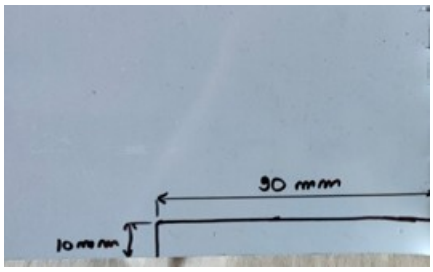

FIG. 8 Cutting layout for one cathode strip

FIG. 9 Completed set of six aluminum cathodes

3.1 Motor Power Supply

The motor requires two electrodes: the cathode, which emits electrons, and the anode, which collects them and neutralizes the charge, allowing only the ionic wind (neutral air flow) to exit the system.

For the power supply system of the ion propulsion unit, we used:

- A battery pack (DC power source) to ensure portability and eliminate the need for a direct AC power connection.
- A high-voltage transformer to generate the voltage required for electrode ionization.

These two components are connected in series, where the battery provides current, and the transformer boosts the voltage to the operational range required by the ion motor.

Table 2. Technical Specifications of the Battery Pack

Component	Voltage (V)	Current (A)	Capacity (mAh)	Weight (g)
LG Battery	3.7	10	3200	47

Table 3. Technical Specifications of the High-Voltage Transformer

Component	Output Voltage (kV)	Input Voltage (VDC)	Current (A)	Weight (g)

Transformer	800–1000	3–6	— (not specified)	53

FIG. 10 Battery Pack (LG 3.7V, 3200 mAh)

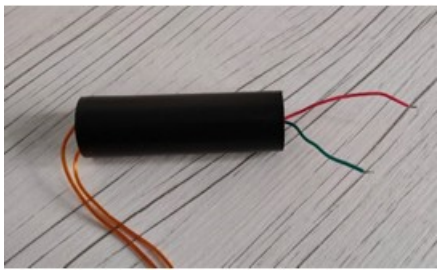

FIG. 11 High-Voltage Transformer (800–1000 kv)

The electrical configuration consists of a battery connected to a high-voltage transformer, which supplies the required potential difference between the cathode and anode of the ion propulsion system. This configuration enables the ionization of atmospheric air and the generation of ionic wind through accelerated charged particles.

The schematic in Figure 12 illustrates the basic wiring layout, including the power supply components, safety considerations, and electrode configuration.

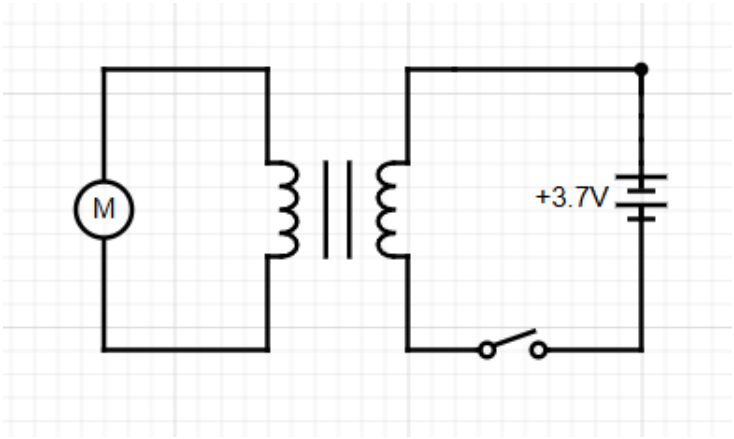

FIG. 12 Electrical Wiring Diagram for the Ion Propulsion System

CONCLUSIONS

Through the fabrication and testing of this prototype, we demonstrated that the phenomenon of ionic wind generation can be reproduced in atmospheric conditions using a relatively simple setup and without any form of propellant, relying solely on ambient air.

One of the main challenges encountered was identifying a sufficiently powerful power source capable of sustaining the high voltage required to initiate plasma formation. A second major obstacle was determining the optimal distance between the electrodes — specifically, the maximum proximity at which plasma is sustained without causing electric discharge (arcing). After multiple experiments and configuration trials, it was concluded that the minimum safe gap between electrodes is approximately 8 mm; reducing this distance further results in uncontrolled electric discharge.

Despite the low thrust generated, we were able to observe and feel the presence of a weak but perceptible ionic wind. Although we currently lack the instrumentation (e.g., an

anemometer) to quantify the airflow precisely, the experiment validates the concept and lays the foundation for future improvements.

Potential areas for further development include:

- Enhancing the thrust-to-power ratio
- Improving electrode geometry
- Introducing diagnostic tools for quantitative performance analysis

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BIO COMPOSITE MATERIALS AS A SUSTAINABLE SOLUTION FOR MODERN INDUSTRIES

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***Abstract**: In the global effort to develop circular economy solutions, bio composite materials have emerged as viable, less toxic, and environmentally friendly alternatives to traditional materials. Due to their advantageous physical and mechanical properties, hemp, flax, jute, and bamboo represent renewable resources with significant potential in industries such as aerospace, construction, transportation, and energy. This article investigates the manufacturing processes and tensile strength characteristics of roving's produced from these materials.*

***Keywords**: Aerospace, bio composite materials, environmental, jute, bio epoxy resin.*

1. INTRODUCTION

In the context of increasing technological impact on the environment and growing demands for sustainable development, industry is facing the need to transition to environmentally oriented technologies and materials. One of the most promising directions in this context is the development and implementation of bio composite materials - multicomponent systems that include natural fibers and biopolymers as a base. Unlike traditional polymer and carbon composites, bio composites have several significant environmental advantages: renewability of raw materials, reduced energy intensity of production, biocompatibility and biodegradability.

Modern research in the field of bio composites is aimed at optimizing their mechanical and operational properties, expanding the raw material range and increasing competitiveness compared to traditional materials. Bio composites combining natural fillers (linen, jute, hemp fiber, etc.) with biopolymers (PLA, PHA, TPS, etc.) provide a solution that simultaneously reduces carbon footprint and improves the efficiency of manufacturing processes. The lower weight and relatively lower cost of natural fibers are the main reasons for their use in composites in these applications. The relevance of the topic is determined not only by the desire to reduce the negative impact on the environment, but also by the needs of high-tech industries in lightweight, durable and multifunctional materials.

In hybrid composite, the physical and mechanical properties are governed by the fiber content, fiber length, fiber orientation, and arrangement of individual fibers, extend of intermingling of the fibers and the interfacial adhesion between the fiber and matrix. [1]

Based on official dictionary of oxford dictionary, jute is a thin thread from a plant, used for making rope and rough cloth. [2]

Table 1- Mechanical Properties of jute [3]

Density (g/cm^3)	Length (mm)	Failure strain (%)	Tensile strength (MPa)	Stiffness GPa	Specific tensile strength (MPa/gcm^3)	Specific Young's Modulus (GPa/gcm^3)
1.3-1.5	1.5-120	1.5-1.8	393-800	10-55	300-610	7.1-39

Its low density makes it ideal for lightweight structures. Besides, its 2-3 times cheaper than fiberglass and fully biodegradable and renewable. As for the getting the material, is quite easy, as it grows quickly and does not require large amounts of pesticides or fertilizers.

2. FABRICATION AND METHOD

In our case, we used a 30x300mm, jute fabric which is a wear and abrasion resistant material.

FIG. 1 Jute fabric [4]

This material was hand-laid up with **LB2 Epoxy Laminating Bio Resin.** LB2 is a high-performance bio epoxy resin suitable for use with a wide range of reinforcements including glass, carbon and aramid fibers as well as natural reinforcements such as flax and jute fiber. This one is a medium viscosity clear two-component epoxy resin system with ~35% resin plant derived content, this offers a lower environmental impact without compromising on performance. [5; 6]

Table 2 - Mechanical Properties of LB2 [5]

Max Service Temp	90	°C
Impact Resistance	25	kJ/m^2
Flexibility	Hard / Rigid	
Tensile Strength	78	MPa
Tensile Modulus	3.23	GPa
Elongation at Break	5.8	%
Flexural Modulus	3.2	GPa
Flexural Strength	127	MPa
Interlaminar Shear Strength	52	MPa
Compressive Strength	107	MPa
Tg Onset (DMA)	90	°C

FIG. 2 LB2 Epoxy Laminating Bio Resin [5]

As a first step, was created an improvised matrix. As the resin has low viscosity, a wooden board was taken and glued with aluminium tape, as to create a smooth surface for the hand-laying the material.

FIG. 3 The layer of aluminium tape

FIG. 4 GLOBALWAX 200/S [6]

The next step was to create a surface that is not sticking to the material itself. It was used GLOBALWAX 200S, which is a release agent that forms a wax layer on the surfaces of molds and models. This product is characterized by a strong non-stick coating with high temperature resistance (GLOBALWAX 200/S up to 180 °C). GLOBALWAX 200/S is spray-applied and does not blur the fine details of the pattern. [6]

The jute fabric was cut into rectangles of size 20x25 cm at 90 degrees and 45 degrees. This resulted in 4 rectangles.

a).

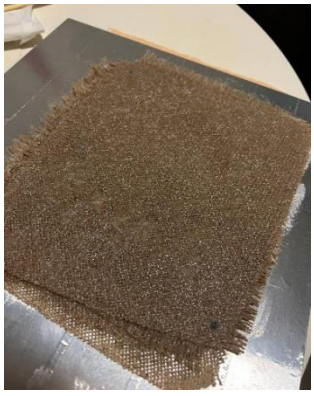
b).

FIG. 5 Rectangles of jute fabric

From the instructions of the LB2, the resin and the hardener were mixed with proportion of 101/28 to create the paste itself. Then layer by layer, with a classic brush, the resin was inserted into the fabric.

a).

b).



c).

FIG. 6 Layering the material

After definitive drying of the material, the result was a stiff plate with 3.9 mm thickness. The board was cut in 6 test tubes for bending and tensile experiment.

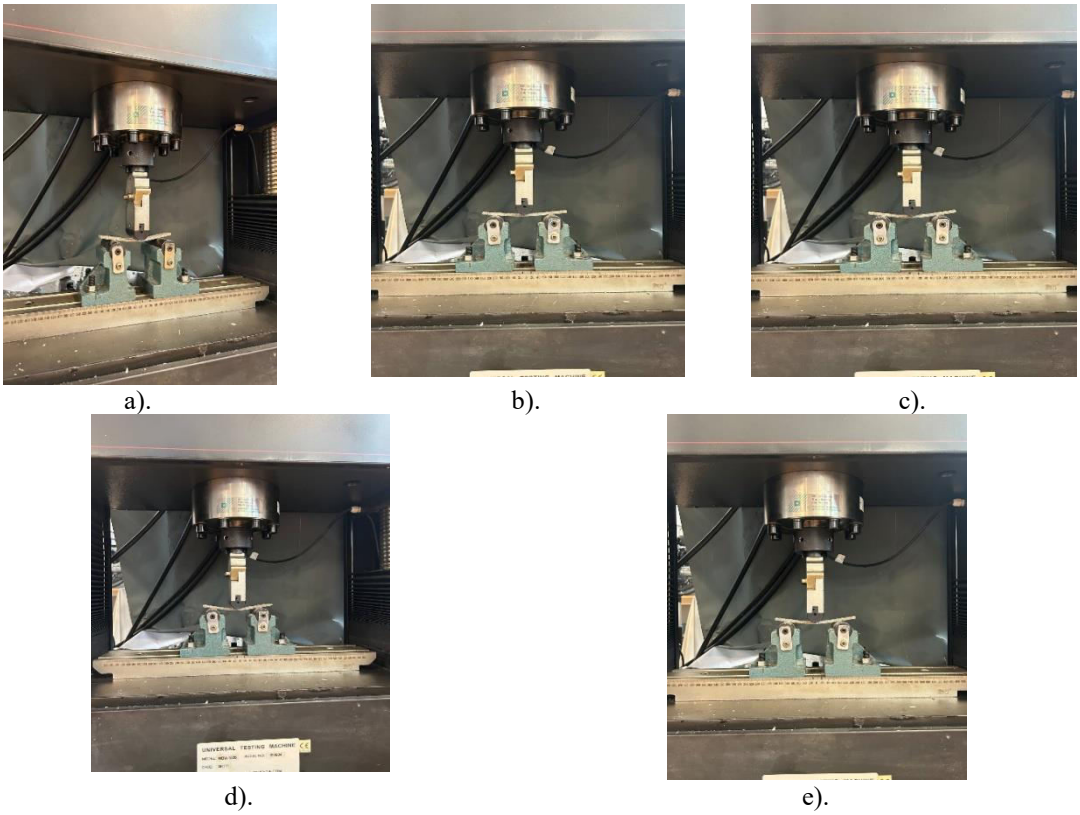
FIG. 7 Test tubes cut from material

Although the strength is lower than that of glass fiber or carbon fiber reinforced plastic, with proper fiber orientation and the proper curing technique, the composite can withstand moderate loads. The low density of jute makes the composite lightweight, which is especially important in the transport industry and structures where weight is critical.

3. MECHANICAL CHARACTERISTICS

For the bending experiment, 5 of the test tubes were placed into the bending machine, WDW-150. This is one of the common mechanical bending test methods used to determine the mechanical properties of composite or polymer materials such as flexural modulus or flexural strength, as well as fragility and ductility. The testing machine consists of a load rod (top) that applies a downward force, two supports (bottom) on which the specimen rests and a central loading blade/punch element that applies pressure to the center of the specimen.

This is a bio composite that is being tested for its mechanical properties for possible applications in aerospace engineering.



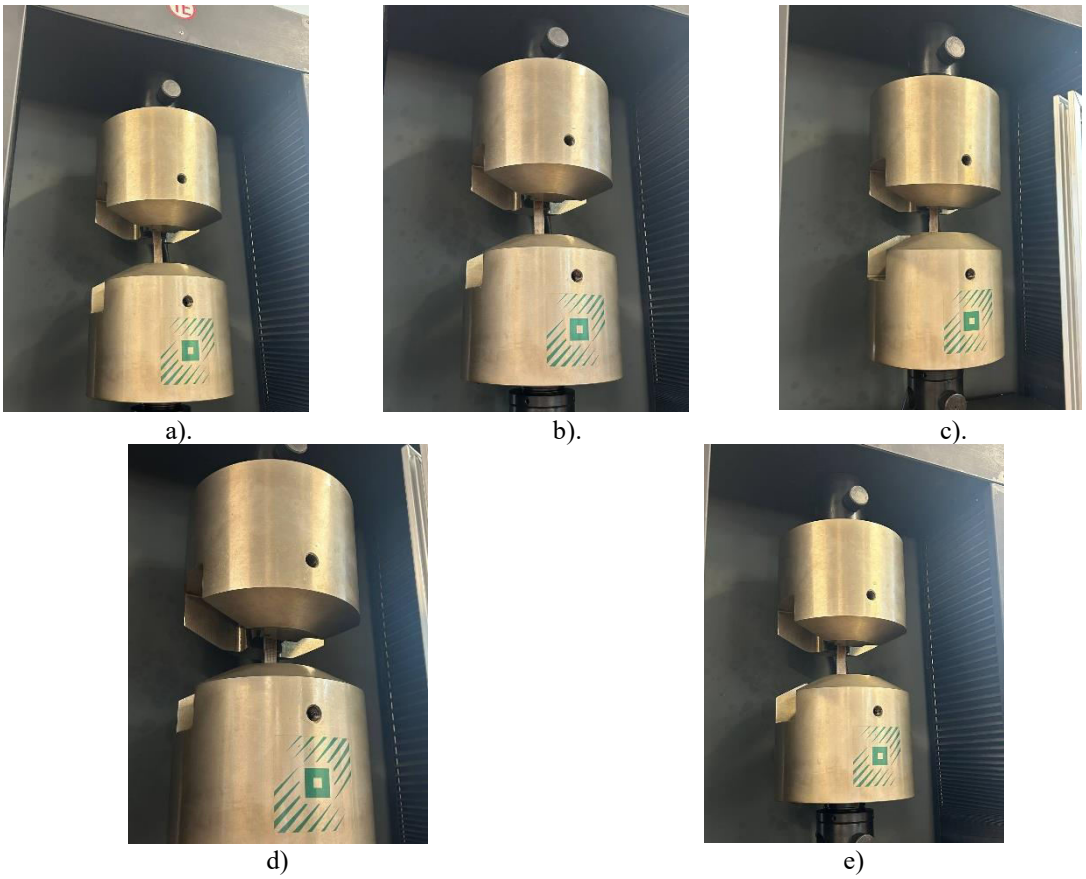
a). b). c).

d). e).

FIG. 8 - Test tubes tested on the bending machine

The test tubes are placed on two supports (bottom part). A force is applied from above at one point in the centre, the load is gradually increased and the machine records the value of the force and deflection. This allows the load-deflection diagram to be plotted and calculated.

As for the tensile testing, the purpose is to determine how the material behaves under an axial tensile force, the material is clamped between two grips, one upper and one lower. The machine begins to pull the sample by applying a load at a constant rate until failure occurs.



a). b). c).

d) e)

FIG. 9 - Test tubes tested for tensile strength

Upper and lower grips (grippers) are used to clamp the test piece for uniform load transfer. The cylindrical housings protect the mechanisms and transfer force with uniform distribution. The purpose of testing is to determine how resilient the composite is to stress under actual operating conditions.

Table 3 - The comparison between Jute composite and Hemp composite for the bending test [7]

Test tubes	Maximum Tensile Strength for Jute [MPa]	Maximum Tensile Strength for hemp [MPa] (7)
I 1	70	181
I 2	63	174
I 3	77	147
I 4	66	188
I 5	77	100

Table 4 - The comparison between Jute composite and Hemp composite for the tensile strength test [7]

Test tubes	Maximum Tensile Strength for jute [MPa]	Maximum Tensile Strength for hemp [MPa] (7)
I I	32	6
I II	31	10
I III	31	6
I IV	17	6
I V	33	14

As we can see, the difference between these 2 materials is quite noticeable. In bending, the hemp-based composite exhibits significantly higher strength, indicating good resistance of this fiber to bending stresses. This makes hemp promising for applications where flexural performance is important, such as panels and enclosures.

In tension, the jute composite performs significantly better, making it preferable for elements that work under tensile loads - for example, in load-bearing joints or reinforcing elements. Both materials confirm the potential of bio composites, but show differences in mechanical behavior, which underlines the need for individual selection of the reinforcing filler depending on the construction tasks.

CONCLUSION

The use of bio epoxy resin enhances the environmental sustainability of the material without adversely affecting the tensile strength characteristics. This confirms the potential of bio epoxy resins as full-fledged substitutes for traditional synthetic matrices in the production of bio composites. The combination of natural fibers with biodegradable epoxy resin shows high potential as an alternative to synthetic composites, especially in the context of sustainable development and environmentally friendly production. However, the mechanical performance requires the selection of the fiber type for the specific operating conditions.

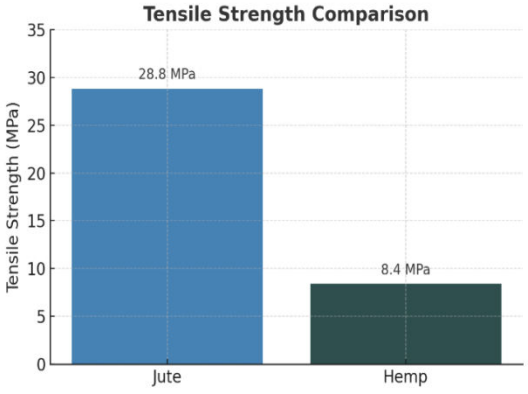


FIG. 10 Tensile Strength Comparison

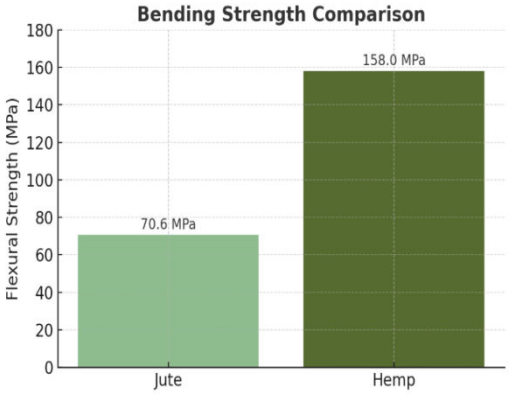


FIG. 11 Bending Strength Comparison

ACKNOWLEDGEMENT

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ENERGY EFFICIENCY OF CNN ARCHITECTURES USING FPGA

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Abstract: *This paper explores the importance of optimizing FPGA accelerators in the context of energy efficiency and enhanced performance for processing convolutional neural networks (CNN) in resource-limited environments. A reconfigurable RTL-level accelerator for CNN-based object detection systems is proposed, focusing on hardware and power consumption optimization techniques. Various aspects such as the importance of CNNs in artificial vision, their fundamental structure, and their acceleration on FPGA-SoC devices are presented. Additionally, the benefits of integrating FPGA with SoC and the design requirements to achieve optimal performance and energy efficiency are discussed. This research highlights the significance of innovative approaches to attaining the desired energy efficiency and performance in resource-constrained environments, such as mobile devices, IoT, and electric vehicles.*

Keywords: *FPGA, CNN, energy efficiency, RTL, accelerator*

1. INTRODUCTION

Currently, it is essential to consider how we can use wearable Internet of Things (IoT) sensors to monitor human behavior and determine their health conditions. Wearable tracking sensors are widely used in the medical field, and IoT aids in data collection through decision-making tools. Diseases are often diagnosed using a cloud computing platform. Additionally, the vast amount of data stored and shared by numerous medical research institutions worldwide makes it difficult for professionals to find relevant information in medical records [1].

As a result, the existing healthcare system continues to demand a significant amount of time and effort from most people to provide accurate medical diagnoses. Furthermore, the urgent development of a high-precision medical diagnostic wearable device is necessary to address this issue.

The term "artificial intelligence" was first used in the 1950s, and since then, the field has evolved rapidly. Throughout its history, AI has undergone several periods of advancement and stagnation, with significant progress in recent decades due to increased computational power and available data [2].

In recent decades, the significant increase in computing power and access to large datasets has led to remarkable advancements in convolutional neural networks (CNNs) for tasks such as image classification, object detection, and facial recognition. Compared to traditional machine learning algorithms, CNNs provide superior accuracy and performance, even surpassing human capabilities in certain aspects. However, as accuracy improves, CNN architectures have become deeper and more complex.

As a result, the number of parameters and computational demands have increased significantly, making CNN implementations more challenging [3,4].

To address this, new deep neural network compression algorithms have been introduced to reduce CNN model complexity. Most of these algorithms utilize low-rank approximations, data quantization, or network pruning. However, general CNN accelerators are still not efficient enough to process compressed models effectively. Instead, these accelerators primarily focus on maximizing computational parallelism and reducing memory bandwidth requirements, making them suitable only for CNN implementations with well-structured architectures. In the case of commonly pruned CNN models, filters do not maintain a uniform structure due to the random pruning of weights. Consequently, current algorithms fail to fully exploit the performance potential of CNN accelerators.

Furthermore, CNN-based object detection applications have been widely integrated into various systems, including FPGA devices, spanning from personal mobile devices to industrial machines such as medical equipment, intelligent surveillance systems, advanced driver assistance systems (ADAS), drones, and logistics robots. To achieve high recognition accuracy, CNNs have become a crucial component of numerous object detection devices, whether cloud-based or operating on edge devices.

However, one of the primary challenges in implementing CNN applications lies in their high computational complexity and power consumption, which are necessary to ensure both fast processing speeds and high accuracy. In resource-constrained hardware environments with limited energy availability, many researchers have proposed CNN accelerators at different design levels to enhance performance and reduce power consumption.

These studies [7,8] highlight advancements in CNN pruning methodologies, accelerator designs, and optimization techniques to address challenges related to computational complexity, power consumption, and real-time processing speed in various application domains.

In the broader context of the paper, a hardware architecture is proposed that utilizes three biomedical ExG signals on an FPGA platform to accelerate the CNN convolution process. This architecture can be adapted to compute convolution for any input size and modify stride values.

Additionally, a 1-D CNN structure is discussed, which is tailored for various embedded applications. Through a Python implementation, an output ensemble from the 1-D CNN layers is obtained with high accuracy, and the 1-D CNN is capable of recognizing ExG signals. The proposed design maximizes hardware resource utilization and minimizes the loss of ExG classification accuracy.

Furthermore, a serial processing unit is designed to ensure excellent performance and efficiency, with low power consumption and optimized hardware resource utilization. The final result is an architecture that accurately identifies ExG signals and achieves superior processing speed compared to traditional methods.

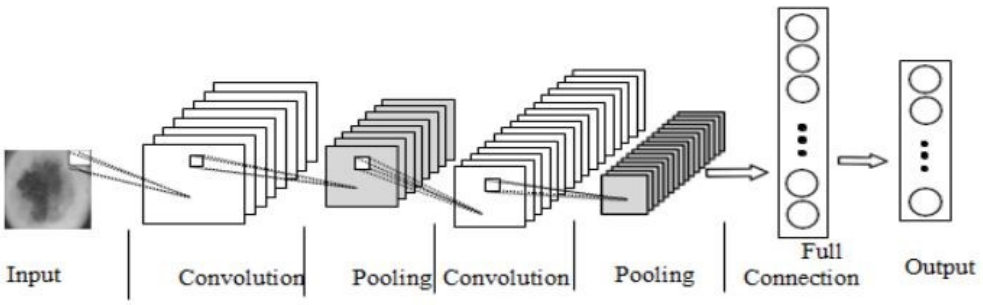

FIG. 1 CNN Arhitecture

2. BACKGROUND

2.1 CNN arhictecture

In the context of artificial intelligence, "CNN" can stand for "Convolutional Neural Network."

Convolutional neural networks are a special type of neural network primarily used in the field of computer vision, such as image recognition or object segmentation in images. These networks are powerful in identifying and extracting features from images, mainly due to their specific architecture [8].

The key characteristic of convolutional neural networks is the use of convolutional layers. These layers apply filters (or convolutional kernels) across the entire input image to detect different features such as edges, corners, textures, etc. The detected features are then learned by the network and used to make predictions.

Convolutional neural networks are essential in a variety of applications, including object recognition in images, medical image classification, sentiment analysis in images, and many others. They have had a significant impact on artificial intelligence and have enabled remarkable advancements in solving complex problems in computer vision [8].

Over time, the importance and complexity of convolutional neural networks (CNNs) and CNN accelerators on FPGA-SoC devices have been explored and highlighted. One key idea is the design of CNN accelerators and the application of specific techniques to reduce power consumption at the RTL (Register Transfer Level).

CNNs (Convolutional Neural Networks) are implemented and accelerated on FPGA-SoC (System-on-Chip) devices to ensure optimized performance and energy efficiency in artificial intelligence applications such as object recognition, image classification, and other complex visual data analysis tasks [5].

This highlights the use of CAD tools and development platforms, as well as the importance of platform-based design flow and RTL code generation. Additionally, specific power reduction techniques at the RTL level, such as clock gating and batch normalization, are described.

The paper [9] presents the fundamental structure of CNNs and the VGG16 model. This is the work of the research team at Google, which introduced the "VGG" (Visual Geometry Group) convolutional neural network, characterized by its depth and its remarkable performance in image classification on the ImageNet dataset.

By implementing CNNs on FPGA-SoC, the goal is to maximize computational performance while minimizing power consumption. This is achieved through efficient parallelization of operations, optimization of memory access, and the use of specific techniques to manage limited hardware resources.

Furthermore, CNN accelerators on FPGA-SoC must be flexible and reconfigurable to accommodate different neural network architectures and diverse workloads. This requires careful design of the hardware architecture and data flow to ensure compatibility and operational efficiency.

2.2 FPGA-Soc

FPGA-SoC (System-on-Chip) devices represent an integrated solution that combines the benefits of Field-Programmable Gate Arrays (FPGAs) with those of System-on-Chip (SoC) architectures. These devices are used in a wide range of applications, including artificial intelligence, where accelerating convolutional neural networks (CNNs) is becoming increasingly important [5].

By integrating an FPGA with an SoC, FPGA-SoC devices offer both the flexibility and computational power of FPGAs and the ability to run software and interact with other hardware components, which are specific features of SoC systems.

This combination allows developers to efficiently implement and accelerate artificial intelligence algorithms, such as CNNs, with high performance and energy efficiency [6, 7].

Using FPGA-SoC devices, developers can take advantage of the ability to customize and adapt hardware for specific applications, as well as integrate hardware and software solutions into a single system. This makes FPGA-SoC devices ideal for applications requiring both computational power and implementation flexibility [10].

As the field of artificial intelligence continues to evolve, the use of FPGA-SoC devices for accelerating machine learning algorithms is expected to grow, thanks to their ability to provide high performance and energy efficiency in an integrated and customizable package.

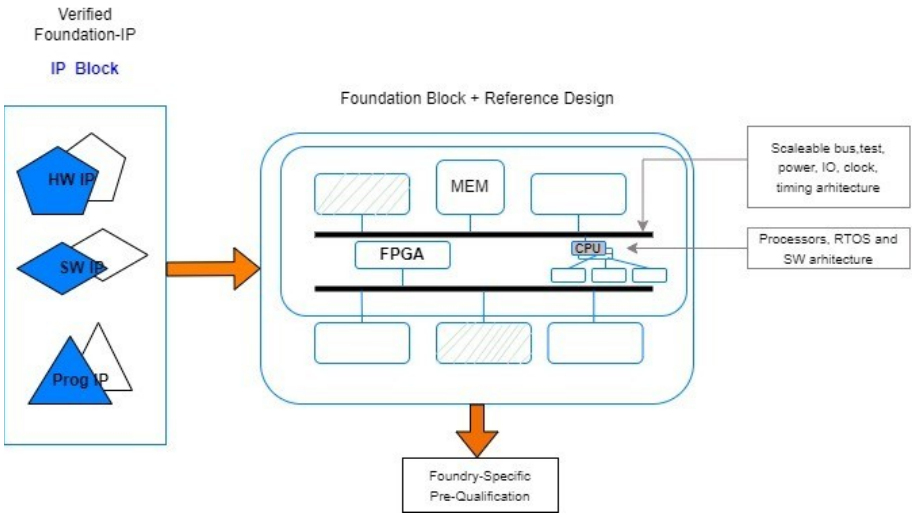

FIG. 2 FPGA Soc

With the information presented above, a complete picture is structured on how CNN accelerators are designed and implemented on FPGA-SoC devices, while also understanding the structural fundamentals of CNNs and specific models such as VGG16. This provides a comprehensive perspective on the field and the research directions in this continuously evolving domain.

3. ARCHITECTURE

In the context of efficiently processing convolutional neural networks (CNNs) on resource-constrained devices, developing an optimized hardware architecture that balances performance and energy consumption is essential. Traditional CNN implementations on general-purpose processors or GPUs are often inefficient in environments where hardware resources and power consumption are critical factors. To address these challenges, we propose a reconfigurable hardware architecture based on FPGA-SoC, optimized for accelerating CNNs used in object detection systems. This solution combines the flexibility of FPGAs with the energy efficiency of RTL (Register Transfer Level) optimizations, providing a scalable and adaptable accelerator for various embedded applications. Unlike traditional methods, our architecture employs an advanced parallelization strategy for convolution operations, reducing latency and energy consumption through efficient FPGA resource management.

Additionally, by integrating memory and power optimization techniques, our accelerator surpasses conventional software-based solutions and offers a significant advantage in power-constrained environments such as mobile devices, IoT systems, and electric vehicles.

3.1. Architectural Design of the FPGA-SoC Accelerator

The proposed architecture for CNN acceleration on FPGA-SoC is designed to optimize both performance and power consumption using an efficient RTL-level implementation.

3.1.1. General Structure of the Accelerator

To achieve efficiency and performance objectives, the accelerator architecture consists of the following key components:

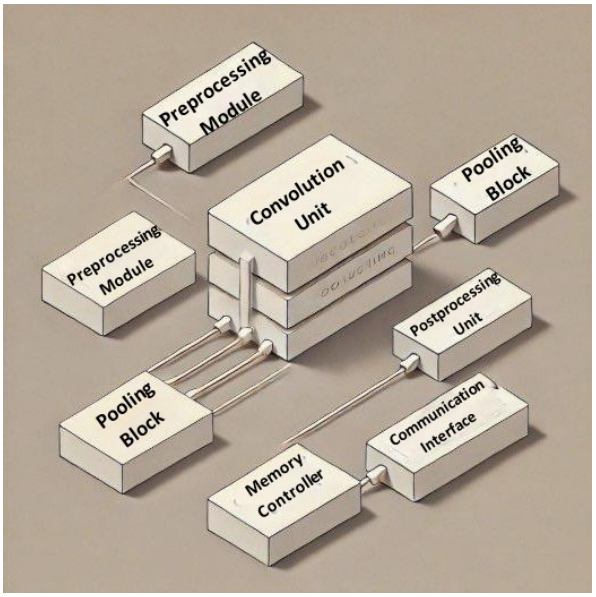

FIG. 3 General Structure of the Accelerator

Preprocessing Module:

- Normalizes and converts input data into an optimized format for FPGA execution.
- Reduces the number of operations required in subsequent stages, thereby lowering energy consumption.

- Our proposal**:** Integrating a numerical precision reduction technique to decrease the processed data volume without significant accuracy loss.

Convolution Unit:

- Implemented using optimized multiply-accumulate (MAC) units.
- Supports advanced parallelization for concurrent execution of multiple convolution operations, reducing latency.
- Our proposal**:** Implementing an adaptive parallelism reconfiguration mechanism, allowing dynamic adjustments based on CNN complexity and available resources.

Pooling Block:

- Applies max pooling or average pooling operations, reducing the size of intermediate data.
- Optimized to minimize memory transfers and power consumption.
- Our proposal**:** Using a hybrid algorithm that adaptively selects the pooling method based on image type and application requirements.

Postprocessing Unit:

- Handles scaling and formatting of results before transmission to the decision unit.
- Our proposal**:** Integrating a customized post-processing quantization scheme to maintain accuracy under limited resource conditions.

Memory Controller:

- Efficiently manages data transfer between FPGA and external memory using advanced memory access techniques.
- Minimizes latency and optimizes power consumption by reducing redundant memory accesses.
- Our proposal**:** Implementing an intelligent buffer that preloads necessary data based on a predictive analysis of the CNN model.

Communication Interface:

- Ensures compatibility with other embedded system components, enabling accelerator integration into various applications.
- Our proposal**:** Introducing a low-latency communication protocol that significantly reduces data transmission delays between FPGA and processor.

The architecture designed for accelerating object detection in convolutional neural networks (CNNs) based on FPGA consists of programmable logic. Each block is specifically defined and modularized to improve the efficiency of implementing different CNN models.

This text presents an overview of the architecture of a proposed processing unit designed to accelerate object detection in CNNs based on FPGA. To implement a CNN architecture in FPGA that includes convolution and pooling operations, we will describe the fundamental steps involved in this architecture [11].

Input data, such as images, are brought into the FPGA using various interfaces, such as MIPI CSI for video cameras or memory interfaces for stored images. Computing blocks in FPGA are used to perform convolution operations.

These blocks can be implemented using dedicated hardware resources such as DSP (Digital Signal Processing) blocks to accelerate calculations. CNN parameters, such as convolution kernels, are stored in memory for quick access during convolution operations. This memory can be organized as RAM blocks or other available FPGA memory resources. Input data is passed through convolution layers, where convolution operations are applied using kernel filters stored in memory. These operations generate feature maps that help in identifying patterns from the input data.

After the convolution layers, pooling operations can be applied to reduce the size of the feature maps while retaining dominant features.

Pooling blocks can be implemented using average or max pooling operations and can be optimized for parallel processing on FPGA.

Intermediate results from convolution and pooling operations are temporarily stored in memory to be used in subsequent layers of the network.

The final CNN processing results are transmitted through output interfaces, such as display screens or communication interfaces, to be used in the final application.

3.2 Comparison with Other FPGA Accelerators

To demonstrate the advantages of our FPGA-based CNN accelerator, we compare it with two widely known FPGA accelerators: the FINN framework from Xilinx and the Edge TPU-based FPGA accelerator.

3.2.1. Comparison with Xilinx FINN Framework

Architecture Differences:

- The FINN framework is designed for ultra-low-latency inference using quantized neural networks, primarily focusing on Binary Neural Networks (BNNs), whereas our accelerator supports full-precision CNNs with reconfigurable parallelization for convolution operations.
- FINN employs a highly parallelized execution of binary convolutions, significantly reducing computational complexity but at the cost of lower accuracy. In contrast, our accelerator utilizes an adaptive parallelization strategy that balances energy efficiency and model accuracy.

Performance Comparison:

- Our accelerator achieves a higher precision in complex tasks such as object detection due to its capability of handling floating-point operations and maintaining more significant feature map integrity.
- FINN provides lower power consumption due to its extreme quantization, making it more suitable for applications that require ultra-low energy usage.

3.2.2 Comparison with Edge TPU-based FPGA Accelerator

Architecture Differences:

- Google's Edge TPU-based FPGA accelerator is optimized for low-power AI inference at the edge, relying on 8-bit quantized models. Our FPGA accelerator, on the other hand, offers flexibility in precision settings, supporting both fixed-point and floating-point operations.
- The Edge TPU-based solution is a dedicated AI inference accelerator that is tightly coupled with Google's ecosystem, whereas our solution is designed to be more adaptable across different embedded platforms and application domains.

Performance Comparison:

- In terms of energy efficiency, our FPGA accelerator demonstrates a power consumption reduction of approximately 30% compared to Edge TPU solutions when running similar CNN models in resource-constrained environments.
- Our accelerator provides greater flexibility in processing different CNN architectures, making it suitable for various applications beyond AI inference, such as biomedical signal processing and real-time analytics.

Table 1. Performance Metrics Comparison Table

Feature	Our FPGA Accelerator	Xilinx FINN	Edge TPU-based FPGA
Supported Precision	Floating-Point & Fixed-Point	Binary & Quantized	8-bit Quantized
Power Consumption	Low	Ultra-low	Low
Processing Speed	High	Medium	High
Flexibility	High	Medium	Low
Appliction Scope	AI, IoT, Biomedical, Edge Devices	AI, Low-Power Inference	AI, Google Ecosystem

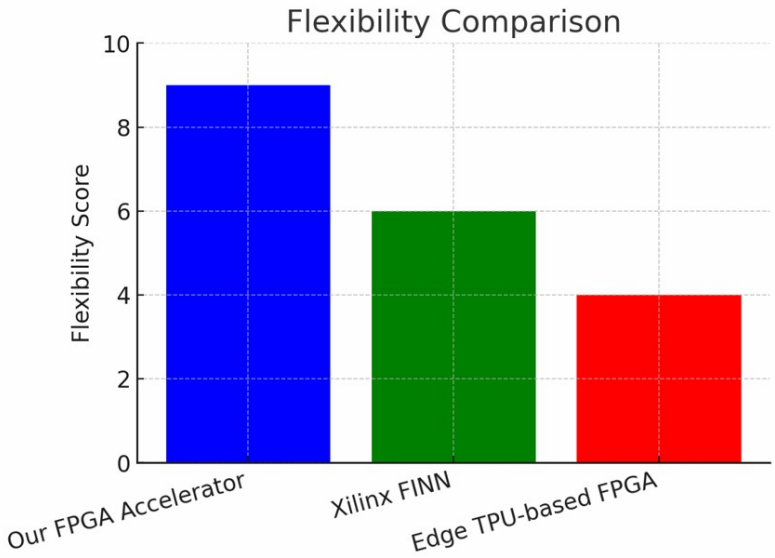

FIG. 4 Flexibility Comparison

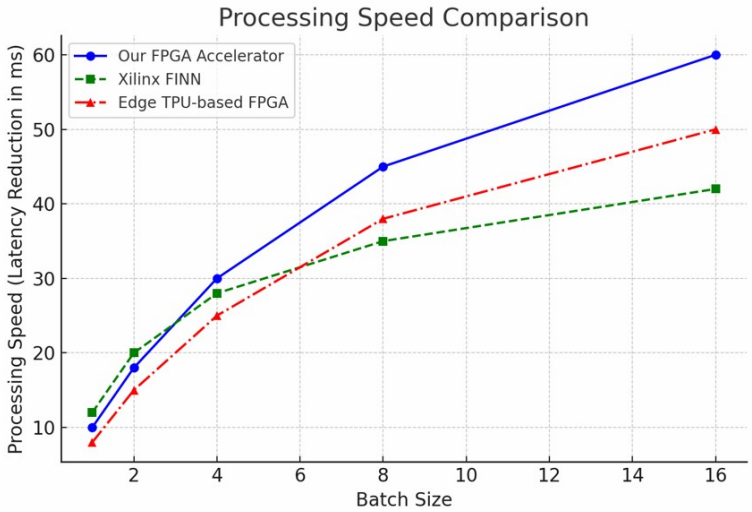

FIG. 5 Processing Speed Comparison

CONCLUSIONS

Compared to traditional GPU, our architecture offers the following advantages:

- High energy efficiency – By leveraging RTL-level optimizations and intelligent hardware resource management, the accelerator reduces power consumption compared to conventional software-based solutions.

- Scalability and flexibility – The modular design enables quick adaptation to different CNN models, facilitating use in diverse applications.
- Low latency – Parallelized execution and optimized MAC units enhance real-time processing, crucial for embedded applications.
- Memory optimization – Data transfers are efficiently managed, minimizing external memory access, thereby reducing power consumption and execution time.

As future ideas we have:

- Further Optimization of Power Consumption

Investigating advanced power management techniques, such as Dynamic Voltage and Frequency Scaling (DVFS), to dynamically adjust power consumption based on the requirements of the processed CNN.

- Extending Support for More Complex CNN Models

Adapting the architecture for more advanced neural networks, such as Vision Transformers (ViTs) or hybrid CNN-ViT models, to enhance performance in computer vision applications.

- Integration with Other Hardware Technologies

Exploring the possibility of integrating with RISC-V processors or other low-power architectures to create a comprehensive hardware-software solution.

Evaluating the use of the accelerator with non-volatile memory (NVM) for improved efficiency.

In conclusion, this a paper highlights the importance of optimizing FPGA accelerators in the context of energy efficiency and improved performance for processing convolutional neural networks (CNNs) in resource-constrained environments. By proposing an approach based on an RTL-level reconfigurable accelerator for CNN-based object detection systems, the paper emphasizes the significance of hardware optimization technologies and energy consumption management.

The key aspects covered in the paper include the relevance of convolutional neural networks, their fundamental structure, and how they are accelerated on FPGA-SoC devices. Additionally, it discusses the benefits of integrating FPGA with SoC and the design requirements needed to achieve performance and energy efficiency. Research underscores the importance of innovative approaches to achieve the desired energy efficiency and performance in resource-limited environments such as mobile devices, IoT, and electric vehicles. These efforts are essential for the continuous development of technology and for creating more energy-efficient solutions.

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UNCONVENTIONAL WARFARE INDICATORS IN MOLDOVA

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***Abstract*:** *Considering that most of the recent specialized military literature is strongly focussed on the concept of hybrid warfare, in all its forms, this paper aims to establish the current relevance of a specific 20th century concept, which facilitated the evolution of hybrid warfare - unconventional warfare.*

In order to answer this question, the main approaches to unconventional warfare in recent history were evaluated, and subsequently, an analysis was conducted on the hypothesis that in the period 2022-2024, the Russian Federation carried out activities specific to unconventional warfare on the territory of Moldova. The most significant information that formed the basis of the case study refers to the public information of the Intelligence and Security Service (SIS) of Moldova, regarding the interference of the Russian Federation in the electoral process of Moldova.

The results indicate the presence on the territory of Moldova of five of the six activities specific to unconventional warfare, as understood by the doctrine of the United States of America (USA), but taking into account the ambiguity specific to unconventional warfare and the relativity of the current information environment, formulating a verdict on this subject is not certain.

However, this article manages to provide an objective perspective on the Russian Federation's interference in the internal affairs of Moldova, highlighting the relevance of unconventional warfare in the current operational environment.

Keywords: *Unconventional warfare, Moldova, Special Operation Forces, insurgency, Russia*

1. INTRODUCTION

At a time when international public opinion and specialized military literature are focusing all their attention on the war initiated by the Russian Federation on Ukraine, through *"ghibridnaia voina"* type actions, completely different from the Western conception of hybrid warfare, it is of interest to objectively analyze the hypothesis according to which the Russian Federation takes advantage of this scenario and executes, in parallel, soft offensive actions, with a high degree of ambiguity, specific to unconventional warfare (UW) on the territory of a country directly targeted by the *"Novorossiya"* concept - the Republic of Moldova [1].

As described by Lesenciuc in 2023 [2], ghibridnaya voina applied in Ukraine simultaneously involves actions specific both to soft and hard wars, with the purpose of total destruction of the enemy: *"Ghibridnaya voina is not a form of hybrid warfare, but one of total war, a massive war, of yesterday, wearing the illusory cloak of the war of future"* [2]. On the other hand, the conduct of UW facilitates the achievement of strategic-level objectives through structures that act at the tactical level, predominantly indirectly, through soft-type actions and with support of the local populace. This hypothesis also implies the existence of the Russian Federation's intention to install a favorable political elite in Chisinau, which would promote the Kremlin's interests both in Moldova and on the eastern flank of the NATO/ EU alliance.

In the attempt to carry out an objective analysis on this subject, only information validated by representatives of public institutions with responsibilities in the field of national security of Moldova was interpreted. The main source of information that was subjected to this critical analysis is the Public Report of the Intelligence and Security Service (SIS) of Moldova dated 23.12.2024, on „*Electoral Frauds Found in the Presidential Elections and the Republican Referendum"* [3].

The research was carried out sequentially, starting with the study of the military doctrines specific to the UW. This was followed by the collection, verification, processing and analysis of data presented by the media channels of Moldova, Romania and Russia, and finally, these were corroborated with the information published by SIS Moldova regarding the interference of the Russian Federation in the elections of Moldova.

During the case study, independent use of data presented by media organizations was avoided due to possible interference by the Russian Federation in this area. Carrying out checks by consulting multiple official sources was one of the measures that contributed to the clear distinction between propaganda and accurate public information.

2. UNCONVENTIONAL WARFARE - DIFFERENT APPROACHES

UW is understood differently by the major global military powers, therefore it is natural to review the main methods of implementing this type of confrontation in contemporary military art.

In US military doctrine, the concept of UW encompasses *"activities that are conducted to enable a resistance movement or insurgency to coerce, disrupt, or overthrow a government or occupying power by operating through or with an underground, auxiliary, and guerrilla force in a denied area"*[4]. This definition highlights the essential condition underlying the initiation of the UW planning process - the existence of a segment of the population motivated to oppose the governing force.

In the early phase of the UW mission planning process, specific activities related to Preparation of the Environment (PE) are performed, as Special Operations Forces (SOF) detachments are made up of a small number of specialists and are extremely vulnerable once infiltrated into enemy territory (denied area). At the same time, this is the moment when the ideology and capabilities of the resistance/ insurgency group are evaluated in order to establish the reliability of the UW mission.

In this context, the quality of the inter-institutional collaboration between SOF and the intelligence structures represents the guarantor of the success of the PE missions and, subsequently, of the UW: *"PE is an umbrella term for activities conducted by selectivity trained SOF to prepare the operational environment for potential special operations. (...) The information provided by these operations can enhance joint intelligence preparation of the operational environment to support subsequent military operations"* [4].

In his book *On Guerrilla Warfare*, Mao Tse-tung structures UW into three main phases, which must be completed in a mandatory sequence so that the threshold of violence is not crossed prematurely: *strategic defense* (preparation, organization, and consolidation), *strategic stalemate* (progressive expansion), and *strategic attack* (destruction of the enemy) [5].

The US military academic environment strongly resonates with this approach, and the three phases of UW proposed by Mao are studied and successfully applied both during the training of future operators within the SOF and during the planning and execution of combat missions.

Based on the three pillars established by Mao Tse-tung, the US SOF proposed a more detailed approach to UW, in seven phases, the duration of which is dictated by the evolution of the operational environment. Transitioning too abruptly from one phase to another can permanently compromise the mission and trigger immediate repressive actions on one's own forces, culminating in the deterioration of political and diplomatic relations between the opposing states/ entities. To mitigate this risk, it is recommended to regress to an earlier phase in the event of prematurely reaching a threshold of violence atypical for the operational environment. The gradual implementation of the activities corresponding to the seven phases is carried out as follows: *Preparation, Initial Contact, Infiltration, Organization, Buildup, Employment and Transition* [4].

At the opposite pole, the strategy adopted in recent years by decision-makers in the Russian Federation (2014 - Crimea, 2022 - Ukraine), reveals a distinct approach to activities that can be associated with the UW spectrum. During the execution of these missions, the Russian Federation demonstrated the ability to significantly compress the time allocated to the early phases of the conflict in order to capitalize on the enemy's surprise and to achieve an almost instantaneous transition to conventional warfare [6].

According to the military reorganization that the armed forces of the Russian Federation underwent in 2009, the specific UW duties are assigned to the SOF *(Силы специальных операции - SSO)*, in close coordination with the Main Intelligence Directorate (*спецназ - GRU Spetsnaz*): *"SSO and GRU Spetsnaz train and support proxy forces conducting offensive actions"* [7].

General Valery Gherasimov's vision of the use of SOF in new forms of conflict is detailed in his work *"The Value of Science Is in the Foresight. New Challenges Demand Rethinking the Forms and Methods of Carrying out Combat Operations"* [8]. The general confirms the Russian Federation's increased interest in continuously adapting military strategy to the combat characteristics of the current operational environment and proposes several research directions for the Russian military scientists, including the integration of artificial intelligence into military operations, the robotization of the battlefield and, last but not least, the large-scale use of SOF for conducting informational and asymmetric operations (specific to UW), which would capitalize on the experience of the Russian Army in using resistance/ insurgency forces: *"we must not forget about our own experience. I mean the use of partisan units during the Great Patriotic War and the fight against irregular formations in Afghanistan and the North Caucasus"* [8].

In contrast to the current situation on the Ukrainian front, where the conflict has the characteristics of a total war, the military strategy of the Russian Federation has developed around ideological concepts strongly anchored in the specifics of UW. Relevant is the concept of subversion-war, proposed by Evgeni Messner, who highlighted the importance of influencing the population and amplifying their grievances in order to achieve political objectives: *"Direct or indirect utilization of already existing domestic political, social, economic and other turmoil, created by accelerated political-socio-cultural transformations, for political benefits"* [9].

According to Romanian legislation, the SOF are responsible for executing UW missions *"on the territory of the Romanian state or outside it, independently or together with other national and/ or allied forces"* [10].

The same document highlights the existence of legislative gaps regarding *"the definition, development, experimentation and implementation of the concept of armed resistance"* (an essential element for the successful execution and countering of UW missions) and aims to clarify them in the period 2021-2024 [10].

Another relevant clarification for Romania's approach to UW is found in the 2021 Romanian Defense White Paper, which states that (in a state of war situation) *"in the event of temporary occupation of a part of the national territory, the Romanian Army is the structure responsible for leading the resistance movement while preparing and executing the counter-offensive to restore territorial integrity, in a national or allied context"* [11].

Therefore, the Romanian Army proposes the use of UW as the main instrument specific to the state of war, in the context of executing a counteroffensive, through which the SOF operates on the territories occupied by the aggressor, with the aim of organizing and leading resistance forces to counter the occupation forces and shape the battlefield in favor of its own conventional forces. At the same time, the SOF represents a force multiplier for the achievement of strategic level objectives of the Romanian Army or NATO, through the execution of missions by tactical level elements.

3. CASE STUDY – INDICATORS OF UNCONVENTIONAL WARFARE IN MOLDOVA. ANALYSIS FROM THE AMERICAN MILITARY DOCTRINE PERSPECTIVE

Intelligence. UW-specific intelligence activities have several particulars, but the most important of these is that they ensure the survival of the resistance/ insurgency group and the SOF operators involved in the UW. Since the UW is carried out in a denied area, the development of an intelligence network that ensures early warning of its own forces is essential. If the operational environment allows, the network is completed before the SOF infiltrates enemy territory. To achieve this goal, the underground forces develop a network that allows permanent monitoring of any repressive actions planned by the security forces against the resistance/ insurgency group.

In this context, it is important to clarify the term underground force, as they significantly contribute to the quality of intelligence actions: *"An underground is a cellular covert element within unconventional warfare that is compartmentalized and conducts covert or clandestine activities in areas normally denied to the auxiliary and the guerrilla force"* [12].

Having maximum freedom of movement in enemy territory, these forces are able to collect information about the operational environment, capabilities, movements, plans and morale of the enemy, respectively about its critical infrastructure, contributing to situational awareness and to the planning of missions in the UW spectrum.

Two of the main characteristics of intelligence actions are discretion and dissimulation, and for this reason, this study does not aim to identify the intelligence agency of the Russian Federation on the territory of Moldova, but to correlate information relevant to this subject that is available through open sources and has been validated by public authorities with responsibilities in the area of national security of Moldova.

It is relevant to analyze the three press releases of SIS Moldova [13, 14, 15] from February 2023, July 2023 and July 2024, according to which four people were investigated on suspicion of intelligence gathering and treason.

On 27.02.2023, SIS Moldova identified two foreign citizens who carried out data and information collection activities for the implementation of a plan to destabilize the internal situation in the country, with the aim of violently changing the constitutional order of Moldova.

They carried out reconnaissance missions of critical infrastructure and government institutions. The two were declared undesirable persons for a period of 10 years and were expelled from the country.

On 31.07.2024, SIS Moldova made public the information according to which two officials from the Parliament, respectively from the Border Police, were arrested and are being investigated for treason and conspiracy against Moldova, as a result of collecting information and providing it to an employee of an embassy in Chisinau.

Information activities. These use the power of word as a tool to agitate the population, by constantly and consistently promoting themes and messages, personalized for each segment of the population. The main goal of these methods of influence is to identify the grievances of the target audience and to create the false impression that the sender sincerely empathizes with the needs of the receiver.

Moldova's intelligence services identified five main themes on the basis of which Moscow's propaganda messages were developed: (1) Promoting civil disobedience, (2) Denigrating the West, the European Union (EU) and the referendum for EU accession, (3) Promoting the image of the Russian Federation and the Eurasian Economic Union, (4) Imminence of war as a result of the militarization of Moldova and (5) Denigrating the government and state institutions. Table 1 provides a comparative analysis of the methods of influence used by the broadcaster, depending on the grievances of the target audience [3].

Table 1 – Influence methods used by Russian Federation in Moldova

Influence method	Exploited grievances	Targeted populace
Spreading messages through religious personnel In 2024, Approx. 500 Moldovan priests traveled to Moscow	Validation and appreciation from religious personnel; Monetary compensation of clerical personnel.	Orthodox Christians; Elderly; Rural environment; Clergy personnel.
Political Parties as a Means of Propaganda „Chance", „Renaissance", „Victory" and „the Alternative Force for the Salvation of Moldova"	Members of the political environment confer a certain level of authority in the collective mind; Using semantics to trigger emotions.	People with civic spirit; Young people; People with a certain level of education; Urban environment; People with a sense of patriotism.
Indoctrination through participation in camps. Get to know Russia; The land of childhood; Eurasia - the continent of opportunities.	Participants are rewarded through scholarships - a relationship of dependency of the participant towards the organizer	Young people; People with low financial income; Rural environment.
NGOs that promote the interests of the Russian Federation. Cultural Moldovan Educational Center	The need for group affiliation; Patriotism.	Diaspora; Urban environment; People with a certain level of education; People with civic spirit.
Mass media (Russian, Romanian and English) Radio, TV, Printed materials, Social-Media, call-centers; Russia Today, Sputnik, > 43 Vkontakte bots, > 70 Facebook groups, > 90 Tiktok channels, >110 Telegram channels.	The desire for information, group affiliation, and the need for validation in the case of social media	All age groups, All social backgrounds, regardless of financial status or education level; National and international public opinion.
Symbols Ilan ȘOR; Church; Chance, Renaissance, Victory and the Alternative Force to Save Moldova.	The politician's name is the core of the resistance/ insurgency movement developed in Moldova; The name of the political bloc Victory generated a sense of fihting on the winners side; The names of the parties that were included in the political alliance trigger strong patriotic emotions.	Ilan ȘOR supporters; Patriotic people; Pro-Russian segment of the population; Political supporters of the four parties.
Personalized materials with the symbol "victory" Placards, clothing, office items	Group membership; reward through goods.	People with low financial income.

In order to promote the five main themes mentioned above, the Russian Federation developed a cellular, decentralized network specific to auxiliary forces, whose activity contributed to the main specific objective of the UW – the establishment of political figures favorable to the Kremlin at the leadership of Moldova. According to the definition, auxiliary forces are *„the support element of the irregular organization whose organization and operations are clandestine in nature and whose members do not openly indicate their sympathy or involvement with the irregular movement"*[12]. Most often, the auxiliary are not realizing the extent of the UW network of which they are part due to decentralization.

In the present example, a pyramidal auxiliary network has been developed at the level of Moldova, which provides a high level of protection through decentralization. The network includes 119 territorial cells to which over 1900 primary cells are subordinated. Each primary cell corresponds to a certain number of activists, and the chain ends with the recruitment of voters (sympathizers) by the activists. The advantage of such a network is that if a cell or a leader is compromised, the network can continue to carry out its activity [3, 19].

Subversion represents the set of actions aimed at undermining the military, economic, political or moral power of a governmental authority [12].

This activity has two roles in the execution of UW: strengthening the ideology around which the resistance/ insurgency group is coagulated and influencing public opinion (both nationally and internationally) to obtain support from the population, which is essential in UW campaigns.

During 2024, an intensification of subversive actions carried out by the Russian Federation against Moldova was observed, some of the most significant being: interference in the electoral process to establish political elites favorable to the Kremlin (the success in taking over political control over the Autonomous Territorial Unit of Gagauzia is noteworthy), compromising the path towards Moldova's European integration (influencing voters against the referendum for EU accession), energy blackmail starting with January 2025 (impact on both the economic field and the morale of the population), respectively the organization of meetings with the aim of indoctrinating Moldovan citizens in favor of the Kremlin [3].

Subversive manipulation of the masses. This activity requires extensive planning, and the basic condition for achieving the desired result is that a relevant segment of the target audience resonates strongly emotionally with the grievances exploited and amplified by the agitators.

According to the SIS report, in July 2024, a number of 115 citizens of Moldova traveled to Moscow, where they were involved in training sequences on techniques, tactics and procedures (TTP) specific to subversive manipulation of the masses: (1) Tactics of provocation of the police; "intelligent" confrontation of police cordons; (2) Procedures for disarming public order forces; (3) Procedures and tactics for using pyrotechnic and smoke devices; (4) Procedures for launching improvised "projectiles" (stones, eggs, paint balloons); (5) Tactics for protecting leaders/key individuals during protests; (6) Tactics for "neutralizing" police officers who carry out their activities undercover during protests [3].

While the training sequence carried out in the Russian Federation (Moscow) focused mainly on non-lethal TTPs, an advanced training sequence was organized on the territory of Bosnia and Herzegovina (Banja Luka) where Moldovan citizens were taught including violent TTPs, specific to the process of manipulating the masses: preparation of homemade incendiary devices; tactics for penetrating police cordons; blinding police officers with paint or light signals; use of drones (Unmanned Aerial Vehicle - UAV) and mass psychology.

These situations reveal the practice of the Russian Federation of using one of the specific UW instruments, the sanctuary, which involves the use of a relatively safe area (in this case - Moscow and Banja Luka) where the training of resistance/ insurgency forces can take place in maximum safety conditions.

The specific training for subversive manipulation of the masses was put into practice and validated by the influence agents of the Russian Federation in Moldova during peaceful protests organized at the Chisinau courthouse (26.06.2024, 03.07.2024). In their modus operandi, specific indicators of training in the field of mass manipulation were identified, such as the use of vocal leaders (as agitators) to promote themes and messages of interest to Kremlin propaganda.

The agitators demonstrated minimal training in the field of mass manipulation, spreading messages supporting Russian narratives through sound amplification devices (megaphones and microphones). In parallel, individuals responsible for directing the protests were identified, who aimed to distort reality and manipulate public opinion through video images transmitted online. They distributed banners to protest participants and repositioned people in the crowd in such a way that young people occupied the front positions of the group, creating the false impression that a significant number of people from diverse social categories were participating in the protest and wanted to send a sincere, unified message to the political environment.

The reality is that the representative segment of the population that accepted to participate in the protests were retirees, and their motivation is financial and not ideological. The consequence was a state of general apathy of the participating masses, a state of repulsion towards the messages they were supposed to chant and, in some situations, confusion regarding the purpose of organizing the protests [16].

Sabotage consists of *„act or acts with intent to injure, interfere with, or obstruct the national defense of a country by willfully injuring or destroying, or attempting to injure or destroy, any national defense or war materiel, premises, or utilities, to include human and natural resources"* [17]. Nevertheless, there is also a variation with a reduced coefficient of violence – simple sabotage. This activity does not involve specialized training and can be carried out by ordinary citizens, and not infrequently, it is used to increase the morale of the resistance/ insurgency group (confidence targets), and to train insurgents for the execution of more and more complex missions.

The SIS report reveals that some of the people who benefited from training in the camps organized in Moscow were paid (5,000 EUR) to engage in simple sabotage activities by vandalizing institutions with symbolic value for Moldova - breaking windows and spraying paint on the offices: Teleradio Moldova, the Supreme Court of Justice, the Central Electoral Committee, the Ministry of Labor and the Government [3].

Guerrilla warfare is characterized by military and paramilitary operations carried out predominantly by resistance/ insurgency forces, in hostile or enemy-controlled territories (Ibidem). This is the most violent side of UW and most of the time, UW objectives cannot be achieved without the use of kinetic means. However, US military doctrine recognizes that premature use of guerrilla warfare poses a significant risk to force protection and recommends implementing kinetic actions only when the other mechanisms of UW (information activities, intelligence, subversion) are working within normal parameters.

In the case of this case study, it can be appreciated that if the guerrilla forces controlled by the Russian Federation exist, they are currently underdeveloped, and initiating direct actions against the Moldovan security forces would be a mistake. On the other hand, in the SIS report on the Russian Federation's external interference in the electoral processes of Moldova, there is information according to which Moldovan citizens have benefited from military training that can be used to carry out ambushes,

raids or sabotage (preparation of homemade incendiary devices and the use of UAVs). However, the Russian Federation's modus operandi involved the use of a sanctuary to train Moldovan citizens, which reveals the lack of mobility of any guerrilla forces on the territory of Moldova [3, 18].

Another relevant argument in support of the idea of training guerrilla forces by the Russian Federation refers to the press release of the Police of Moldova dated 17.10.2024, which uses the term *"guerrilla camps"* to describe the sanctuary in which Moldovan citizens were trained [18]. Representatives of the police confirm much of the information made public by SIS Moldova in 2023 and their role contributes to the state's objective of increasing citizen resilience through institutional transparency, communication and education.

4. LESSONS IDENTIFIED. THE PARTIAL SUCCESS OF RUSSIA UW IN MOLDOVA

4.1. Exploitation of the linguistic component

Observation: The Russian Federation has professionally exploited the linguistic component of the electorate in Moldova.

Discussion: The propaganda efforts undertaken by the Russian Federation have addressed both Russian and Romanian/ Moldovan speakers. This approach has allowed the expansion of the sphere of influence of Russian propaganda and access to the majority of citizens of Moldova, regardless of the language spoken. Communication through a single language can generate a sense of exclusion among some segments of the population, resulting in their aversion to the broadcaster.

The results of the census conducted by the National Bureau of Statistics of Moldova in 2014 show that people who declared that they usually speak Russian represent approximately 14.5% of the population [20]. However, it is certain that the percentage of the population that is able to communicate in Russian is significantly higher.

Conclusion: The narratives of the Russian Federation were submitted in the main languages of circulation in Moldova in order to target all segments of the population, and this modus operandi represents a model of good practices in order to execute effective informational operations.

Recommendation: Development of themes and messages, personalized, in all languages of circulation in the area of influence but also in the area of interest, for each segment of the population.

4.2. Identifying and exploiting electorate motivations

Observation: The Russian Federation capitalized on the urgent financial needs of the electorate, with formidable effects in recruiting personnel for the auxiliary group.

Discussion: The majority of individuals who joined Moscow's efforts to compromise the elections in Moldova were retirees willing to sacrifice their time for financial benefits. This need was properly capitalized on, and the periodic remuneration of network members for spreading propaganda, participating in protests, and recruiting new network members produced results.

Conclusion: The efficient development of a network for financing illicit activities on the territory of Moldova and the use of funds for constant rewarding of members contributed to the quantitative growth of the insurgency group, but not its qualitative growth.

Recommendation: Achieving a balance between financial and ideological recruitment, to obtain both quality (key positions) and quantity for the insurgent group.

4.3. The role of new technologies in unconventional warfare

Observation: New technologies (cryptocurrencies, encrypted communication channels) were integrated into the process of developing and protecting the electoral scheme financing network

Discussion: The successful use of new technologies is noted, mainly in order to increase the efficiency of network protection measures. In this regard, members of the auxiliary forces were trained to use the Telegram messaging application for conducting communications in an encrypted (relatively secure) manner. On the other hand, there were situations in which cryptocurrencies and virtual bank cards (BYBIT, BYNANCE) were used by network members for the illegal financing of electoral and propaganda activities [3, 19].

On the other hand, the messaging application facilitated the easy dissemination of propaganda materials, communication between network members, monitoring the activity of sympathizers, evaluating performance and keeping a clear record of staff fluctuations.

A disadvantage of integrating new technologies into the management of the auxiliary network refers to the difficulty of adapting the elderly to their use. One of the consequences required the allocation of additional human resources to familiarize network members with smart devices.

Conclusion: The efficient use of new technologies for the development of UW-specific financial and communication networks in the current operational environment is noted. The UW doctrine represents the method of application, but it provides flexibility for the choice of means that lead to the achievement of objectives.

Recommendation: Integrate new technologies into UW planning and execution, with an emphasis on the Think Outside the box principle.

4.4. The relevance of the sanctuary in the current operational environment

Observation: The Russian Federation trained members of guerrilla forces outside Moldova, in order to minimize the risks of exposing its own forces.

Discussion: The guerrilla forces were trained in sanctuaries, in order to maintain a low level of violence on the territory of Moldova. The main reason why the Russian Federation resorted to this tactic refers to the political context at the end of 2024. The conduct of the presidential elections, but also the referendum for accession to the EU, determined the Russian Federation to adopt additional measures to protect the auxiliary and underground network already developed on the territory of Moldova, as there were chances that they could achieve the strategic objective of compromising the elections without exceeding the threshold of violence. Moreover, the training of guerrilla forces through the sanctuary reveals a possible uncertainty interval that the Russian Federation has taken into account - the development of guerrilla forces for the situation in which the objectives of the mission cannot be achieved without the use of violence.

Conclusion: The sanctuary allowed the protection of the auxiliary and underground group by developing, in parallel, guerrilla forces on the territory of other states.

Recommendation: The use of sanctuary when the operational environment does not allow the development of guerrilla forces in the denied area, simultaneously with the use of underground and auxiliary forces to execute non-kinetic offensive actions.

4.5. Security culture in unconventional warfare

Observation: The Russian Federation has paid special attention to the development of the security culture of the insurgent group.

Discussion: Good practices in the implementation of security policies to increase the level of protection of the organization were noted at the level of the insurgent group. Participants in protests and meetings were occasionally trained in the risks they expose themselves to by discussing political issues on the phone, or with people outside the

network. One of the practices adopted unanimously refers to the use of the encrypted messaging application, Telegram [3, 16].

The network adheres to the principles of decentralization, to limit the interaction between microstructures and to implement the need-to-know principle. Intermediaries have been introduced to manage funds transferred from the Russian Federation and to protect key individuals in the organization.

Recruitment of network members based on referrals is another factor contributing to the active measures to protect the network.

Conclusion: The importance given by the Russian Federation to the implementation of the security culture of the resistance/insurgency group for its sustainable development is noted.

Recommendation: The only guarantee for the survival of UW networks in the denied area is the cultivation of a security culture for all members of the resistance/insurgency group.

4.6. The will of change from the populace

Observation: UW is set for failure if the population does not have the desire to change the political class.

Discussion: Moldova is represented by an electorate oriented mostly towards the West and towards democracy. Two of the reasons are represented by the majority migration of the population to the West and the significant number of Moldovans who have acquired Romanian citizenship (between 01.01.2000 and 31.12.2020, a number of 642,149 Moldovans obtained Romanian citizenship) [21]. This aspect contributed to the embrace of democratic values, to their promotion among the family environment in Moldova and implicitly, to the determination of the diaspora to exercise their vote in favor of joining the EU (the Moldovan diaspora that cast their vote in the EU accession referendum represented a number of 235,503 votes, of which 76.79% were in favor of joining the European organization) [22].

The Russian Federation tried to mobilize a resistance/insurgency group to divert Moldova from its European path, despite the reality that demonstrated that a large part of the population does not want this.

In the case of Moldova, the shaping of the operational environment by the Russian Federation was still underway at the time of the elections at the end of 2024, but the chance to change Moldova's European path forced the Russian Federation to act, hoping for a favorable outcome.

Conclusion: Before initiating UW missions, it is necessary to establish their viability. In the initial phase of the mission, it is necessary to prioritize resources to obtain national and international support from the populace.

Recommendation: The execution of UW missions is not viable without the support of the populace.

4.7. Measures to counter unconventional warfare

Observation: Moldova managed to counter Russia's actions through societal resilience, strategic communication and the support of international public opinion.

Discussion: Although the effects of Russian actions managed to mobilize a significant percentage of Moldova's population to compromise the elections, the measures adopted by the state authorities to counter these illegalities had an effect. Strategic communication of the authorities with responsibilities in the field of national security, the free press as a tool for educating citizens, the condemnation of Russian interference in the Moldovan electoral process by the EU and the numerical reduction of the Kremlin's propaganda channels were the main defensive measures successfully implemented in Moldova.

As Lesenciuc concluded in his work on the current manifestations of hybrid warfare, *"the anti ghibridnaya voina shield implies protecting society through education and security culture, through strategic communication and through societal resilience"* [2].

Conclusion: The permanent orientation of the political environment towards security culture, meeting the needs of citizens, quality strategic communication and decision-making transparency, significantly reduces the risk of strengthening an insurgency group within the state.

Recommendation: Adopt proactive measures to increase societal resilience, security culture and strategic communication of the population.

CONCLUSIONS

This paper has achieved its objective of identifying the relevance of specific UW activities in contemporary conflicts. At the same time, it can be stated that, strictly related to the relationship between the Russian Federation and Moldova, the Russian military strategy has not abandoned the old doctrinal concepts that emphasize non-lethal tactics, but has only adapted them to the current context. Until now, the destabilizing actions carried out by the Russian Federation on the territory of Moldova coincided, to a large extent, with the principles of the American UW doctrine, but the physical presence of operators from the Russian SOF could not be confirmed.

On the other hand, the offensive activities of the Russian Federation against Ukraine demonstrate that the Russian doctrine of hybrid warfare (ghibridnaya voina) has taken over some of the specific activities of UW, but has replaced guerrilla warfare with the large-scale use of conventional forces to wage total war. In this way, one of the basic principles of UW, which is to ensure that the population and territories to be conquered suffer minimal physical damage, has been abandoned.

According to the UW definition, the study was able to highlight the efforts of the Russian Federation to use resistance/ insurgency movement to create and develop auxiliary and underground forces in a denied area, with the ultimate goal of constraining, disrupting or overthrowing the government and Moldova's European path.

Although the threats specific to UW have gained momentum in Moldova, the effort made by the current government to counter the aggression of the Russian Federation by improving the security culture, intensifying strategic communication and increasing societal resilience is noteworthy.

I consider that this paper draws attention to a scenario that may be repeated in the future and to a country like Romania. It is necessary to realize that political stability is extremely fragile in the face of the ambiguity of the modern battlefield. In this regard, it is necessary to increase the level of inter-institutional cooperation between the Romanian SOF, which have an important role in countering and conducting UW and the other structures of the national defense system, respectively the implementation of measures to increase the resilience and resistance of the population.

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LEADERSHIP DEVELOPMENT IN THE AIR FORCE - A CURRICULAR PERSPECTIVE ON TRANSFORMATIONAL AND TRANSACTIONAL THEORY FOR THE DEVELOPMENT OF CADET OFFICER'S LEADER COMPETENCY

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Abstract: *Effectiveness has been and will continue to be one of the basic conditions for achieving success in an organization. From the military perspective, one of the aspects related to effectiveness in the military organization is reflected in the results obtained due to the training of human resources. In the case of officers, good personal development is reflected throughout the entire military career, in the way they lead their subordinates.*

The institutionalized training framework for officers represents the starting point in the training and subsequent development of the competencies expected to be displayed by them throughout their career. That of leadership is the first of the four aimed at being implemented in the behavior of leaders.

Keywords: *leadership, transformational and transactional theory, education, leader competencies, leadership development, Romanian Air Force.*

1. INTRODUCTION

One of the fundamental missions of the military organization is to ensure national safety and security, within the national defense system, together with its other constituent elements. The success of this endeavor depends on many elements and human resources, more precisely their training, is one such factor.

The institutionalized framework in which personnel within the military organization are trained and improved throughout their career is regulated in such a way that, through educational tools, a continuous improvement of those competencies imposed by the military organization to be demonstrated by its members can be achieved.

By members of the military organization, for the purposes of this material, I will refer to officers within the Romanian Air Force, even if those presented by me can constitute elements with a high degree of generality so that they can be applied within any category of the armed forces.

2. A BRIEF OVERVIEW OF THE TRANSFORMATIONAL AND TRANSACTIONAL LEADERSHIP MODEL

In the leadership studies, the transformational approach is considered one of the most popular and current approaches to leadership, having been at the center of much research since the early 1980s. The essential characteristic of this approach is the special attention paid to the charismatic and affective elements found in leadership.

In the spirit suggested by its name, transformational leadership is a process that create inner changes to people, transforms them in a manner which is directly correlated to their personalities, character and long-term goals.

Transformational leadership involves an exceptional form of influence that leads followers to adopt a higher level of motivation and to achieve in this regard, more than what is usually expected of them, being a process that often incorporates elements of charisma and vision.

Burns, in 1978, was the first to make a distinction between the two types of leadership, as different from each other. In his opinion, *transactional leadership refers to the majority of leadership models that focus on the exchanges that take place between leaders and their followers*. [1] The exchange dimension of transactional leadership is very common and can be observed, at many levels, in almost all types of organizations.

Unlike transactional leadership, transformational leadership, which is also identified as a process, can be described as the interaction by which at least two persons engages and creates connections with each other. This results in developing a quantity of higher motivation at the same time with the raise of the level of morality, in both the leader and the follower.

Burns points to Mohandas Karamchand Gandhi as a classic example of transformational leadership. Gandhi raised the hopes and demands of millions of people and, in the process, was himself changed.[1]

Transformational theory is also related to another theory, that of the charismatic leader, which is a sophisticated approach to trait theory, focused on the transcendent qualities of extraordinary leaders.[2] It is considered, in this way, that charismatic leaders are those who act in accordance with certain high moral beliefs, have a strong sense of influencing others, use dramatic methods to articulate goals, model desired attitudes and behaviors, appeal to the high ideals of subordinates and have the ability to impel them to action.[1] Mitchell, Green and Wood believe that transformational leaders display specific behaviors, compatible with many of these characteristic traits.[3]

Transformational leadership is concerned with improving followers' work performance and developing them to their full potential.[4] People who practice transformational leadership often draw on a strong internal set of values and ideals and "*are effective in motivating followers to act in ways that support the greater good, which is more important than serving their own interests"*.[5]

The general hypothesis that transformational leadership motivates followers to do more than is expected of them was also one of the main ideas of Bass's studies in leadership.[6] His findings were the basics who reinforced that belief, and were materialized through the following aspects:

(a) by creating the need for followers to understand the importance and value of specified, idealized goals;

(b) by directing subordinate to followers to see beyond their own interest and focus on that of the organization;

(c) by changing followers in the sense of adhering to the immediately superior needs of one's own organizational level.

3. CURRICULAR PERSPECTIVE ON TRANSFORMATIONAL AND TRANSACTIONAL THEORY FOR THE DEVELOPMENT OF CADET OFFICER'S LEADER COMPETENCY

The dynamics of the transformation process are highlighted by Bass in his model of transformational and transactional leadership.[6]

The transformational and transactional leadership models incorporate seven different factors, as illustrated in Fig. 1.

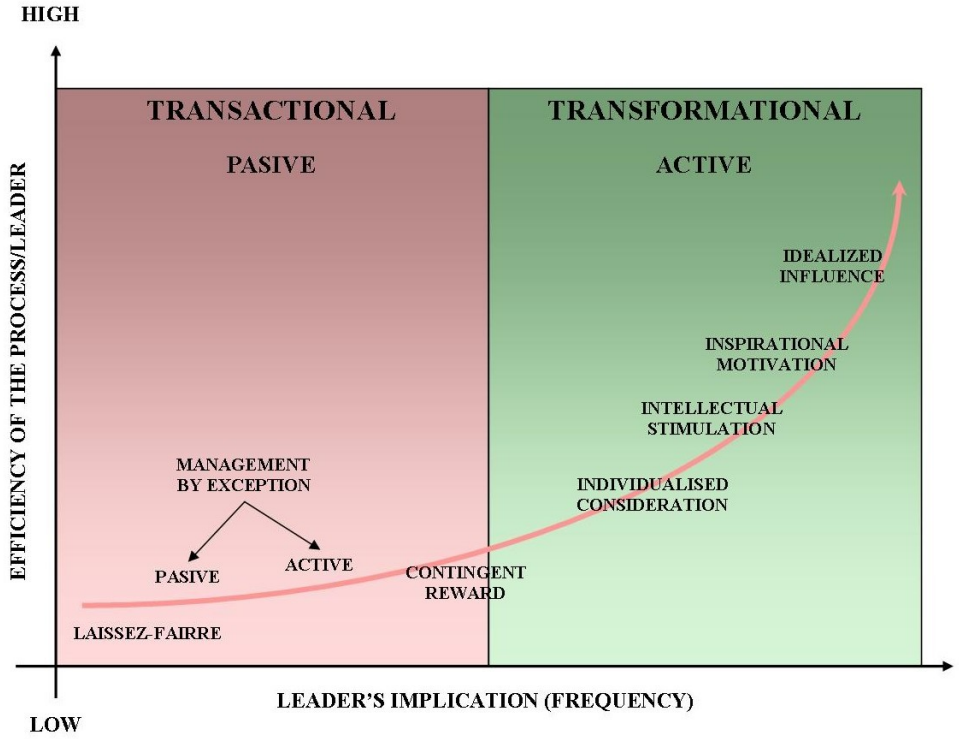

FIG. 1 Full Range Leadership Development model
Sourse: Adapted from Bass, B. M., Avolio. B. J., *Improving Organizational Effectiveness Through Transformational Leadership*, SAGE Publications Inc., 1994 apud Northouse, P. G., *Leadership - Theory and practice*, *Seventh Edition*, SAGE Publications, 2016, p. 168.

The best clarification of the elements, presented in the model above, was provided by Avolio, in his book, *Full Leadership Development: Building the Vital Forces in Organizations*, edited in 1999.

Factor 1, as shown in Fig. 1, is located on the graph in the position of maximum effectiveness and involvement on the part of the leader. It describes leaders who act as strong role models for followers, who identify with them and strongly want to imitate them.[7] Idealized influence can also be seen as a process, a way in which followers are helped by leaders to deal, in a more than positive manner, with difficult situations encountered during the performance of current tasks at work.[8] The optimism that characterizes this type of leader plays an important role in this process. This is also one of the things that leads to the creation of a relationship based on special respect combined with a sense of trust born of a deep understanding of the vision conveyed. Personal example in doing things is essential for modeling ethical behavior. The standards to which the leader performs are very high, which leads to the strengthening of the belief that they are doing the right thing. For these reasons, this factor is considered to be the emotional component of leadership.[9]

An example from the military organization can be that of a young second lieutenant who, being at the beginning of his career and in search of ideals in everything he undertakes, identifies in the commander of his own squadron the embodiment of all the elements sought. His actions, a father figure, are elements that have the highest success rate in shaping the young officer. This is the moment when the desire for change can be instilled in him, by adopting the behavior displayed by the commander.

Personality traits, such as the desire to dominate/influence others, a great self-confidence but also a strong set of moral values will have to be cultivated by integrating, in the academy training program, elements that lead to increased responsibility. Ethics is particularly important, and this is, at the moment, one of the fundamental disciplines that are covered in higher military education.[10]

The second factor, if we are looking down below, on the scale of efficiency and implication, is known as inspirational motivation. As the name suggest, this factor depicts a leader who is very good at sharing organizational vision to followers. Motivation, for this leader, represent the perfect tool for communicating high expectations to the followers, aspect which in practice can be recognized in the use of symbols or other meanings for focusing the group members in achieving the organizational goal.

Team spirit is enhanced with this type of leadership. Fulfilling functional duties, in the military system, is one of the basic requirements of the job description. This is the document that specifies what an individual has to do and especially what is the standard that is expected of him to be achieved.

An educational program is based, among other things, on the definition of certain objectives, planned to be achieved at certain performance standards. The military student's overcoming of these standards can be achieved due to the desire instilled in him to surpass himself by the platoon commander, the teaching staff, the mentor or tutor of the group to which he is a part. The common vision must be represented by the proposed goal of becoming an officer of excellence of the military organization, and this can only be achieved through permanent contact. Team spirit must be maintained at all times, throughout the military student's academic career.

Factor 3, intellectual stimulation, includes leadership that stimulates followers to be creative and innovative by challenging their own beliefs and values as well as those of the leader and the organization. An example of this type of leadership is a platoon commander who promotes the individual efforts of subordinates to develop unique ways to solve problems that have caused the training process to slow down. In academia, intellectual stimulation must be constantly promoted among students through participation in innovative activities, possibly included in disciplines that can support this approach. A good example in this regard can be the discipline of Tactics, where the element of creativity is fundamental in planning combat actions.

Factor 4 of transformational leadership is known as individualized consideration. This factor is representative for the leaders who are comfortable within a supportive climate, created by them. This climate was born from the need of knowing all of their followers by personality and needs. The proper way for leaders, to maintain such a climate, is by constantly provide followers with constant counseling and coaching sessions. The result of this actions should be a constant grow from the followers, and this can be done through personal challenges delegated from leaders. A good example for this case is the one of a platoon size commander who spends his time treating each subordinate in a unique, personalized way.

In the case of the military academy, the special role of individual counseling activity is the one that will have to be exemplified by direct commanders or tutors within the study programs. The special attention they pay to listening and solving at the same time the shared needs of the military students will be reflected, over time, thanks to their personal example, in their behavior.

Factor 5, contingent reward, is the first of the two factors of transactional leadership. This is the point, on the scale, where followers start to demand rewards and where the action is no longer a volitional way for them.

The follower's effort, in achieving the organizational objectives, is now traded for benefits, under an agreement, and the leader's role in this transaction is to find the proper approach for negotiation. An example of this type of transaction is a sub-unit commander negotiating with subordinates about the tasks they have to perform in order to recognize their merits through additional monetary rewards.

In a positive sense, future air force officers will have to learn to master the art of negotiation. This element can be developed through the skills acquired through communication courses in conjunction with the practical work carried out as a graduate student. The graduate student is the one who is responsible for leading and guiding the activity of a group of students from the younger years. The art of negotiation will thus be honed through their actions of persuasion and motivation, for the involvement of those junior colleagues in the execution of tasks, not through the promise of being remunerated with a certain amount of money, which they could not do anyway, but by identifying intrinsic motivating factors, such as the values or symbols to which they adhered.

Factor 6 is called management by exception. It is the type of leadership that involves corrective criticism, negative feedback, and negative reinforcement. Management by exception can take two forms: active and passive. An example of active management by exception can be illustrated by the leadership of a commander who monitors daily how subordinates approach assigned tasks. He quickly corrects soldiers who are late in carrying out orders received in the prescribed manner.

A leader who uses the passive form intervenes only if standards have not been met or problems have arisen. An example of passive management by exception is illustrated by the leadership of a subunit commander who gives a subordinate a poor performance evaluation without ever talking about it in person or about his previous performance on the job. In this case, communication and performance-focused counseling are the elements that will need to be mastered in order to avoid reaching such unproductive situations. Providing feedback is essential in achieving organizational performance and interpersonal communication is what favors creating the conditions for achieving it.

As a partial conclusion, it is obvious that transformational leadership has, as its finality of actions, a result that exceeds, as an effect, what can be achieved through transactional leadership. The achievements obtained through transactional leadership are predictable and do not have any performance element, but are just simple achievements of the standards in force. On the other hand, the application of transformational leadership materializes, from a performance point of view, in results far above the usual standards.

Transactional leadership differs from transformational leadership in that the transactional leader does not individualize the needs of followers nor does he focus on their personal development. Kuhnert analyse this difference and conclude by the idea of that transactional leaders exchange things of value with followers in order to advance both their own agenda and that of their followers.[5]

Factor 7 represents the absence of leadership. The name *laissez-faire* comes and reinforces the description of the type of leader who abdicates responsibility, delays decisions, does not provide feedback and makes little or no effort to help followers meet their needs. There is no interaction with followers or attempts to help them develop. An example of a laissez-faire leader can be considered that of an air base commander who does not convene periodic meetings with subordinate group/squadron commanders, does not have a vision or long-term performance plan for the unit, acts detached and has minimal physical contact with subordinates.

The theoretical elements advanced through this theory will prove insufficient to help an individual identify the level of training he possesses in leadership competence.

It is not enough to possess the minimum knowledge; it is also necessary to know the degree of excellence in which you master it.

This aspect was thought and performed, in the form of a measurement instrument of transformational leadership, by Bass, who created, and later developed, a questionnaire called the Multifactor Leadership Questionnaire (MLQ). This questionnaire has become, over time, the most commonly used instrument worldwide.

4. CONCLUSIONS

As I have presented in the lines above, the transformation process of a leader begins at school, when those specific knowledge, skills and habits for the formation of leadership competencies are defined and are finalized throughout the entire career, either through education or experience. What is important, in my opinion, is how you set off on this adventure. Hence the conclusion that the way you set off is fundamental and the methods by which this is achieved will depend on the mastery of those who are part of the party that takes care of achieving this.

Training programs must be designed in such a way that their purpose coincides with the desiderata proposed by the graduate model. The theory supports the idea that transformational leadership is far beyond transactional leadership and the military organization must adopt a way of preparing its human resources by emphasizing, more than it currently does, the development of human resources from the perspective of using transformational skills. This can be achieved by reviewing and rethinking the educational contents so that they can support the effort made in this regard.

The elements that need to be emphasized and that were presented previously would, in my opinion, be well implemented within some disciplines, as basic knowledge and skills, and supplemented with practical activities for sedimentation and deepening in terms of the use and application of skills. In this way, it can be stated that the proposed goal can be achieved, the one of training and subsequently developing the air force officer capable of building trust, acting with integrity, inspiring others, encouraging innovative thinking, coaching people, rewarding achievement, monitoring mistakes, fighting fires without avoiding involvement. Such an example of a leader will be able to display leadership that proves to be productive for the military organization by generating extra effort, being efficient and generating satisfaction among their subordinates.

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TEACHING AVIATION WEATHER VOCABULARY TO ROMANIAN AIR FORCE CADETS – QUALITATIVE ERROR ANALYSIS

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Abstract: *The article provides a qualitative analysis of aeronautical meteorology adult learner errors in ESP. The discussion revolves around a few main vocabulary topics in aeronautical meteorology: precipitation, the atmosphere and their relevant effects for air traffic management. The corpus is based on traditional vocabulary-focused activities: matching and multiple choice lexical reinforcement exercises. Based on a previous quantitative analysis of the same real-life, classroom-produced materials, this approach is meant to provide complementary information concerning the challenges that Romanian undergraduate Air Force cadets have encountered, in an attempt to map noteworthy insecurity areas, to explain why they arise and suggest potential solutions to be integrated in everyday teaching practice.*

Keywords: *metacognition, ESP, aviation weather, error analysis*

1. THEORETICAL BACKGROUND, PURPOSE AND METHODOLOGY

We have previously advocated for the integration of metacognition and error analysis into broader second language (L2) learning frameworks [1], based on groundwork set by recent theoretical developments in Foreign Language Teaching (FLT) [2, 3, 4, 5, 6, 7, 8].

To add to this line of thought, we intend to come up with a series of two-stepped researches – quantitative and qualitative – meant to analyze errors in Aviation English made by Romanian adult (undergraduate-level) learners. Precisely we set out to generate two analyses per classroom-produced corpus, one quantitative, the other, qualitative, to come up with a set of useful conclusions. A first, quantitative step has already been undertaken in the article cited above [1], concerning the quantitative distribution of mistakes around common topics in aeronautical meteorology. The corpus used in the said approach was made out of answers given to traditional matching and multiple-choice exercises.

As the second, complementary interpretation of the first (aviation weather-oriented) corpus, this article provides a qualitative perspective on the errors quantified and mapped in *Teaching Aviation Weather Vocabulary to Romanian Air Force Cadets – Qualitative Error Analysis Based on Matching and Multiple-Choice Exercises* [1], and will rely heavily on our previous results.

Of course, also we legibly build on Ian Stephen Paul Nation and Teresa Mihwa Chung's the idea that topic-centric acquisition is essential in vocabulary acquisition, especially when it comes to specialized lexicon teaching and learning in applied linguistics and English for Specific Purposes (ESP) [9, 10].

But beyond the theories which laid the foundation for our cited article, we will need to make mention of two other directions which provided methodological and theoretical background we use in the present article and which have been instrumental in shaping the necessary framework for our qualitative interpretations.

Concerning methodology, our first concerns were ethical. In this sense, we openly specify that all the materials cited and investigated in the series have been anonymized for data privacy concerns and the learner's permissions to use the materials as corpus for the said research purposes under the condition of anonymity has been obtained *a priori*. Then, in terms of the actual qualitative methods used in this contribution, we followed in the footsteps of seminal contemporary authors in the field [11, 12, 13].

Of course, in addition to the works of reference used in our quantitative approaches, specific theoretical standpoints have articulated our approach, especially as our objective set from the very beginning of the project was for the series to highlight the bearing of first language (mother tongue or L1) interference in FLA, to the ultimate aim of addressing the basic difficulties that Romanian users of ESP in the aviation industry come across during their learning process. Thus, an innovative concept which lies at the very core of our qualitative approach is the concept of mental translation. At the intersection of cognitive psychology, the psychology of language and applied linguistics [14], mental translation has been first defined by Richard G. Kern , as the "mental reprocessing of second language words, phrases, or sentences in the first language forms" [15], i.e., by heavily relying on formal resemblance and displaced/transplanted language structures from L1 into L2. Of course, this leaves room for development and it is a major prerequisite of L2 learning, this also leaves room for mistakes based on false resemblance (e.g., if we only consider the common problem of what is popularly called 'false friends') and dysfunctional, malformed structures (e.g., the wrong use of prefixes/suffixes based on L1 in word-formation, word-order as a major issue in syntax at both phrase and clause/sentence level – and not to mention more subtle, but essential structures such as abbreviations when we consider aviation English). It is no wonder that the concept has had a rather thundering debut (if the pun is to be permitted) in applied linguistics after its emergence with Kern [15] and Cohen [16] during the last two decades [see 16, 17, 18]. Starting with 2020, it has reached classicization in high-authority theoretical sum-ups such as the periodical ones proposed by Routledge/Taylor & Francis Group [see 19] and has just entered the Romanian scientific space [see 20].

2. SUM-UP OF THE PREVIOUS RELATED QUANTITATIVE ANALYSIS

As explained in the first section of this contribution, this is a second article in a series and is meant to complement or accomplish our first two-fold take on Aviation English with a qualitative interpretations of the results entailed by our previous qualitative research of lexical competence in aeronautical meteorology. In the article we have dedicated to the quantitative analysis of vocabulary errors by topic in aviation weather vocabulary as a higher education study subject, titled *Teaching Aviation Weather Vocabulary to Romanian Air Force Cadets – Qualitative Error Analysis Based on Matching and Multiple-Choice Exercises* [1], we have shown that the distribution of errors varies visibly from topic to topic. As we set out to bank on our findings there, a brief presumptive overview of the core quantitative outcomes is unavoidable as the opening act of the upcoming demonstration.

To come up with a highly efficient and legible summary, meant to be as illustrative and user-friendly as possible, we have used a simple freeware online software (Pie Chart Maker, available at https://piechartmaker.co/) to create descriptive pie charts and bar graphs as visual support.

As a general outline of our results, there are three pertinent, quantified error distributions that need to be mentioned as a starting point here. The first distribution – shown in figures 1, 2 and 3 – displays the proportions of what we will call here the "Topic item count", i.e., the comparative quantitative analysis of 'wrongly solved items' around the selected major topics in aviation weather terminology. Mention must also be made that the lexical structures were organized under 3+1 major topics, i.e., Topic 1: Weather and Precipitation (T1-W&P), Topic 2: Air Movement (T2-AM), Topic 3: Sky Cover and Visibility (T3-SC&V), while Topic 4, titled Other* (T4-O*), was supposed to cover for miscellaneous related vocabulary [1].

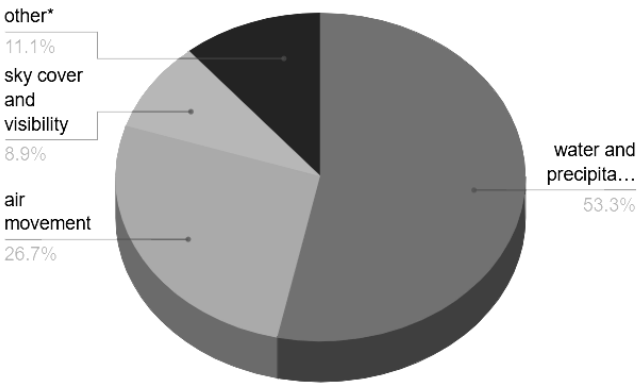


FIG. 1 Topic item count pie (percentage of errors per major topic)

The 'Topic item count pie' above (in Fig. 1) is a comparative visual image of the proportions in which the major topics were represented in the classroom materials used as corpus. This visual shows information which must be taken into account in the interpretation of the error count in the bar graph below (in Fig. 2).

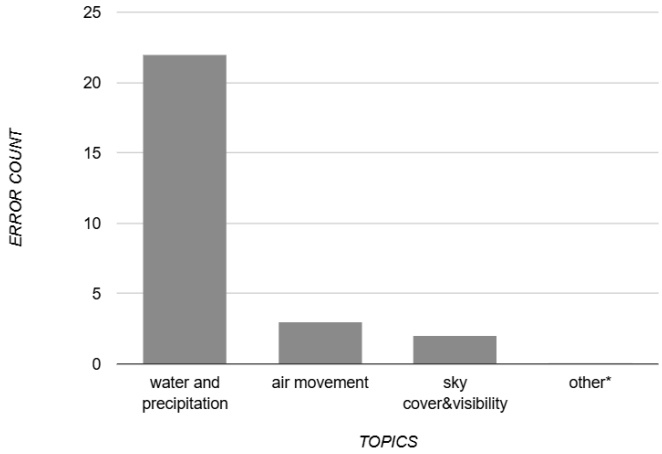


FIG. 2 Topic error count bar graph (number of wrongly solved items per major topic)

The 'Topic error count bar graph' in Fig. 2 shows the number of mistakes related to each topic as shown by the corpus. More specifically, out of 27 errors (versus 94 correct answers out of a total of 121, as shown in another table in the same article) [1], there were 22 errors related to Weather and Precipitation (T1-W&P), 3 to Air Movement (T2-AM), 2 to Sky Cover and Visibility (T3-SC&V), and no errors under miscellaneous structures in the given semantic field (for further details, see [1]). Thus, topics 1, 2 and 3 are the topics deserving a closer look, even though the proportion of error per topic differs greatly.

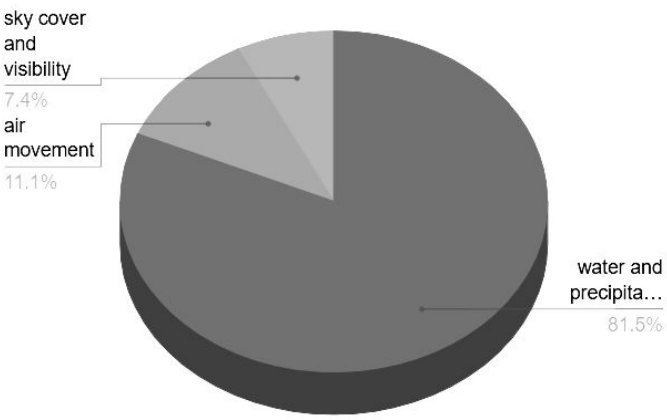


FIG. 3 Topic error count pie

In this sense, the "Topic error count pie" in Fig. 3 clearly displays the semantic field which posed the greatest difficulty to the cadets involved: T1-W&P attracted 81.5% of all mistakes, with T3-SC&V on second place (much less represented in the tests and/or exercises than T2-AM – 8.9% versus 27.6% –, it collected a comparable error count; as the figure shows, T4-O* is not represented at all on the error chart at a relatively higher level of representation than both T2 and T3). But as a first qualitative remark, note must also be taken that the vocabulary under T4 is by definition less specialized and less technical than the other three.

The second relevant distribution based on this quick outline – shown in figures 4, 5 and 6 – displays the proportions of errors per sub-topics. Under T1-W&P, we had organized the following sub-topics: T1.1-METAR codes, T1.2-buildup, T1.3-snow/ice, T1.4-runway conditions; under T2-AM: T2.1-wind, T2.2-turbulence and chop; and finally, under T3, given the low representation of the topic, we had organized no sub-categories [1]. Under Figure 4 we generated an visual presentation of the mistake count per each sub-topic.

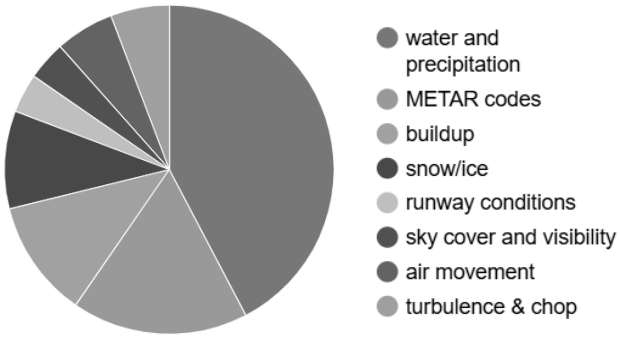
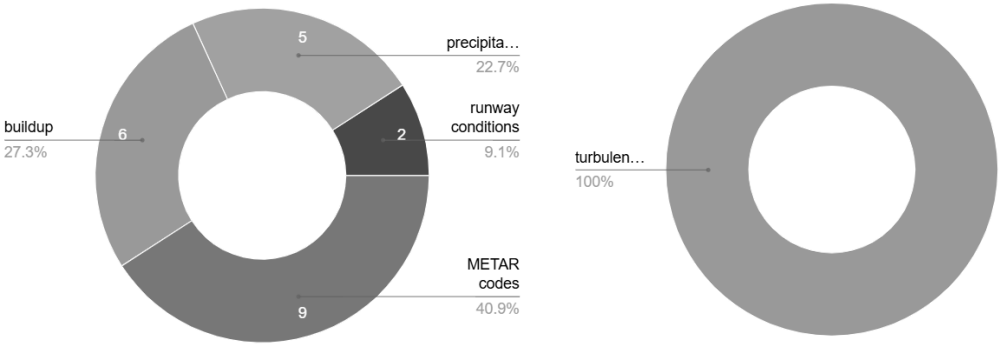


FIG. 4 General sub-topic proportions (number of wrongly solved items per each sub-topic)

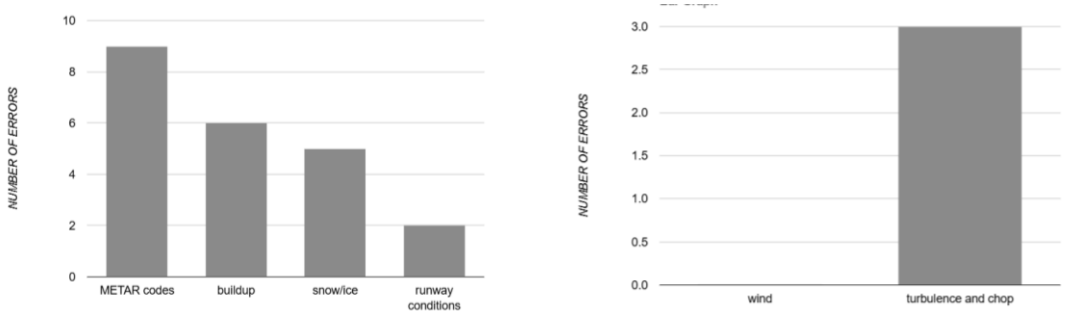
However, it is also relevant to have a closer look at the error count under each sub-topic as organized per each of the major topics dissociated as such – major topics T1-W&P and T2-AM (Fig. 4).



(a) (b)

FIG. 4 Error count proportions (percentages) for each of the sub-topics under major topics T1-W&P (a) and T2-AM (b).

While under T2-AM, the only semantic field causing visible difficulty was T2.2-turbulence and chop, under T1-W&P there is a more proportional distribution of errors, with runway conditions causing the smallest number of problems. The bar graphs below (in Fig. 5) display the numeric value of the same comparative proportions of T1 and T3 sub-topics.



(a) (b)

FIG. 5 Error count for each of the sub-topics under T1-W&P (a) and T3-SC&V (b).

Given the summary of results in this section, what we need to considered under the qualitative analysis are the three major topics covering Weather & Precipitation vocabulary (T1-W&P), Air Movement (T2-AM), and Sky Cover & Visibility (T3-SC&V), with a higher focus on T1 sub-topics in the following order of their relevance T1.1-METAR codes, T1.2-buildup, T1.3-snow/ice, T1.4-runway conditions and T3.2-turbulence and chop. However, T2 will also be briefly discussed, under both sub-topics, as well as T4-Other*.

3. QUALITATIVE ANALYSIS

3.1 Overview. Even though the general proportion of errors among against the total number of answers is rather low (27 wrong answers out of 121, i.e., a total error percentage of 32.67%), considering the degree of specialization of the language structures involved, certain vocabulary fields and terminologies seem to require special attention. Leading, with a umber of 22 errors out of the total of 27 is the semantic field of weather and precipitation [1]. Out of these, METAR codes ranked first, with 9 mistakes, buildup resulted in a number of 6 mistakes, snow and ice caused a similar proportion of 5 mistakes.

Under air movement, the semantic field of winds was fully unproblematic, while turbulence and chop ranked 4th with 3 failed answers. Runway conditions caused by liquid precipitation and errors related to sky cover and visibility both counted 2 wrong answers, ranking last. In what follows, we will analyze each problematic sub-topic and we will also interpret the non-problematic character of T2.1-Wind and T4-Other*.

3.2 The semantic field of weather and precipitation: T1.1-METAR codes. Most mistakes under Topic 1 were related to METAR codes. A closer look at the corpus shows that all occurrences concern almost all the freezing and frozen precipitation types (phases) included in the items, even though the subjects were aware of the codes based on previous knowledge in specialty-related disciplines. According to our observation, GR (hail) is often confused with PL (ice pellets), GS (graupel, also called snow pellets or small hail) is also confused with GR (hail), less frequently, FZRA (freezing rain) is also mistaken for GS; IC (diamond dust / ice crystals) and GR (hail) are also confusing.

Of course, at least two visible explanations can be found here. One major difficulty is generated (with a general term) by form. First, the presence and configuration of the codes themselves is difficult to handle for Romanian users: the chosen acronyms and/or code descriptions do not only resemble greatly (especially GR, GS, hail/GR and small hail/GS, or PL/ice pellets and GS/snow pellets); the descriptors also alternate (hail/GR vs. small hail/snow pellets/GS vs. ice pellets/PL); moreover, there is no connection between the English noun phrases and the initials/letters in the acronym (IC for diamond dust is a further example here, to add to the other illustrations displayed above); to add to all of that, they do not resemble the Romanian terminology at all – not even when such terminology is present.

Thus, as far as form is concerned, the teacher may explain that GR and GS are based on the French words for hail (*grêle*), while in the USA it includes small hail, and again, on the French word for small hail (*grésil*), respectively; they may insist on these issues during practice and reinforcement exercises. But they will remain problematic for most learners and sometimes, they will always cause the entry-level Professor to work extra to remember them.

Obviously, the other difficulty (i.e., the lack of corresponding vocabulary when it comes to fine-tuned terminological discriminations) is cultural in nature: while English has a wide range of precision fin-tunings when it comes to all precipitation types (be it liquid, freezing or frozen), the Romanian vocabulary is much poorer, which even generates problems in specialist dictionaries. For example, the Second Edition (issued in 2014) of the Meteorologic Dictionary (*Dicţionar Meteorologic*) authored by Runcanu *et al.* [21] is fairly unable to make some of these distinctions for sheer lack of differentiable Romanian terms. As one example out of many regarding precipitation, it provides the equivalent "măzăriche moale" (where "moale" means soft) for small hail/snow pellets/GS, but for "măzăriche tare" (where "tare" means hard/solid/dense), it provides both ice pellets and small hail, that is to say, snow pellets as equivalents, while the genus "măzăriche" also corresponds to "small hail" [21]. The layer of cultural difference is probably a double, superimposed layer: while the British climate may have originally resulted in richer vocabulary concerning precipitation, a contemporary cultural feature added greatly to it as far as aviation weather terms are concerned: the fact that English remains the main international language of aviation in general, with some terms never being used in vernacular languages – and the vocabulary of METAR is one of them, just like radiotelephony phraseology and other aviation-related codes (e.g., codes related to sky cover), including the above-mentioned weather phenomena as designed by ICAO (the International Civil Aviation Organization) and other international organizations. Thus, there wasn't much use in actually setting off on a lookout for local equivalents.

From another perspective and as a side remark, it also relevant to mention that most of these errors occurred with the same subjects, mainly subjects A8 and A9, followed by A10 (the last with significantly fewer mistakes, i.e., one mistake concerning IC and GR). Thus, learner plain English competence may as well paly a role here, as well as their cognitive skills, psychological profile etc. Lack of personal interest or poor learning techniques might also be taken into consideration, while lack of professional interest cannot (they major as Aeronautical Meteorology officers).

3.3 The semantic field of weather and precipitation: T1.2-buildup, T1.3-snow/ice, and T1.4 runway conditions. "Compacted snow", "snow bank", "snow rut", "snow drift", "pool of water", "standing water" and "puddle" generated most of the difficulties around water, ice and snow buildups and runway conditions, with some students becoming totally undecisive or marking several or all of the answers as correct. Students A8 and A10 also found these vocabulary items difficult to handle as well, with A10 marking all four answers in a multiple choice 4-answer grid, and A8 marking two wrong answers out of four. Other students (B3) made less serious mistakes, e.g. confusing such rather similar terms as "compacted snow" and "snow bank".

These noun phrases are rather plain English structures, so one should expect them to seem friendlier to learners than what the results show. However, there is one rather clear explanation here as well (besides of the fact that some terms are rather similar, as shown): it is the lack of corresponding terms in the subjects' mother tongue (L1) that generates these difficulties: "bank" exists as "bancă" (a financial economic agent – which is also a paronym of the Romanian word for "bench") or seems similar to "banc" (standing for a heap of sand, mud, or cobbles, but also for a group of fish or other marine life forms); "rut" is a false friend of the Romanian "rut", meaning sexual activity period in mammals; "drift" has no semantically similar equivalent in context, and so on. Thus, the lack of correspondents in L1 for these plain, but less usual noun heads affect the legibility of the entire phrases, especially for lower-intermediate students.

3.4 The semantic field of air movement: T2.1-wind. Wind-related vocabulary structures were fully unproblematic for good reason: most of the specialist terminology is extremely similar and recognizable in form based on L1, e.g. anabatic (L2/EFL) – anabatic (L1), catabatic (L2/EFL) – catabatic (L1), geostrophic (L2/EFL) – geostrofic (L1) etc. Other terms are easily understood based on basic-level plain English knowledge, e.g. downdraft or down draught vs. updraft or up draught, veering wind, crosswind etc. Therefore, formal similarity and the basic intelligibility of noun phrase elements, as well as cultural correspondence can account for the lack of challenging vocabulary management.

3.5 The semantic field of air movement: T2.1-turbulence and chop. In this case, most errors revolved around confusions between semantically close noun phrase designators in the Beauford Scale, such as moderate versus severe turbulence. Two rather competent (upper intermediate-level) cadets displayed insecurities or even faulty matches in this area (C1 and C3). It may be that the modifiers were processed as unspecific (even though similar terms in both form and meaning exist in Romanian as well: "moderat" and "sever"), but it is likelier (given the strong L1-L2 correspondence) that the main difficulty was generated here by the poor acquisition of specialist definitions than lack of English proficiency – in the sense that the terms were understood, but the phrases were incorrectly associated with specialized definitions due to the poor internalization of and/or interest in the corresponding specialist knowledge (especially since for C1 and C3, the given practice groups major in ATC and air staff, which makes meteorology adjacent to their main specialist language corpus).

3.6 The semantic field of sky cover and visibility. METAR cloud coverage codes were again responsible for the errors committed under this topic. BKN (broken) and SCT (scattered) were the most problematic and were confused for one another by students whose main qualification is air staff – so again, the vocabulary is related, but adjacent to their targeted job profile, which could account for the poor management of knowledge in this area. Just like with turbulence and chop, the definitions seemed to be mor challenging than the abbreviated phrases, since again, the two terms are next to each other in the METAR scale.

3.7 Miscellaneous related vocabulary structures. A small number of similar and related structures in Aviation English were introduced in the tests and exercises in the corpus for safe discrimination, such as "drift" (as opposed to "snow drift", for example). These differentiations resulted in a total number of zero mistakes, which shows that the subjects have a firm grip on and outstanding control over the separation of major specialist vocabulary areas withing the field of Aviation English.

4. LIMITATIONS

One limitation of the present study has already become visible under the analyses in section 3, while not readily obvious under the quantitative interpretation alone. It is the fact that besides individual difference in proficiency levels as far as plain English is concerned (inducing unavoidable effects in the management of specialized vocabulary), student motivation in seriously dealing with vocabulary which seems less important or adjacent to one's targeted sub-specialty may also affect results, such as some of the mistakes under topics 2 and 3 (concerning air movement and sky cover/visibility conditions, respectively).

Another (somewhat related) limitation is the distribution of items per topic(s), as weather and precipitation hold the major focus with more than 80 percent of the total number of items involved. One justification of this fact is simply that some of the materials were not originally designed with research in mind (as corpus); as they were deemed relevant, they were added to the main corpus. Another (the main) explanation is the intentional focus on precipitation in class (as also reflected by the approved curriculum and course syllabus) since the topic perceptibly stood out as a special challenge we have noticed cadets in various generations tend to struggle against during class activities and exams.

We also intend to further develop this pre-research experiment (done within the framework and set timeline of a research project meant to support further analyses – for clarification, see the Acknowledgement section), as new generations of cadets agree to furnish additional material.

5. CONCLUSIONS

The complementary qualitative analysis provided by this second fold in our research in the English of aeronautical meteorology has proven its efficiency and has demonstrated three main points. On the one hand, it has highlighted Topic 1 – Weather and Precipitation as the major difficulty area for Romanian learners. The interpretation of the errors can provide both tutors and learners with food for thought as far as classroom solutions, teaching/study methods and points of interest are concerned, among which the reinforcement of knowledge through intense exercise may meet the need to introduce a few advanced language theory notions such as noun phrases and their functioning, or even to research abbreviations and their form and/or contextual use in Aviation English.

Techniques such as the keyword technique or word part analysis suggested by Nation need to be made good use of [10] in congruence with the more general (and useful) topic-centered teaching of vocabulary. Syllabus adjustment and specific class material generation are also crucial, as some topics may prove to be more challenging than others.

At the same time, it also showed the role of L1 interference and mental translation in language acquisition. Therefore, classroom activities should also focus on shortlisting and showcasing essential areas of interference, with a focus on form and culture as the core points of interest in classroom materials design and research, at all times, including as part of the course provider's (new) language input methodology. Terms such as 'false friend' or 'paronym', 'homonym', 'homograph', perhaps even 'mental translation' [15] and/or 'semantic transfer' as defined by Jiang [17] may be of use in the classroom, as concisely explained as possible. Last but not least, incongruencies between L2 and L1 must be spotlighted and more than that – explained, for students to be given the possibility to logically associate, contextualize and remember difficult terminology. This is not the same as using L1 in the classroom to redouble L2 immersion: this is about providing logical support in English as before, but while referring (or even eliciting) wrongful metal translations from one's students to then provide them with input they may feel (or intuitively become) further psychologically motivated to remember.

Last but not least, the present qualitative complement to the quantitative analysis of errors has shown that the cultural dimension of knowledge which needs to be integrated here is much more relevant than usually expected in the area of what is generally termed as 'technical vocabulary' [9] or ESP (as a sub-branch applied linguistics). And what we mean is not just a simple matter of including elements of etymology (as with the analyzed METAR codes describing precipitation) or considerations around learner psychology: cultural elements are at the root of the semantic-symbolic organization of language as worldview and the general organization of experience and interpretation, a matter of both common and distinctive identity features evolving together or separately in time and space and resulting in equivalence/correspondence or the lack of congruity between L1 and L2 language structures. This realization in both tutors and adult learners seems to be of the essence in associating sign and meaning in general and in opening foreign language acquisition / teaching techniques to self-aware, constructive error analysis and metacognition as suggested by contemporary directions in specialist literature [2, 3, 4, 5, 6, 7, 8].

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HUNGARIAN LANGUAGE MEDIA IN ROMANIA: SETTING MINORITY PERCEPTIONS OF RUSSIA's WAR AGAINST UKRAINE

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Abstract: *This paper studies the framing of Russia's war against Ukraine in Hungarian language online media in Romania. It considers the research of various authors and organizations who described the Hungarian language media system in Romania as subject to the Hungarian Government's influence, due to the centralized media ownership and financing structure, but also as supporting ethnic parallelism. As recent surveys show the Hungarian ethnic minority in Romania is less critical towards Russia's aggression of Ukraine, in contrast to the Romanian majority, our research objective is to study how the war in Ukraine was presented to the Hungarian minority. We conduct a content analysis of news published between May 2024 – January 2025, to problematize on the potential of the media to shape the public perceptions of its consumers.*

Keywords: *media, Hungarian ethnic minority, Russo-Ukrainian war, public perceptions*

1. INTRODUCTION

Russia's full-scale invasion of Ukraine in February 2022 was condemned by the Western society, with NATO and EU leaders expressing firm stances against the aggressor and reiterating over the course of the conflict their support for Ukraine. This support was followed by practical measures across various instruments of power, as NATO and EU member states, conducted efforts to help Ukraine to resist the invasion, and deter Russia.

A full-scale war in Europe was unimagined and it generally shocked public opinion across most European and transatlantic states, mobilizing decision makers to react promptly in support of Ukraine. The level of support and involvement of the states differed, however, from the very beginning, both in terms of taking practical measures (like imposing sanctions against Russia, or cutting previous deals), but also in the leaders' public discourses about the war, with Hungary being considered an outlier in EU, due to its unpopular stances.

The securitization framework referring to the discursive representation of threats that lead to policy measures, proposed by scholars associated with the Copenhagen School [1], provides some clarity on the Hungarian Governments' approach towards the military aggression.

Studying the discourses of the Hungarian Prime Minister Viktor Orbán and his apparatus with regards to the Russia-Ukraine war, shortly before the invasion, and in the first months of the war (1 January – 3 April 2022), to describe Hungarian security identity

in the context of the confrontation, Göransson highlights [2], among others, that the war was depicted as an impersonal force, with scarce accusations of Russia. The Hungarian government promoted a "Hungary first" discourse, responsible for itself and its population, including Hungarians leaving in neighboring nations, especially those in Transcarpathia, with no moral obligations for helping Ukraine. Hungarian political leaders discursively constructed the threat posed to their national security in the changing geopolitical environment by victimizing Hungary and promoting the following themes, as the conflict escalated: Hungary as a Central European state risks being a victim in a conflagration between the West and the East; Ethnic Hungarians in Ukraine might be subjected to restrictive Ukrainian minority policy; Hungary will not let itself drift/be drawn into the conflict. While "othering" the West and East, Ukraine (in relation with minority policies) or its political opposition, the Hungarian Government suggested that Hungary is ready to respond together with its allies to a military threat, but more is needed to be done in order to ensure economic and energy security. Thus, measures such as imposing sanctions (proposed by the West and the political opposition) or terminating the contract with Russia for building the Paks II nuclear power plant (proposed by the political oppositions), were portrayed as "immediate dangers" that would draw Hungary into war, even if they did ultimately agree with different sets of sanctions.

Hungarians' public perceptions appear to be generally aligned with the stances expressed by the Government. In November 2023 national consultations, it resulted that 69% of the population was against providing support to Ukraine, until Hungary receives the EU funds it is allegedly entitled to, while 74% were against financing Ukraine's arming [3]. In another survey from October 2024, the number of Hungarian respondents who reported negative perceptions of Russia decreased. Among FIDESZ voters, 41% considered Russia's activities an aggression, while 44% believed that Russia started the war to defend itself [4]. Another Telex survey [5] showed that the majority of Hungarians (61%) opposed Ukraine's EU membership in 2024, but in April 2025 the results of another survey [6] showed that the opinions were more polarized. While 47% of respondents agreed with Ukraine's accession to EU, 46% were against. Hungary announced a referendum on the topic, whose results are to be announced in the summer of 2025. Meanwhile, the FIDESZ Government sent letters to its citizens, explaining the alleged drawbacks for Hungary and its citizens if Ukraine joins EU, emphasizing severe economic issues for families, farmers, but also for security and the labor market [7].

Hungary's policies towards the Hungarian minorities in neighboring states are widely known as having strengthened since FIDESZ took office in 2010, with some of the measures causing dissatisfaction among "host" states, such as the possibility for Hungarians minority communities to acquire Hungarian citizenship. The investments in kin communities abroad have also been widely common ever since. Hungary considers itself the guardian of Hungarian ethnics abroad, which are considered a part of the "Hungarian political nation" [8] that are expected to contribute to language and culture preservation. As we argued previously, Hungary achieves the "virtual unification" of the "Hungarian political nation" by implementing a "soft power" approach, which is most visible, in Romania's case, through investments in various sectors, one of the most questionable being the Hungarian language media system [9]. In Romania, Viktor Orbán is highly appreciated in the Hungarian minority community, an opinion poll in 2020 showing that 92% of Hungarians in Covasna (Hungarian majority county in Romania) reported confidence and great confidence in the political leader [10]. Consequently, the Hungarian community members' consistent stances with the Hungarian Prime Minister, even on the topic of Russia's war against Ukraine, should not come as a surprise.

In the latest war-related polls with the Hungarian community in Romania, it resulted that 49% of Hungarians (by contrast to 44% in 2022) believed that the war was provoked by Ukraine, because it strengthened relations with NATO. In the Romanian society only 21% expressed agreement on the matter in 2024. Similarly, while 46% of Romanians believed that Russia is the aggressor in 2024 (also decreasing by contrast to 2022), only 19% Hungarians in Transylvania shared the same opinion [11]. Frequently such results are interpreted in the Romanian media landscape as a result of the minorities' consumption of Hungarian government-controlled media.

According to Kiss [12], the Hungarian minority media system in Romania supports "ethnic parallelism" which translates in a lack of participation of the minority members to the public sphere in Romania, as they live in the state but more connected to Hungary. The perspectives presented in Hungarian online media in Romania lack pluralism of perspectives due to the concentration of the media. This favors the Hungarian Government's efforts to frame the reality of the Hungarian community.

The most popular Hungarian news websites in Romania, belong either to the FIDESZ' sponsored Association of the Transylvanian Media Space (ATMS) or are affiliated with the Democratic Alliance of Hungarians in Romania (DAHR). If prior to 2011 the relation of FIDESZ and DAHR has known some tensed episodes, reportedly a "non-aggression pact" was established between the political parties [13], which resulted in favorable media coverages of both.

Guided by the objective to problematize on the potential of Hungarian-language online media in Romania to shape the perceptions of the Hungarian minority community in Romania, in relation with the war in Ukraine, we conducted a content analysis of the media coverages, with the purpose to investigate the framing of the war and involved parties (belligerents, relevant actors supporting Ukraine).

2. RESEARCH METHODOLOGY

2.1 Theoretical approach and framework. The analysis of the media content as a research method is usually used as follows: as an independent method; in research designs that seek to explore the influence over the contents; and in studies that seek to analyze media effects [14]. Our research corresponds with the last approach, as we seek to problematize on the influence that the media coverage about Russia's aggression of Ukraine has on its consumers.

In analyzing the potential of mass media to shape public opinion, we adhere to Georg Gebner's cultivation model, that acknowledges both the power of the media and the selectiveness of individuals in processing contents [15]. This implies that meaning is constructed in accordance with the audience's culture.

Considering the main approaches of media discourse analysis, we considered the analysis of media framing as adequate to our research purpose. According to Cotter [16], the concepts of framing and narrative, familiar to discourse analysts, are increasingly more used by media studies scholars. Discourse analysis of (news) media has three components: the textual dimension (the story materialized in spoken, written or visually represented text), the process of news production and its alignment to audiences. As we are interested to study the representations of the war in Ukraine in the media, our research refers to the analysis of the textual dimension of the media. Most linguists studied the text from two vantage points: the first consisted of analyzing the discourse structure and its linguistic function, while the second consisted of studying the impact of the discourse that "bears ideology".

The concept of framing introduced by Goffman [17], was a valuable contribution to the first vantage point, according to Cotter [16], which seeks to provide insights for the study of the structure, function and effects of the text, characterizing the very important role of the media in shaping public discourse.

The framing theory, initially proposed by Gaye Tuchman who compared frames with a window to see the world [18], offers an operational model for studying media framing, by considering Entman's approach [19]. For the theorist, **to frame means to select certain aspects of the perceived reality and to make them salient in the communicating text**, so that **they convey a certain problem definition, causal interpretation, moral evaluation or remedy suggestion**. Entman further details that the functions of frames in a text are either to define problems (determine what an agent does, with the cost and benefits involved, measured by common cultural values) diagnose causes (identify the forces that cause problems); make moral evaluations (evaluate the causal agents and their effects) or suggest remedies (offer and justify problem treatments). While Entman recognizes that frames are common in more elements of the communication process, he explains that texts contain frames that represent reality which are manifest through the presence or sometimes absence of certain words, sentences, phrases or stereotypical images which compose judgement clusters. However, ultimately, the presence of frames in a text is not a guarantee they will influence the audiences' thinking, as salience is a product of the interaction between the text and the receiver.

Another relevant contribution of framing is that it offers an operational definition for understanding the notion of dominant understanding of a text. Entman argues that the dominant understanding is the problem interpretation, cause, evaluation or remedy which has the highest chance of being observed, processed and accepted by most people, and so, naming the dominant content is equivalent to naming the frame suggested in a text [19]. For the theorist, the study of mass communication also benefits from an explicit and common understanding of the concept of frames. In content analysis that seeks to understand the textual dimension of the media discourse, the main task should be to identify and describe the frame. By using Entman's theory we can investigate the salient frames about the war in Ukraine in the discourse of (news) media.

2.2 Type of research and research design. For the purpose of our analysis that seeks to understand the dominant contents promoted by Hungarian language online media in Romania on the topic of Rusia's aggression of Ukraine, we operationalized the following research question "What are the dominant contents promoted by Hungarian language online media in Romania with regards to Russia's aggression of Ukraine?", establishing the following study variables: frequency of news related to the topic, communicator, media objectivity and pre-eminent frame (as described by Entman's framing theory).

To conduct the analysis with a relevant body of articles, we conducted a multilevel sampling. The first level consisted of selecting relevant media sources – Hungarian language news websites in Romania by their popularity.

The selection of news websites by their popularity was made by the number of unique users in the month of April 2024 as tracked by Semrush – a digital marketing portal. The majority of the top listed websites were those known to be somehow connected or affiliated to the Hungarian FIDESZ Government, or to the major Hungarian political party in Romania – DAHR. For the websites affiliated with the latter, it is still common to receive funding from Hungary. From the list of monitored channels we chose to neglect three publications known as independent (atlatszo.ro, transtelex.ro and uh.ro), given their publishing of investigations that were critical towards the political control over Hungarian media. We were left thus with ten news portals with over 9000 unique viewers per month

at the date of the selection (szekelyhon.ro, maszol.ro, kronikaonline.ro, 3szek.ro, szatmar.ro, e-nepujsag.ro, hirmondo.ro, hargitanepe.ro, foter.ro, erdon.ro) as listed in the figure below (Fig. 1).

No.	News website	Addressability	Unique visitors/ April 2024 (Semrush)	Affiliation
1.	szekelyhon.ro	regional (Covasna, Harghita, Mureș counties)	411820	Hungarian Government ASMT
2.	maszol.ro	national	215116	RMDSZ Progress Foundation
3.	kronikaonline.ro	national	79675	Hungarian Government ASMT
4.	3szek.ro	local (Covasna county)	72218	Editorial staff (It promotes however on the portal websites that are part of ASMT conglomerate)
5.	szatmar.ro	local (Satu Mare county)	37049	RMDSZ Communitas Foundation
6.	e-nepujsag.ro	local (Mureș county)	17915	RMDSZ Communitas Foundation and supported by the Hungarian Government through The Bethlen Gábor fund
7.	hirmondo.ro	local (Covasna county)	13348	Hungarian Government ASMT
8.	hargitanepe.ro	local (Harghita county)	11660	Harghita County Council
9.	foter.ro	national	9502	Hungarian Government ASMT
10.	erdon.ro	local (Bihor county)	9208	Inform Media, owned by an investor that is close to the Hungarian Government

FIG.1 First level sampling (popular websites)

The second level consisted of collecting the news by using as a sampling model the "constructed week". According to Hester and Dougall [20], this model of sampling is more efficient than random sampling or consecutive day sampling, assuming that there is a systemic or cyclic variation of news, depending on the day of the week. While these authors argued that for a study population comprised of six months of Yahoo!News, two constructed weeks are sufficient for content analysis due to cyclical variations, in our research design, where we were interested in the framing of a specific topic in the news and its frequency, we studied the articles published over a period of almost eight months (26 May 2024 – 29 January 2025), by constructing 4 weeks and 4 days (news published over 32 days in total), with a sampling interval of 8 days (Fig. 2).

Month / Day	May	June	July	August	September	October	November	December	January	February
Monday		3-Jun-24	29-Jul-24		23-Sep-24		18-Nov-24		13-Jan-25	
Tuesday		11-Jun-24		6-Aug-24		1-Oct-24	26-Nov-24		21-Jan-25	
Wednesday		19-Jun-24		14-Aug-24		9-Oct-24		04-Dec-24	29-Jan-25	
Thursday		27-Jun-24		22-Aug-24		17-Oct-24		12-Dec-24		06-Feb-25
Friday			5-Jul-24	30-Aug-24		25-Oct-24		20-Dec-24		14-Feb-25
Saturday			13-Jul-24		7-Sep-24		02-Nov-24	28-Dec-24		22-Feb-25
Sunday	26-May-24		21-Jul-24		15-Sep-24		10-Nov-24		05-Jan-25	

FIG.2 Sampling structure by "constructed week" model

We collected the news both by using Feedly news aggregator and manually for the websites that were not compatible with it. This solution was less costly than the alternative represented by automated brand marketing tools which collect news (or mentions) based on key words. The latter solution would have allowed us to collect more news published during the eight months period that we covered, specifically on the topic of interest, but would have lacked one essential condition of research – replicability.

The research universe is represented by the total number of articles published by the news outlets during the study period, in the 32 days included in the sampling plan. We observed the variables in the published articles by manually analyzing the texts published in relation to the topic.

3. MEDIA FRAMING OF RUSSIA's WAR OF AGGRESION AGAINST UKRAINE

3.1 Frequency of war-related articles. The number of articles collected during the 32 monitored days, from the ten selected news websites, totalled 6160 news. We excluded the collection of sports and weather news, which are usually in dedicated sections on news websites, considering that we did not expect to find relevant coverage about the studied topic there. Out of the total number of collected articles, we selected primarily the titles that appeared to be referring to the research topic, which made up 220 articles. As the number shows, the topic of Russia's war against Ukraine has a low frequency in the news publishers' agenda. The highest number of relevant articles was published by erdon.ro website, which functions partly as a news aggregator, reposting news both from Hungary and Romania. As pointed on the media portal, daily developments in relation with the war, are selected from a selection of news published by the Hungarian media agency MTI, and the Hungarian media portals Magyar Nemzet, Mandiner and Origo. Both erdon.ro and the other monitored websites published both original and re-distributed contents from other news assets in Romania and Hungary.

3.2 Media objectivity. In most articles, the news websites covered the Russia-Ukraine war objectively, with scarce subjective interpretations with regards to the war or the concerned parties. However, as the framing theory states, despite apparent objective reporting, the news can still make salient a certain dominant content, by promoting a certain problem statement, moral evaluation, causal interpretation or suggest a remedy [19]. In the context of our study, the frames were most often identified in the quotes from communicators or paraphrases of the communicators' perspectives that were prioritized.

3.3 Communicator. The most active communicators quoted in media coverages about the war were the political leaders. As a significant part of the news referred to the Hungarian Government's perspective about the conflict, the most quoted leaders were the Hungarian Prime Minister Viktor Orbán, followed by the Minister of Foreign Affairs Péter Szijjártó, and, to a lesser extent, other Hungarian Government representatives. In another set of articles that did not refer to Hungary's perspective but were instead coverages of the war-related developments, the most quoted communicators were the president of Ukraine, Volodymyr Zelensky, Russia's president Vladimir Putin, but also other military/ diplomatic representatives of the belligerent states. From the states supporting Ukraine, the most quoted communicators were US representatives, including the former US president Joe Biden, and in specific instances European leaders, as certain support measures for Ukraine were announced. The perspective of Romanian leaders about the war had a low media coverage, with the former president Klaus Iohannis being the one quoted on most related mentions.

3.4 Pre-eminent framing of the war and of the parties involved. The war-related media coverage in the collected sample can be grouped in a few broad categories, with identifiable frames for each, as follows: Hungary's political approach/ vision about the war; EU & US support for Ukraine; Belligerent's perspectives of the war and battlefield developments.

a. Hungary's political approach/ vision about the war

In this category we have grouped an important number of news (73 articles), as Hungary likely sought to legitimize its approach towards the war and warring parties. With reference to Göransson's research [2], who studied the representation of Hungary's security identity as resulted from Hungarian government representative's speeches at the beginning of the full-scale war, we identified through frame analysis in news articles how Hungarian perspectives were presented in relation with the war itself, belligerent parties, partner states and organizations supporting Ukraine. In this regard, the following frames were salient:

- **The Hungarian Prime Minister is the only one who can avoid the war upon Hungarians**: This problem statement was particularly promoted during the European Parliament (EP) elections campaign, with the suggested remedy for Hungarians to "say yes to peace", by voting Orbán (and FIDESZ). A related frame was the one that presented Hungarian leaders responsible to keep Hungarians out of war.

- **The Hungarian Prime Minister is on a mission for peace**: This frame was several times presented in association with the frame that there is a "war psychosis" in Brussels [21]. Referring to Campbell's [22] definition of "othering" (articulate "other" as a threat to define own security identity) and Göransson's observations that processes of "othering" were used by the Hungarian Government at the beginning of the war to describe Hungary as a Central European country, situated between Russia and "the West", exposed to the effects of policies and actions of the parties in Ukraine [2], it was interesting to note how "othering" processes continued. In the news articles included in our sample, Orbán and his apparatus did not antagonize any partner state in particular, "othering" Brussels instead, understood as the EU block overall which is in the wrong side of history, and isolated in the United Nations [23]. Viktor Orbán even suggested that Brussels's approach could lead to the Third World War which Hungary fights to avoid, given its history and understanding of the consequences. Another problem statement about Brussels was that it is trying to silence those who support peace: under this frame, FIDESZ-KDNP also accused EU of sanctioning Hungary on its immigration policies, because it is against war. In some instances, Hungary also legitimized the Russian narrative that Ukraine is just a proxy in the war between the collective West and Russia, with Péter Szijjártó stating that **the West wants to fight until the last remaining Ukrainian youth** [24].

- **The Hungarian political opposition is pro-war "háborúpárti":** This frame, making a moral evaluation of the opposition, was also part of the FIDESZ EP campaign, with billboards stating "Stop háború. Június 9. Csak a FIDESZ"("Stop war. June 9. Only FIDESZ.") while depicting the faces of political opposition leaders and George Soros. The Hungarian Government frequently antagonized the opposition with this name-calling technique.

- **Hungary is pro-peace:** was another frequent moral evaluation frame invoked, in contrast to Brussels. It was vaguely explained how this alleged pro-peace path could be put into practice by the belligerents besides referring to peace talks. According to the Hungarian Government representatives' stances there are no solutions for war on the battlefield. When further developing what is at stake if the war continues, it is notable that Hungary avoids referring to wins/ losses for the parties and explains instead that the war has created enough damage for the whole world: energy prices increase, inflation and affected food security.

As a partner supporting this "pro-peace" position, from the EU block, Slovakia was seldom mentioned, given the known friendship of the two Prime Ministers. Such an example was the Slovakian Prime Minister's, Robert Fico, accusations towards Ukraine that even if they restrict petroleum exports from Russia his state will not change its pro-peace approach [25].

- In relation with Ukraine, the pre-eminent problem statement was that **Ukraine does not recognize minority rights**, a frame reiterated in the context of the topic of EU accession. Another contentious issue with Hungary referred to the fact that Ukraine is blackmailing Hungary for preventing arms delivery, by blocking energy supply (to both EU "pro-peace" states Hungary and Slovakia). In return, **Hungary** is presented **as helping Ukraine with the largest humanitarian action in its history** [26]. Moreover, following Hungary's take-over of the rotational presidency of EU Council, Viktor Orbán went on a visit to Russian President V. Putin, allegedly as a peace negotiator without consulting with EU partners or Ukraine. The accompanying frame in this case was that **Hungary can act as a peace negotiator**. In relation with Ukraine's request to join NATO, Orbán also clearly presented this as dragging NATO into war with Russia.

b. EU and US support for Ukraine

The monitored websites published constantly neutral news with regards to the military and financial support for Ukraine to resist war. Even if such news were narrated rather in an impersonal and informative manner, they do support legitimizing the Hungarian official perspective that **money and military equipment from the West serve Ukraine to continue the war**. We exemplify by the following:

- "Pentagon: the United States will send another arms shipment worth a quarter billion dollars to Ukraine" [27].

- "…it is essential to continue supporting Ukrainians for as long as necessary to guarantee the defense and security of the country and the entire continent", as stated in the official statement of the French President, Emmanuel Macron [28].

In contrast to the articulation of Hungarian Government's leaders' vision with regards to the war, there were significantly fewer contents where the Romanian political leadership presented perspectives on the war itself, the belligerents or about cooperation with partners on tackling war-related challenges. The identified frames were the following:

- **Romania is a safe state that will not be attacked by Russia** (a problem statement by the Romanian Prime Minister Marcel Ciolacu): While the frame likely sought to reassure the domestic audience, it is observable how, by contrast to Hungary's political leaders', in Romania the aggressor is portrayed as being Russia. Similarly, the Romanian President Klaus Iohannis referred to **Russia** as **the biggest risk for European security**.

- **Romania supports Ukraine:** this was salient mostly in news about the Patriot air defence system that was given to Ukraine, and training of pilots, even if the first issue was covered together with the disagreements on the matter.

c. Belligerent's perspectives of the war and battlefield developments

Another set of articles consisted of perspectives by the Ukrainian and Russian side with regards to the war. Part of these articles are political statements especially by the Ukrainian president Volodymyr Zelensky and the Russian president Vladimir Putin, and another set consists of battlefield developments where it resulted that both states did damage to each other, and that their actions were both offensive and defensive.

In news covering **Zelensky**'s quotes, oftentimes he is **presented as asking for more from the West to resist Russia**:

- "There is no nation that can stop such a war only by its own efforts. We need the participation of world leaders" [29].

- "Ukraine is grateful for Western partners' support, but the aid is coming too late, which complicates the situation in the first line" [30].

- "Inviting Ukraine to NATO would be a step towards peace" [31].

In news quoting Russian officials' perspectives, some dominant causal interpretation and problem definition frames were the following:

- **Inevitability of war escalation if the West continues arming Ukraine**.

- **Nuclear damage could be caused by Ukraine**, in the context of Putin's accusations that the Ukrainian armed forces attacked Kursk nuclear power plant [32].

- **Russia is ready to negotiate for peace with the new US administration** [33].

The battlefield related news show that the actions conducted by the states cause similar damages to the other. In the covered period, this become particularly possible as Ukraine was allowed by the US to strike into Russian territory with Western weapons but also following the invasion in the Russian region of Kursk. Thus, Russian perspectives on damages suffered are also reported, showing with similar claims that Ukraine has when presenting damages or war crimes by Russia, as follows: "…soldiers of the Ukrainian army destroyed the Church of the Ascension of Christ (…). Houses were destroyed in the bombings, and civilians were killed or injured…" [34].

Across the three pre-established categories, the dominant frame types we identified, were the following: nine problem statement frames; two causal interpretations; two moral evaluations and one remedy suggestion (for the category of news covering "Hungary's political approach/ vision about the war"); four problem statements and one moral evaluation (in news referring to EU and US support for Ukraine), four problem statements and two remedy suggestions (in news referring to the belligerents' perspectives of the war and battlefield developments. The dominance of problem statement frames served in highlighting the approach and perspectives of the war, held by the parties.

4. DISCUSSION AND CONCLUSIONS

The Hungarian-language online media present the topic of Russia's war against Ukraine in a reduced number of articles, with the Hungarian Government's vision about the war making up a significant portion of the coverages (one third in our research sample).

As previously documented by Göransson [2] who studied the official Hungarian Government's discourse at the beginning of the war, the conflict continued being presented as an impersonal force that must be stopped immediately, with no sensitivity on what this would mean for the aggressed state, Ukraine. The Hungarian officials' discourses referred rather to the consequences of the war for the rest of the world, implicitly tangible security effects for their audiences, that are likely more appealing at an individual level as people can directly relate to them (price increases, energy and food security issues). The main Hungarian communicators, the Prime Minister Viktor Orbán and the Minister of Foreign Affairs Péter Szijjártó employed "othering" to Brussels, Ukraine and their political opposition for continuing the war and thus affecting Hungarians, whose security they are protecting, but they avoided making any accusations against Russia.

On the other hand, in neutral media coverage presenting related developments, the war was covered as a conflict between two belligerents who blame one another for damage and crimes.

Russia was, however, accused and named as the aggressor in statements by EU, NATO and quoted member states leaders, including Romania, whose discourses were not however as frequent and arguably, not adapted to the Hungarian audience. On the other hand, Russian communicators were also quoted with their perspective on the war and Westerners' involvement in it which could lead to escalations.

While the effects of media representations on public opinion are a result of the interaction between the text and the reader, we argue that Hungarian online media coverage of Russia's war against Ukraine has the potential to shape minority perceptions for several reasons. The first argument is that, as evident in Bourdieu's definition of symbolic power [35], the speaker's authority gives power to the statement he is articulating. Considering the high level of confidence that the Hungarian minority has in Viktor Orbán, his war-related perspectives are likely more appealing and convincing for the Hungarian minority.

A second argument goes back to the framing theory notion of dominant contents, which as resulted, abound in a specific problem statements of the conflict, where Ukraine does not appear as much as a victim and nor does Russia appear as much as an aggressor. Rather, the conflict is an impersonal force in the "neighborhood" that brings losses to everybody.

Arguably though, the Hungarian minority in Romania is subject to a complex information environment and not just the Hungarian-language online media. However, we argue that the media consumed by Hungarians (including media outlets in Hungary) set the discourse, from where sub-discourse in other channels, such as social media further emerge.

A third argument we believe may be found in the perception of the audiences with regards to the conflict, as fewer Hungarians perceive Russia as an aggressor, in contrast to the beginning of the conflict. Likely, the shock generated by a surprising full-scale war in 21st century in Europe, determined the public to name with more certainty the aggressor as the invader. However, as the war unfolded and conflicting narratives were built around it, the Hungarian community in Romania adhered to those that made more sense for their own culture and reality, as represented by the media and trusted opinion leaders.

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DEVELOPING WRITING SKILLS BY INTEGRATING FEEDBACK INTO THE PROCESS OF TASK-BASED TEACHING

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Abstract: *The article illustrates a method of including feedback into the language learning process by rendering a series of class activities leading to the enhancement of writing skill proficiency. The case study focusses on a qualitative analysis of the typical discourse-level mistakes of intermediate students, specifically focussing on discourse content and organisation. Providing feedback on these aspects is identified in the study as representing a way of raising learners' awareness of the specific aspects of written text production, more specifically, opinion statements, and helping them acquire efficient ways to apply self-correction, an absolute necessity in language learning.*

Keywords: *writing skills, text coherence, task-based teaching, feedback*

1. INTRODUCTION

Developing writing skills is probably the most challenging undertaking in language learning both for students and teachers, especially when working towards higher level proficiency. In the standard classroom, writing is often used as a tool for assessment (in which case the accuracy and coherence of the text is only indirectly evaluated) or as a support activity for other skills, such as notetaking during listening or even speaking.

The emergence of the communicative method, favouring student interaction, may have contributed to writing getting less attention; however, the emergence of communicating through the internet and social media has reintroduced activities that designate writing skills as the main objective [8]. Concomitantly, the emphasis on the practical aspects of writing has brought forward the need for more realistic contexts to be used in the classroom, focussing on the dialogic nature of this activity.

Task-based learning is a subcategory of the communicative method focussing on the accomplishment of various realistic and genuine tasks. Writing is undertaken within various realistic scenarios, usually with an addressee in mind. This complexity entails students' drawing on their schematic knowledge (as they employ their background knowledge on genres and situations required by the task) and their social awareness when they decide on the style (e.g. formality/informality) they should use in their text [9, 3].

The process involves preparation for the task, its performance and, finally, a consistent activity of language focus which provides meaningful feedback on the language used by the learners. This stage of the learning process has a predominantly reflective aspect during which students become aware of their weaknesses and the efficient ways in which they can continue learning.

The present study focusses on this post-task phase of the activity discussing feedback as an activity that provides an efficient modality for students to appropriate certain writing practices but also offers the teacher a ground for experimenting in order to adequately adjust activities and material to learners' needs and profile. In this respect, the relevant factors include the students' professional background as future military personnel, their specific level as (upper)intermediate learners and as young adults who use writing mainly to communicate through texting and may encounter difficulties when producing a longer essay.

In order to address the first two aspects, the guidelines of two frameworks for assessment have been used, the Common European Framework and the requirements formulated in the Standard Nato Agreement (STANAG) for military personnel. Their provisions for the level of writing proficiency corresponding to an intermediate learner (B1 and level 2, respectively) stipulate a user able to produce a personal point of view on a relatively familiar subject, while higher proficiency levels (B2, level 2+) describe a the ability to discuss a wider range of topics, adding more elaborate details and demonstrating higher language accuracy.

The aim of the feedback activity described in this case study has been to achieve an increased awareness among students regarding the characteristics of higher complexity writing by relying on their existing schematic knowledge (paragraph structure, marking transition between ideas) and their social awareness (topics of general interest). The general expectation is that students developing awareness of the general and more specific principles of text production may be able to successfully render an elaborate opinion on a variety of (even less familiar) general topics.

2. FEEDBACK IN LANGUAGE LEARNING

With the emergence of learner-centred approaches, feedback and error correction have been acknowledged as essential in the learning process due to their role of raising students' awareness of their deficiencies and helping them overcome them. Nevertheless, the idea that not enough and not adequate feedback is given to students still persists [6].

Providing feedback is to a great extent determined by the students' needs, the general or specific objectives underlying the teaching process and various contextual factors. The various types of feedback are classified around focus, scope and strategy [4]. Focus represents local or global perspectives, ranging from the sentence- or word-level error correction to that which examines a text in its larger, discursive dimension. While the first one aims to develop language accuracy and is more frequently present with lower level learners, global feedback benefits higher proficiency learners as it targets text coherence on a discursive level where relevant content and adequate organisation are foregrounded.

In terms of content, the overall clarity of the message is examined, including the adequacy of the details, such as providing a clearly worded message and rendering sufficient and not redundant or repeated details. Organisation of the discursive elements pertains to the logical and formal connection of the ideas worded in the text, such as the existence of a topic sentence, that is followed by relevant supporting details which consistently elaborate on the main idea of the paragraph. These categories, together with the local-level language of a text jointly convey the global meaning of a text.

The scope of feedback can vary depending on the specific aims of the writing task, whether the accuracy of specific linguistic elements is targeted or a general assessment of a text is pursued.

Classroom practice demonstrates that teachers prefer making assessments of the overall quality of students' writing performance, since it may be more beneficial for individual students' progress [4].

Strategy of feedback pertains to the way in which the teacher chooses to indicate a particular mistake, directly providing an alternative or a suggestion to the student, or simply marking it, indirectly pointing out the error or inadequacy.

Standard feedback is usually provided through written corrective feedback (WCF), that is, the local, direct, sentence-level signalling of grammar mistakes. Indeed, students' perception of the adequately written text is influenced by this general practice, as they tend to ignore discourse level rules when producing a written text [7]. However, what is commonly acknowledged is that corrective observations provided by the teacher are valued by students if they are addressed to students individually, focussing on the individual profile of the language learner and their delivery in a constructive way elicits positive engagement on the students' part [6].

A further aspect relevant for the present study is the issue of peer feedback which has had a mixed acceptance among the teaching community [6]. While they may represent a lower rate of positive engagement on the students' part, in situations when group cohesion is higher it may generate an environment of camaraderie and mutual support. During the activities illustrated in the present case study samples used in the feedback session were anonymous.

3. WRITING SKILL DEVELOPMENT AMONG THE AVIATION CADETS

As pointed out earlier, the best choice of feedback, or indeed, the details of the entire teaching process, pertains to the students' particular needs and profile. With the present case study, this profile revolves around the language proficiency requirements that military personnel has to fulfil in their professional capacity.

In the specific context of language teaching for aviation cadets, developing higher level writing skills can be operationalised by targeting the concrete linguistic functions which involve transitioning from an intermediate level (B1) to an upper intermediate (B2) one [1]. These values mainly correspond to levels 2 and 2+ in the STANAG 6001 description of proficiency levels, used in NATO countries [2]. Concerning the content and the nature of the tasks formulated at this level, this challenge is materialised in addressing topics which require a more analytical approach rather than merely rendering factual data on personal experience. The transition from familiar, concrete details to more complex and general content is described similarly by the two frameworks which underlie language proficiency assessment in the European Union (Common European Framework) and NATO (STANAG 6001).

Level B2 in the CEF description is named *Vantage level* due to the learner's uplift above the '*intermediate plateau*', *acquiring 'a new perspective'* and *breaking 'with the content so far'*. This new perspective is marked both by an increased amount of discourse the learner can produce through more details and a wider range of topics, even less familiar ones, that he/she can tackle. While an intermediate B1 communicator typically *'expresses main points'* and *'personal views'* in more abstract topics, a B2 *'can provide relevant explanations, arguments and comments'*. With a specific reference to overall written production, the B1 level is described as producing *'straightforward connected texts'* on familiar subjects, whereas a B2 writes *'clear, detailed texts'* on a variety of subjects.

In the case of the B2 level, the CEF emphasizes the emergence of *'a new degree of language awareness',* through which this learner can occasionally correct themselves and consciously monitor the language they produce, a feature which is absent from lower levels.

Although the description in the NATO document is less detailed, a correspondence with the B1/B2 transition is traceable. The level 2 characteristics of a written text are described as *'roughly organized according to major points or straightforward sequencing of events',* a user being able to produce *'connected prose',* with paragraphs that connect or contrast, with transitions that are described as occasionally *'awkward'.* The level 2+ is also described as *'less effective'* when supporting opinion and *'inconsistent'* in *'abstract linguistic formulations'*; however, what distinguishes the 2+ user from lower levels is the *'relative coherence'* of his/her text which contains *'considerable detail'.*

As students work themselves towards developing more elaborate written texts, focus from the accuracy of grammar patterns and lexis or adequate sentence structure (typical of lower-level writing activities) shifts towards text coherence [5, 6]. Indeed, their main challenge at this level is to find the appropriate wording to express abstract or general ideas they are less used to tackle in the target language. Given that the conceptual frames the language user can tackle at this level are more varied, it is equally important for learners to activate their knowledge on the general conventions of writing and become aware of their specific aspects.

In the case of writing skill development, opinion statement may be the most relevant indicator of a transition to a higher level of proficiency as it allows progress to be traced in terms of quantity (sufficient amount of detail) and quality (adequate phrasing in terms of coherence, clarity and language accuracy).

4. METHODOLOGY

The series of activities pertaining to the task took place among five groups of 80 students altogether, grouped in smaller groups of 15 or larger ones 20 or 25 students. As in most classes the students' level is not homogenous, their average language level ranging from B1 to even B2, in some cases. It was expected, therefore, that students with a higher proficiency level would perform better and produce texts with a high degree of accuracy, with adequately developed and logically linked ideas. However, this did not exclude the possibility of inconsistencies occurring in the use of coherence devices or arrangement of the information.

The specific aim of the task pertained to the linguistic function of stating an opinion, meant to elicit the use of conceptual and linguistic elements that illustrate the transition from a B1 level to a B2. This implied the use of the paragraph as an organisational frame and topics adequate for the production of a higher complexity text. This entailed a selection of general topics that require detachment from personal experience but common enough for students to approach and express opinion on. Throughout the procedure it was expected that students would formulate extended arguments on the issues that were presented in the form of statements which students reacted to, first in spoken form, then, in the realization phase, solving the main task in writing. For example:

'Working from home is preferable to working in an office.'
'Graduating from college may be the best choice you get to make in your life.'
'Smart phones can be efficient tools in education.'
'Physical training should be compulsory for all students and employees.'

The process revolving around the writing activity included the stages according to task-based learning [9, 3], comprising of pre-task phase, task preparation, task realisation and post-task activity, the latter representing the feedback session conducted with the aim of raising student awareness of typical deficiencies in the organisation of their discourse. Although sentence-level or formal errors were pointed out and discussed, the activity aimed issues related to discourse organisation, such as clearly formulated position on the subject (degree of agreement or disagreement), clearly formulated arguments with logically and clearly rendered supporting details. This implied a focus on:

4.1. Pre-task phase. As each phase had a specifically established goal in the process, the activities occurred throughout several 90-minute classes as follows: in the first class of the series students were reminded of the paragraph pattern, with the purpose of reactivating their schematic knowledge related to the conventions on a written paragraph. This session was organized as a standard presentation-practice-production class through which more scaffolding was provided at first, gradually getting to the phase when students formulated their own topic or detail sentences. The activities involved the presentation of a sample paragraph, followed by a series of exercises involving the selection of adequate topic and detail sentences, organized as a multiple choice exercise. In the final phase of the lesson students formulated their own examples on given topics, which were subsequently discussed in class. In the larger framework of the task-based teaching pattern, this class represented the pre-task phase (sample paragraph) and a part of the preparation for the task.

4.2. Task preparation. In the second session the preparation for the task continued with a reenforcing speaking activity with the objective of students formulating elaborate arguments by providing a supporting argument (for or against the statement) and developing explanations or providing examples to support their argument. In this activity, the speakers were expected to produce a complete 'paragraph-length' argument. The speaking activity undertaken in preparation for the writing task was conducted within the frame of a contest between two or three groups (depending on the number of students). A member of the group extracted a statement from a pile and together with the other group members sought possible arguments on the internet. *(The class took place in the language laboratory financed through The Ministry of National Defence Research & Development Sectorial Plan / 2023)* After the allowed time expired, the members of the group formulated as many arguments as possible within a given amount of time (3 or 4 minutes, depending on the number of participants). During this time the other group(s) made sure that the same argument or the same example would not be used more than once and timed the session. Groups would take turns in formulating arguments and the winner was the group which had more arguments (recorded by the teacher). As the main goal was to produce well-developed arguments, students were given the freedom to find both arguments that supported or opposed the extracted statement.

The activity can generally engage students due to its interactive nature; however, it may prove problematic with larger groups as it may not engage all the students' attention. Moreover, the best setup for this activity is one in which two groups of a maximum number of 6 students are engaged. A similar task-preparation activity can be performed without applying the frame of the contest by simply asking members of the class to extract a statement and then allow the whole class to interact on the topic. As the objective is the practice of formulating a paragraph-length argument consisting of main idea and explanation/example, the teacher's role is to point out the absence of these constituting elements or point out if any of these is unsuitable or irrelevant for the statement.

4.3. Task realisation. In the task realisation phase, the third class in the process, the students had to produce an approximately 150-word text in which to state their opinion on one of the statements 'rehearsed' in the task preparation phase, during the argument contest. It was required that students write a three-paragraph text, introduced with a short opinion statement, clarifying their stance on the subject and add two arguments in the form of two paragraphs. Similarly to the previous activity, students were allowed to formulate arguments supporting or opposing the statement as long as they clearly specified their position on the subject in the introduction. The task also reminded them to focus on language (adequate vocabulary and grammar), organisation (well-constructed paragraphs, use of the necessary transitional expressions) and relevance of content (two clearly formulated different arguments pertaining to the given subject). The allotted time for this activity was 40 minutes.

4.4. Language focus/Feedback. The feedback session which took place during the fourth class was conducted in accordance with the principle underlying task-based learning: raising students' awareness of the typical mistakes they are making. The post-task activity usually includes language focus through which certain problematic vocabulary or grammar issues which have occurred during the activity are discussed. Further practice is provided or the language items in question may become the focus of a subsequent task.

In the feedback session, students received both local and global feedback in the form of WCF and addressed questions, requested clarifications individually. Since the scope of the feedback activity primarily concerned aspects related to content and organisation on a discourse level, local errors concerning sentence-level grammar patterns, collocations or use of vocabulary were only discussed individually with the students, if necessary. The strategy of the feedback was predominantly direct as the teacher used WCF in both local and global feedback, adding a suggested rephrasing in the case of the latter. Indirect feedback was only used in cases of repeated individual errors (e.g. plurals, repeated vocabulary, subject-verb agreement errors, etc.), or in situations when the inadequacy of the linguistic element used was obvious (colloquial expressions, such as '*kinda*', '*guy*', '*stuff*', '*bad thing/good thing'*).

This standard feedback session was followed by an interactive class activity in which various excerpts from the written texts were discussed. Groups of two or three students received text fragments, anonymously, and were asked to identify their flaws and try to improve them. The teacher made sure that an excerpt did not get to the student who wrote it, given that he/she had already received a suggestion by the teacher on the paper. The students' solutions were compared with the original ones and discussed by the whole class.

It must be stated, that at this level, reformulations were not much more successful than the originals students were working on. However, the activity aimed not as much obtaining better phrasings than raising students' awareness on the typical inconsistencies of their writing style at this point. The first question addressed to the students was to identify what may be 'wrong' in the excerpt and what is it that makes it 'sound' artificial.

5. FINDINGS

In terms of the global assessment of the texts, the rephrasing activity based on the excerpts from the students' writings focussed on issues related to the content and the organisation of their arguments on the provided subject.

While their opinions were obviously formulated in the individual style of each learner, inadequacies spotted on a discursive level do bear some common characteristics, due to the students' linguistic level and profile.

5.1. Content and text coherence. Mistakes concerning content and text coherence have been pointed out at the level of clarity of the message, concerning adequacy of phrasing (wordiness, repetition, rephrasing, lack of details) or relevance of provided details (unnecessary details). Due to the unfamiliarity or complexity of the subject, students' main concern usually is to write a sufficient quantity of text (number of words as specified in the task) without considering the clarity of their ideas and the need for a more concise phrasing at times. On other occasions, ideas are insufficiently developed, thus, affecting the clarity of the message.

In addition, lack of lexical resources or possibly the familiarity with a more colloquial English due to social media and popular culture leads to the use of informal terms in writing. Although imposing formality was not the main scope of this activity, given the level and the personal aspect of the task, it was considered important to raise awareness on the inappropriate use of terms like '*stuff*', '*thing*' (as in *'this is not a good thing'*) or *'guy'*.

Given the students' unfamiliarity with a more general subject, the text of the written opinion statements is characterised by wordiness and awkward phrasing. In their attempt to convey a clear statement of opinion and, at times, to employ a more formal style, learners at this level struggle to get their message across. In the following example, the writer repeated details and phrases without succeeding to clarify the advantage related to graduating from college:

I think that graduating college is the best choice because the moment you get your bachelor's degree, you can legally perform what you have learned for the past years, assuming that you went to a college that you were dreaming of. If you go to the college, you have ever wanted to go, this will be the best experience because you only get to become better at what you like to do.

The phrases *'assuming that you went to a college that you were dreaming of'* and *' ... the college you have ever wanted to go'* are not only repeated but they add a detail that the writer does not develop either by referring to what happens if you do not join a college of your choice or what becoming '*better*' or the *'best experience'* may imply. In such situations an additional explanation was suggested or elicited from the students (e.g. *'you become better because continue learning about your domain by getting hands-on experience')*. In most of these situations a local-level vocabulary is also implied, however, the aspect focused on is the clarity of the idea, which is not sufficiently explained.

Lack of clarity is often caused by an insufficient development of the idea, as in the following thesis statement: *'... technology has been progressing even for the little ones in school'*. The argument continues with an example referring not to the development of technology per se, but to the fact that the internet provides information and is a learning resource: *'the internet is full of tutorials that teach you 'how to make money from a young age'. So, for us, students, the internet represents a better way of learning anything. Now we learn from a young age things that our parents, or grandparents have discovered way later or even not have discovered, yet.'* While the original thesis statement is too general, therefore, unclear, the explanatory statement *'the internet represents a better way of learning'* may have been a more adequate choice for it. Therefore, in this excerpt, the lack of clarity is also due to an organizational issue.

In addition, the last sentence of the excerpt, *'we learn from a young age things our parents or grandparents …'* is redundant, or could be replaced by a simple phrase in the thesis statement (e.g. *'better way of learning than earlier generations had').*

The redundancy of details is more obviously present in another text, in which opinion is stated about working from home: *'One argument in favour of this statement supports the ones who have to take care of their baby or an old member of the family, who cannot do it by themselves. For example, my uncle is working for an IT company from home, with a flexible schedule, that gives him the opportunity to help his sick mother, nobody but him being able to do it.'*

It was not only the additional phrases *'cannot do it by themselves'* or *'nobody but him being able to do it'* that were considered redundant, but students were encouraged formulate a more concise thesis statement as well, in an attempt to avoid metadiscursive formulations like *'one argument in favour of this statement'* (e.g. *For those who have a family member in their care, working from home can represent an advantage).*

Frequently, extensive details of a certain situation given as a supporting example may constitute an entire narrative, as in the case of the following opinion statement on the choice of graduating college: *'On the other hand, learning is not easy for everyone. Some people might not be able to graduate from college even if they start it. Or maybe they graduate after long, hard years and will not be good and professional in their future jobs, or worse, they would hate their job. Trying too hard and not succeeding could be depressing. For example, graduating from Math college after years of hard work could be meaning that you will not be a good Math teacher. Maybe Math is not for you and as hard as you try you will not be happy with what you do. You would have been happier by doing something else but you insisted on graduating from college just to get that diploma because your parents wished so.'*

Throughout the excerpt the same idea is rephrased, that of *'trying hard'* contrasted with *'not succeeding'* or Maths being *'not for you'* and not being *'happy'* doing it. In this situation students were encouraged to synthesize the two ideas into one complex sentence and either omit the additional detail of the *'parents' wish',* or add it in a more concisely formulated explanation (e.g. *Graduating a college may not be a guarantee for professional success. For example, people who choose a college due to their parents' pressure may not be happy working in that domain.)*

5.2. Organisation. Inadequacies concerning the organisation of the paragraphs were less frequent than those related to content and text coherence. Those that occurred were related to formulating the same or very similar examples for the arguments stated. For instance, a student wrote in the thesis statement of his first argument:

'Smart phones can be useful in schools to improve teenagers' knowledge', and continued by pointing out that *'they can use the phone to find out whatever they want to know. If they have a project at any class, they can search for useful information on different websites for finishing the project and for beneficial ideas.'*

In the second paragraph the student argued that *'smart phones make teenagers' school life much easier because they don't need to search in hundreds of books to do their tasks'* but continued with an explanation that was, in fact, a rephrasing of the idea in the first paragraph: *'They can easily search online anything they want with just a click. Any person can improve his education level by using a phone. If a student wants to learn a new language, he can by using his phone, searching for books and exercises and also phone applications in that language without any kind of external help.'*

A further, more formal aspect pertains to the heading-like phrasing of the thesis statement of the paragraph, as in the following paragraph:

Flexibility of schedule: online learning offers a very flexible program because you can access any time a lesson. For example, at 9 a.m. you cannot go to the second class of Math because you have to go to the hospital but at 13 p.m. you will be back at home and start the course.

The phrase *'flexibility of schedule'* indicates a 'telegraphic' style that is probably due to the students' using writing predominantly as a means of synthesizing and classifying information. It also echoes the practice of notetaking used in the language classroom as the main method of indirectly practicing writing skills.

CONCLUSIONS

Discourse-level inconsistencies of the analysed written opinion statements have indicated the a typical struggle of the intermediate learner with the wording of ideas related to issues that have a more general relevance than the concrete familiarity of everyday personal experience. Although consistent in quantity and relatively accurate (with high-frequency grammar and lexis), the samples reveal a lack of familiarity with producing more general content, displaying inadequacies in coherence and clarity, with details either exceedingly rendered by repeated reformulations and irrelevant details or on the contrary, phrasings that remain too general or vague, due to lack of explanatory details.

The significantly few mistakes that occurred regarding the organisation of the paragraphs may be due to the students' schematic knowledge on paragraphs and opinion statements that they have been practising in their first language and the activation that happened during the speaking activity undertaken in the task preparation phase. The fact that they still occurred in some instances may be caused by the absence of a consistent draft devised before writing the paragraphs.

The interactive feedback activity aimed to raise the students' awareness on the types of challenges they are facing at this phase of their language acquisition and attempted to provide an insight to the characteristics of the texts that are produced on a higher proficiency level.

ACKNOWLEDGMENT

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NEUROCOGNITIVE STIMULATION IN MILITARY TRAINING: IMPACT ON PERFORMANCE AND EMOTIONAL REGULATION

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Abstract:*This research investigates the impact of neurocognitive stimulation on performance and emotional regulation in military training. Historically, research has focused on the physical and objective factors of performance, often neglecting the neurocognitive and emotional aspects that are crucial in high-stress operational conditions. The study proposes an integrated approach combining EEG monitoring with non-invasive neurostimulation using the HALO Sport device to assess its impact on focus, emotional regulation, and physical performance. In a simulated military biathlon experiment, participants were exposed to complex tasks under three experimental conditions: no stimulation, active stimulation, and placebo stimulation. The results revealed that neurostimulation with HALO Sport significantly improved cognitive and motor performance while reducing negative emotional responses such as anxiety and enhancing mental resilience. The study demonstrates that neurocognitive stimulation can be an effective method for optimizing military training, contributing to better emotional self-regulation and more efficient operational performance under stress. The findings suggest that this integrated neurocognitive approach could revolutionize military training strategies, fostering a balance between physical and mental performance crucial for critical operational contexts.*

Keywords: *neurocognitive stimulation, emotional regulation, performance, EEG, HALO Sport neurostimulation, military training, operational stress, self-regulation, cognitive performance, motor performance.*

1. INTRODUCTION AND RESEARCH PROBLEM

For a long time, research in the field of operational performance psychology has predominantly focused on external and objective factors of training—such as tactical routines, workload, or physical conditions. Only recently have cognitive science and applied neuroscience begun to integrate more subtle, yet essential, variables into performance analysis: cognitive stress, sustained focus, mental engagement, and emotional self-regulation under pressure.

In the military environment, where each decision made under pressure can have major implications, the ability to maintain focus, manage acute stress, and remain functional in a hostile climate becomes critical. Additionally, the reality of modern military training involves increasing task complexity, sustained cognitive effort, and constant emotional expenditure. These aspects can no longer be ignored in operational preparation, but must be analyzed and optimized through scientific methods.

In the military environment, characterized by intense demands, constant pressure, and a high level of unpredictability, the emotional component plays an essential role in determining professional efficiency.

Emotions are not merely transient reactions, but complex psychophysiological processes that influence perception, decision-making, attention regulation, and the ability to act in critical situations. Unlike other fields, where emotional management can be flexible, in the military system, emotional balance is a key determinant of safety, cohesion, and operational performance (Rusu, 2024).

Flood and Keegan (2022) emphasize that cognitive resilience is a key factor in managing operational stress among military personnel, and neurocognitive interventions can effectively support maintaining performance under pressure.

Similar to how emotions were once considered disruptive elements in organizations (and therefore neutralized or ignored), stress or cognitive fluctuations are often treated as secondary or inevitable factors. However, like emotions, these mental states decisively influence behavior, efficiency, and adaptability. They cannot simply be eliminated from the performance equation, but must be understood, measured, and, where possible, regulated.

This research aims to address these needs through an integrative approach combining neurophysiological data (obtained via EEG), behavioral analysis, and the application of an emerging neurostimulation technology HALO Sport.

Modern military training requires a comprehensive approach that integrates both physical and cognitive training, considering that performance under operational stress depends on the ability to respond quickly and efficiently to challenges. Blacker *et al.* (2018) emphasize the importance of cognitive training for enhancing executive functions and adaptability in demanding environments (Yanilov & Boe, 2014; Dugan, 2020; Lesenciuc & Sauciuc, 2022; 2023).

In my previous dissertation research titled "The Impact of Cognitive Stress on Pilot Performance: An Analysis Using EEG Monitoring," I explored in-depth the relationship between cognitive stress and the operational performance of military personnel from a neuropsychological perspective.

The main focus of the research was on the neurophysiological changes induced by stress and the possibility of monitoring and interpreting these changes through EEG biosignals. The experiment took place in a controlled yet simulated environment, using a military biathlon scenario where participants were exposed to complex tasks involving movement, rapid decision-making, and sustained focus under controlled stress conditions designed to replicate operational stress. Since implementing such a protocol in real flight conditions was not feasible, the simulation provided a controlled but intense environment. The experiment lasted for three days:

- **Day 1**: Participation without external interventions, for baseline comparison.
- **Day 2**: Introduction of the HALO Sport neurostimulator, aimed at optimizing cognitive and motor performance while supporting emotional balance.
- **Day 3**: Testing the effect to verify the observed outcomes.

The central issue of the research stems from the question: Can the cognitive and emotional performance of military personnel be optimized, or in other words, can the neurocognitive architecture of military personnel be effectively modified through non-invasive neurostimulation methods? And, additionally, can these transformations be objectively measured with the help of brain biosignals?

To capture ongoing phenomena, such as focus, relaxation, or cognitive alertness methods of investigation beyond behavioral observation are needed. In this regard, real-time EEG monitoring and applied neurostimulation technology open new horizons for applied research in the military field. Capturing brain activity is no longer solely a medical mission, but becomes an adaptive training tool for performance optimization (Sauciuc, 2023).

2. RESEARCH RELEVANCE

Current literature on operational performance in a military context increasingly highlights the need for a more nuanced approach that integrates the neurophysiological dimension and the impact of cognitive stress on operational efficiency. Particularly, there is a noticeable underrepresentation of studies systematically addressing neurocognitive variables such as acute mental stress, attention fluctuations, or emotional self-regulation, all of which are essential for optimizing individual performance in high-demand contexts. While many studies examine tactical and physical performance aspects, few have successfully correlated these dimensions with their cerebral substrates, measurable in real-time, and with optimization possibilities using non-invasive methods (Sauciuc, 2023).

This work seeks to fill a significant gap in the literature by addressing a topic with direct and immediate applicability to military training: optimizing emotional performance under simulated stress conditions, using modern neurostimulation technologies and EEG monitoring. The relevance of this research stems from the fact that modern military preparation can no longer be conceived solely as physical or procedural training; an integrated approach is needed that takes into account brain and emotional responses to operational challenges.

In this context, previous research, such as that conducted by Blacker *et al.* (2018), shows that applied cognitive training can support the development of essential skills for military performance, such as concentration, quick decision-making, and adaptability under stress.

Moreover, this research advocates for a paradigm shift in military training: from an exclusively physical-tactical perspective to one where emphasis is placed on the neurocognitive development of the soldier. Non-invasive brain stimulation, combined with EEG analysis and behavioral observation, could become a key component in the future of operational training, both at the individual level and in the development of adaptive training programs (Rusu, 2024).

Therefore, the contribution of this research lies in proposing an integrated model of analysis and intervention, which would allow for the identification and regulation of critical mental factors influencing military performance.

This approach can be further expanded and validated in real operational contexts, offering a solid methodological framework for future research in the field of neuro-performance applications.

3. SCIENTIFIC CONTRIBUTION AND NOVELTY ELEMENTS OF THE RESEARCH

The originality of this research stems from the convergence of several current scientific directions - applied neuroscience, performance psychology, and non-invasive brain stimulation technology—and their integration into a specific military framework, which has rarely been explored in the literature. In a field where performance analysis is typically centered on quantitative and behavioral criteria (accuracy, reaction time, tactical efficiency), this work proposes a deeper approach, focused on the cerebral substrate of performance from an emotional perspective.

The experimental approach conducted with the military biathlon simulator, under standardized conditions, provides a controlled but realistic environment for studying cognitive and emotional reactions in stressful settings.

The application of an emerging technology—HALO Sport neurostimulator—along with real-time EEG brain activity monitoring, allows not only passive observation of mental states but also active intervention, in an adaptive and non-invasive manner (Rusu, 2024).

The innovative contribution of this research includes the following directions:

- Introducing a triadic experimental protocol conducted over three consecutive days: one day without stimulation, one day with active neurostimulation, and one day with a placebo, allowing for a rigorous inter-condition comparison.
- Combining EEG data with behavioral observations and psychological self-reports, providing a comprehensive picture of military personnel's neurocognitive responses in stressful simulated conditions.
- Applying a commercially available technology in a professional military context, thus bridging fundamental research with immediate applicability in operational training.
- Identifying correlations between the use of neurostimulation and improvements in attention, stress reduction, and increased motor efficiency—factors that could underpin future neurocognitive training protocols.

Furthermore, this research leverages a user-friendly and accessible technology (HALO Sport) that can be easily integrated into training scenarios without requiring sophisticated equipment or hard-to-access resources.

Through all of this, the study not only explores the theoretical relationship between stress, focus, performance, and emotional states but also proposes a concrete method of intervention, empirically tested and supported by objective data. This gives the research a pronounced applied character, with potential for replication and expansion in military personnel training programs.

4. EMOTIONAL REGULATION IN TACTICAL CONTEXTS: EEG RESULTS AND NEUROFUNCTIONAL INTERPRETATIONS

In simulated tactical contexts, such as the military biathlon scenario, performance is strongly influenced by emotional state. Emotions such as frustration, time pressure, or anticipation of failure trigger automatic neurophysiological reactions in the brain, which can directly affect: attentional focus, decision-making accuracy, fine motor control, as well as impulse regulation under stress.

Thus, emotions in the military environment are not a secondary factor but a core element of psychological preparation, with a direct impact on cognitive and decision-making functions. Understanding, measuring, and optimizing them should become a strategic priority for maintaining human efficiency in modern operations.

The experimental study I will present was initially conducted as part of my dissertation, with the general objective of investigating the effects of transcranial neurostimulation on military performance in a simulated stress context. At that stage, the analysis integrated motor and cognitive dimensions using a military biathlon simulator within the COMIND (Combat Mindset) laboratory - Fig. 1, which includes the cross-country skiing and shooting tests - Fig. 2 (for measuring time and shooting accuracy), in combination with the Halo Sport neurostimulator - Fig. 3 (for analyzing the impact of transcranial electrical stimulation on cognitive and motor performance) and the Emotiv EPOC+ EEG headset - Fig. 4 (for evaluating brain activity, specifically brain waves and various emotional and cognitive states).

Previous studies have shown that transcranial direct current stimulation (tDCS) using the Halo Sport device can significantly enhance physical and cognitive performance.

For example, a study by Huang et al. (2019) demonstrated that the application of tDCS significantly increased average power in repeated sprint cycling and improved cognitive performance in the Stroop test.

FIG. 1 The COMIND Laboratory with the SymWay Biathlon Simulator

FIG. 2 The Cross-Country Skiing and Shooting Tests within the Biathlon Simulator

FIG. 3 The Halo Sport Neurostimulator

FIG. 4 The Emotiv EPOC+ EEG Headset

The subjects were exposed over three days to the same complex tasks in three different conditions: no stimulation, active stimulation, and placebo effect. In all conditions, EEG biosignals were monitored, and physical-cognitive performance and emotional responses were recorded.

The new direction of analysis proposed in this paper focuses exclusively on the emotional dimension, with an emphasis on brain activation in areas involved in affective processing (prefrontal cortex, limbic system, amygdala, hippocampus, anterior cingulate cortex) and on how neurostimulation influences emotional self-regulation in operational stress situations.

By reevaluating EEG data, with a focus on alpha, theta, beta, and gamma brain waves, the goal is to identify objective correlations between brain activity and emotional states reported by participants. The current objective is to determine to what extent neurostimulation with HALO Sport contributes to maintaining emotional control, reducing affective reactivity, and increasing emotional resilience, compared to the lack of stimulation and the placebo effect.

To understand how the participants' emotional states were analyzed, it is important to mention that these processes are based on brain waves, which result from the synchronized activity of neurons. Through EEG, five types of waves were monitored: theta (4-8 Hz), alpha (8-12 Hz), beta (12-30 Hz), and gamma (30-100 Hz), each reflecting distinct mental and emotional states. For example, alpha waves indicate relaxation and calm, beta waves reflect a state of concentration and vigilance, and gamma waves are associated with advanced cognitive processes and emotional integration. These oscillations were correlated with parameters such as stress, engagement, relaxation, and emotional control, providing an objective picture of how participants emotionally responded in the three testing conditions (Sauciuc, 2023).

Cerebral activity during the training reflects the task intensity, stress level, and emotional involvement. In the study, we analyzed the distribution of brain waves (theta, alpha, beta, and gamma) at three distinct moments. The intensity of each wave was visually highlighted, providing clues about the level of neuronal activation and emotional regulation at each stage (Sauciuc, 2023; Lesenciuc & Sauciuc, 2023).

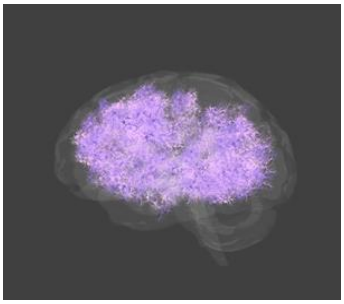

FIG. 5 Activation of Alpha Waves

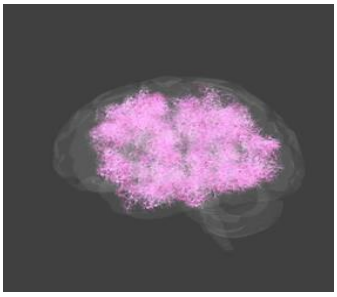

FIG. 6 Activation of Beta Waves

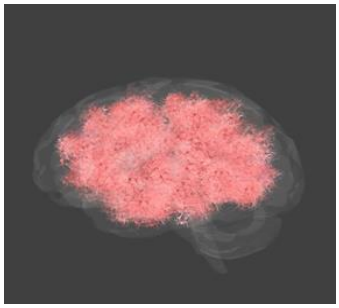

FIG. 7 Activation of Gamma Waves

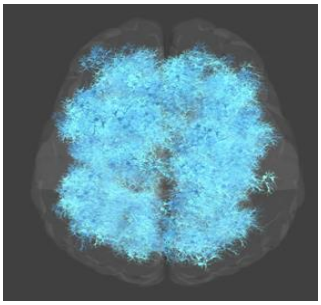

FIG. 8 Activation of Theta Waves

Brain Areas Involved in Emotional Processing and Observed EEG Changes

Applied neuroscience studies suggest that areas such as the prefrontal cortex (involved in self-control and decision-making), the amygdala (regulating fear and responses to threats), and the insula (awareness of emotions) are actively involved in adapting military personnel to specific military system conditions. Dysregulation of these circuits can significantly affect emotional regulation, responses under pressure, and even moral judgment in demanding operational contexts. Therefore, modern military training increasingly integrates emotional regulation techniques, biofeedback, or even neurostimulation, with the aim of enhancing mental resilience and performance.

This analytical shift toward the emotional dimension has allowed for a deeper understanding of how neurocognitive stimulation influences affective regulation in challenging contexts. Based on the EEG data collected at three key moments during training, significant variations were observed in beta wave activity (associated with alertness and cognitive control) and gamma waves (linked to information integration and emotional awareness). Additionally, the correlations between the activation of certain brain regions (such as the medial prefrontal cortex, anterior cingulate gyrus, and limbic structures) and levels of perceived stress or emotional self-regulation reported by participants suggest a direct impact of neurostimulation on emotional balance.

This analysis emphasizes that military performance cannot be separated from the individual's emotional state, and neurocognitive interventions may represent a viable solution for optimizing emotional responses under pressure. The main findings from the EEG analysis, affective self-reports, and comparisons between the three experimental conditions will be presented next.

The analysis focused on four key brain regions, which play a major role in emotional balance and stress adaptation: the medial and dorsolateral prefrontal cortex, the amygdala, the anterior cingulate cortex, and the insula.

To understand the emotional impact of each key moment during the military biathlon test, I will first analyze the brain areas involved in emotional processing based on the three distinct sequences: before training, the actual physical effort, and the shooting test moment.

1. **Before Training** - The EEG analysis highlighted predominant activation in the medial prefrontal region, Brodmann areas 10 and 11, associated with cognitive anticipation, emotional self-regulation, and preparation for executive control.
2. **During Physical Effort (Cross-Country Skiing)** – Activation was redistributed toward the motor and premotor areas (BA 4, BA 6), while gamma activation was maintained in the anterior insula and anterior cingulate – regions involved in interoceptive monitoring, awareness of bodily sensations, and emotional response integration to effort. This activation suggests a neurophysiological adaptation combining physical endurance with emotional regulation under stress.
3. **During the Shooting Test** – Psychological pressure and the need for emotional inhibition led to a peak in gamma wave activation in the dorsolateral prefrontal cortex and stabilization of beta waves in the posterior parietal cortex, reflecting intense attentional focus, as well as an increased capacity for emotional control and impulse inhibition. This configuration is crucial for maintaining calm, precision, and quick decision-making under pressure.

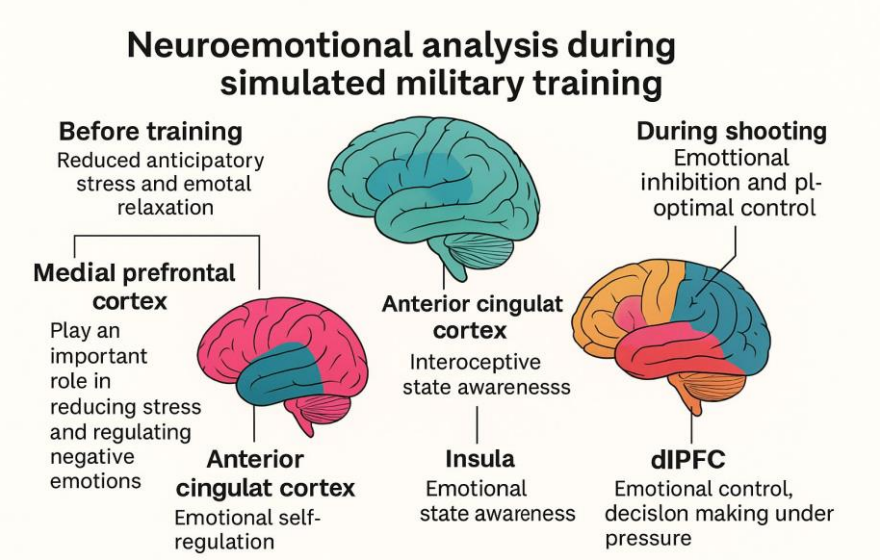

FIG. 9 Neuroemotional Analysis During Training Sessions

This spatial and temporal distribution of neural activation demonstrates that military performance is not strictly a function of physical effort or motor accuracy, but rather a deeply integrated emotional-cognitive process, involving collaboration between emotional self-regulation networks, executive monitoring, and stress resilience.

In this sense, the use of the HALO Sport neurostimulator appears to have accelerated the synchronization of these networks, facilitating a smoother transition between states of alertness, effort, and precision under stress, with direct benefits on emotional state and operational performance.

The following analysis aims to highlight the activation of the key brain regions involved in emotional regulation by correlating the types of EEG waves recorded with the variations observed in the three experimental conditions, in order to outline a differentiated profile of emotional response based on the type of stimulation applied.

1. Medial Prefrontal Cortex (mPFC) – Actively involved in emotional self-control, planning, impulse inhibition, and self-regulation, predominantly beta waves were recorded, associated with intense cognitive effort, but also alpha and theta waves, reflecting moments of mental calm and internal processing of emotional states.

Day	EEG Activation	Emotional Interpretation
Day 1 (no stimulation)	Increased beta waves and slightly elevated theta	Emotional overload, effort of self-control
Day 2 (Halo)	Increased alpha and theta waves, decreased beta	Calm, emotional clarity, efficiency in regulation, with theta indicating a centered and reflective mental state
Day 3 (placebo)	Moderate beta and alpha activation	Relatively stable emotional state, but not optimized

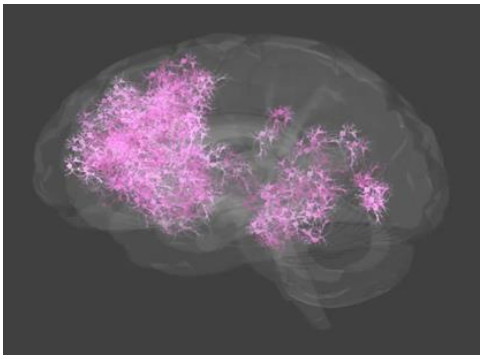

FIG. 10 Beta Waves Activated in the Prefrontal Cortex (Dorsolateral, Ventrolateral, Orbitofrontal, and Medial), as well as in the Auditory Cortex

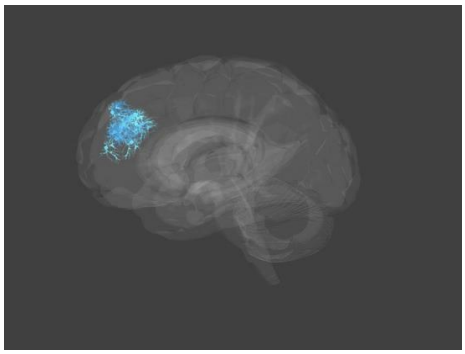

FIG. 11 Theta Waves Activated in the Prefrontal Cortex

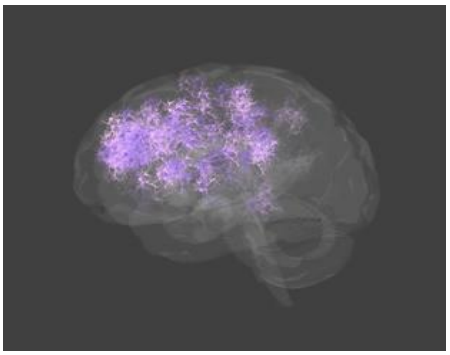

FIG. 12 Moderate Activation of Alpha and Beta Waves

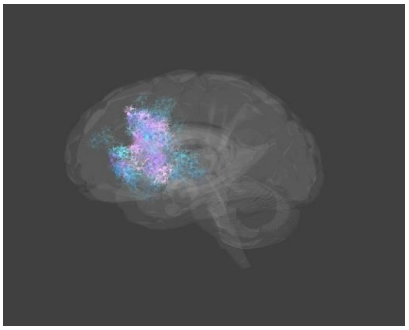

FIG. 13 Increased Alpha and Theta Waves and Decreased Beta Waves

2. Amygdala – A key structure in processing threat-related emotions, it was involved in triggering stress responses, being predominantly associated with high activation of Hi-Beta waves, typical of anxiety. However, this activation was significantly reduced on Day 2, suggesting a top-down emotional regulation process facilitated by prefrontal and medial cortical stimulation through alpha and theta waves.

Day	EEG Activation	Emotional Interpretation
Day 1	Indirect activation through Beta in the prefrontal cortex	Intense emotional reactions, heightened stress, anxiety
Day 2	Indirect inhibition through dlPFC and mPFC activation via alpha waves	Superior emotional control, reduced reactivity through top-down inhibition (dlPFC and mPFC)
Day 3	Partial activation	Present emotions, but better controlled than on Day 1

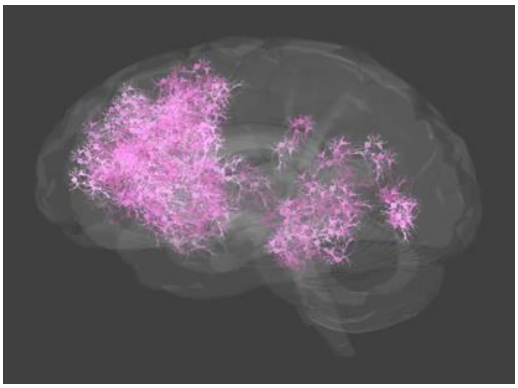

FIG. 14 Beta Waves Activated in the Prefrontal Cortex, Cingulate Cortex, Auditory Cortex, and Amygdala on Day 1

3. Anterior Cingulate Cortex (ACC) – Involved in integrating emotions into decision-making processes, detecting emotional conflicts, processing threats, and triggering rapid emotional responses, the ACC showed predominant activation in the Gamma, Beta, and Theta bands, suggesting heightened emotional attention, active monitoring of internal states, and efficient adaptive regulation, particularly on the day of active stimulation. However, it is inherently active under conditions of acute stress, and the Halo Sport indirectly contributed to top-down regulation of the amygdala through stimulation of the dorsolateral prefrontal cortex (dlPFC), which inhibits excessive emotional reactivity.

Day	EEG Activation	Emotional Interpretation
Day 1	High Beta Activation	Intense effort of emotional integration, emotional overload
Day 2	Balanced Gamma + Theta Activation	Emotional flow state, decision-making clarity, and active monitoring of internal states
Day 3	Intermediate Alpha Wave Activation	Partially controlled emotional response

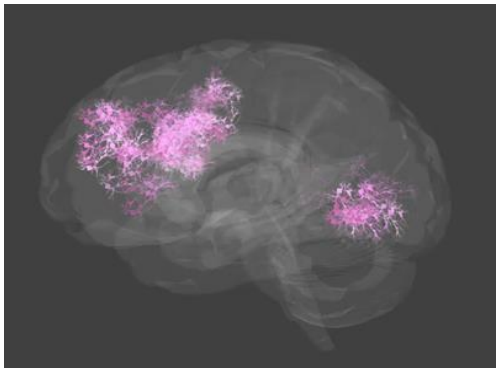

FIG. 15 Beta Waves Activated

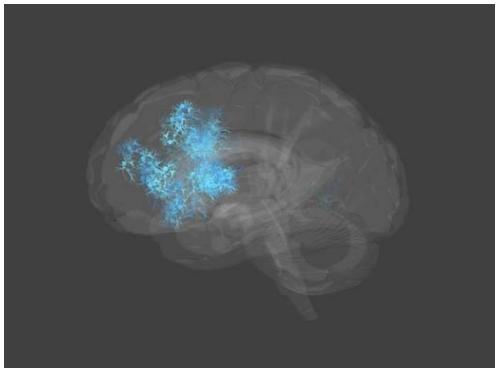

FIG. 16 Theta Waves in the Anterior Cingulate Cortex

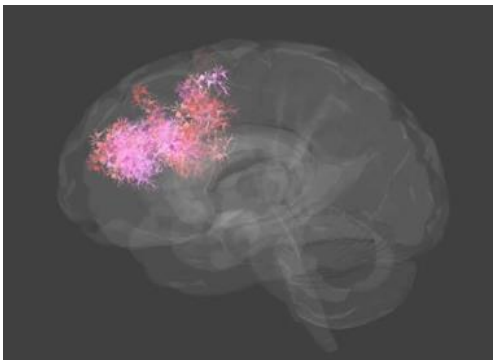

FIG. 17 Gamma and Beta Waves Activated

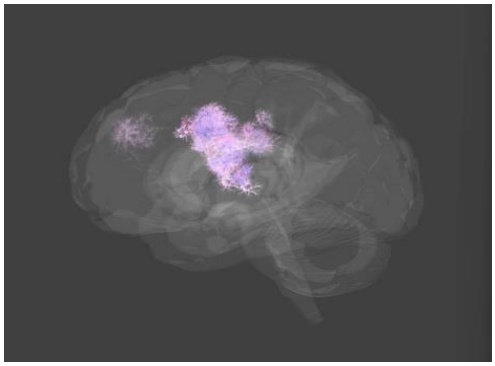

FIG. 18 Alpha Waves Activated

4. Insula – Responsible for awareness of bodily sensations and perceived stress, emotional adaptation, and specifically for integrating emotion and decision-making, the insula was activated primarily in the Gamma, Beta, and Theta bands, reflecting a balance between interoceptive monitoring, stress response, and emotional awareness without overload.

Day	EEG Activation	Emotional Interpretation
Day 1	Increased Gamma + Beta	Internal tension, high physiological stress
Day 2	Balanced Alpha	Calm bodily awareness, without overload
Day 3	Intermediate Activation	More stable emotional state, but without clear optimization

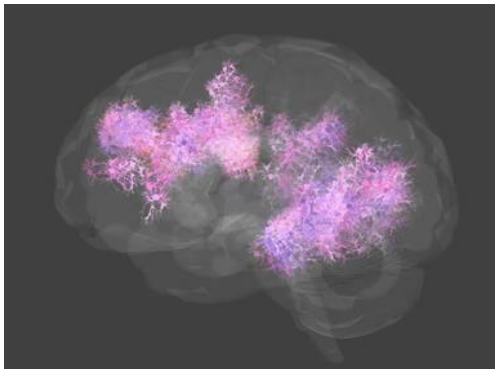

FIG. 19 Alpha and Beta Waves Activated in the Limbic Area, as well as the Insula

5. Dorsolateral Prefrontal Cortex (dlPFC) – Plays a crucial role in executive control, attentional focus, and "top-down" emotional regulation of subcortical structures (such as the amygdala). It is involved in maintaining concentration under pressure and inhibiting automatic emotional reactivity. In EEG activity, its involvement is reflected by the presence of Beta waves (cognitive vigilance) and Gamma waves (real-time integration of emotional-cognitive information).

Day	EEG Activation	Emotional Interpretation
Day 1 (no stimulation)	Fluctuating activation in Beta band, low in Gamma	Unstable emotional control, difficulties in maintaining emotional and cognitive focus
Day 2 (Halo)	Significant increase in Gamma waves and balanced Beta	Sustained emotional focus, effective inhibition of stress, and clear decisions under pressure
Day 3 (placebo)	Moderate Beta activation, decreased Gamma compared to Day 2	Partial emotional control, but lack of optimal integration of emotional responses

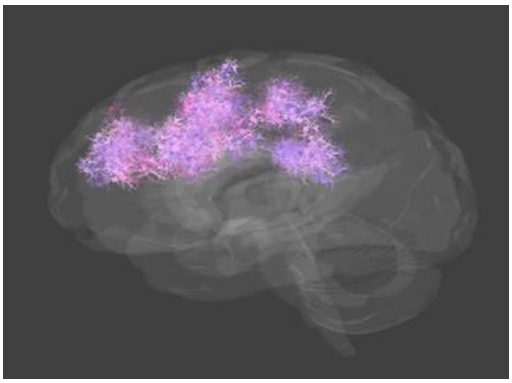

FIG. 20 Alpha and Beta Waves Activated in the Dorsolateral Prefrontal Cortex

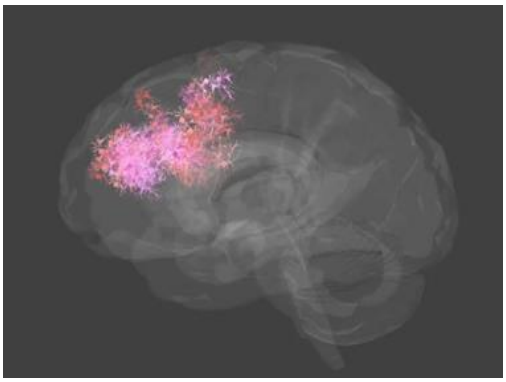

FIG. 21 Gamma and Beta Waves Activated in the Dorsolateral Prefrontal Cortex

The activation of brain waves does not occur sequentially but rather in a rapid and often simultaneous manner, reflecting the complexity of integrating cognitive and emotional functions. In demanding contexts, the brain mobilizes different neural networks simultaneously, represented by alpha, beta, theta, and gamma waves. This synchronous activation allows for efficient adaptation, rapid response, and fine regulation of behavior in real-time. Thus, emotional regulation, attention, and decision-making are not separate processes, but part of a unified and rapid brain response to the external context. In other words, the brain simultaneously processes emotions, thoughts, and actions.

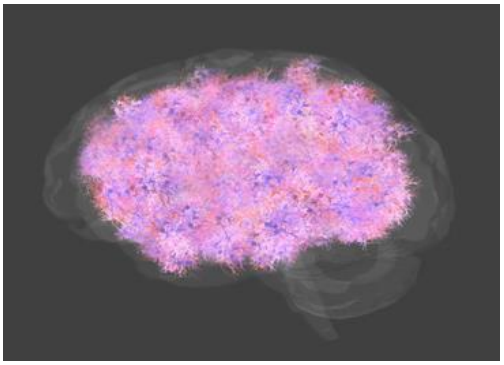

FIG. 22 Alpha, Beta, and Gamma Waves Activated in the Human Brain

Thus, on the first day (no stimulation), increased brain activation was observed in the prefrontal cortex and the limbic system, associated with emotional overload and acute mental stress. The EEG showed an increase in high Beta waves (Hi-Beta), which are correlated with anxiety and hypervigilance. On the second day (with Halo Sport), a significant decrease in negative emotional activation was recorded, along with an increase in alpha and theta waves, associated with states of calm, mental flow, and emotional self-regulation. The subjects reported improved emotional clarity, focus, and greater control. On the third day (placebo effect), the emotional response was intermediate, suggesting that the effect of Halo cannot be attributed to mere suggestion. The EEG confirmed moderate brain activation, but without the optimization observed on day two.

On the day of active stimulation, the EEG suggested a functional regulation of the limbic system, directly involved in emotional control (hippocampus, amygdala). This indicates that Halo Sport may facilitate an adaptive stress response through top-down modulation of limbic activity by the frontal cortex. Thus, emotional brain activity was significantly optimized on day 2 (Halo Sport stimulation), with:

- Reduced anticipatory stress (reduced Beta, increased Alpha)
- Emotional adaptation during effort (balanced insula and ACC)
- Effective emotional inhibition during shooting (increased Gamma in dlPFC)

Here's the comparison of neurophysiological and emotional responses based on daily stimulation:

Component	Day 1 – No Stimulation	Day 2 – With Halo Sport	Day 3 – Placebo
Emotional Activation	Intense, reactive, high stress	Controlled, calm, relaxed	Fluctuating, uncertain
Dominant EEG Waves	High Beta (Hi-Beta) – anxiety	Alpha/Theta – active relaxation	Mixed (Low Beta/Alpha)
Attention Focus	Dispersed, fluctuating	Focused, sustained	Partially sustained
Emotional Control	Low – frequent frustrations	High – efficient self-regulation	Medium – variable between subjects

CONCLUSIONS

The results of the study show that emotional regulation in operational stress contexts is not a simple adaptive reaction, but a high-level neurocognitive function that can be influenced by precise interventions such as neurotechnological stimulation (Halo Sport).

EEG observations and subjective feedback indicate that optimal performance occurs when emotions are not suppressed but actively integrated into the decision-making and action processes. Balanced activation of alpha, theta, beta, and gamma waves allows access to lucid calm, stable focus, and effective emotional self-regulation, which are essential for rapid, clear decisions and behavioral control in high-risk situations.

In the military environment, where pressure-induced reactions can make the difference between success and failure, training and optimizing emotional responses become critical components of tactical and mental performance. An emotionally balanced brain not only reacts but does so with intention, clarity, and adaptability traits essential for an operator prepared to face uncertainty and operational stress.

Halo Sport, through transcranial stimulation applied to the frontal regions, provided a stable neurophysiological framework conducive to the operational flow state a balance between challenge and internal emotional resources. Thus, the study demonstrates that non-invasive neurocognitive stimulation not only improves cognitive and motor performance but also facilitates emotional homeostasis, which is essential under tactical pressure conditions.

This study, initially conducted as part of my dissertation, aimed to analyze the impact of neurostimulation on cognitive and motor performance in simulated operational stress conditions. The results clearly show that using a neurostimulator, particularly the Halo Sport system, generated significant differences, leading to visible improvements in concentration, coordination, and reaction capabilities compared to states without stimulation or with placebo effects.

Based on this initial experimental core, I extended the analysis into a crucial but often neglected direction: the emotional component. Although less visible, the emotional aspect plays a critical role in military performance, as emotional responses determine how a soldier reacts, makes decisions, and maintains control in high-stakes situations. From this perspective, EEG results showed not only cognitive and motor optimizations but also evident emotional regulation, with reduced anxiety levels, improved affective clarity, and increased mental resilience. Therefore, the Halo Sport neurostimulator demonstrated beneficial effects not only in cognitive and motor domains but also in the emotional domain, highlighting its integrative potential in the psychophysiological preparation of military personnel.

At the same time, the role of simulators proved to be fundamental. Only through realistic simulations in controlled conditions can we observe and analyze authentic brain and behavioral responses specific to tactical contexts. The military biathlon simulator in the COMIND laboratory provided the ideal framework for conducting such an applied study, faithfully replicating the real operational environment and allowing for a deep investigation of human reactions under pressure. The Emotiv Epoc+ EEG headset played an essential role in recording and interpreting brain activity in real-time, while Halo Sport demonstrated, by comparison, that neurostimulation can bring not just subtle but measurable improvements in an individual's overall performance.

Of course, like any scientific endeavor, this study has certain limitations. These include:

- The small sample size, which limits the generalizability of the conclusions;
- The variability of individual responses to stimulation, due to neurophysiological differences between participants;
- The lack of a long-term evaluation to confirm the persistence of observed effects beyond the immediate testing context;
- Methodological limitations of EEG;
- Uncontrolled external factors.

Despite these limitations, the study opens valuable perspectives for applied research in the field of military performance, laying the foundation for integrated interventions where EEG technology and neurostimulation combine with simulated training to support the development of a soldier who is not only physically prepared but also mentally and emotionally resilient. In an era where the complexity of the operational field is continuously growing, the ability to maintain emotional balance becomes as important as shooting accuracy or reaction speed. This study unequivocally highlights the potential of modern technology in achieving this ideal.

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