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SOFTWARE APPLICATIONS FOR MILITARY EMERGENCY RESCUE EQUIPMENT

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Abstract: *Soldiers operating in combat zones face countless risks, often in unpredictable and hazardous environments. Among the leading causes of mortality for combatants in armed conflict is, blood loss, often resulting from trauma to the limbs. One of the most significant challenges in the design of military protective equipment is ensuring effective auto-hemostasis for individuals wounded on the battlefield. The current paper addresses this issue by proposing three advanced technological solutions aimed at integrating an innovative, autonomous primary hemostasis system within military equipment. The proposed system automatically activates a pneumatic tourniquet upon detection of bleeding in the limbs, thus inducing hemostasis and preserving lives of the combatants. This system not only focuses on functionality, specifically the automatic response to bleeding—but also takes into account the comfort and mobility of the combatant, which is essential during intense military operations. To visualize the components of the protective combat suit, 3D modeling and simulation technologies were employed using the OptiTex software suite. These simulations provided an effective technique of assessing the design and functionality of the suit's integrated hemostasis system. Additionally, the undergarment fabric was antibacterially treated, enhancing hygiene and preventing infections, while the combat suit was also designed with infrared camouflage through screen-printing technique, ensuring both tactical advantage and protection in diverse combat environments. The paper outlines the promising potential of these technological innovations in improving the safety and survival of soldiers in battlefield conditions.*

Key words: *conductive fabrics, electronic circuit, hemostasis, pneumatic tourniquet, combatant, 3D simulation.*

1. INTRODUCTION

The *smart textiles* market is experiencing significant growth, particularly within the Military and Defense sectors, due to the unique ability of these materials to monitor both the wearer and their environment. This allows them to respond to external stimuli, providing crucial support in dynamic and high-risk situations [1], [2].

Conductive textiles are a key category within the field of smart textiles, and it is projected that the market will show a remarkable expansion, with a compound annual growth rate (CAGR) of 15.8%, from $3.28 billion in 2024 to an estimated $10.63 billion by 2032 (Fig. 1) [3].

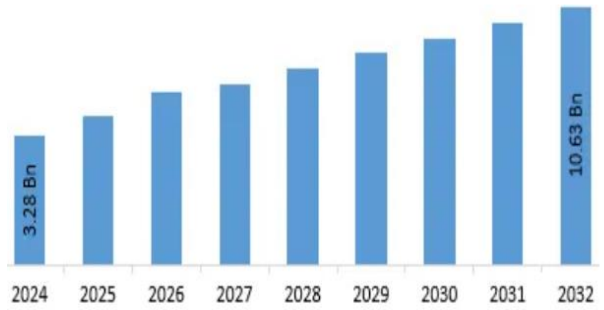


***Fig. 1**: Eatimated size of the conductive textiles market for 2024-2032* [3]

The integration of conductive textiles in the military and defense sectors represents a pivotal advancement, offering real-time monitoring, enhanced situational awareness and improved safety for personnel, all of which being critical in combat and emergency response scenarios. In the latest developments, fabrics conducting electricity have been integrated into military Personal Protective Equipment to enhance both protection and performance, offering unique functionalities such as real-time body monitoring, environmental sensing and energy harvesting, all crucial for modern military operations [4], [5].

Various electrical functionalizations of fibres, yarns and textile surfaces can be obtained, during:

- ❖ the fabrication process of the fibres;
- ❖ the spinning process of the yarns;
- ❖ the obtaining process of braided, woven, non-woven and knitted materials;
- ❖ the finishing process of fibres, yarns and textile surfaces,

enhancing the wearability and durability of protective military clothing, addressing key issues such as comfort and operational efficiency without compromising on protection, directly impacting the survivability and operational efficiency of soldiers [6].

2. MATERIALS AND METHODS

2.1 Materials

To identify the optimal technological solution for the design and production of intelligent combat suit equipped with an automatic primary hemostasis system, the basic need of the combatants in operation was considered, namely, ensuring survival after bleeding caused by shooting or cutting, through producing auto-hemostasis. The major challenges of this stage were given by the need to obtain the functionality for which the intelligent equipment was designed, namely the automatic activation of the pneumatic tourniquet upon detection of bleeding in the limbs, while ensuring the comfort of the combatant, in conditions of armed conflict.

Special fabrics were selected in order to respond to the critical needs: functionality, comfort and camouflage of the soldier:

- electroconductive knitted fabric, 90% cotton+ 10% elastane, with antibacterial surface treatments against gram-positive bacteria (eg. *S. aureus*) and gram-negative bacteria (eg. *E. coli*)- for undergarment ensemble;
- woven fabric, designed with infrared camouflage, achieved through screen-printing, 5 masking colours being used: navy, brown, bordeaux, green and black- for the camouflage suit.

The military rescue equipment consists of 2 modules, namely:
- *the undergarment ensemble*, consisting of a long-sleeved blouse and long trousers, made of antibacterial knitwear with electroconductive properties;
- *the infrared (IR) camouflage suit*, consisting of a combat jacket and trousers, made of woven fabric in IR camouflage colors.

2.2 Methods

Automatic hemostasis system

Three technological solutions were developed, which have in common *the principle of producing autohemostasis*, by automatic inflation of the pneumatic tourniquets (5), actuated by the pneumatic circuit (4), based on the signal received from the Central Unit (3) and triggered by the interruption of the electrical circuit of the textile material (2), by shooting or cutting (1) (fig. 2).

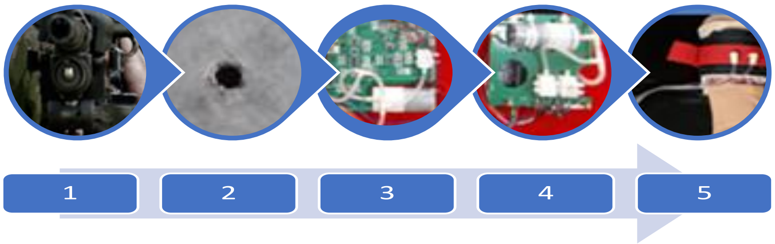


Fig. 2*: Activation of the automatic primary hemostasis system*

Military emergency rescue equipment

In order to define and visualize the components of the combat equipment, several 3D simulations were performed on a parameterized mannequin, corresponding in dimensions to size 48, using the OptiTex software suite [7]. Based on the autohemostasis principle presented in Fig. 2, the disposing of the system elements on the undergarment assembly, can be visualized in Fig. 3.

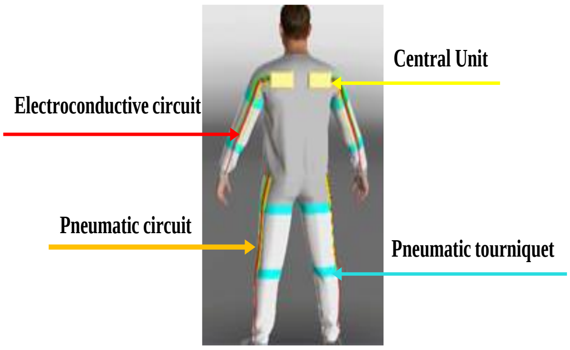
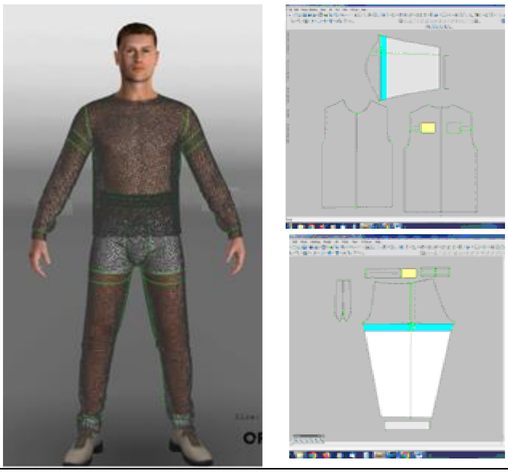
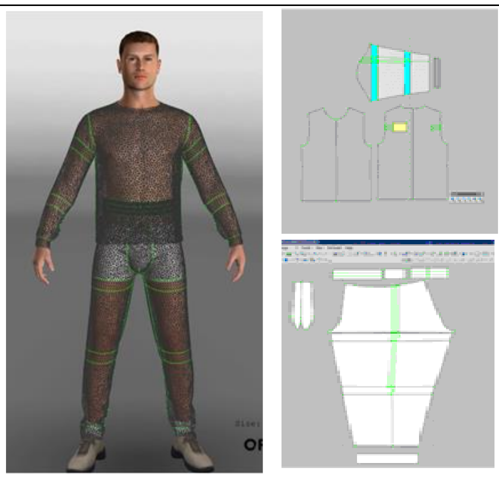
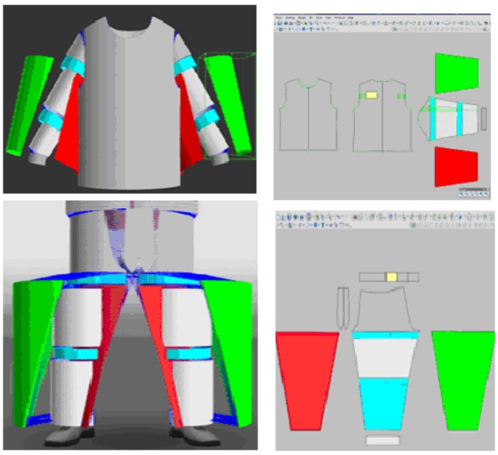
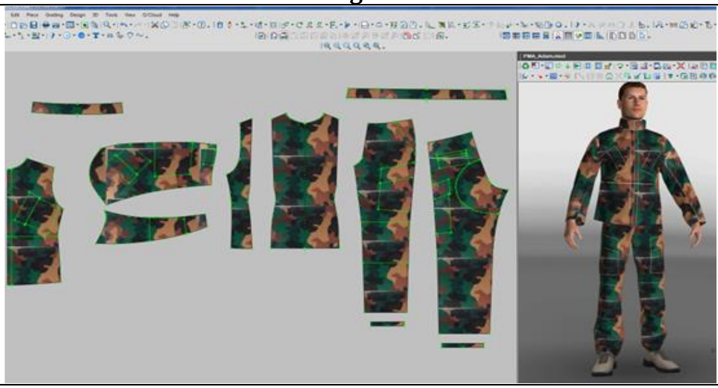


Fig. 3*: The elements of the automatic hemostasis system*

Three technological solutions were provided for the integration of the automatic primary hemostasis system into the undergarment assembly, which represents the inner layer of the intelligent equipment and one technological solution for the infrared camouflage suit, representing the outer layer of the intelligent equipment (Tab. 1).

Table 1: *Technological solutions for the design of military emergency rescue equipment*

Undergarment assembly	
Design 1. *4 pneumatic tourniquets and 4 electroconductive circuits*	
A single-layered undergarment assembly, made of antibacterial knitwear with electroconductive properties, equipped with the following configuration of the automatic primary hemostasis system: ❖ 4 pneumatic tourniquets: 1 for each limb; ❖ 4 control units: 1 for each tourniquet; ❖ 4 electroconductive circuits: 1 for each control unit; ❖ 4 pneumatic circuits: 1 for each tourniquet.	
Design 2. *8 pneumatic tourniquets and 8 electroconductive circuits*	
A single-layered undergarment assembly, made of similar fabric from the first solution provided, but with a different configuration of the automatic primary hemostasis system: ❖ 8 pneumatic tourniquets: 2 for each limb; ❖ 4 control units: 1 for each limb; ❖ 8 electroconductive circuits: 2 for each control unit; ❖ 8 pneumatic circuits: 1 for each tourniquet.	
Design 3. *8 pneumatic tourniquets and 8 electroconductive circuits, modular structure*	
A multiple layer undergarment assembly, composed of 3 layers in the conductive areas, made of antibacterial knitwear with electroconductive properties , equipped with the following configuration of the automatic primary hemostasis system: ❖ 8 pneumatic tourniquets: 2 for each limb; ❖ 4 control units: 1 for each limb; ❖ 8 electroconductive circuits: 2 for each control unit; ❖ 8 pneumatic circuits: 1 for each tourniquet.	

IR camouflage combat suit

For all the three proposed solutions for the creation of the Intelligent Equipment with integrated automatic primary hemostasis system, the IR Camouflage Suit will be used, a clothing ensemble composed of a combat jacket and trousers, made of woven fabric dyed and printed in IR masking colors, with the role of ensuring the camouflage of the combatant in operation.

4. CONCLUSIONS

The design and development of military emergency rescue equipment face significant challenges due to the critical need of integrating advanced technological solutions, the automatic primary hemostasis system, in this case. However, achieving this functionality is not enough on its own; the system must also ensure that the combatant's comfort and camouflage is maintained while the equipment functions optimally in high-stress environments.

To tackle these complex challenges, various technological solutions have been explored, and a series of 3D simulations were conducted using the OptiTex software suite on a parametrized mannequin. These simulations played a crucial role in visualizing and refining the component parts of the intelligent military equipment. By simulating the interactions between the equipment and the combatant's body, the effectiveness of the system in terms of functionality, ergonomics and user comfort were validated.

As a result, the development of this intelligent emergency rescue equipment represents a significant step forward in improving combatant survival rates and operational effectiveness in military settings.

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REFERENCES

[1] Imarc, *Conductive Textiles Market Report by Fabric (Cotton, Nylon, Polyester, and Others), Product (Woven Textiles, Non-Woven Textiles, Knitted Textiles), Application (Military and*

Defense, Healthcare, Sports and Fitness, and Others), and Region 2024–2032, 2024. [Online]. Available: https://www.giiresearch.com/

[2] Research and Markets, *Conductive Textiles Market Report by Fabric, Product, Application, and Region 2024–2032*, 2024. [Online]. Available: https://www.researchandmarkets.com/

[3] Research and Markets, *Conductive Textiles Market: Global Industry Analysis and Forecast (2025–2032)*, 2025. [Online]. Available: http://www.maximizemarketresearch.com

[4] Molliflex®, 2024. [Online]. Available: https://intelligenttextiles.com/

[5] R. A. Chapman, *Smart Textiles*, The Textile Institute, Woodhead Publishing, 2013.

[6] Shieldex, *Military & Defense*, 2025. [Online]. Available: http://www.shieldex.de

[7] ASRO, *SR 13544:2010_Îmbrăcăminte. Dimensiunile corpurilor şi mărimi de confecţii pentru bărbaţi*, 2010.