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Redesigning Nigerian Security Attire: Exploring E-Textiles as a Technological Response to Insecurity

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ABSTRACT

This study investigates the potential application of smart electronic textiles (e-textiles) in redesigning Nigerian security uniforms to enhance operational efficiency and personnel safety. Through a qualitative review of literature on wearable technology, IoT-enabled fabrics, and military smart textiles, the research proposes a conceptual framework for integrating sensors, conductive fabrics, and communication technologies into security attire. The study also evaluates the feasibility of implementing such technologies in Nigeria, highlighting potential technical, economic, and infrastructural challenges. Findings indicate that smart textiles could significantly improve threat detection, biometric monitoring, and situational awareness, but their adoption will require strong research investment, local production capacity, and strategic policy support.

Keywords: Smart textiles, Electronic textiles (E-textiles), Security technology, Military wearables, Internet of Things (IoT)

INTRODUCTION

Nigeria is currently confronted with numerous internal security challenges arising from factors such as religious extremism, inter-ethnic conflicts, kidnapping, armed robbery, and other forms of organised crime. These security threats have significantly undermined public safety and national stability. Although the government has rejected claims that it lacks the capacity to address these problems, the persistence and expansion of insecurity across the country suggest that existing measures have produced limited results. The situation has therefore generated widespread concern among scholars, policymakers, and the general public.

Several scholars have examined the causes and dynamics of insecurity in Nigeria. Asaolu (2012) argues that security agencies rely primarily on surveillance and intelligence gathering as strategies for addressing security threats. Similarly, Jibrin (2022) attributes the persistent security crisis partly to the recklessness of political elites and concludes that the government has yet to develop a comprehensive and sustainable solution to the problem. In an interview with The Guardian, Professor Adeniyi Olatunbosun also suggested that poverty should be considered a significant factor contributing to criminal activities, although many criminal justice experts argue that poverty alone cannot fully explain criminal behaviour (Adeyemi & Agboluaje, 2019).

The primary responsibility of any government is the protection of lives and property. This obligation is reinforced by Duerksen (2021), who emphasises that ensuring citizens' safety is a fundamental function of state authority. In Nigeria, this responsibility is not merely a moral obligation but a constitutional requirement. The 1999 Constitution of the Federal Republic of Nigeria (as amended) guarantees the right to life under Section 33 and states in Section 14(2b) that the security and welfare of citizens shall be the primary purpose of government (Alliances for Africa, 2018). This constitutional principle aligns with international human rights frameworks. For instance, Article 3 of the Universal Declaration of Human Rights affirms that every individual has the right to life, liberty, and security of person. Likewise, Article 4 of the African Charter on Human and Peoples' Rights declares that human beings are inviolable and that no individual shall be arbitrarily deprived of life. Despite these legal protections, the prevailing security challenges in Nigeria indicate that these rights are frequently violated.

In response to these challenges, several security institutions have been established and empowered to maintain law and order. Nigeria's security architecture includes the Nigerian Armed Forces comprising the Nigerian Army, Nigerian Air Force, and Nigerian Navy, alongside the Nigeria Police Force, the Nigeria Security and Civil Defence Corps, and other paramilitary organisations. These institutions operate under statutory authority granted by Acts of Parliament and function under the overall command of the President as the Commander-in-Chief of the Armed Forces.

Each of these security organisations is identifiable by a distinct uniform that differentiates one agency from another. Typically, these uniforms consist of a fitted jacket or shirt, trousers for male personnel and skirts for female personnel in some cases, headgear such as caps or berets, and accessories including boots, belts, badges, and insignia that communicate rank and institutional identity. Beyond their functional purpose, these uniforms also serve symbolic and organisational roles within security institutions.

Despite the deployment of various security technologies, including automated surveillance systems such as closed-circuit television (CCTV), insecurity continues to persist. Keval (2009), cited in Paki, Sani, and Babagana (2015), notes that automated visual surveillance technologies are widely used by governments and financial institutions to enhance safety and security by monitoring activities and triggering alarms when suspicious behaviour is detected. While such technologies are useful for documenting incidents and supporting investigations, their effectiveness is limited because security personnel typically respond only after an incident has already occurred.

Technological innovation has historically been a key driver of societal advancement, influencing nearly every sector of human activity. Consequently, addressing Nigeria's security challenges may require the adoption of innovative technological solutions. One promising approach is the integration of smart textile technology into security uniforms. Smart textiles are materials designed to sense and respond to environmental stimuli, including mechanical, thermal, chemical, electrical, and magnetic signals (Ajmera, 2022). These fabrics combine traditional textile structures with embedded electronic components to perform specialised functions beyond those of conventional clothing.

Smart textiles must satisfy several important criteria, including comfort, adaptability to different body forms, durability, and aesthetic acceptability. Melin (2010) explains that smart fabrics are capable of sensing external conditions and responding to them in predetermined ways. Such capabilities make them suitable for applications in environments where real-time monitoring and adaptive responses are essential. Beyond the conventional reliance on weapons and other military technologies, the incorporation of smart textile systems into security uniforms offers significant potential for enhancing operational effectiveness. Through interdisciplinary collaboration involving fashion design, textile engineering, electronics, artificial intelligence, fibre technology, information technology, molecular engineering, and nanotechnology, smart garments can be developed to improve safety, communication, and situational awareness among security personnel. On this basis, the study aims to explore the potential of smart textile technologies in the redesign of Nigerian security uniforms in order to enhance operational effectiveness, safety, and situational awareness in addressing contemporary security challenges.

Research Methodology

This study adopts a qualitative exploratory research design based on systematic literature analysis. The approach is appropriate because the study seeks to conceptualise and evaluate the potential integration of smart textile technologies within Nigerian security uniforms rather than to conduct experimental testing.

Literature Search Strategy and Selection Criteria

Relevant literature was retrieved through structured searches in major academic databases including Scopus, Web of Science, Google Scholar, IEEE Xplore, and ScienceDirect. The search employed combinations of keywords such as: smart textiles, electronic textiles, military wearable technology, IoT-enabled clothing, smart fabrics in defense applications and wearable sensors in security systems.

Publications were selected using peer-reviewed journal articles, conference papers, and technical reports. Studies focusing on Nigerian security, smart textiles, wearable electronics, and military applications were considered. Also, Literature addressing sensor integration, biometric monitoring, and wearable IoT systems and research discussing design, functionality, as well as practical implementation of e-textiles.

Analytical Framework

The collected literature was analysed using a thematic analytical framework that examined three major dimensions:

i. Technological Dimension includes: sensor integration, conductive yarns and circuits, energy systems and connectivity
ii. Functional Dimension involves: biometric monitoring, environmental hazard detection, communication and data transmission
iii. Implementation Dimension includes: economic feasibility, manufacturing capability, institutional and policy readiness in Nigeria

This framework enabled the study to synthesise existing knowledge while assessing how smart textile innovations could be adapted to the Nigerian security environment.

Security Challenges in Nigeria: An Overview

Security challenges in Nigeria have attracted considerable scholarly attention, with various researchers examining their causes, manifestations, and consequences. One widely held view is that the current wave of insecurity intensified with the emergence of the Boko Haram insurgency following the extrajudicial killing of its leader, Mohammed Yusuf. According to Abu-Bashal (2022), the insurgency has persisted for over a decade and has had devastating social and economic consequences.

Initially concentrated in northeastern Nigeria, the activities of Boko Haram have gradually spread to other parts of the country, contributing to a broader climate of insecurity. Ibrahim (2022) reports that more than 35,000 people have lost their lives, while over three million individuals have been displaced as a result of the insurgency. Data from the Nigeria Security Tracker (NST) further indicate that between January and March of the referenced year, at least 2,968 individuals were killed and 1,484 abducted across the country (Ibrahim, 2022). Regional analyses reveal that during this period, 181 people were killed in the South-East, while the South-West and South-South regions recorded 127 and 85 deaths, respectively.

In addition to Boko Haram, other armed groups have contributed to the country's security crisis. These include bandit groups operating in northwestern Nigeria, the Indigenous People of Biafra (IPOB) and its paramilitary wing known as the Eastern Security Network (ESN), the Islamic State in West Africa (ISWA), kidnappers, and various organised criminal networks. The activities of these groups have resulted in widespread destruction of lives and property.

Reflecting the gravity of the situation, former President Muhammadu Buhari reportedly described the country's security situation as approaching a "state of emergency" (Duerksen, 2021). In response to this crisis, Adeyemi and Agboluaje (2022) argue that the government must create an enabling socio-economic environment that reduces crime and addresses the underlying causes of insecurity.

Nigerian Security Force in Digest

Security agencies are governmental institutions responsible for intelligence gathering and maintaining internal and external security within a nation (Nigerian Finder, 2022). In Nigeria, the security sector comprises military forces, police institutions, and several paramilitary organisations.

These institutions operate under the authority of the executive branch of government, with the President serving as the Commander-in-Chief of the Armed Forces. Their primary mandate includes enforcing the laws of the country, protecting national sovereignty, and safeguarding citizens against internal and external threats.

The Nigerian Armed Forces consist of the Nigerian Army, Nigerian Air Force, and Nigerian Navy (Armed Forces of Nigeria, 2022). Historically, these forces evolved from the Royal West African Frontier Force, which was established during the colonial period and later transformed into the Nigerian Armed Forces following the country's independence in 1960.

In contrast, the Nigerian Police Force is primarily responsible for maintaining internal security and addressing civil disturbances within the country's territorial boundaries. In addition, several paramilitary agencies contribute to national security efforts, including the Nigeria Customs Service, Nigeria Security and Civil Defence Corps, Nigeria Immigration Service, Nigeria Correctional Service, and the Nigeria Peace Corps.

NIGERIAN SECURITY UNIFORMS

Nigeria has numerous security agencies, each with distinctive uniforms that symbolise institutional identity and authority. However, this study focuses primarily on the uniforms of the Nigerian Armed Forces and the Nigerian Police Force.

Typically, these uniforms consist of several components, including jackets or shirts with insignia and badges, trousers, headgear such as berets or caps, boots, belts, helmets, stockings, and other accessories. Military personnel generally wear camouflage patterns designed to provide tactical concealment in operational environments (Stephens, 2020).

The Nigerian Armed Forces Uniform

According to Audu (2020), the Nigerian Army uniform serves multiple functions beyond basic clothing. It communicates rank, length of service, professional specialisation, and awards received by personnel. Nigerian Army uniforms are generally categorised into three types: Combat or Field Uniform, Service Uniform, and Dress Uniform (Figure 1).

Military clothing also possesses historical and symbolic significance. Adrianna (2018) notes that military uniforms represent authority, discipline, and institutional heritage. In Nigeria, the use of camouflage patterns has traditionally been restricted to military personnel. However, the widespread commercial availability of older camouflage patterns led to their misuse by insurgents and criminals posing as soldiers (Nigerian Armed Forces, 2020). To address this challenge, the Nigerian government introduced new camouflage designs in 2014 that are produced under strict manufacturing control and issued across the various branches of the armed forces (Adrianna, 2018).

Figure 1: *Nigeria Army Uniform*

Note: The DHQ warns politicians and others against wearing military uniforms in 2022. From The Premium Times, Nigeria, by Agency Report http://www.premiumtimesnigeria.com

The Nigerian Air Force uniform features distinctive insignia, including a golden horse emblem and a red eagle symbolising strength and honour, with a dark blue base colour. Pilot combat uniforms typically use a green-khaki colour scheme. Additional elements include black caps, white gloves, and gold-coloured epaulettes (Adrianna, 2018) (figure 2). Similarly, the Nigerian Navy utilises uniforms in white, blue, and camouflage variations, each designed for specific operational contexts (Thabit, 2016) (Figures 3 and 4).

The Nigerian Police Uniform

The Nigeria Police Force is a federal institution with a centralised command structure headed by the Inspector-General of Police (IGP), who reports directly to the President (Nigeria Police Watch, 2022).

Historically, the police uniform has undergone several changes. Adrianna (2018) notes that the uniform evolved from a green-grey colour scheme to the current black-based design (figure 5).

According to Badejo (2012), the police later introduced an operational camouflage uniform composed of black, white, and grey patterns (figure 6). More recently, a bluish-tinted uniform has been introduced for senior officers (Fassan, 2012) (figure 7). Additionally, policy changes have permitted the inclusion of the hijab as part of the uniform for female Muslim officers (figure 8).


Figure 2: *Air Force Uniform*
Note: Air Force promotes 19 officers to air vice-marshal, 33 to air commodore by Ayokunle Daramola, From The Cable (2024), http://www.thecable.ng/air-force//

Figure 3: *Naval Administrative Uniform*
Note. From PIECE (2024), by Damilare Aanu https://www.withinnigeria.com

Figure 4: *Naval Field Uniform*
Note. From PIECE (2024), by Damilare Aanu https://www.withinnigeria.com

Figure 5: *Police Black Uniform*
Note. From *Pinterest*, (2024), https://www.pinterest.com/pin/248542473164773074/

Figure 6: *Police camouflage*
Note. From Pinterest (2024), https://www.pinterest.com/pin/248542473164773074/

Figure 7: *Police bluish tint uniform*
Note. From Pinterest (2024), https://www.pinterest.com/pin/248542473164773074

Figure 8: *Police uniform with hijab*
Note. Police adopt new dress code, hijab allowed for female police officer by Instablognaija (2022), From PM news, https://pmnewsnigeria.com/2022/03/06/nigerian-female-cops-can-now-wear-hijab-with-uniform-photos/?amp=

SMART TEXTILES: FASHION FOR COMBATING INSECURITY

Clothing constitutes one of the basic physiological needs identified in Maslow’s hierarchy of human needs. Historically, clothing has also been one of the earliest forms of wearable technology developed by humans (Luis, Wolfgang, & Santi, 2017).

Smart textiles represent a new generation of fabrics that integrate digital and electronic technologies into traditional textile materials. Muscato (2020) defines smart textiles as fabrics embedded with computer-based technologies capable of performing specialised functions.

Fernández-Caramés and Fraga-Lamas (2018) further describe smart textiles as wearable electronic systems designed to operate on or near the human body to provide intelligent services within a broader technological ecosystem. Due to their large contact area with the skin, garments such as shirts provide an effective platform for integrating sensors capable of monitoring biometric signals such as heart rate and respiration (Figure 9).

Figure 9: *Ralph Lauren PoloTech Shirt*
Note. Ralph Lauren makes Tech Wearable with Polo Tech by Juliana Medinna (2015), http://www.hauteliving.com

Hence, it becomes easier to pick where the incidence happens and be able to maximise the meaning. Tomico, Hallnäs, Liang, and Wensveen (2017) posit that wearables include clothing and textile-based accessories that incorporate smart textiles and electronic interfaces to enable responsive and interactive experiences. Xiaopei Wu and Li (2019) explained that the key distinguishing quality of smart textiles is that they are "soft" materials with flexibility and drapability, because there are a great deal of smart textiles which are not used toward wearables but toward applications which do not require removal of the textile once applied (such as car interiors or wallpaper).

Smart Textile Classification

The classification proposed by the International Electrotechnical Commission (IEC), particularly by its IEC Technical Committee 124, represents an ongoing effort to standardise the field of wearable electronic devices and technologies. According to Francisco J. Fernández-Caramés and Paula Fraga-Lamas (2018), smart wearable technologies can be categorised into four principal types: accessory wearables, textile or fabric wearables, patchable wearables, and implantable wearables (Fig. 10). However, the present study focuses specifically on textile/fabric wearables and accessory wearables, as these categories have direct relevance to the development and improvement of Nigerian military uniforms.

Similarly, the classification proposed by Luis L., Wolfgang T., and Santi R. (2017) closely aligns with the earlier framework but organises smart textiles into three broad categories: Passive, Active, and Intelligent smart textiles. Passive smart textiles primarily function as conduits and do not possess sensing or actuating capabilities. Active smart textiles incorporate sensors and actuators; however, these components remain physically separate from the fabric structure. In contrast, intelligent smart textiles integrate sensing, actuating, or energy-generating capabilities directly into the fabric itself. Such textiles are capable of responding to environmental stimuli and automatically adjusting certain functional parameters in accordance with ambient conditions.

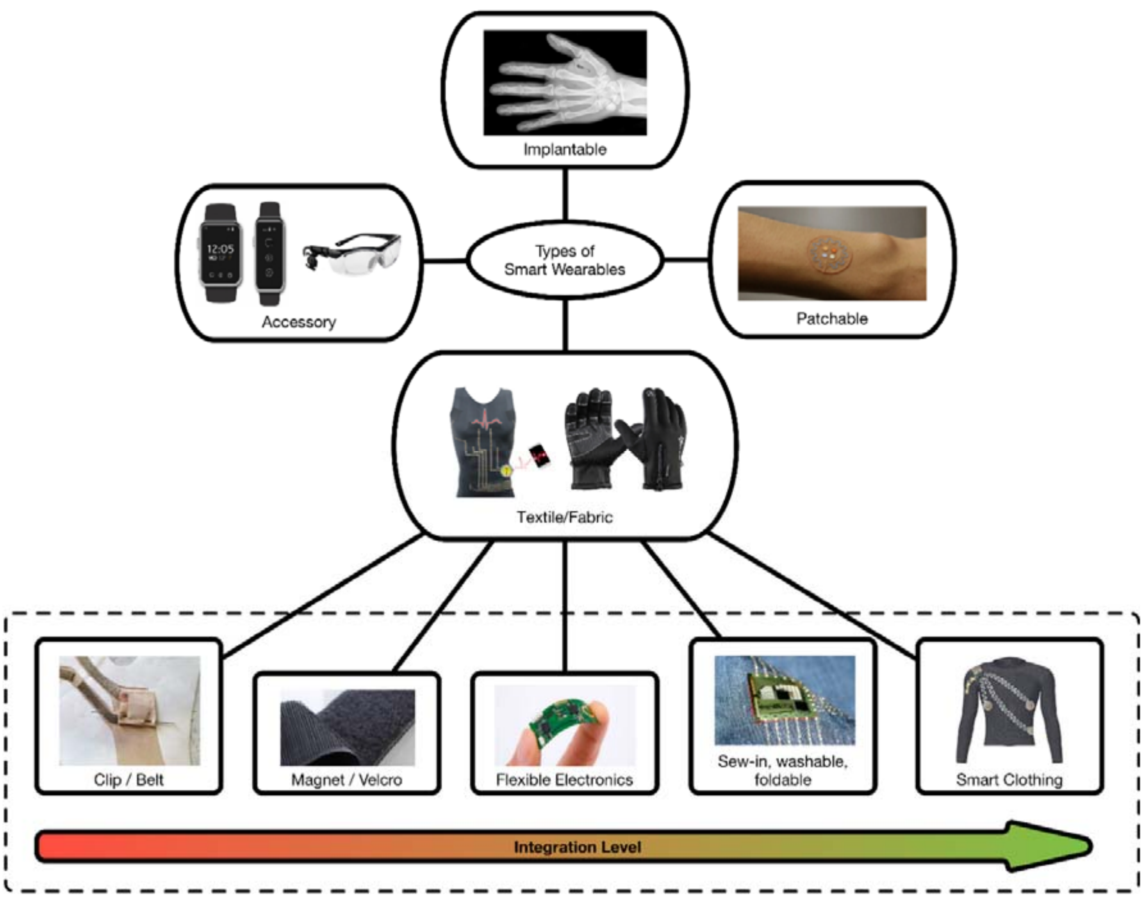

Figure 10: *Main Types of Smart Wearables and Textile/Fabric Wearables*
Note. From Towards the Internet of Smart Clothing: A Review on IOT Wearables and Garments for Creating Intelligent Connected E-Textiles by T. M. Fernández-Caramés and Fraga-Lamas 2018, *Electronics*, 7(12), p-405, https://doi.org/10.3390/electronics7120405, Copyright 2018 by MDPI

Furthermore, Kapfunde (2018) observes that the convergence of fashion and technology is increasingly being driven by designers and manufacturers who are developing innovative materials that enhance user convenience and functionality. In this context, smart garments and wearable technologies must be designed to ensure comfort and ergonomic compatibility with the human body to achieve their intended functional performance.

It is also important to note that smart wearable technologies have been widely adopted by several countries for military applications, particularly for personnel operating in harsh and demanding environments. These technologies enable the monitoring of various physiological and environmental parameters, including heart rate, respiration, fatigue, stress levels, geographic location, and the presence of toxic gases. In such contexts, wearable systems can provide real-time feedback to users, thereby enhancing operational efficiency, safety, and situational awareness (Fernández-Caramés and Fraga-Lamas, 2018).

For example, a smart vest reported by Fernández-Caramés and Fraga-Lamas (2018) integrates multiple sensors, including electrocardiogram (ECG), Thoracic Electrical Bio-impedance (TEB), and an Inertial Measurement Unit (IMU). These sensors are connected via Bluetooth to an Android tablet, where the collected data are processed, stored, and visualised for monitoring and analysis purposes.

REDESIGNING NIGERIAN SECURITY OUTFITS THROUGH SMART TEXTILE INTEGRATION

Smart textiles have gained significant relevance in contemporary military technology due to their ability to integrate sensing, communication, and protective functionalities into wearable systems. Recent studies show that wearable electronic textiles enable real-time monitoring, adaptive camouflage, and integrated communication systems within military garments, thereby improving situational awareness and operational efficiency (Dias & Ratnayake, 2021; Hughes-Riley, Dias, & Cork, 2022; Yetisen *et al*., 2022). The authors highlighted two major areas of applications of smart textiles in security and defense operations below.

Enhancing Security through Smart Textile Technology

Smart textile systems can integrate sensors capable of monitoring physiological parameters such as heart rate, respiration rate, fatigue level, and stress indicators while simultaneously detecting environmental hazards such as toxic gases or chemical agents (Heo, Kim, & Park, 2021; Stoppa & Chiolerio, 2020; Zhang *et al*., 2023). These systems can transmit real-time information to command centres using wireless communication technologies embedded within textile architectures, enabling rapid medical response and tactical decision-making during combat operations (Hughes-Riley *et al*., 2022; Tao, 2021).

Recent experimental military uniforms developed by defense agencies integrate adaptive camouflage systems, flexible displays, and optical sensors capable of altering visibility under night-vision surveillance, thereby improving stealth and operational survivability (Yetisen *et al*., 2022; Zhao, Li, & Wang, 2024).

Facilitating Operational Efficiency

The integration of conductive yarns and textile-based circuitry allows energy and data to be transmitted through fabrics, reducing the complexity and weight of conventional electronic wiring systems used by soldiers (Dias & Ratnayake, 2021; Stoppa & Chiolerio, 2020).

Textile-based power distribution systems enable seamless connectivity between communication devices, GPS units, sensors, and wearable displays integrated within military garments (Heo *et al*., 2021). Such developments significantly reduce equipment weight and enhance soldier mobility during missions (Zhang *et al*., 2023).

REQUIREMENTS FOR THE DEVELOPMENT OF NIGERIAN SMART MILITARY UNIFORMS

For smart military uniforms to be successfully adopted in Nigeria, several critical requirements must be considered to ensure functionality, usability, and cultural acceptability:

i. Functional Requirements: Smart military garments must be lightweight, flexible, and durable to accommodate intense physical movement while maintaining reliable sensor performance (Dias & Ratnayake, 2021).

Additionally, textile-embedded electronic components must be resistant to moisture, heat, and mechanical stress to ensure stable functionality under extreme operational conditions (Tao, 2021; Yetisen *et al*., 2022). Washability and maintenance also represent key design challenges in wearable electronics, requiring the development of durable conductive materials capable of withstanding repeated laundering cycles (Zhao *et al*., 2024).

ii. Aesthetics requirements. Uniform design must preserve institutional identity and visual symbolism while integrating technological components into garments without compromising professional appearance (Hughes-Riley *et al*., 2022). According to Muscato (2020), design considerations must include fibre selection, yarn construction, fabric performance, colour coordination, garment fit, and accessory integration.

iii. **Cultural requirements**. The design of smart military garments must also reflect social and cultural expectations associated with uniformed services. Studies on wearable technology adoption emphasise that cultural acceptance and institutional identity play critical roles in determining the successful implementation of smart garments (Dias & Ratnayake, 2021).

iv. **Environmental requirements**. Nigeria's tropical climate requires smart textiles that promote breathability, moisture management, and thermal comfort. Advanced textile engineering research suggests that natural fibres and moisture-wicking fabric blends provide better thermal regulation for wearable electronic systems in warm climates (Heo *et al*., 2021; Zhang *et al*., 2023).

Nigerian Military Uniform as a Smart Textile Platform

Recent advances in wearable electronics demonstrate that traditional military uniforms can function as integrated digital platforms capable of supporting sensors, communication modules, and energy-harvesting systems (Tao, 2021; Yetisen *et al*., 2022). The current Nigerian combat uniform features camouflage patterns composed of irregular amoebic shapes in olive green, lemon green, dark brown, golden brown, and peach colours.

In the proposed smart textile design, selected darker segments of the camouflage pattern could incorporate conductive inks and flexible electronic circuitry capable of sensing environmental threats and transmitting signals. Such integrated systems could detect the presence of weapons, explosives, or unusual environmental conditions within a defined proximity. Zhao *et al*. (2024) stated that conductive inks and flexible circuitry integrated into camouflage fabrics can enable detection of environmental threats while simultaneously providing feedback signals such as thermal alerts or optical indicators. When a threat is detected, the smart textile system could alert the wearer through thermal feedback or visual signals, such as controlled light emission through lighter segments of the camouflage pattern. This adaptive colour response could provide immediate tactical awareness without compromising stealth (Figure 11a & b).


a.


b.

Figure 11: *Military Camouflage*

Note. The Millitary camouflage. From Legit Nigeria 2004, Copyright 2004 by the Legit Nigeria http://www.legit.ng

Such technology would be particularly beneficial in environments where armed individuals may be concealed within civilian populations. The system could also assist in detecting buried explosive devices or landmines by integrating proximity sensors capable of identifying metallic or electronic signatures underground. Additionally, the uniform could incorporate infrared therapeutic modules that emit controlled radiation to assist in muscle recovery during fatigue or prolonged physical exertion. Textile-based communication networks embedded within garments have already been tested in prototype military systems designed to reduce equipment weight while improving connectivity among soldiers during field operations (Hughes-Riley *et al*., 2022).

A similar concept has been explored in the United Kingdom through the Broadsword Spine system, which integrates power and data networks into military garments using conductive fabrics instead of traditional wiring systems (Larkin, 2018). This technology allows electronic devices to connect directly to garments through textile-based USB connectors, reducing equipment weight by approximately 40%, which significantly benefits infantry personnel carrying heavy operational gear (figure 12).

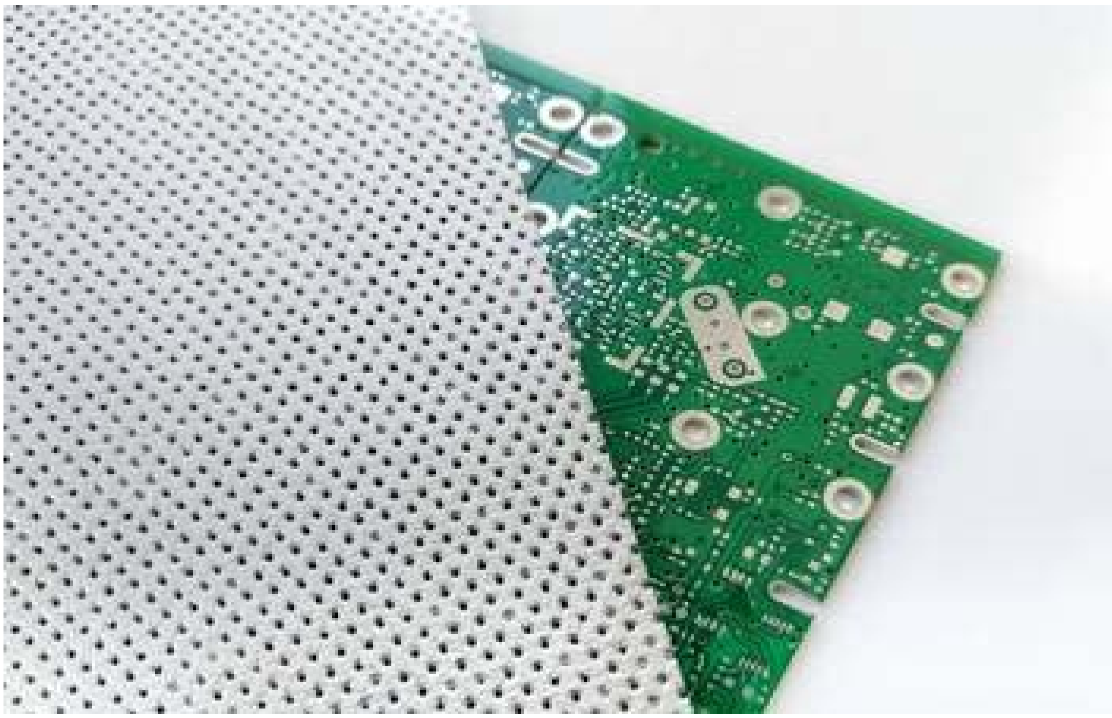

Figure 12: *Electronic Chips Embedded in Clothing*
Note. From Electronic chips embedded in clothing by Audrius Merfeldas (2019), Copyright 2019 by Shutterstock https://www.shutterstock.com/search/electronic-chips-embeded-in-clothing

Electrically Reactive Military Uniform
Another proposed innovation involves the development of electrically reactive military garments capable of generating controlled electric pulses during close-combat situations. Conductive fabrics embedded within the uniform could produce a non-lethal electric discharge designed to temporarily incapacitate hostile attackers during physical confrontation. The integration of conductive fibres and flexible electronic circuits within textile structures has been widely explored in smart textile research, demonstrating the feasibility of embedding electrical functionality directly into garments (Stoppa & Chiolerio, 2014; Tao, 2001).

To ensure operational safety, the inner layers of such garments would incorporate insulating protective materials that prevent electrical transmission to the wearer while allowing outward conductive discharge. Textile-based electronic systems can be engineered with multilayer protective structures that combine conductive yarns with insulating substrates, thereby enabling controlled electrical functionality without compromising wearer safety (Coyle, Morris, Lau, Diamond, & Moyna, 2010). Such technology could provide security personnel with an additional non-lethal defensive mechanism during physical encounters with hostile actors while awaiting reinforcement or rescue.

Stoppa & Chiolerio (2020) and Zhang *et al*. (2023) argue that electrically reactive smart garments represent an emerging area of research in wearable defense technologies. Conductive textile architectures can generate controlled electrical outputs for applications including non-lethal defense systems and active protective clothing. When combined with appropriate insulation layers, such garments can safely deliver controlled electrical pulses without exposing the wearer to harmful currents (Heo *et al*., 2021).

Nigerian Military Electronic Boots

Smart textile technology can also be extended to military footwear systems. Sensor-embedded boots equipped with conductive yarns and pressure sensors can detect landmines or underground explosives through electromagnetic or vibration-based detection mechanisms (Zhao *et al*., 2024). Textile-based sensing technologies have demonstrated the capability to detect pressure, strain, temperature, and electromagnetic signals when integrated into wearable systems (Cherenack & van Pieterson, 2012; Hughes-Riley, Dias, & Cork, 2018).

When a potential explosive device or suspicious object is detected, the boot could activate heat-based neutralisation mechanisms or wireless signal transmission systems to alert nearby units or command centres. Smart textile sensing systems integrated into wearable equipment have already been explored for applications such as environmental monitoring, soldier health monitoring, and hazard detection in military operations (Fernández-Caramés & Fraga-Lamas, 2018; Stoppa & Chiolerio, 2014). The integration of such technologies into military footwear could significantly reduce casualties associated with landmines and improvised explosive devices (IEDs) during patrol and reconnaissance missions.

FEASIBILITY AND IMPLEMENTATION CHALLENGES IN NIGERIA

Although smart textile technologies have been increasingly adopted in advanced military systems worldwide, their implementation in Nigeria faces several practical and structural constraints. While these technologies offer promising solutions for enhancing soldier safety, communication, and environmental awareness, several technological, economic, and institutional barriers may limit their immediate adoption within the Nigerian security sector.

i. **Technical Constraints**

The development of Internet-of-Things (IoT) enabled security garments requires sophisticated technologies, including flexible electronics, conductive fibres, miniaturised sensors, and embedded power systems. These components enable garments to function as wearable computing platforms capable of sensing, communication, and data processing (Stoppa & Chiolerio, 2014; Hughes-Riley, Dias, & Cork, 2018). However, Nigeria currently has limited industrial capacity for producing such advanced materials locally.

Most critical components, including microcontrollers, biosensors, flexible circuits, and conductive polymers, would likely need to be imported, thereby increasing production costs and creating dependence on international supply chains (Tao, 2015; Yetisen *et al*., 2016). Furthermore, the absence of specialised fabrication laboratories and large-scale e-textile manufacturing infrastructure within Nigeria presents additional challenges to the domestic production of smart security garments.

ii. **Cost Implications**

Smart textile systems are significantly more expensive than conventional military uniforms because of the integration of electronic components, advanced materials, and specialised manufacturing processes. Research in wearable technology indicates that smart garments may cost several times more than standard textile products depending on the number of embedded sensors, communication modules, and power management systems (Cherenack & van Pieterson, 2012; Fernández-Caramés & Fraga-Lamas, 2018).

For a developing economy with multiple competing budgetary priorities, including healthcare, education, and infrastructure, large-scale deployment of smart textile uniforms across Nigerian security agencies could therefore pose significant financial challenges. Without domestic manufacturing capabilities, the cost of importing technological components could further increase the overall expenditure associated with adopting such systems.

iii. **Infrastructure and Maintenance Challenges**

Another critical challenge concerns the long-term maintenance and operational sustainability of smart textile systems. Electronic garments require periodic calibration, battery replacement, software updates, and technical support to maintain optimal functionality. These requirements necessitate reliable digital infrastructure and specialised maintenance facilities (Dias, 2015; Stoppa & Chiolerio, 2014).

In many operational environments across Nigeria, particularly in rural or conflict-affected regions, access to reliable electricity, data networks, and technical maintenance services remains limited.

These infrastructural constraints may reduce the operational reliability of smart security garments if adequate support systems are not established.

iv. **Policy and Institutional Readiness**

The successful integration of smart textile technologies into Nigeria's security architecture would also require supportive institutional frameworks and coordinated policy initiatives. Effective implementation would depend on the development of:

- Strong defense technology policy frameworks
- Increased government investment in research and development
- Strategic collaboration between universities, textile industries, electronics engineers, and defense institutions.

Studies on technological innovation in developing countries emphasise that interdisciplinary collaboration between academia, industry, and government is critical for the successful adoption of emerging technologies (Etzkowitz & Leydesdorff, 2000; Yetisen *et al*., 2016). However, such coordinated innovation ecosystems remain relatively underdeveloped within Nigeria's research and industrial landscape.

POTENTIAL BENEFITS

Despite these challenges, the potential advantages of smart textile integration in military systems are substantial. Smart military garments could enable real-time monitoring of soldiers' physiological conditions, including heart rate, body temperature, fatigue levels, and stress indicators. These systems could also provide location tracking during tactical operations and detect environmental hazards such as toxic gases or chemical exposure (Fernández-Caramés & Fraga-Lamas, 2018; Hughes-Riley *et al*., 2018).

Furthermore, wearable sensor networks integrated into military uniforms can enhance situational awareness and improve communication between soldiers and command centres during combat operations (Cherenack & van Pieterson, 2012). Countries such as the United States and the United Kingdom have already developed prototype smart military uniforms that integrate wearable sensors, wireless communication systems, and energy-harvesting textiles into combat gear.

Adapting similar technologies, while scaling them to Nigeria's economic and technological capacity, could significantly improve the operational effectiveness, safety, and survivability of Nigerian security personnel.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are proposed:

Sensor-Integrated Headgear: Security headgear could incorporate sensor systems capable of identifying and remotely disabling registered firearms through magnetic or electronic identification mechanisms.

Development of Full-Body Smart Military Suits: Military uniforms could be redesigned as integrated smart body suits capable of monitoring physiological conditions, environmental hazards, and tactical information.

Increased Investment in Security-Oriented Research: The Nigerian government should increase funding for interdisciplinary research in textile engineering, wearable technology, artificial intelligence, and nanotechnology to develop indigenous smart security technologies.

Collaboration between Academia and Defense Institutions: Universities, textile research institutes, and defense agencies should collaborate in developing prototype smart security textiles tailored to Nigeria's security environment.

CONCLUSION

Smart textile technology represents a promising frontier in modern security and defense innovation. When properly developed and integrated into military apparel, smart textiles can significantly enhance situational awareness, operational efficiency, and personnel safety.

The integration of communication technologies into wearable garments aligns with the broader technological transformation of the twenty-first century. Smart military uniforms could be designed to monitor biometric indicators such as heart rate, fatigue levels, and stress conditions, thereby assisting medical personnel in evaluating soldiers' physiological states during operations. Furthermore, adaptive camouflage systems capable of adjusting colour patterns according to environmental conditions could provide enhanced concealment during tactical operations. For example, uniforms capable of darkening during night missions could improve stealth capabilities and facilitate ambush strategies against hostile forces.

Overall, the potential applications of smart textiles in security operations are extensive. With strategic investment, interdisciplinary collaboration, and technological innovation, smart textile solutions could contribute significantly to addressing Nigeria's persistent security challenges while modernising the operational capabilities of its security agencies.

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