Personnel Shielding

Today's warfighters and first responders face a dangerous, uncertain, and ever evolving threat landscape. They are at risk from direct and indirect fires, improvised explosives, chemical and biological agents, radiation, and a wide variety of other occupational hazards. To ensure that personnel are shielded from these threats, next-generation protective equipment relies on multiple technologies and improved designs. Protective kit must be robust, multifunctional, and lightweight, while preserving mobility and comfort in extreme environments.

Enabling Science and Technology

Advanced materials

Body armour, helmets, respirators and other protective gear rely on a variety of advanced materials to enable functionality. A goal of recent research has been to balance the weight and comfort of equipment with performance characteristics (e.g., ballistic resistance). Some of the materials contributing to improved protection have been ultra-high molecular weight polyethylene (UHMWPE), auxetic materials (in which viscosity increases upon exposure to shear strain), metal-organic frameworks (to capture and degrade toxins), and a variety of composites and smart textiles, often based on nanomaterials.

Improved sensors for detection and identification

To detect threats in the field and to rapidly identify toxic substances with a high degree of confidence, personnel can use a growing number of compact, field-portable, sensitive and specific devices such as lab-on-chip instruments, electronic noses or biosensors, often functionalized with nanoparticles. Standoff detection of chemicals and explosives is also being enabled through technologies such as quantum cascade lasers.

Wearable electronics for body sensing

Wearable sensors (e.g., embedded in textiles or helmets) can be used to measure heart rate, body temperature, and other variables. Alone and in combination, these measurements inform assessments of fatigue, stress, head injury, and other conditions which affect safety and performance. Research for protective wearables is ongoing in areas such as signal accuracy, ergonomic design, durability, energy management (i.e., power source and longevity) and supporting communications and analytics.

Information and communications technologies (ICTs)

R&D into new materials, real-time threat sensing by identification, and situational awareness all depend on advanced computing platforms and techniques such as simulation by modelling, algorithms, wireless devices and communications, cloud computing, data analytics and artificial intelligence.

> ***Much work is still needed to advance the capabilities of the on-board [protective] technologies while simultaneously ensuring they meet the biocompatibility, reliability, and durability standards required for the extreme environments endured by the warfighter.***
>
> – **NATO,** *Smart Textiles for the NATO Warfighter*, 2014

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Signals

Academic

Cranfield University (UK) and the Massachusetts Institute of Technology are leaders and frequent collaborators with security organizations. Chinese and European universities excel in technical textiles. In Canada, several universities have strong research programs in photonic sensing and protection against biological pathogens.

Government

Military organizations such as the U.S. Army's Natick Soldier Research Development and Engineering Center conduct leading edge research into protective technologies. Other key government players include standards and health and safety agencies.

Collaboration

Research networks are frequently anchored by military research labs working with partners. Collaborations are influenced by geographic proximity, probably as a result of security concerns and differing national threat landscapes (e.g., terrorist threats, wildfires, recent overseas military campaigns).

Non-governmental organization (NGO)

Organizations such as ASTM International play an important role in developing standards for protective gear. The United Nations and humanitarian organizations advocate for improved equipment, operational guidelines, and legal frameworks to protect against disease, chemical or biological warfare, and landmines.

Corporate

Defence contractors such as Safran have been instrumental in the development of advanced uniforms, and technical fibre manufacturers such as 3M, DuPont or Teijin are key commercial players. Leading firms in wearable sensing include Samsung, Nymi and Hexoskin.

> ***A substantial R&D effort is required to reduce the data from the physiological monitoring devices and present it to commanders and/or medical staff in the form of a dashboard containing only the most vital information.***
>
> – **Burrell C, Love RJ, and Stergiopoulos S.,** [DRDC] *Integrated Physiological Monitoring*, 2016.

Impact

Social

Evolving threats and the prospect of terrorism mean that a wide group of users (e.g., healthcare workers, first responders, airport security agents) require better and more varied protection.

Policy

Regulation and standards must evolve to match new threat environments and available solutions. For instance, there are few regulations for wearable devices or for protection of personal data collected in body area networks.

Economic

Some newer technologies (e.g., metal-organic frameworks) compete against older, much cheaper alternatives (activated carbon). As a general rule, the cost of sensing platforms has diminished greatly in the last decade, making certain aspects of protection much cheaper.

Environmental

Synthetic biology can enable more functional materials or effective vaccines. However, it could also create more virulent pathogens. Biosecurity of facilities engaged in synthetic biology (solutions or countermeasures) needs to be strengthened.

Defence

Protective solutions will always be considered a high priority in defence. New designs feature integrated, modular components that can be added or removed as needed. Current research also links protection to command and control systems, for real-time awareness and decision making.

> ***Future trends advocate for a more aggressive and comprehensive assessment [of protection] that informs the development of materials in new and strategic ways... [protection] is part of a broader "survivability" perspective... [in which] survivability, mobility, and lethality are linked in a dynamic and evolving relationship.***
>
> – **Zheng JQ, Walsh SM.** *Materials, Manufacturing, and Enablers for Future Soldier Protection*, 2016.

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