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DEVELOPMENTS IN LIGHTWEIGHT COMPOSITE BALLISTIC HELMET MANUFACTURE

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Abstract

The design and manufacturing considerations for modern lightweight military helmets are discussed by an original equipment manufacturer (OEM.). The core functional requirements of contemporary military helmets are outlined, describing the performance measures that are routinely requested to quantify these requirements within specifications. The challenges for OEM and end-user are highlighted, as there are many ways of measuring this performance and many different levels of performance desired by different end users.

The OEM states the compromises that are made in order to maximise helmet performance whilst balancing the complex and competing requirements of military helmets. The use of lightweight fibre-reinforced composite structures in modern military helmets is described. The composite materials commonly used in these helmets are discussed, highlighting the key properties of the materials used and the use of hybridised shell constructions using many different materials in order to achieve optimum helmet shell performance. The challenges faced when hybridising helmet constructions in this way, using often incompatible materials is considered.

The two most common helmet manufacturing processes are also outlined, and the paper discusses how careful selection of processing parameters is key to realise the full potential of the materials used: how the increased use of ultra-high molecular weight polyethylene in ballistic helmets has led to the use of new manufacturing processes, such as deep draw, for the manufacture of fibre reinforced composite helmets rather than the traditional compression moulding.

These preferences and the experience gained during the development initiatives are considered to provide insight and guidance to those specifying requirements for their own helmets, such as the technical representatives of international Ministries of Defence.

Keywords: lightweight composite, military helmet, ultra high molecular weight polyethylene

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BALİSTİK KORUYUCU HAFİF KOMPOZİT BAŞLIK ÜRETİMİNDE GELİŞMELER

Öz

Günümüzde sıklıkla kullanılan hafif kompozit askeri miğferlere ait tasarım ve üretimine dair düşünceler orjinal ekipman imalatçısı (OEM) gözüyle tartışılıp değerlendirilmektedir. Modern hafif kompozit askeri miğferlerin fonksyonel isterleri ana hatlarıyla özetlenmekte, bunların ölçümünde kullanılan ve rutin olarak istenen performans ölçme değerlendirme kriterleri teknik şartnameler kapsamında açıklanmaktadır. Bu performans ölçümlerinde pek çok farklı ölçme tekniği ve pek çok farklı son kullanıcı tarafından istenen pek çok farklı performans seviyeleri olduğundan, üretici ve son kullanıcının malzeme ve son ürün seçimi yapmakta sıklıkla karşılaştığı farklı zorluklar vurgulanmaktadır.

Hafif kompozit askeri miğferlerin performansını mümkün olan en yüksek seviyeye getirmeye yönelik çalışmalar kapsamında her an karşımıza çıkan oldukça karmaşık ve birbiriyle çatışan isterlerin dengelenmesi gerekliliği orjinal ekipman üreticisi gözüyle açıklanmaktadır. Modern hafif kompozit askeri miğfer yapımında fiber destekli hafif kompozit yapıların kullanımı detaylandırılmaktadır. Miğferlerde sıkça kullanılan kompozit yapılar tanıtılmakta, bunların öne çıkan özellikleri belirtilerek, en etkin miğfer yapısına ulaşacak farklı kompozit malzemelerden oluşan melez yapılı kabuk dizilimleri açıklanmaktadır. Bu melez yapıların oluşturulmasında karşımıza çıkan malzeme uyumsuzluklarına dair sorunlar ve olası çözümleri üretici ve kullanıcıların dikkatine sunulmaktadır.

En yaygın iki kompozit miğfer üretim tekniği ayrıca özetlenmektedir. Bunlar derin çekme ve basınç altında kalıplamadır. Makale, basınç, sıcaklık, süre gibi ana proses girdilerinin kullanılan malzemenin gerçek potansiyelini doğru biçimde yansıtacak şekilde seçiminin önemini vurgulamaktadır. Bu yapılırken hafif kompozit miğfer üretiminde gittikçe artan ultra yüksek moleküler yoğunluklu polietilen malzeme kullanımının geleneksel basınç altında kalıplama yöntemleri dışında derin çekme gibi yeni ve daha karmaşık yöntemlere gerek duyduğu vurgulanmaktadır.

Geliştirme çalışmalarında yapılan bu seçimlerin ve elde edilen deneyimin, kendi miğferlerinin performans kriterlerini belirleyen uluslararası savunma bakanlıkları teknik dairelerine ışık tutacağı ve rehber olacağını düşünmekteyiz.

Anahtar Kelimeler: Hafif kompozit, Askeri başlık, ultra yüksek molekül ağırlıklı polietilen

INTRODUCTION

Soldiers have used helmets for head protection throughout history. These helmets are designed to protect against the prevalent threats of the time, the ballistic and fragmentation performance being balanced against the encumbrance of the solutions available. This information is recognized up till today since the current helmets provide increased protection for the same helmet mass. However, modern-day helmets offer more than just protection, they are increasingly platforms for situational awareness: communications, friend /foe identification and vision systems.

So, military helmets demand lightest weight, while offering greater protection and enabling head-borne system integration. This can only be achieved by maximising the potential of modern day materials and the most advanced manufacturing techniques.

This paper presents a framework for the design and manufacturing considerations of a modern helmet original equipment manufacturer (OEM) striving to maximise helmet performance whilst balancing complex and competing requirements. It describes the compromises that are made in order to balance the use of different materials and processes to deliver the broad range of properties required in modern military helmets. These development initiatives may offer insight and guidance to those specifying requirements for their own helmets, such as the technical representatives of international Ministries of Defence.

1. REQUIREMENTS OF A MILITARY HELMET

The modern military helmet is now a system being able to be configured in many ways to support multiple tactical roles. However, this paper will focus on not the broader system requirements but the core functions that such helmets are expected to deliver. These core functions are:

1. The helmet is expected to be lightweight: increasingly a shell mass below 1 kg is asked for. This still requires an impact liner and chinstrap to be added that can add anything up to an additional 400g to the overall helmet mass.

2. The helmet must provide fragmentation protection. This is often defined by a V50 (NATO, 2003) value for 1.1g fragment simulating projectiles (FSP.) These values can be very different depending on the customer requirement. Performance against other sizes of fragment can also be stipulated by some customers.

3. The helmet must provide ballistic protection. Today, the stopping of 9mm handgun rounds is usually the minimum requirement for military helmets. Some requirements ask to defeat rifle rounds such as 7.62x39mm AK47 ball rounds. In extreme cases customers have even considered threats

up to 7.62x51mm amour piercing ammunition. The higher levels of protection will often require the use of add-on appliques to provide the extra protection at the cost of added mass. This might require the use of advanced ceramic materials such as alumina, silicon carbide or boron carbide which are comparatively heavy and brittle. Even if rifle rounds are stopped, survival chances are lower due to the impact loading on the neck potentially breaking it, or (as described in point 4) excessive deformation behind the impact causing injury (Landwijt and Romek, 2015:106). Some threat scenarios consider rifle threats at lower velocity and angles to represent more realistic ranged impacts from these threats.

4. It (the helmet) needs to minimise backface signature when stopping ballistic threats. This is particularly challenging when stopping rifle threats. It is pointless stopping the round if the helmet deforms so much in doing so that the deformation still causes grievous injury (Hisley, Lee, and Gurganus, 2010:89).

5. It must have sufficient structural strength to maintain its shape in use. The compression resistance is measured in multiple orientations, temporary and permanent deformation is measured, and the helmet is also visually examined for any through thickness cracks or delaminations that should not occur (Anctil and Bayne, 2014:1).

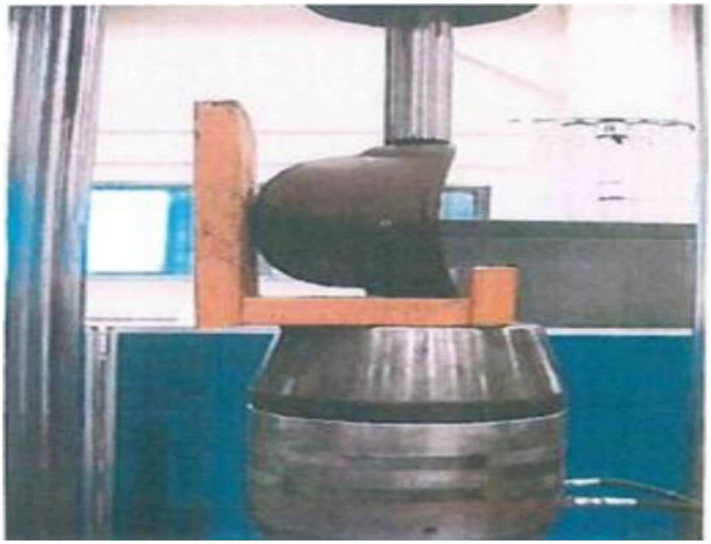

Figure-1. helmet being compression tested ear to ear

6. It must provide impact protection. Most of the helmet impact performance is delivered by the liner and pad system used inside the helmet. However, the shape of the helmet can affect the protection offered. Changing the size of the impact contact area on the shell by how domed or flat the helmet surfaces are has a significant effect on performance. The helmet shell should also ideally not permanently deform or delaminate on impact.

7. Flame resistance: The nature of this requirement can vary widely from customer to customer. The main purpose is to ensure that the helmet will not catch fire readily when exposed to flame. In some cases, simple coatings are sufficient, these may be combined with the use of different inflammable materials depending on the nature of the target requirement.

8. Another core function of the helmet is to maintain all other properties in hostile environments: The helmets can be worn in theatres of operation ranging from Arctic to desert and the helmet must maintain its protection. The way this is assessed varies widely from customer to customer.

In addition to these core characteristics, other helmet considerations include:

- Infra-red signature: It refers to ensuring that the helmet does not standout in IR optics which is normally driven by the paint system used for the helmet. Increasingly the paint also must be CARC to be resistant to chemical and biological weapons. The paint system needs to be compatible with the shell surface to ensure paint adhesion.

- Comfort and stability: It refers to the design of the liner and chinstrap to increase adjustability and customization by the user to promote comfort and better integration with other head-borne systems.

The scope of this study will be bounded by the material and manufacturing decisions that a helmet manufacturer will consider when developing helmet constructions to achieve the core functions, numbered 1-8 above. Almost anything is possible depending on mass and budgetary constraints.

1.1 **Measuring Performance**

The international helmet marketplace is more challenging than most of the other markets for ballistic protection, as it is the one sector that currently does not have an industry-wide recognised test standard. There are a variety of test standards in existence, many of which are decades old and have not been updated to reflect the current threat environment and the way modern warfare has evolved in this time.

The lack of a recognised standard has led to different customers specifying desired helmet performance measured in a way that is unique to them. This can be challenging for helmet OEM's as the perceived performance of a helmet can vary depending on how this performance is measured. This makes it difficult for customers too, who find it challenging to compare helmets in the market place from different helmet OEM's when the methods for gathering the data are not standardised.

If we consider the measurement of 9mm ballistic performance as an example, some questions come to mind. Is the helmet tested as a bare shell or as a complete helmet? Is it mounted in a frame or on a headform? What is the shape / design of the headform? What material is the headform made from? Is the headform rigidly mounted or on a biofidelic neck? How should the helmet liner be adjusted to fit the headform? How is deformation measured? Is it using a clay material, laser or alternate method? This is by no means an exhaustive list, merely an illustration of the complexities of testing and how measurements can be different depending on the set-up of the test itself. Until an international test specification emerges care should be taken when comparing helmets from different manufacturers, especially by customers looking to specify their own requirements.

2. MATERIALS USED IN MODERN BALLISTIC HELMETS

Military helmets used to be made of steel, not only for its fragmentation resistance, but also because the material could be formed into the relatively shallow bowl shapes used, in a single cold pressing operation. Today, contemporary helmets are generally made of composite structures, providing lighter weight solutions and allowing more design freedom for shapes that offer improved integration and stability on the head.

The first composite helmets were made in the late 1960's, typically using ballistic nylon (Shephard, 2014). Shortly after, aramid reinforcements were introduced and eventually became the material most widely used in military helmets. Although ultra-high molecular weight polyethylene's (UHMWPE) have been proven in ballistic applications for many years they have only recently started to be supersede aramid in helmet applications. Over the last five years or so, with manufacturing processes developing and specifications becoming more challenging, UHMWPE has become the most prevalent material used in the most advanced high performance lightweight ballistic helmets.

This paper will not delve deeply into the myriad of materials used in ballistic helmets, but just touch on the key materials at a top level only by way of introduction. Much more information is widely available from the manufacturers concerned. Some of the important material characteristics are mentioned by highlighting the reasons why these materials are commonly used in helmet manufacture.

2.1 Aramids

Aramid fibres have excellent impact and abrasion performance. They are very strong fibres that are also thermally stable, offering excellent temperature stability and flammability performance. In helmets, they have been most widely used in woven form, combined with phenolic /PVB resin systems, to produce many of the military helmets fielded around the world. Phenolic PVB resins are toughened systems that also have excellent flammability resistance. The most widely-known aramid fibres are Kevlar from Du Pont and Twaron from Teijin. The fibres are available in different formats and weave styles offering different levels of performance to suit price points and ballistic performance, so the helmet manufacturer must choose the correct fabric for their requirement.

2.2 Ultra-high Molecular Weight Polyethylene (UHMWPE)

Dyneema from DSM, Spectrashield from Honeywell, Tensylon from Du Pont and Endumax from Teijin are the best-known brands of UHMWPE in the market today. UHMWPE fibres are thermoplastic in nature characterised by an extremely long molecular chain. The molecular chains are highly aligned and fibres are produced with very high specific strength and stiffness. These high strength fibres have demonstrated very high ballistic penetration resistance for a given areal density, the best in the market today.

The fibres are supplied on a roll, as uni-directional layers impregnated with proprietary resin systems by the material manufacturers. These resin systems are also usually thermoplastic in nature. The thermoplastic nature of these materials mean that they are not as thermally stable as aramid materials.

The UHMWPE pre-pregs come in different grades representing different fibre types combined with varying resin matrices. The different grades are manufactured to have characteristics ideal for use in specific ballistic applications, such as ballistic plates, soft armour vests, vehicle spall liners and helmets. Some grades can cross-over between applications in some cases, where the requirements are similar.

2.3 Hybridisation

The core functions of military helmets have already been discussed within the scope of this study. The materials used in helmets often have characteristics that suit one or more of these functions, but invariably conflict with other functions. An example of this is that UHMWPE materials excel at defeating ballistic and fragment threats, but deform more than other materials resulting in backface signature becoming a concern. The most effective helmet constructions cannot therefore rely on one material to meet all of the requirements efficiently. Consequently, helmet constructions combine many different materials in hybrid constructions to optimize the performance to meet individual customer requirements. This can mean combining ballistic materials with traditional structural composite materials such as carbon or glass in order to meet the overall range of properties required of the helmet.

Table-1. Material Suitability for Core Helmet Functions

Core Function	**Aramid**	**UHMWPE**	**Structural**
Fragmentation Protection	Average	Best	Poor
Ballistic Protection	Average	Best	Poor
Reduced Backface Signature	Average	Poor	Best
Structural Performance	Average	Poor	Best
Impact Performance	Average	Poor	Best
Low Flammability	Best	Average	Best
Environmental Performance	Average	Average	Average

Table-1 ranks the common materials used in helmet constructions against the core functions of military helmets. It shows that the UHMWPE materials excel at defeating ballistic and fragment threats but need to be combined with other materials to provide the overall performance required by a customer.

Environmental performance is generally controlled by choosing the appropriate coatings to deal with any weaknesses that might exist in the chosen hybrid construction.

Although hybrid constructions are the routes for the most efficient helmet structures, there are some manufacturing challenges with hybrid designs. This is mostly due to resin system incompatibility. Some resin systems are thermosets, others are thermoplastics. They may have very different resin chemistry leading to poor bonding of one material to another within the construction. Each of the materials will also have different cure cycles required to fully consolidate the material, leading to compromises in processing conditions in order not to degrade the performance of the materials being used.

Raw material suppliers are also constantly focusing on improving the materials in the market place. UHMWPE grades are now being offered with alternate resin matrices that are stiffer than the traditional offerings in order to improve the structural properties and backface signature, that have been the traditional weakness of these materials. This improved structural performance generally comes at the expense of fragmentation performance but could still provide an overall solution that is lighter than some hybrid constructions.

Helmet manufacturers are constantly evaluating materials that can better fulfil roles within a hybrid scheme, looking for optimal combinations that can provide greater performance at even lighter weight.

3. MANUFACTURING

This section focuses on the manufacturing of composite ballistic helmets and compares the traditional moulding of aramid / phenolic helmets with the processing required today for optimised contemporary UHMWPE helmets.

3.1 Part Processing

Manufacturing of Aramid/phenolic composite helmets is very different to manufacturing UHMWPE helmets. Phenolics are thermosetting resins with recommended curing conditions of temperatures between 165°C and 175°C and pressures between 10 and 100bar for optimal performance. Typical curing times are 15-30 minutes and parts do not require significant cooling before removing from their mould. Once the resin has cross-linked, the parts can normally be de-moulded.

UHMWPE materials require more carefully controlled processing to get the most from them (Werff and Heisserer, 2016:74). The fibres themselves being thermoplastic means that they are susceptible to thermal damage, losing the fibre structure and all the ballistic properties with it. The fibres are sold on a roll, as layers impregnated with proprietary resin systems by the material manufacturers. These resin systems are normally thermoplastic in nature as well, so the processing window must be carefully controlled so that the matrix reaches its melt temperature while remaining below the temperature that would melt or change the crystallinity of the fibre. UHMWPE materials require significantly higher moulding pressures to achieve optimum performance when compared to aramid processing methods. The parts must also be heated and significantly cooled, leading to much longer cure times when compared to thermoset and traditional fibre processes.

Temperature control is very important when processing UHMWPE. Steam heating and oil heating are typically used to supply heat to helmet tools. Super-heated steam temperature can vary more widely and is harder to control, so oil heating is the preferred method to control temperature most effectively. Even with oil heating, because the processing window for optimal performance is so small, care must always be taken to be certain that the manufacturing process remains in control.

3.2 Tooling Design

The need for more rapid heating and cooling has led to increased focus on tooling design: minimising thermal mass speeds up process cycle times. The challenge has been to do this effectively while maintaining the mould integrity under the higher moulding pressures that are required to achieve maximum ballistic performance from UHMWPE parts. Use of modern computer modelling is invaluable to prevent potentially costly mistakes while optimising the tooling design as far as possible. Heat transfer and deformation under load can be separately modelled to ensure that optimised tool designs are produced.

The tool designs also consider flow of material into the mould, in an even way to achieve uniform thickness around the moulded helmet shell.

3.3 Material Orientation

Material orientation is important for all fibre-reinforced composite parts, but it is extremely important to the ballistic performance of UHMWPE parts. The raw material is usually supplied in 2-ply or 4-ply formats, consisting of layers of uni-directional fibre arranged in cross-plied form (at 0^o and 90^o.) Each ply of material off the roll should be arranged such that the top-most fibre orientation is the same from ply to ply – this ensures that the material retains its 0/90/0/90 layup throughout its thickness. This layup achieves maximum ballistic performance.

Consequently, care must be taken during the laying up of material during the manufacturing process to make sure that all layers are correctly aligned.

3.4 Manufacturing Methodology

The proprietary manufacturing methods of helmet OEM's are closely guarded. There remain generally two methods of turning essentially flat off-the-roll materials into helmet forms. Namely these are a traditional method termed "petal" process and a more modern approach termed "deep drawing." The paper will discuss both methods in general terms without disclosing any proprietary information.

Traditional aramid/phenolic helmet processing commonly used the compression moulding process where the layers used within the construction were known as 'petals' because of the cuts used within them, this moulding process consists of:

1. Cut ply shapes from the pre-preg material.

Shapes are cut from the pre-preg material, making best utilisation of the raw material. A mix of different sizes are used to ensure that the number of layers of material around the helmet are the same. Cuts are placed in the plies to make wrapping into a helmet shape easier and end up with a laminate which has a consistent through thickness.

2. Lay-up plies according to defined construction.

The cuts in the plies cause overlaps of material when the plies are placed in a mould. These overlaps are accounted for in the number of layers and sizes of layers placed in the mould. The plies are also aligned such that the cuts are staggered around the finished shell so that there are no points of weakness in the construction.

3. Preform shape.

The shape is preformed typically by hand using proprietary preform mould tooling and methods to generate the preformed helmet shape. It is important to align the layers correctly making sure that the cuts are offset from layer to layer and that the material overlaps are in correct and consistent places.

4. Place in heated mould.

Placing the material onto the tool is typically a manual process. Care is required to ensure that the preform is positioned correctly to fill the tool cavity correctly. If it is not then the resulting helmet will have variable numbers of layers around the shell due to overlaps not being positioned correctly, or darts in the layup opening up. This will lead to variable strong and weak points around the helmet giving inconsistent performance.

5. Press, applying heat and pressure.
6. Demould

This manufacturing method is employed because the raw material (woven aramid, impregnated with phenolic) is effectively anisotropic in nature. However, as described in section 3.3 the UHMWPE is isotropic, so more attention must be paid to material orientation. It is possible to use a similar manufacturing process, but each ply in the layup has to be cut from the roll individually to ensure that the fibre has the same orientation on each ply, while rotating the cuts in the material to avoid a stack up of potential weak points. The ply thickness for UHMWPE is very much thinner than that of aramid / phenolic, so the number of layers required is greater leading to longer cutting times and much longer lay-up and preforming steps.

UHMWPE suppliers suggest using a “deep drawing” methodology which is similar in many ways to a traditional metallic deep drawing process. In this process the layers of materials do not have cuts in them in the way that the petals do. This allows the fibre lengths to be maintained giving helmets manufactured by the deep drawn process improved ballistic and fragmentation performance. The energy of the ballistic and fragmentation impacts is absorbed over the longer fibre lengths more easily. It is possible to get a 10% improvement in ballistic performance over the same construction manufactured in the alternate way.

In truth all helmet manufacturers mould in their own proprietary way. Aramid helmet moulding has now become a routine moulding operation that almost any company can achieve, with helmet performance between companies being mostly as good as one another. Making a helmet with UHMWPE requires a company to develop equipment and processes to optimise performance. Spending time and effort to develop and applying good knowledge of materials still differentiates OEM's. CES has extensive experience of both the petal moulding process and deep draw process. The experienced engineers and technicians take the best elements of the UHMWPE moulding process and improve on it for better material distribution, temperature control, enhanced process repeatability and reduced cycle times.

3.5 Machining and Drilling of Moulded Parts

Composite helmets have always been challenging to machine or drill successfully. Specialist set ups and drilling methods are required to get a good cut or drill the perfect hole. Automation is used in this area to maximise throughput and repeatability.

4. PRACTICAL EXAMPLES OF HYBRDISATION

Table 2 below shows some examples of the effects of hybridisation.

Table-2. A comparison of the performance of helmets made with different construction

Ref.	**Construction**	**Helmet Size**	**Shell Mass (g)**	**1.1g FSP V_{50} (m/s)**	**Permanent Deformation (mm)**
1	UHMWPE 1	M	750	775	24
2	UHMWPE 2	M	705	755	3.75
3	UHMWPE 1 + Reinforcement	M	755	753	1.7
4	UHMWPE 1 + Reinforcement	L	905	830	2
5	UHMWPE 2	L	870	805	2.5

The fragmentation performance and ear-to-ear compression performance (tested in accordance with ASTM procedure D-76, permanent shell deformation within 5 minutes after completion of a compression test, the loading profile being 1340N for 24 cycles) are compared for two grades of UHMWPE processed though the proprietary CES moulding process.

Examining the performance of the medium helmet shells, the data shows that UHMWPE 1 has poor compression resistance when used in a helmet by itself. In comparison UHMWPE 2 has acceptable performance when moulded in the CES process, with a cost of a 20m/s drop in fragmentation protection.

Hybridising UHMWPE 1 with a proprietary CES structural reinforcement improves the compression performance beyond that of even UHMWPE 2, without compromising on the mass of the overall solution. The fragmentation performance of the hybridised solution is also comparable with UHMWPE 2.

This effect is also demonstrated in the large helmet shells. Here fragmentation performance in excess of 800m/s is achievable with helmet shells weighing only 900g.

5. FUTURE DEVELOPMENTS

The weaknesses of the materials used in today’s ballistic helmets are acknowledged by the raw material suppliers. New grades that not only improve the strengths of the materials further but also focus on improving the characteristics that currently provide the negative contributions that they make to the overall protection scheme are continually being developed. Both developments will drive improved helmet performance, or lighter weight solutions.

Themes that emerge can be summarized as following: helmets are increasingly seen as upgradeable, modular platforms to be tailored for the tactical roles required (Lewis and Clarke, 2018). The modern helmet is becoming a skeleton structure that can be configured to the desired area of protection from just the crown right up to full head coverage and upgraded using additional armour elements to provide protection starting from bump protection and increasing in stages up to ballistic protection capable of stopping rifle rounds. The trade-offs are between protection and encumbrance, protected area and situational awareness. As protection increases, stability, comfort, ease of sighting weapons and integration of multiple systems tends to be compromised.

The future challenges for contemporary helmet OEM’s will centre on handling the integration issues from head borne systems. The ballistic and non-ballistic helmet performance will become features that do not differentiate. In the future, it will be the integration support that will distinguish between helmet suppliers.

CONCLUSIONS

The expertise of the helmet OEM is developing the correct mix of materials and process to achieve the detailed specification required, which itself quite often has a number of competing requirements that must be met.

Threat levels and other non-ballistic requirements have increased over time. Modern materials and manufacturing methods have enabled helmet design to keep pace with the change in protection required for a weight level that remains tolerable for the user.

There is a need for an internationally recognised helmet standard that will aid both customers and helmet manufacturers to assess and report performance in a standard and comparable way.

The requirements drive the solution, so it is incumbent on the requirements setter to make the requirements appropriate. The skill of the requirements setter is to not blindly add 50m/s to a V50 in the expectation that a higher number means that the item is more protective. Instead, be guided by a threat analysis of what the extant threat is in theatre. For example, if the fragmentation requirement is being driven by grenade fragment protection and it is known that the grenade fragments travel at 550m/s, there is no protective benefit in a helmet that offers 750m/s rather than a 650m/s V50, both will defeat the threat. It would be better to reduce the thickness of the higher performing shell and reduce its protection level to 650m/s and enjoy the benefit of a lighter weight helmet shell.

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