Clothing Comfort, Health and Wellness in General Duty Police Load Bearing Vests from 2008 to present day.

Novel development possibilities in advanced textiles and garment design, that can be derived from motorcycle wear and sports wear.

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Certificate of Authorship/Originality

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

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Date:

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Contents

Contents

Contents

List of Figures

Abstract

This research document reveals recent developments in advanced textiles and in technical garment design which may assist in the design development of human load carriage garments. From discussions into human load bearing systems, load bearing garments, advanced textiles for comfort, health and wellness derived from motorcycle and sportswear, reviewers will learn that there are a multitude of novel possibilities available to assist them in the development of future load bearing vests for Police Officers and Emergency Service Personnel.

Motorcycle wear is generally well advanced in terms of providing high levels of user protection aimed towards reducing injury and improving user health and wellness through enhancing factors such as climate control (breathability) and increased movement. Through the use of advanced textiles in modern motorcycle wear and by the way in which these garments are constructed structurally, they provide a much higher level of protection than what was previously available to motorcyclists. Likewise, sportswear has increasing become more high-tech, as athletes have demanded so much more of the garments they use. Increasing performance characteristics such as improving climate control for example, can significantly enhance user performance, health and wellbeing. This research document further explores motorcycle wear and sportswear as being relevant areas of garment design that may assist in informing load bearing vest design.

Glossary of Terms

3D Three dimensional
ABS Australian Bureau of Statistics
APPOINTMENTS Terminology that NSW police use to describe the equipment that they carry such as handcuffs, their pistol etc.
BACKPACK Another term used for a rucksack, or a haversack.
BOBBY Colloquial term for a police officer from Great Britain.
CAPSICUM SPRAY/PEPPER SPRAY An aerosol spray containing oils derived from cayenne pepper, irritating to the eyes and respiratory passages and used as a disabling weapon. This term is used in Australia only.
COMPOSITE TEXTILE Is defined as a combination of two or more materials (reinforcing elements, fillers, and composite matrix binder), differing in form or composition on a macro scale. The constituents retain their identities, that is, they do not dissolve or merge completely into one another although they act in concert.
CORDURA A material
DUTY BELT The belt that a police officer uses to carry equipment
EQUIPMENT BELT Another name for a duty belt.
GPS which stands for Global Positioning System, is a radio navigation system that allows land, sea, and airborne users to determine their exact location.
LBV Load Bearing Vest
LOAD CARRIAGE The act of humans conveying; carrying load.
NSW New South Wales
NSWPF New South Wales Police Force
HWP Highway patrol
INTERFET International Force for East Timor
MNVG Monocular Night Vision Goggles

NMI neuromuscular incapacitation; when you apply a high-voltage, low-amperage electric charge to muscle tissue, it's as if you're overloading its communication system. Taser's electric pulses cause affected muscles to contract up to nineteen times per second. Under normal conditions, your body moves by relaxing one set of muscles while contracting another. But if an electronic pulse hits your body, both sets of muscles may try to contract at the same time. Generally speaking, the stronger muscles win out. But because the pulses override the commands from your brain, you have no conscious ability to control their movements. As a result, the affected area of your body will tense up as the surrounding muscles contract. You may lose your balance and fall. Depending upon where you've been hit, you may not be able to break your fall or catch yourself. That's why people who have been hit by a Taser sometimes suffer superficial cuts, bumps and bruises.

LAC New South Wales Police term for a Local area command

LOAD BEARING PLATFORM Another term for a Load Bearing Vest (LBV).

LOAD BEARING SYSTEM Another name for a Load Bearing Vest (LBV).

LOAD CARRIAGE SYSTEM Another term for a Load Bearing Vest (LBV).

OC SPRAY An aerosol spray containing oils derived from cayenne pepper, irritating to the eyes and respiratory passages and used as a disabling weapon.

OH&S Occupational Health & Safety, sometimes known as

PEPPER SPRAY/CAPSICUM An aerosol spray containing oils derived from cayenne pepper, irritating to the eyes and respiratory passages and used as a disabling weapon.

PCM A phase-change material (PCM/Phase Change Textile) is a substance with a high heat of fusion which, melting and solidifying at a certain temperature, is capable of storing and releasing large amounts of energy. Heat is absorbed or released when the material changes from solid to liquid and vice versa; thus, PCMs are classified as latent heat storage (LHS) units.

RUCKSACK Another term used for a backpack, or a haversack.

SA Situational Awareness is the perception of environmental elements with respect to time and/or space, the comprehension of their meaning, and the projection of their status after some variable has changed, such as time.

SOPs Standard operating procedures

STANO Soldier surveillance, Target Acquisition and Night Observation

TASER Electronic control device. A taser is an electroshock weapon sold by Taser International. It uses electrical current to disrupt voluntary control of muscles causing neuromuscular incapacitation (NMI) - see neuromuscular incapacitation NMI.

TRANSPORT PHYSICAL OBJECT Backpack or rucksack

TWS Thermal Weapon Sights

UAV Unmanned Aerial Vehicle

WORKCOVER An organisation in Australia that administers and controls workers compensation.

Chapter 1

Introduction to the thesis

In just the space of what is literally a few years, General Duty (GD)[1] Police Officers around the World have experienced a major shift towards the acquisition of new technologies that have changed the face of general duty policing forever. These new technologies and equipment essentially provide a greater range of options to police officers as to how they go about making an arrest, but how do they impact on a General Duty Police Officer's health, wellness and performance? The answer may lie in the way by which Police departments manage this issue as to how they can best enable individual Police Officers to carry an increased equipment load and yet still maintain best practice Work, Health and Safety (WHS).[2]

1 General Duty Police Officer; Typical duties relate to keeping the peace, law enforcement, protection of people and property, and the investigation of crimes.

2 Work, Health and Safety (WHS) laws define occupational health and safety in the workplace. The work place is defined to include any place where a worker goes, or is likely to be, while at work.

The New South Wales Police Force (NSWPF) in Australia, like many other International police forces has added newly introduced equipment to the duty belt of General Duty Police Officers. So much newly introduced equipment has been added in recent years that there is literally no space remaining on the duty belt to add more equipment. This issue has forced Police departments to explore of a range of different load carrying options as alternatives to the duty belt, which will be discussed now.

1.1.1 Overview of the thesis structure

The chapters in this research study are structured and sequenced from the start point where research analysis of General Duty Police duty belts and load bearing vests begins with an introduction to the problematic.

Chapter 1: Introduction to the thesis outlines the research problem and demonstrates approaches that have been taken in the past that were aimed at resolving the issues of the over-burdened equipment load in General Duty Police duty belts. The introduction also aims to address in brief terms, broader research perspectives where products and garments from different safety categories or market segment, may be further investigated with the aim of finding positive benefits of these types of load carriage devices related to improving user comfort and wellness.

Chapter 2: Literature review, proceeds to evaluate cases studies that demonstrate the research that currently exists around the load carriage of equipment in both Police Forces and in the Military. The reader begins to see the issues that exist in the military with regards to load carriage burden analyses, in the first two literature reviews, then the reader is able to view research around the science of and how to improve clothing comfort. The duty belt as introduced by Sam Browne is evaluated in terms of ergonomics and considerations for female users.

Chapter 3: A critical analysis of the New South Wales Police load bearing vest implementation, goes onto discuss the design brief or tender documents provided to garment manufacturers and the processes that were involved in designing and constructing the New South Wales Police load bearing vest. Initially discussions are made around ballistic protection and thermal management analysis in terms of user comfort and wellness. The study then goes on to discuss wear-ability considerations in garments design and the biomechanical aspects of human load carriage.

Chapter 4: Garment design for multi-performance, being the final chapter, considers how garment design and the use of advanced textiles may best assist in resolving design characteristics in load bearing vests related to reducing the thermal burden, improving breathability and climate control.

The conclusion to this research study discusses future design recommendations for load bearing vests that may be employed in future years by Australian police forces or by International police forces.

1.1.2 The duty belt as used by General Duty Police Officers

A fully laden New South Wales (NSW) Police Officer in Australia carries in excess of approximately twelve kilograms of weight on their duty belt. The standard issue leather belt, which is known in the United States as the Sam Browne duty belt, named after its founder, can weigh half a kilogram itself. The significance of this issue is centred around the carrying of an ever increasing equipment load and has been highlighted around the World as Police forces have seen a marked increase in worker compensation claims. The issue has manifested itself to such a degree that in the state of New South Wales, Australia, approximately one million dollars is attributed to such claims annually, the belts are responsible for more than 1000 injuries to Police Officer a year because of their excessive weight (Benson 2009).[3] A recent independent inquiry found that Victorian police in Australia, have made in excess of two-hundred Workcover[4] claims which related to back pain caused by heavy duty belts, this cost the state almost AUD 7 million dollars over a period of four years. In the state of Queensland, Australia, Police have complained of mild to extreme back pain because of the uneven weight of their duty belts strains muscles while standing or sitting in police cars for long periods (Dibbenk, 2008).[5]

International studies show that duty belt weight related issues, date back some fifteen years in a number of North American Police forces. Such studies were aimed at assessing the occupational risk factors for the first-onset and subsequent course of

3 Benson, S. 2009, 'New police vests will carry Tasers', viewed September 16, 2009, *Daily Telegraph*, September 14, viewed 10 October, 2009, <http://www.dailytelegraph.com.au/news/new-police-vests-will-carry-tasers/story-e6freuy9-1225772439721>.

4 Workcover; The scheme which provides compensation for workers who are injured in the course of their employment in New South Wales, Australian.

5 Dinnenk, K. 2008, 'Vests for the thin blue line Police drop heavy belts', Sunday Mail Brisbane, August, p.18.

low back trouble (Burton et al. 1996).[6] In the US state of California, if you have been a serving Police officer for five years or longer, lower back injuries are presumed to be a result of wearing the duty belt. Californian Labor Code: 3213.2. (a) (b) (c) February 13th, 2012.

> The Californian Labor Code states; The compensation that is awarded for lower back impairments shall include full hospital, surgical, medical treatment, disability indemnity, and death benefits as provided by the provisions of this division. Police Officers are also permitted to a period of three calendar months leave for duty belt injuries for each full year of the requisite service (Californian Labor Code: 3213.2. (a) (b) (c) 2004).[7]

In the year 2005, the New South Wales Police Force[8] introduced a trial of an alternative to the leather duty belt called the Shape Shifter[9] duty belt, as an interim, low-cost alternative, aimed at reducing injuries and duty belt discomfort. The trial involved the purchase of one-hundred Shape Shifter duty belts. The Shape Shifter duty belt weighs less than a typical leather duty belt, at around six-hundred and fifty grams and was promoted by its manufacturer as an orthopaedic shaped duty belt that provides back support. It has a laminated ventilating liner and is primarily constructed from Cordura®.[10] Cordura® is the brand name for a collection of fabrics used in a wide array of products including luggage, backpacks, pants, military wear and performance apparel. Cordura® fabrics can be made using one-hundred per cent synthetic fibre or in blends with cotton or other natural fibres. Trials concluded however that the Shape shifter duty belt was an inadequate solution to avoid duty belt related injuries in New South Wales General Duty Police Officers.

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6 Burton, A., Tillotson K., Symonds T., Burke C. & Mathewson T. 1996, 'Occupational risk factors for the first onset and subsequent course of low back trouble'. *Spinal Research Journal*, vol 21, no 22,pp 35-39.

7 Californian Labor Code: 3213.2. (a) (b) (c) 2004 (California Department of Industrial Relations).

8 New South Wales Police Force (NSWPF)

9 Shape Shifter duty belt, a curved light weight duty belt constructed from laminated foam and Cordura®, alternative duty belt to the traditional leather duty belt commonly worn by General Duty Police Officers.

10 Cordura® is a Du Pont® registered trade name, known for its superior durability and resistance to abrasions, tears and scuffs.

In the year 2005, the then project manager and New South Wales Police Association executive member, made these comments below in relation to the Shape shifter duty belt trial (Hannon, 2004).

> The current design of the Shape shifter belt does not assist officers with the sciatic and muscular problems they're experiencing.[11]

1.1.3 The load bearing vest as used by General Duty Police Officers

A Load Bearing Vest (LBV)[12] is a garment that has been predominantly used by the military in recent decades as a means of carrying heavy equipment loads on the anterior torso,[13] in recent times a large number of Police forces Worldwide have scrambled to adopt load bearing vests, aimed towards reducing the injuries that Police have experienced in the past whilst using traditional duty belts. The full benefits of load bearing vests are yet to be fully realised, as there are currently at the time of writing this research document, no major studies whereby Police departments have fully examined the benefits or disadvantages associated with load bearing vest over use of the duty belt. The load bearing vest however is regarded in military circles and some studies suggest, that it is an efficient method of human load carriage, because equipment loads are spread over the larger human anterior torso. This is as opposed to the duty belt whereby a significant proportion of weight carried is centralised in one part of the body, the hips and waist area. Furthermore the load bearing vest allows the user to carry most equipment in the forward area of the chest for ease of access to duty equipment, whereby a duty belt may have a equipment located at the rear of the belt which is out of view and becomes an protrusion issue for officers when they are seated in a motor vehicle or when seated in an office environment. Police Officers using a load bearing vest may experience a reduction in the amount of issues and injuries related to entering and exiting patrol cars. Injuries related to a traditional fully laden duty belt being used in a Police station office environment, interfering with a Police officers sitting position may also be reduced. From this ergonomic perspective, Police Officers may experience greater levels of comfort and wellness, and from an force administrative viewpoint, reduced levels of ongoing workers compensation costs.

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11 Hannon, L., 'NSW accoutrement belt trial underway' *Police Journal Online*, vol. 85, viewed 20 October 2009 < http://www.policejournalsa.org.au/0405/14a.php>

12 Load Bearing Vest/s (LBV/s); A vest used by military, police and emergency services workers such as fire and ambulance to carry duty equipment on the torso.

13 The Anterior Torso is the front chest of a human.

Figure 1. New South Wales General duty police duty belt images

Image above: *A fully laden New South Wales police officers duty belt as viewed from the front.*
Image below: *A fully laden New South Wales police officers duty belt as viewed from the rear.*

Source; Overloaded: how the New South Wales Police accoutrement belt plagues its wearers, 2004 <http://www.policejournalsa.org.au/0401/12a.html>

Figure 2. Patent leather and synthetic general duty police belt examples

Image above: *A Sam Brown Duty Belt 2-1/4 inch (57mm) wide. A typical police leather duty belt that can weigh up to 5 kilograms.*

Image below: *A Shapeshifter Cordura® duty belt that was trialled by the New South Wales Police Force.*

Source; America Wear, 2011. <www.americawear.com>, Cross Fire, 2012 <www.crossfire.com.au>

Figure 3. New South Wales police force General Accoutrement Vest (GAV) prototype

Images above: *New South Wales police force General Accoutrement Vest (GAV) prototypes (2007). The GAV vest was trial by more than one police department in Australia, but never adopted as police felt that the design was not aesthetically relevant. Constructed from canvas over shaped plastic moulded pockets*

Source; General Accoutrement Vest: Solution or Problem?, 2009 <www.articlesbase.com/health-articles/general-accoutrements-vest-solution-or-problem-956684.html>

As another interim step aimed towards eliminating the issues associated with duty belt injuries, the New South Wales police force Operational Training Safety Command commenced a trial of fifty six load bearing vests in the year 2006, of what was termed as the General Accoutrement Vest (GAV).[14] At this time it was the only available moulded[15] load bearing vest in the World and won the Australian Design Award in the year 2006, for materials and textile Innovation. However the GAV trial was unsuccessful. It was reported to be too small to enable loading and carriage of all the necessary duty equipment that general duty officers are required to carry. Some Police Officers that tested the GAV expressed that they refused to wear it after one day, due to the fact that it was either too hot to wear, or because it looked ridiculous. In fact, Doug Nicholson who served for over nine years with the Northern Territory Police Force in Australia and who later became a qualified workplace assessor and trainer, made the following comments in relation to the GAV.

> The General Accoutrement Vest (GAV) is made by an Australian company, Personal Protective Clothing, (PPC), in Victoria, Australia. Again, this vest has been trialled by operational Police, and I have yet to hear one officer who has trialled it saying that they would wear it. In fact, the only comments I have received from testing officers is that they refused to wear it after one day due to the fact that it was either too hot to wear, or it looked utterly ridiculous.[16]

The GAV was not eventually implemented by the New South Wales Police force after field trials concluded. It is interesting to note that there may have potentially been more positive ergonomic outcomes related to the GAV over traditional duty belts, because of the fact that in principle part of the total duty equipment load was being transferred from the waist to the torso area which is advantageous from an ergonomic perspective. However in the year 2006, the equipment load carried by New South Wales Police was less than present day, in the year 2012. Since the year 2006, New South Wales Police have introduced new duty equipment such as the taser control device[17] in the year 2009 and this would have meant that there would not have been enough space on the GAV to carry a taser and additional newly introduced future duty

14 General Accoutrement Vest (GAV) is made by an Australian company, Personal Protective Clothing, (PPC), in Victoria. The GAV sits on the upper torso front area of the body, covering the trapezius muscle, covering the pectoralis muscle down to the mid point of the mid-point of the rectus abdominus muscle.

15 Moulded refers to the design of the equipment pockets on the vest which take a hard form, where the pocket does not collapse like a soft textile pocket does.

16 Nicholson, D. 2011, 'General Accoutrements Vest: Solution or Problem?', *Health Insurance AU blog*, viewed 15 November 2011, <http://www.healthinsuranceau.com.au/general-accoutrements-vest-solution-or-problem/>.

17 TASER Electronic control device. A taser is an electroshock weapon sold by Taser International. It uses electrical current to disrupt voluntary control of muscles causing neuromuscular incapacitation (NMI).

equipment anyway.

1.2 Signficance of the research

The research undertaken in this study is primarily focused around General Duty Police Officers, as opposed to Police Officers from specialist units.[18] For example, the New South Wales Police Public Order and Riot Squad (PORS)[19] as opposed to General Duty Police Officers, are equipped with a broader range of specialist equipment, these specialist Police Officers wear specialised uniforms and specialised load bearing vests to carry their equipment. The load bearing vests that such specialist police squads use are in the most part, derived from military type applications. The term load bearing vest is not only limited to Police load bearing vests, many different types of emergency services use load bearing vests, such as the fire and ambulance services both locally in Australia and Internationally. Load bearing vests, as suggested previously, were first used for military type applications in the Vietnam War and this is another potential area where future research could be broadened to analyse wearer efficiencies gained in relation to future military human load carriage[20] applications. Military personnel tend to carry a heavy equipment load, well beyond that of General Duty Police Officers, when required a soldier may carry up to sixty kilograms of equipment on their person. The research potentially could also inform the design of similar type load carriage systems,[21] such as baby carrying harnesses and rucksacks,[22] for example.

18 Specialist units NSW Police; After three years General Duties Policing, Police Officers have the opportunity to specialise. They may continue in operational Policing as General Duties Officers, transfer to one of the many and varied traffic Policing duties, or apply to undertake further training in order to meet the professional requirements of Detectives or Specialist Operations.

19 The Public Order and Riot Squad (PORS) is the full-time 'riot squad' of the New South Wales Police Force. PORS is within the command of Field Operations under the Major Events and Incidents Group (MEIG) which is responsible for planning for major events such as Operation Vikings, APEC, the World Youth Day and New Year's Eve celebrations. Size: one-hundred full-time Officers.

20 The act of humans conveying; carrying load.

21 Load carriage system; is a system of devices or harnesses used to carry load more efficiently on the human torso.

22 Rucksack, another term used for backpacks, or a haversack.

1.2.1 General Duty Police Officer injuries related to the duty belt: An International perspective

General Duty police officers in the field both locally in Australia and Internationally, have suffered injuries in recent years because of the fact that they are required to carry a large array of duty equipment on their duty belt. New solutions to carrying this equipment have not been fully explored or implemented until recently. Load bearing vests are now being deployed by some Police forces locally and Internationally. The Work, Health & Safety (WHS) issues caused as a result of wearing a fully laden duty belt, have been for the most part, been related to back pain and in the lower back. Low back pain has been experienced by a large amount of Police Officers in the field. In a study undertaken in Canada in 1998 entitled, *Back Pain in a Large Canadian Police Force*[23], it was found that amongst a random sample of one-thousand and two serving members of the Royal Canadian Mounted Police, the prevalence of chronic or recurring low back pain since joining the force was approximately fifty-four per cent.

> Low back pain is a common problem throughout the industrialised world with reported one year prevalence rates between twenty five per cent and sixty two per cent. Prevalence of low back pain among people who drive motor vehicles for a significant part of the day appears higher than in the general population. Among Police Officers, one year prevalence rates of between forty four per cent and sixty two per cent have been reported (Brown et al. 1998).[23]

General Duty policing requires Police Officers to enter and exit patrol cars on a regular basis throughout the course of undertaking their daily duties. The research study *Ergonomics and Police Duty Belts Easing Their Load*, Espinoza (2009) described the following scenarios in relation to police patrol vehicle seats.

> Unlike regular sitting in a chair, when a patrol car is in motion the seated body is subject to different forces: accelerations and decelerations, lateral swaying from side to side, and whole-body up and down vibrations. The feet are actively being used and cannot be used to support and stabilise the lower body as normally happens when they are placed on the floor, like they do when sitting in a chair.[24]

23 Brown, J., Wells, G., Trottier, A., Bonneau, J & Ferris, B. 1998, 'Back Pain in a Large Canadian Police' *Spine,* vol. 23, NO. 7, PP 821-827.

24 Espinoza, K. 2009, 'Ergonomics and Police Duty Belts Easing Their Load', *Clinics in Occupational and Environmental Medicine*, viewed 21 November, 2009, <http://www.agrip.org/sites/agripnew/uploads/doc

Figure 4. Load carriage examples

Images above: *NSW Police Force Load Bearing Vest rear and front images; vest introduced in 2011.*

Source; NSW Police, 2012 <www.police.nsw.gov.au>

It is therefore necessary to create comfort with regard to automotive seating. In the same research study, Espinoza (2009) found the following vehicle support measures effective in creating comfort while driving;

i. An added seat cushion with upholstered memory foam and a rubber layer underneath will decrease the tendency to slide as the officer enters or exits the vehicle.

ii. A contoured, upholstered lumbar cushion with a plastic insert to maintain its shape and straps to hold it in place around the backrest of the seat will provide additional lumbar support for the back.

iii. A combination back and seat cushion with hinged back and seat sections will provide additional support for the back and pelvis.

1.2.2 The broader research perspective

The research initially looks at analysing current and past load carriage solutions that have been derived from military type applications such as military load bearing vests, that enable users to carry a greater load on their torso as opposed to their duty belts. Additionally, when dealing with the broader research perspective, it is important to consider that the user at the centre of this design issue and to consider the unique operational conditions that Police, emergency service workers and the military face in performing their routine duties.

The research analyses newly developed advanced technical textiles which can aim to provide new ways of resolving problems relating to thermal stress or to improve garment climate control which may enable greater user comfort, improved health and wellness and increased physiological health. The research also explores similar type load carriage devices and systems which are more advanced from a load carrying perspective than load bearing vests, these load carriage devices are baby carrying harnesses and transport physical objects[25] such as ruck sacks.

uments/other_articles/PoliceErgonomics.pdf>.

25 Transport physical object, such as a ruck sack or back pack.

Both baby carrying harnesses and some more advanced ergonomic ruck sacks use a combination of shoulder straps and hip support to better distribute load across the human torso, whereas load bearing vests tend to distribute load solely across the shoulder region. Again, baby carrying harnesses and ruck sacks may also incorporate a range of additional capabilities which improve user comfort, wellness and fit. Improved user comfort, wellness and fit in these devices is achieved by providing an additional effective adjustment range of below and above the medium torso length (refer to Figure 5, page 25).

Additionally, the New South Wales Police Force has recently introduced a load bearing vest in the year 2010 to combat injuries caused by overloading the duty belt with newly introduced duty equipment. The New South Wales Police Force has acquired two-thousand load bearing vests, officers with an existing duty belt related injury were issued with a load bearing vest first, then the remainder of Police Officers were issued with a load bearing vest. It is interesting to note that the load bearing vest is only worn by Police Officers at their discretion. For example it may not be appropriate to wear a load bearing vest on a very hot day and in this case officers can revert back, if they choose to, to wearing all their duty equipment on their duty belt. These load bearing vests which are constructed completely from soft textiles and open weave mesh, cost approximately AUD170 dollars each as when purchased in 2010. In comparison, in Britain, General Duty Police Officers generally purchase their own load bearing vests, with the exception of the London Metropolitan Police, who use a stab-proof vest that can carry a small amount of duty equipment, such as a radio-hand piece and two-way communications radio. In most London Boroughs and Counties Police Officers do not carry small arms, as these are generally only reserved for specialist police units, this does have the effect of reducing the overall duty equipment load for Police Officers.

1.2.3 Incorporating ballistic protection into load bearing vests

It is important to note that the New South Wales Police Force have chosen not to incorporate ballistic protection into the load bearing vests that they issued to Police Officers in the year 2009. Each Police patrol car in the state of New South Wales has ballistic vests located in the vehicle for Police to access and use as necessary. However in Victoria, Australia, the load bearing vest that was introduced by the police department in the year 2011, does incorporate ballistic protection, this is a unique

example. There are various levels of ballistic protection available depending on the weapons types and calibres that one wishes to protect against. There are also vests available that only protect against knife attack. In the United Kingdom, London Metropolitan General Duty Police Officers use stab proof vests only.

This research thesis does not consider the incorporation of ballistic protection or stab proof protection for a number of different reasons as outlined below;

- The fact that many local and international Police Forces have varying opinions regarding the necessity for their officers to use ballistic or stab proof protection.

- In some countries such as the United Kingdom for example, most General Duty Police Officers are unarmed (they do not carry a firearm) and the threat is predominantly perceived to be from knives and sharp weapons so Police Officers wear a stab proof vest.

- In the state of Victoria, Australia for example, the newly introduced load bearing vest does incorporate ballistic protection, but this is not a requirement at present in the remaining states and territories of Australia.

- In the state of New South Wales, Australia, the police force supplies load bearing vests without ballistic protection, ballistic vests are supplied in each patrol car, for use only when confronted with an imminent threat that requires ballistic protection.

1.3 Cultural issues related to Policing, modern Policing and the need for new technologies

Cultural issues related to inbuilt belief systems within a modern police force do have their place when it comes to the interface they promote and maintain between the police and the community. These cultural issues can determine the particular appearance and uniforms that are worn by police as they interface with the general public. For example a particular police force may believe it's important to use uniforms that give them almost a military like presence when they are on patrol and when they are dealing with the general public so that they may gain more authority. Paramilitary policing has been woven into public order policing as an effective, efficient use of force (Redekop et al.).[26] Should police forces consider other types or styles in policing, such as community-based policing, repressive policing or protest policing when considering how to best implement load bearing vests and the issue of exactly what equipment types, both lethal and non-lethal, should be carried on a general duty police officer?

When the metropolitan Police force was established in London, the emphasis was on a strong identification with the community.

> Uniforms where more civilian than military and the constable was considered as a "civilian in uniform." The hidden baton became a metaphor for a popular mythology that emerged regarding the metropolitan police. The metropolitan police appeared to be unarmed and benign; as such they cultivated moral authority and the image of the sometimes bumbling, friendly, not too effective, and very human "bobbies" contributed to public support. The baton was in their pocket and it could be more lethal than what people generally thought. Though constables did not carry side arms, guns were available for special incidents. In other words, what passed in bthe public minds as a police service was, in reality, more of a police force than was the popular image. We should consider different styles of policing in order to best develop a more considerate, further reaching design brief to conceptualise and develop load bearing vests (Redekop et al.).[27]

26 Redkop, V & Paré, S., *Beyond Control: A Mutual Respect Approach to Protest Crowd–Police Relations*, Bloomsbury Academic, London.

27 Redkop, V & Paré, S., *Beyond Control: A Mutual Respect Approach to Protest Crowd–Police*

Likewise physiologists support colour theory where darker colours when used in a police uniform may promote greater respect from the general public. So is it's perhaps advantageous for police to develop and implement a uniform that generates authority through its design and use of stronger more authoritarian colours or is it more advantageous to use a uniform with colours such as light blue, which the NSW police use as the colour of choice for the duty shirt, which promote peace and tranquillity above everything else? These are important questions to pose as design parameters, as these may contribute to the overall success and implementation of load bearing vests into police forces.

It's interesting then to note also, that some police forces around the World believe that they can tackle and reduce crime more effectively by using for the larger part plain clothes detectives as opposed to uniformed officers. Is covert or overt policing more effective in reducing crime? This is an important question also to pose, do uniformed officers carrying a large array of equipment have a greater ability to reduce crime rates, than plain clothes detectives carrying only a pistol, a baton and handcuffs?

1.3.1 Reasons relating to the increase in equipment load

The New South Wales Police carry a large list of duty equipment, which they would argue in the modern day allows them to deploy a greater range of equipment both lethal and non-lethal, when it is required that they do so. Technologies such as police radio have made it possible for greater communication to exist between police officers and command centres.

The following comments were made by (Redekop et al. 2007);

> In relation to attire worn in crowd control and protest situations, experience has shown a less aggressive crowd appearance reduces the risk of triggering a violent reaction from the crowd. They can produce negative bodily reactions.[28]

Relations, Bloomsbury Academic, London.

28 Redkop, V & Paré, S., 2010, *Beyond Control: A Mutual Respect Approach to Protest Crowd–Police Relations*, Bloomsbury Academic, London.

Non-lethal weapons such as capsicum spray (CS spray)[29] is unpleasant enough and make those in contact with police retreat, they also offer, as the NSW police would likely argue, an alternative in the first place to the deployment of lethal weapons such as pistols. The baton is one of the oldest types of equipment that police carry. Modern batons are collapsible or telescopic for ease of storage on duty belts and are supposedly less lethal than previously designed solid full batons. In addition to these types of equipment police commonly seen on police officers in many countries throughout the World, in the United States government agencies are frequently using video surveillance equipment supplied by Motorola. Motorola has tested camera surveillance equipment in major police forces throughout the United States in recent years. In fact some police forces have armed their officers with video cameras, and the military use video cameras (some with GPS [30] position location recording) in current conflicts such as Iraq and Afghanistan. This allows a command centre to monitor soldiers or police that are on the ground responding to a incident, through live video streaming and even allows officers that are behind those that have responded to a call and are on the scene first to patch into the cameras that are located on first despatch officers so that they can better monitor and assess the situation. In this case officers benefit from the fact that they are more aware of the situations before they enter the scene, police officers experience enhanced situational awareness and improved response.

The reality in modern day police forces, is that officers will in the future be more than likely required to carry an even greater equipment load. Criminals are accessing data and information constantly through smart phones and digital devices that allow wireless internet access to compete with the police. Police forces need access to those similar types of digital devices just to keep up. In the United States once again Motorola have developed a device called the LEX 700 [31] which is connected to public safety broadband. The device is a small hand held computer weighing two-hundred and eighty grams, which provides critical information to officers in the field, access to maps, criminal records and the device can be used also as a mobile phone. The device also has video and audio capabilities and a built in high powered led torch. In addition police use the device to administer infringements, identity verification, and

29 Capsicum Spray (CS Spray), also named pepper spray in North America and Europe. An aerosol spray containing oils derived from cayenne pepper, irritating to the eyes and respiratory passages and used as a disabling weapon. This term is used in Australia only.

30 GPS which stands for Global Positioning System, is a radio navigation system that allows land, sea, and airborne users to determine their exact location.

31 LEX 700 Mission Critical Handheld, 2012, viewed 28 June 2012, <http://www.motorola.com/Business/US-EN/Business+Product+and+Services/Public+Safety+LTE/LEX700>

evidence tagging at the scene.

New South Wales General Duty Police can access this type of information in the field but need to return to their patrol car which has a computer inside (typically the size of a fifteen inch laptop). Most police forces would argue that this type of equipment gives their officers much greater focus and efficiency in the field. There is little doubt that the acquisition of new technologies will always be adopted by police forces and whilst computer hardware manufacturers are generally responding to consumer demands for smaller hardware, this will become a priority in the near future given the ever increasing and overburdening load carried by general duty police officers around the World.

1.3.2 The tasks that New South Wales General Duty Police undertake on a daily basis

General duty New South Wales police officers are the first point of contact between the public and police. They are the local police who work in a Local Area Command (LAC). They possess a sound knowledge of all aspects of policing for duties including:

- Attendance, assistance and investigations of jobs such as domestic violence, assaults, break and enters, property theft and malicious damage
- Patrolling the streets by vehicle, foot or bicycle
- Traffic control and coordination of traffic accidents
- Responding to Triple Zero (000) emergency calls

In relation to load bearing vest considerations general duty police must undertake sedentary tasks such as performing office duties, where they may be required to be seated for extended periods of time whilst wearing a load bearing vest or duty belt. They must also enter and exit patrol cars on a regular basis, which has OH&S implications when police officers are wearing a duty belt with around twelve kilograms of equipment. General duty police are required at times to give chase on foot, meaning they are at times weighed down/and or disadvantaged by their duty

Figure 17. Current New South Wales Police General Duties uniform in the year 2012

Image above: *Current issue NSW General Duty police load bearing vest*

Source; Justice & Police Museum New South Wales, personal photograph, photographed Vaughan, S., 2012

equipment and in the case of the load bearing vest they have the majority of their equipment load on their chest, which may serve to place them off balance when they are required to jump across obstacles, and scale fences for example.

In addition to general duty policing, once police undertake three years' probation, from when they first join the force, they are eligible to join other specialist units such as the Air Wing, Bicycle Patrol, Dog Unit, Highway Patrol, Mounted Police, Police Rescue, the Bomb Disposal Unit or the Water Police. Police are still required to carry a large array of duty equipment on their person whilst working in these specialist units.

1.3.3 Overview

This research undertaken is secondary research and due to the scope of the masters research no physical prototypes have been designed or evaluated in this study. The research is aimed at surveying and analysing existing load bearing vests used across local and international markets, and dissects the current problems/issues associated with current load bearing vests. The research information contained in this thesis would help to potentially inform future load bearing vest prototype designs and is applicable at the initial conceptual design stages for the potential new product development of load bearing vests. The conclusion to this research study discusses design recommendations for load bearing vests that may be employed in future years by Australian police forces or International police forces.

The research study itself identifies avenues for design opportunities relating to General Duty Police load bearing vests from the year 2008 onwards. This study also identifies research areas that have not been undertaken or fully exploited in previous studies. Previous studies have almost always focused on injuries relating to accoutrements belts rather than focussing on ways by which load bearing vests can assist in reducing load carriage related injuries. The specific areas of research relate to the impact of thermal management in load bearing vests, whereby health and wellness may be best managed through the use of advanced textiles, garment construction and ergonomics.

Load bearing vests may also be best able to assist users in reducing injuries, by

allocating and spreading total equipment load over various sites of the body and not just the torso area, as is the case with load bearing vests. For example it may serve to reduce load carriage related injuries, to locate a pistol or a capsicum spray canister on the thigh using a drop-leg holster, rather than adding such items to the load bearing vest, where the vest could then become overloaded and unbalanced.

The fourth and final chapters of this thesis deal with advances in textiles that have brought about new possibilities in garment design and construction, aimed towards enhancing characteristics such as; breath-ability (textiles for climate control), comfort (textiles that provide climate control and cushioning such as 3D spacer fabrics), safety and high visibility textiles to increase health, safety and wellness.

Chapter 2

Literature review

2.1 Soldier modernisation in Australia

Colonel Jason Blain, Soldier Technology Conference UK, May, 2012

I attended the conference "Soldier Technology 2012," which was held in the United Kingdom, May, 2012. I would like now to review a number of presentations that relate to the focus day held on May 24th, 2012 entitled, "Soldier Power and Reducing the Burden."

Colonel Jason Blain from Diggerworks,[18] Australian army, discussed in his presentation - Future soldier modernisation in the Australian army; the presentation specifically focused on the Land 125 Soldier Combat System and phase four of this programme, which is the defence capabilities plan for the next major project upgrade to Australia's soldier combat system. Land 125 Soldier Combat System refers collectively to various pieces of infantry equipment, which is currently being planned and phased in by the Australian military. It is designed to enhance the performance of the individual Australian close combat soldier and small teams as part of a network enabled force.

The term "dismounted soldier," is a term given to a soldier who is on foot and away from any available transportation, this soldier is on the battlefield and is wholly responsible for his or her equipment and full load carriage.

18 Diggerworks is an organisation of Army personnel in the Defence Material Organisation and the Defence Science and Technology Organisation.

As a background to the project plan, Colonel Blain discussed just how much the Australian soldiers equipment levels have changed in recent years. In the year 1999, Australia participated in peace keeping operations in East Timor, this International force was called INTERFET[19] and the equipment cost per soldier then was approximately AUD3700. The equipment cost in the year 2011 Afghanistan operations was a staggering AUD27700 per soldier, largely due to the increased technology carried on the soldier and the greater range of protection equipment worn by the soldier. The main differences between the year 1999 and the year 2011 soldier equipment kit are demonstrated in the graphical images on the following two pages. It is important to note that Colonel Blain defines a soldier combat system as;

> The equipment used by a soldier to apply lethal or non- lethal effects, communicate and gain situational awareness, survive, sustain, move and operate as part of a team within the close combat environment (Blain 2012).[20]

As Colonel Blain suggested in his presentation, not every soldier within a platoon are likely to be equipped with the same operational kit, in future years there will be three tiers of soldiers, specialists, close combatants and general combatants, this tiered system is aimed at optimising and reducing the load each soldier carriers as well of course as maximising the spend per dismounted soldier. This example is an intelligent way to dissect and reduce the burden of load carriage across a higher number of soldiers in a platoon. This approach could have particular benefits if applied to police forces also, as an example perhaps there could be greater divisions between general duty police commands. Colonel Blain made the following point in his presentation, that;

> The soldier must be considered as an integrated Soldier Combat System, rather than simply the aggregation of individual components (Blain 2012).[20]

19 INTERFET - The International Force for East Timor (INTERFET) was a multinational peacekeeping taskforce, mandated by the United Nations to address the humanitarian and security crisis which took place in East Timor from 1999–2000 until the arrival of United Nations peacekeepers. INTER FET was commanded by an Australian, Major General Peter Cosgrove.

20 Blain, J. 2012, 'Soldier modernisation in Australia', paper presented at the Soldier Technology Conference, London UK, 21-24 May.

1999 INTERFET East Timor
approx. equipment cost: $3,700

Figure 18. Australian Soldier Kit as used in East Timor in 1999

Source; Soldier Technology conference UK May, 2012

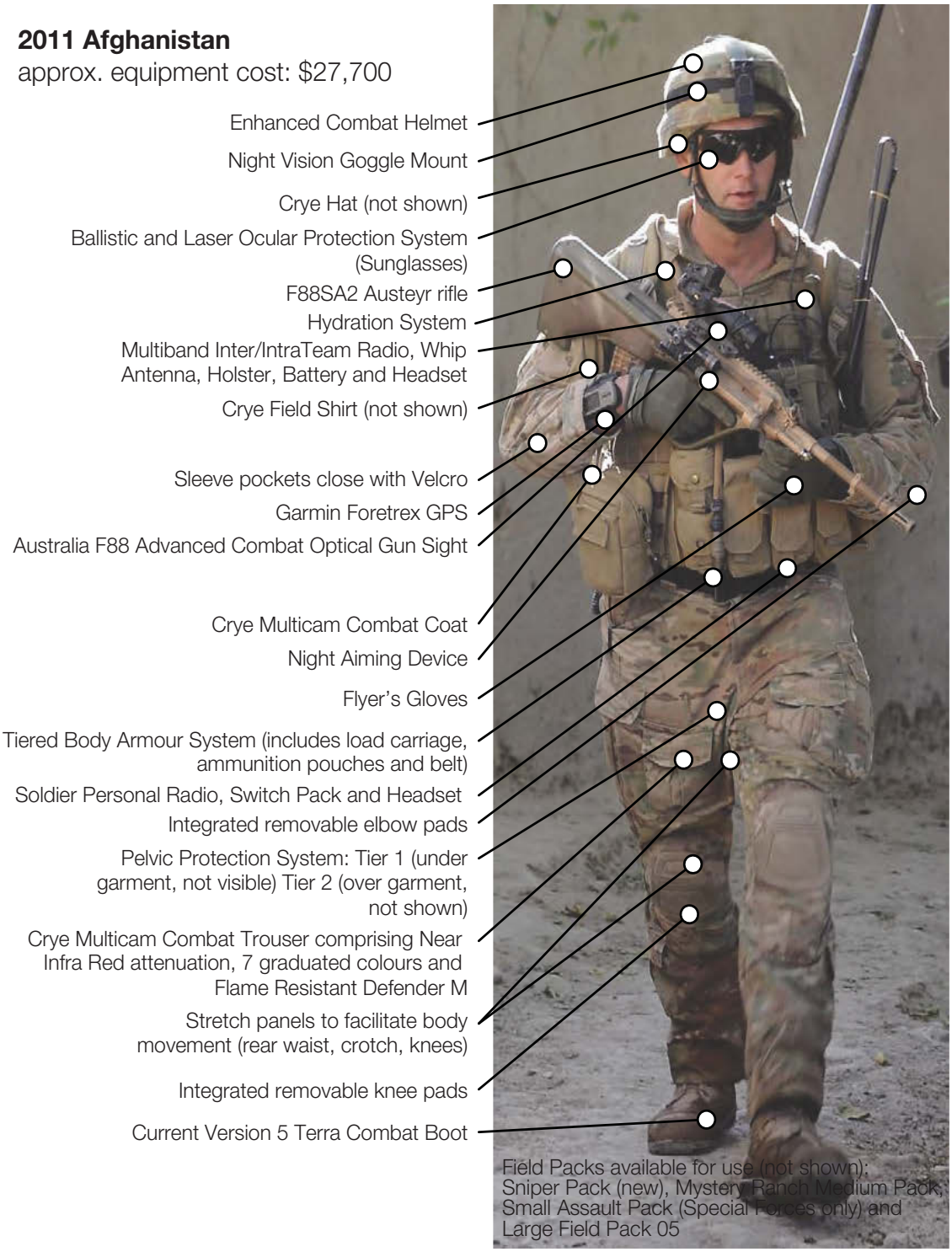

Figure 19. Australian Soldier Kit as used in Afghanistan in 2011

Source; Soldier Technology conference UK May, 2012

If we were to apply this to a Police Force model, we could perhaps realise advantages around Police working in pairs sharing an equipment load. Whether or not this is related to managing or reducing costs, the fact is that the New South Wales Police already do this on a micro level, in that only selected Police Officers, who are trained specifically in the use of a taser stun gun, will carry this weapon on their load bearing vest. In other words this ensures that Officers in a group have a slightly lesser load.

In addition, Colonel Blain discussed the fact that with technologies superseding themselves at such a rapid rate in the modern era, logistics acquisitions is undertaken in small lots, as opposed to acquiring equipment that would be rolled out to an entire regiment all in one lot. This 'adaptive acquisition' as it is termed by the Australian army, may well allow the Australian army to better integrate newly emerging technologies, when such technologies become readily available it may help to streamline the process between acquisition and usage in the field. The adaptive acquisition strategy considers partnership with stakeholder communities, responding and adapting to threats being encountered and emerging technological opportunities, in order to improve performance/reduce the load burden and ensure that capability decisions are evidence based. Adaptive acquisition also considers that the soldier system must be integrated with the soldier, fitting, training and adapting the system to user feedback is vital to success, as is learning from operations and responding to insights from users conducting real tasks and confronting real World threats.

The Diggerworks Soldier Combat System 125 phase four, incorporates a large number of future technological considerations for the dismounted soldier, such as Unmanned Aerial Vehicles (UAVs)[21], robotics, bionics[22], human enhancements[23], wearable computers, battery power to name a few. The reality is that the dismounted soldier of the future will no doubt interact with the aforementioned technologies, however if we consider a platoon of Australian soldiers which may consist of between twenty-six to fifty soldiers, perhaps only eight specialist soldiers in the former smaller group total of twenty-six soldiers, may need to carry wearable computers, used

21 An unmanned aerial vehicle (UAV), commonly known as a drone, is an aircraft without a human pilot on board. Its flight is either controlled autonomously by computers in the vehicle, or under the remote control of a navigator, or pilot (in military UAVs called a Combat Systems Officer on UCAVs) on the ground or in another vehicle.

22 The study of mechanical systems that function like living organisms or parts of living organisms.

23 Human enhancement refers to any attempt to temporarily or permanently overcome the current limitations of the human body through natural or artificial means. The term is sometimes applied to the use of technological means to select or alter human characteristics and capacities, whether or not the alteration results in characteristics and capacities that lie beyond the existing human range.

primarily for controlling UAVs, for example. This reduces the load burden across a platoon, giving consideration to the platoon as being a system as opposed to considering the dismounted soldier as an aggregation of individual components. The future soldier program considers that a future strategy is to buy less more often as previously suggested, which is delivered in synch with the army's force generation cycle.

The final point of interest relating to load carriage in Colonel Blain's presentation is the fact that the future soldier program considers acquisition of new technologies to equip the dismounted soldier in a very comprehensive manner. The 'Diggerworks and Land 125 system context diagram' in Colonel Blain's presentation, presents current programmes and future considerations. The soldier combat system considers, sustainability (human sustainability such as field endurance), mobility, survivability, lethality and computer technologies.

2.1.1 Overview

The reality is that Australian army modernisation strategies relating to the acquisition of new technologies, and essentially promoting the concept of buying less more often seems to make logical sense. It is appropriate when hardware technologies and equipment is generally becoming smaller and lighter, to consider these sorts of buying options from a procurement perspective. Arming police officers with lighter more advanced equipment in more frequent procurement cycles may actively serve to reduce the load burden.

Of interest also, is the three year force generation cycle used in the procurement process, which considers polling (including solicited/unsolicited feedback), planning, proposing, proving and placing. A strategic system of polling may assist in gaining valuable feedback aimed towards continuous improvement, for deployment programs involving load bearing vests in police forces. The important point is made in this presentation that this future soldier systems strategy is aimed towards outcomes or enablers which encompass reductions in combat loads (reducing the burden), increasing performance, survivability and soldier confidence. Considerations around improving the health and wellness in police officers is also important, it is beneficial to improve a police officers performance and levels of alertness by reducing the load

carriage burden.

2.2 Canadian Army soldier burden analysis

Major John Herbert, Soldier Technology Conference UK, May, 2012

The presentation delivered at the Soldier Technology Conference UK, entitled 'Canadian Army soldier burden analysis' was given by Major John Herbert of the Canadian Army. This presentation was of particular relevance to load carriage and burden analysis, because it charts throughout history, from World War one, to the present day the ramifications and effects of load carriage in the Canadian army. Canadian dismounted soldiers circa the year 1917 carried an individual load of around thirty kilograms, in the year 2003 a Canadian dismounted soldier carried a load of around thirty-four kilograms, where the present day dismounted soldier in the year 2012 carries a load of just over fifty-four kilograms.

The dismounted soldier system evolution from the year 1917 to the year 2012 in the Canadian army has led to an overall weight increase of a factor of 1.8 times the load of the year 1917. Factors that have contributed to this increased load are suggested to be increases in protection levels due to the forces Land Operations 2021 framework[24], the force employment concept for Canada's army of tomorrow and a modern political climate which demands high levels of a soldiers personal protection. In terms of weapons and ammunition, load increase has doubled from that of 1917 to the present day, this is contributed to the Land Operations 2021 framework, and the reduced faith in the ability to conduct secure logistical activity. In terms of water and rations, the Canadian dismounted soldier must carry double the three kilograms load of that of the dismounted soldier in the year 1917. In terms of soldier surveillance, target acquisition and night observation (STANO)[25] and power requirements, the present day load is four times greater, due to the Land Operations in the year 2021 framework, and a modern political climate that also demands high levels of situational awareness (SA) and precision command.

The average body weight of a dismounted soldier in the Canadian army is approximately eighty-two kilograms. The NATO maximum soldier operational weight is thirty-two per cent of body weight, this in effect means that the Canadian soldier

24 Department of National Defence 2007. Land Operations 2021, *Adaptive Dispersed Operations: The Force Employment Concept for Canada's Army of Tomorrow. provides the overarching framework for how the Army will successfully operate in the future operating environment.* Department of Na tional Defence, Canada.

25 STANO stands for Surveillance, Target Acquisition, & Night Observation.

carries an average excess weight of twenty-two kilograms to this NATO maximum.

The future soldier systems goals for the Canadian army is to dramatically reduce weight by up to seventy-five per cent and reduce bulk, increase fitting comfort, adjust-ability and range of motion. The Canadian army are also considering water recycling and purification, integrated power generation, integrated heating and cooling and flexible computer displays as a way of reducing the burden to the dismounted soldier of the future. The load carriage platform of load bearing vests and backpacks as carried by a Canadian dismounted soldier incorporates a quick-release mechanism, which allows soldiers to release and drop their load carriage platform hastily in emergency situations and allows for immediate medical access.

2.2.1 Overview

It is very interesting and relevant to note that Major Herbert outlines in his presentation, methods by which the load burden must be managed in the future and that is by enforcing soldier load carriage weights, careful planning selection of appropriate equipment and systems, educating and training soldiers on clothing layering to reduce thermal burden to the soldier and load carriage. Beyond the year 2016, Major Herbert advocates increased reliance on human factors[26] expertise and more efficient load burden placement. Again the ramifications of the prior statement related to police load bearing vests are around using different sites of the body to place and assist in load carriage, being mindful of human factors considerations. Police forces must carefully select the appropriate equipment for future use and train officers in usage of this equipment. There is no doubt, as the Canadian army are advocating, that clothing layering may also effectively assist to reduce thermal stress to police officers who are using load bearing vests in hot climatic conditions.

26 Human Factors is a discipline of study that deals with human-machine interface. Human Factors deals with the psychological, social, physical, biological and safety characteristics of a user and the system the user is in.

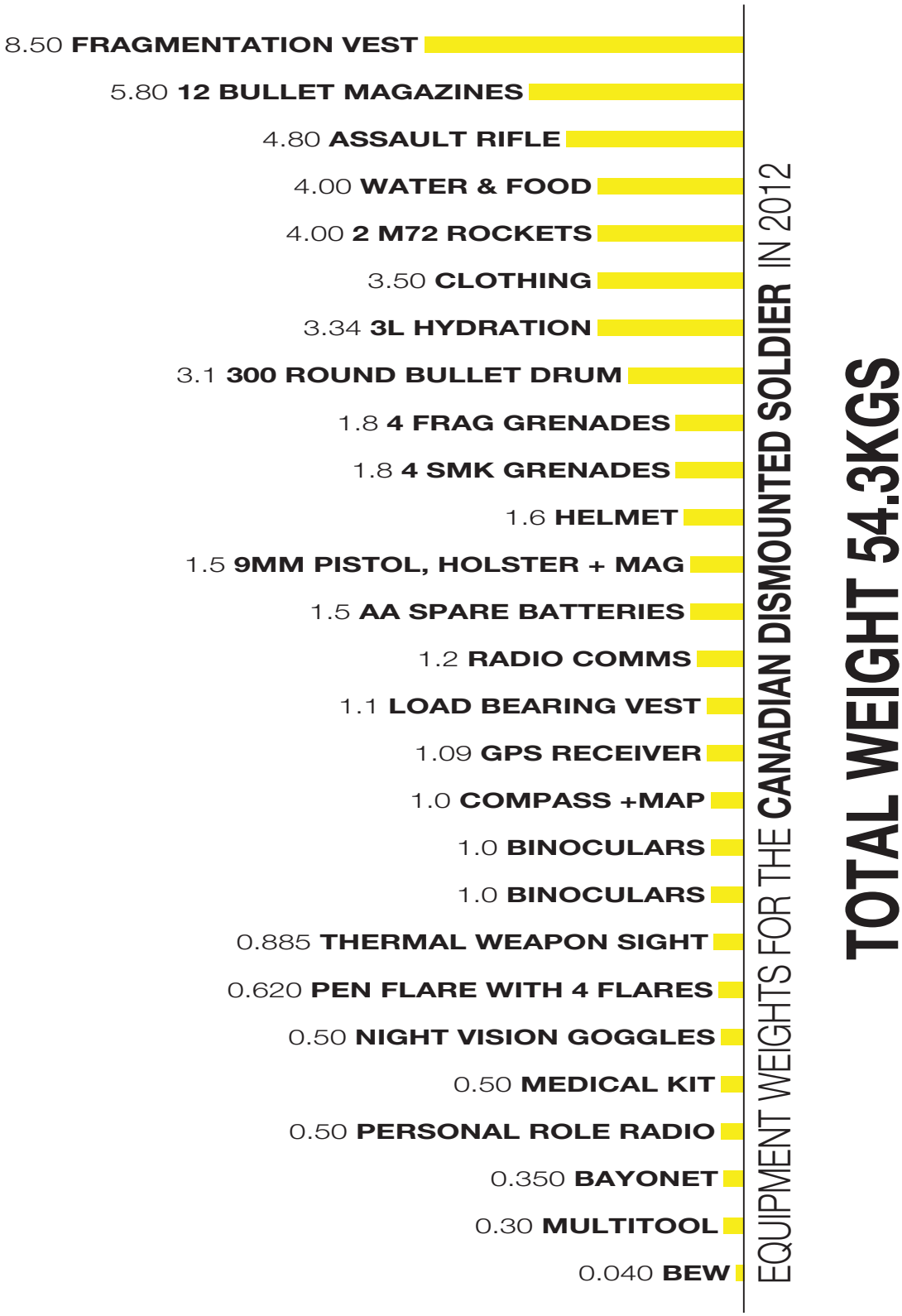

Figure 20. Equipment Weights for the Canadian Dismounted Soldier, 2012

Source; Soldier Technology conference UK May, 2012

Figure 21. Canadian dismounted fully ladened soldier in Afghanistan, 2012

Source; Soldier Technology conference UK May, 2012

Figure 22. Equipment photos of the soldier kit for the Canadian Dismounted Soldier, 2012

Source; Soldier Technology conference UK May, 2012

Figure 23. Canadian Army, Family of Land Combat Systems (FLCS)

The Family of Land Combat Systems is a grab bag of future CF projects that covers artillery, vehicles, and even the individual soldier equipment. 'Omnibus' components include: Future Combat Vehicle Systems (including Close Combat Vehicles), Future Direct Fire Capability, Future Indirect Fire Capability, Future Soldier Systems, Future Service Support Systems, Future Network Capability, Autonomous Systems, etc. Here we review the major vehicle components of FLCS.

Source; Designing Canada's Army of Tomorrow. A Land Operations 2021 Publication, Page 55; Ontario, Canada, 2011.

Figure 24. UK Dismounted soldier load carriage examples, 2012

Source; Soldier Technology conference UK May, personal photograph, photographed Vaughan, S., 2012.

Figure 25. UK Dismounted soldier load bearing vest (LBV), 2012

Source; Soldier Technology conference UK May, personal photograph, photographed Vaughan, S., 2012.

Figure 26. UK Dismounted soldier load bearing vest (LBV), 2012

Source; Soldier Technology conference UK May, personal photograph, photographed Vaughan, S., 2012.

Figure 27. Prototype for the UK future dismounted soldier programme (FIST), 2012

Source; Soldier Technology conference UK May, personal photograph, photographed Vaughan, S., 2012.

2.3 Science in clothing comfort

Apurba, Das and R. Alagirusamy. May, 2011

Clothing Comfort is one of the most important aspects of garment construction and textile characteristics. Understanding at a basic level, comfort aspects of textile materials is extremely useful for fibre, yarn and fabric manufacturer, researcher, garment designer, processing industries, garment houses, users of the fabrics for specialty applications and all others related with textile and garment industries. Understanding of the interrelationship between fibre material, yarn structure, fabric structure, transmission characteristics (air, heat and moisture) and tactile aspects of textile materials on thermo-psychological and neuro-physiological processes of clothing comfort is extremely helpful for engineering of clothing for specific applications.

In the present day society a person expects a high level of clothing design and textile application. In most societies clothing is used for the purpose of expressing wealth, status, occupation, age, occasion and gender. The factors which influence clothing selection can be divided into four major groups, social factor, economic factor, environmental factor and physical factor. Social factors may include where a person lives (urban or rural) cultural background, gender, occupation, occasion and social status. Depending on where a person lives, the clothing pattern changes. In Vietnam for example, the indigenous people called the Hmong people, who live close to the Chinese border in the mountainous area of Sapa wear a particular dress and design patterns in their clothing that are specific to their culture. In some cases a person selects clothing depending on the occupational requirement, police for example wear a certain type of clothing so that they can easily be identified apart from the common man. Among economic factors are the economic condition of society, economic status of individual and the availability of technology or raw material. The environmental factors include climatic conditions (too cold, too hot, raining, chilled wind, etc), protection from extreme environments, (unusual place, space or under water). Depending on environmental conditions the clothing need changes and the performance factors are the dominating parameters.

A person requires different clothing for different climatic conditions and clothing is therefore generally divided into two distinct seasonal groups for winter and summer.

It is interesting to note though that a police load bearing vest is used across both seasons. Clothing pattern changes depending on the environmental threat, such as clothing for explosives and poisons. The last factor is the physical conditions of a person, which include age, condition of health of a person (wellness), body structure, physiological response of the body, activity level, etc. The clothing pattern also changes with the age of the person due to psychological and physiological changes with time. Clothing selection depends on the physical build of the body such as whether the wearer is fat or thin, tall or short. A person with special physical characteristics may require specific clothing. In certain situations a person may feel colder or hotter or sweat more than other persons, this is due to the fact that the thermo-physiological responses are different for different persons. Selection of clothing also depends on level of activity and under heavy activity, the body naturally sweats more. The clothing a person wears in this case should be able to dissipate and transmit the heat and sweat quickly to keep the body heat under control.

A sports person needs special sports wear depending on the sport, and people in challenging activities and sports could use smart clothing that can sense the wearer's condition or situation and modify its structure for protection or breathability, such as is the process with a phase change garment. The comfort characteristic is an important functionality of clothing. Human thermo-physiological comfort is associated with the thermal balance of the human body, which is highly dependent on metabolism rate, physical activities, ambient temperature, and thermal moisture transmission of the worn clothing. Clothing creates a micro-climate between the skin and the environment, which supports the body's thermo-regulatory system to keep its temperature within a safe range, even when the external environment and humidity changes to quite an extent.

2.3.1 Components of clothing comfort

Comfort is one of the most important aspects of clothing and comfort has been defined by many different researchers in many different ways. Comfort is influenced by the physiological reaction of the wearer. Comfort is temperature regulation of the body. Comfort is the absence of unpleasantness or discomfort. Comfort is the state of pleasant psychological, physiological and physical harmony between a human and the environment. All three aspects are important because the absence of any one makes a person feel uncomfortable.

Broadly there are four basic elements of clothing comfort;

(1) Thermo-physiological aspect

(2) Sensorial or tactile aspect

(3) Physiological aspect

(4) Fitting Comfort

2.3.2 Overview

Clothing comfort is an essential aspect of load bearing vest design and one which should be incorporated into the design brief for load bearing vests of the future. Even if garments are well designed and employ advanced textile elements, fitting comfort may not be optimum unless the garment fits well to the human body and to the specific user. A garment which a user may feel is restrictive, may have a sensorial aspect that means the user does not feel that comfort has been optimised. There are many complexities in clothing comfort and these should not be overlooked if a designer is to best meet the needs of the end user.

2.4 Improving comfort in clothing

Guowen, Song. April, 2011

Wearer comfort has been listed as the most important property of clothing demanded by users and consumers according to recent studies. A fundamental understanding of human comfort and a knowledge of how to design textiles and garments to maximise comfort for the wearer is therefore essential in the clothing industry. Improving comfort in clothing reviews the latest developments in the manufacturing of comfortable apparel and discusses methods of improving it in various articles of clothing.

Human comfort is complex and subjective, and is influenced psychologically and physiologically by clothing and surrounding environmental conditions. Clothing as a near environment of the human body plays a vital role in achieved human clothing comfort.

The text begins by outlining the fundamentals of human comfort in clothing, from the human perception of comfort in apparel and factors which affect it such as the properties of fibres and fabrics, to laboratory testing, analysing and predicting of the comfort properties of textiles. Part two discusses methods of improving comfort in apparel, from controlling thermal comfort and managing moisture, to enhancing body movement comfort in various garments. Part three reviews methods of improving comfort whilst maintaining function in specific types of clothing such as protective garments, sports wear and cold weather clothing.

2.4.1 Overview

Improving comfort in clothing should be viewed by designers as a means to constantly improve garment comfort. When a load bearing vest is released to the end user, well qualified user trials and user feedback should be incorporated into the next model load bearing vest. As equipment and technologies are constantly changing, so too should the design and fabrication of general duty police load bearing vests so that comfort is best achieved.

2.5 Sam Browne and beyond: A look at duty belts

Stone, Rebecca. Police: The Law Enforcement Magazine, November, 2000

2.5.1 Who was Sam Browne?

Sam Brown is the name behind the belt worn by so many officers is named after British General Sir Samuel Browne (1824-1901). It is described by Webster's as "a belt with a shoulder strap running diagonally across the chest, worn as part of a military or police uniform." Common legend has it that the belt was designed by Browne after his left arm was severed during battle in India. The original strap, which was supported by a strap passing from the left side of the belt over the right shoulder is said to have helped to stabilise the belt for the one-handed drawing of a sabre and may also have helped to take weight off the hips. Comments around stability and weight distribution (Stonem 2000) are made in this article, as below;

> Stability is still critical and weight distribution more important than ever.[27]

Comments (Stone, 2000) are also made in the article with regard to the heavy load that police officers are expected to carry at present and that;

> A belt that is too stiff or that is ill-fitting can be not only an officer safety issue but a health hazard as well, in the form of fatigue, pinched nerves, sore backs and bruises.[27]

Material and textiles applications are considered in this article and the comment is made related nylon duty gear (Stone, 2000);

> Today, more and more officers seem to be realising that nylon gear has definite advantages. It is non-reflective and relatively silent, two features that address concerns expressed by the tactically minded. Some are especially concerned with higher gloss gear, such as Clarino (patent leather), seen in some agencies, feeling

27 Stone, R. 2000, 'Sam Browne and beyond: A look at duty belts', *Police: The Law Enforcement Magazine,* November, 2000, viewed 28 January, 2009, < http://www.iwitts.org/law-enforcement/resources/142-sam-browne-a-look-at-duty-belts>.

> that it compromises Officer safety for the sake of looks.[28]

When it comes to preferencing leather over nylon in the U.S. these comments are made in the same article (Stone, 2000);

> So, is the pure leather Sam Browne still the preferred duty belt or have more agencies gone over to the synthetics and laminates? Judging from information gathered by Police from calls to various agencies across the country, it may be a fairly even split. Some feel there are geographical preferences.[28]

2.5.2 Ergonomic considerations

Several officers who spoke with police said that either they or others they knew had experienced back trouble in the course of undertaking duties. According to Ira Janowitz, an ergonomics consultant at the University of California; San Francisco/ Berkeley Ergonomics Program (Stone, 2000);

> The problem of duty belt discomfort is a significant health and safety issue for uniformed personnel nationwide.[28]

Other problems cited by Janowitz include total weight of the gear being located on the duty belt, rigidity of the belt and holster system, location and shape of the belt buckle, holster and loop or shank, vertical location of the holster in relation to hip and pelvis and cant of the weapon. Janowitz told police that these problems appear to multiply for women, he said (Stone, 2000);

> Rounded, padded edges on top and bottom conform to the body and distribute load better.[28]

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28 Stone, R. 2000, 'Sam Browne and beyond: A look at duty belts', *Police: The Law Enforcement Magazine,* November, 2000, viewed 28 January, 2009, < http://www.iwitts.org/law-enforcement/resources/142-sam-browne-a-look-at-duty-belts>.

2.5.3 Considerations for Women

Donna Milgram, executive director of the Institute for Women in Trades, Technology and Science (IWITTS), often conducts seminars for women in policing. She told police that while women recruits in the academy may be reluctant to complain about duty gear fit, Milgram has found that most working female officers have reported problems. A couple of years ago IWITTS conducted a survey in three police departments. Results indicated that one-third of women officers had problems with uniforms and equipment fit, which they reported. But due to the fact that problems persist, solutions seem to be slow in coming, said Milgram. Milgram made these comments below in relation to equipment fit (Stone, 2000);

> It's so important for academy instructors to be aware. She added, a lot of departments don't realise there are dedicated women's sizes. She said many probably don't think about it. It's important to educate departments as injuries can be severe and permanent. There are options, she told Police.[29]

Milgram points out in the report, that police equipment and uniforms are not sized to fit women, that is most gear is designed for male officers and is based on tests with male officers, and cut down versions don't really work for women. Milgram commented further (Stone, 2000);

> Improperly fitting equipment and uniforms pose a health and safe hazard which could endanger the lives of police officers and of others.[29]

Milgram urges manufacturers and police department management to be on hand performing sizing checks when uniforms and equipment are issued in the academy. She also urges departments to look for vendors that offer women's sizing.

Officer Jackie Slater, a four-year veteran of the Bloomingdale (Ohio) Police Department wears nylon gear and like the lighter weight.

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29 Stone, R. 2000, 'Sam Browne and beyond: A look at duty belts', *Police: The Law Enforcement Magazine,* November, 2000, viewed 28 January, 2009, < http://www.iwitts.org/law-enforcement/resources/142-sam-browne-a-look-at-duty-belts>.

Officer Slater comments (Stone, 2000);

> Women have smaller waists and can't fit all the equipment on the duty belt. There's just not enough space, so I keep some things in the car. I make sure I have the important stuff on the belt. But it's crowded.[30]

Officer Slater, who carries a knife her pocket, admits that this situation can impact safety (Stone, 2000);

> Like gloves. If I go to scene and need them immediately in a bloody situation, I can't go running out to the car.[30]

Suzi Huntington has similar problem in that she simply has no room for the additional equipment she's given (Stone, 2000);

> They keep handing me stuff and I put it in the trunk. I carry pepper spray, a radio, hand cuffs on my left and the gun on the right, with extra magazines up near the buckle.[30]

Officer Huntington said that she will often keep the taser and nunchakus in the trunk of the patrol car. LAPD Officer Sara Faden wears a department-issued plain Sam Browne, Faden makes the following comments around the duty belt (Stone, 2000);

> The belt is as comfortable as can be, except for weight, she said, adding that the belt took about a year to stretch to where it conformed to her body.[30]

30 Stone, R. 2000, 'Sam Browne and beyond: A look at duty belts', *Police: The Law Enforcement Magazine,* November, 2000, viewed 28 January, 2009, < http://www.iwitts.org/law-enforcement/resources/142-sam-browne-a-look-at-duty-belts>.

Figure 28. Serpa® ergonomic drop leg pistol holster

Image above: *Serpa® brand holster with two magazine pouches along side. The holster is constructed from a plastic composite - this is ingenious as it has a latch that does not allow for the weapon to be drawn, but when needed it can be drawn one-handed.*

Source; Tactical Defense Solutions, 2012 <www.tds-us.com/catalog.php/tds/pd2092299 2012>

Figure 29. Blackhawk® Omega Drop Leg Medical Pouch

Image above: *A drop leg pouch which uses the same principles to carry equipment in a way that provides improved ergonomics to the user.*

Source; Patriot Outfitters, 2011 <www.patriotoutfitters.com/ad121109.htm>

Figure 30. Recon brand Military style Load Carrying Chest Rig

Image above: *A military load carrying chest rig, which is slightly different to a load bearing vest because it does not extend down to the waist line.*

Source; Recon Chest Rig, 2012 <www.soldiersystems.net/tag/215-gear/page/3/>

Officer Faden experiences belt-inflicted back pain. In fact, she said that LAPD officers even have a name for it: Sam Browne Syndrome. Faden, who goes to a chiropractor occasionally, commented (Stone, 2000);

> I'd say about 85 percent of officers go there (to see a chiropractor) men and women.[30]

Law enforcement trainer, Kat Kelley deals with this subject in many of her presentations on training and equipping the female officer for survival.

> I've had numerous women tell me they've had problems with their backs sciatica.[31]

Officer Kelley and some others question the effectiveness of the Sally Browne types of belts, which are cut on the bias and designed with a curve to accommodate men. Officer Kelley commented (Stone, 2000);

> Women are not all cut the same. I can't wear a Sally Browne (patent leather belt.[31]

But she acknowledges that at least manufacturers are making an effort to come up with alternatives. Conversely, a representative manufacturer, Gould said;

> We have a number of customers who feel the Sally Browne has a great advantage. It's true that not all women are shaped the same. But most women are not shaped like men.[31]

Officer Kelley cites the drop leg holster as one design solution that aims to solve some of the problems resulting from the fact that women tend be shorter waisted than men. This physical reality causes women to have to draw higher and inhibits a smooth draw, pistols sometimes dig into the ribcage and canting out at an angle in the holster over a woman's hip structure occurs.

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31 Stone, R. 2000, 'Sam Browne and beyond: A look at duty belts', *Police: The Law Enforcement Magazine,* November, 2000, viewed 28 January, 2009, < http://www.iwitts.org/law-enforcement/resources/142-sam-browne-a-look-at-duty-belts>.

Officer Kelley commented (Stone, 2000);

> I used to have to walk the gun in my hand to adapt before I had a drop holster.[31]

She says a drop, holster allows lower/smoother draw. Spacers, available through some manufacturers, can also help the gun hang straight. She said moving the holster forward on the belt can be a quick fix.

According to Officer Kelley, sitting in the car can also be an issue, with all the extra equipment in the car interfering with all the equipment on the officer. That must be taken into consideration as well when researching and designing better alternatives to the duty belt. Comfort and health are not the only products of a good fit. Accuracy and speed are also affected and these are tactical issues. Officer Kelley commented (Stone, 2000);

> An agency has an obligation to fit employees with correct equipment.[32]

Like Milgram, she thinks that a lot of agencies just don't know what's out there and available.

It is reasonably clear that there is much variation in belt wear among agencies nationwide. Most professionals agree that sizing, proper fit and adequate maintenance are crucial. Many also pointed out the importance of equipment placement and urged officers never to wear items, such as cuffs, on the back portion of the duty belt, in the area of the spine. But regardless of what is worn and where it's worn, consistency is important. Many, like Police Officer Ed Nowicki are concerned with safety when switching to unfamiliar gear. He cautioned (Stone, 2000);

> The new security holster may be completely different than the old one. The draw may be different. Practice with duty gear. Find how to wear the gear and don't

32 Stone, R. 2000, 'Sam Browne and beyond: A look at duty belts', *Police: The Law Enforcement Magazine,* November, 2000, viewed 28 January, 2009, < http://www.iwitts.org/law-enforcement/resources/142-sam-browne-a-look-at-duty-belts>.

> change. “When you’re under stress, that’s when it’s going to be a factor. You’re going to revert to your training. You want to be able to use your gear without looking at it. [33]

Officer Nowicki advised officers to seek out those with similar body shapes and good professional attitudes for advice. Officer Nowicki further commented (Stone, 2000);

> Even if the department supplies all the gear, you can still make small modifications and practice with your body armour on![34]

2.5.4 Overview

This journal article makes some good suggestions around alternatives to load bearing vests, such as the chest rig which may be beneficial from a load carriage and reduction of thermal burden viewpoint. The fact that a chest rig is a smaller load carriage device may assist with creating a load carriage device that has greater breathability to reduce heat stress. The chest rig as a load carriage device may also provide a greater range of movement and flexibility for when police officers are compromised throughout lifting tasks, such as when exiting a vehicle which involves a range of at times, awkward twisting movements under load stress (i.e. as they are carrying twelve kilograms of duty equipment on their person).

The drop-leg pistol holster is a very important device also, considering that it provides beneficial ergonomic advantages. Many police forces, including the NSW police force have evaluated drop leg pistol holsters. At the time of writing this thesis, it is interesting to note that the NSW police force have now adopted drop leg holsters, such pistol holsters are used in combination with a load bearing vest. There is further opportunities to use drop leg pouches, such as the example shown on page 59, on the opposite leg to the drop leg pistol holster, such as Victorian police do in order to carry their capsicum spray canister.

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33 Stone, R. 2000, ‘Sam Browne and beyond: A look at duty belts’, *Police: The Law Enforcement Magazine,* November, 2000, viewed 28 January, 2009, < http://www.iwitts.org/law-enforcement/resources/142-sam-browne-a-look-at-duty-belts>.

34 Stone, R. 2000, ‘Sam Browne and beyond: A look at duty belts’, *Police: The Law Enforcement Magazine,* November, 2000, viewed 28 January, 2009, < http://www.iwitts.org/law-enforcement/resources/142-sam-browne-a-look-at-duty-belts>.

2.6 Updating Sam Browne: Designing Better Load Bearing Systems for the Modern Peace Officer

Officer Brian K. Irons Golden Gate University July 30, 2004

2.6.1 Regarding the abstract to this journal article

Placing too much weight on the hips causes pain and injury and this is related to the weight peace officers carry in relation to their equipment. In recent times these such injuries have come to be known as "Sam Browne Syndrome." The overall goal of this particular study was to design better load bearing systems for the modern peace officer and make individual recommendations to individual officers, departments and manufacturers so they can make recommendations to reduce the associated problems of wearing a duty belt. The solutions will look outside the Sam Browne duty belt. Note there is a female version of the Sam Browne duty belt which has been named the Sally Browne duty belt: a version of the Sam Browne duty belt that has been cut and curved in such a manner that it fits the hips of female peace officers better than the usual straight cut of the Sam Browne duty belt. When laid flat, the Sam Browne resembles a straight line while the Sally Browne resembles the curve of a smile.

2.6.2 Introduction

The result of using the out-dated technology of the traditional Sam Browne duty belt to carry the increased amount of modern equipment with its associated additional weight, has resulted in an increase in the number of peace officers suffering Sam Browne-related chronic pain and injury. The number of peace officers[35] suffering pain or injury due to their Sam Browne duty belt is greatly under reported due to the tradition-bound and stoic organisational culture of law enforcement in general, in which complaints of temporary pain or discomfort are often seen as weakness. The military, although considered by some to be steeped in tradition, is the most advanced organisation in regards to the research and development of improved load bearing systems.

35 Peace Officer is another term for a General Duty Police Officer as used in the United States of America

2.6.3 Literature review within the article

This literature review is going to be divided into three sections. The first section will look at the history of the Sam Browne belt, and the concept behind its design. The second section will discuss and critique the findings of the limited number of studies that have examined the shortcomings of the modern Sam Browne duty belt. A subsection of the second section will discuss the Workers Compensation presumption regarding Sam Browne duty belt related injuries, and the viewpoints of different organisations upon the validity of this California Workers Compensation law. The third section will present the currently available and marketed Sam Browne duty belt designs and alternative load bearing systems. The concepts behind the designs of these modern systems will be explained, with the focus being upon the problem that each one of these different systems attempted to alleviate.

The Montfort Injured Workers Centre in Orleans, Ontario, Canada, conducted a study in the year 2002, that examined the problems caused by the Sam Browne duty belt. What made the Montfort study unique was that it focused solely upon the use of external suspenders to lift the weight of the Sam Browne duty belt up and off of the hips. The study utilised eight to ten peace officers who were under active rehabilitation therapy for Sam Browne related injuries. In fact, eighty-seven per cent (seven out of eight) of the Peace Officers who utilised the suspenders reported less pain in the hips, back, and stomach. It was not mentioned if any of the peace officers in the study had shoulder or neck pain related to the use of the suspenders. The testing also included duty related physical performance testing of the Peace Officers wearing the Sam Browne duty belt with and without the suspenders.

An overwhelming majority of Peace Officers tested showed improvement in both physical performance and in the reduction of pain (Leach & Thibualt, 1999). The significance of the Montfort study is that it actually measured performance in a quantitative manner, rather than just a qualitative and anecdotal reduction in pain which has been the focus of most Sam Browne duty belt manufactures. The author believes that the Montfort study is the base from which a superior load bearing design that still utilises the Sam Browne duty belt should come. The weight of the equipment has to be distributed to other parts of the body other than the hips. The studies did generally address the same types of complaints; pain, numbness, bruising, sciatica,

skin irritation, and even an instance of exacerbation of colitis [36] due to having to wear the Sam Browne too tightly to keep it from falling off the officer. The percentage of peace officers suffering from Sam Browne related injuries has only been anecdotally quoted at about eighty-five per cent and this is based on the number of officers seeking chiropractic care (Stone, 2000).

The true nature of Sam Browne duty belt pain is well stated by Karin Richard-Jacobi (2002): Overuse injuries do not happen suddenly or without warning. There are always physical signs that typically move from mild discomfort in the earliest stages of an injury to (sometimes) severe pain in the late stages. Long-term overuse injuries occur when stress is placed on the same part of the body over an extended period of time. Eventually that part of the body just begins to wear out, and you never completely recover from the injury. Peace officers in the State of California are afforded protections under Worker's Compensation Law, which are called presumptions. These presumptions came about due to the lobbying efforts of public safety unions and other law enforcement organisations. The Sam Browne duty belt presumption was signed into law in the year 2001 by Governor Gray Davis. It was amended in 2002 to cover all individuals employed as peace officers Updating Sam Browne regardless of their agency.

2.6.4 Overview

Research data produced by the Montfort study demonstrated that the use of external suspenders to lift the weight of the Sam Browne duty belt up and off of the hips was infact a worthwhile consideration. As previously mentioned some eighty-seven per cent of the Peace Officers who utilised the suspenders reported less pain in the hips, back, and stomach. Suspenders can be utilised in conjunction with the load bearing vest, load is managed in the torso region using a load bearing vest and a suspender type mechanism is employed to control and stabilise load on the duty belt. This way load is being managed ergonomically across different sites of the body and this is advantageous. Police load bearing vests, such as those used in NSW, do attach via series of loops to the duty belt,l essentially providing load carriage support to the duty belt similar in principle to a duty belt suspender.

36 In medicine, colitis (pl. colitides) refers to an inflammation of the colon and is often used to describe an inflammation of the large intestine (colon, caecum and rectum).

2.7 Ergonomic load bearing systems;

Blackhawk Products Group, US Department of Justice 2010

Police duty belts, and the weight and shape of the equipment carried on them, not only cause discomfort and fatigue to the officers wearing them, but over the years of the Officer's career are believed to cause chronic physical problems for some officers, including, it is believed, serious back, leg, hip and nerve ailments.

Due to the conservative nature of the United States of America, police community, and the demand that officers present a traditional and sharp appearance in uniform, the solution to these problems most likely to be accepted by the greatest number of police agencies appears to be a concealable duty belt suspender system which is worn underneath the Officer's uniform shirt. The suspenders are attached with keepers to the duty belt through small openings sewn into the officer's uniform shirt for this purpose.

After considering different conceptual approaches to the load-bearing problem, and creating and analysing prototypes of several of these concepts, Blackhawk[37] developed two versions of a "concealed" duty belt suspender system. Both versions were initially field tested by a small group of experienced Officers (Round I), after which one of the two versions was selected for further testing. This selected prototype version was then field tested by a second group of Officers (Round II). After minor refinements, the prototype was further field tested by a third group of officers (Round III).

In total, the three groups of field testers represented a wide range of individual body types, sizes, ages, degrees of experience, and physical condition. Data and comments were gathered from a total of twenty field testers, comprising twelve males and eight females. The field testers, who were primarily Patrol Officers, used the suspenders on the job for lengths of time generally ranging from a few weeks to over eight months.

With a few notable exceptions discussed below, the majority of the testers found that the suspenders provided significant improvement in the comfort of wearing their duty

37 Blackhawk is a duty gear manufacturer founded in 1993 by former Navy SEAL Mike Noell.

Figure 31. Blackhawk® Velcro Strap Adjustable System

Image above: *A velcro harness- which is adjustable and has a broad range fit for any type of body armor or body type.*

Source; Ergonomic Load Bearing Systems, 2006 <www.ncjrs.gov/pdffiles1/nij/grants/229710.pdf>

belts,and/or relieved the waist, hip and back pain they regularly experienced when wearing their duty belts. Accordingly, with minor refinements in design and materials as indicated by the field testing feedback, it thus appears that concealable duty belt suspenders of the type developed through this program may relieve the discomfort reportedly caused by police duty belts for many officers. The prototype suspender system may also prevent or alleviate the chronic physical problems reportedly caused by the long-term wearing of duty belts, although an appropriate medical study would likely be needed to definitively make this determination.

2.7.1 Overview

Blackhawk have produced a concealed duty belt suspender system which should be considered by police forces as a device to best assist in managing duty equipment load. The fact that the duty belt suspender is concealed does mean that the duty shirt needs to be modified to allow for external connections. Future load bearing vest prototypes should consider the potential advantages of using a concealed duty belt suspender system. There may be advantages in designing a load bearing vest which is used in conjunction with a concealed duty belt suspender as this may allow for a greater range of movement between the torso and waist throughout twisting movements. In other words, when a load bearing vest is connected via a series of loops to the duty belt, this may actually serve to reduce and limit movement rather than promote greater flexibility.

2.8 Battle rattle: The stuff a soldier carries

Halberstadt, Hans. December, 2006

A foot soldier's load currently consists of weapons, armour, rations, digging tools, uniforms. They carry around one-hundred pounds or forty-five kilograms of equipment on their person and have been known to exceed 150 pounds of equipment. The soldier's individual load is part of a fundamental struggle on the battlefield, the conflict between agility and sustainability.

An insurgent for example may only carry a rifle or a rocket launcher, they are incredible agile on the battle field. Contrast this with an American or British war fighter, who carries a minimum of seven magazines (two-hundred and ten rounds), torso armour and helmets, a radio, grenades, one or more knives and a lot of additional kit that weighs forty-sixty pounds (eighteen-twenty-seven kilograms). The soldiers load has always had two parts, one is the fighting load and the other is the approach load. A ll the items needed to keep a warrior out in the field for an extended period. For many years the optimum load for any soldier has been established as thirty percent of their body weight.

2.8.1 The vest system

The advantage of the vest system or an Load Bearing Vest is the PALS/MOLLE[38] straps which permit placement of pouches of different sizes in a modular configuration. The same user can set up a vest differently for different missions. You'd think there would not be too much to differentiate the products from one company to another however soldiers generally have strong opinions about such things and many have strong brand loyalty. Construction details have a lot to do with durability and reliability, two features marines and other warriors consider crucial.

38 MOLLE (pronounced molly, as in the female name) is an acronym for Modular Lightweight Load-carrying Equipment. It is used to define the current generation of load-bearing equipment and rucksacks utilized by the United States armed forces, especially the United States Army, and its use is also growing in the British Army in the form of the Osprey Modular systems. The system's modularity is derived from the use of PALS webbing, rows of heavy-duty nylon stitched onto the vest as to allow for attachment of various MOLLE-compatible pouches and accessories

Figure 32. Modular Lightweight Load-carrying Equipment (MOLLE) system

Image above: *A MOLLE system's modularity is derived from the use of PALS webbing, rows of heavy-duty nylon stitched onto the vest as to allow for attachment of various MOLLE-compatible pouches and accessories.*

Source; Mayflower brand MOLLE system, 2011 <www.tactical73.com/prodotto.lasso?lang=en&idric=377&tableric=articoli>

2.8.2 The RACK

An alternative to an LBV is the RACK adapted for the 75th Ranger Regiment from the chest rig used by Pakistan, Afghanistan, China and other armies employing the AK series of weapons. Since its adoption RACK has become a generic term in the US military for any chest rig. They offer a good supply of a soldier's most important stuff - ammunition in a very accessible location without lots of frills and extra weight. The chest rig places the load a little higher than the same gear on a LBV and makes more use of the centreline portion of the garment since no zipper is required. Variations on the rig are available but all resemble their humble origins. Whatever foundation used the MOLLE (is an acronym for Modular Lightweight Load-carrying Equipment) concept permits the use of specialised containers for everything that each warfighter needs to carry – holsters, pouches for magazines (pistol or rifle), pouches for radios of many shapes and sizes, knives, grenades, crowd control batons, pepper spray, first aid kits and survival kits.

2.8.3 Overview

The military long ago adapted the MOLLE system. This allows military personnel to locate equipment at any location along a horizontal strap in any configuration on their load bearing vest. This has specific advantages for handedness, where a load bearing vest can be configured for left and right hand users. The MOLLE system may also allow for superior ergonomic advantages, where equipment is more accessible depending on a persons reach and better balanced as the user decides where equipment is placed and equipment weights can be balanced at anytime. Police forces may not see this as an advantage however when it comes to considerations around training. Having a set configuration when it comes to training may be slightly easier to manage, training manuals and physical instruction would only need to consider one common equipment layout configuration.

2.9 Future Soldier – Expanded System: Rheinmetall to supply the Bundeswehr with cutting-edge "Gladius" infantry equipment

The German Bundeswehr has placed an order with the Düsseldorf-based Rheinmetall Group to supply it with state-of-the-art infantry equipment. A contract to this effect has now been signed at the Federal Agency for Defence Technology and Procurement (BWB) in Koblenz.

Under the initial order, a total of nine-hundred soldiers (ninety infantry sections or squads) will be outfitted with the new equipment. Specially developed by Rheinmetall on behalf of the Bundeswehr, it is the most advanced system of its kind anywhere. Units due to deploy to Afghanistan in the year 2013 and the year 2014 will be the first to be equipped with Gladius.

This forward-looking system is an important step in the process of providing German infantry troops with significantly improved capabilities in current and future deployments.

Back in the year 2009, Rheinmetall was awarded a contract to develop a pre-series demonstrator version of the Gladius system for the Bundeswehr. It supplemented the basic Future Soldier (IdZ) system which Germany ordered in the year 2005 as an interim response to an urgent operational requirement.

Now ready for fielding, Gladius is intended to expand and improve the capabilities of the existing system, particularly with regard to networking, command and control, and combat effectiveness. Responding to heightened requirements on the part of the Bundeswehr and building on the results of extensive trials and operational experience, Gladius is a far-reaching, highly advanced new development.

A prominent feature of the Gladius system is a holistic design approach that takes full account of the complex operational requirements levied on modern soldier systems. Gladius is intended first and foremost to bring the ten-man infantry section and its vehicle into the network-enabled operational loop. This network, consisting

of reconnaissance, command and control components, and weapons, enables rapid exchange of information as well as shared situational awareness as the basis for planning and conducting operations. The individual soldier receives all relevant data concerning the tactical situation, the position of friendly forces, the mission, and system status. It includes a Global Positioning System (GPS) and an inertial navigation system as well as a magnetic compass, facilitating reliable orientation on the ground.

Equally impressive are the system's ergonomic features, especially with regard to weight reduction, miniaturisation and improved integration of individual components. The modular battle dress uniform, body armour and harness system provide excellent protection from detection in the visual and infrared spectrum as well as from the weather – even in extreme climate zones – and especially from biological and chemical agents. Flame-retardant equipment and vector protection round out the system's high level of protection. The system is integrated into an "electronic backbone" that contains the radio, core computer, batteries and Global Positioning System (GPS) module.

The Gladius system puts Bundeswehr infantry men on the global cutting edge, placing them ahead of their peers in terms of networking capabilities, command and control, and operational command.

2.9.1 Overview

The Gladius system may contain technological advantages which could be transferred across to police load bearing vests. Considerations around incorporating GPS and inertial navigation systems into police load bearing vests may help police monitor officers on the ground during emergency situations. The manufacturer has considered miniaturisation of equipment, this could also prove advantageous when it comes to police load bearing vest design/procurement. It may be that a greater range of police forces with similar or identical duty equipment requirements collaborate with manufacturers in order to develop lighter weight and smaller duty equipment.

Figure 33. Gladius infantry equipment

Source; Rheinmetall infantry equipment, 2012 <http://www.afv-news.com/2012/08/gladius-infantry-equipment-rheinmetall/>

Figure 34. Gladius infantry equipment breakdown of components

Source; Rheinmetall infantry equipment, 2012 <http://www.afv-news.com/2012/08/gladius-infantry-equipment-rheinmetall/>

Chapter 3

Critical analysis of the New South Wales Police load bearing vest (LBV) design and implementation

This section of the research document will discuss factors related to the overall success of load bearing vest design and implementation in the New South Wales Police Force. The first case study presented will be to assess the implementation of the New South Wales Police and other recent Australian Police load bearing vest implementation programmes, since the year 2008.

Since the year 2008, International Police Forces and emergency services began to roll out load bearing vests more frequently. The next part of the critical analysis of Police load bearing vests discusses similarities and differences between the New South Wales Police load bearing vest implementation and international examples thereof.

Military load bearing vests and particularly chest rigs, which are in reality a cut-down load bearing vest, where the height of the garment stops mid-way down the anterior torso, will be compared to General Duty Police load bearing vests. Military load bearing vests were first introduced in the 1970's by the United States Marine Corp, for use in the Vietnam War. This particular load bearing vest as used by Marines, can really be considered as the early pioneer in this garment category, aimed at addressing human load carriage issues. Finally some of the more specific Police load bearing vest design constraints and wear-ability issues directly relating to human comfort and wellness will be discussed. Again it is important to remember that the research methodology used in this section is formed around secondary research rather than primary research. The masters thesis uses secondary research as the precursor to a more comprehensive design analysis which could be further explored if

the product is to be developed as a working prototype. The intention is that primary research and extensive user trials of a future Police Force load bearing vests would need to be undertaken as part of a future product design development initiative.

3.1 New South Wales Police load bearing vest (LBV) design analysis

Before the New South Wales Police introduced the load bearing vest to General Duty officers in the year 2011, Police previously used a duty belt to carry all their required duty equipment. Whilst equipment weights are indeed important if one was to understand the impact of load carriage on officers, then a comprehensive analysis of individual equipment weights needed to be undertaken. This is central to the research, as spreading the equipment load to different parts of the body, such as by means of a drop leg pistol holster, may improve the overall load carriage efficiency of a load bearing vest. Balancing the equipment load across the upper body or torso is equally important, as is understanding how equipment loads may impact on a Police officers stability when running or when lunging and jumping when involved in a foot chase. Such studies that may serve to understand the dynamics of load bearing vest wear-ability have at present not been undertaken, this is something that will be of most value in the future to emergency services departments looking to implement load bearing vests, this is because this load when carried upon the human is not carried statically.

Certainly when Police Officers equipped with a load bearing vest operate in a dynamic environment, that is an environment where users must undertake a variety of dynamic movement oriented tasks, such as entering and exiting patrol cars, restraining individuals, entering into physical contact and even sitting at an office desk, they are exposed to complex biomechanical demands. On Page 94, actual equipment weights relating to standard duty equipment issued to New South Wales General Duty Police officers, in the year 2010 are listed out. The equipment, or appointments[37] as

37 Appointments; Another term used by New South Wales Police to describe General Duty equipment such as hand cuffs for example.

New South Wales Police refer to them as, vary greatly in weight range and importantly in the frequency they are needed by Police officers. For example the two-way radio may be one of the most used pieces of equipment in terms of frequency of use, down to the other end of the scale, where officers would hope they never need to use their appointment known as the Glock 22, or the pistol Police officers carry. In terms of equipment spread, the load bearing vest as introduced by the New South Wales Police in the year 2011, has a varying range of appointments spread over the torso area. The pistol has remained on the duty belt, there are superior ergonomic solutions to carrying the pistol on the duty belt, such as by using a ergonomic drop leg pistol holster, as reviewed in the previous chapter. The New South Wales Police unlike their Victorian Police counterparts have not adopted the ergonomic drop leg pistol holster, some experts in the field believe that the ergonomic drop leg pistol holster can result in awkward and delayed pistol draw times. The fact that the ergonomic drop leg pistol holster sits more forward on the thigh, can mean that when an Officer is faced with a situation where they are crawling face down it is more difficult to access their pistol. Also because the hand needs to travel slightly further past the duty belt to access the pistol, this may mean a slight delay in draw time.

The conceptual sketch on Page 84, details the load bearing vest duty equipment configuration as at design brief stage in the year 2009. The New South Wales Police tender documentation[38] specifies the desirable design and manufacturing criteria in its entirety as below;

- Capacity and capability to provide products (including delivery considerations, availability of stock and accessibility of product range).
- Industry experience, production, technical and organisational capacity, warranty and quality assurance systems to service the contract.
- Specifications and quality of samples: durability, wearability and accessibility to appointments.
- Pricing considerations and value for money
- Industry (or SME)[39] participation plans.

38 New South Wales Police Force 2010, *17082009 - Supply of Load Bearing Vests (LBV),* NSWPF, Sydney.
39 SME; Small to Medium Enterprise

Additionally the load bearing vest general requirements in the New South Wales Police Force tender documentation states that;

> The load bearing vest shall allow New South Wales General Duty Police Officers to be able to sit comfortably in a car, walk a patrol or be involved in a foot chase and allowing reasonable freedom of movement.[40]

40 New South Wales Police Force 2010, *17082009 - Supply of Load Bearing Vests (LBV),* NSWPF, Sydney.

Figure 35. New South Wales General Duty Police officers duty equipment load weights, circa 2010, total weight 12 kilograms

Source; Police Journal, South Australia, 2006 < http://www.policejournalsa.org.au/0401/12a.html >

Figure 36. New South Wales General Duty Police officers duty equipment load weights, circa 2012, total weight 12 kilograms

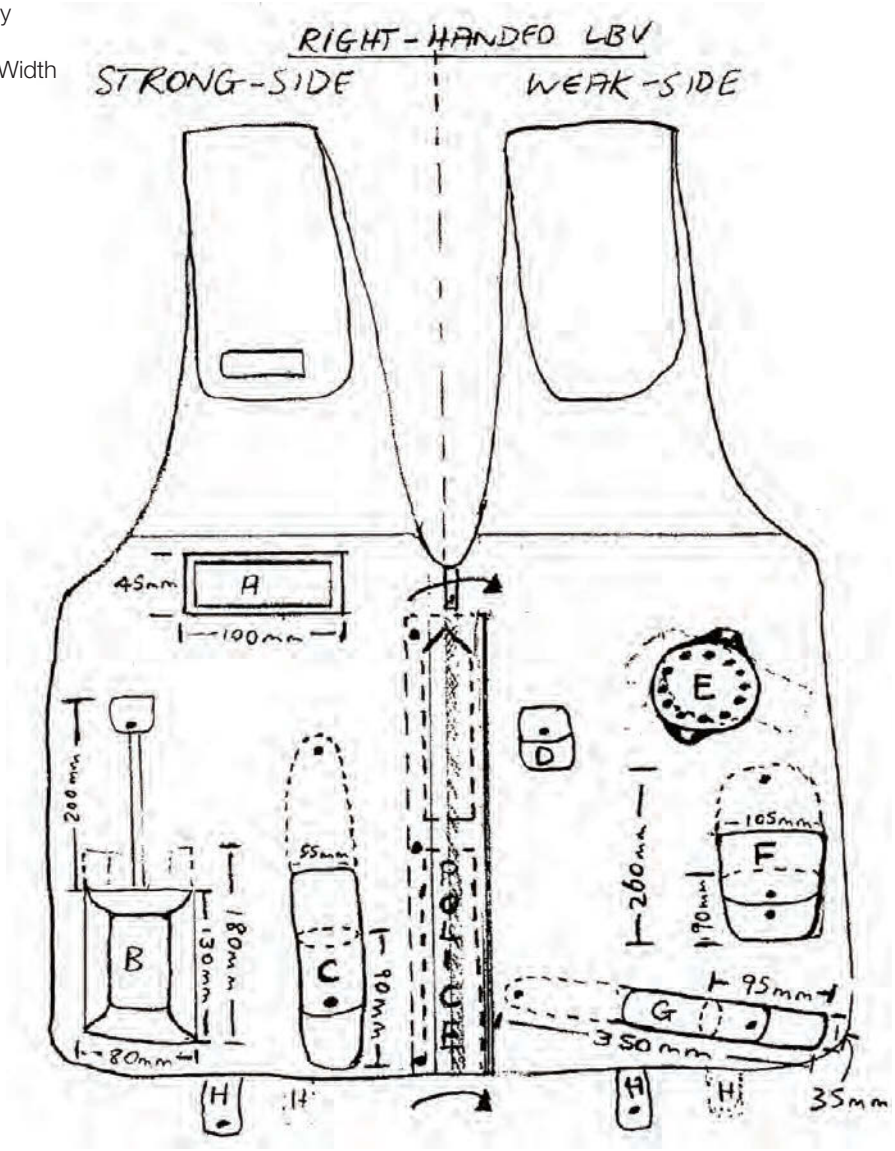
Source; AAP Newswire, 2010 < http://multimedia.aapnewswire.com.au/SearchPreview.aspx?url=20100624000242743357 >

Figure 37. New South Wales General Duty Police load bearing vest images

Source; AAP Newswire, 2010 < http://multimedia.aapnewswire.com.au/SearchPreview.aspx?url=20100624000242743357 >

Key:

A Name Badge 45 mm (H) x 100mm (L)
B Radio Carrier Width
C O/C Spray
D Taser Cartridge Pouch
E Taser Base Plate To fit 'Blackhawk – Serpa Holster & angle away from body
F Handcuffs
G Extendable Baton Width
H LBV Keepers



Actual design brief notes from NSW police.

This example drawing indicates a right handed vest.

The Taser Holster as shown is indicative only of where a Mounting Plate to attach such a carrier, could prospectively be positioned.

The Taser cartridge is to be placed on the opposite or away from the radio.

Figure 38. Supply of Load Bearing Vests (LBV) for the NSW Police Force industry brief document Ref: 17082009RFT

Source; New South Wales Police Force, 2009 < https://tenders.nsw.gov.au/?event=public.rft.showArchived&RFTUUID=793A25BD-AE25-48E8-D7D40D3939E28181

3.1.1 Incorporating ballistic protection into load bearing vests; Strategic design considerations

It is also important to note that the New South Wales Police Force tender document for supply of load bearing vests does not call for the inclusion of any type of body armour including covert or overt vests and ballistic strike plates. Dissecting this last point is of major importance, because the reality is that a New South Wales General Duty Police officer is left without ballistic protection, and in the event that they require ballistic protection, they must remove the load bearing vest. In the year 2009, the New South Wales Police Force also upgraded all ballistic vests that are typically stored in the boot[41] of a Police vehicle and accessed when the situation required it to be used. It is still unclear as to whether or not a ballistic vest could be worn underneath a load bearing vest when considering the bulkiness of both items this may be a limiting factor to the wear-ability of both vests being worn in tandem. The time involved for Police officers to remove a load bearing vest and then put on a ballistic vest and then replacing the load bearing vest could become critical, dependant upon a given situational threat. Whether or not a ballistic vest could be placed over a load bearing vest is unclear, possibly not though, as a ballistic vest should be sitting on the torso snugly fit to the body, if not a projectile could enter the vest at an angle and the vests ability to provide optimum ballistic projection could be compromised.

3.1.2 User comfort and wellness; Thermal management analysis

The New South Wales Police Force tender documentation for the supply of load bearing vests or the design brief itself, does not comprehensively consider user comfort and wellness relating to thermal management. This is a critical design aspect to consider in garment design, particularly if the garment is going to be deployed to wearers operating in hot climatic conditions. Such extreme hot climatic conditions may be experienced in the Summer months in New South Wales, where temperatures for example even in Autumn of the year 2012 have previously reached 38.2° Celsius (100.76° Fahrenheit) in Tibooburra, New South Wales.[42] In Summer, locations in

41 Boot; Another term for the trunk of a motor vehicle.

42 Bureau of Meteorology 2012, Seasonal Climate Summary for New South Wales, Australia, September 2012, Product code IDCKGC15R0, Canberra, viewed 21 September 2012, <http://www.bom.gov.au/climate/current/season/nsw/summary.shtml>

Australia such as Marble Bar in Western Australia, have recorded a mean maximum temperature of 44.9° Celsius in February (112.82° Fahrenheit).[43] User comfort and wellness related to factors such as temperature, humidity and the movement of air are design decisions that need to be fully considered and evaluated at design brief level. Appropriate advanced textiles that enhance climate control performance in conjunction with clothing layering also need to be considered at design brief level.

The tender documentation states with regards to load bearing vest specifications;

- Vest Material; Fire Retardant
- Vest Material; Heat Management (no further detail given, this may have been discussed verbally at the industry presentation)
- Construction (no further detail given)
- Sample Sizing; Quantity one small (S); and two extra large (XL).
- Name Plate & Markings
- Weight Distribution & Vest Retention Systems (no further detail given, this may have been discussed verbally at the industry presentation)

Functional clothing can be purposefully designed to support the body's thermal regulation system. When temperatures are warmer or during physical activity, perspiration should be drawn away from the body quickly and released into the environment, in order to support cooling of the body. A fundamental distinction is made between the thermo-physiological aspects of clothing, i.e. the management of warmth and moisture, and how the textile feels on the skin (skin sensibility). In the case of a Police load bearing vest, the base layer used by Police is quiet often a short sleeve garment, constructed from one hundred percent cotton textile.

It is important to realise that the base layer, in the garment layering system, is the layer which controls management of warmth and moisture wicking, because of the fact that the skin emits heat and moisture. When thermal management textiles such as an open weave meshes (the same material used predominantly to fabricate the New

43 Bureau of Meteorology 2012, Seasonal Climate Summary for New South Wales, Australia, September 2012, Product code IDCKGC15R0, Canberra, viewed 21 September 2012, <http://www.bom.gov.au/climate/current/season/nsw/summary.shtml>

Centre Line;
Load should ideally, be spread evenly across the torso front on either side of the centre line, so that a human can maintain optimum balance.

1. Galea Aponeurotica
2. Epicranius
3. Orbicularis Oculi
4. Nasalis
5. Levator Labii Superioris
6. Zygomaticus major & minor
7. Orbicularis Oris
8. Risorius
9. Depressor Anguli Oris
10. Depressor Labii Inferioris
11. Mentalis
12. Omohyoid
13. Sternohyoid
14. Sternal Head of Sternocleidomastoid
15. Scalene
16. Trapezius
17. Deltoid
18. Pectoralis Major
19. Serratus Anterior
20. Rectus Abdominis
21. External Abdominal Oblique
22. Biceps Brachii
23. Brachialis
24. Pronator Teres
25. Brachioradialis
26. Flexor Carpi Radialis
27. Extensor Carpi Radialis
28. Tensor Fasciae Latae
29. Iliopsoas
30. Pectineus
31. Sartorius
32. Adductor Longus
33. Gracilis
34. Rectus Femoris
35. Vastus Intermedius
36. Vastus Lateralis
37. Vastus Medialis
38. Gastrocnemius
39. Peroneus Longus
40. Tibialis Anterior
41. Soleus
42. Peroneus Brevis
43. Extensor Digitorum Longus

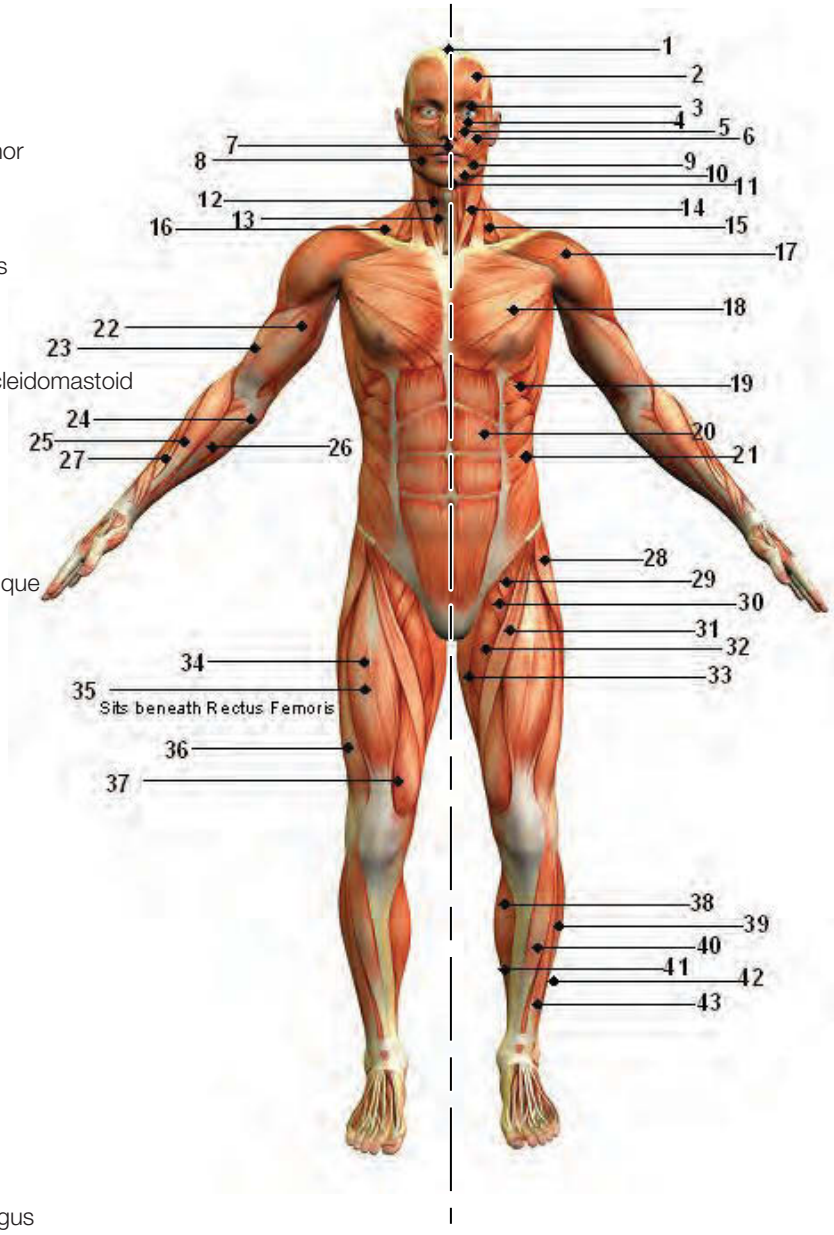


Figure 39. Muscular System Picture Anterior (Front) View and load centralisation about a centre line.

Source; Sports Fitness Advisor, 2012 < http://www.sport-fitness-advisor.com/muscular-system-picture.html >

South Wales Police load bearing vest) are used in conjunction with a textile base layer with poor thermal management properties, the ability to control the thermal climate may be greatly reduced. It is common place for textiles such as wool to be used in military and even Police clothing to provide superior thermal management to the wearer. The General Duty Police in San Francisco, USA, for example currently use a merino wool duty shirt and duty trousers, which provides adequate heat insulation to keep out the cold when temperatures are cool and when temperatures are warmer or during physical activity, merino provides thermal management. Specific parameters such as, thermal insulation and moisture transport resistance are measures for breathability, perspiration transport and sweat buffering, and drying time, need to be included in the design brief document. These parameters characterise the thermo-physiological quality of textile materials. The New South Wales Police seem to have omitted this valuable information relating to garment design parameters from their tender documentation.

3.1.3 Wear-ability considerations in garment design

The New South Wales Police Force tender documentation states that;

> The wearing of the load bearing vest will be at the discretion of each individual Officer. If an officer decides to wear a load bearing vest it will be procured and issued as an individual tracked item.[44]

The fact that a New South Wales Police officer is given the option to wear a load bearing vest or revert when they wish to, back to wearing only a duty belt could possibly influence factors such as the time it takes to locate and draw a weapon and could bring about mishaps in the field where the wrong appointment is chosen incorrectly when needed. In the year 2009 Sergeant Sheree Bissett, a General Duty New South Wales Police Officer attended a dispute in Auburn New South Wales, during this dispute Sergeant Bisset drew her pistol and fatally shot the suspect Adam Salter. A Coronial inquest found that Sergeant Bisset had mistakenly drawn her pistol rather than her taser resulting in a terrible mistake that killed the suspect, Adam Salter. As Police often operate under extreme stress when encountering such situations,

44 New South Wales Police Force 2010, *17082009 - Supply of Load Bearing Vests (LBV),* NSWPF, Sydney.

Figure 40. Victorian General Duty Police Officer wearing a load bearing vest which incorporates ballistic protection into the vest design.

Source; Victoria Police, 2012 < http://www.legear.com.au/FLS-Load-Bearing-General-Duties-Hi-Viz-Yellow-Vest-p/fls-fld500yl.htm >

could the fact that an Officer has a completely different uniform/weapon configuration possibly affect a Police Officers ability to choose the correct appointment?[45]

Following on from garment choice options that are given to Police Officers, the reasons why a Police Officer may wish to revert back to their duty belt rather than continue wearing an load bearing vest is an important question to consider, this type of question may very well be related to wear-ability considerations. Furthermore, is a load bearing vest a hindrance rather than an aid to reduce potential injuries to Police Officers in periods of extreme hot weather conditions? Is there a propensity to elevate the thermal burden that officers may experience in hot climatic conditions that may lead to increased dehydration? It may be that future load bearing vest models employ superior thermal management through the use of advanced textiles and garment construction. It may also be that future load bearing vest models incorporate a hydration bladder, similar to those used by the New South Wales Bicycle Squad and similar to what military forces use, as an effective means of hydration support.

There are also some issues which occur when garments are constructed solely from soft textiles, such as open weave meshes and Cordura®. Soft textiles when used as a garment pocket do have a tendency to collapse once an appointment is removed from them, making it more difficult when faced with a physical situation with an offender for an officer to return an appointment to a pocket single handedly. There are also some issues around the interaction between high visibility rain wear that is issued to New South Wales Police when used in conjunction with either their load bearing vest or even their duty belt. The issues are related to appointment accessibility, once a full length high visibility rain coat is worn by a Police Officer, only their pistol can be readily accessed as it sits on the outside of the rain coat. Other electronic devices such as the Motorola radio and mobile phone are shielded from rain and placed underneath the rain wear. There may in this case, be an option to develop a future load bearing vest that could be placed over rain wear, and employ waterproof pockets to protect electronic devices. Possibly having appointments readily available may ensure that officers can respond to a threat in a reduced time frame and not

45 Bibby, P, 'Police response an utter failure: coroner', Sydney Morning Herald, 14 October, viewed 28 February 2012, <http://m2.smh.com.au/nsw/Police-response-an-utter-failure-coroner-finds-20111014 1lo17.html>.

have to deal with processes around opening and closing their rain wear.
The image on the Page 107, demonstrates an example of a Victorian Police officer wearing a load bearing vest over a chemical safety wear garment. In a similar way it may be possible to consider wearing a load bearing vest, with waterproof pockets for hardware, over the top of a full length rain coat.

3.1.4 The physiological and biomechanical aspects of load carriage

Load centralisation is where the load carried is located as best it can be, evenly around the centre line of the human anterior view. When a Police officer needs to move dynamically, for example when it's necessary to run or even when they enter and exit a patrol car, the load should be balanced as evenly as possible on the left and right side of the anterior torso. This ensures that the muscular system is working evenly and the human can maintain good posture, balance and maintain load control. The previous page demonstrates the muscular systems anterior view and the centre line of the human body. Appointment weights were not listed out in the New South Wales Police supply of load bearing vests, tender documentation and this may have made it difficult for manufacturers to achieve a best practice load carriage solution.

There is no modularity in the New South Wales Police load bearing vest appointment configuration to make allowance for when appointments become superseded or when new equipment is procured and introduced in the future. This is why the military essentially use a MOLLE[46] (Modular Lightweight Load-carrying Equipment) load bearing vest system, refer to the image on Page, 108. The MOLLE system essentially allows for modifications to the equipment configuration and re-configuration of the equipment load when necessary. Modularity does perhaps bring about new issues around training and when a load bearing vest is configurable as experienced with the MOLLE system, the users likes or dislikes may mean that training would have to be specific to the individual, so the cost of training may greatly increase. At present the New South Wales Police provide a training session for all members to familiarise themselves with the load bearing vest when it is first issued to them and the training is

46 MOLLE (pronounced molly, as in the female name) is an acronym for Modular Lightweight Load-carrying Equipment. It is used to define the current generation of load-bearing equipment and rucksacks utilised by the United States armed forces, especially the United States Army, and its use is also growing in the British Army in the form of the Osprey Modular systems.

Figure 41. Victoria Police, Preparing for the worst: Exercise Hades

Image above: *The image demonstrates the fact that police are already wearing a load bearing vest over chemical protective wear, that could easily be a similar garment such as rain wear.*

Source; Victoria Police, 2012 < http://www.google.com.auimgres?um=1&hl=en&safe=images&sa=X&biw=1728&bi-h=1302&tbs=isz:l&tbm=isch&tbnid=cH81cZFX3jELaM:&imgrefurl= >

Equipment can be configured and re-configured anywhere on the LBV using PALS (Pouch Attachment Ladder Systems).

Figure 42. Modular Lightweight Load-carrying Equipment MOLLE) example

Source; Airsoft Forum, 2011 < http://www.airsoftforum.com/board/lofiversion/index.php/t225860.html&docid=uRUcCs-88Jl9PrM&imgurl= >

the same across the board because the load bearing vest is configured to one layout only.
Additionally, the ability to have a modular load configuration may also address ballistic protection possibilities. As is the case with the Victorian Police load bearing vest, could there be an option to incorporate ballistic strike plates in the New South Wales Police load bearing vest? A ballistic plate could possibly be inserted into a custom pocket in the interior of a load bearing vest. Officers could quickly retrieve a ballistic strike plate from a vehicle for example and place this inside their load bearing vest when faced with a firearm or related threat, whilst still being able to access all of their appointments on their load bearing vest.

Energy cost and reducing the load burden to improve officer efficiency is an important factor when analysing physiological and biomechanical aspects of load carriage. When a Police officer is fatigued through carrying excessive load their physiological health may be decreased which may in turn affect their decision making ability. Police officers at times need to make split second decisions and their alertness and physical health is paramount in these situations. Gender differences and physiological factors such as body stature and body mass are generally associated with load carriage. Military load carriage research related to gender differences and physiological factors such as body stature and body mass have proven this link. In other words, a Police officer of smaller stature and lower body mass is more than likely to be more affected by load carriage related injury.

3.1.5 The biomechanics of the human spine: Loads on the spine

During load carriage, a human experiences many different forces loads that act upon the spine. Such loads include body weight, tension in the spinal ligaments, tension in the surrounding muscles, intra-abdominal[47] pressure and any applied external loads such as a fully laden load bearing vest. The major form of loading on the spine when a human is standing is axial[48] loading, this type of loading contributes to spinal compression. When a human is standing, the total body centre of gravity is anterior

47 Intra-abdominal pressure (IAP) is the pressure concealed within the abdominal cavity.
48 In physics, axial bearing, or axial loading, refers to the longitudinal force exerted perpendicularly along the line of an axis.

to the spinal column, this places the spine under a constant forward bending moment as seen in Figure 4, on Page, 110. To maintain body position, the forward being torque must be counteracted by the back extensor muscles.[49]

The spinal muscles have very small moment arms related to the vertebral joints and they must generate large forces in order to counteract torques produced about the spine by the weights of body segments and external loads. The major force experienced by the spine is usually that derived by muscle activity. Compression on the lumbar spine actually increases when sitting and increases even more when sitting in a poor postural position such as when a human slouches. Ergonomically designed chairs that provide lumbar support enable that more weight is supported by the thighs and this has been shown to reduce load on the spine.

> Pressure within the inter-vertebral discs changes significantly with body position and loading, but is relatively consistent through the different regions of the spine. During static loading, the discs deform over time, transferring more of the load to the facet joints. After thirty minutes of dynamic spinal flexion, such as might occur with a lifting task, the general stiffness of the spine is decreased, and deformation of the discs in combination with the elongation of the spinal ligaments results in altered loading patterns that may predispose the individual to low back pain.[50]

Also during standing body weight also loads the spine in shear, particularly for the lumbar spine. Shear is the main force on the spine during flexion and during activities which require a human to backward lean on the trunk. Excessive shear stress is understood to contribute to disc herniation. During repeated trunk flexion and extension movements over time, the flexion relaxation period is lengthened, which reduces lumbar stability and may predispose the individual to low back pain.[50]

Another factor which affects spinal loading is body movements speed. Previous studies have demonstrated that when lifting in a rapid or jerking fashion, compression and shear forces are dramatically increased. This is one of the reasons why when

49 The extensor muscles are attached to the posterior (back) of the spine and enable standing and lifting objects. These muscles include the large paired muscles in the lower back (erector spinae), which help hold up the spine, and gluteal muscles.

50 Hall, S. 2012, Basic biomechanics, 6th edn, McGraw Hill, New York.

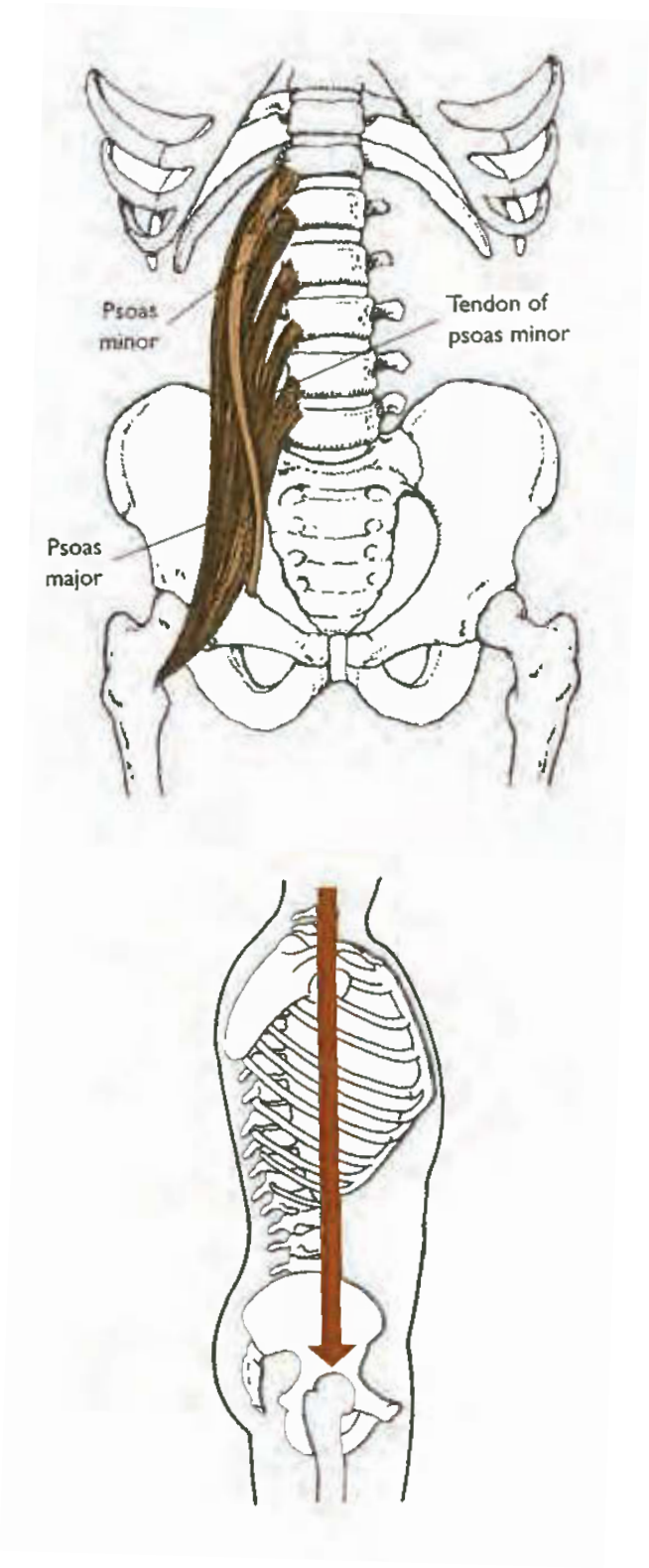


Figure 43. Anatomical images and the direction of torque on the spine

Source; Basic Biomechanics Sixth Edition, 2012

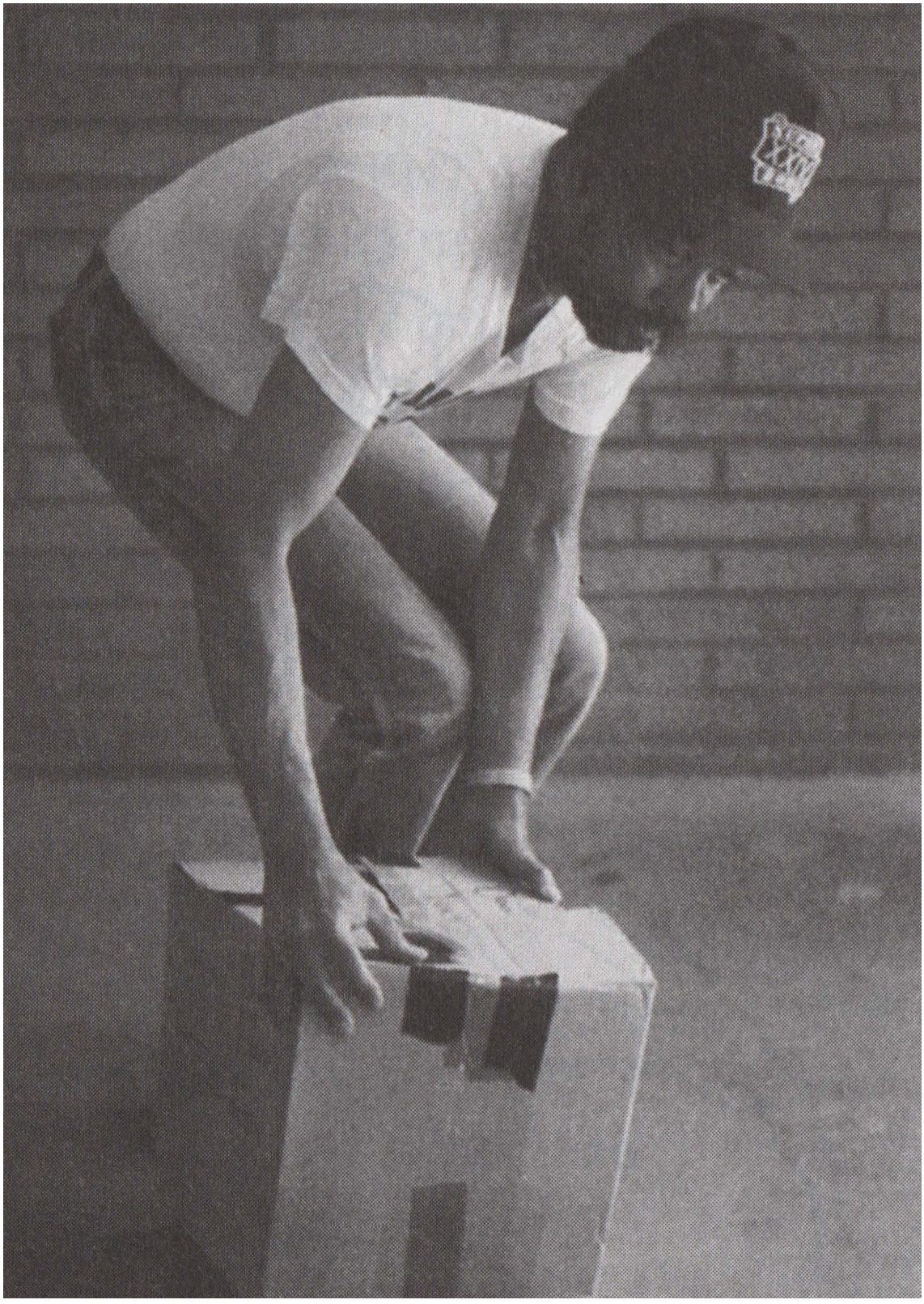
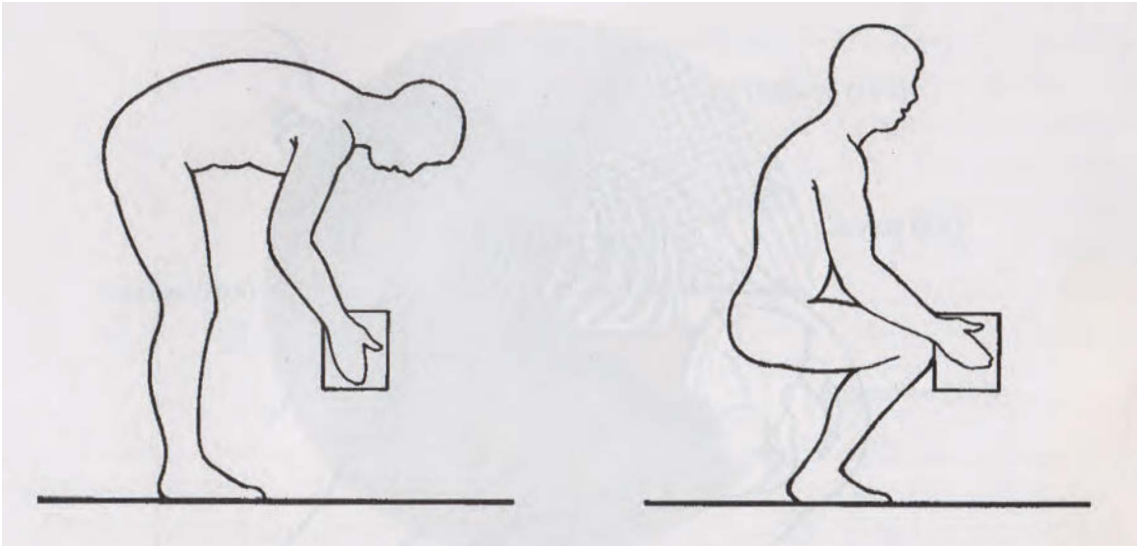


Figure 44. Lifting while twisting: to be avoided

Source; Basic Biomechanics Sixth Edition, 2012



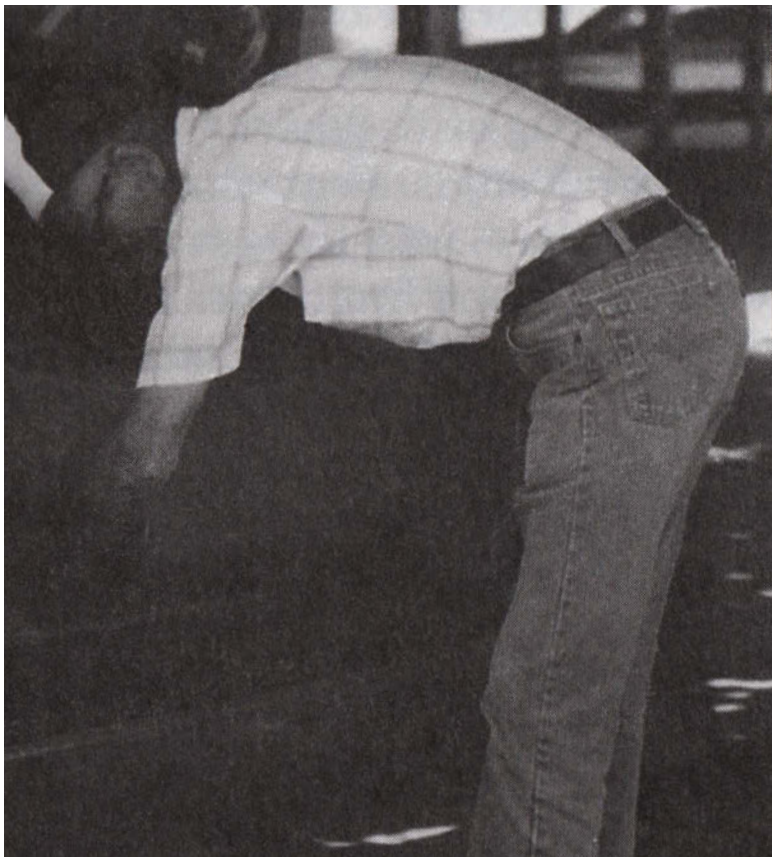
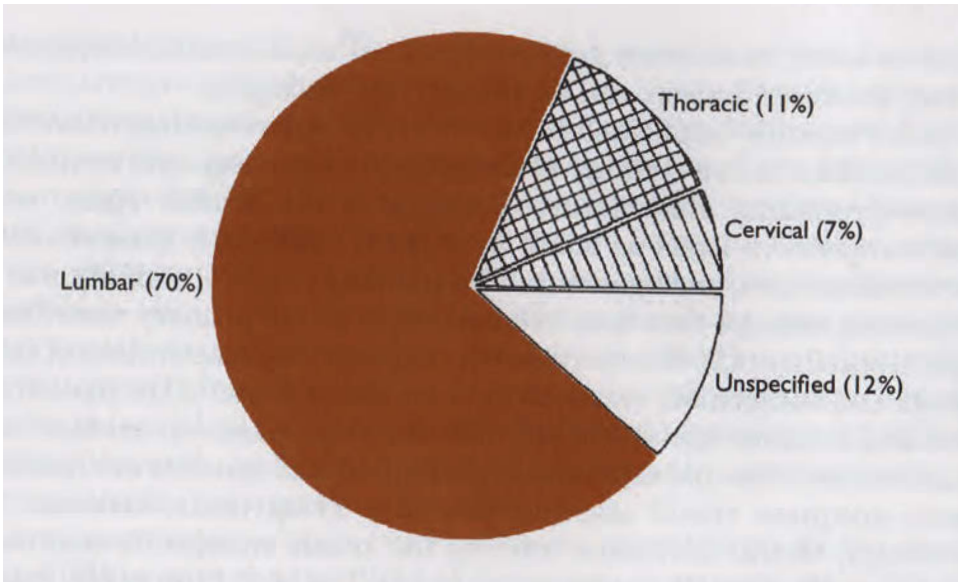


Figure 45. Maintenance of lumbar curvature in lifting

Image above: *It is important to maintain normal lumbar curvature rather than allowing the lumbar spine to flex when lifting, as discussed in the text. The image below is related to the fact that many daily activities on the low back are stressful. The constraints of the automobile make it difficult to lift with the spine erect.*

Source; Basic Biomechanics Sixth Edition, 2012



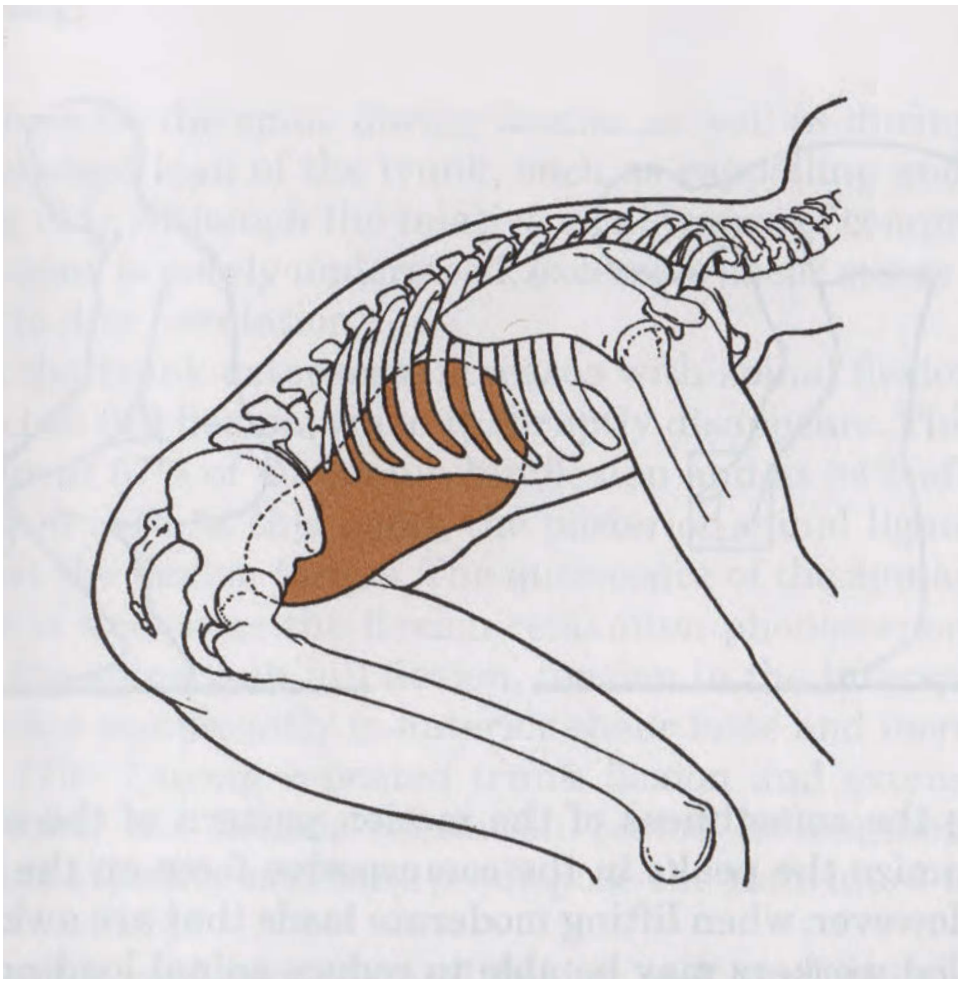


Figure 46. Significance of lifting injuries and intraabdominal pressure in lifting

Image above: *The chart demonstrates that the majority of injuries that result in lost work time involve the lumbar region*
Image below: *Intraabdominal pressure, which often increases during lifting, contributes to the stiffness of the lumbar spine to help prevent buckling.*

Source; Basic Biomechanics Sixth Edition, 2012

undertaking resistance training exercises, a gym user should be cautious to perform theses exercises slowly and in a controlled manner.

> The old adage lift with the legs and not the back refers to the advisability of minimising trunk flexion and therefore minimising the torque generated on the spine by body weight. However, either the physical constraints of the lifting task (such as when a Police Officer exits a patrol car) or the added physiological cost of leg-lifting as compared to back-lifting often make this advice impractical. Research suggests that a more important focus of attention for people performing lifts may be by maintaining the normal lumbar curve, rather than either increasing lumbar lordosis or allowing the lumbar spine to flex.[51]

(Hall, 2012), goes on to discuss loads on the spine such as when using a load carriage device such as a backpack;

> Carrying a loaded book bag or backpack loads the spine, with the heavier loads resulting in postural adjustments including forward trunk and head lean and reduced lumbar lordosis. Research shows that placing the load low within the back pack and limiting the load to no more than fifteen per cent body weight minimises these postural adaptations.[51]

According to Australian Bureau of Statistics[52] data, in the year 2007 - 2008 the average body mass of an Australian male was approximately eighty-five kilograms and the average body mass of an Australian female was approximately seventy kilograms. Based on the quote above, the maximum load for an average Australian man should be approximately twelve kilograms and for the average Australian women approximately ten kilograms. Currently in the year 2012 a female Australian Police Officer may carry a duty equipment load of approximately twelve kilograms. It is interesting to note then that a Police Officer of smaller stature and body mass of for example sixty kilograms, should carry a maximum load weight of nine kilograms.

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51 Hall, S. 2012, Basic biomechanics, 6th edn, McGraw Hill, New York.

52 Australian Bureau of Statistics 2011, *Measuring Australians*, July 2012, cat. no. 4841.0, ABS, Canberra, viewed 6 August, 2012, <http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/4841.0Chapter22011>.

3.1.6 The biomechanics of the human spine: Common injuries of the back

Low back pain is an extremely common problem according to (Hall, 2012);

> Up to eighty-five per cent of people experience low back pain at some time during their lives and more than half the population having had back pain . . . Low back pain is second only to the common cold in causing absences from the work place, and back injuries are the most frequent and most expensive of all workers' compensation claims in the United States.[53]

The reality is that psychological and social components do play a role in some low back pain cases, mechanical stress (caused by load carriage and lifting) plays a much larger role in the development of low back pain.

> In the United States, perhaps because of their pre-dominance in occupations involving the handling of heavy material, men experience low back pain about four times more frequently than do women. However, some female-dominated groups, such as nurses' aides, registered higher rates of low back injury than do male workers in general.[53]

Finally, it is interesting to note the following comments made by (Hall, 2012) below in relation to occupational injuries related to low back pain;

> High incidences of low back pain have been found in workers who sit for prolonged periods and in those unable to sit at all during the work day. High-risk occupations for the development of low back pain, in order of frequency, include labourers, truck drivers, garbage collectors, warehouse workers, mechanics, nursing aides, materials handlers, timber workers, practical nurses and construction labourers.[53]

53 Hall, S. 2012, Basic biomechanics, 6th edn, McGraw Hill, New York.

In terms of soft tissue injuries to the back, contusions, muscle strains and ligament strains compose the most common injury of the back. In fact ninety-seven per cent of all back pain in the general population, can be related to soft tissue injuries. Soft tissue injuries typically occur because of overloading of the muscles, particularly those of the lumbar region.

3.1.7 Future procurement considerations

It may become a solution well worth exploring in the future, to consider that load carriage can be distributed amongst a group of Police officers, or even in partnership. What may actually decrease load carriage related injuries in Police Officers, may be to take a shared approach to load carriage. For example a Police Officer of smaller stature and with a relatively low body mass may partner with an Officer of larger stature and with a higher body mass whilst on duty and distribute a total equipment load according to these physiological factors - the officer of smaller stature may only carry say four kilograms of equipment, whilst his or her partner who is of larger stature might carry a greater load of say ten kilograms. This strategy is being applied to military platoons, as suggested earlier in this research document, where not every soldier within a platoon is equipped with the same operational kit, there may be a variety of tiers within a platoon such as, specialists, close combatants and general combatants, this tiered system is aimed at optimising and reducing the load each soldier carriers as well of course as maximising the spend per dismounted soldier.

There are many new and existing technologies being developed around digital hardware. It is important that there is a strong future alignment between procurement of these hardware technologies that may offer reduced weight options and the release to General Duty New South Wales Police Officers. For example there are Police communication radios that can be used both as a communications radio and a mobile phone, this eliminates the need for two devices, thus generating a weight reduction outcome.

3.1.8 New South Wales Police Annual Report 2011

The New South Wales Police Annual Report in the year 2011, detailed somewhat, the amount and types of injuries sustained to Police Officer during this year. The injuries were broken into two groups; significant and non-significant injuries. The table below, Figure 8, provides injury data for New South Wales Police in the year 2011, there is no break-up of injuries relating to load carriage and it is interesting to note that the comment is made below the table;

> We began rolling out load bearing vests to police in the field to minimise lower back strain.[54]

There is no data provided to suggest however the extend to lower back strain injuries, nor is there any such data provided to support the comment made previously that load bearing vests do minimise lower back strain.

NSW Police workers compensation claims in 2011

INJURY CLAIM TYPE	2005-06	2006-07	2007-08	2008-09	2009-10	DIFFERENCE	PERCENTAGE
Significant injury	1,890	1,598	1,686	1,976	2,162	186	9.41%
Non-significant injury	1,072	1,033	1,156	1,226	1,095	-131	-10.68%
TOTAL CLAIMS	2,962	2,631	2,842	3,202	3,257	55	1.72%

Note: A significant injury is a workplace injury that is likely to result in the worker being incapacitated for more than seven continuous calendar days.

We achieved some significant health and safety milestones this year

- We implemented a new online incident and accident investigation system and a complementary safety risk management framework
- We implemented a new fatigue management framework in collaboration with the NSW Police Association and the University of South Australia
- We commenced off duty (recall to duty) targeted drug testing of police officers
- **We began rolling out new load bearing vest to police in the field to minimise lower back strain**
- We implemented injury management and return to work key performance indicators, with revised policies and supporting documents.

Figure 47. New South Wales Police workers compensation claims in 2011

Source; New South Wales Police Annual Report, 2011

The workers compensation insurance policy covers work place related injuries for all un-sworn staff and all sworn officers recruited after 1 April 1988. For the year 2009-2010, the workers compensation premium increased by twenty-five per cent. This was due to increases in wages and claims costs.

54 New South Wales Police Force 2011, *Annual Report 2011*, NSWPF, Sydney.

3.1 International Police load bearing vests; A general design analysis

At the same time that the New South Wales Police have implemented load bearing vests, many other international countries have been undertaking similar implementation programs.

The British Metropolitan General Duty Police have a slightly different approach to load bearing vests than that of Australia, wish will be discussed shortly. The United States have begun to also introduce load bearing vests to General Duty Police Officers, this is recognition in part that the reality is that Police Officers have to deal with an increasing load burden associated with the introduction of new equipment. German General Duty Police Officers also wear a load bearing vest that has ballistic protection and allows for a small amount of duty gear to be carried on the vest also. Two separate International Police load bearing vest design analyses will be discussed in the following section.

3.2.1 British General Duty Police load bearing vests

I will now start to introduce some examples of load bearing vests that have been introduced in Britain. London Metropolitan General Duty Police wear as standard issue, a stab proof vest. The stab proof vest also doubles as a load bearing vest where there are a number of items that are located on the vest. This approach is markedly different to most Police forces around the world for the simply fact that the metropolitan Police do not carry firearms and so the perceived threat is to be around knifes, hence the reason why they wear a stab proof vest. Outside London many General Duty Police in the counties typically purchase load bearing vests at their cost. There are several online forums which discuss load bearing vests for use in conjunction with General Duty Police.

In Britain there is an online forum which discussed best practice purchase decisions relating to commercially available generic load bearing vests. The Arktis® load bearing vest is discussed and many officers opt to purchase an Arktis® load bearing

vest. The Arktis® high visibility load bearing vest is issued to British Transport Police and is shown on the following pages. This load bearing vest was actually trialled by the New South Wales Police, but the Arktis® brand was not purchased, an Australian, Victorian based supplier was awarded the contract to supply load bearing vests to New South Wales General Duty Police. The Arktis® load bearing vest is very similar to the New South Wales Police load bearing vest in that they employ very similar textiles and the construction of the load bearing vest is very similar. The method of fitting to the body via straps and buckles positioned close to the ribs is almost identical also. New South Wales Police do not use a high visibility version such as the British Transport Police, however the Police Western Australia are currently issued with both a dark blue and a high visibility load bearing vest, which they swap all appointments to when a particular duty requires them to do so. Included on the following pages are some examples of British General Duty Police load bearing vests, refer to Figure 48 & Figure 49, on Pages 121-122.

3.2.2 United States General Duty Police load bearing vests

Police departments in the United States have been slowly adopting the load bearing vest as a means to carry duty equipment. Included on the following pages are some examples US General Duty Police load bearing vests.

The first example is of a load bearing vest introduced by Sanger Police in the year 2009,[55] refer to Figure 50, on Page 123. The Sanger Police Department is located approximately two-hundred kilometres from San Francisco, California. The Sanger Police Department claim they introduced the load bearing vest in order to reduce injuries to Police Officers. The Sanger Police also claim that General Duty Police Officers carry approximately eleven kilograms of duty equipment, a very similar weight range of duty equipment to that of New South Wales Police. Finally the Sanger Police make an interesting claim around thermal burden characteristics and aesthetics of the load bearing vest;

> The vests are also easy to take off, which allows the officer to cool himself down faster in the summer months. The vest lets the officer keep a professional look for Patrol Officers and doesn't create the appearance of a tactical Officer.[55]

55 Melkonian, A. 2009, 'Vests help officers carry a heavy load; weight redistribution is intended to cut down on fatigue and injuries', *Sanger Herald*, 29 July, viewed 14 March 2010, <http://www.thesangerherald.com/articles/2009/07/30/news/doc4a70caaa9a625619166703.txt>.

Figure 48. British Transport Police Officer wearing an Arktis® high visibility load bearing vest, frontal image

Source; Personal photograph, photographed Vaughan, S., 2012

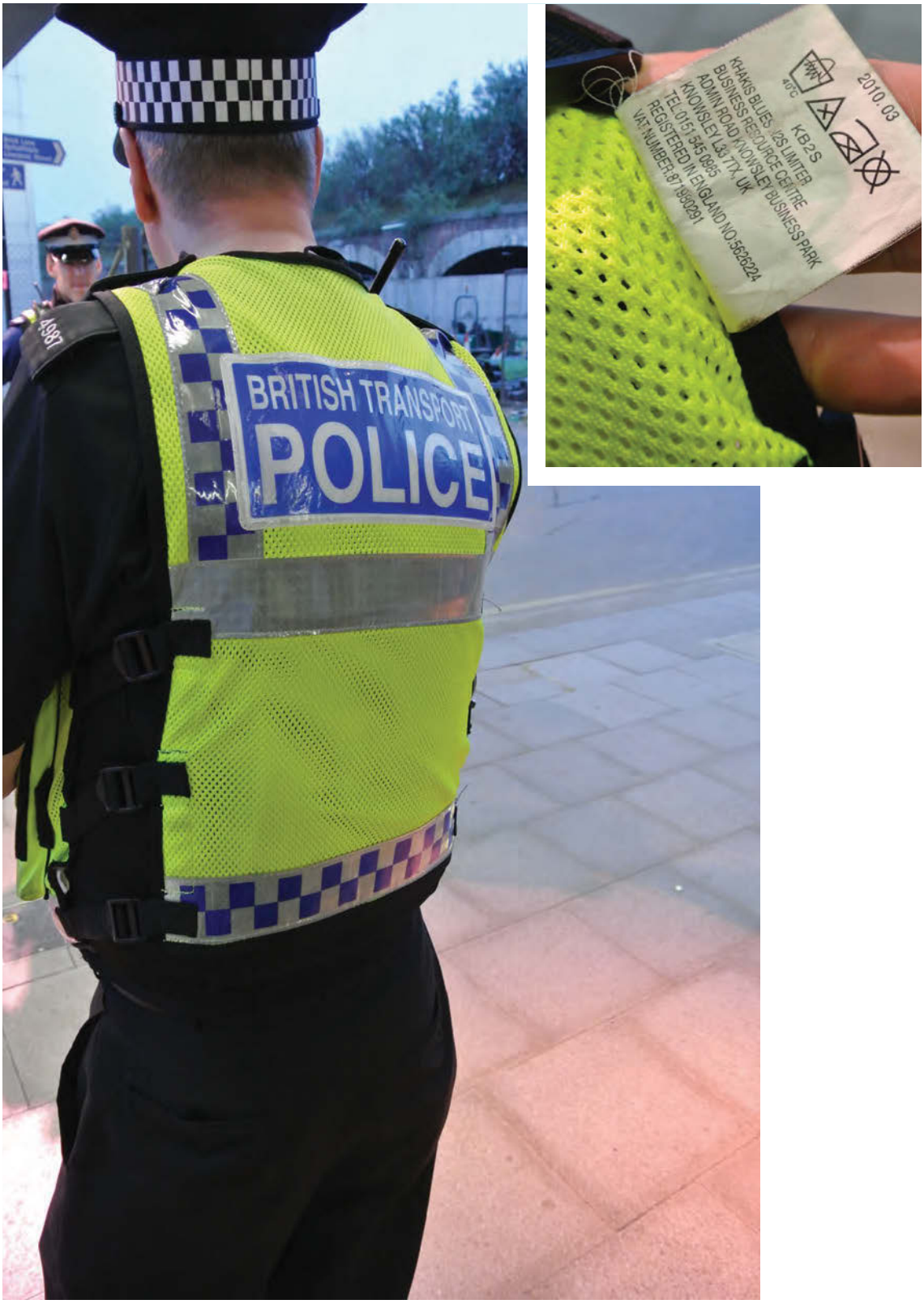


Figure 49. British Transport Police Officer wearing an Arktis® high visibility load bearing vest anterior image

Image inset: *Shows a close up view of the garment tag. The vest was issued in the year 2010. The textile is an open weave mesh for breathability.*

Source; Personal photograph, photographed Vaughan, S., 2012

Figure 50. United States General Duty Police Officers from Sanger use a load bearing vest in conjunction with a pistol holster located on their duty belt

Source; Vests help officers carry a heavy load, 2009 < http://www.thesangerherald.com/articles/2009/07/30/news/doc4a70caaa9a625619166703.txt >

Figure 51. United States General Duty Police Officers from Sanger use a load bearing vest, image shows the close up view of the textile used which is not breathable

Image above: *The same manufacturer distributes these load bearing vests for Police agencies in New Mexico, California, Arizona, and Minnesota. The image shows the vest with a Taser® X26.*

Source; Vests help officers carry a heavy load, 2009 < http://www.thesangerherald.com/articles/2009/07/30/news/doc4a70caaa9a625619166703.txt >

Figure 52. United States General Duty Police Officers from Lincoln use a load bearing vest in conjunction with an ergonomic drop leg pistol holster

Source; Lincoln police officers sport new look, 2010 < http://lincolnnewsmessenger.com/detail/148110.html >

Figure 53. Example of a New York General Duty Police Officer wearing a typical duty uniform with duty belt

Source; Photographed Traini, J., 2012.

Figure 54. Example of a San Francisco General Duty Police Officer's uniform

Image above: *The uniform uses one-hundred per cent woolen textiles in the construction of the duty shirt and duty pants. Note that the Police Officer is carrying a wooden (non-collapsible) baton.*

Source; Personal photograph, photographed Vaughan, S., 2012

Figure 55. German General Duty Police Officer's wearing a combination ballistic proof vest and load bearing vest

Image above: *The ballistic protection is suitable to protect a nine millimeter round (Class III ballistic protection).*
Inset image: *New German 'Polizei' uniforms released in the year 2012 show the uniform is now a softer blue as opposed to black as it was in the year 2009.*

Source; Personal photograph, photographed Vaughan, S., 2009

Figure 56. Example of an Italian General Duty Police Officer's uniform

Source; Photographed Traini, T., 2012

Chapter 4

Garment design for multi-performance

In the World today specialised application-based garment design is predominantly related to garment construction techniques. As such, garment construction techniques are aimed towards achieving specified multi-performance criterion. For example, when hard and soft textiles are mixed together, it is possible to create a motorcycle jacket specifically for use in hot weather, perhaps created from soft advanced textiles that may have superior breathability and crash protection performance characteristics? Hard textiles are those regarded as materials that have a certain degree of rigidity when incorporated into the garment design, whereas soft textiles are typically those characterised by not having any real rigidity. A hard textile plate constructed from a composite plastic may be sewn to an open weave mesh textile for example, this fabrication then becomes a hard and soft textile fabrication.

Multi-performance characteristics in garment design can be achieved by incorporating a range of advanced textiles into the garment construction. Advanced textiles, when used for multi-performance may address criteria such as cushioning for comfort, or even cushioning to improve airflow and breathability. By using a mixture of advanced textiles in a garment construction to reduce the thermal burden, certain areas of the torso, such as the armpit area where heat and perspiration naturally builds up during physical exercise, can be addressed.

4.1 Advanced textiles: Applications for health and wellbeing

Advanced textiles used in garment construction for health and wellbeing are often divided into textile categories according to their relative application in garment design and construction. Different types of advanced textiles are typically used in combination, and can be used in many different parts of the garment pattern. Advanced textile categories for use in multi-performance garments such as those used in load bearing vests, motorcycle wear and sports wear can be divided into the following groups; advanced textiles for climate control, advanced textiles for safety and high visibility and advanced textiles for durability.

4.1.1 Advanced textiles for climate control; Three-dimensional (3D) spacer textiles

In military combat wear and active motorcycle wear three-dimensional (3D) spacer textiles are used to provide a cooling channel between the base layer garment and the following layer garment. A three-dimensional spacer textile generally consists of an open weave mesh that is between three to twenty millimetres in thickness. The construction of the textile employees two outer layers on the external faces that can be made from textiles such as polyester that are sandwiched between a polyester micro-filament element. The three-dimensional construction allows consistent air circulation and works to provide cushioning and shock absorbency and has excellent recovery properties. Three-dimensional spacer textiles in this textile class are multi-functional, they reduce heat build up by increasing air circulation for wellness, plus they provide cushioning for comfort.

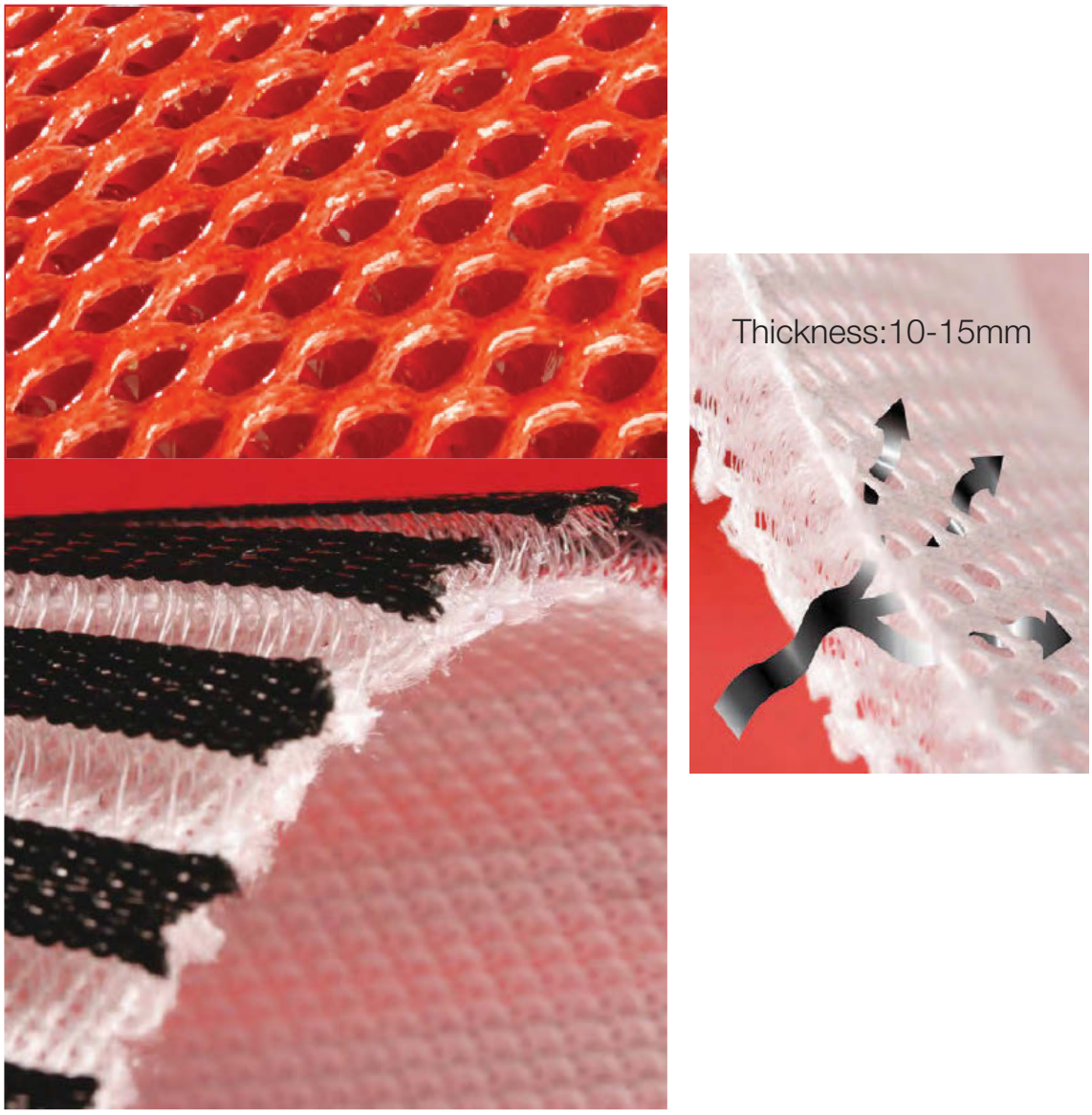


Figure 57. Examples of 3D spacer fabrics used in motorcycle garments

Image directly above: *Black and white channel 3D spacer fabric is used by Israeli military so that military personnel stay cooler in hot climatic conditions.*

Source; Heathcoat Textiles UK, 2009 < www.heathcoat.co.uk >

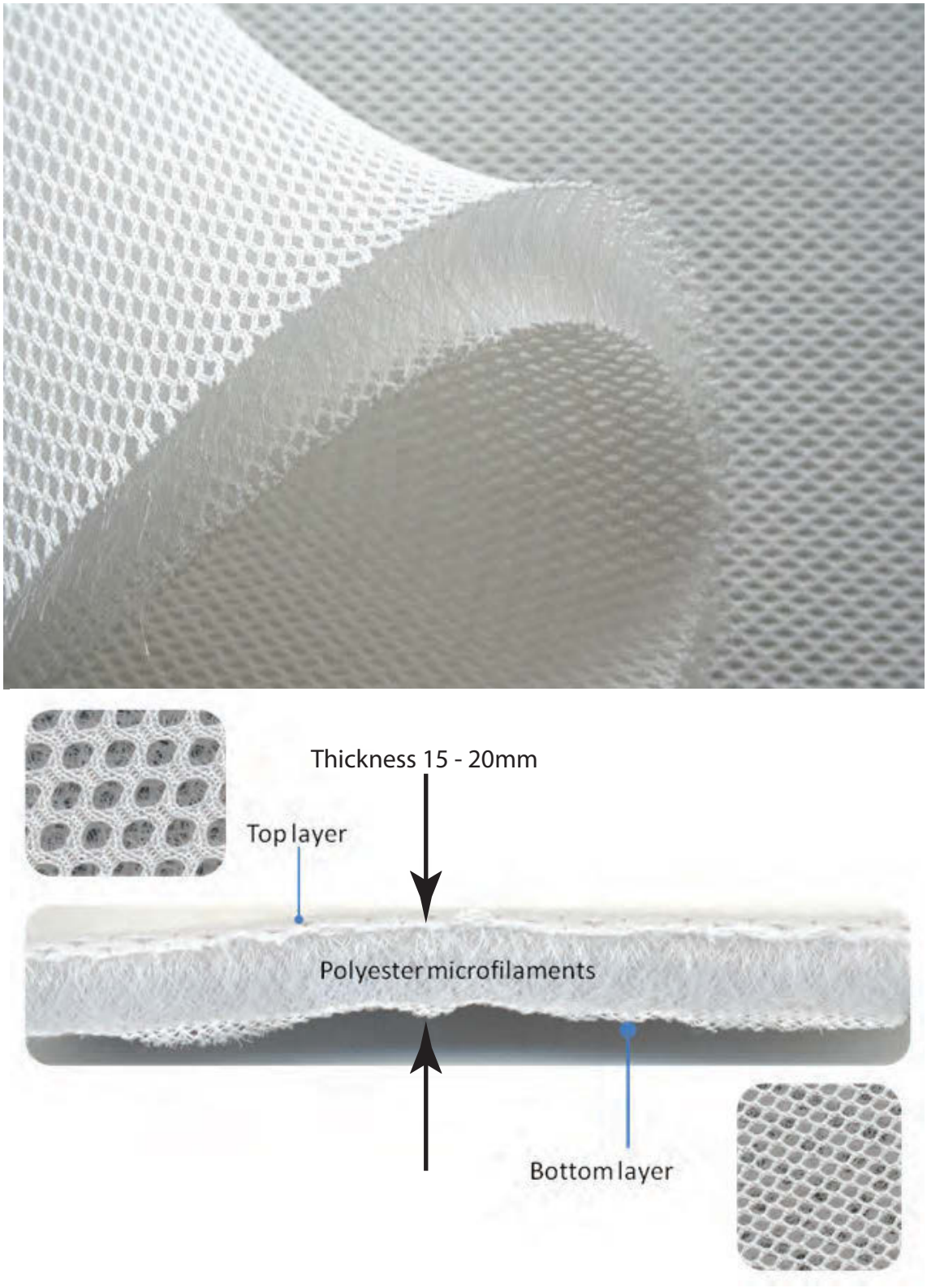


Figure 58. An example of a 3D spacer fabric used in bedding and sofas

Image above: *The thickness in this case is between 15-20mm, this product may be used in applications such as bedding or sofa cushioning. When used for these applications, the 3D spacer fabric acts as a breath able cushion for comfort.*

Source; Heathcoat Textiles UK, 2009 < www.heathcoat.co.uk >

Figure 59. An example of a motorcycle vest constructed from an open weave mesh

Image above: *An example of a garment that is constructed using an open weave mesh. The vest is highly breathable and can be used underneath a leather or synthetic motorcycle jacket*
Inset image: *Close up detail of the open weave mesh textile used in the fabrication*

Source; Dainese®, 2012 <www.dainese.it>

Figure 60. An example of a exoskeleton motorcycle garment constructed from an open weave mesh

Image above: *An example of a garment that is constructed using an open weave mesh. The garment may be used as an exoskeleton vest in hot climates. The vest is highly breathable and still provides safety protection in the even of a crash, by using a hard plastic spinal protector at the rear of the vest*

Inset image: *Close up detail of a 3D spacer fabric used in a leather motorcycle jacket used to improve breathability and comfort*

Source; Dainese®, 2012 <www.dainese.it>

A base layer garment constructed from super fine merino wool may be used by a motorcycle rider to control the amount of heat build-up in hot climatic conditions, then a three-dimensional spacer textile can be placed over this garment, before the final outer layer garment is placed on the rider. The final outer layer garment in the case of a motorcycle rider may be a leather jacket, which is a protective garment that is designed to ensure rider safety in the event of an accident where a motorcycle rider may slide along tarmac, protecting the riders skin from injury. The fact that a three-dimensional spacer textile is used in the scenario just given, means that a cooling channel works to enable moisture to be evaporated from the base layer, in this case the merino wool base layer provides moisture transfer, so when a rider perspires during exertion, this perspiration is absorbed and released into the air. Specialist finishes can be applied to three-dimensional textiles, such as an antibacterial coatings and the textile can be heat-moulded and shaped. In recent years three-dimensional spacer textiles have been incorporated into military combat and active motorcycle wear and this is aimed at reducing user heat stress. Additionally three-dimensional spacer textiles can be used as in garment construction as soft elements for padding and to support hard textile elements such as plastic composites.

4.1.2 Wool as a wicking layer

Wool has recently become a highly regarded textile for it's ability to provide superior levels of wearer climate control. It is a renewable fibre that is biodegradable and has a multitude of qualities that cotton or man made fibres can't replicate. Wool typically absorbs perspiration during exertion and releases it into the air, it is naturally anti-microbial and through its absorption properties. From a thermal viewpoint it reacts to body temperature by keeping the wearer warm when they are cold, but releasing heat and moisture when a wearer is perspiring. Wool has a chemical composition of fibres that are naturally anti-microbial and when combined with its ability to wick moisture away from the skin, odours are reduced significantly. In terms of comfort, gone are the days where wool was typically know for it's harshness against the skin, new generation super fine merino wool is very soft against the skin, this is because of the way that fibres are processed during manufacture. Wool is used in military combat wear, police uniforms and active motorcycle wear. It is interesting to note that General Duty Police in San Francisco, USA, currently wear woollen shirts and pants that provide greater climate control to the wearer.

4.1.3 Phase Change Materials (PCM)

Phase Change Materials (PCM) are active temperature controlling advanced textiles that take advantage of latent heat that can be stored or released from a material over a narrow temperature range. Phase change materials possess the ability to change their state with a certain temperature range and are materials that can absorb, store and release heat while the material changes from solid to liquid and back to solid, this is known as a phase change. Water changing from solid (ice) to liquid is an example of this phenomenon.

In the context of active wear or multi-performance garment design, the heat generated by the body during rigorous activity is not released into the environment in the necessary amount, this in turn increases thermal stress. When a wearer uses a garment that incorporates a phase change material and their excessive body heat increases, their body heat is absorbed by the encapsulated phase change materials and released when necessary. In actual fact a phase change material uses opening and closing pore technology that is embedded within the textile. So the applications of phase change materials in garment design relate also to clothing for cold climates, where the membrane automatically changes state to keep the wearer warm. Conversely as previously mentioned the membrane automatically opens to keep the wearer cool during periods of high intensity activity. Phase change materials possess the ability to change their state with a certain temperature range.

It is interesting note that (Manfield, 2004) made following comments where made in conclusion with regard to the effectiveness of phase change materials;

> Phase change materials produced a small, temporary heating or cooling effect when garments made of the material went through a step change in temperature. The PCM heating and cooling effects changed body heat loss by an average 2-13 Watts for the first fifteen minutes of the environmental transient, and then the effects were over. The magnitude of the effect increased as the number of garment layers and the amount of body coverage with PCM fabrics increased.
>
> When sixteen male subjects moved from a warm to a cold environment, their average leg skin temperature was significantly higher when wearing the PCM ski ensemble as compared to the control. However, their other skin temperatures and their subjective responses were not significantly different during the

> environmental step change at low activity. There were no significant differences in the skin temperatures and thermal sensations of males wearing the PCM ski ensemble during the four remaining exercise/rest periods in the cold. The effect of PCMs in clothing would probably be maximised if the wearer were repeatedly going through temperature transients or intermittently touching hot or cold objects with PCM gloves.[56]

Furthermore (Havenith, 2002) discusses the effectiveness of phase change materials in relation to phase change textiles;

> The recent introduction of phase change materials (materials containing substances that change their chemical structure at a certain temperature by absorbing or releasing heat, comparable to the phase change of water to ice and vice versa) has opened up the opportunity for buffering of heat in circumstances where people regularly move between different climates. With this buffering activity, they should reduce the climatic stress on the wearer and improve comfort. Unfortunately the currently available materials have only a small heat buffering capacity and substantial advantages have not yet been shown. The technology is promising for the future, however.[57]

It does not seem clear whether or not incorporating a phase change material into a garment can assist in dramatically improving wearer comfort related to thermal stress.

4.1.4 Hard and soft textiles combinations in garment design

The combination of hard textile elements such as composite plastics for abrasion resistance and soft textile elements such as three-dimensional spacer textiles or open weave meshes are currently used in motorcycle protective footwear. Motorcycle protective footwear combines a large range of hard and soft textiles and safety features. For example Alpinestars®, a motorcycle clothing manufacturer produces motorcycle boots that feature soft mesh thermoplastic polyurethane (TPU) elements for breathability. Elements such as a rubber compound sole offer excellent grip, feel and flex and these elements are combined

56 Manfield, R. 2004, 'Phase Change Materials', Textile World, viewed 15 April 2011, <http://www.textileworld.com/Articles/2004/March/Features/Phase_Change_Materials.html>.

57 Havenith, G. 2002, 'The Interaction of Clothing and Thermoregulation'", viewed 2 May, 2011, < http://www.raids.org.uk/media/wwwlboroacuk/content/lds/downloads/research/researchgroups/environmentalergonomics/clothing-thermoregulation.pdf>.

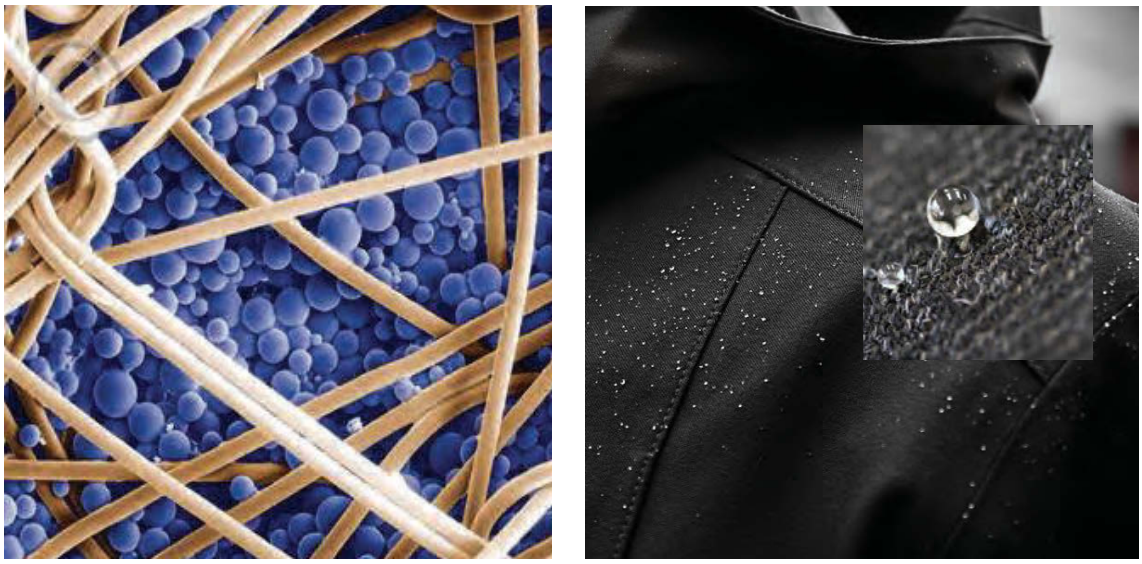


Figure 61. Advanced textiles; Phase Change Materials (PCM)

Image above: *An example of the three stages that Phase Change Materials undergo*

Phase Change Materials are active temperature controlling,windproof, waterproof and breathable

Source: Schoeller Textiles AG, 2011 <www.schoeller-textiles.com>

with hard or rigid elements such as the ankle brace, which is constructed with a lightweight fiberglass charged polyamide.

The combination of hard and soft textiles in garment design opens up many new possibilities in relation to the development of future load bearing vests. Future load bearing vests which may contain hard textile elements such as pistol or taser holsters and soft textiles elements such as three-dimensional spacer textiles, may increase wearer comfort and breathability.

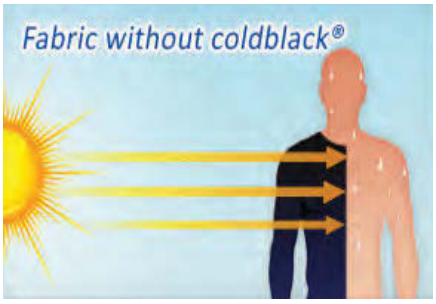
4.1.5 Textile finishes for climate control

Textile finishes can dramatically change the performance characteristics of textiles. One such textile finish which has seen a dramatic increase in its use is the textile finish Coldblack®, developed through a cooperation between Schoeller Technologies AG® and Clariant International Ltd., both based in Switzerland. Coldblack® technology, enables dark-colored textiles to reflect rather than absorb the sun's rays and offers dual protection from solar heat and ultraviolet (UV) rays. Coldblack® textile finish can reduce the absorption of heat rays, particularly in the case of darker colours. In the case of Police garments, which in the large part use darker colour textiles, a fabric finish such as Coldblack® can provide protection from thermal stress due to the fact that it deflects sunlight more efficiently and allow wearers to perspire less. Providing greater wearer comfort in hot climatic conditions is advantageous, with no notable adverse effects on aesthetics, feel or breathability.

4.1.6 Advanced textiles: Innovations that inform protective garment design

Dainese®,[58] a protective wear and motor cycle wear manufacturer based in Italy, have designed a spinal protection device that is incorporated into their motorcycle jackets and in ski wear and performance surf wear. This protective garment features a cored-in aluminium honeycomb structure that possesses a crumpling mechanism that deforms and progressively crumbles around the spine in the event that a rider falls off their motorcycle and makes contact with a hard surface such as bitumen paving. This is not unlike modern motor vehicles that also possess active crumple zones at the front and rear of the vehicle, that progressively crumble to reduce the amount of

58 Dainese, a protective wear and motor cycle wear manufacturer based in Italy. Dainese produce protective wear for dynamic sports such as motorcycling, skiing, surfing and equestrian <www.dainese.com>.



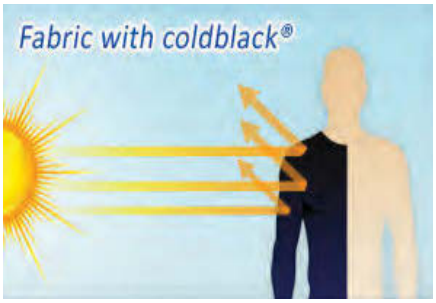


Figure 63. Coldblack® textile finish

Image above: *A dark coloured garment treated with Coldblack® finish. Coldblack® UV absorption & reflective finish applied to dark fabrics makes them reflect sunlight with 86% efficiency of light fabrics*

Image below: *Another application for Coldblack® is for use in automotive seating, to cool the fabric*

Source: Schoeller Textiles AG, 2011 <www.schoeller-textiles.com>

collision energy in the event of an accident. Reducing the collision energy in the event of an accident, is found to substantially reduce injury to occupants in motor vehicle accidents. The cored-in aluminium honeycomb structure is incredibly strong in order to stand up to the rigours of daily use, but is also soft enough to crumble in the event of an accident. The geometry of a honeycomb structure allows for the minimisation of the amount of used material, reduces the component weight and material costs and is highly breathable. Dainese incorporate this spinal protection element into their winter motorcycle jackets but also offer this protection in lightweight, breathable summer motorcycle jackets also. This is testament to the fact that this safety device is applicable for use in garments which need to be highly breathable when used in hot climatic conditions, so as to reduce wearer fatigue. The structure of this safety device features hard rigid elements such as plastics and soft elements such as the aluminium honeycomb structure and soft textiles. The device changes state from being a rigid structure suitable for daily use to one that is soft enough to deform in the event of an accident to enable provision of spinal protection to the user.

Honeycomb composite structures could possibly be applied to load bearing vest design and construction. Consideration of hard composite materials could offer novel design solutions outside of purely traditional soft textile design solutions such as open weave mesh textiles. A load bearing vest that is constructed from composite materials, could perhaps have a significantly longer lifecycle than a textile only load bearing vest. This could potentially reduce ongoing costs to Police forces and increase product sustainability because of increased gain in the the product life-cycle.

Textile innovation in motorcycle and sportswear and the potential for the use of such textiles in load bearing vest construction should be considered in the design process. There are many advanced textiles derived from motorcycle and sportswear that could be incorporated into the design of future load bearing vests and these will be categorised and discussed later in Chapter 4 of this theses.

Figure 62. Biomechanical ankle brace for use in motorcycling

Images above: *The inner boot has a double hinged inner and outer torsion bar to progressively absorb flex and rotational stress on the ankle and reduce pressure and risk of hyper extension injuries to the lower leg joints.*

Source; Alpinestars®, 2012 <www.alpinestars.com>

Figure 64. Dainese® Wave air exoskeleton jacket as viewed from the front

Image above: *Aluminum honeycomb frame. Liner in thermoformed polyethylene foam. Liner inside back in polyester mesh fabric.*

Source; Dainese®, 2012 <www.dainese.it>

Figure 65. Dainese® Wave air exoskeleton jacket as viewed from the rear

Image above: *Inner core is comprised of Nidaplast® extruded polypropylene for outstanding protection. External anti-shock perforated corrugated structure permits ventilation. Ergonomics and riding comfort are guaranteed thanks to jointed pads, a patented lumbar support joint.*

Source; Dainese®, 2012 <www.dainese.it>

The textile categories in this research study related to comfort and wellness, can be divided into these specific groups;

- Textiles for climate control and breathability
- Three-dimensional (3D) spacer fabrics
- Textiles for safety and high visibility
- Textiles for load carriage
- Compression textiles

Textiles used for climate control and breathability may have moisture wicking capabilities. Textiles such as wool, as previously discussed on Page 140, have the ability to wick moisture and perspiration away from the skin. There are also textiles which have inherent moisture management and thermo-regulation such as those referred to as open weave textiles in the form of a mesh (Refer to Figure 59, on Page 134, to see an example of an open weave mesh). Open weave mesh textiles are fairly durable for use in military wear and are used for providing enhanced breathability in garment design. Many load bearing vests as used in General Duty Police wear use open weave mesh panels on the front and rear of the vest for greater breathability.

Three-dimensional (3D) spacer fabrics are also used to enhance ventilation and provide cushioning in motorcycle jackets. Three-dimensional spacer fabrics may also have cooling channels built into the textile (Refer to Figure 57 and 58 on Pages 132 & 133 to view examples of three-dimensional spacer fabrics).

Textiles for safety and high visibility are also important to consider, as these types of textiles may need to be incorporated into the design of a police load bearing vest. Whilst New South Wales General Duty Police Officers only have one overt style load bearing vest issued to them, General Duty Police Officers in the state of Western Australia, have two types of load bearing vests issued to them. Depending on the duties they are assigned on any given shift, one load bearing vest is dark in colour for street patrol and the other high visibility for road duties, street patrol and when specific duties require it.

Textiles for load carriage include hard textiles, such as composite structures, Kevlar® is one of these hard textiles. Load bearing textiles should be able to hold a load in place, in a specific location on a garment and not loose shape. Hard plastic or Kevlar™ protective elements such as those used for in motorcycle wear are important considerations in load bearing vest design and construction.

Compression textiles aim to enhance user performance and play an injury reduction role by provoking high blood lactate concentrates at a specific site on the body. Compression textiles are used by sports wear company 2XU and Skins.[59]

According to (Berry et al. 1987) the following has been documented in regards to compression wear;

> Recent research with athletes has shown that compression garments may provide ergonomic benefits for athletes during exercise by enhancing lactate removal, reducing muscle oscillation and positively influencing psychological factors. The early research on compression garments demonstrated a reduction in blood lactate concentration during maximal exercise on a bicycle ergo-meter.[60]

The following research (Kraemer et al. 1998) demonstrates a slightly different finding in relation to the benefits of compression wear;

> Later investigations have shown improved repeated jump power and increased vertical jump height.[61]

---

59 2XU is a sportswear clothing company that promote the use of compression garments for improved sports performance <www.2xu.com> Skins is a sportswear clothing company that promote the use of compression garments for improved sports performance <www.skins.com.au>

60 Berry, M. & McMurray, R. 1987, 'Effects of graduated compression stockings on blood lactate following an exhaustive bout of exercise', *American Journal of Physical Medicine*, vol. 66, pp. 121–32.

61 Kraemer, W. & Bush, J. 1996, 'Influence of compression garments on vertical jump performance in NCAA division 1 volleyball players', *Journal of Strength and Conditioning Research*, vol. 10, pp. 108–83.

According to (Doan, et al. 2003) there were certain factors leading to improved jumping ability in relation to compression garment wear;

> The suggested reasons for the improved jumping ability with compression garments include an improved warm-up via increased skin temperature, reduced muscle oscillation upon ground contact and increased torque generated about the hip joint. Combined, these results show that compression garments may provide both performance enhancement and an injury reduction role during exercises.[62]

62 Doan, B., Kwon, Y., Newton R., Shim J., Popper, E., Rogers R., Bolt L., Robertson, M. & Kraemer W. 2003, 'Evaluation of a lower-body compression garment', Journal of Sports Science, 21(8), pp. 601–10.

4.1.7 Novel solutions that may be derived from motorcycle and sportswear design

There are many elements in relation to the design of load bearing vests that may benefit from all of the research and development that has been attributed to motorcycle and sportswear. In the areas of both motorcycle and sportswear design, manufacturers have strived in recent years to produce garments that are comfortable, highly breathable (aimed at reducing thermal stress) and enable a greater range of flexibility for the user in terms of allowing increased movement or flexibility through areas such as the torso and arms. The link between motorcycle garment design and the reduction in rider injury is a beneficial one.

In motorcycle wear these key areas of garment functionality such as range of movement for the user and fit to the human body can substantially improve rider safety. A recent Australian study in the year 2011 provided new evidence regarding the injury reduction benefits of using approved motorcycle clothing (Rome et al. 2011).[56] The study is the first of its kind and one of the key findings of the study found that riders were significantly less likely to be admitted to hospital if they crashed wearing a motorcycle jacket, pants, gloves or boots. When motorcycle protective garments included fitted body armour there was a significantly reduced risk of any injury. This included a reduced risk of any injury to the upper body by twenty-three per cent, legs by thirty-nine per cent, hands by forty-five per cent and feet by forty-five per cent. The results also found riders wearing shoes or joggers, which provide little or no ankle support, had a much higher risk of foot and ankle injuries, and any type of boot reduced risk of injury by fifty-three per cent.

So there are elements of motorcycle wear that can be applied to load bearing vests. Similarly, fit to body, freedom of movement and the combination of rigid or hard support structures, such as those used for providing ankle support in motorcycle boots, for example hard durable plastic or composite textiles[57] and soft textiles such

56 Rome, L., Invers., R., Fitzharris., Du., W., Haworth, N., Heritier, S & Richardson, D, 'Motorcycle protective clothing: Protection from injury or just the weather?', The George Institute for Global Health, The University of Sydney, Australia, viewed 15 January 2012, <http://www.georgeinstitute.org/sites/default/files/pdfs/Gear%20Study%201_George%20Instit_2011.pdf>.

57 A composite textile is defined as a combination of two or more materials (reinforcing elements, fillers, and composite matrix binder), differing in form or composition on a macro scale.

4.2 Hard and soft textiles: A Dainese® motorcycle safety wear product study

Approaching motorcycle garment design from a different perspective can bring about innovative solutions that resolve existing issues in motorcycle protective armour. It is no surprise that a recent study undertaken by The George Institute for Global Health in Sydney in the year 2011,[63] found that riders were significantly less likely to be admitted to hospital if they crashed wearing a motorcycle jacket, pants or gloves. When these garments also included fitted body armour, there was also a major reduction in injury – reducing the risk of foot and hand injuries by forty-five per cent, leg injury by thirty-nine per cent and upper body injury by twenty-three per cent. Furthermore, boots of any kind were preferable to shoes or joggers when riding, more than halving the risk of injury in the event an accident occurs.

Dainese® is an Italian company that has produces protective clothing and gear for motorcycle riders and dynamic sports such as skiing, snowboarding, surfing and mountain biking. The Dainese® wave back protector is good example of a multi-sport protection garment, that provides high levels of user protection, is lightweight ergonomic, and has high levels of garment ventilation. The Dainese® wave back protector as shown in the images on the following page, is used in sports such as motorcycling, skiing, surfing, mountain biking just to name a few. If we consider traditional motorcycle protective wear such as leather garments, motorcyclists would typically use leather or more recently a Cordura® full length sleeved jacket. This type of garment is perfect for use in cold weather, however in hot weather motorcycle riders will typically face heat stress wearing a jacket that has little ventilation or breathability through the textile. Heat stress may indeed burden a motorcycle rider, to the point where they may become fatigued more rapid in hot weather, distracted and loose focus when riding. The garment has rigid external corrugated plates for better impact energy distribution and a lightweight core made of aluminium honeycomb and Astrosorb®. Ergonomics and riding comfort are increased through jointed pads and a lumbar support joint, the perforation of the structure, the use of breathable fabrics, and ample volume adjustment possibilities.

63 The George Institute for Global Health 2011, *The George Institute study findings*, viewed 20 November 2011, <http://www.swanninsurance.com.au/communications/761>

The back protector component of the garment has rigid external corrugated hard textile plates constructed from polypropylene for better impact energy distribution. Polypropylene is a synthetic polymer used to produce the stiff shell in protectors, distinguished by elevated resistance to abrasion and impact. Polypropylene is lightweight and completely watertight as polypropylene is used to fabricate water tanks and pipes for farm irrigation also. The external corrugated hard textile plates, allow for greater breathability through a series of moulded circular patterned holes.

4.2.1 Fitting comfort: Ergonomics related to garment construction

Multi-functional garments are those that not only consider the use of advanced textiles , but also consider the garment construction as a means of providing wearer comfort. So whilst climate control through a well designed layering system may provide increased levels of wearer comfort and wellness, the garment construction and patterning must also be considered in the design process.

Physiological wear comfort in relation to garment design may include factors such as; thermophysiological, skin sensory, ergonomic and psychological wear comfort. Thermophysiological wear comfort includes aspects such as fibres, fabrics and garment design. Skin sensory wear comfort includes aspects such as fibres, fabrics. Ergonomic wear comfort involves garment construction and fit, whilst psychological wear comfort includes design, branding and perception.

Good moisture management is essential when a wearer is perspiring heavily. Body mapping technology taking different heat and moisture releases of particular body areas into consideration should also be incorporated into a garment design as should wear comfort in direct skin contact scenarios.

The ability of clothing to allow free movement of the body, reduce stress or follow the contours of the body or body part in garment construction needs to be part of the design brief when it comes to multi-functional clothing. In the case of motorcycle wear, a rider must be afforded the freedom of movement to allow for dynamic movement when wearing protective clothing. A motorcycle rider will often change position depending on the riding environment, urban or open road, and throughout manoeuvres such as cornering. Freedom of movement whilst wearing protective motorcycle wear is vitality important to rider safety, a rider must not be restricted by the garments worn. Likewise a General Duty Police Officer and military personnel

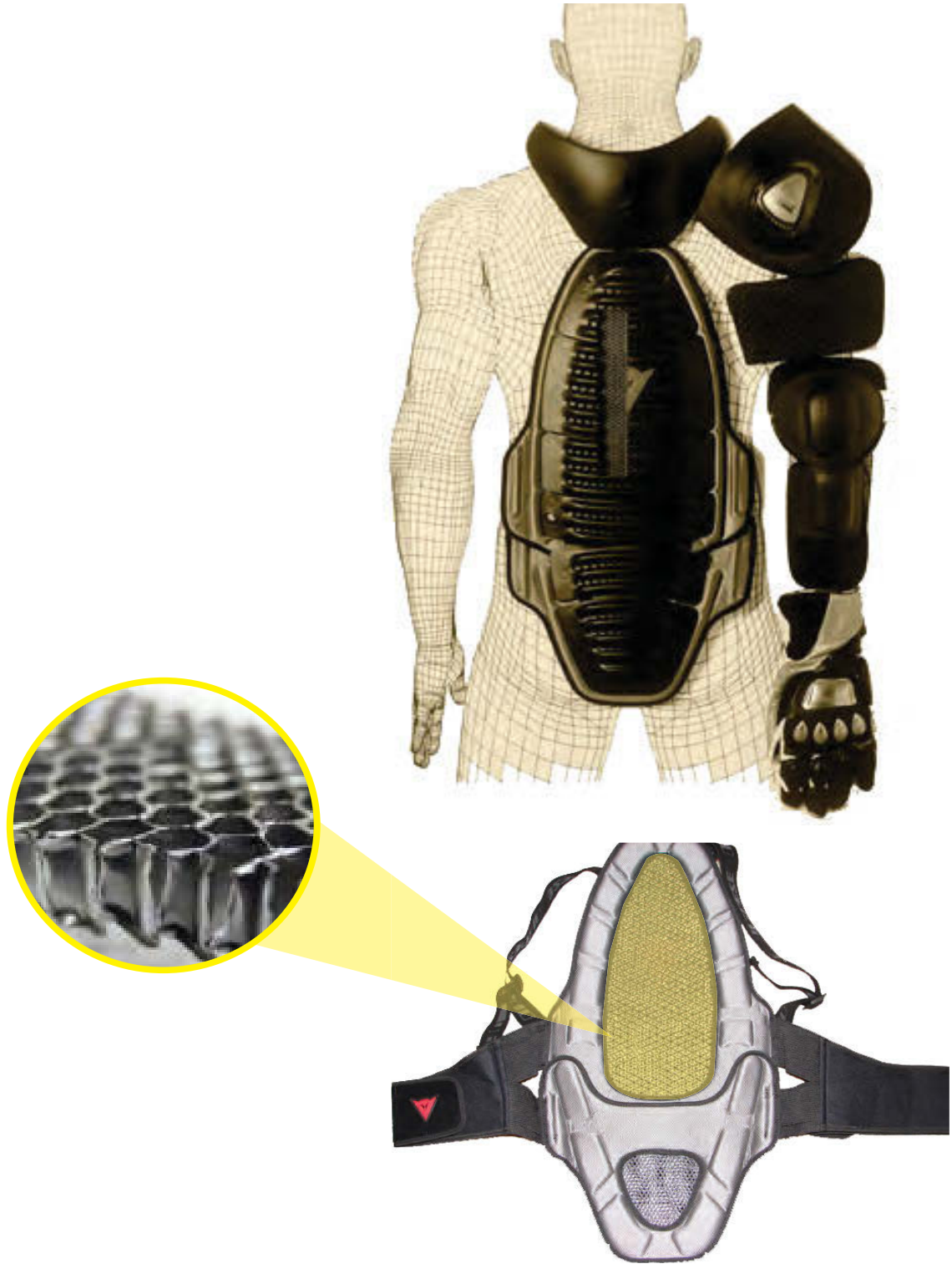


Figure 66. Dainese® Wave air back protector; Internal construction

Image above: *Inside view and the highlighted section which contains a lightweight and breathable internal aluminium honeycomb structure, offering elevated levels of injury protection. The Wave Back Protector is a multi-sport protection garment, and can be used in the following sports; motorcycling, skiing, surfing and equestrian*

Source; Dainese®, 2012 <www.dainese.it>

alike must have a good range of movement whilst wearing a load bearing vest, restricting movement may result in a Police Officer being inhibited from taking aim with a pistol for example, which could have dire consequences. An article entitled, 'Body armour puts Diggers in danger'[64] purportedly claimed that the body armour issued to Australian soldiers restricted their freedom of movement whilst on patrol in Afghanistan in the year 2012;

> Troops said the armour, known as the Modular Combat Body Armour System (MCBAS) is so heavy and inflexible that at times they could not even adopt the correct firing position to use their weapons. The armour also lacks ventilation which can also be a life or death issue when temperatures hit forty-five degrees Celsius for weeks on end. Special forces soldiers and infantry trainers working in the Operational Mentor and Liaison Teams (OMLTs) training Afghan troops, are permitted to wear a lighter armour rig, which is six kilograms lighter, named American Eagle.[64]

When considering ergonomics in sports clothing there are many different sports to consider let alone all the of the variables that come into play when realising the variations in the anatomy of users. Ergonomics in sports wear and multi-functional wear, quiet often needs to consider a wide range of sports, some sports garments are; swim wear for the competition pool and ocean, motor racing suits, mountaineering wear, ski wear, athletics wear to name a few. The study of protective garments in a variety of extremes in sports and industrial contexts, such as those used for mountaineering, will continue to be an ongoing research area in garment ergonomics.

64 McPhedran, I. 2009, 'Body Armour puts Diggers in danger in Afghanistan', The Daily Telegraph, 6 October 2009, viewed 6 October 2009. <http://www.dailytelegraph.com.au/news/body-armour-puts-diggers-in-danger-in-afghanistan/story-e6freuy9-1225783081153>.

Figure 67. Dainese® motorcycle protective wear elements

Clockwise from top: Motorcycle gloves, full height road motorcycle boots with exoskeleton ankle protection, sport motorcycle high top boots

Source; Dainese®, 2012 <www.dainese.it>

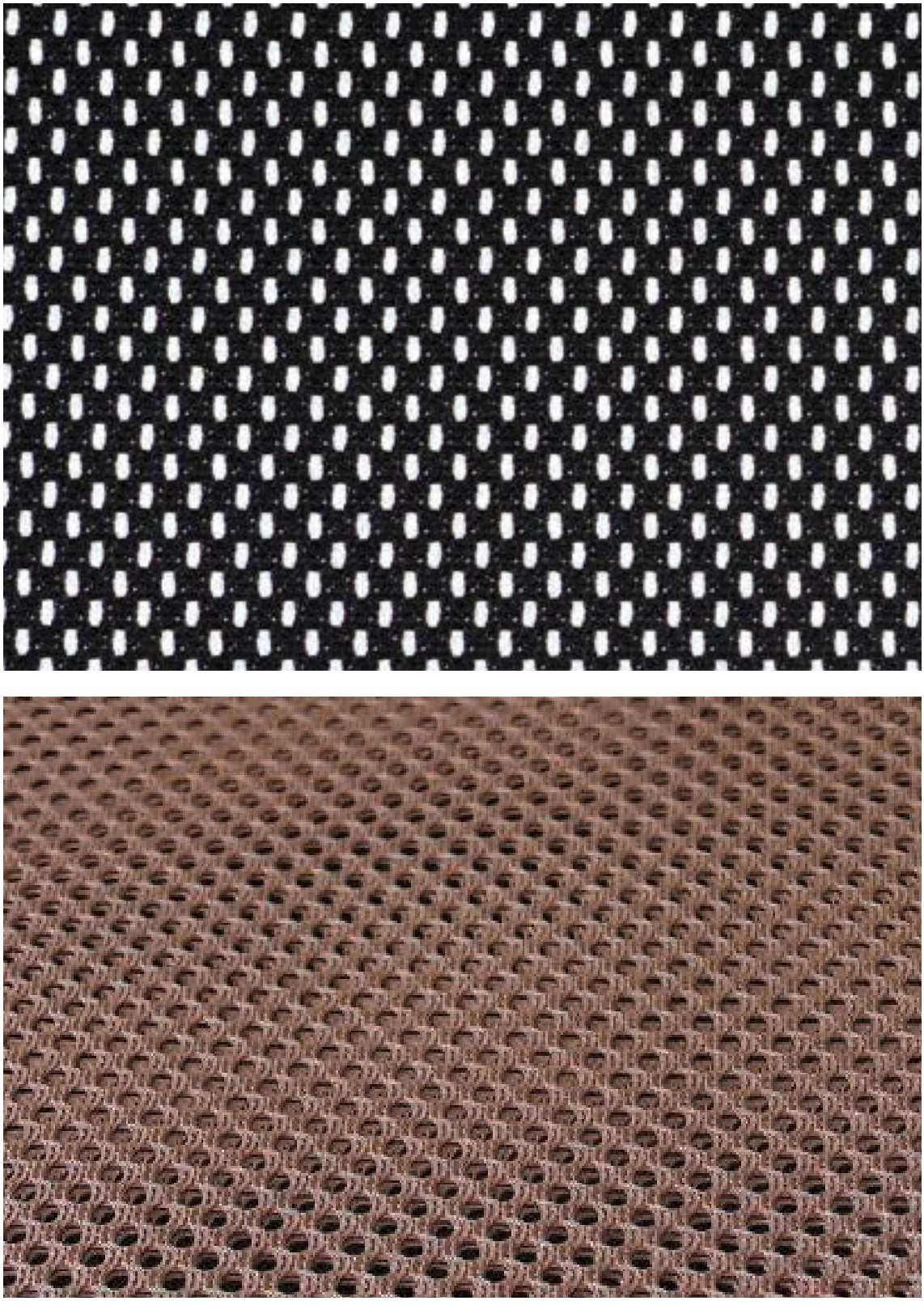


Figure 68. Examples of open weave meshes

Image above: *An open weave mesh textile, used in sportwear, motorcycle wear and in soft luggage.*

Image below: *A similar open weave mesh textile used for military applications.*

Source; Heathcoat Textiles UK, 2009 < www.heathcoat.co.uk >

The excerpt below (Reilly, 2009) discusses both sports brassieres and compression garments which have a direct relationship to ergonomics in garment design;

> A concern addressed by (Bowles et al. 2005) was that sports bras were too tight and restricted breathing. The investigators recommended that active females wear a sports brassiere to reduce breast movement and related breast pain. In view of individual differences in size, a proper fit is important. Encapsulated bras are more suitable for large-breasted joggers, whereas compression bras are preferable for the majority of runners. The superiority of the compression bras was demonstrated by (White et al. 2009) who reported the least discomfort with the compression design. Compression garments have been promoted for use in sport as well as other contexts. Compression stockings are commonly used by airline travellers to reduce the risk of incurring deep-vein thrombosis. In sport, compression clothing has been designed to improve recovery following exercise and training. Although this fashion has gained acceptance among professional athletes, the physiological mechanisms for any positive benefit are not clearly established.[65]

4.2.2 Ergonomics related to load carriage

The fact that Police Officers vary dramatically in physical stature and body weight is directly related to the ergonomic challenges that are presented in human load carriage. Ergonomic factors and user injuries related to load carriage have been conclusively linked to gender.[66] User injuries related to load and also physical stature and weight of users undertaking load carriage tasks. Ergonomics related to load carriage, is a key consideration when realising the issues presented around load bearing vest design for police officers.

Research around ergonomics in law enforcement (Czarnecki, 2003) outlines the fact that law enforcement ergonomics and safety issues are approached with three priorities that are essential for this particular occupation and sometimes are oppositional; public safety, officer survival, and avoidance of litigation.[67]

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65 Reilly, T. 2009, *Ergonomics in Sport and Physical Activity*, Human Kinetics, Champaign

66 Knapik, J. & Reynolds, K. 2007, 'Load Carriage in Military Operations', *Borden Institute*, pp. 14-25.

67 Czarnecki, F. & Janowitz, I., 2003, 'Ergonomics and safety in law enforcement', Clinics In *Occupational and Environmental Medicine*, vol. 3, viewed 6 October 2009, <http://www.theppsc.org/Staff_Views/Czarnecki/ergonomics_and_safety_in_law_enforcement.htm>.

Police Officers serve and protect the public, must insure their own safety, and make sure that their actions do not create litigation against themselves or their agencies. In relation to duty belt ergonomics and load carriage (Czarnecki, 2003) suggests that;

> Police Officers should avoid placing hard objects (typically handcuffs) on the lumbar spine at the rear of the duty belt. In case of a fall, the spine could be severely injured by placing handcuffs or similar duty gear on the duty belt in proximity to the lumbar spine. Duty gear placed on the duty belt at various points around the waist could also create back pain from constant pressure being applied to the lower back while sitting in a patrol car or at a desk in a police station. Therefore it is recommended that a soft pouch, containing soft items such as latex gloves for example, be placed on the duty belt close to the lumbar spine area.[68]

Ergonomics must consider, even distribution and placement of duty gear on the duty belt around the circumference so that weight is distributed evenly. Even weight distribution of duty gear, in the case of a General Duty Police load bearing vest is also a very important consideration for garment designers. Load carrying platforms such as baby carrying harnesses can be considered as a step forward in potentially improving human load carriage. This is because of the fact that there is a reduction in the likelyhood for injuries related to load carriage, provided the load is spread between the large load bearing areas of the torso which are the shoulders and hips. Ergonomics must best consider even weight distribution of duty equipment across the torso and the sites at which the load will be carried on the body, such as the thighs and waist, so as to enable even weight distribution in the vertical and horizontal axis's. Ensuring that even weight distribution is achieved can improve balance and stability whilst a Police Officer is on foot patrol, running or jumping.

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68 Czarnecki, F. & Janowitz, I., 2003, 'Ergonomics and safety in law enforcement', Clinics In *Occupational and Environmental Medicine*, vol. 3, viewed 6 October 2009, <http://www.theppsc.org/Staff_Views/Czarnecki/ergonomics_and_safety_in_law_enforcement.htm>.

Figure 69. Hard and soft textile combinations in garment design

Image above: *A combination of hard and soft textiles are used in order to optimise safety in motorcycle boots. Hard textile elements ensure that ankle injuries are reduced in the even of an accident, while soft textiles provide flexibility for movement where needed*

Source; Alpinestars®, 2012 <www.alpinestars.com>

Figure 70. Dainese® Wave air exoskeleton jacket

Image above: *A multi-functional protective garment for sportswear. The Dainese® Wave® back protector is used across sports such as motorcycling, surfing, skiing, to name a few. The hard textiles elements in this multi-functional safety garment provide crash protection. The soft textile elements provide flexibility for greater freedom of movement*

Source; Dainese®, 2012 <www.dainese.it>

Testing result for Cordura® when laundered

100% Nylon plain weave 160g/m² after 50,000 turns

65% Polyester / 35% Cotton twill 310g/m² after 50,000 turns

100% Cotton twill 355g/m² after 50,000 turns

CORDURA®fabric in canvas construction 200 g/m² after 300,000 turns

Figure 71. Cordura® testing results shown above after laundering

Image above: *The results illustrate that Cordura® has the same level as resistance and durability in the textile after 300,000 turns in a washing machine as textiles such as cotton, nylon and polyester/cotton mix after just 50,000 turns in a washing machine*

Source; Mascot® Workwear, 2012 <www.mascot.dk>

Figure 72. Earlier version Dainese® Wave air exoskeleton jacket

Images above: *Illustrate the fact that the jacker is very breathable due to open weave mesh fabrication and has the following ergonomic benefits; Fastening system: lateral chest zip, Closing/Adjusting system: buckles/ straps on shoulders, elbows braces removable, on the back protector, Lumbar belt: elastic belt with double strap wrist gaiters, Light weight 1600 grams*

Source; Dainese®, 2012 <www.dainese.it>

Figure 73. Dainese® protective knee brace for motorcycle wear

Source; Dainese®, 2012 <www.dainese.it>

Figure 74. Examples of a three-dimensional (3D) spacer fabrics

Image above: *A Dainese® 3D spacer fabric used to construct prototype undergarments in motorcycle wear, 2008*

Image below: *Heathcoat Spacetec 3D spacer fabric with colling chaneels.*

Source; Dainese <www.dainese.it>, Heathcoat Textiles UK, 2009 <www.heathcoat.co.uk>

4.3 User comfort and wellness

There are many fundamental elements relating to human comfort & wellness in clothing, these elements include; human perception of comfort in apparel and factors which affect it such as the properties of fibres and fabrics, scientific or laboratory testing and analysis, and predicting the comfort properties of textiles.

4.3.1 Comfort and wellness in clothing design

The publication *Improving comfort in clothing* [69] (Song 2011), which was previously reviewed in Chapter 2, starts by analysing the above mentioned fundamental elements relating to human comfort and wellness. Part two of the publication discusses methods of improving comfort in apparel, discussing methods of controlling thermal comfort and managing moisture, to enhancing body movement comfort in various garments.

A key factor around garment design and user wellness, is the physical conditions of a person, which may include amongst other data, age, condition of the health of a person (wellness), body structure, physiological response of the body, and activity level. It is suggested in this publication (Song, 2011), that clothing comfort is one of the most important aspects of garment construction or garment pattern making and textile characteristics. The following points are made in relation to comfort and textile materials;

> Understanding at a basic level comfort aspects of textile materials is extremely useful for fibre, yarn and fabric manufacturer, researcher, garment designer, processing industries, garment houses, users of the fabrics for speciality applications and all others related with textile and garment industries.[70]

Comfort is influenced by the physiological reaction of the wearer. Comfort is temperature regulation of the body and is the absence of unpleasantness or

69 Song, G. 2011, Improving comfort in clothing, vol. 106, Woodhead Publishing, Oxford ; Philadelphia.
70 Song, G. 2011, Improving comfort in clothing, vol. 106, Woodhead Publishing, Oxford ; Philadelphia.

discomfort. Comfort is the state of pleasant psychological, physiological and physical harmony between a human and the environment. All three aspects are important because the absence of any one makes a person feel uncomfortable. Comfort may even vary from person to person, even if a garment is fitted to a person correctly from a sizing perspective, using the same garment as a reference point. The comfort characteristic is an important functionality of clothing. Human thermo-physiological comfort is associated with the thermal balance of the human body, which is highly dependent on metabolism rate, physical activities, ambient temperature, and thermal and moisture transmission of the worn clothing. Clothing creates a microclimate between the skin and the environment, which supports the body's thermoregulatory system to keep its temperature within a safe range, even when the external environment and humidity changes to quite an extent.

Broadly there are four basic elements of clothing comfort;

(1) Thermo-physiological aspect

(2) Sensorial or tactile aspect

(3) Physiological aspect

(4) Sizing and shape (fitting comfort)

The following comments in the same publication are made around specialist type garments, and a load bearing vest should be considered as a specialist type garment;

> Understanding of interrelationship between fibre material, yarn structure, fabric structure, transmission characteristics (air, heat and moisture) and tactile aspects of textile materials on thermo-psychological and neuro-physiological processes of clothing comfort is extremely helpful for engineering of garments for specific applications. The clothing a person wears in this case should be able to dissipate and transmit the heat and sweat quickly to keep the body heat under control and reduce user stress.[71]

As environmental factors are a key subject study area in this research, it is essential to realise the substance of these comments around this topic. The environmental

71 Song, G. 2011, Improving comfort in clothing, vol. 106, Woodhead Publishing, Oxford ; Philadelphia.

factors may include climatic conditions (too cold, too hot, raining, chilled wind, and so on) and may include protection from extreme environments (unusual place, space or under water). Depending on environmental conditions the clothing need changes and the performance factors are the dominating parameters. A person requires different clothing for different climatic conditions and as we know clothing is sometimes divided into groups for cold and warm weather. It is interesting to note though that a Police load bearing vest needs to be used across all seasons, which is a challenge for garment designers.

4.3.2 Clothing layering for comfort and wellness; Thermal management for comfort

Clothing layering is essentially wearing a combination of clothes to regulate your body temperature so you don't overheat or get cold. There are three categories when it comes to clothing layering, this may be dependent on the season; the inner, mid and outer layer which act in unison to trap heat or wick moisture, however individually each layer performs specific functions.

Working from the inner layer, also called the base layer (this is the first layer garment that goes against the skin) up to the final layer ensures optimum garment breathability, this is paramount when it comes to user comfort in hot climatic conditions. Questions also need to be asked around whether a Police Officer's shirt, specifically in the case of a New South Wales Police Officer, which is worn against the skin, is sufficiently breathable and is able to wick moisture away from the body. At the time of writing this thesis, New South Wales Police Officers wear one hundred percent cotton shirts as their base layer. A load bearing vest may employ highly breathable materials such as open weave meshes or even three-dimensional textiles, but if the base layer is not breathable, the user will not benefit from a load bearing vest constructed from advanced textiles used in the following and subsequent layers.

International Police forces in Europe have researched base layer garments and the benefits of garments that are more aimed towards climate control. The Airport Police based in Geneva Airport, Switzerland, wear a base layer garment that is completely perforated and that uses a textile that has perspiration wicking capabilities. In

this case, the base layer is typically constructed from a Coolmesh®[72] fabric and is specially knitted with a micromesh filament polyester. This assists in expelling heat and sweat away from the body to help keep the user cool and dry. The fit of this garment is very close to the body (against the skin) and the garment is very similar in style to a shirt that runners or cyclists would normally use to improve climate control. Even though Switzerland has a climate where temperatures at times can drastically plummet, the Police force has considered that it's members operate mainly in the micro-climate or an air-conditioned environment of an airport and the Police had perhaps considered that it best to employ climate control garments that may assist in reducing the stress and fatigue of its officers. Uniform logistics had perhaps made an informed choice to use a base layer garment with climate control as opposed to the typical heavy duty cotton or polyester garments that most Police departments, both locally and Internationally wear as a base layer garment, which typically has a limited amount of breathability.

Locally in Australia, comments were made in the year 2011 around the success of load bearing vest trials by currently serving General Duty Police Officers in Queensland, Australia. Police Officers commenting on uniform garment introductions, sometimes use social networking sites to do this, as opposed to well documented field trials or studies. The formal trial of a small number of General Duty Police Officers using load bearing vests in the Queensland Police Service was undertaken in the year 2010, and as an example of comments made around textile breathability, this is what a serving Queensland Police Officer said on a social networking web page dedicated to this trial;

> Have been seeing these on the beat, bobbies in England have used these for years. They really like the better weight distribution. However maybe a better material to stop heat rash for our people here in Australia. It is a bit hot for several months a year to wear something like this![73]

Another Police Officer Sargent Russell Garrard (2010) made these comments on a

72 Coolmesh® a high performance sport fabric uses a Moisture Management system and mult-filament technology that draws moisture away from the skin to the outer surface where it quickly evaporates, leaving skin cool, dry and comfortable.

73 Load Bearing Vests, by Queensland Police Service, Facebook 2011, viewed 3 May 2011, <http:/www.facebook.com/media/set/comments/?set=a.10150130531398254.299810.339665603253>

social networking web page dedicated to the Queensland police service load bearing vest trial;

> Re: bodily temperature of an officer, are these hotter to wear than a duty belt? Any limitation or restriction on movement?[74]

Of importance when it comes to online internet forums such as blogs and social networking sites, is that these forms of social media do often allow serving Police Officers, who generally possess significant field experience, to contribute their comments and suggestions. This type of commentary could be seen as being invaluable in the process of trialling a new garment such as a load bearing vest. Police Officers also look to these forums as a way of being able to contribute or input their views as to the conceptual and technical design of products such as the load bearing vests. Their feedback in such forums and particularly with anonymous surveys can be given without fear that officers may jeopardise their position or employment. This area of survey is important to recognise, given the sensitive nature of a Police Officer's employment and the political nature of the introduction of new products such as the load bearing vest to Police departments and emergency services alike.

4.3.3 Introducing the load bearing vest into Police Forces: Occupational Health & Safety (OH&S) considerations

Occupational Health & Safety (OH&S) considerations around the introduction of load bearing vests into Police Forces, should also take into account the fact Police Officers need to operate in different climatic regions and throughout different seasons of the year. Essentially load bearing vests are another garment that a Police Officer wears, another clothing layer in effect that needs to be considered from the point of view of layering and breathability. Textile choice is a very important consideration in relation to load bearing vest garment construction and layering. It may be very well to improve the load carrying capabilities for Police Officers by issuing load bearing vests to them and see a possible reduction in load related injuries, however it is paramount to realise that Police Officers may experience greater levels of fatigue throughout the course of their duties if the load bearing vest does not use the best possible solutions in terms of textile breathability and allow a good range of movement whilst in use. Load bearing vests aid the user in being able to carry greater loads by utilising the

74 Load Bearing Vests, by Queensland Police Service, Facebook 2011, viewed 3 May 2011, <http:/www.facebook.com/media/set/comments/?set=a.10150130531398254.299810.339665603253>

Figure 75. Ergon BC1 backpack

Images above: *Both hard and soft textiles are used in the fabrication. Ergonomic, flexible, superlight poly propylene (PP) frame allows eighty per cent of the load to be carried on the hips. Soft textile used is 420D nylon. Anatomically formed carrying system in two sizes. The carry-system has an adjustable hip belt regulating fit and hip adjustment*

Source; Ergon®, 2011 <www.ergon-bike.com/us/en/product/bc1>

human torso as opposed to the waist in isolation. In the case of the duty belt, the duty equipment load is centralised to one part of the body being the waist, which is problematic because of the fact that the load in not spread over a larger area such as the torso, which may improve the load carriage capabilities of a user. However load bearing vests or what are broadly known as load carrying platforms such as back packs and baby carrying harnesses, aim to distribute weight between the shoulders and hips, and provide in some cases lumbar support. The user, in the case of a baby carrying harness, must iintially ensure that the device is adjusted fairly well, in terms of fit to the torso, so that the load is spread proportionately between the shoulders and the hips, otherwise the user is at risk of spinal injury. A BabyBjörn ®[75] baby carrier can be used to carry babies up to a maximum weight of twelve kilograms. This fact makes the baby carrier and interesting product from load carriage research viewpoint, as it is similar to a General Duty Police load bearing vest - it is used to carry loads on the forward torso and is capable of carrying similar loads to that of a General Duty Police load bearing vest as used by New South Wales Police Officers.

4.3.4 Considerations around duty equipment innovations

New innovations in equipment technologies are an important and relevant consideration. Duty equipment is constantly changing and for the most part is becoming smaller in footprint and lighter in weight. This has the potential to reduce the load carriage burden for Police Officers, however new technologies must be evaluated hand-in-hand with the design of future load bearing vests to ensure that an optimal platform design is generated, that is as light weight and comfortable as possible.

4.3.5 Chapter conclusion

There are certainly many factors to consider when it comes to garment design for multi-performance. Advanced textiles, garment construction techniques and garments from categories such as motorcycle wear and sports wear, may help to inform the future design direction of load bearing vests for general duty police officers. Innovative solutions to duty equipment industrial design and logistical purchasing decisions will play an important role in reducing the duty load burden in the future.

75 BabyBjörn ®, a manufacturer of baby carrying harnesses <www.babybjorn.com>.

The research is an investigation and assessment and is not practice based research at this point in time. In this case practiced based prototypes are not being designed or developed as part of this research study. Due to the scope of the research undertaken at masters level, this was not possible given the realities involved in researching and developing a potential product design (load bearing vest) that would involve human trials.

Conclusion

The research has the potential to inform future design development in relation to General Duty Police load bearing vests, which are deployed in increasing numbers both locally in Australia and in Police Forces around the World.

The protection clothing market segment related to Police clothing is growing significantly, as Police Forces struggle to maintain the health and wellbeing of their members, at a time where much more duty equipment has been introduced, that requires Police Officers to carry an ever-burdening load. Police Forces have also begun to realise that providing higher levels of protection to their employees can reduce the frequency of compensation claims. A General Duty Police Officer's health, wellness and performance in operational situations is paramount and bsenteeism rates can be reduced through injury prevention. The safety wear market is also growing as Police Forces around the World break from tradition, in favour of uniform fabrications which employ advanced textiles aimed towards improving user comfort and wellness. This is clearly evident in just one part of the World, yet there are many more examples in the United States, for example the Spanish Guardia Civil have introduced a new uniform for General Duty Police Officers in the year 2011, which replaces a uniform design that has remained unchanged for decades. The new uniforms came at a cost of EUR 21.5m (AUD 26.6m) in total and are significantly more durable than the uniforms they replace.

The study aimed to make a positive contribution to user comfort and wellness related to reducing the human load carriage burden, through researching advances garment fabrication. Human load carriage from a physiological viewpoint may be considered in

terms of reducing the load burden and additionally can be considered in terms of the thermal burden to the user, particularly in hot climates

5.1 Research methodology discussion and the sigificance of the research

The nature of the main arguments in this research study were centred around researching General Duty Police duty belts and their related load carriage advantages and disadvantages. The main arguments presented in this research study were aimed at ascertaining how General Duty Police load bearing vests may improve load carriage efficiencies for Police Officers who carry an ever burdening equipment load, and how load bearing vests may reduce lower back injuries. The research study attempted to compare different types of related load carriage products, such as baby carrying harnesses and ruck sacks, to determine how such load carriage products could best inform load bearing vest design.

The study also questioned what role advanced textiles may have in improving comfort and wellness in human load carriage. Research based evidence around motorcycle and sports wear demonstrated that advanced textiles can be employed in garments such as the load bearing vest to improve comfort through usage of a combination of hard and soft textiles. Advanced textiles may prove to address additional issues, those issues that lead on from lower back injury protection, around reducing the thermal burden that users experience when wearing a load bearing vest in hot climatic conditions. Research based evidence suggests that humans may experience increased levels of comfort and wellness in such garments that employ advanced textiles that aim to increase breathability. Garments such as those used predominantly in motorcycle safety wear, such as motorcycle jackets that employ hard and soft textile elements may offer superior levels of fitting comfort and the garments themselves may due to the hard textile elements offer new ways of designing load bearing vest fabrications to better support load where it is needed.

The research study considered how load may be best carried over a larger surface area of the human body. Potentially the load could be split up across sites such as the torso, the waist and hips, and the legs, by using an ergonomic drop leg pistol holster for example. New and innovative ways that the military attempt to manage

issues around load carriage is also important to realise and further evaluation of these methods has been undertaken in this research study. If injuries related to load carriage can be reduced by sharing non-essential duty equipment across a greater range of police officers in the field this may prove to be advantageous in reducing injury.

Research based evidence suggests that load carriage and related injuries can be linked to the physical stature and the body mass of a human, those of greater stature and body mass are able to handle heavier loads more efficiently and the risk to users of receiving lower back injuries in this category is reduced. Such research based evidence can be found in Chapter 3, Page 109 prior to and under the sub-heading; The biomechanics of the human spine: Loads on the spine.

5.1.1 The significance of the research, new contributions to the field of load carriage

The significance of the research should be viewed in terms of the amount of users affected by human load carriage injuries and the fact that load carriage injuries in Police and Military applications have only increased in recent years with the advent of so much newly introduced duty equipment.

The research aims to clarify the complexities around judging whether or not load carriage methods that employ load bearing vests are biomechanically superior in being able to reduce back injuries. As Police Forces around the World scramble to address and attempt to reduce load carriage related injuries, it is important to try to understand the advantages and disadvantages over traditional load carriages methods such as duty belts.

Of significance is the fact that the amount of duty equipment is increasing as a greater range of duty equipment becomes available. Police Forces level these new technologies to better manage and reduce crime rates. In the United States there is a trend towards Police Officers carrying wearable computers to access data when they need it on foot patrol rather than having to return to their patrol vehicle as they traditionally would to access a laptop installed in the patrol car. Certainly future soldier combat systems all seem to feature wearable computers and this trend aims to broaden digital hardware availability in the field.

There is certainly no doubt that the applications of load carriage devices such as

load bearing vests and drop-leg holsters and pouches will become used in increased numbers across a broad range of Police departments and emergency service departments such as Fire and Ambulance. In a typical Police department alone their is potential to deploy load carriage equipment to Police units such as those that use motorcycles, bicycles, horses and even to water Police units in their daily duties where load carriage devices are required.

User field trials of prototype load bearing vests will be important in future studies and it may be possible to undertake field trials in conjunction with mannequin trials. There are at present "sweating mannequins" available for comfort performance testing in the United States. These types of research trials could become useful in future research studies to examine the effects of thermal burden and comfort performance in regard to current model load bearing vests versus newly developed future load bearing vest prototypes.

5.1.2 Discussion around the research methodology used in this research study

Secondary research was used as the main research methodology, human load carriage, biomechanics, advanced textiles and garment fabrication research was collated and a synthesis of existing research was conducted, as opposed to using primary research as the main research methodology. It is proposed that primary research methodologies be employed in future research studies where data is collected from user trials of prototype load bearing vests.

There were many pre-existing views that were challenged throughout the research study. That fact that garment design and fabrication in relation to advanced textiles and hard and soft textiles itself may have the ability to greatly improve user comfort and wellness in load bearing vest design is an important research outcome to realise. The initial industry belief that load bearing vests were themselves alone a catalyst for improved user comfort and wellness and to what extent they can prevent lower back injury was somewhat challenged during the research study. Load bearing vests may well improve human load carriage, however at this point in time, this has not yet been substantiated through well qualified studies anywhere in the World. Load bearing vests may provide a solution in part to reducing lower back pain, however to what extent must be measured more comprehensively perhaps in future studies against other performance factors such as breathability and the thermal burden impact that humans experience in conjunction with garment wear.

What was also realised during the research study was that similar load carriage products such as baby carrying harnesses, where load is carried primarily on the forward torso, spread the load mass across both the shoulders and hips. Spreading a load across a greater surface area and different regions of the human body may well prove to have greater biomechanical advantages.

5.1.3 The limitations and subsequent implications of these limitations related to this research study

There were many obstacles involved in obtaining valid research data relating to load bearing vest design throughout the duration of this research study. The reality is that there are limitations around obtaining well qualified data because of the sensitive nature of enquiries related to injury management in major Police Forces. More time is needed to negotiate with stakeholders such as is the case with the NSW Police Force in order to be able to administer future surveys or interviews that may proposed as being completely anonymous, so that richer research data may be obtained.

The study focuses on sourcing appropriate advanced textiles, therefore is important to note that the majority of manufacturers of these textiles which may assist in the reduction of injuries and superior comfort and wellness are based outside Australia. There is some difficulty in accessing such textile samples as manufacturers tend to want to deal with organisations that are of a substantial size before they start to provide textile samples. Textile manufacturers are also very cautious to release detail and textile samples to members of the general public because of issues related to confidentiality and intellectual property. Some manufacturers of advanced textiles also tend to create textiles that are fabricated exclusively for their brand. Companies such as Dainese® motorcycle safety wear and sports wear companies such as 2XU® fabricate their own textiles, they may have between fifty to one-hundred textiles that have been developed specifically for intended design criteria relating to the garments they design.

5.2 The main findings of this research study; New knowledge that has been discovered

To ensure that the research problem is better understood, realising the complexities of garment design and fabrication is key. Load bearing vest design needs to consider a wider ranging design brief that attempts to form strategies as to how Police can manage load carriage more efficiently.

The main findings demonstrate that much work needs to done in relation to what the biomechanical cost to the user is when they use a load bearing vest rather than a duty belt primarily and how load bearing vest design may encompass a greater range of factors to better improve user health and wellness.

Advanced textile developments and particularly making informed choices around the combinations of hard and soft garment fabrications may possibly produce innovative solutions for improving user comfort and wellness in load bearing vest design. Users and this is applicable to Police Officers in the NSW Police Force, may be able to better access hard textile pockets for example and re-insert duty equipment into these pockets single handed. Soft textile pockets tend to collapse and make it difficult for users to re-insert duty equipment when their hands are full.

Reducing the thermal burden for the load bearing vest user will ultimately be the tipping point for the overall success or failure of load bearing vest roll-out programs in major Police Forces throughout the World. It is important to realise that the environment that users work within may become a limiting factor due to thermal burden. The reality is that users, again using NSW Police Officers as an example, may suffer less in terms of back injuries, however they may in hotter climates, become exhausted more rapidly and suffer negative side effects from wearing a load bearing vest over extended periods of time. Clothing layering has particular advantages when aiming to manage the thermal burden to users, this is a relatively new concept for Police Forces that has not yet been fully exploited or considered to reduce thermal stress.

This study examines the fact that we are yet to really understand how load bearing vests act in terms of promoting improved spinal health and wellness. What are the long term effects of load carriage on the anterior torso? What are the effects of load carriage when seated, when entering or exiting a motor vehicle, running, leaping and in many dynamic movement scenarios? These are questions that have not been conclusively answered, it is important to validate data obtained from user trials so that users may benefit from enhanced load carriage equipment.

What perhaps has not been considered more comprehensively and strategically also, is the fact that Police Forces, such as the NSW Police Force, must attempt to predict the new technologies that they will wish to invest in ahead of composing a design brief for any future load bearing vest programmes. To that end, Police Forces must perhaps consider integrating more flexibility into future load bearing vests such as the military undertake to achieve, in using the reconfigurable Modular Lightweight Load-carrying Equipment (MOLLE) system for attachment of duty gear in a flexible, modular layout. Equipment innovations are rapidly changing the mass of duty equipment and purchasing decisions may need to incorporate staged roll-outs, or adaptive acquisition as the Australian Army terms this process, rather than purchasing technologies for an entire force that become superseded ever so quickly. The NSW Police may also consider strengthening relations with equipment manufacturers by partnering with other states and territories in Australia to obtain access to more advanced equipment, purchased on mass in order to gain more competitive pricing structures.

Ideal human load carriage mass limits seem to be something that eludes most load carriage administrators. Military Forces around the World no doubt struggle with this challenge of reducing the load burden to military personnel. In some cases the military use load to body mass ratios of around sixty per cent and even more in some cases, when research studies clearly demonstrate that humans should ideally use load to body mass ratios around fifteen per cent maximum. Military concepts around managing load carriage over a whole platoon rather than just at individual level, may also have merit in terms of reducing the likelihood or frequency of injuries in Police Officers of smaller stature and lower body mass who are most vulnerable to load carriage related injuries.

5.3 Future research and design development recommendations

This section contains an overview of possible future research and design development recommendations for Police Forces that wish to implement load bearing vests into their departments. The list of recommendation and considerations related to future load bearing vest design is not exhaustive and should be flexible enough to consider new research and solutions in load carriage as they evolve.

5.3.1 *Recommendation:* Advanced technical textiles, textile finishes

Recommendations in regard to the incorporation of advanced textiles into future load bearing vest prototypes and manufacturing are crucial in order to tackle issues around reducing the thermal burden to Police Officers in hot climatic conditions. Advanced textiles such as 3D spacer textiles, because of their inherit open wear configuration, offer solutions around garment cushioning and enhance garment climate control. Improved air flow generated by using 3D textiles means better air circulation between the layers and thus heat stress to the user can be reduced.

Textiles finishes such as ColdBlack® produced by Schoeller Textiles AG, also offer valid solutions in order to address climate control issues. Because of the fact that Police Forces generally tend to use dark colours in their uniforms, ColdBlack® may be beneficial in ensuring that dark coloured textiles behave in a similar way to light textiles when exposed to strong UV light, reflecting the heat more efficiently.

Better controlling the negative aspects of thermal stress, may ensure that Police Officers do not need to continually revert from wearing a load bearing vest, back to wearing a duty belt so frequently, simply because of hot climatic conditions.

More research needs to be undertaken in regards to Phase Change Materials (PCM) also, which may offer solutions towards improving climate control. Limited research at present suggests that Phase Change Materials may only be beneficial to climate control within a certain temperature range. This research at present does not seem to be conclusive.

5.3.2 *Recommendation:* Garment layering to enhance climate control;

Layering of garments is another component of garment design used to address climate control. The fact that the military and indeed some Police Forces are using wool as a base layer garment (as the first layer against the skin) can assist with enhancing climate control. Wool, because of its organic properties, offers superior anti-bacterial protection and is very efficient as a wicking layer, much more so than traditional, lower cost alternatives such as polypropylene wicking layers which are not efficient at exhausting perspiration when the temperature heats up.

5.3.3 *Recommendation:* Strategies to reduce the load carriage burden to General Duty Police Officers;

It should be noted that recent strategies used in Military applications to reduce the carriage load burden, by spreading equipment loads over an entire platoon collectively, may prove to be advantages to Police Forces. Additionally future procurement strategies should consider duty equipment that has a smaller foot-print and decreased mass if possible. Major manufacturers such as Motorola® may be able to provide better product forecasting as to what duty equipment may be available before it is released to market. It is therefore important that there is a strong future alignment between procurement of new duty equipment and hardware technologies that may offer reduced weight options.

5.3.4 *Recommendation:* User field trials for prototype General Duty Police load bearing vests;

Field trials are important in measuring gains and performance efficiencies when researching and analysing load bearing vest design. As so many Police Forces are now either implementing or considering introducing load bearing vests, it is important to gather and share data discovered in field trials. This information could be beneficial to accelerating superior solutions in load carriage systems both now and in the future.

Field trials should aim to be fairly comprehensive in terms of gaining valid data over longer testing periods. Factors such as general health and wellness, fitting comfort,

thermal burden analysis and physiological and biomechanical aspects of user field trials should be measured. The use of sweating mannequins in conjunction with user field trials may also be beneficial to providing a more holistic future research study.

5.3.5 *Recommendation:* Hard and soft textile combinations in load bearing vest design and fabrication;

Hard and soft textile combinations in garment design can be beneficial to load bearing vest design and fabrication. Hard and soft textile combinations are typically used in motorcycle wear to provide stiffness to the garment when required. In the case of a load bearing vest, it may be possible to better secure duty equipment on the vest by using hard textile elements. Ensuring that the duty equipment load is close to the torso may be better achieved also through the use of hard textiles.

5.3.6 *Recommendation:* Ballistic and stab proof protection;

In the case of New South Wales Police Force and like many International Police Forces, ballistic protection is not considered for incorporation into the load bearing vest. Ballistic and stab proof protection is generally not advantageous when it comes to climate control. The New South Wales Police Force ensures that Police Officers can access dedicated ballistic vests kept in patrol cars, however it may be possible to only carry ballistic or stab proof inserts that could be placed into pockets of future load bearing vests. Such ballistic inserts as opposed to using separate dedicated ballistic vests, could ensure that Police Officers are quickly protected when required. Police Officers could still access all their duty equipment that is carried on their load bearing vest in the case where inserts are added, as duty equipment at present cannot be carried on a dedicated ballistic vest. Also when hot climatic conditions emerge, Police Officers would not have to manage the extra thermal burden created by ballistic or stab-proof protection.

5.3.7 *Recommendation:* Deploying load bearing vests in conjunction with high visibility garments;

Police Officers may in the future be able to use a lightweight, compact and foldable high visibility vest in conjunction with a load bearing vest. When required, Police Officers could remove a high visibility vest from a pocket located on the load bearing

vest, the vest could be tailored in such a way to not interfere with access to duty equipment holsters and pockets. This could prove to be a superior alternative to what Police currently do in New South Wales where they use a high visibility vest to go over the entire vest making it much more difficult to access duty equipment. In the state of Western Australia, General Duty Police Officers are issued with a convert and high visibility load bearing vest. This has particular disadvantages relating to the ritual of use, where Police Officers need to swap their whole duty equipment load as required between the two vests, making it difficult to readily swap operative tasks. Also, a smaller surface area of high visibility textiles may be possible to achieve in conjunction with the use of lightweight LED strobe lighting as used in bicycle wear.

5.3.8 *Recommendation:* Occupational Health and Safety (OH&S) - The physiological and biomechanical aspects of load bearing vest design;

Police departments or uniform logistics may consider the need to establish an integrated programme of using 3D body scanning technologies for each and every Police Officer when they are being issued with a new uniform , to ensure improved fitting comfort and ergonomic considerations are address. This process is undertaken with soldiers in the United States Marine Corps at present, so that fit to body is superior.

Spreading the duty equipment load over the shoulders and hips when undertaking to design the load bearing vest is important to consider. The hips and shoulders are generally employed in combination in load carriage products such as baby carrying harnesses or even ruck sacks that are used predominantly in mountaineering. Garment designers leverage the fact that load is spread more evenly across the hips and shoulders and provide better comfort. When both the hips and the shoulders are used in load carriage tasks, the equipment load is dispersed more evenly.

Another area that is valid in terms of improving the load carriage around physiological wellbeing it to consider sharing equipment load across other sites on the human body such as the thighs. The quadriceps muscles of the thigh are are big muscle that can easily accommodate a portion of the total duty equipment load. An ergonomic drop

leg pistol holster could be used on one leg, whilst a ergonomic drop leg pouch or even a taser could be carried on another leg.

5.3.9 *Recommendation:* Creation of strategic industry partnerships with major specialist manufacturers of technical garments;

In recent times companies such as Dainese® have teamed up with NASA, to develop specially designed garments that astronauts can wear in outer space. Dainese became involved in this ambitious challenge at the request of M.I.T., the Massachusetts Institute of Technology of Boston. The bulky spacesuits worn today that are pneumatically pressurised by a special device on the back will be replaced by lightweight suits that ensure greater freedom of movement. The Biosuit will be aided by certain points in the human body to which high pressure can be applied without limiting freedom of movement.

These sort of industry partnerships allow for specialised garments such as load bearing vests to be developed with the aid of textile designers who have an intimate knowledge of the processes involved in the development of new and innovative textiles, aimed at addressing specific performance criteria. Innovations related to custom made textiles created by major motorcycle and sports wear companies should be considered. Making strong bonds with garment manufacturers who lead the way in the creation of advanced textiles would enable access to a larger pool of advanced textiles, such as those produced by garment manufacturers such as 2XU® and Skins®.

5.3.10 *Recommendation:* Creation of an International research collaboration around load bearing vest implementation programmes into major Police Forces;

Military allies research and develop new technologies in many instances by collaborating with one another in order to achieve an optimum result. Police Forces may benefit from a larger body of research to develop new ways and means of creating load carriage systems. An International data bank of injury information compared to a subjects body mass and height may begin to help researchers to

gain a better understanding the negative effects of load bearing vests when used in operative situations.

5.3.11 *Recommendation:* Monitoring health and wellness in General Duty Police Officers;

Regular scheduling of health checks for General Duty Police Officers targeted specifically at spinal health and wellness, may allow Police Forces to develop a broader picture of the way in which they can look towards preventing load carriage issues in the first place. Scheduled spinal health and wellness checks could also allow Police Forces to better manage issues that occur as a result of load carriage injuries.

5.3.12 *Recommendation:* Sourcing of lightweight energy storage hardware for electronic duty gear;

Energy requirements for Military and Police applications will always probably become even more demanding than what exists in the current era. Lithium ion batteries and LED technologies have assisted in making a range of duty equipment available to Police Officers. Vibration energy harvesting devices may in the future help to produce the energy that can be stored in batteries. There is no doubting that batteries will become smaller in the future and more efficient which will benefit human load carriage. Solar technologies may also inform garment design in the future as they too become more efficient and realistic means of generating the power required to use wearable computers, digital radios, mobile phones, torches and alike.

5.4 Chapter overview

In conclusion this research study has identified the need for improved research and development strategies into load bearing vest roll-out programs for General Duty Police. The research study also realised the fact that injuries related to load bearing vests and load carriage, still needs to be carefully monitored and evaluated to ensure that Police are well protected from ongoing back injuries caused as a result of load carriage when using a load bearing vest.

When it comes to organising primary research, this could be earmarked for future research studies that may involve field user trials of prototyped load bearing vests. It will be important to realise that field trials should consider studying a variety of users ranging from small stature to large stature, additionally, other factors such as thermal burden could be evaluated so that the study is more comprehensive in terms of overall occupation health and wellness. Future studies should consider producing a wide range of prototype load bearing vests sizes and this will involve considerable costs. This was a limiting factor in this research study, and one that could be better addressed perhaps in future studies, where time limits are less compressed. Not only is a good budget required to produce a series of effective load bearing vest prototypes, but funds must be allocated to training Police Officers in the use of the prototypes if they are to be used in field trials and this has a costs attached.

The richness of this research study and the commitment undertaken to make sure these studies were successful, involved researching International approaches to General Duty Police load bearing vest design. The positive aspect to this research study is that it will enable the writer to develop stronger future research outcomes and help inform the design and development of a series of future load bearing vests for use in field trials. With the advent of newly introduced Work Health and Safety (WHS) legislation and the harmonisation of WHS laws there will no doubt be increased demanded placed upon public sector employers such as the New South Wales Police to provide protective wear to its member to ensure their ongoing health and wellness. The field of Industrial Design can also benefit from cross-discipline studies into related industry areas such as technical fashion design, an industry that has been growing substantially as a result of a new demand for increased levels of Occupational Health and Safety in garment design and development.

References and Bibliography

Antonelli, P., Greenspun, J., Washburn, A. & Museum of Modern Art 2005, 'Safe: design takes on risk', Museum of Modern Art, New York.

Blain, J. 2012, 'Soldier modernisation in Australia', *Soldier technology conference*, London, viewed June 15 2012, < http://www.wbresearch.com/soldiertechnologyeurope>.

Braddock, S. & O'Mahony, M. 2002, 'SportsTech: revolutionary fabrics, fashion and design', Thames & Hudson, London.

Braddock, S. & O'Mahony, M. 1998, 'Techno textiles: revolutionary fabrics for fashion and design', Thames and Hudson, London, England.

Braddock, S. & O'Mahony, M. 2005, 'Techno textiles 2: revolutionary fabrics for fashion and design', Thames & Hudson, London.

Brian, K. 2004, 'Updating Sam Browne: designing better load bearing systems for the modern peace officer, *Irons Golden Gate University*, July 30, 2004.

Bryan, J., Stevenson, M., Bossi, L., Reid, S., Pelot., Morin, E. 2004. 'Optimizing load carriage systems', Ergonomics in design, winter 2004, pp.12-17.

Chauhan, D. 2000, 'Review of Literature on cooling garments', EA Journals, viewed 5 December 2011, <http://www.ergonomics.org.au/downloads/EA_Journals/Cooling_Garments_-_chauhan.pdf>.

Craik, J. 2005, 'Uniforms exposed from conformity to transgression', Berg, New York.

Das, A. & Alagirusamy, R. 2010, 'Science in clothing comfort', Woodhead Publishing, New Delhi.

Department of National Defence 2011, Designing Canada's Army of Tomorrow, Department of National Defence, Ontario, Canada.

Defence Research and Development Canada 2004, *Development and assessment of the Canadian personal load carriage system using objective biomechanical measures*, Taylor & Francis healthsciences, Ontario, Canada.

Defence Research and Development Canada 2006, *Assessment of Design Modifications to Final Clothe the Soldier Rucksack*, Department of National Defence, Toronto.

Department of Innovation, Industry, Science and Research 2011, *Trends in manufacturing to 2020*, Future Manufacturing Council, Canberra.

'Future soldier expanded system: Rheinmetall to supply the Bundeswehr with cutting-edge Gladius infantry equipment', *Defense News*, June 19.

Halberstadt, H. 2006, 'Battle rattle: the stuff a soldier carries', Zenith Press, St. Paul, MN.

Hall, S. 2011, 'Basic biomechanics', 6th edn, McGrath Hill, Australia.
Hancock, P.A. & Szalma, J.L. 2008, Performance under stress, Ashgate Pub. Co., Burlington, VT.

Havenith, G, 2000, *The Interaction of Clothing and Thermoregulation*, Human Thermal Environments Laboratory, Department of Human Sciences, Loughborough University, UK.

Herbert, J. 2012, 'Canadian Army soldier burden analysis', *Soldier technology conference*, London, viewed June 15 2012, < http://www.wbresearch.com/soldiertechnologyeurope>.

Knapik, J. & Reynolds, K. 2010, 'Load Carriage in Military Operations', Borden Institute Monograph Series, viewed 20 November 2010, <http://www.usariem.army.mil/pages/download/LoadCarriagePDF.pdf>.

Kuklane, K. & Holmér, I. 2000, 'Ergonomics of Protective Clothing', 1st European conference on protective clothing, viewed 2 August, 2011, <http://www.es-pc.org/proceedings/1th_ECPC.pdf>.

Lee, S., Du Preez, W. & Jones, N.T. 2005, Fashioning the future: tomorrow's wardrobe, Thames & Hudson, London.

Li, Y., Dai., X. & Textile Institute 2006, 'Biomechanical engineering of textiles and clothing', CRC Press; Woodhead Publishing, Boca Raton; Cambridge.

Murray, K. 2004, 'Training at the speed of life the definitive textbook for military and law enforcement reality based training', Armiger Publications, Gotha, FL.

Myers-McDevitt, P. 2004, 'Complete guide to size specification and technical design', Fairchild Publications, New York.

NATO Research and technology organisation 2001, 'Soldier Mobility: Innovations in Load Carriage System Design and Evaluation' Papers presented at the RTO Human Factors and Medicine Panel (HFM) Specialists' Meeting held in Kingston, Canada, 27-29 June 2000.

O'Mahony, M. 2011, 'Advanced textiles for health and wellbeing', Thames & Hudson, London.

Orloff, H., Csonka, P., Csonka E. & Ho Lee, T. 2001, 'Effects of load carriage on curvature of the spine', Biomechanics Symposia 2001, University of San Francisco, pp. 180-183.
Preez, W. & Jones, N. 2007, 'Fashioning the future : tomorrow's wardrobe', Thames & Hudson, London.

Redkop, V & Paré, S. 2010, 'Beyond Control: A Mutual Respect Approach to Protest Crowd Police Relations', Bloomsbury Academic, London.

Reid, S., Bryant, J., Stevenson, J. & Abdoli, M. 2005, 'Development of a Dynamic Biomechanical Model Version 2 of Human Load Carriage', Defence Research and Development Canada, viewed 12 November 2011, <http://www.dtic.mil/dtic/tr/fulltext/u2/a481128.pdf>.

Robin, M., Johnston, V., Coyle, J. & Pope, R. 2011, 'Load carriage and the female soldier', Journal of Military and Veterans' Health, vol. 19, no. 3, pp. 25-34.

Royal Melbourne Institute of Technology 2011, *The Assessment and Evaluation of the Comfort and Protection of Advanced Textiles*, International Specialised Skills Institute, Melbourne.

Seymour , S. 2008, 'Fashionable technology : the intersection of design, fashion, science and technology', Springerwien, New York.

Silverman, E. 1999, 'NYPD battles crime: innovative strategies in policing', Northeastern University Press, Boston.

Song, G. 2011, 'Improving comfort in clothing', vol. 106, Woodhead Publishing, Oxford, Philadelphia.

Stone, R. 2000, 'Sam Browne and beyond: A look at duty belts', *The Law Enforcement Magazine*, viewed January 28, 2010, <http://www.iwitts.org/law-enforcement/resources/142-sam-browne-a-look-at-duty-belts>.

Sweeney, P., Ferguson, T. & Sweeney, P. 2004, 'Modern law enforcement: weapons & tactics', 3 edn, Krause Publications, Iola, WI.

The Force: 150 years of NSW Police 2012, Justice & Police Museum, Sydney 12 May - 7 October.

Tsvetanov, B. & Ing, M, 2010, '3D textile Structures – technology overview', The Institute of Textile Science 107th Scientific Session, Québec, viewed November 2011, <http://www.textilescience.ca/downloads/3D_textile_structures.pdf>.

U.S. Army Research Institute of Environmental Medicine 2000, *The effects of backpack weight on the biomechanics of load carriage*, no.T00-17, U.S. Army Research Institute of Environmental Medicine, Natick, MA.

U.S. Department of Justice 2010, *Ergonomic Load Bearing Systems*, Blackhawk Products Group, Virginia, USA.

Appendix

ITEM 1 New South Wales Police Load Bearing Vest Tender document, 2009.

ITEM 2 Specifications for Load Bearing Vests (LBV) for the NSW Police Force.

ITEM 3 NSWPF Load Bearing Vest Concept, Daily Telegraph, 2009.

ITEM 4 Confirmation of candidature product images, 2012.

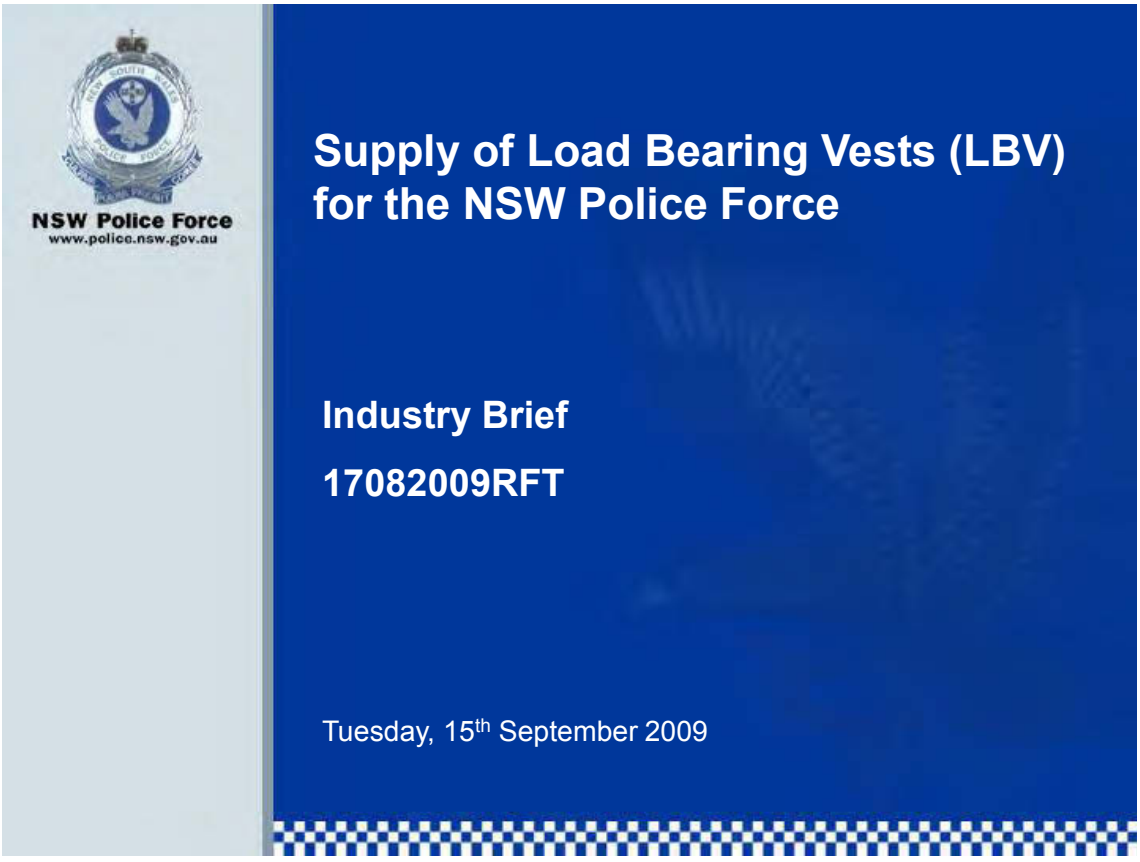
ITEM 5 Australian Army Uniform Issues, Daily Telegraph, 2009.

ITEM 6 L-REFLEX® Brochure.

ITEM 7 SoldierTech conference UK, 2012.

ITEM 1

New South Wales Police Load Bearing Vest Tender document, 2009.


NSW Police Force
www.police.nsw.gov.au
Supply of Load Bearing Vests (LBV) for the NSW Police Force
Industry Brief
17082009RFT
Tuesday, 15th September 2009

Introduction

Welcome

Speakers today include:

- Mark Herrero, Procurement Manager
- Senior Constable, Paul Bugden
- Inspector, Peter Davis

NSW Police Force

Objective

The objective of today is to provide all prospective Suppliers a comprehensive understanding of NSWPF requirements and expectations.

NSW Police Force

Industry Brief Agenda

- Background (Senior Constable, Paul Bugden)
- Tender process and documents (Mark Herrero)
- LBV Specifications (Inspector, Peter Davis)
- Questions

NSW Police Force

Tender Details

RFT Name	Supply of Load Bearing Vests (LBV) to the NSW Police Force
RFT Number	17082009RFT
RFT Closing Time and Date	**9:30am, Tuesday, 27th October 2009**
Address of Tender Box	e-Tenders - https://tenders.nsw.gov.au **and** One (1) hard copy marked "original" and two (2) hard copies marked "copy" to be delivered to:- NSWPF Tender box, NSW Police Force Headquarters 1 Charles Street, Parramatta NSW 2124
Samples To:	NSW Police Force 1 Charles Street Parramatta NSW 2150

NSW Police Force

Background

Senior Constable, Paul Bugden

NSW Police Force

Background

Due to an increase in the amount of operational equipment carried by NSWPF officers, there has been a gradual increase of weight on the appointments belts. This increase in weight has resulted in injury and discomfort to some operational officers. The common issues relate to back pain and this has been attributed to the appointments belt and the weight of that belt.

The NSWPF is seeking proposals for a Load Bearing Vests (LBV) that meets the NSWPF requirements. The wearing of LBV will be at the discretion of each individual officer. If an officer decides to wear a LBV it will be procured and issued as an individual tracked item.

NSW Police Force

Time Table for Tender Process

Event	Date
RFT issued	2nd September 2009
Industry Briefing held (see Clause 8.1)	10:30am, Sydney Time Tuesday, 27th September 2009
RFT closes (Closing Date)	9:30am, Sydney Time Tuesday, 27th October 2009
Evaluation of Proposals	Early November 2009
Successful Respondent announced	Mid to Late November 2009

Evaluation will commence immediately after the closing date.

NSW Police Force

Clarifications & Point of Contact

If you require clarification regarding this RFP, send an email to

procurement@police.nsw.gov.au

Mark Herrero
Procurement Manager
Strategic Procurement & Contract Services
Phone: +61 2 8835 9155
Fax: +61 2 8835 8076

NSW Police Force

Tender Process and Documents

This RFT is made up of Parts A to D.

Part A – Conditions of Tender

Part B – Terms and Conditions

Part C – Specifications LBV

Part D – Tender Response

Each Tenderer must check that it has each Section of the RFT document.

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Addenda to RFT Document

Each proponent that has downloaded the RFP will receive an email notification of the release of a new addendum.

Part A – Conditions of Tendering

Provide you with the conditions of tendering

Provides an introduction to tender documents, outlining the process, the details of the proposal and a brief overview of the requirements

NSW Police Force

Term of the Contract

The contract term is three (3) years, with the option to extend for a further two (2) by one (1) year periods to a maximum of five (5) years.

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Part B – Terms and Conditions

Terms and Conditions of the Contract

It is a condition of this tender that the Respondent substantially accepts the terms and conditions of this Agreement. It is felt that unless there is a serious error or omission or lack of clarity in the document, the NSWPF will generally not enter into negotiations relating to any changes to the agreement.

NSW Police Force

Part C - Specifications

The Supplier is required to supply and deliver Load Bearing Vests (LBV) to meet the requirements of the NSWPF.

The LBV is not to include any type of Body Armour (including; covert vests; overt vests and ballistic strike plates).

The RFT will include the following service provisions:

- Source or Manufacture Goods;
- Warehouse:
- Distribution; and
- Tracking of items (LBV).

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Part D – Tender Response

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Format of Proposals

All responses must be compatible and accessible with Microsoft 2003 applications

Examples:
Microsoft Word 2003
Microsoft Excel 2003
Access as Access 2003
Diagrams a Visio 2003 compatible or JPG images
PowerPoint as PowerPoint 2003
Project Plans as Project 2003

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Presentation of Proposals

An Executive Summary of the Proposal;

Proposed response addressing all areas identified in Part D of this RFT; and

Any other relevant information

Follow the format of questions outlined in Part D.

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Statement of Compliance

Provide a statement of compliance in respect of Parts A, B and C.

Compliance with Part B – Terms & Conditions

-up version of the Terms & Conditions with all amendments sought.

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Samples

Respondents to the tender are to provide samples of their proposed LBV.

One of each size sample to be provided in the following sizes:

1. Small (S); and
2. Extra Large (XL).

Note: One sample vests is to be Left Hand and the other sample vest is to be Right Hand.

Respondents may submit more than one vest.

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Tender Criteria

MANDATORY CRITERIA

- Compliance with proposed Specifications (as listed in the Specifications as a **MUST**)

NSW Police Force

Tender Criteria

DESIRABLE CRITERIA

- Capacity and capability to provide products (including delivery considerations, availability of stock and accessibility of product range).
- Industry experience, production, technical and organisational capacity, warranty and quality assurance systems to service the contract.
- Specifications and quality of samples:
  - Durability
  - Wearability
  - Accessibility to Appointments
- Pricing considerations and Value for Money
- Industry (or SME) participation plans.

NSW Police Force

Lodgement

All Proposal must be submitted by electronic lodgement through the NSW Government eTendering website.

www.tenders.nsw.gov.au

Electric files should be a format that can be read by standard office software.

If you require clarification regarding this RFT, send an email to procurement@police.nsw.gov.au

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Lodgement (cont)

Retain Part A, B and C when submitting your Proposal.

Submit Part D and any attachments. Ensure they are cross referenced to the appropriate clause or question.

NSW Police Force

NSW Government eTendering Website

This website is managed by:

NSW Procurement - eBusiness Solutions
NSW Department of Commerce

Email: ebs_supportdesk@commerce.nsw.gov.au

(02) 9372 8333 (International +61 2 9372 8333)

Hours of operation are 8:30am - 5:00pm, Monday to Friday.

NSW Police Force

LBV Specifications

Inspector, Peter Davis

NSW Police Force

LBV Specifications

General Requirements

This Specification is for the supply and delivery of LBV to the NSWPF.

The LBV shall allow NSWPF officers to be able to sit comfortably in a car, walk a patrol or be involved in a foot chase and allowing reasonable freedom of movement.

NSW Police Force

LBV Specifications

Vest Material, Construction and Sizing

- Fire Retardant
- Heat Management
- Construction
- Sizing
- Name Plate & Markings
- Weight Distribution & Vest Retention Systems

NSW Police Force

LBV Specifications

Appointment Carriers

- Oleoresin Capsicum (OC) spray
- Extendable Baton
- Handcuffs
- Portable Motorola Radio
- TASER (Electronic Control Device) and Cartridges

NSW Police Force

ITEM 2

Specifications for Load Bearing Vests (LBV) for the NSW Police Force.

NSW Police Force
www.police.nsw.gov.au

1.1 Appointment Carriers

Please refer to Part C – Appendix A – Example drawing

The configurations of the appointments are NSWPF suggested only.

Depending on configuration required, the LBV should have the potential to carry the following five (5) appointments:

1.1.1 Oleoresin Capsicum (OC) spray

- The OC spray canister is 110mm (height) x 37mm (diameter)
- The carrier portion of the unit (ie. NOT including the closing flap) **must be no more than 80mm in height** (i.e allowing 30mm of the canister to protrude out the top of the carrier for easier access)
- The carrier unit itself **must be cylindrical in shape.**
- The material itself **must be rigid, with a hard-shell-style casing to enhance deployment and provide a level of protection to the canister from unintended impact / pressure'.**
- The enclosing flap of the carrier has to come down firm on top of the OC and be secured in place by a durable closure system by utilising, where possible, either a combination of both press-stud and 'silent' velcro (e.g. 'Duel Lock' offered by 3M).
- Position on LBV: (STRONG side – NSWPF suggest the lower portion of LBV, as close to central zipper as possible – please refer to Part C – Appendix A – Example drawing)

1.1.2 Extendable Baton

- The carrier needs to be capable of holding the NSWPF issue extendable baton which (when collapsed) is 195mm (height) x 25mm (diameter)
- The carrier portion of the unit (ie. NOT including the closing flap) **MUST** be no more than 130mm in height (i.e allowing 65mm of the canister to protrude out the top of the carrier for easier access)
- The carrier unit itself **MUST** be cylindrical in shape

- The material itself **MUST** be rigid, 'with a hard-shell-style casing so it remains contained within the carrier'.
- The enclosing flap of the carrier has come down firm on top of the baton. The unit must be secured in place by a durable closure system utilising, where possible, either a combination of both press-stud and 'silent' velcro (e.g. 'Duel Lock' offered by 3M).
- POSITION ON LBV: (SUPPORT side - NSWPF suggest angled approx 20 degrees away from centre line of body - please refer to Part C – Appendix A – Example drawing)

1.1.3 Handcuffs

- Of the two model of handcuff on issue, the Saflok Mk V are the largest with dimensions 130mm (height) x 75mm (wide) x 25mm (depth).
- The carrier unit itself **MUST** be squared off at the TOP and BOTTOM (i.e. NOT taper into the lower edge of the LBV) so as to enclose the handcuff without making them come out of 'rachet', prevent excessive noise and movement, and possibility of the handcuffs falling out of the carrier, when running or jumping objects or restraining offenders.
- The enclosing flap of the carrier has come down firm on top of the Saflok Mk V and **MUST** be secured in place by a durable closure system by utilising, where possible, either a combination of both press-stud and 'silent' velcro (e.g. 'Duel Lock' offered by 3M).
- The Saflok Mk IV handcuffs are also on issue to police, and approximately 20mm smaller in height (ie. 110mm). The other measurements of the Mk IV are the same as those of the Mk V.
- Therefore, the one carrier itself should be able to accommodate the Mk IV or Mk V Saflok handcuffs.
- To allow for the smaller Mk IV model, the enclosing flap of the carrier **MUST** have **a second press-dud approximately 20mm lower than the main press-dud on the inside of the enclosing flap.**

POSITION ON LBV: (SUPPORT side - NSWPF suggest behind expandable baton, just above hip – please refer to Part C – Appendix A – Example drawing).

1.1.4 Portable Motorola Radio

- The radio carrier consists of the unit itself with a double length of elastic attached to the front of the unit beneath a piece of nylon.
- The radio currently on issue to NSWP is the Motorola XTF 3000 model. The dimensions of this unit are 180mm (height – not including control dials / aerial & handpiece attachments on top) x 65mm (width – not including handpiece attachment) x 40mm (depth).
- The carrier **MUST** have the ability to house the portable hand piece and provide a microphone docking station of some kind for the radio.
- Suggested width and (horizontal) depth of the carrier is 70mm X 45mm.
- However, as with the other carriers, the radio carrier **MUST** be rigid and squared of at the top and bottom (i.e. NOT taper into the lower edge of the LBV) so as to enclose the radio and prevent excessive movement and the possibility of the portable falling out of its carrier, when running or jumping objects or restraining offenders.

- The double elastic fastening strap which comes down over the top of the radio attaching at the front of the carrier, **MUST** have a double stud clip to secure the radio in place.

POSITION ON LBV: - (STRONG side – NSWPF suggest the lower portion of LBV beside OC carrier – please refer to Part C – Appendix A – Example drawing)

1.1.5 TASER (Electronic Control Device) and Cartridges

The NSWPF has two (2) options for the inclusion of Taser into these vests:

1. The TASER & Cartridges are placed on LBV** – it's a requirement of a 'locking /coupling system, for the Blackhawk 'Serpa' TASER. The holster can be clipped on and off and be interchangeable between officers.

OR

2. The TASER & Cartridges remain on belt

**Cartridge Pouch – The 'Serpa' holster does not offer an attached Electronic Control Device (ECD) spare cartridge carrier directly to the holster, as is the case with the current Blade-Tech holster. However to meet this requirement a spare cartridge carrier is to be mounted to the load bearing vest in a purpose built carrier. The material out of which this carrier should be made is of a hard shell-style design carrier to protect the TASER cartridge from damage and allow for greater ease of deployment /replacement.

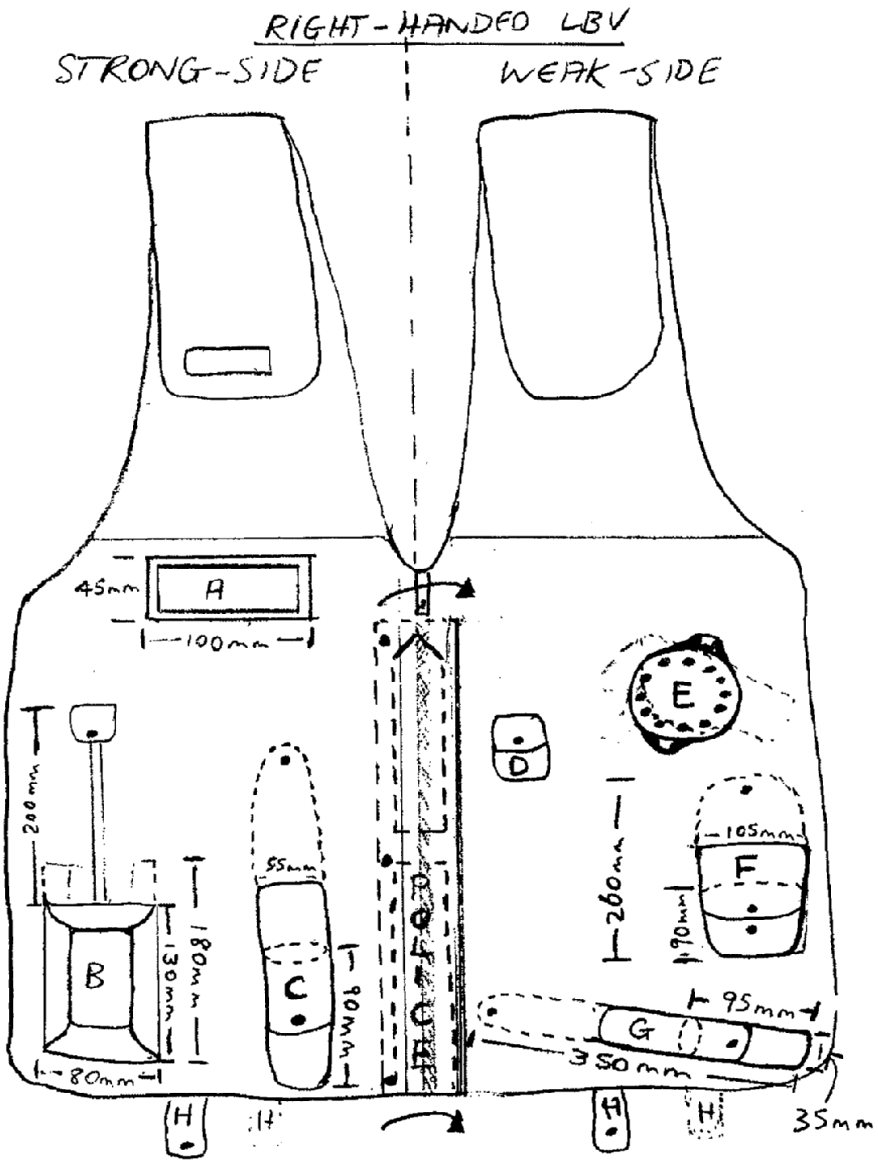
POSITION OF TASER (MOUNTING PLATE) ON LBV: (SUPPORT side – the Taser **MUST** be placed in a cross-draw position, closer to the lateral line of the body rather than on the centre line of the body / torso / chest / upper physiognomy - please refer to Part C – Appendix A – Example drawing)

POSITION OF SPARE CARTRIDGE POUCH ON LBV: (SUPPORT side – NSWPF suggest the upper portion of the LBV close to the central zipper – please refer to Part C – Appendix A – Example drawing).

2 Appendix A – Example Drawing

Key:

Letter	Description	Measurements
A	Name Badge	45 mm (H) x 100mm (L)
B	Radio Carrier	Width (across top) - 80mm Height (entire pouch) -180mm Height (carrier section) – 130mm Length (fastening strap) – 200mm Depth (carrier unit) – 60mm
C	O/C Spray	Width (across top) - 55mm Height (with flap open) -260mm Height (carrier section) – 90mm Diameter (carrier section) – 35mm
D	Taser Cartridge Pouch	
E	Taser Base Plate	To fit 'Blackhawk – Serpa Holster & angle away from body
F	Handcuffs	Width (across top) - 105mm Height (flap open) -260mm Height (carrier section) – 90mm Depth (carrier unit) – 35mm
G	Extendable Baton	Width (across top) - 35mm Height (flap open) - 350mm Height (carrier unit) – 95mm Diameter (carrier unit) – 25mm
H	LBV Keepers	Refer to clause Part C 4.6 of this document



- This example drawing indicates a right handed vest.
- The Taser Holster as shown is indicative only of where a Mounting Plate to attach such a carrier, could prospectively be positioned.
- The Taser cartridge is to be placed on the opposite or away from the radio.

ITEM 3

NSWPF Load Bearing Vest Concept, Daily Telegraph, 2009.

dailytelegraph.com.au | monday, september 14, 2009

Stunning new style on streets

Simon Benson
State Political Editor

A $1 MILLION redesign of the NSW Police uniform has been ordered because police aren't able to fit Tasers on to their belts.

From next year all officers will be issued with load-bearing vests to carry up to 7kg of equipment.

The Daily Telegraph has learned that a tender was issued last week to replace all police belts with load-bearing vests and it is believed the Government has budgeted for a cost of more than $1 million.

Police sources confirmed that the belts currently used by police to holster a range of items, including guns, batons, capsicum spray and torches, could not accommodate the roll out of stun guns.

The radical new look for the police, modelled on the UK and European uniforms, will be rolled out before the end of the year. It is expected guns will be relocated from belts to thigh holsters.

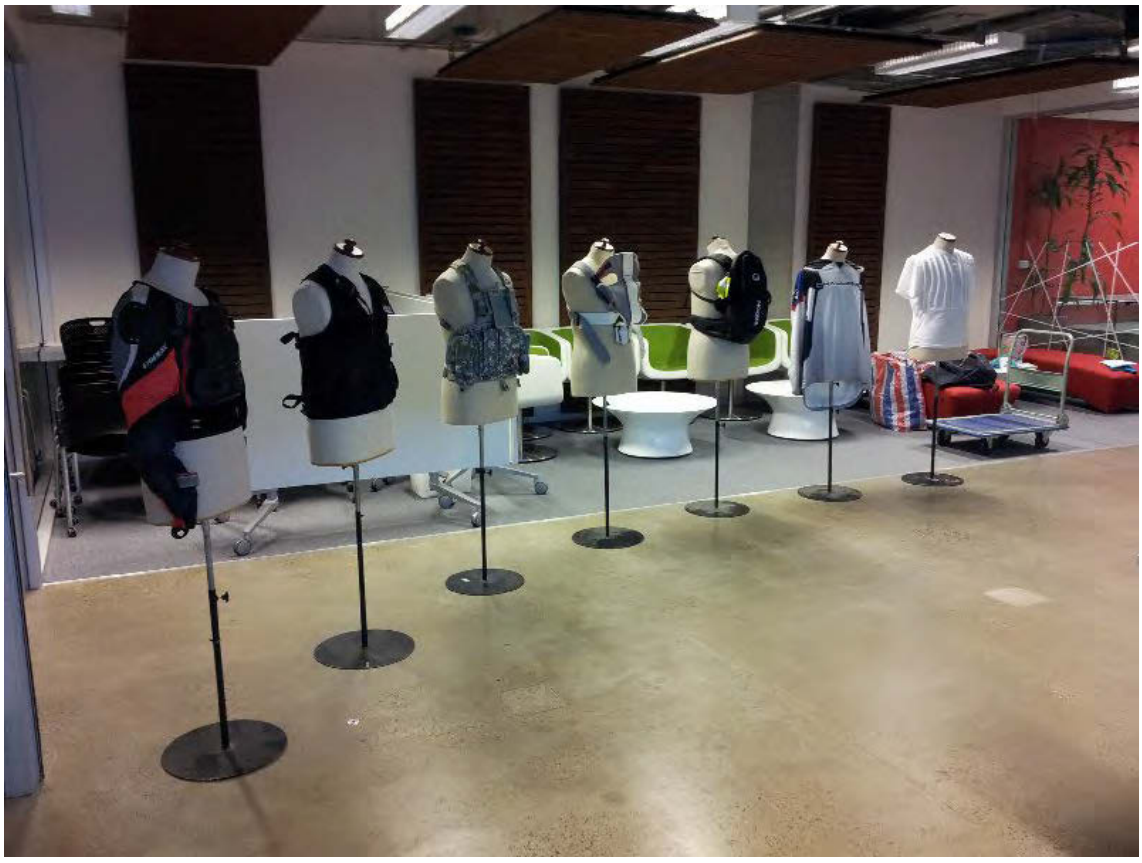
NSW Police Association secretary Peter Remfrey said the belts caused more than 1000 back and hip injuries a year among police officers, and women struggled to fit all their equipment on them.

"We've trialled the vests and they work," he said.

It is expected the vests will save up to $1 million a year in worker compensation claims.

ITEM 4

Confirmation of candidature product images, 2012.



ITEM 5

Australian Army Uniform Issues, Daily Telegraph, 2009.

Body armour puts Diggers in danger

exclusive

Ian McPhedran
Defence Writer

AUSTRALIAN soldiers fighting on foot in Afghanistan are being put at greater risk of enemy fire because they have to wear heavy, hot body armour that does not allow them to fire their weapons properly.

Troops said the armour, known as the Modular Combat Body Armour System (MCBAS) is so heavy and inflexible that at times they could not even adopt the correct firing position to use their weapons.

Getting themselves into an effective position under their heavy load added valuable seconds to the response times of troops serving in mobile combat teams, potentially placing them at greater risk of enemy fire.

The armour also lacks ventilation which can also be a life or death issue when temperatures hit 45C for weeks on end.

Special forces soldiers and infantry trainers working in the Operational Mentor and Liaison Teams (OMLTs) training Afghan troops, are permitted to wear a 6kg lighter armour rig called American Eagle.

Despite numerous complaints up the chain of command, soldiers from the Townsville-based 1RAR have been forced to endure a blistering summer with 10.8kg of body armour on top of all their other equipment.

The Australian Defence Force has admitted that the MCBAS, which was delivered in large numbers in 2008, is not suited to Afghanistan and has promised to remedy the situation by providing a new lighter-weight armour plate.

"Originally designed for use in Iraq where the majority of operations were mounted, it is now being adapted to better deal with the dismounted operations increasingly being conducted in Afghanistan," a Defence spokesman said.

"These tasks require a much greater level of individual mobility than previously experienced in Iraq."

The army's director of logistics Colonel Andrew Bottrell said the army was trying to obtain the right balance between ballistic protection and mobility.

"Things change and we recognise that," Colonel Bottrell said.

He said a new system would be introduced to give the commander on the ground the flexibility to decide what form of armour should be worn based on whether the threat came from blast or mobility.

Both forms of armour have saved troops from the Taliban's improvised explosive devices (IED).

However, soldiers who have been ambushed have found the MCBAS armour to be too cumbersome.

"These things are not only heavy they are bloody dangerous," an un-named soldier told *The Daily Telegraph*."

Online interactive

Go on tour with Aussie soldiers in Afghanistan

dailytelegraph.com.au

Heavy lifting

1. Kevlar helmet
2. Radio headset and microphone
3. Ballistics sunglasses
4. Admin pouch containing maps, GPs and compass
5. Squad radio
6. 2L Camelback drink bottle (on his back)
7. Steyr rifle
8. 40mm high explosive grenade launcher
9. Rations and night vision goggles
10. First aid kit
11. Three pouches each with three magazines with 30 rounds
12. Drop bag (for empty magazines)
13. Ballistics plate (front and back)

ITEM 6

L-REFLEX® Brochure.

The 3 FAQ's

Why does L-REFLEX® perform better than traditional reflective materials?

A garment manufactured in L-REFLEX® reflects light off its entire surface, allowing the wearer to remain visible in all situations, without running the risk of accidental concealment as with traditional single reflective bands which can become dirtied or obscured.

Being a fabric, can L-REFLEX® be used to manufacture an entire garment werden?

L-REFLEX®, used on all or only part of a garment, can be considered preferable for the manufacture of sport or leisure garments with visibility requirements, as it avoids the use of anti-aesthetic reflective bands usually associated with workwear safety clothing and allows for greater design possibilities.

Do garments manufactured with L-REFLEX® comply with current safety norms?

In accordance with European norm UNI EN 471, all personnel working on road networks or construction sites are obliged to wear a professional high-visibility safety garment. Clothing manufactured in L-REFLEX® fully complies with the above norm.

Lenzi Egisto S.p.A. Via G. Di Vittorio, 39 59021 Vaiano (PO) Italy Tel. +39 0574 946030 **www.lenzie.it**
Edition 01/2007

LENZI

BE SEEN TO BE SAFE

HIGH-INTENSITY REFLECTIVE FABRIC

Light is reflected back directly by the fabric's glass microsphere structure

SAFETY ON THE ROADS

Builders and overseers on construction sites, as well as security and surveillance personnel, are obliged to wear high-visibility clothing using fluorescent reflective fabrics or bands.
Poor visibility can cause damage and accidents: car drivers, or fire-fighters and police forces on night shifts, are less protected outside daylight hours.
In order to avoid accidents and reduce risk, Lenzi has created reflective fabrics that render their wearer visible from all angles up to a distance of 140 metres.
Opportunities for serious accidents abound.
For example, under normal night-time conditions, a pedestrian can only be seen from approx. 38 metres away: shorter than the safe braking distance for a car travelling at speed.
A reflective garment renders the pedestrian visible from 140 metres, in other words at a safe braking distance.
A person crossing a road who notices a vehicle approaching from a distance always believes that they can be seen by the driver, but this is not always the case, unless the pedestrian is wearing reflective clothing.

In the past, the simplest types of reflective bands involved attaching large reflective plates onto garments using safety pins. Even then, statistics highlighted the high mortality rate on roads and construction sites due to poor safety measures, but it was not until the 1990's that a more precise and rigorous definition of road worker safety was established.

From then onwards, general European norms have made the use of "visibility clothing" obligatory.

Currently, all those working on or near construction sites are obliged to wear fluorescent reflective high-visibility garments bearing the **CE** symbol, in compliance with the requirements of norm **UNI EN 471**. Police forces are also perfectly visible at night due to their use of reflective bands and garments.

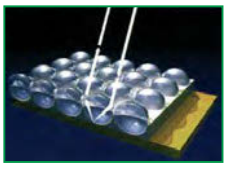
Furthermore, the use of reflective bands has become obligatory for alerting attention to stationary vehicles on the road. Safety awareness has also caught the attention of fashion designers, and the sports clothing industry has taken night-visibility on board as an essential contribution to quality of life: many rucksacks, tracksuits and jackets now have reflective bands incorporated into their design.

Garment producers are obliged to label their products with the **CE** symbol according to each product's safety classification.
Lenzi has created special fabrics capable of providing optimal visibility properties even under heavy rainfall, retaining these characteristics over time even when subjected to heavy and frequent use.

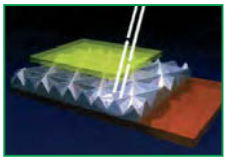
FROM THE LENZI RESEARCH PROGRAMME

In order to optimise response to market demand for both daytime and night-time visibility, Lenzi has developed a series of reflective fabrics based on two different technologies: **microsphere** technology (thousands of glass microspheres partially sunk into a special flexible resin) and **microprism** technology (trihed ral directional microprisms in a transparent resin).

The Lenzi research team works in close contact with garment producers: this synergy leads to new garment designs that increase night-time visibility and therefore safety for the wearer.



Microspheres



Microprisms

WHO USES IT

- Cyclists
- Motorcyclists
- Hikers
- Police forces

ADVANTAGES

- Greater illumination
- Improved visibility
- Larger reflective range with less possibility of accidental concealment as with normal reflective bands

3M

a member of SATRA TECHNOLOGY CENTRE

L-protection® LENZI

ITEM 7

SoldierTech conference UK, 2012.

The Meeting Place For The Global Soldier Modernisation Community

Soldier Technology is the single largest gathering of soldier modernisers in the world, attracting senior government programme managers and their industry counterparts from more than 40 nations each year. And year on year they come back to collaborate to enhance capabilities for the future dismounted soldier making this a one-stop shop for need-to-know data and information and professional contacts in the soldier modernisation marketplace.

Now more than ever soldier modernisation is being seen as a preferred investment by national defence investment directorates over costly large-scale capital projects that carry risk and longer lead times, many of which are being cancelled or postponed indefinitely. In fact our research shows MoDs around the world plan to strengthen their dismounted capabilities over the coming years in light of the new budgetary environment making Soldier Technology a timely and highly relevant forum for you to attend in 2012.

600+ attendees to meet

125 innovative contractors exhibiting and attending

90 government agencies participating

40 nations supporting

32 hours of presentations, workshops, interactive panels and roundtable discussions

24 hours of exhibition time to test the latest equipment

20 hours dedicated to help you develop your professional network

What Makes Soldier Technology The Must-Attend Soldier Modernisation Event?

Receive valuable new information to

- Apply the lessons learned by other organisations from over 40 nations in your own soldier modernisation programmes saving you time and money in a challenging budgetary environment
- Quickly identify defence businesses offering the best commercial off the shelf equipment for the soldier to reduce cost and time across your soldier system portfolio
- Understand national soldier modernisation spending plans so you can make sure your priorities align with those of your allies in preparation for future coalition operations
- Help you make tough decisions for example whether or not to invest in commercial cellular mobile communications over traditional C2
- Assist you in making the best strategic decisions about technology and capability development in your soldier programmes so you don't waste valuable time pursuing lost causes

Get a High Return on Investment by

- Spending focused time with more than 65 expert speakers across 4 days who will give you recommendations about how and who to talk to next to move your soldier programmes forward
- Introducing yourself to new colleagues, partners and clients at multiple networking functions in a relaxed and intimate environment where the emphasis is firmly on building new relationships
- Visiting 60+ exhibition booths packed with the latest soldier equipment for you to benchmark your own product lines against plus meet hard-to-meet technical experts from the smallest and biggest soldier equipment manufacturers!

Don't Just Take Our Word For It, Here's What Delegates Say About This Must-Attend Event:

…enables me to make better judgement and get the best equipment into service for the British soldier. As well as seeing what other countries are using and developing…

Trials Officer, Infantry Trials and Development Unit, **British Army**

…kee ps me in touch with tactical challenges and with solutions emerging from applied technology…

Branch Chief, Force Protection and Sustainment Branch, **US Army**

…the only conference on soldier modernisation I attend where government briefings reference technology you then test in the exhibition… a unique opportunity…

Business Development Manager, Raytheon **UK**

…enhances my understanding of capability gaps and interoperability issues for the warfighter and emergent technology solutions…

Deputy Head of Capability Special Projects and CBRN, **UK MoD**

… very informative and useful for enhancing the soldiers capabilities…

Director, Technical Management of Combat Vehicles and Engineering, DRDO

Contact Us To Receive The Full Agenda, Alternatively Visit

Unmissable Sessions

11:45 May 22 Land Equipment Modernization in France
Brigade General Dominique Luzeaux, Director, Land Procurement, DGA, French MoD

Don't miss this in-depth briefing from France's head of defence land procurement at the DGA to discover all the latest plans to modernise French land forces. In this talk Brigade General Luzeaux will discuss the roadmap of land equipment modernization including soldier equipment, armored personnal carrier vehicles and combat infantry vehicles. You will also receive an update on the FELIN program, which is the first integrated equipment suite under production and combat proven among modern armies. Don't miss it!

09:30 May 22 Assessing the New UK Approach to Dismounted Close Combat
Brigadier Mark Gaunt, Commander, Individual Capability Group, Defence, Equipment and Support, UK MoD

As dismounted close combat takes centre stage for military capability developers there is no one better placed than Brigadier Gaunt to tell you all about the new priorities for soldier modernisation in the UK. During this briefing you will receive new a clear view on a new unified approach to soldier modernisation in the UK, how the biggest challenges for the soldier are being addressed including weight and where investments will be made in the near future to keep dismounted soldiers superior on the battlefield.

12:45 May 22 Land Modernisation in Indonesia
Brigadier General Agus Suyarso, Director of Technology and Industry, Indonesian MoD

For the first time at Soldier Technology you will receive up-to-date reports on Indonesia's defence spending plans directly from the key decision maker in Indonesia's MoD, Brigadier General Suyarso. Make sure you attend this briefing to understand how Indonesia will invest in soldier and vehicle modernisation over the coming years, a time when traditional markets in the West are taking more cautious approaches to defence spending.

14:30 May 22
Brigadier General (ret'd) Gurmeet Kanwal, Director, Centre for Land Warfare Studies, Modernisation of India's Infantry Battalions

Meet and learn from a highly respected figure in India's defence community, a retired senior officer who has commanded at every level and who is now responsible for advising government on defence policy. During this briefing you will gain the best possible understanding of defence requirements in India, stakeholders in India's defence sector, how to approach doing business or partnering with Indian military organisations and of course an update on current threats and strategies to defeat them. This is a must attend session.

12:00 May 23 Soldier Modernisation and Land Transformation in Australia
Colonel Jason Blain, Director, DiggerWorks, Australian MoD

As one of the biggest spenders on soldier modernisation in recent times much can be learnt from Australia in terms of soldier system integration. Project Land 125, the Australian soldier modernisation project, will be covered in detail by Colonel Blain as part of a wider assessment of land modernisation in Australia. Attend this session to get a clear view on future spending plans in Australia as well as insight into new soldier requirements.

Speaker Line-Up

- Gabi Dobresco, Project Manager, Israeli Advanced Soldier, Israeli MoD
- Colonel Terry Tan, Programme Manager, Advanced Combat Man System, Singaporean MoD
- Colonel Jason Blain, Director, DiggerWorks, Australian Army
- Mike McCarthy, Program Manager and Director of Operations, Future Force Integration Directorate, Mission Command, US Army
- Brigadier General Agus Suyarso, Director, Technology and Industry, Defence Facilities Agency, Indonesian MoD
- Brigadier Mark Gaunt, Commander, Individual Capability Group, Defence, Equipment and Support, UK MoD
- Brigade General Dominique Luzeaux, Director, Land Procurement, DGA, French MoD
- Mark Richter, Program Manager, Marine Expeditionary Rifle Squad, MCSC Enhanced Company Operations Coordinator, Marine Corps Systems Command
- Per Arviddson, Chairman. NATO Weapons & Sensors Working Group
- Andy J Fawkes, Deputy Head of Capability JTES (Simulation) Cap (Joint Training Evaluation Simulation), UK MoD
- Colonel Andy Sykes, Assistant Director Dismounted Close Combat, Capability Directorate Combat, UK MoD
- Brigadier General (ret'd) Gurmeet Kanwal, Director, Centre for Land Warfare Studies, India
- Captain Vidar Engmo, Procurement Officer, Plans and Developments, Norwegian Armed Forces
- Luc de Beer with Derek Riezebos, Power Expert, KEMAD
- Magnus Lifgren, Director, Soldier Modernisation Programmes, FMV, Sweden
- Colonel Henrik R. Sommer, Commander, Danish Army Combat Centre
- Lt Colonel Kenneth Tapper, Project Manager, MARKUS, Swedish Land Warfare Centre
- Major Matti Honkela, Programme Manager, Warrior 2020, Finnish Defence Forces
- Major Bruce Gilchrist, Project Director, Small Arms/ Integrated Soldier System Project, DLR, Canadian DnD

New For 2012

- Government Delegations from across Asia, Australasia and the Middle East!
- Regional Roundtable Discussions with government decision makers from South Asia/Pacific, Middle East and Americas!
- Broad UK government support including DE&S, Capability Ground Maneouvre, Capability Combat Directorate, Infantry Trials and Development Unit, DSTL and more!
- Updates on new procurement programmes in Sweden, Netherlands, Jordan, Brazil, UK, US and more!
- UK Soldier Reference Centre to be demonstrated by the UK's Infantry Trials and Development Unit!

Visit WWW.SOLDIERTECHNOLOGY.COM for live updates!

www.SoldierTechnology.com For The Up-To-Date Information

May 21st am

Future Firearms to Improve Lethality while Reducing the Logistical Burden on the Soldier

08:00	Registration and Coffee
08:45	**Chairman's Welcome Address** Per Arvidsson, Chairman, Weapons and Sensors Working Group, NATO Land Capability Group 1, Dismounted Soldier
09:00	**UK Approaches to Soldier Weapon Modernisation** Colonel Peter Warden, Team Leader, Lethality, Defence Equipment and Support, UK MoD
09:30	**Soldier System Lethality – The Role of Weapons in the Future Lethality Chain** Robert Marshall, Technical Lead, Future Dismounted Close Combat Research, SEA Group
10:00	**NATO's Approach to Increasing Interoperability in the Weapon System to Maximise Lethality for Coalition Forces** Per Arvidsson, Chairman, Weapons and Sensors Working Group, NATO Land Capability Group 1, Dismounted Soldier
10:30	**Panel Discussion – Challenges and Solutions for Small Arms Modernisers in the Next Decade** Colonel Peter Warden, Team Leader, Lethality, Defence Equipment and Support, UK MoD Major Bruce Gilchrist, Project Director, Small Arms/Integrated Soldier System Project, DLR, Canadian DnD Per Arvidsson, Chairman, Weapons and Sensors Working Group, NATO Land Capability Group 1, Dismounted Soldier Phil Macey, Programme Manager Research and Consultancy, SEA Group
11:15	Morning Coffee and Networking
11:45	**Assessing the Canadian Approach to Small Arms Modernisation to Increase Lethality for the Dismounted Soldier** Major Bruce Gilchrist, Project Director, Small Arms/Integrated Soldier System Project, DLR, Canadian DnD
12:15	**The Powered Rail – A Bridging Technology** Carl J. Wallace, Chief Executive Officer, T-Worx Ventures
12:45	**Reducing the Weapon System Burden on the Dismounted Soldier** Professor Jeremy Smith, Head of Simulation and Analytics, Cranfield University, UK Defence Academy
13:15	Lunch and Networking

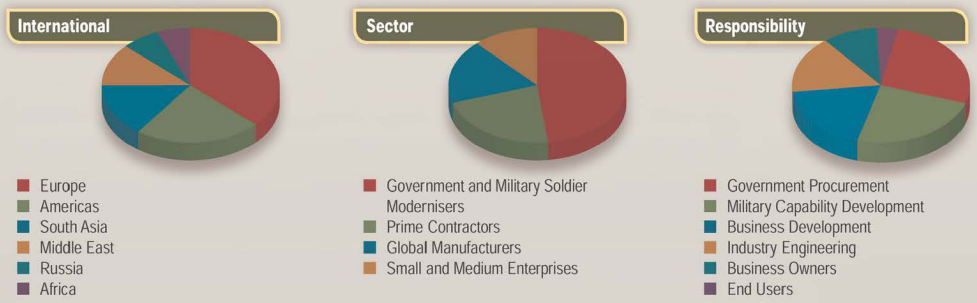
May 21st pm

New Approaches to Improve Situational Awareness for Dismounted Close Combatants

13:30	Registration and Coffee
13:55	Chairman's Welcome Address
14:00	**How the US Army is Progressing with Smart Technology and Digital Applications for Soldier Situational Awareness** Mike McCarthy, Programme Manager & Director of Operations, Brigade Modernization Command - Mission Command Complex, US Army
14:30	**Israel's Approach to Improving Situational Awareness for the Dismounted Soldier** Nir Israeli, Head of Urban Warfare, Israeli MoD
15:00	**Situational Awareness through Wearable Interfaces** Matti Honkela, Programme Manager, Warrior 2020, Finnish MoD
15:30	**Panel Discussion: Next Generation Technologies to Enable Situational Awareness at the Dismounted Level** Mike McCarthy, Programme Manager and Director of Operations, Brigade Modernization Command - Mission Command Compex, US Army Nir Israeli, Head of Urban Warfare, Israeli MoD Matti Honkela, Programme Manager, Warrior 2020, Finnish MoD Richard Hansen, Former Project Manager, Soldier Warrior, PEO Soldier, US Army
16:15	Afternoon Coffee and Networking
16:45	**Sights and Sensors Modernisation for the Dismounted Soldier** Christopher Briggs, Team Leader, Sights and Sensors, DSTL
17:15	**US Procurement Initiatives to Increase Situational Awareness for the Soldier: Army-Wide Round Up** Richard Hansen, Former Project Manager, Soldier Warrior, PEO Soldier, US Army
17:30	End of Day

Major General Carew Wilks, former head of Individual Capability Group, DE&S receives a tour of the exhibition in 2011. **Networking with senior military leaders from around the world is part of the onsite experience.**

Network with a High Quality Audience of Decision Makers at Soldier Technology 2012:



Visit www.SoldierTechnology.com To View The

May 22nd

Strategic International Soldier Modernisation Updates

08:00	Registration and Coffee	
08:45	**Chairman's Opening Comments** Mark Richter, Deputy Chairman, NATO Land Capability Group 1, Dismounted Soldier	
09:00	**NATO International Soldier Modernisation Approaches** Mark Richter, Deputy Chairman, NATO Land Capability Group 1, Dismounted Soldier	NATO Update
09:30	**The Role of the Individual Capability Group in Dismounted Soldier Modernisation** Brigadier Mark Gaunt, Head of Individual Capability Group, Defence Equipment and Support, UK MoD	UK Insight
10:00	**Capability Planning Dismounted Modernisation: Reducing The Burden and Situational Awareness** Colonel Gavin Thompson, Deputy Head (Equipment Programme), Capability Ground Manoeuvre, UK MoD	UK Insight
10:30	**Panel Discussion – Dismounted Close Combat After Operations in Afghanistan** Mark Richter, Deputy Chairman, NATO Land Capability Group 1, Dismounted Soldier Brigadier Mark Gaunt, Head of Individual Capability Group, Defence Equipment and Support, UK MoD Colonel Gavin Thompson, Deputy Head (Equipment Programme), Capability Ground Manoeuvre, UK MoD	
11:00	Early Morning Coffee And Networking	
11:45	**Land Equipment Modernization in France** Brigade General Luzeaux, Director, Land System Procurement, DGA, French MoD	FELIN exclusives
12:15	**FELIN on the Field, Usability and Evolution Perspective** Patrick Curlier, Vice President, Business Development, Optronics and Defence Division, Sagem, Safran Group	FELIN exclusives
12:45	**Land Capability Development and Equipment Procurement in Indonesia** Brigadier General Agus Suyarso, Director, Technology and Industry Procurement, Indonesian MoD	Exclusive from Indonesia
13:15	Lunch and Networking	
14:30	**Modernisation of India's Infantry Battalions** Brigadier General (ret'd) Gurmeet Kanwal, Director, Centre for Land Warfare Studies, India	New Updates from India
15:00	**Research, Development and Procurement in Singapore's Advanced Combat Man System** Colonel Terry Tan, Programme Manager, Advanced Combat Man System, Singapore Army	Singapore Focus
15:30	**Panel Discussion – Assessing the Drivers for Soldier Modernisation in Asia over the Next Decade** Brigadier General (ret'd) Gurmeet Kanwal, Director, Centre for Land Warfare Studies, India Brigadier General Agus Suyarso, Director, Technology and Industry Procurement, Indonesian MoD Colonel Terry Tan, Programme Manager, Advanced Combat Man System, Singapore Army	
16:15	Afternoon Coffee and Networking	

	Stream A – Soldier Modernisation in the Nordic Region	Stream B – Emerging Challenges in Coalition Forces	Stream C – Middle East and Asia Roundtable Discussions
16:45	**Successful Strategies to Execute Your Soldier Modernisation System Plan** Captain Vidar Engmo, Project Manager, NORMANS, Norwegian Army Procurement Office	**Infantry Challenges In a Coalition Force** Colonel Henrik R Sommer, Commander, Danish Army Combat Centre	**How to Meet Indonesia's Soldier Equipment Requirements** Brigadier General Agus Suyarso, Director, Technology and Industry Procurement, Indonesian MoD **Introducing the Full Range of Future Land Procurement Programmes in Jordan** Colonel Yousef Al Aitan, Programme Manager, King Abdullah Design and Development Bureau **Successful Strategies to Work with the Indian Government** Brigadier General (ret'd) Gurmeet Kanwal, Director, Centre for Land Warfare Studies, India **Approaches to Soldier Modernisation in the United Arab Emirates discussion leader being co-ordinated by** Brigadier Saleh Al Aidraous, Defence Attache, UAE Embassy in London **Soldier Modernisation in Malaysia, Malaysia Future Soldier Programme discussion leader being co-ordinated by** Brigadier General Othman Jamal, Defence Attache, Malaysian Embassy, London. See website for updates.
17:15	**Sweden's New Soldier System Plan** Lt Colonel Stefan Lundmark, Programme Manager, MARKUS, Swedish Land Warfare Centre Magnus Lifgren, Director, Soldier Modernisation Programmes, FMV	**Soldier Modernisation Under the Umbrella of the European Defence Agency:** Benjamin Fuchs, Head of Precision Engagement, Euroepan Defence Agency	
17:45	**How Nordic Nations Plan to Reduce the Burden for the Soldier** Captain Vidar Engmo, Procurement Planner, Norwegian Army Office Magnus Lifgren, Director, Soldier Modernisation Programmes, FMV, Sweden Major Matti Honkela, Programme Manager, Warrior 2020, Finnish MoD	**Panel Discussion – New Requirements for Coalition Forces to Modernise Soldier Equipment** Mark Richter, Deputy Chairman, NATO Land Capability Group 1, Dismounted Soldier Colonel Henrik R Sommer, Commander, Danish Army Combat Centre Benjamin Fuchs, Head of Precision Engagement, European Defence Agency	
18:15	Exhibition Drinks Reception		
19:00	Networking Awards Dinner with Guest Speaker to be Announced Shortly	Visit www.soldiertechnology.com for up to date information	

Most Up To Date Agenda And Presentation Details

May 23rd

Tactical International Soldier Modernisation Updates

08:00	Registration and Coffee
08:30	**Chairman's Welcome Address** Colonel (ret'd) Richard Hansen, Former Project Manager, Soldier Warrior, PEO Soldier, US Army
08:35	**How Dismounted Close Combat will Evolve Over the Next Decade** Colonel Charlie Sykes, Assistant Director Dismounted Close Combat, Capability Directorate Combat, UK MoD UK Combat Directorate
09:05	**A Closer Look at the UK's Coherent Approach to Dismounted Close Combat** Marcus Bruton, Team Leader, Integrated Soldier System Executive, Defence, Equipment and Support, UK MoD
09:35	**Digital Solutions for Low Light Level and Night Vision Applications** Dr. Gert Nutzel, Chief Scientist Officer, Photonis
10:05	**Panel Discussion – New Approaches to Providing Soldiers with Superior Situational Awareness** Marcus Bruton, Team Leader, Integrated Soldier System Executive, Defence, Equipment and Support, UK MoD Lt Colonel Matt Stovin-Bradford, Commanding Officer, 30 (IX) Commando, UK Royal Marines Colonel Jason Blain, Director, Diggerworks (Integrated Soldier System Development Directorate), Australian MoD
10:50	Early Morning Coffee and Networking
11:20	**How Technology Shaped Operations Against the Taliban** Lt Colonel Matt Stovin-Bradford, Commanding Officer, 30 (IX) Commando, UK Royal Marines UK Royal Marines
11:50	**How the Australian Army will Deliver Improved and Integrated Soldier Combat Systems (SCS)** Colonel Jason Blain, Director, Diggerworks (Integrated Soldier System Development Directorate), Australian MoD Australia Update
12:20	**The Future in Sight** Lennart Ljungfelt, President, Aimpoint
12:50	**How Israel Manages Risk to Deliver a Range of Advanced Capabilities for the Dismounted Soldier** Gabi Dobresco, Programme Manager, ANOG, Israeli MoD Israel's Programme News
13:20	Lunch and Networking

	Stream A – Future Research and Development to Benefit the Dismounted Soldier	Stream B – Personal Protection and Human Factors	Stream C – Roundtable Discussions with Soldier Modernizers from the Americas
14:30	**How the UK Ensures Current and Relevant Research and Development is Exploited in the Equipment Programmes** Christopher Briggs, Director, Science Gateway for Dismounted Close Combat, DSTL	**Next Generation Soldier Helmet Protection** James Thagard, Global Marketing Manager, Helmets, Honeywell Advanced Composites and Fabrics	**Progress in the Brazilian Combatiente Brasiliero Programme to Modernise the Soldier Platform** Name to Be Announced Shortly, Programme Manager, Combatiente Brasiliero, Brazilian MoD **Connecting Soldiers to Digital Applications** Mike McCarthy, Programme Manager and Director of Operations, Future Force Integration Directorate, US Army **Marine Corps Priorities for Soldier Modernization** Mark Richter, Programme Manager, Marine Expeditionary Rifle Squad, US Marine Corps Systems Command
15:00	**Innovations for Soldier Systems** Dr. Adelbert Bronkhorst, Business Line Manager, Human Effectiveness, TNO Netherlands	**Personal Protection for the Dismounted Soldier in Sweden** Helena Lundberg, Programme Manager Protection, FMV, Sweden	
15:30	**Panel Discussion – Research Focuses to Improve Soldier Situational Awareness and Reduce the Burden** Christopher Briggs, Director, Science Gateway for Dismounted Close Combat, DSTL Dr. Adelbert Bronkhorst, Business Line Manager, Human Effectiveness, TNO Netherlands Lt Colonel Christopher Woodburn, Capability and Requirements Manager, Marine Expeditionary Rifle Squad and Infantry Combat Equipment, US Marine Corps Combat Developments Command	**Panel Discussion – Where Innovation is Required to Continue to Protect the Soldier** James Thagard, Global Marketing Manager, Helmets, Honeywell Advanced Composites and Fabrics Helena Lundberg, Programme Manager Protection, FMV, Sweden Duncan Stewart, Operational Analyst, Close Combat Systems, DSTL	

16:00	Afternoon Coffee and Networking
	Interactive Workshop: Transforming Soldier Training through Technology
16:30	• The Changing Training Landscape • Exploiting the Latest Technologies for Training • How much Live Training is necessary? • Convergence of Training, Mission Preparation and Operational Aids? Andy J Fawkes, Deputy Head of Capability JTES (Simulation) Cap (Joint Training Evaluation Simulation), UK Ministry of Defence
17:30	Close

For the full comprehensive agenda and speaker information visit www.SoldierTechnology.com

May 24th am

Improving Power to Increase Mobility for the Dismounted Soldier

08:00	Registration and Coffee
08:45	Chairman's Welcome Address
09:00	**Evaluating the Latest Advances in Worn Power for the Soldier to Reduce Weight and Increase Mobility** Marcus Bruton, Team Leader, Integrated Soldier System Executive, Defence, Equipment and Support, UK MoD
09:30	**ABSL Power Solutions – Power Management to Reduce Burden on the Soldier** David Goodwin, Business Development Manager, ABSL Power Solutions Ltd
10:00	**Introducing Canada's Soldier Adaptive Power Programme to Support New Power Sources into the Integrated Soldier System Project** Vivier Lefebvre, Project Manager – Energy, Directorate of Science and Technology – Land, Defence R&D Canada
10:30	**Panel Discussion – What will the Future Soldier System Look Like and What will be the Power Need?** David Goodwin, Business Development Manager, ABSL Power Solutions Ltd Derek Riezebos, Power Expert, KEMA (on behalf of the Dutch MoD) Vivier Lefebvre, Project Manager – Energy, Directorate of Science and Technology – Land, Defence R&D Canada Marcus Bruton, Team Leader, Integrated Soldier System Executive, Defence, Equipment and Support, UK MoD Adam Best, Director, Worn Power, CSIRO
11:15	Morning Coffee and Networking
11:45	**Marine Expeditionary Rifle Squad: An Update on USMC Requirements Approach to Lightening the Load and Capabilities Integration** Lt Colonel Christopher Woodburn, Capability and Requirements Manager, Marine Expeditionary Rifle Squad and Infantry Combat Equipment, US Marine Corps Combat Developments Command
12:15	**Game-changing Power Capabilities Delivered from the Dutch E-Lighter Programme to Give Longer Lasting Energy for the Full Spectrum of Soldier Applications** Derek Riezebos, Power Expert, KEMA
12:45	**Research Breakthroughs in Worn Power for the Soldier** Adam Best, Director, Worn Power, CSIRO
13:15	Lunch and Networking

May 24th pm

Reducing the Burden for the Soldier

13:30	Registration and Coffee
13:55	Chairman's Welcome Address
14:00	**How the UK MoD is Reducing the Burden for the Dismounted Soldier** Colonel Peter Rafferty, Team Leader Protection, Defence Equipment and Support, UK MoD
14:30	**US Marine Corps Approaches to Reducing the Burden for the Soldier** Carl DeSantis, Director, Marine Corps Gruntworks Facility, US Marine Corps Systems Command
15:00	**Measuring the Capability of the Dismounted Soldier: The Effect of Burden** Duncan Stewart, Operational Analyst, Close Combat Systems, DSTL
15:30	Afternoon Coffee and Networking
16:00	**How Brazil Plans to Invest in Lightweight Equipment for the Soldier** Name to Be Announced Shortly, Programme Manager, Combatiente Brasiliero, Brazilian MoD
16:30	**Australia's Requirements for Lighter Soldier Systems** Speaker being Coordinated by Major Robin Davies, Capability Development Group, Australian MoD
17:00	**Panel Discussion – How to Help Soldiers Reduce Weight Across the Soldier System** Carl DeSantis, Director, Marine Corps Gruntworks Facility, US Marine Corps Systems Command Colonel Peter Rafferty, Team Leader Protection, Defence Equipment and Support, UK MoD Speaker being Coordinated by Major Robin Davies, Capability Development Group, Australian MoD Name to Be Announced Shortly, Programme Manager, Combatiente Brasiliero, Brazilian MoD
17:45	End of Conference

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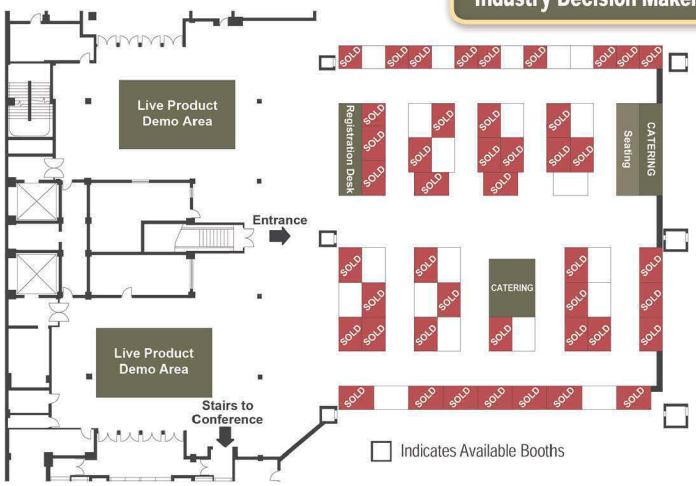

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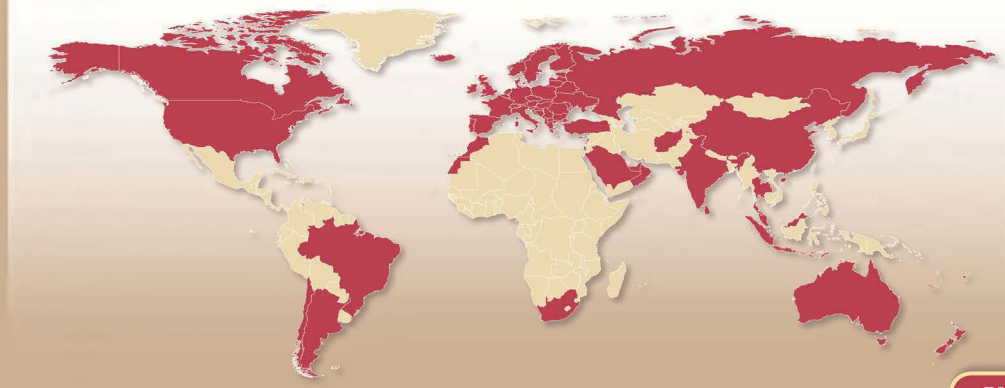

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Focus Session Options on May 21st and 24th

May 21st, am Future Firearms to Improve Lethality
May 21st, pm Dismounted Situational Awareness

May 24th, am Improving Power to Increase Mobility for the Dismounted Soldier
May 24th, pm Reducing the Burden for the Dismounted Soldier

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