

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.

Shelden Vaughan

A thesis submitted for the degree of Master in Design
2012

University of Technology, Sydney (UTS), Australia.

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.

Signature of Student:

Date:

Acknowledgments

I would like to acknowledge my Supervisor, Alana Clifton-Cunningham and express my sincere thanks to her for all her patience, dedication, encouragement and guidance during this design masters.

Professor Marie O'Mahony inspired me to write this thesis originally and drove my interest in technical textiles and technical fashion design.

For their ongoing support, I thank my parents Peter and Jennifer and my sister Tennille and her husband Jason and my brother Keir. To Carlos, you have always supported me and I always appreciate this.

To my dear partner, Milena, thank you for all you encouragement, you helped me to get there in the final months with your kindness.

I dedicate this work to my late Uncle Barry Breen,
who always believed in me and who always wanted the best for me.

Contents

I.	Chapter 1: Introduction to the thesis	12
	1.1.1 The duty belt as used by General Duty Police Officers	13
	1.1.2 The load bearing vest as used by General Duty Police Officers	15
	1.2 Significance of the Research	20
	1.2.1 General Duty Police Injuries related to the duty belt: An International perspective	21
	1.2.2 The broader research perspective	22
	1.2.3 Novel solutions that may be derived from motorcycle and sportswear design	26
	1.2.4 Considerations around equipment innovations	27
	1.2.5 Incorporating ballistic protection into load bearing vests	27
	1.3 Cultural issues related to policing, modern policing and the need for new technologies	30
	1.3.1 The problematic and why police forces have perceived that they have needed to go high tech	31
	1.3.2 The evolution of the New South Wales Police uniform	35
	1.3.3 The tasks that New South Wales General Duty Police undertake on a daily basis	36
	1.4 Thesis plan: Outline of the chapters	48
II.	Chapter 2: Literature Review	50
	2.1 Soldier modernisation in Australia	50
	2.2 Canadian Army soldier burden analysis	56
	2.3 Science in clothing comfort	66
	2.3.1 Components of clothing comfort	67
	2.4 Improving comfort in clothing	69
	2.5 Sam Browne and Beyond: A Look at Duty Belts	70
	2.5.1 Who was Sam Browne?	70
	2.5.2 Ergonomic considerations	71
	2.5.3 Considerations for Women	71
	2.6 Updating Sam Browne: Designing better load bearing systems for the modern Peace Officer	79
	2.6.1 Regarding the abstract to this journal article	79
	2.6.2 Introduction	79
	2.6.3 Literature review within the article	80
	2.7 Ergonomic load bearing systems	82
	2.8 Battle rattle: The stuff a soldier carries	85
	2.8.1 The vest system	85
	2.8.2 The RACK	86
	2.9 Future Soldier – Expanded System: Rheinmetall to supply the Bundeswehr with cutting-edge “Gladius” infantry equipment	
III.	Chapter 3: A Critical analysis of the New South Wales load bearing implementation	92
	3.1 New South Wales Police load bearing vest design analysis	93

Contents

3.1.1	Incorporating ballistic protection into load bearing vests; Strategic design considerations	100
3.1.2	User comfort and wellness; Thermal management analysis	
3.1.3	Wear-ability considerations in garment design	100
3.1.4	The physiological & biomechanical aspects of load carriage	103
3.1.5	The biomechanics of the human spine: Loads on the spine	106
3.1.6	The biomechanics of the human spine: Common injuries of the back	109
3.1.5	Future procurement considerations	116
3.1.8	New South Wales Police Annual Report 2011	117
3.2	International police load bearing vests; a general design analysis	118
3.2.1	British general duty police load bearing vests	119
3.2.2	US general duty police load bearing vests	119
		120
IV.	Chapter 4: Garment design or multi-performance	130
4.1	Advanced textiles; Applications for health and wellbeing	131
4.1.1	Advanced textiles for climate control; Three-dimensional (3D) spacer textiles	131
4.1.2	Wool as a wicking layer	136
4.1.3	Phase change materials (PCM)	137
4.1.4	Hard and soft textile combinations in garment design	138
4.1.5	Textiles finishes for climate control	140
4.1.6	Advanced textiles: Innovations that inform garment design	140
4.2	Hard and soft textiles: A Dainese® motorcycle safety wear product study	149
4.2.1	Fitting comfort; ergonomics related to garment construction	150
4.2.2	Ergonomics related to load carriage	155
4.3	User comfort and wellness	163
4.3.1	Comfort and wellness in clothing design	163
4.3.2	Clothing layering for comfort and wellness; Thermal management for comfort	165
4.3.3	Introducing the load bearing vest into Police Forces: Occupational Health & Safety (OH&S) considerations	167
4.3.4	Considerations around duty equipment innovations	169
4.3.5	Chapter conclusion	169
V.	Chapter 5: Conclusion	170
5.1	Research methodology discussion and the significance of the research	171
5.1.1	The significance of the research, new contributions to the field of load carriage	172
5.1.2	Discussion around the research methodology used in this research study	173

Contents

5.1.3	The limitations and subsequent implications of these limitations related to this research study	174
5.2	Overview of the thesis structure and main findings	175
5.2.2	The main findings of this research study; New knowledge and information that has been discovered	176
5.3	Future research and design development recommendations	178
5.3.1	Recommendation: Advanced technical textiles, textile finishes	178
5.3.2	Recommendation: Garment layering to enhance climate control;	179
5.3.3	Recommendation: Strategies to reduce the load carriage burden to General Duty Police Officers;	179
5.3.4	Recommendation: User field trials for prototype General Duty Police load bearing vests;	179
5.3.5	Recommendation: Hard and soft textile combinations in load bearing vest design and fabrication;	180
5.3.6	Recommendation: Ballistic and stab proof protection;	180
5.3.7	Recommendation: Deploying load bearing vests in conjunction with high visibility garments;	180
5.3.8	Recommendation: Occupational Health and Safety (OH&S) - The physiological and biomechanical aspects of load bearing vest design;	181
5.3.9	Recommendation: Creation of strategic industry partnerships with major specialist manufacturers of technical garments;	182
5.3.10	Recommendation: Creation of an International research collaboration around load bearing vest implementation programmes into major Police Forces;	182
5.3.11	Recommendation: Monitoring health and wellness in General Duty Police Officers;	183
5.3.12	Recommendation: Sourcing of lightweight energy storage hardware for electronic duty gear;	183
	Bibliography	184
	Appendix	186

List of Figures

Figure 1.	New South Wales General duty police duty belt images (<i>Overloaded: how the New South Wales Police accoutrement belt plagues its wearers, 2004</i>)	17
Figure 2.	Patent leather and synthetic general duty police belt examples (<i>America Wear, 2011</i>) (<i>Cross Fire, 2012</i>)	18
Figure 3.	New South Wales police force General Accoutrement Vest (GAV) prototype (<i>General Accoutrements Vest: Solution or Problem?, 2009</i>)	19
Figure 4.	Load carriage platform examples (<i>BabyBjorn®, 2012</i>) (<i>New South Wales Police, 2012</i>)	23
Figure 5.	BabyBorn® carrier miracle fitting instructions (<i>BabyBjorn®, 2012</i>)	25
Figure 6.	Comparing equipment weights versus new product technologies (<i>LED Lenser®, 2012</i>) (<i>Maglite®, 2012</i>)	28
Figure 7.	Motorola® LEX700 hand held computer used by police in North America (<i>Motorola®, 2012</i>)	33
Figure 8.	The first New South Wales Police uniform c1876 (<i>Justice & Police Museum, New South Wales, 2012</i>)	38
Figure 9.	Historical images of the New South Wales Police uniform (<i>Justice & Police Museum, New South Wales, 2012</i>)	39
Figure 10.	Women police officers Amy Millgate (left) and Gladys Johnson, New South Wales Police, January 1948 (<i>Justice & Police Museum, New South Wales, 2012</i>)	40
Figure 11.	New South Wales Police Carnival official programme, 17 February, 1934 (<i>Justice & Police Museum, New South Wales, 2012</i>)	41
Figure 12.	New South Wales Police Constables on patrol, 1884 (<i>Justice & Police Museum, New South Wales, 2012</i>)	42
Figure 13.	Photograph from New South Wales Police album of uniforms 1963 to mid-1960s (<i>Justice & Police Museum, New South Wales, 2012</i>)	43
Figure 14.	New South Wales Police duty equipment, c1883 (<i>Justice & Police Museum, New South Wales, 2012</i>)	44
Figure 15.	New South Wales police duty equipment, c1876 (<i>Justice & Police Museum, New South Wales, 2012</i>)	45
Figure 16.	New South Wales Police duty equipment in the 1970s (<i>Justice & Police Museum, New South Wales, 2012</i>)	46
Figure 17.	Current New South Wales Police General Duties uniform in the year 2012 (<i>Justice & Police Museum, New South Wales, 2012</i>)	47
Figure 18.	Australian Soldier Kit as used in East Timor in 1999 (<i>Soldier Technology conference UK, 2012</i>)	52
Figure 19.	Australian Soldier Kit as used in Afghanistan in 2011 (<i>Soldier Technology conference UK, 2012</i>)	53
Figure 20.	Equipment Weights for the Canadian Dismounted Soldier, 2012 (<i>Soldier Technology conference UK, 2012</i>)	58
Figure 21.	Canadian dismounted fully laden soldier in Afghanistan, 2012 (<i>Soldier Technology conference UK, 2012</i>)	59
Figure 22.	Equipment photos of the soldier kit for the Canadian Dismounted Soldier, 2012 (<i>Soldier Technology conference UK, 2012</i>)	60
Figure 23.	Canadian Army, Family of Land Combat Systems (FLCS) (<i>Designing Canada's Army of Tomorrow. A Land Operations 2021 Publication, 2011</i>)	61
Figure 24.	Dismounted soldier load carriage examples, 2012 (<i>Soldier Technology conference UK, 2012</i>)	62
Figure 25.	UK Dismounted soldier load bearing vest (LBV), 2012 (<i>Soldier Technology conference UK, 2012</i>)	63

Figure 26.	UK Dismounted soldier load bearing vest (LBV), 2012 (<i>Soldier Technology conference UK, 2012</i>)	64
Figure 27.	Prototype for the UK future dismounted soldier programme (FIST), 2012 (<i>Soldier Technology conference UK, 2012</i>)	65
Figure 28.	Serpa® ergonomic drop leg pistol holster, 2012 (<i>Tactical Defense Solutions, 2012</i>)	74
Figure 29.	Blackhawk® Omega Drop Leg Medical Pouch (<i>Patriot Outfitters, 2011</i>)	75
Figure 30.	Recon brand Military style Load Carrying Chest Rig (<i>Recon Chest Rig, 2012</i>)	76
Figure 31.	Blackhawk® Velcro Strap Adjustable System (<i>Ergonomic Load Bearing Systems, 2006</i>)	84
Figure 32.	Modular Lightweight Load-carrying Equipment (MOLLE) system (<i>Mayflower brand MOLLE system, 2011</i>)	87
Figure 33.	Gladius infantry equipment (<i>Rheinmetall infantry equipment, 2012</i>)	90
Figure 34.	Gladius infantry equipment breakdown of components (<i>Rheinmetall infantry equipment, 2012</i>)	91
Figure 35.	New South Wales General Duty Police officers duty equipment load weights, circa 2010, total weight 12 kilograms (<i>Police Journal, South Australia, 2006</i>)	96
Figure 36.	New South Wales General Duty Police officers duty equipment load weights, circa 2010, total weight 12 kilograms (<i>AAP Newswire, 2010</i>)	97
Figure 37.	New South Wales General Duty Police load bearing vest images (<i>AAP Newswire, 2010</i>)	98
Figure 38.	Supply of Load Bearing Vests (LBV) for the NSW Police Force industry brief document Ref: 17082009RFT (<i>New South Wales Police Force, 2009</i>)	99
Figure 39.	Muscular System Picture Anterior (Front) View and load centralisation about a centre line (<i>Sports Fitness Advisor, 2012</i>)	102
Figure 40.	Victorian General Duty Police Officer wearing a load bearing vest which incorporates ballistic protection into the vest design (<i>Victoria Police, 2012</i>)	104
Figure 41.	Victoria Police, Preparing for the worst: Exercise Hades (<i>Victoria Police, 2012</i>)	107
Figure 42.	Modular Lightweight Load-carrying Equipment (MOLLE) example (<i>Airsoft Forum, 2011</i>)	108
Figure 43.	Anatomical images and the direction of torque on the spine (<i>Basic Biomechanics Sixth Edition, 2012</i>)	111
Figure 44.	Lifting while twisting: to be avoided (<i>Basic Biomechanics Sixth Edition, 2012</i>)	112
Figure 45.	Maintenance of lumbar curvature in lifting (<i>Basic Biomechanics Sixth Edition, 2012</i>)	113
Figure 46.	Significance of lifting injuries and intraabdominal pressure in lifting (<i>Basic Biomechanics Sixth Edition, 2012</i>)	114
Figure 47.	New South Wales Police workers compensation claims in 2011 (<i>New South Wales Police Annual Report, 2011</i>)	118
Figure 48.	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 (<i>Vests help officers carry a heavy load, 2009</i>)	121
Figure 49.	United States General Duty Police Officers from Lincoln use a load bearing vest in conjunction with an ergonomic drop leg pistol holster (<i>Lincoln police officers sport new look, 2010</i>)	122
Figure 50.	Example of a New York General Duty Police Officer wearing a typical duty uniform with duty belt (<i>Photographed Vaughan, T., 2012</i>)	123
Figure 51.	Example of a San Francisco General Duty Police Officer's uniform (<i>Personal photograph, photographed Vaughan, S., 2012</i>)	124

Figure 52.	United States General Duty Police Officers from Lincoln use a load bearing vest in conjunction with an ergonomic drop leg pistol holster (<i>Lincoln police officers sport new look, 2010</i>)	125
Figure 53.	Example of a New York General Duty Police Officer wearing a typical duty uniform with duty belt (<i>Photographed Vaughan, T., 2012</i>)	126
Figure 54.	Example of a San Francisco General Duty Police Officer's uniform (<i>Personal photograph, photographed Vaughan, S., 2009</i>)	127
Figure 55.	German General Duty Police Officer's wearing a combination ballistic proof vest and load bearing vest (<i>Personal photograph, photographed Vaughan, S., 2009</i>)	128
Figure 56.	Example of an Italian General Duty Police Officer's uniform (<i>Photographed Vaughan, T., 2012</i>)	129
Figure 57.	Examples of 3D spacer fabrics used in motorcycle garments (<i>Heathcoat Textiles UK, 2009</i>)	132
Figure 58.	An example of a 3D spacer fabric used in bedding and sofas (<i>Heathcoat Textiles UK, 2009</i>)	133
Figure 59.	An example of a motorcycle garment constructed from an open weave mesh (<i>Dainese®, 2012</i>)	134
Figure 60.	An example of a exoskeleton motorcycle garment constructed from an open weave mesh (<i>Dainese®, 2012</i>)	135
Figure 61.	Advanced textiles; Phase Change Materials (PCM) (<i>Schoeller Textiles AG, 2011</i>)	137
Figure 62.	Biomechanical ankle brace for use in motorcycling (<i>Alpinestars®, 2012</i>)	138
Figure 63.	Coldblack® textile finish (<i>Schoeller Textiles AG, 2011</i>)	139
Figure 64.	Dainese® Wave air exoskeleton jacket as viewed from the front (<i>Dainese®, 2012</i>)	140
Figure 65.	Dainese® Wave air exoskeleton jacket as viewed from the rear (<i>Dainese®, 2012</i>)	141
Figure 66.	Dainese® Wave air back protector; Internal construction (<i>Dainese®, 2012</i>)	143
Figure 67.	Dainese® motorcycle protective wear elements (<i>Dainese®, 2012</i>)	144
Figure 68.	Examples of open weave meshes (<i>Heathcoat Textiles UK, 2009</i>)	145
Figure 69.	Hard and soft textile combinations in garment design (<i>Alpinestars®, 2012</i>)	148
Figure 70.	Dainese® Wave air exoskeleton jacket (<i>Dainese®, 2012</i>)	151
Figure 71.	Cordura® testing results shown above after laundering (<i>Mascot® Workwear, 2012</i>)	152
Figure 72.	Earlier version Dainese® Wave air exoskeleton jacket (<i>Dainese®, 2012</i>)	154
Figure 73.	Dainese® protective knee brace for motorcycle wear (<i>Dainese®, 2012</i>)	155
Figure 74.	Examples of a three dimensional (3D) spacer fabrics (<i>Heathcoat Textiles UK, 2012</i>)	156
Figure 75.	Ergon BC1 backpack (<i>Ergon®, 2011</i>)	166

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 increasingly 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.