Where We Fit: Body Sizing and Standards from Industrial into Digital Contexts

Abstract

The development of global systems to manufacture and distribute ready-to-wear clothing that occurred during the twentieth century, saw the demise of individually fitted garments produced by tailors and seamstresses across all but elite market sectors. Mass produced clothing, like most industrialised products, has depended on generalised sizing standards based on anthropometric norms. In New Zealand, as in many other smaller economies, garment sizes were based on standards developed in other countries.

The huge demographic and lifestyle shifts that have occurred globally over the last half century are also reflected in changing body sizes and shapes. The need for more relevant global sizing standards has seen the development of new national sizing initiatives such as Size UK (2001) and Size USA (2005), which have been assisted by the development of 3D body scanning technologies and software. While the datasets generated from these surveys have been used to develop more accurate and current national sizing information, a number of other applications for scanning technology and body shape data are being explored in relation to both global and local markets.

Some of these developments, such the linking of scan data to CAD technologies and the potential this offers for pattern development, garment customisation and fit optimisation, are considered through a review of recent literature in the field. The potential of these new technologies are discussed in relation to the New Zealand fashion sector, where structural changes have seen domestic manufacturing decrease dramatically, while the high value end of the market, with an emphasis on niche products supported by more flexible and scaleable design and production processes, has grown. It will be argued that the new resource offered by shape information technologies supports the ethos of the New Zealand Fashion brand, supporting the use of quality materials, innovative design and new technologies to enable product value, better fit and greater customer satisfaction.

1: Introduction

The huge demographic and economic shifts that have occurred globally over the last half century are also reflected in changing human body sizes and shapes. Within the fashion and apparel industry globalization has also affected manufacturing systems, and within the New

Zealand context, provoked a shift in focus from purely local supply to export markets. Within this context the issue of garment sizing systems and standards has become critical.

Generalised sizing standards were developed over the nineteenth and twentieth centuries, underpinned by vast social and technological changes including mass migration and warfare, and driven by the development of industrial systems for manufacturing and distributing ready-to-wear clothing. The manual process of identifying and recording sets of particular body measurements of representative numbers of individuals from across a population so as to establish a set of norms, was time consuming, affected by human transcription errors and was often personally demanding of participants. The photographs reproduced in figure 1. were taken during the U.K Woman's Measurements and Sizes Survey, conducted by Her Majesty's Stationary Office (HMSO) in 1957. They convey the process - and some of the awkwardness - of manual measuring methods. Her Majesty's Stationery Office (HMSO) was subsequently developed into The Office of Public Sector Information (OPSI). OPSI has a broad remit to advise on and regulate the operation of the re-use of public sector information. HMSO continues to exist and fulfil its core activities including responsibility for the publication of legislation and the management of Crown copyright operating from within OPSI.

In addition, the processes used to select populations surveyed were often specific rather than representative, for example, many sizing standards were based on the measurements of military personnel who had already been screened so as to meet physical norms as criteria prior to admission to the armed services. The history, methods and impacts of establishing sizing standards will be discussed further in this paper.

The need for more relevant global sizing standards has seen the development of new national sizing initiatives such as Size UK (2001) and Size USA (2005) which have been assisted by the development of digital 3D scanning technologies and information systems. The datasets generated from these surveys have been used to develop more accurate, detailed and current information about the body sizes and shapes of particular populations. Data from such surveys has become a valuable commodity in itself. Additional information about lifestyles and buying habits has also been collected from participants in these surveys, providing valuable information to support sizing and styling decisions in relation to particular market sectors.

Body scanning technologies are also being linked to other data collection and optimisation systems. Some of these applications, such the linking of scan data to CAD technologies and

the potential this offers for garment customisation and fit optimisation, may offer significant opportunities within the New Zealand context.

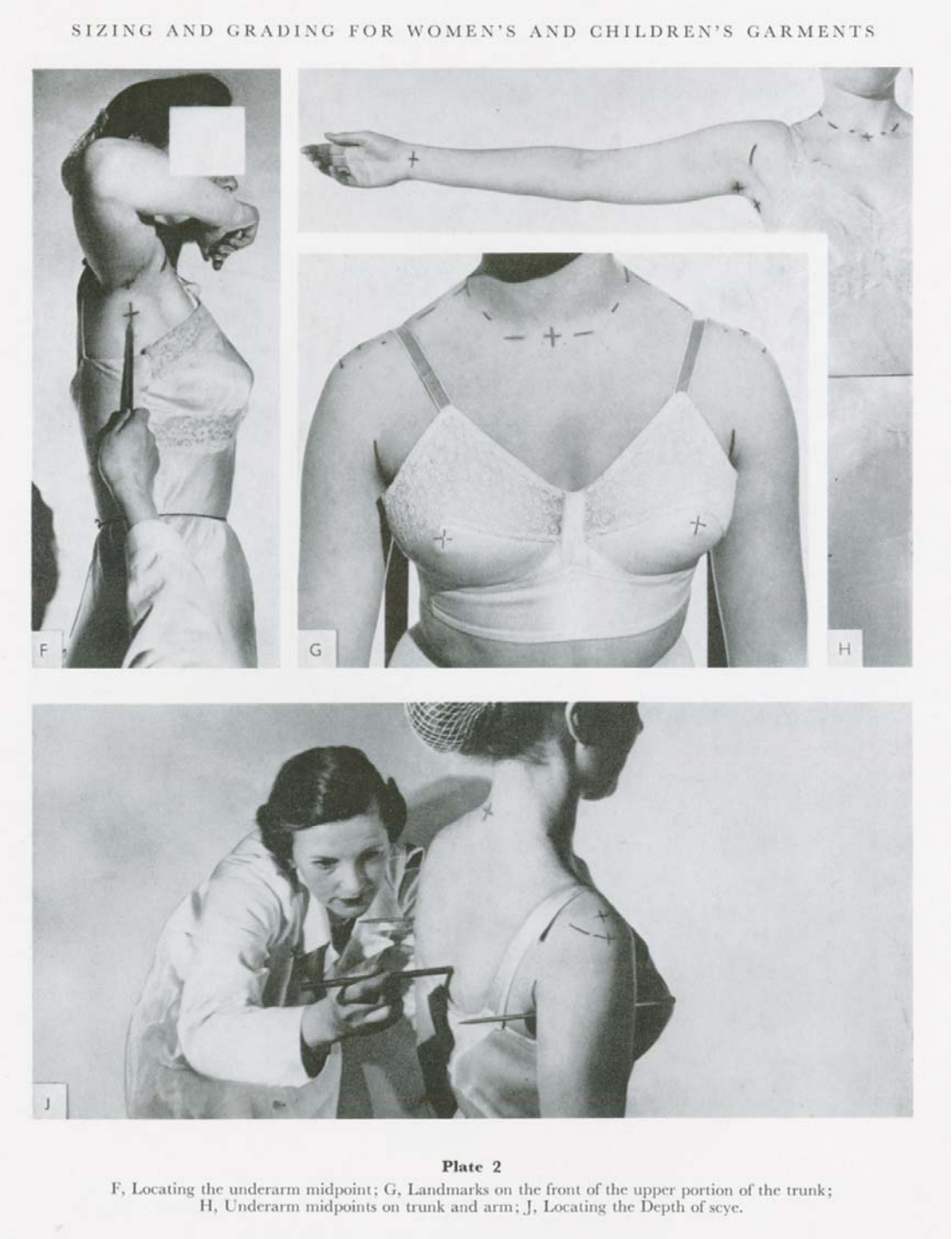

Figure 1. Photographs from *Woman's Measurements and Sizes H.M.S.O* 1957, from Kunick. P., *Sizing, Pattern Construction and Grading for Woman's and Children's Garments*, published by Philp Kunick Ltd, London, 1967.

Within this paper some recent international developments and applications are considered through a review of literature in the field. The New Zealand context is discussed in light of

current research into sizing practices in the local fashion and apparel sector. Some opportunities and possible directions are identified in relation to initiatives underway at the Textile and Design Laboratory (TDL) and the Institute for Sport and Recreation at the Auckland University of Technology (AUT) in partnership with the Bioengineering Institute at the University of Auckland.

The TDL was formed in 2006 and is focussed on design and innovation through new fashion and textile technologies. Within New Zealand structural changes have seen domestic manufacturing decrease dramatically, while the high value end of the market, with an emphasis on niche products and innovation, supported by more flexible and scaleable design, production and distribution processes, has grown. It will be argued that the new resource offered by shape information and body modelling technologies can enhance the practices and ethos of the New Zealand fashion sector, supporting the use of quality materials, innovative design, production and distribution systems to increase product value, ensure better fit, greater customer satisfaction, innovation and sustainability.

2: The Development of Sizing Standards

The earliest mass production of ready-to-wear clothing was motivated by the organized workforce requirements of groups such as sailors, slaves, and miners. Up until the beginning of 19th century garments were handmade, usually produced for ordinary families by the women of such families or commercially by tailors and dressmakers. The development of ready to wear coincided with urbanization and the great wave of immigrants that moved between Europe and other parts of the world in the last decades of the 19th century and early decades of the 20th century, which disrupted traditional artisan modes of dressmaking. The ready-to-wear industry expanded significantly between the 1860s and the 1880s due to the increased mechanisation of the garment manufacturing processes and the development of systems for sizing men's and boys' clothing in North America. These were initially based on the measurements of thousands of soldiers that had been recorded for making military uniforms during the Civil War, 1861-1865 (NIST, 2003). Company sizing systems were also developed for women and children's wear. The development of garment sizing systems was closely related to the growth of new retail distribution systems, for example dresses in the Sears mail order catalogue were coded with bust, girth and age guidelines from 1902 (Swearingen, 1999).

However it wasn't until the twentieth century that the science of anthropometrics was formalised, with the US Federal government creating the National Bureau of Standards (NBS) a non regulatory agency in 1901, for the purpose of standardising measurements for science

and industry (Armstrong, 2000). In 1921 the first report of an American anthropometric survey with clothing sizing was published. This was based on data collected from 100,000 men during demobilisation at the end of First World War.

Later in the 1930's the first systematic national sizing study using civilian populations was initiated. Between 1937 and 1941 a size survey of some 147,000 boys and girls was conducted across the United States. From 1939 to 1940 a further study on some 150,000 American women was conducted. The report entitled 'Women's Measurements for Garment and Pattern Construction' was published in 1941 by the US Department of Agriculture. From the 1940s to the 1990s the accurate sizing of garments for men, women or children, based on comprehensive sizing standards became a major focus of the garment industry, and various countries introduced their own surveys and national sizing regimes (see figure 2.).

In New Zealand, as in many other parts of the former British Empire, garment sizes were initially based on standards developed in the UK in the 1950s. In 1968 Sweden made the first official approach to the International Organisation for Standardation (ISO) on the subject of sizing of clothing. It was proposed that the creation of an international system would be of great public benefit. Seventeen member countries participated, including New Zealand. This work or system, called '*Mondoform'* eventually led to the publication of ISO8559 'Garment Construction and Anthropometric Surveys-Body Dimension' in 1989[1], which is currently used as an international standard for all types of size survey. These standards propose ratios of over all body size to specific body measurements. They are developed in relation to the information required for garment construction and mass production and to provide more general sizing information for labelling that is consistent and understandable to the public. Many countries, including the United Kingdom, New Zealand, Japan and South Korea revised their sizing systems by adopting the ISO standard. Such sizing labelling systems described body measurements with two or three key dimensions that the garment was made to fit (Yoon, 1992).

The development of industrial systems to manufacture and distribute ready-to-wear clothing that occurred during the first part of the twentieth century saw the demise of individually fitted garments across all but elite market sectors. As the product of mechanized production and distribution systems, mass produced clothing depended on scientifically driven sizing standards based on anthropometric norms. This regime of generalised measurement ratios has simultaneously addressed and problematised the issue of garment fit.

[1] The length of time taken between proposing the survey and the publication of the standards reflected both the organisational complexity of such a project, and the labour involved in manually collecting, processing and analysing data.

Date	Country	Group	Survey Size	Standard
1937-41	USA	Boys & girls	147,000	
1939	USA	Women	150,000	
1945	Mail Order Assoc. USA			CS151-50
1947	British Standard Institution	Women		BS1345
1950	British Board of Trade	Women	5,000	
1945	Denmark	Women		DS923
1955-59	Polish Academy of Science	Men, Women and Children		National sizing standards
1957	UK	Military personnel		Sizing survey
1957 - 58	Germany			Size table of body measurements
1957 -56	Former USSR	Men, women and children		Sizing survey
1958	NBS, US	Women	Based on 1939-40 survey data	CS215-58
1962	Germany	Women		Sizing survey
1969	Australia	Women	11 455	Survey
1972	South Africa	Men		Code of practise 039 standards
1974	China	Men, women, children		GB1335-81
1974 -1981	Switzerland	Men, women, children		ISO 3636, 150, TC133
1980-1986	Netherlands	Men, women	10 000	Survey
1982	Britain	Men, women, children.	3728	BS3666
1983	Germany	Women	9402	ISO System Sizing survey
1989	ISO (International)	Men, women and children		ISO 8559
1992-94	Japan	Men, women, children	3400	First sizing survey to use body scanning
1995	USA	Older women	6000	ASTM D 5586-95
1997	Chinese	Men, women, children		GBI 335-97
1999-2002	UK	Men, women, children	11,000	Size UK survey
2002-2003	USA	Men and women	10800	Size USA survey
2004	Mexico	Men and women	6600	Size Mexico survey
2005	Croatia	Men, women, children	30,866	Croatian Anthropometric System

Figure 2. Chart identifying some national sizing initiatives and standards, 1940 – 2004, based on information from various sources including Fan, Yu and Hunter (2004), Bourgourd (2005).

3: Standards and Fit

Clothing fit is important in terms of clothing appearance and feel. It is a critical issue in terms of customer satisfaction and therefore of great economic significance. While the Oxford Dictionary defines fit as 'the ability to be the right shape and size', this definition does not identify who the fit is 'right' for. Good fit is a complex issue. It is complicated by disagreement among the various stakeholders involved: the designer of the clothing, the patternmaker/grader, and the customer.

> Each stakeholder often has a very different concept of fit. The designer is interested in creating a specific aesthetic look in relationship to the body, the patternmaker/grader must maintain this aesthetic over a range of different bodies (generally with a limited number of sizes), and the consumer has his or her own personal preferences about how their clothing should fit. The principles of fit are not always clearly understood, the definitions of fit vary from time to time and depend on fashion, culture, industrial norms and individual perception of fit (College of Human Ecology, 2005).

Returns caused by size and fit problems are a considerable cost factor both for retail, for the standard mail order trade and e-commerce. In 1999, return costs to the online apparel industry were reported to exceed $240 million in the US alone. The largest single reason for garment return was poor fit. In 2004 US consumers sent back an estimated 30% of product online apparel purchase orders, amounting to a $6 billion annual problem for apparel e-tailers. On average, these return costs stood at 27% of gross sales as e-tailers pay for all shipping to and from the consumer to ensure consumer loyalty (Beck, 2004).

The later half of the twentieth century has seen another series of enormous social and economic shifts towards a globalised economy underpinned by digital systems of production and distribution. Amidst these changes, the efficacy of established sizing systems has come under scrutiny. One response by American manufacturers in the 1970's was the development of body dimensional merchandising, which emphasised speciality sizes, including Large and Petite. This initiative was an attempt to give consumers better fit and was effective in reviving the women's ready to wear sector. For a time the special size was the fastest growing segment in the fashion market place (Choon-Yun and Jasper, 1994).

Sizing systems have been criticized for a number of reasons. They are often based on outdated anthropometric data, when population demographics have changed significantly. Many sizing systems that currently exist in the industry are not based on systematic,

objective standards or procedures so that each system delivers a different fit (College of Human Ecology, 2005). Different manufacturers have used different sets of standard body measurements and proportions for the same size code (Delk and Cassil, 1989). The standard body measurements associated with certain size codes have varied not only among manufacturers but also within individual manufacturers over time (Delk and Cassil, 1989). The numerical size codes of garments fitting consumers having a certain body measurements have gradually become smaller (Pray, 1987, Choon-Yoon and Jasper, 1994). Size labels attached to the garment do not inform consumers of the body measurements associated with specific codes (Pray, 1987). Sizing systems generally do not accommodate the wide variations of body sizes and proportions that exist in the population. Existing systems are often influenced by social norms and ideals rather than actual circumstances - for example the 2004 American D6192-98 Standard Tables of Body Measurements for Girls, Sizes 7 to 16, includes slim and regular but not plus. There is a D6860-03 Proposed Standard Tables of Body Measurements for Boys, Sizes 6 to 24 Husky but not an equivalent for girls (Fasenella, 2005).

Diversified sizing systems have caused manufacturers, retailers, and consumers much confusion as well as financial loss (Pray, 1987). In addition the development of niche and specialty markets have become significant and require specialised sizing systems related to lifestyles and consumer preferences rather than generalised norms.

If we are to agree with some predictions that e-commerce will grow to such an extent that “estimates are that internet will handle half of all apparel sales in the future” (Frings, 2001), then perhaps it is time to have a greater individual understanding of our own personal sizing, rather than relying on inconsistent and confusing sizing structures that are currently used. For example it is clearly more useful to know that a woman’s dress has been made to fit a body size of bust 92cm, waist 74cm, hip 97cm than to know it is a New Zealand size 12, a USA size 10 or an Italian size 44.

Many established online companies are placing greater emphasis on the communication of fit/size details; Marks and Spencers offers a useful size guide related to their products on marksandspencer.com. However many online services stock a number of labels from a variety of suppliers (each with different grading regimes), so they simply can’t communicate accurate sizing information. Inevitably the result for the consumer involves a lot of guess work.

4: The New Zealand Context

Dramatic political and economic shifts in the 1980s forced New Zealand to move from an agrarian economy dependent on concessionary British market access and a highly protected local market, to a more globally competitive, free market model. During this period of transition, a number of well known New Zealand manufacturing companies that were not export focussed or research and development capable, closed down (Thompson, 2003). Key sectors, like farming, underwent radical and often traumatic changes to long established practices of land tenure, production, distribution and marketing. The fashion and textile sector was also exposed to these reforms and suffered a dramatic decline in the face of reduced tariff protection, competition from synthetic fibres, the rapid development of textile and garment manufacturing industries in Asia and a corresponding flood of cheaper garments and products from these countries (Joseph, Reilly, et al. 2007).

New Zealand apparel companies face a number of particular problems including a small local market, a reduced local manufacturing sector and loss of expertise, limited local availability of fabrics and accessories and the geographic distance from export markets. Among apparel companies that have survived, adapted or developed in this changing context, there are three distinct strategies and economies of design and manufacturing.

One of the smaller sectors is locally designed and manufactured apparel, mainly for high end fashion or luxury tourist markets. These companies use 'New Zealand made' as a point of difference in both local and international markets. This is a position that a number of younger fashion designers, as well as those working with luxury local fibres (such as possum-merino fabrics) also identify in terms of sustainability, environmentalism and the 'clean, green' New Zealand brand. Fashion designers like *Miranda Brown* and knitwear brands such as *Tapestry* and *Snowy Peak* are exemplars of this field.

Many of the more widely recognised 'design led' New Zealand fashion and apparel companies focus on specialist or niche markets, are strongly export driven, design in New Zealand and manufacture offshore. Brands like P*umpkin Patch* (children's wear) *Icebreaker* (sport and lifestyle wear), *Orca* (high performance sportswear), *Karen Walker* (women's fashion) and *Bendon* (underwear) are high profile examples of this approach. Many of these companies are also strongly associated with the New Zealand brand through distinctive and innovative design and quality of product.

There are also a number of larger companies producing apparel for the New Zealand market. Product ranges are designed in New Zealand, are often strongly influenced by

international trends with most if not all manufacturing done offshore. Many of the larger store ranges are produced this way, for example *Farmers* and *The Warehouse*. Production companies are contracted to produce such ranges, which form the backbone of medium to low cost local garment supply.

Each of these business contexts has specific issues in relation to garment sizing, be they related to local and/or international production systems or target markets. The issues of sizing standards and practices within the New Zealand context are not fully researched or understood. While some recent research has proposed that New Zealand manufacturers and retailers do not have sizing problems (Webster, 2007) the industry experience and initial research conducted by the authors indicates there are a number of significant sizing issues. Our research to date includes a small survey of New Zealand apparel companies and discussions with over fifty leading New Zealand designers and manufacturers conducted at the first *Sizing and Body Modelling Forum* held in Auckland on the 7th of December 2007.

The authors question the conclusions and the methodology used in Webster's research, including the initial reliance on postal survey rather than unstructured interviews, which has not produced an adequate or detailed enough industry response to provide significant data. In addition the reliance on manufacturer's opinion as to whether there are sizing problems may not be a reliable way to evaluate this situation. In 1994 manufacturers and retailers in the USA would not support the American Society for Testing and Materials to conduct a new sizing survey because they thought they didn't have problems with sizing (McLaughlin, 2007). However it has since been recognised that companies use sales data to get feedback on what sizes are selling and in what proportions – but that sales data never captures lost sales (TC2.com). New Zealand companies take a range of approaches to sizing and face a number of different sizing problems. The method of accessing or developing sizing systems is extremely varied - some companies have in house sizing systems, some use house models, while others work off commercial mannequins. While some companies work to best practice standards, in others a 'number 8 fencing wire' approach is taken. The New Zealand Design Task Force (2003) recognised the 'number 8 fencing wire' approach, which was an ingenious response to making do with limited resources in a new and geographically distant colony, as underpinning the ability of New Zealanders to invent and work with whatever was at hand. The Task Force recognised the historical value of this attitude but also suggested that it contributed to a lack of product sophistication that needed to be addressed if New Zealand was to make the transition to a knowledge-led, design-based, economy.

At least two of the bigger New Zealand apparel retailers (The Warehouse and Farmers) have conducted their own their surveys of specific market populations and have amended their pattern grading accordingly. One of the authors of this paper was part of a team who performed the measuring and sizing tasks for a children's survey in 2000-2001 and was responsible for developing the grading system according to the gathered data. Subsequently the garment returns for this company decreased significantly. The data from this survey is commercially sensitive and therefore proprietary. In New Zealand, as in other developed nations, there has been a huge change in both children's and adult's body sizes and old systems are no longer relevant.

In a recent limited survey involving five smaller local fashion companies, undertaken by one of the authors, it was established that all these companies used in house models to establish sizing data. As a last resort the companies sometimes use available mannequins. In the event of the 'regular model' being absent a next available person is often used as a back up. The problems created by such casual approaches are potentially costly. For example, an individual model's posture and proportion will determine the shaping and garment fit and may not be suitable for a specific target market, for example using flat busted models for garments that will be worn by bigger breasted women. While the companies have different labels for different age groups, often the same model is used for all groups. Body proportions change with age, even when the garment size doesn't. Only one of the companies used a different grading system for older figures. Body proportions are also related to lifestyles and activities. A house model may not represent the body norm for a specialist target market. The dress maker's mannequins available to these companies were, in most instances, inadequate for developing sizing systems in that they did not resemble real figures. In addition only three of the companies in the survey had body measurement charts and these were all based on imperial measurements (rather than metric ones which are used in New Zealand), creating problems of having to convert the measurements from one system to the other, with the potential for inaccuracies.

While this survey sample is too small to demonstrate any statistical validity and certainly does not imply that other New Zealand companies take the same approach, feedback from other apparel companies also indicated that the lack of access to current New Zealand sizing data is an issue that inevitably costs them time and money, even when best sizing and grading practices are being followed. Companies with a strong export focus are also keen to access current sizing data for the countries they sold into.

There is currently a limited understanding of how sizing and grading systems are used in New Zealand and the impact of these various approaches on the industry. However comparable research into the validity and use of Australian sizing standards (Honey and Olds, 2006) suggests that the New Zealand apparel industry faces similar problems. We propose that while it is useful to understand the approaches and problems of older sizing and grading systems in New Zealand, it may be more important to consider the opportunities and benefits offered by body scanning technologies and data systems and to consider how they might be used to assist and create new opportunities and value for New Zealand's design and apparel industries.

5: New tools: Body Scanning and Information Technologies

The huge demographic and lifestyle shifts that have occurred globally over the last half century are also reflected in changing body sizes and shapes.

The parameters of earlier surveys did not relate to today's context, for example the UK survey undertaken in the 1950's was limited to women aged 16 – 65 years, an age range that corresponded to average life expectancies. By 2001 it was necessary to extend the age expectation beyond 80 years (Bourgourd, 2005). The need for more relevant global sizing standards has seen the development of new national sizing initiatives such as SizeUK (2001) and SizeUSA (2005), which have been assisted by the development of 3D optical body scanning technologies and data management software.

In a few seconds a scanner can capture highly accurate 3D body maps which allow a computer to automatically extract hundreds of measurements from a scan

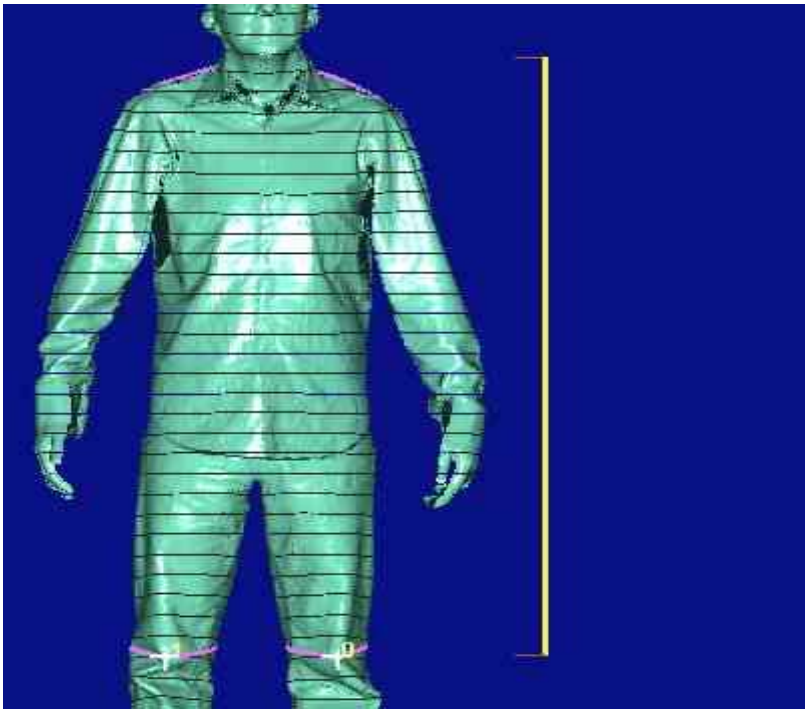

Figure 3. Body scan test image, Lyle Reilly, 2005

These new tools and systems have many advantages (Treleaven, 2004). Scanning technologies enable a quicker and easier method of measuring representative groups of individuals within populations. They offer a more accurate way of recording data without human transcription errors and provide thousands of data points which can give more than just standard height, bust, waist, hip measurements. Data is immediate available allowing it to be mined, analysed and interpreted in relation to other scans without the long delays that were inevitable in earlier manual surveys. They enable the capture of body shape and posture, not just measurements. Large scale, low cost surveys can be completed in a relatively short time

Associated software enables measurements extraction and provision of statistical analysis of what is measured. The survey process can be automated from subject registration to data analysis. Finer grained breakdowns or specific data can be extracted as required. Data optimisation processes can be linked to assist with developing sizes and grading. Data can be used in other digital systems, e.g. customised whole garment knit.

Some problems with scanning technologies for sizing surveys include difficulties in locating some measurement points e.g. the waist measurement which is the mid point between the iliac crest of the hips and the bottom rib, can be reliably located by hand but not always recognised on scans if a subject is fuller bodied (Treleaven, 2004). Some body scanners have difficulties in obtaining data from some hidden areas of the human body. For example,

the armpits, the crotch and areas under the bust and chin are sometimes shaded (Daanen & Jeroen-van de Water, 1998). This can result in areas of data being missed (Brunsman, Daanen &Robinette 1997). The human body is constantly changing, even when standing still. Movement due to swaying, breathing and posture changes during scanning can affect measurements, such as the chest circumference (Daanen, Brunsman & Robinette, 1997). The dimensions and price of early scanning systems made them difficult to set up and transport and unaffordable in many economies (Biederman, 2003).[2] The skills needed to interpret scanned data and select and apply it to pattern grading and other applications are not widely available within industry.

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Internationally, the development of this new approach to body measurement has had an immediate impact on the ways apparel companies are approaching garment sizing and fit and this has led to greater customer satisfaction and direct economic benefits for the companies involved.

McLaughlin (2007) cites the example of the American plus size clothing company *Lane Bryant*, in relation to the development of their new line of *Right Fit* jeans, which were based on scans of 14,000 customers in a survey conducted by *Intellifit Corporation*. *Lane Bryant's* in-house size experts analysed the data, and identified that a customer with a 34" waist could have hips that measured anywhere from 36" to 47"—a range that a single size couldn't cover. Their response was to build three different fits for each waist size: "A woman with a 34" waist wears a "straight" if her hip measurement is between 36" and 39"; she's "moderately curvy" if her hips measure between 40" and 43"; she's "curvy" if her hips are between 44"and 47"(McLaughlin, 2007).

Another example of garment design related to body shape is evident in a project recently completed by *[TC]²* ,[3] scanning 1,400 customers for the underwear company *Victoria's Secret* to help the company refine its bra designs. 'After careful analysis of the scans, six *Victoria's Secret* technical designers came to a breakthrough conclusion: women's breasts come in four distinctive shapes that vary independently of size, geographic location, age or

[2] These problems have been addressed by a number of technology manufacturers, for example the company TC2 now produces a streamlined scanner, the fourth generation of a device that measured about 21 by 15 feet by 8 feet high when first produced in 1997 to a more feasible 5 by 9 by 8 feet. It costs US $40,000, compared with $125,000 for the first model.

[3] [TC]2 is the company that provided the scanning technology for the SizeUK and SizeUSA projects. They develop solutions for the sewn products and related soft goods industries specializing in technology development and supply chain improvement. See http://www.tc2.com/index.html

ethnicity'(McLaughlin, 2007). Such insights into body shape will assist the development of better bra fit.

One of the original companies that sponsored the Size USA study, *J.C. Penney's*, has recognised that the data "allowed us to see who our customer was" (Hannaford, cited in McLaughlin, 2007). This has enabled the company to make sure that the styling of each house brand lines up with its fit, so that a woman's business suit, for example, isn't cut to fit a 14-year-old body shape.

These examples are directly related to the analysis and use of sizing and demographic data from body scanning surveys. The development of body shape systems, rather than just standard sizing systems, leads to better fit, greater customer satisfaction, more sales and less items returned. These issues are economically significant, for example, all the companies involved in sponsoring the Size UK project have reported economic benefits to their companies (Bourgould, 2007). This type of anthropomorphic data is also valuable to other product design areas–'from clothes to coffins, airplane seats to bicycles' (Treleaven, 2004). There are also a number of new applications and economic opportunities for apparel design, manufacturing and supply that are being developed in association with body scanning technologies, anthropomorphic data and new software.

Part Six: New Applications and Opportunities

One of the most immediate and well publicised commercial initiatives to utilize body scanning technologies in a retail environment was carried out by the American menswear company, *Brooks Brothers*. In 2001 a scanner was set up in their 'first made to measure apparel store' in Manhattan and presented as an alternative to the established but time consuming and detailed process of hand measuring and fitting for the bespoke tailoring of men's suits. While the technology had an immediate curiosity value, and helped reduce the time and cost of a personally fitted suit by several hundred dollars, Brooks Brothers did not roll out this technology to other stores in the USA. In 2003 it reported that less than 30% of its New York customers choose to use the scanning technology (Biederman, 2003) preferring instead the engagement, the highly personalised service – and the higher cost - of an expert tailor.

This example probably says more about the traditional values and emotional experience associated with fitting and buying a bespoke suit than it does about the significance of body scanning technologies. The value of bespoke tailoring is as much about personal service and the luxury of the handmade in an industrialised society, as it is about garment fit. In this

instance the use of technology cannot – and probably won't ever – compete. This process, of a new technology used initially in a way that is predicated by or mimetic of an older method or technology – in this case using body scanning in one of the few remaining commercial arena's of personalised garment construction, bespoke tailoring - is an example of a seemingly inevitable process of technological innovation, where time is needed to explore and develop a deeper understanding of a new technology and its see its real potential, so as to be able to move beyond existing conventions (Joseph, 2003).

Body scanning technologies and shape data are now starting to be considered and utilised in more original and productive ways. These include areas of design, customisation and online retailing.

Body scanning and CAD technologies conceptually shift the design approach to working with 3D body shapes rather than with linear body measurements and 2D shapes. One significant advance in this field has been the development of 'virtual mannequins'. These allow measurements from body scans to be superimposed on a virtual figure and, if required, a number of different body shapes superimposed and aligned to find an average body shape or size. Examples of virtual mannequins are *Figura* by the German company *Human Solutions* and the *Parametric Human Modulator (PHM)* by Hong Kong based *TPC*. Both these companies provide services whereby customised virtual mannequins can be easily and cheaply cast into polystyrene mannequins. The value of virtual mannequins is being recognised by companies that have their clothing manufactured offshore. In the future local designers and cutting supervisors in offshore manufacturing centres will be able to try identical sample garments on identical dress forms, and make adjustments to get the fit exactly right, using these systems.

Both *Human Solutions* and *TPC* have also developed associated pattern making and grading software. *TPC's Parametric Pattern Generator (*PPG) works with the virtual model so that a garment shape can be displayed on the figure and simultaneously on a flat pattern representation. Changes to the 3D design are immediately visible on the 2D pattern. A number of companies involved with pattern making and cutting systems for the textile and apparel industries, such as *Lectra* and *Gerber* have also linked body scanning with pattern drafting and grading systems. *Wholegarment* knit technology developer *Shima Seiki* is currently refining a body scanning to knit design capability to add to their *SDS-One* CAD system.

While there are now many New Zealand companies using CAD/CAM software to assist pattern making and cutting, and a number of knitwear companies manufacturing with whole garment or seamless knit technologies, to date we have not been able to identify any New Zealand apparel companies using body scanning technologies and data in relation to pattern grading and garment shaping.

The integration of body scanning, CAD and CAM will enable greater flexibility of production and ease of customisation. The ability to design and automate the production of garments for particular niche markets or individual body shapes is supported by these developments. However, earlier notions of bringing custom tailoring to the masses have been replaced with mass customization and personalization strategies to meet changing market considerations such as the growing heterogeneity of demand from consumers, the advent of so called "Long Tail Markets"[4] and increasing product complexities. These developments are also related to new information, communication and distribution system developments enabled by the internet.

One example of a company that has developed a novel and successful model of selling clothes to fit online is *Zafu*. They guarantee to help 'find your perfect jeans, pants or bra in three minutes'. The *Zafu* approach relies on a set of underlying assumptions or agreements based on body shape data, detailed product knowledge and a simple user interface that requires two simple measurements and a few questions about garment fit problems and preferred styling from the consumer. The company makes its money from commissions paid on online sales by apparel companies, rather than as a retail shop. It is very easy to use and seems to have developed a system that provides good fit, albeit only with American brands. The strength of the *Zafu* model is that it does not rely on consumers having to get body scans made, but still provides good advice on fit and styling in relation to a consumer's stated preferences. It may be that once or if body scanning systems become more widely available they will also be incorporated into *Zafu* types of online retail system.

As it stands at present this type of online fit evaluation system and detailed local garment product knowledge could be extremely valuable in New Zealand, where geographical distance is being broached by the internet. Such an approach could help New Zealand designers sell more product off shore and better promote local design to 'cultural' and 'eco'-

[4] The concept of the Long Tail Market refers to the notion that products which are in low demand or have low sales volume can collectively make up a significant market share that rivals or exceeds the relatively few current bestsellers and blockbusters, if the distribution channel is large enough. Such markets have developed with the advent of online marketing where global access to individuals with specialist demands can generate a significant sales volume.

tourists who while interested in local fashion and design often don't have much time to work out which local designer's sizing is best for them. It may also assist sales to local customers who may spend time trying on clothes they'd like to buy only to find they just don't fit properly.

Another developing area using 3D scanning and modelling systems is in relation to healthcare applications (Treleaven and Wells, 2007). While it is beyond the scope of this paper to discuss these developments in detail, the relevance of precise, individualised measurement data for heath related apparel (e.g. pressure garments, support garments etc) may also be relevant to New Zealand's growing health and performance sportswear sectors.

Conclusion

Human beings are shaped and behave very differently from one another. The development of sizing regimes based on generalised norms from data obtained through hand measured national sizing surveys was a significant feature of the development of industrial modes of garment production and distribution during the nineteenth and twentieth centuries.

The expectation that clothes can be sized uniformly to properly fit different body shapes and garment requirements across various populations is an unrealistic one. Problems with sizing and fit are costly. In addition human body shapes and sizes across populations are changing due to factors such as migration, different eating habits and lifestyles. Market considerations such as a growing heterogeneity of demand from consumers, the advent of so called "long tail markets" and increasing product complexities are leading to the development of mass customization and personalization strategies to meet consumer demand.

New scanning and modelling technologies offer a radically different approach to measuring, recording, analysing and developing standards and gradings for the apparel industry. The process is 'no longer a routine of mathematical calculations, but takes a morphological approach… whereby grading techniques are generated from the total equilibrium ratio of the actual body.'(TPC, 2007)

New 3D body scanning technologies, data management software and associated applications offer the potential not only to conduct large scale anthropometric surveys more easily, promptly and inexpensively, but also new opportunities to support better market understanding, product customisation, and retail opportunities, particularly through online sales.

Several national sizing surveys have been conducted - or are about to be run - using body scanning technologies. Within New Zealand there has been little activity to date within this sphere. The new resource offered by shape information technologies has much to offer the apparel industry. The potential of these technologies, particularly in relation to mass customisation strategies and online retailing, supports the ethos of the New Zealand fashion brand, furthering the use of innovative design and new technologies to enable niche developments, product value, better fit and greater customer satisfaction. The Textile and Design Laboratory (TDL) at AUT University, in association with the Institute for Sport and Recreation (AUT) and the Bioengineering Institute at the University of Auckland have formed a partnership to further investigate and develop these opportunities in association with the New Zealand apparel sector.

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