INFORMATION SOCIETY TECHNOLOGIES (IST) PROGRAMME

E-TAILOR

"Integration of 3D Body Measurement, Advanced CAD, and E-Commerce Technologies in the European Fashion Industry *(Virtual Retailing of Made-to-Measure Garments, European Sizing Information Infrastructure)*"

OFFICIAL DOCUMENT

Task 4.1 European Sizing Survey

-White Paper-

Manual for Conducting standardised 3D Body Scan Surveys as Basis for International Anthropometric Database

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1 EXECUTIVE SUMMARY

This document has been prepared as an additional outcome of the E-Tailor Project [IST-1999-10549]. It incorporates the lessons learned from the various pilot sizing surveys carried out as part of the project in France, Germany, Greece and Britain. Much of the information has been informed from previous experiences of two of Europe's leading exponents of size surveys, namely Hohenstein Institute (Germany), and Nottingham Trent University (UK). It involved the experiences for organisation, recruitment and realisation of the first survey with 3D laser scanner technology in Germany in 1999 and 2002 (3,000 female and male persons). It also takes advantage of the experiences of NTU researchers as part of the SizeUK Project in 2001/02, a survey which involved nearly 11,000 adults across the UK.

The aim is to provide guidance for countries which want to carry out similar large-scale size surveys. Experiences out of already finished surveys are valuable for simplification of organisation and realisation of plant surveys in other countries. The main objective of this documentation is to define requirements to reach international comparable measurement data as basis for an unique European anthropometric data base. A major investment is involved, with overall costs of such a project being typically in the range of €60 - €200 per person. It therefore is appropriate to ensure maximum value is obtained with minimum risk.

This document describes to ways to collect data, with stationary booth and with movable scan truck. Preparation, organisation, advantages and bottlenecks of both methods are defined.

This document will consider each major aspect in turn, starting with the recruitment strategy to deliver the data set required. Sampling statistics and accuracy parameters are considered. Also included in this document will be suggestions for market research questionnaires which could sensibly accompany the survey, as there are some correlation between body dimensions, shape and market segmentation. Data protection and ethical issues are considered, though local and national variations must be borne in mind.

There are now several 3D scanners available for use in size surveys, each with technical variations of hardware and data extraction software. They go a long way towards automating the previously labour-intensive aspects of expert manual measuring of people. Though the technology continues to improve, it is likely that some measurements would still be required to be taken manually (e.g. weight and height). This document assumes such a combination, and is in general independent of particular scanner.

The main sections of the document deal with the detail of preparation, organisation and realisation of a survey which includes site set-up, equipment, operator training, survey procedures and data gathering. Factors are highlighted which need to be considered and acted on in order to ensure that the sizing survey fieldwork process runs as smoothly as possible and, in doing so, projects a professional image to all participants.

The document describes different methods by using stationary and moveable scanner systems and different organised measurement teams.

Some consideration is given to the issues of Data Hosting, Data Analysis, and finally Press & Public Relations. A large size survey tends to create a great deal of public interest. This can be used positively to help recruitment in the first place, then as a marketing and promotion tool assuming outcomes should ultimately benefit your consumers.

2 INDRODUCTION

The development and technical standard of 3D body-scanner technology currently available opens up completely new opportunities to record human body measurements. Whereas in manual sizing surveys in the past, the volunteers were no longer available after the measuring process had been completed if the data needed to be checked, the use of 3D scanner technology today means that a virtual twin of those measured is available even after the actual measurements have been taken. This data can be used for additional purposes, such as deriving information on three-dimensional body forms. This opens up virtually unlimited opportunities to derive body dimensions in the form of surface measurements, cross-sections etc. which can be used for more than just the basis for designing clothes and sizing systems; important information can also be extracted for use in other sectors, e.g. architecture, or the construction of furniture or sports equipment. It will also be possible to use the three-dimensional geometrical data as a basis for future comparative studies on changes to the body as a result of ageing. Extensive data is already available in Great Britain, Greece and Germany as results of sizing surveys carried out on over 20,000 individuals. This data will primarily be used to update existing national clothing sizing systems.

But given the increasing globalisation of international markets, information on body measurements and market shares from different countries are an essential prerequisite for success in the international marketing of clothing and other industrial goods which are developed on the basis of body measurements. The infrastructure and IT platform necessary for a generally accessible database has been created within the E-Tailor project in the form of the EAD (European Anthropometric Database). What has been missing until now has been sizing surveys throughout Europe in order to enter up-to-date information in the database.

The data which is currently available from the individual countries is often out-of-date and generally no longer corresponds to the current body proportions of the cross-section of the population. In the majority of cases, the measurements cannot be compared, as they have been compiled on the basis of different measurement definitions and measuring techniques. An initial attempt to standardise the definitions of measures and measuring techniques used has been made by the CEN (EN 13402). This norm contains standardised definitions of measures and measuring techniques which are predominantly aimed at manual measuring. This has been extended within the EU project e-T Cluster, and prepared specifically for measuring using virtual 3D human models. Standards for data exchange formats for the 3D geometric data and body measurements were also defined. This has created the foundations for an international body measurement database of a quality which cannot be achieved with information gained by manual methods. It should be in the interests of all countries to enter information in this platform in order to create an international pool of data which will form the basis for a European sizing system and can be used to derive information on market shares. This will simplify cross-border trading for everyone involved – in particular the clothing sector in this instance.

2.1 PROBLEMS OF NATIONAL SIZING SYSTEMS IN A GLOBAL MARKET

Clothing is manufactured on the basis of standard sizes. The sizing systems used for this tend to vary from country to country. The measuring data which is used as the basis for the national sizing systems is often out-of-date or is simply based on empirical values from individual companies. As a result of the different definitions of measurement ranges and the fact that the sizing systems are based on different figure types and/or heights, it is often not possible to compare results derived from sizing surveys. Differences in when the sizing surveys were actually carried out in the different counties also make it impossible to make direct comparisons. However, information on the up-to-date body measurements of the population and the percentage distribution of the various standard sizes in the individual countries are a prerequisite for the successful marketing of clothing on an international level.

Sizing charts do exist in many countries, but information on the market shares of the various sizes are often either not available or are out-of-date. Information on the distribution of sizes and body proportions for foreign markets is therefore inadequate, making it impossible to calculate potential sales and market success.

Sizing surveys carried out throughout Europe could help to resolve this problem. A European sizing system derived from this with tables detailing market share, based on an international evaluation of the data, would enable uniform size labelling and could supply the missing information on the percentage distribution of the sizes, thus offering a platform for fair competition for all partner states in the international marketing of clothing.

2.2 THE HISTORY OF SIZING SURVEYS

Since the 1950s, sizing surveys have been carried out for clothing in different European countries. A sample of the population was measured in ten European countries. In the majority of cases, the data was recorded using manual methods. The first measurements using scanner technology were carried out in Great Britain in 1996 as part of an internal company project. The first official sizing survey using 3D laser scanner technology took place in Germany in 1999 (see table: Sizing Surveys within the last 50 years part 1 and part 2).

Country	Target Group	Number of persons	Points measured	Method	Year	Organisation
Austria	Women	3000	20	manual	1976	Hohenstein
Belgium	Men, Women, Children	3000 3000 3000	 32		1990	Kledingfederatie,
France	Men Women Girls Boys Babies	7283 8037 14000?	31 26	manual manual manual manual manual	1965/66 1969/70 1969/70 1969/70 1958	CETIH
Germany	Women	8000 8500 8500 8600 1500 1100	13 21 21 24 82 82	manual manual manual manual scanned scanned	1957/61 1970 1981 1994 1999 2002	Hohenstein
	Men	6122 300	23 8	Manual scanned	1979 2001	Hohenstein
	Girls	1500 1500 1400	21 21 24	manual manual manual	1970 1981 1994	Hohenstein
	Boys		21	manual	1978/79	Hohenstein

Table: Sizing Surveys within the last 50 years – part 1

Country	Target Group	Number of persons	Points measured	Method	Year	Organisation
Greece	Women	700		scanned	1999/2000	SOMA
	Men	2950		scanned	1999/2000	SOMA
	Boys (6-17)	1100	30	manual	1973	ELKEPA
	Girls (6-17)	1100	26	manual		
	Children	300		scanned	1999/2000	SOMA
Italy	Women/Me n	1500		scanned	2002	D´appolonia
Spain	Women	5000	25	manual	1967	AIEC, Barcelona
	Men	6000	30	manual	1967	AIEC, Barcelona
UK - Great Britain	Women	5000 2500 2500 2500 5500	37 >150	manual scanned scanned scanned scanned	1950/57 1996 1998 1999 2001	Board of Trade NTU NTU NTU 3-D Centre UCL
	Men	2500 5500	 >150	Scanned Scanned	1999 2001	NTU 3-D Centre UCL
Nether-lands	Women	3300 750	24	Manual Scanned	1984 1999/2000	VGT DenHaag TNO
	Men	3300 750	22	manual scanned	1984 2000	VGT DenHaag TNO
	Girls		24	manual		
	Boys	3300	22	manual		
Sweden	Women	1000 ?	22	manual	1973	TEFO, Goteborg
	Men			manual	1975	TEFO, Goteborg
Turkey	Girls			manual	1994	Izmir University
Finland	Women	1600 ?		manual manual	1978 1999	Vateva, Helsinki
	Men			manual	1988	Vateva, Helsinki
	Children			manual	1984	Vateva, Helsinki

Table: Sizing Surveys within the last 50 years – part 2

In Germany, over 10,000 women and girls were measured every 10 years and the results were documented in size charts and market share tables. The reason for the study being carried out in this way was to investigate to what extent body proportions alter over time. The results demonstrated significant changes in body dimensions and size distribution between the different stages in the study. People are getting bigger, and on average have larger girth measurements than in the earlier series of measurements (see diagrams: Changing market shares of Body Height and Bust girth). This change in body proportions is certainly not limited to Germany – it is representative of a trend common to other countries.

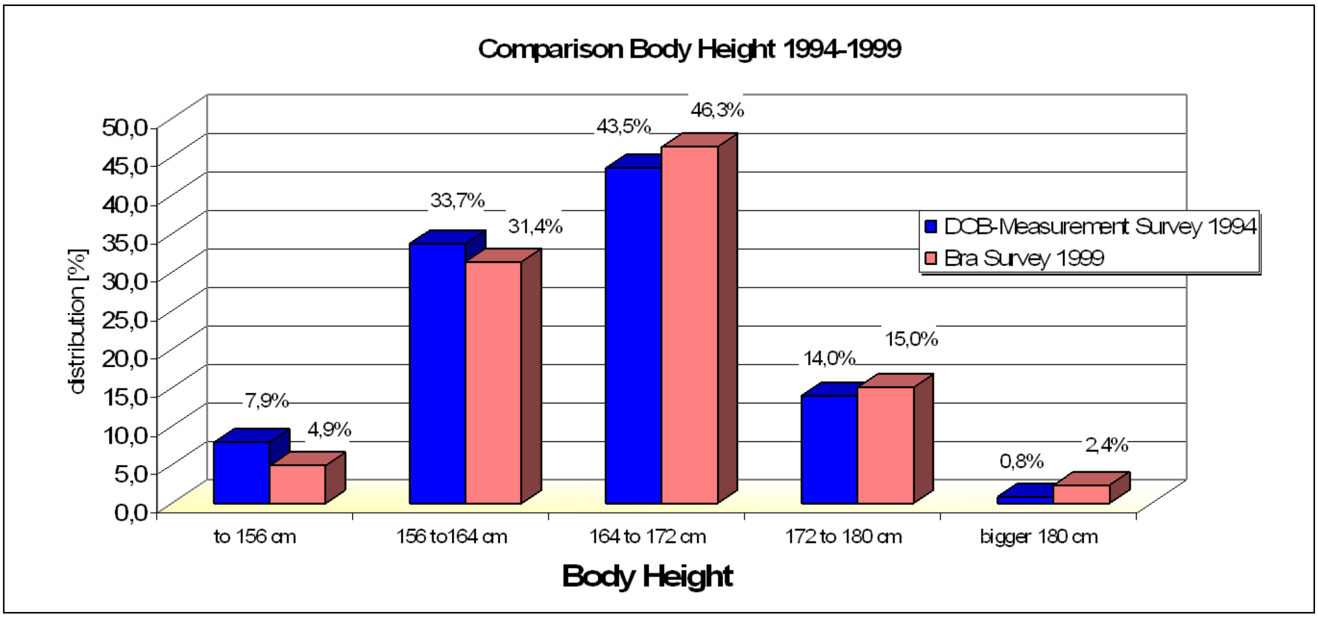


Diagram: Changing market shares of the Body height

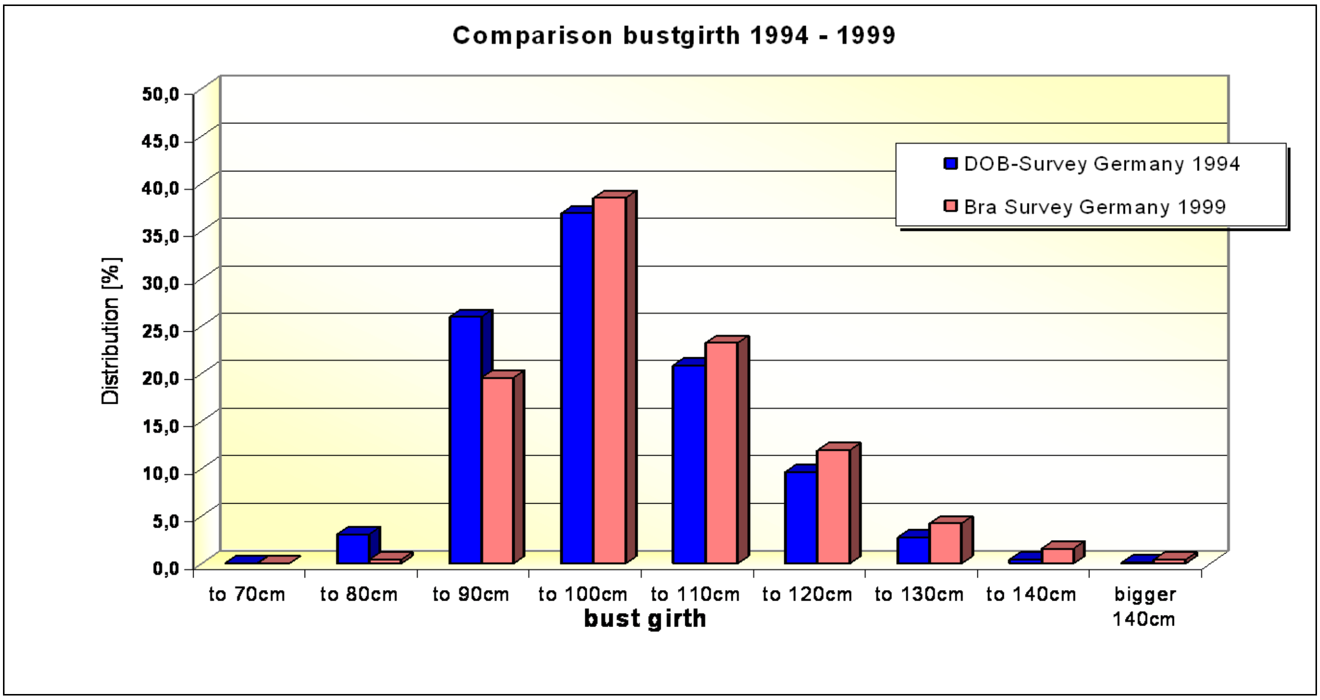


Diagram: Changing market shares of the Bust Girth

2.3 STATE OF THE ART OF THE CURRENT DEVELOPMENT

Following initial trials measuring human bodies using 3D scanner technology, attempts have been made, or are in the process of being made, in various countries to carry out sizing surveys on a large scale using 3D scanners. Following the lead of Germany and Great Britain, France is also planning to carry out an extensive sizing survey using scanner technology.

Greece:

- Since 1999, 2400 women, 3150 men and 1900 children have been measured. The measurements have been carried out on behalf of companies in the clothing industry. Scanner technology was used to record the data, which simply provides a three-dimensional model of the participant's torso.

The data recorded and the way in which the data has been evaluated is essentially compatible with the standards specified in E-Tailor and eT-Cluster. The data is the property of the party carrying out the survey and is currently not officially available.

Germany:

- In 1999, the first sizing survey using scanner technology to have official backing was carried out. 1500 women aged between 16 and 70 were measured. The data was recorded at two venues. The first measuring venue, in the south of the country, represented the population group from this region. The second venue, in a densely populated area in the west of the country, covered population groups from central and northern Germany.

- In 2002, another project with official backing was launched to compile the body measurements of 1100 women aged between 50 and 80 using 3D scanner technology. These measurements were carried out using a mobile scan truck. The participants were measured at five sites – in the south, central west, north, central east and south-east of the country.

The data was and continues to be recorded and evaluated in line with the specifications and methods laid down in E-Tailor and eT-Cluster. The data is officially available and can therefore be used within the EAD as a basis for the European sizing information infrastructure.

Netherlands:

- 1999/2000 measurement survey within the scope of the CEASAR project. 1500 persons (female and male) were measure with 3D scanner.

The raw data is officially available and has to be purchased. The data recorded is essentially compatible with the standards specified in E-Tailor and eT-Cluster.

Italy:

- 2001 measurement survey within the scope of the CEASAR project. More than 800 persons (female and male) were measure with 3D scanner.

The raw data is officially available and has to be purchased. The data recorded is essentially compatible with the standards specified in E-Tailor and eT-Cluster.

Great Britain:

- In 2001, 11,000 women and men were measured as part of a project initiated by industry and the retail sector. A TC^2-scanner was used to record the data. Participants were measured at eight different venues. In addition to the scanned data, extensive manual measurements were also carried out to supplement the data.

The measurements and evaluation of the data were carried out in line with the specifications laid down in E-Tailor and eT-Cluster, with details merely being modified to meet the requirements of the companies involved. The data is not yet officially available and will only be available to the general public after a retention period.

France:

- 2002/2003, sizing survey planned to measure 10,000 women and men using 3D scanner technology.

The measurements will be the first in which the specifications defined in E-Tailor and eT-Cluster relating to the way the survey is carried out and the methodology to be used can be directly put into practice.

2.4 AIM OF THE EUROPEAN SIZING SURVEYS

The principal aim of the European sizing surveys must be to compile comparable data on the body proportions of the European population which can be used to set up a universally accessible database. This database will then form the basis for the development of a uniform European sizing system which will make the international marketing of clothing considerably simpler for everyone involved.

However, other industrial sectors could also benefit from the information on the body measurements of the population being available on a European level; this would increase marketing opportunities for products which are closely linked to body measurements, such as those from the automobile or furniture industry etc.

The aim of a European sizing survey is therefore to ensure that the different national institutions which wish to measure their population are guided by uniform standards when carrying out and evaluating sizing surveys. These specifications have been developed within E-Tailor and eT-Cluster and are essentially described in this document. National requirements must take second place.

3 MEASUREMENT DATA AS BASIS FOR HARMONISATION OF EUROPEAN SIZING SYSTEMS

Size designations for clothing vary from country to country both within Europe and on a global level. As described in Chapter 2, this is due to the fact that national sizing systems are based on incompatible principles, and that the basis used to develop size designations also varies. Within the international clothing market, it is therefore now common practice to list the approximate equivalent size designations for all countries of destination on the garment label. However, this practice is simply a makeshift solution and does not solve the underlying problem of the incompatible sizing systems. To solve this problem, the WG 248 of the CEN has been working towards the harmonisation of sizes within Europe since 1996. The principles behind the harmonisation of sizes have already been developed and will soon be available as EN 13402-1 to EN 13402-3 - Definition of

Measurement Ranges, Primary und Secondary Dimensions for Clothing and Body Measurements and Intervals.

The size coding will be worked out in Part 4 of the Standard. At present, work has hit a standstill. Basic information on the current body proportions of the European population and the percentage distribution within Europe is lacking. Without this information, it is not possible to develop a sizing system which would be valid throughout Europe and which would be representative of the European population. An initial step towards solving this problem is to carry out sizing surveys in all European countries, and to make the results of these available to a group of experts for evaluation.

3.1 CURRENT SITUATION

The sizing systems currently in place within the various European countries vary considerably in some instances. The sizing systems are often based on different body heights and girth measurements (see table: Current SIZE INDICATION – EUROPE - Comparison Hip). In some cases, body heights are increased within the sizes, therefore it is only possible to make a comparison with sizing systems established on the same basis (see diagram: Body height - ranges in different countries). From this, it can be deduced that there are often significant differences between the body measurements used for the sizes, even where the same size designation is used. It is therefore only to be expected that there will be problems with fit when purchasing clothes from other European countries.

Size	***8***	***10***	***12***	***14***	***16***	***18***	***20***	***22***
U.K. Freemans	89	94		99	104	109	114	119
U.K. (a. Wilson)			91	97		102	107	112
U.K. (source Ebsco)	87	90	95		100	105	110	115
U.K. M&S		91	95	99	103	108	113	118
Size	***36***	***38***	***40***	***42***	***44***	***46***	***48***	***50***
France cross-section		89	93	97	101	105	109	113
Spain (Sist. Velez-Per)	86	90	94	98	102	106	110	114
Spain (Inst. P.V Ferrer)		90	94	98	102	106	110	115
Spain (Escuela Gerrero)	86	88	90	96	100	104	108	112
Spain (Cent. Superior)		94	98	102	106	110	114	118
Spain (Costura 1992)	88	92	96	100	104	108	112	116
Spain (Goymar)	84	88	92	96	100	104	108	112
Size	***40***	***42***	***44***	***46***	***48***	***50***	***52***	***54***
Italy (Postalmarket)	90	93	96	99	104	107	111	115
Italy (cross-section)		90	94	98	102	106	110	116
Size	***34***	***36***	***38***	***40***	***42***	***44***	***46***	***48***
Germany	90	94	97	100	103	106	110	115
Netherlands	87	92	96	99	102	105	109	114
Belgium(La Redoute)	86	90	94	98	102	106	110	114
Belgium(Matentab.)	93	96	99	101	104	107	110	113
Sweden	90	93	96	99	102	106	110	115
max. difference Hip	***9***	***8***	***9***	***6***	***6***	***8***	***7***	***7***

Table: Current SIZE INDICATION – EUROPE - Comparison Hip

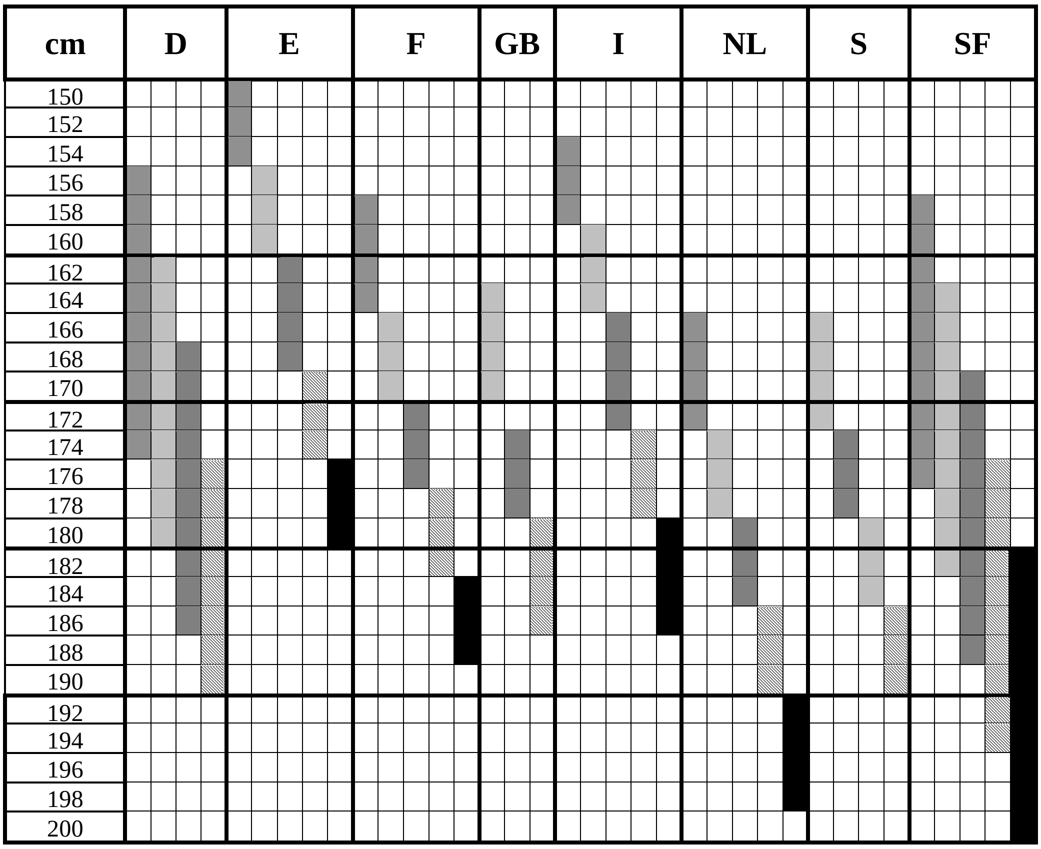


Diagram: Body height - ranges in different countries

Legend:

extra short
short
normal
tall
extra tall

3.2 PREREQUISITES FOR THE HARMONISATION OF SIZES WITHIN EUROPE

As mentioned earlier, information on the current body proportions of the European population form the basis for the development of a European sizing system for clothing. On the basis of this data, it will then be possible to define uniform size codes as a European Standard. Standardisation of sizes within Europe will be achieved by the implementation and use of this Standard to designate standard sizes within industry and the retail sector.

A prerequisite for the collection of the data is a survey of a representative sample of the population of all European countries following uniform criteria in order to obtain data which can be compared between the various countries. In order to achieve this objective, the sizing surveys used, both those which have already been completed and those planned for the future, must fulfil the following requirements:

- Use of uniform methods to determine the posture used for measurements
- Measuring the volunteers in a comparable state of dress
- Manual measurements and automatic extraction of measurements following standardised procedures
- Availability of the data in a standardised data exchange format
- Centralised data management system, accessible to authorised individuals/institutions poss. for a fee for the commercial use of the data for market analyses
- Safeguarding personal data protection – by depersonalising the data records

The relevant conditions have been developed within the E-Tailor and eT-CLUSTER projects. With the availability of the **E**uropean **A**nthropometric **D**atabase, which was developed within the E-Tailor project, and which is managed by EURATEX, the infrastructure for the central data management system has been created.

More detailed information on the organisation and implementation of sizing surveys can be found in chapters 5 and 6.

4 SCANNER TECHNOLOGY – STATE OF THE ART

The development of 3D scanner technology has reached the stage that it is now possible for it to be used unreservedly to measure human bodies, both in terms of the technical capabilities and the costs involved. This provides a measuring technology which in many respects offers significant advantages over manual measuring techniques when recording human body dimensions (see Chapter 4.5). When measurements are taken manually, information on the posture of the volunteer or information on the three-dimensional body form is no longer available, or is only available to a limited extent, after the measuring process has been completed. 3D measuring using scanner technology provides comprehensive information in the form of a so-called “digital twin” of the person being measured, on the other hand.

Various technical procedures are used to record the three-dimensional body geometry. The quality and coverage of the surface measurements taken vary depending on the individual technology used. The quality of the scan results is directly related to the density of the 3D data points, which determines the accuracy of the virtual image of the person being scanned. The coverage of the body surface measurements is largely influenced by two factors. Firstly, both the number and layout of the scan heads/cameras are crucial in ensuring that full 360° coverage of the body surface is achieved. Secondly, the posture and way in which the extremities are positioned affects shadowing effects, which results in incomplete surface information.

The 3D body scanners currently available can be divided technically into four main groups:

1. Scanners which use a laser beam as the medium to generate a model of the body surface
2. Scanners which use structured light as the medium to generate a model of the body surface
3. Scanners which reproduce the body surface using infra-red distance detectors
4. Scanners which produce a type of silhouette on the side opposite the camera by illuminating the object and which use this to record the two-dimensional outline in different positions also use structured light as a medium to generate a three-dimensional model of the body surface of the volunteer’s torso.

The various technical procedures used to record the body surface share one common objective: the extraction of three-dimensional coordinates of 3D data points. One feature which distinguishes between the various methods is the density of the 3D data points which can be derived from the optical data acquisition. In the case of scanners in the first group, this is affected by the traverse rate of the scan heads, the number of images taken, which is dependent on the hardware and software used, the layout and number of cameras involved. The maximum density of the 3D data points for this group ranges between approx. 1mm and approx. 5mm depending on the length of the scan and the technical equipment used.

For scanners in the 2nd group, the derivable density of 3D data points is affected by the geometric dimensions and the form of the light structure used for the projection (see diagram below). The finer the structure of the light projected onto the object, the more 3D data points can be calculated. If for example horizontal structures in the form of stripes are projected, it is possible to mathematically derive 3D data points at extremely short intervals in the horizontal direction along the light-stripe projection. In the vertical direction, the density of calculable 3D data points is dependent on the width of the stripes.

Camera Images of Sinusoidal patterns from fine and coarse grating projections.

The dimensions of the distance detectors set the limits for the density of the derivable 3D data points for scanners in the third group. The detectors are arranged in the scan heads either side by side or beneath one another for the scanning process. The maximum density of the 3D data points recorded corresponds to the width of the LEDs in the horizontal plane. In the vertical plane, the density is dependent on the number of distance measurements taken as the measuring heads move. The hardware currently available enables a minimum interval of approx. 5 mm between the individual 3D data points in the horizontal direction in an ideal situation.

The derivable density of data points for scanners in the fourth group in areas which are recorded three dimensionally is comparable with that of the 2^{nd} group of scanners, and is dependent on the same criteria. In the areas where three-dimensional coordinates are to be derived from the two dimensional outlines of the bodies recorded, this is only possible with the vertical sections, so a maximum of four points can be defined on a horizontal plane.

Regardless of which technical procedure is used, some scanner types have an additional function to record colour. Two different techniques are used for this: the simultaneous recording of colour during the scanning process and a separate process where the colour information is calculated on the scanned image following the scanning process. The aim of both these technologies is to provide as realistic a representation of the scanned body as possible in colour. The availability of colour information has no impact whatsoever on the measurement process; it is only of interest if the digital human models are to be used e.g. for "virtual try-on" of clothing.

The choice of which scan technology is suitable for the measurement of the human body depends on the individual requirements and how the 3D body data is subsequently to be used. An average density of the 3D data points is more than adequate if the data is to be used to carry out sizing surveys to develop size charts, provided that this also guarantees the exact measurement of smaller body dimensions, such as the wrist circumference (see Chapter 4.5). If the measurements are also to provide more detailed data for ergonomic use, where detailed measurements of the fingers or toes are required, a higher density of 3D data points is necessary.

All four types of scanner have already been used within sizing surveys in different European countries. Guidance and information on how to carry out sizing surveys has been compiled on the basis of experience gained with scanners in groups 1 and 2.

4.1 TECHNOLOGY AVAILABLE

This section contains the list of scanner types which are suitable for measuring human bodies due to their size and the technology used. The versions cited are limited to systems which have already been successfully used in sizing surveys. For some of the scanners, detailed descriptions are available in Chapter 4.7.

Company	*Scanner type*	*Web site*
Cyberware	WBX, WB4	http://www.cyberware.com
Hamamatsu	Body line scanner	http://www.hamamatsu.com
Hamano Engineering	VOXELAN	http://www.voxelan.co.jp
$[TC]^2$	2T4, 3T6	http://www.tc2.com
Human solutions	Vitus Pro, Vitus Smart	http://www.human-solutions.de
Telmat	SYMCAD 3D Virtual Model	http://www.symcad.com
Wicks & Wilson	Triform BodyScan	http://www.wwl.co.uk

4.2 TECHNICAL DATA

System	*Boot size* (WxDxH metres)	*Measure size* (WxDxH metres)	*Colour*	*Resolution* x,y,z (mm)	*Projection system*
Cyberware WB4	3.6x3.0x2.9	1.2x1.2x2.0	Yes	0.5, 2, 5	Laser, class 1
Hamamatsu Body line	1.6x1.7x2.4	0.9x0.5x2.0	no	1, 7.5, 5	Infrared light emitting diodes LED
Hamano Voxelan			No	3.4, 3.4, 3.4	Two vertical laser lines
$[TC]^2$ 3T6	3.3x5.9x2.4	1.1x1.1x2.0	No	1, 2.5, 2,5	Structured light
Human solutions Vitus smart	2.2x2.2x2.8	1.0x1.0x2.1	Optional	1, 2, 1	Laser, class 1
Telmat Symcad	3.9x1.6x2.4		No	No	Light, structured light
Wicks & Wilson Triform Body scanner	2.5x1.5x2.4	0.75x0.75x2.0	yes	1.5, 1.5, 1.5	Structured light

4.3 REPRESENTATION OF SCANNED BODIES

The scanner types listed in the previous two sections differ in the way the scanned bodies are represented only in that they either provide an image of the whole body as a 3D point cloud or simply reproduce the torso.

System	*3D Representation Torso*	*3D Representation Head, Arms, and Legs*
Cyberware WB4	yes	yes
Hamamatsu Body line	yes	yes
Hamano Voxelan	Yes	?
$[TC]^2$ 3T6	Yes	Yes
Human solutions Vitus smart	yes	yes
Telmat Symcad	yes	Only contour
Wicks & Wilson Triform Body scanner	yes	Yes

4.4 EXTRACTION OF MEASUREMENT DATA

The extraction of body measurements is based on different methodologies depending on which scanning system is used. Some suppliers measure and define landmarks on the basis of 3D point clouds, while others use the wireframe derived from the 3D data points. With many systems, the positioning of landmarks on the body scan is automatic, but in some instances these can be modified interactively. Some systems enable additional interactive measurements and individual landmarks to be defined. The overview below illustrates the scanner software which is used to process the scanned images.

System	*Software for measurement*	*landmarking*
Cyberware WB4	Automatic – individual	Automatic – interactive modifications
Hamamatsu Body line	Automatic	Automatic – partly interactive modifications
Hamano Voxelan		
$[TC]^2$ 3T6	Automatic – individual	automatic
Human solutions Vitus smart	Automatic- individual	Automatic – interactive modifications - individual
Telmat Symcad	Automatic	Automatic – interactive modifications
Wicks & Wilson Triform Body scanner	interactive	interactive

4.5 MEASUREMENT ACCURACY

The issue of measuring accuracy comes up time and again in the discussion of the use of 3D scanner technology for sizing surveys. Which method provides the better result? The tailor, who measures the person manually using a tape measure, or the modern 3D body scanner?

The following chapter will examine whether measurements taken manually can be compared with those extracted from the body scan, which technology provides the better result, and which influencing factors essentially affect the quality of the body measurements, regardless of which measuring device is used.

4.5.1 Prerequisites for comparable measuring results

The accuracy and quality of the body measurements can only be checked if uniform measuring conditions have been created in advance. Body measurements are essentially only comparable if uniform measuring methods are in place and if these are also applied consistently. The following criteria must be defined and standardised both for manual measurements and for measuring with the aid of 3D body scanners (see Chapter 6):

- clothing condition: uniform guidelines for clothing during the measurement process
- postures: uniform guidelines for posture during the measurement process
- body measurements standards: uniform definition of body measurements and guidelines for measuring sections and measuring methods
- uniform technical conditions: standardisation of the measuring devices

The technical conditions necessary are described in more detail below:
To ensure uniform technical conditions, the measuring devices must be standardised both for manual measurements and for the scanning process.

Manual measuring devices such as tape measures should be checked to ensure they are equal in length using a calibrated measuring stick. They should also be replaced after a certain period of use as the tape measures may stretch with use, thus giving incorrect measuring results. Equipment such as scales must be calibrated.

Despite standardisation of the technical conditions, it will not be possible to reproduce or compare the results of a manual measurement of intrapersonal and interpersonal variations to a 100% degree of accuracy, even if the operators have undergone rigorous training. It is always possible to place a tape measure around the test subject with too much or too little tension. In any event, sufficient tension must be applied to ensure that the tape measure does not slip from the test subject while circumferential measurements are being taken. The human body is often inadvertently compressed during the measurement process. The amount of tension applied depends on the subjective assessment of the person carrying out the measurement and therefore cannot be standardised.

Uniform technical conditions are also very important for the comparability of measuring data where scanner technology is used to carry out the measurements. Data acquisition technology and measuring software must correspond to standardised requirements which supply comparable measuring results, regardless of the technology being used. The specifications and requirements for this have been developed within the E-TAILOR and ET-CLUSTER projects. It is the job of the scanner manufacturers to implement these specifications.

The measuring accuracy of the scanner technology is often questioned by prospective customers. Hohenstein has attempted to provide incontrovertible evidence of the measuring accuracy of 3D body scanners using a range of tests. Attempts to measure individuals manually before or following the scanning process in an appropriate posture and using the measuring methods employed by the measuring software resulted in an extremely diverse set of test results. The deviations resulted primarily from variations in the body posture and differences between the different measuring personnel or several successive measuring cycles.

The user can carry out an objective, reproducible check of the 3D body scanner by performing a manual comparative measurement in which a display dummy is scanned. It is important that the control measurement contains critical measured values. A requirement for the selection of the control measurement is that the position of the measuring section should be clearly identifiable and that it should be possible to reconstruct this manually. To check the measuring accuracy, it is sufficient to compare a large circumferential measurement (e.g. bust girth), a large vertical distance (e.g. cervical height) and a small circumferential measurement (e.g. ankle girth). The comparison of a small circumferential measurement demonstrates the measurement accuracy of the extremities, which are affected to a large extent by the point density of the scan. The measuring accuracy of measurements in a vertical direction is determined by the comparison of the large vertical distance. By comparing the large circumferential measurement, it is possible to determine the deviation of the measured values for circumferential measurements and horizontal distances in this order of magnitude.

In the test measurements at Hohenstein using a display dummy, the results shown in the table below were obtained using two different scanners. The measured values clearly show that there are only minimal differences between the values obtained from automatic measurements using the body scan and manual measurements.

Measurement	**Bust girth**		**Cervical Height**		**Minimum leg girth R**	
Measuring method	**software**	**manual**	**software**	**manual**	**software**	**manual**
Scanner 1	**102,5**	**103**	**165,0**	**164,5**	**23,5**	**24,5**
Scanner 2	**101,7**	**103**	**163,9**	**164,5**	**24,1**	**24,5**

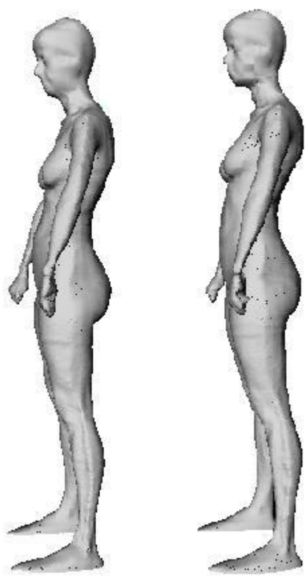
4.5.2 Factors which affect the body measurements

There are natural influencing factors which can have a significant impact on human body measurements, regardless of whether the body measurements are being recorded manually or with the aid of a 3D body scanner.

- Body posture
- Breathing condition
- Muscle tension
- Movement of the test subject

The body posture, breathing condition and muscle tension in the area of the stomach, seat, arms and legs play a critical role in terms of the quality and comparability of the measuring results. If the test subject moves during the measurement process, this can also alter the results: if the measurements are being taken manually, the tape measure may slip, and in the scanning process, it is possible that the surface of the test subject may not be recorded correctly. In some instances, the digital twin therefore no longer corresponds to the real person.

In order to demonstrate the effect of the influencing factors mentioned above on the body measurements, a series of tests was carried out at Hohenstein using a scanner (see diagram: Dependencies between different body condition postures and measurement results:



Posture 1: relaxed posture of the test subject

Posture 2: muscle tension in the areas of the shoulders, arms, stomach, seat and legs

	Posture 1	Posture 2	Difference
	[cm]	[cm]	[cm]
Bust Girth	90,8	93,8	3,0
Underbust Girth	75,9	78,0	2,1
Waist Girth	69,0	71,4	2,4
Hip Girth	100,2	100,9	0,7

Figure : Dependencies between different body condition postures and measurement results

In order to avoid differences in measurements, the test subjects should be instructed as precisely as possible by well trained staff as to which posture they should adopt during the measurement process. The standardisation of the necessary postures is therefore also essential (see Chapter 6).

Although standards help to optimise results, it will never be possible to obtain a result which can be reproduced to a 100% degree of accuracy. The posture and breathing of the test subject are dependent on their level of fitness, their form on the day, health, emotional state, and whether they are nervous or relaxed during the measurements etc..

4.5.3 Quality of manual measurements

This chapter shall look into the problem of reproducing manual measurements. The information is based on a practical measuring test carried out at Hohenstein and on the E-TAILOR document “Outline Specifications for European sizing surveys” (WP4, Task 4.1) by the authors Jean Marc Surville (Lectra) and Cathy Fournier (IFTH). In the French Pilot Survey, manual measurements were also carried out; extracts from the results are listed in this document to provide an idea of the quality of manual measuring methods.

4.5.3.1 Manual measuring test and results - HOHENSTEIN

5 female test subjects were selected – slim to well-built (standard sizes 38 to 50). The measuring team consisted of well trained specialists (3 people) with the same technical background in clothing technology. Measurements were taken using a non-elastic cotton tape, approx. 1 cm wide, rather than using a tape measure, so that the people carrying out the measurements were not able to read off the measured values. Coloured marks, which could be measured at a later stage, were made directly on the tape during measuring. It was therefore not possible for the staff carrying out the

measurements to inadvertently replicate the measured values from the first round in a second round of measurements.

The following body measurements were measured, based on precisely defined measuring sections (as specified in the eT-CLUSTER Standard). The measuring team received thorough training in the measuring techniques specified in the standard in advance of the study:

- Bust girth
- Waist girth
- Shoulder length - right
- Arm length – right (shoulder joint to wrist)
- Wrist girth – right

The test measurements were carried out on two different, non-consecutive days. On the first day of testing, all 5 test subjects were measured by all 3 members of the measuring team twice in succession. This was to ensure that the factors influencing the body measurements, such as changes in posture and the form of the test subject of the day were kept to a minimum as far as possible. Optimal test conditions were therefore created, a basic requirement if the results are to be reproduced. On the second day of testing, the test subjects were once again measured by the same measuring team under the same conditions. The test subjects were instructed to wear the same bras as on the first day of testing.

The differences between the results of the measurements on both days are shown in the table below. Table 1 shows the differences in the body measurements taken between the 1st and 2nd measuring cycle for each test subject on the first day of testing.

1. Day							
Test subject	**Operator**	**Measure A / B**	**Bust Girth [cm]**	**Waist Girth [cm]**	**ShoulderR [cm]**	**ArmLength R [cm]**	**WristGirth R [cm]**
1	I	A / B	0,3	2,0	0,6	0,6	0,1
	II	A / B	0,1	1,4	0,6	0,4	0,0
	III	A / B	1,2	0,7	0,4	0,4	0,1
2	I	A / B	1,4	0,3	1,0	0,7	0,6
	II	A / B	0,7	0,5	0,7	0,4	0,0
	III	A / B	1,2	2,6	1,0	1,1	0,1
3	I	A / B	0,0	1,5	0,4	0,6	0,6
	II	A / B	0,9	0,5	0,3	0,1	0,3
	III	A / B	0,3	0,9	0,4	0,1	0,1
4	I	A / B	5,2	1,2	0,2	0,3	0,3
	II	A / B	0,5	0,3	0,0	0,4	0,1
	III	A / B	1,2	0,2	0,5	0,4	0,1
5	I	A / B	0,1	0,8	0,4	0,2	0,1
	II	A / B	1,0	0,5	0,9	0,0	0,2
	III	A / B	0,3	2,5	0,2	0,3	0,0

Table 1: Differences in body measurements between measuring cycle A and B on the 1st day of testing

In Table 2, the maximum differences in measurements of all the body measurements taken for each test subject are shown. This is based in each instance on the 3 body measurement values which were taken on two different days by each member of the measuring team.

1. and 2. Day						
Test subject	**Operator**	**Bust Girth [cm]**	**Waist Girth [cm]**	**Shoulder R [cm]**	**Arm Length R [cm]**	**WristGirth R [cm]**
1	I	1,1	1,4	0,1	0,7	0,3
1	II	2,9	0,7	1,1	0,7	0,3
1	III	2,4	1,3	1,1	1,0	0,6
2	I	1,0	1,2	1,1	0,6	1,4
2	II	0,5	1,1	1,0	0,9	0,5
2	III	0,7	2,6	1,2	0,6	0,3
3	I	0,9	2,7	0,6	0,9	0,4
3	II	1,0	2,9	0,3	0,5	0,7
3	III	1,5	5,2	1,6	0,6	0,1
4	I	4,9	3,9	0,7	1,9	0,2
4	II	1,2	1,9	0,1	2,2	0,2
4	III	0,6	2,8	0,9	1,4	0,1
5	I	2,5	1,6	0,4	0,9	0,2
5	II	0,8	0,3	0,7	0,4	0,5
5	III	2,3	4,7	0,6	0,2	0,2

Table 2: Maximum differences in body measurements between the 1st and 2nd day of testing

Tables 3 and 4 show the percentage distribution of the differences calculated from Tables 1 and 2.

Differences – measuring cycles A and B: 1st day of testing		
Differences [cm]	**Percentage %**	**Percentage distribution**
0,0	8,0	Tolerance range of 0.0 – 0.3 cm **42,7 %**
0,1	14,7	
0,2	6,7	
0,3	13,3	
0,4	12,0	**57,3 %**
0,5	6,7	
0,6	8,0	
0,7	5,3	
0,8	1,3	
0,9	4,0	
1,0	4,0	
1,1	1,3	
1,2	5,3	
1,4	2,7	
1,5	1,3	
2,0	1,3	
2,5	1,3	
2,6	1,3	
5,2	1,3	

Table 3: A and B on the first day of testing – differences between the measuring cycles

Maximum differences between the 1st and 2nd day of testing		
Differences [cm]	**Percentage %**	**Percentage distribution**
0,0	0,0	Tolerance range of 0.0 – 0.3 cm **18,7 %**
0,1	5,3	
0,2	6,7	
0,3	6,7	
0,4	4,0	**81,3 %**
0,5	5,3	
0,6	9,3	
0,7	9,3	
0,8	1,3	
0,9	6,7	
1,0	5,3	
1,1	6,7	
1,2	4,0	
1,3	1,3	
1,4	4,0	
1,5	1,3	
1,6	2,7	
1,9	2,7	
2,2 - 2,9	12,0	
3,9 - 5,2	5,3	

Table 4: Maximum differences in body measurements between the 1st and 2nd day of testing

The tolerance of 3mm is used due to the problem of different degrees of tension being applied to the tape measure when taking manual measurements.

In spite of optimal measuring conditions due to the fact that the same body measurement was measured twice in succession, the result of the differences in Table 5 proved satisfactory at best. Of 75 differences calculated, only in 6 cases was it possible to accurately reproduce a value, and in only 3 cases was this with the wrist girth, which, as a small circumferential measurement, is extremely simple to measure. Over half of the body measurements (57.3 %) deviated by more than 3 mm. Although minor differences can certainly be disregarded, e.g. with the bust girth, in the case of small body measurements such as the shoulder length this is not acceptable.

Of the maximum differences in Table 4, only 18.7 % lie within the tolerance range and the percentage of large differences is much higher. In comparison to the measurements on the first day of testing, shown in Table 3, it was not possible to measure a single body measurement with 0.0 cm difference on two different days.

Tables 3 and 4 clearly show that it is virtually impossible to reproduce a manual measurement to a 100 % degree of accuracy, even under optimal conditions. Differences occur in virtually every case, and some of these differences are significant.

In contrast to Tables 3 and 4, Table 5 below primarily shows the maximum differences between the measuring results for one test subject taken from the values of all the members of the measuring team on the 1st day of testing, rather than the measuring results established by the individual members of the team.

1. Day (values in cm)							
	Value 1	**Value 2**	**value 3**	**value 4 [**	**value 5**	**value 6**	**max. dif.**
	Bust/chest girth						
Subject 1	102,2	101,0	101,0	101,0	100,9	100,7	**1,5**
Subject 2	93,6	93,5	93,4	92,7	92,3	92,2	**1,4**
Subject 3	119,1	119,1	117,9	117,6	117,3	117,0	**2,1**
Subject 4	112,2	111,1	110,6	108,6	107,4	107,0	**5,2**
Subject 5	92,3	92,2	91,0	90,3	90,0	90,0	**2,3**
	Waist girth						
Subject 1	85,0	84,8	84,6	83,9	83,6	82,8	**2,2**
Subject 2	75,8	74,7	74,4	73,9	73,4	73,2	**2,6**
Subject 3	104,6	104,5	104,2	104,0	103,3	103,1	**1,5**
Subject 4	88,8	88,7	88,6	88,4	87,8	86,6	**2,2**
Subject 5	77,5	75,0	74,3	73,8	73,8	73,0	**4,5**
	Shoulder length R						
Subject 1	13,2	13,0	12,9	12,8	12,4	12,3	**0,9**
Subject 2	14,3	14,2	13,3	13,2	12,5	11,8	**2,5**
Subject 3	13,7	13,3	12,6	12,2	11,5	11,2	**2,5**
Subject 4	13,7	13,2	13,0	12,8	12,5	12,5	**1,2**
Subject 5	12,2	12,0	11,6	11,5	11,3	11,3	**0,9**
	Arm length						
Subject 1	73,2	72,9	72,8	72,5	72,2	71,6	**1,6**
Subject 2	73,7	73,0	72,1	71,2	71,0	70,8	**2,9**
Subject 3	73,4	73,3	73,2	72,6	71,3	71,2	**2,2**
Subject 4	74,6	74,3	71,8	71,4	70,5	70,1	**4,5**
Subject 5	71,7	71,5	71,5	71,4	70,8	70,6	**1,1**

1. Day (values in cm)							
	Value 1	**Value 2**	**value 3**	**value 4 [**	**value 5**	**value 6**	**max. dif.**
	Wrist girth R						
Subject 1	16,4	16,4	16,1	16,0	15,9	15,8	**0,6**
Subject 2	15,8	15,7	15,7	15,2	15,1	15,0	**0,8**
Subject 3	17,8	17,6	17,5	17,0	16,6	16,5	**1,3**
Subject 4	17,2	17,1	17,0	16,9	16,5	16,4	**0,8**
Subject 5	15,8	15,6	15,0	15,0	15,0	14,9	**0,9**

Table 5: Maximum total differences of all measured values calculated on the 1st day of testing

Maximum differences of all body measurements calculated on 24.05.2002		
Differences [cm]	**Percentages %**	**Percentage distribution**
0.0	0.0	Tolerance range from 0.0 – 0.3 cm **0.0 %**
0.6	4.0	0.1 – 1.0 cm **24.0 %**
0.8	8.0	
0.9	12.0	
1.1	4.0	1.0 – 2.0 cm **28.0 %**
1.2	4.0	
1.3	4.0	
1.4	4.0	
1.5	8.0	
1.6	4.0	
2.1	4.0	2.0 – 3.0 cm **36.0 %**
2.2	12.0	
2.3	4.0	
2.5	8.0	
2.6	4.0	
2.9	4.0	
---	0.0	3.0 – 4.0 cm **0.0 %**
4.5	8.0	4.0 – 5.0 cm **8.0 %**
5.2	4.0	5.0 – 6.0 cm **4.0 %**

Table 6: Percentage distribution of the maximum differences of all measured values calculated on the 1st day of testing

When compared with Tables 3 and 4, the percentage distribution of the maximum differences in Table 6 clearly shows that the differences between the measured values established is even larger if comparisons are made between the results of the various people on the measuring team. Although all members of the measuring team had the same level of expertise in clothing technology, the measuring techniques and body measurement definitions were clearly defined and all body measurements were taken on the same day directly after one another, the smallest difference which arose is 0.6 cm. The majority of the differences, i.e. 64 %, lie between 1.0 and 3.0 cm.

This test confirms that it is not possible to reproduce data with a 100 % degree of accuracy using manual methods – even where optimal measuring conditions are in place.

To support the results of the Hohenstein manual test measurements, the results from the manual test measurements taken from the E-TAILOR Pilot Survey in France are shown below.

4.5.3.2 Manual measuring test and results – IFTH/Lectra

Source: WP4, Task 4.1 Outline Specifications for European sizing surveys; Author: Jean Marc Surville - Lectra / Cathy Fournier – IFTH

In this document, the manual measuring results are compared with the measured values from the scan data. To illustrate the problem, Hohenstein has only extracted and compared the manual measurements from this document in order to demonstrate the quality of manual measurements in general.

Description of the protocol applied for the FRENCH PILOT SURVEY

The protocol has been established in co-operation with the main three partners involved in this survey : IFTH/LECTRA/TELMAT

- **Sample:** 100 persons men/ women any sorts of corpulence and so possible disparity in ages.

- **Methodology:**

The subject fills a questionnaire on which will be allocated to him(her) a code included between 1 to –100 or more . At no time the subject **can not be identified** by her/his name .

A visual mark (a white velcro)will be placed to him(her) at the natural waist or where the subject wears his or her trouser. In some cases, it can be different compared with the belt girth .

The subject will be scanned 1 time and measured 2 or 3 times by tape according to the defined list of measurements.

- **Procedure:**

The person will be scanned in compatible underwear with scanners, then will be successively measured by tape or the opposite according to the establishment of premises, the objective being to protect in best the intimacy of the tested persons.

The subject will keep the same posture as in the scanner.

- **Manual measure 1** : a 1st operator will take measures by tape according to the list and will fill a chart for the subject N°X

- **Manual measure 2** : a-2nd operator will take measures by tape according to the list and will fill a chart for the subject N°X

and so on for all the subjects until 100 or more over.

Example 1:

Subject N		male 72			femme 53			
N°	**Measurements**	**Measure 1**	**Measure 2**	**Dif.**	**Measure 1**	**Measure 2**	**Measure 3**	**max. Dif.**
		[cm]	[cm]	[cm]	[cm]	[cm]	[cm]	[cm]
1	Height	167,0	168,0	**1,0**	169,0	169,0	169,0	**0,0**
2	Back waist length	44,5	48,0	**3,5**	43,0	43,5	44,0	**1,0**
3	Cervical height	144,0	145,0	**1,0**	142,0	145,0	146,0	**4,0**
4	Waist height	101,0	102,0	**1,0**	105,0	104,5	105,0	**0,5**
5	Outside leg length	102,5	103,0	**0,5**	105,0	105,0	106,0	**1,0**
6	Inside leg height	75,0	75,0	**0,0**	81,0	82,0	79,0	**3,0**
7	Inside leg length	75,0	76,0	**1,0**	81,0	79,0	79,5	**2,0**
8	Knee height	48,0	46,0	**2,0**	51,0	45,0	45,0	**6,0**
9	Minimum leg girth	20,5	20,5	**0,0**	23,0	22,0	22,5	**1,0**
10	Neck base girth	40,0	41,5	**1,5**	34,0	38,0	40,0	**6,0**
11	Front width	36,0	41,5	**5,5**	33,0	34,0	32,0	**2,0**
12	Bust/chest girth	92,0	91,0	**1,0**	91,0	93,0	91,0	**2,0**
13	Underbust girth	0,0	0,0	**0,0**	75,0	74,0	72,0	**3,0**
14	Waist girth	80,5	81,0	**0,5**	78,0	72,0	71,0	**7,0**
15	Hip girth	0,0	0,0	**0,0**	83,0	87,0	85,5	**4,0**
16	Pelvis girth	91,5	92,0	**0,5**	93,0	95,0	95,0	**2,0**
17	Upper arm girth	28,5	28,0	**0,5**	27,0	29,0	29,5	**2,5**
18	Wrist girth	16,5	16,0	**0,5**	17,0	16,0	16,0	**1,0**
19	Arm length	58,0	60,0	**2,0**	59,0	60,0	62,0	**3,0**
20	Back width	38,0	38,0	**0,0**	32,0	33,5	32,5	**1,5**
21	Shoulder width	44,0	53,0	**9,0**	44,0	40,0	40,0	**4,0**

Example 2:

Subject N°		female 120			male 121		
N°	**Measurement**	**Measure 1**	**Measure 2**	**Dif**	**Measure 1**	**Measure 2**	Dif
		[cm]	[cm]	[cm]	[cm]	[cm]	[cm]
1	Stature/Height	161,0	161,0	**0,0**	180,0	180,0	**0,0**
2	Back waist length	40,5	39,0	**1,5**	51,0	54,0	**3,0**
3	Body height	138,0	138,0	**0,0**	153,5	153,5	**0,0**
4	Waist height	99,0	102,0	**3,0**	106,0	107,0	**1,0**
5	Outside leg length	100,0	100,0	**0,0**	103,5	105,0	**1,5**
6	Inside leg height	73,0	72,0	**1,0**	82,5	82,0	**0,5**
7	Inside leg length (B)	73,0	73,0	**0,0**	83,0	82,0	**1,0**
8	Knee height	45,0	43,5	**1,5**	49,0	50,5	**1,5**
9	Minimum leg girth	21,5	20,5	**1,0**	22,5	24,0	**1,5**
10	Neck base girth	36,0	38,0	**2,0**	46,0	43,0	**3,0**
11	Front width	33,0	34,0	**1,0**	41,0	42,0	**1,0**
12	Bust/chest girth	90,0	88,0	**2,0**	102,5	103,0	**0,5**
13	Underbust girth	79,0	77,0	**2,0**	---	---	**---**
14	Waist girth	74,0	73,0	**1,0**	90,0	90,0	**0,0**
15	Hip girth	86,5	86,0	**0,5**	---	---	**---**
16	Pelvis girth	96,0	95,0	**1,0**	105,0	104,0	**1,0**
17	Upper arm girth	28,0	27,5	**0,5**	31,5	31,0	**0,5**
18	Wrist girth	15,5	15,5	**0,0**	17,0	18,0	**1,0**
19	Arm length	54,0	54,5	**0,5**	61,0	62,0	**1,0**
20	Back width	36,0	37,0	**1,0**	41,0	40,0	**1,0**
21	Shoulder width	39,0	40,0	**1,0**	49,0	47,0	**2,0**

Even when comparing the manual measurements which were taken during the French pilot survey for test purposes, significant differences occasionally occur, thus confirming the series of tests carried out at Hohenstein, indicating that it is not possible to achieve results which can be reproduced to a 100 % degree of accuracy using a manual tape measure.

4.5.4 Comparison of manual measured data and measurements derived from scan data

The comparison of measurements derived from scan data with body measurements taken manually is often discussed and is required for in order to check the quality of the measured values established with the aid of new 3D scan technology. Hohenstein therefore carried out a series of tests to make such a comparison using three defined body measurements.

Uniform measuring conditions, which are described in detail in Chapter 4.5.1, are a prerequisite for the comparison of measurements derived from scan data and manual measured data

It is important that a comparison measurement should contain critical control measurements, such as a large circumferential measurement, a small circumferential measurement and a large vertical difference, as well as containing standardised comparison criteria which should be consistently applied.

Control measurements:

- Bust / Chest Girth – large circumferential measurement
- Minimum Leg Girth – small circumferential measurement
- Cervical Height – large vertical distance

One requirement for the selection of the measurement is that the position of the measuring sections should be clearly identifiable, and that it should be possible to reconstruct this both manually and using the measuring software. The manual body measurements can only be compared with the measurements derived from scan data if manual measurements are taken accurately following the same definition and in the identical spot as specified in the measuring software.

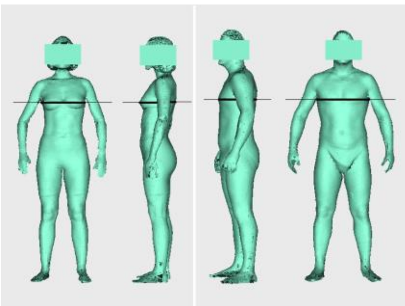
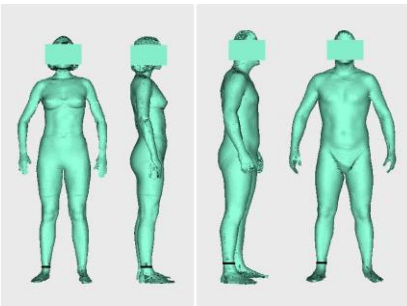
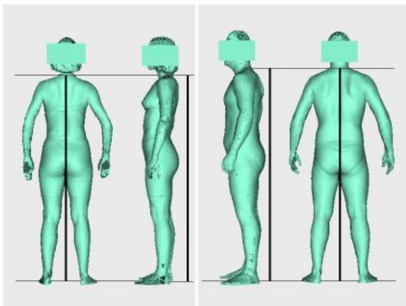
Bust/Chest Girth	**Minimum Leg Girth**	**Cervical Height**
Horizontal girth measured under the armpits (without arms) and at the level of the maximum projection of the bust / chest	Minimum girth of the lower leg measured horizontally just above the ankle	Vertical distance from the Centre Base Neck (seventh neck vertebra) straight to the ground.
		

Figure: measurement definition according to eT-CLUSTER

Measurement test and results - Hohenstein

<u>The following technical equipment was used:</u>

- Scanner used: VITUS/Smart, Tecmath
- Measuring software: Scanworx V 2.5 SL3, cross section with F5: 4mm
- Tape measure for the circumferential measurements
- Measuring device for the distance measurement "body height"

The test subjects were measured manually immediately following the scanning process in line with the framework conditions described in Chapter 4.5.1 in order to ensure the comparability of the results.

At the time of the evaluation of the body measurements described here, Hohenstein held the licence of a version of Scanworx, where the measuring definitions for the body measurements "Chest / Bust Girth" and "Minimum Leg Girth" did not correspond to the definitions of body measurements required for the comparison of the scanned values with the manual measured values. For this reason, the bust girths were measured interactively with the relevant tools. The body measurement values for "Cervical Height" on the other hand could be carried out by the automatic measuring software. Only in a few cases was it necessary to correct the measurements taken by the automatic measuring software (interactive adjustment of the marker or interactive measuring).

<u>Comparison of the body measurement data: Chest / Bust Girth</u>

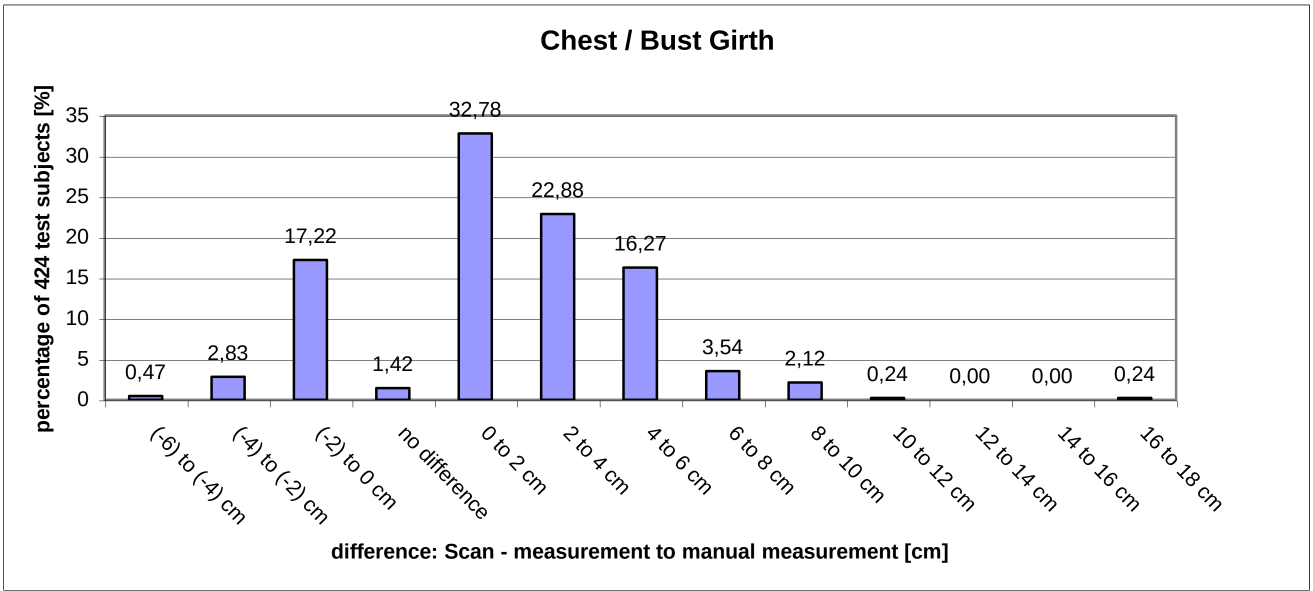


Diagram: Chest/Bust Girth: Comparison of the scanned measurements with the manual values

The differences established by comparing the measured values obtained using the software with the manual measurements are shown in the diagram "Chest/Bust Girth".

The differences are taken from the scanned body measurement measured interactively minus the manual measured value. The differences are shown in a list separated into negative and positive numbers using "no difference" as a base value to establish which measuring method tends to produce a higher or lower result. Differences of less than 0 indicate that the scanned measurement is smaller than the manual measurement. A positive difference on the other hand indicates that the scanned value is larger.

“no difference” means that the measured values compared are identical. The measured value established using the software corresponds 100% to the manual measurement. This result was only achieved in 1.42% of cases.

With 20.52% of the test subjects, the difference established is below 0.0cm, i.e. the bust girths obtained using Scanworx are smaller than those obtained using manual methods. For 78.07% of the test subjects, the difference established is above 0.0 cm, in other words, the bust girths obtained using Scanworx are larger than those obtained manually.

This result confirms the theory that the scanned values generally prove slightly larger as, unlike measurements using a manual tape measure, the software always measures circumferential measurements without applying tension, or with constant low tension.

Even if at 1.42% the percentage of measuring results which correspond is very low, the result should on no account be regarded as negative. In view of the effect on the body measurements by the various influencing factors such as posture, breathing, muscle tension and movement of the test subject (see Chapter 4.5.2) and the fact that measurements recorded manually are not consistent in terms of quality (see Chapter 4.5.3), tolerance ranges must be taken into consideration. In the case of the bust girth, which is affected considerably by the posture and breathing of the test subject and the tension with which the tape measure is placed around the body during manual measurements, a larger tolerance range should be specified.

A tolerance range of +/- 4 cm must be accepted on the basis of the criteria mentioned above. Based on this tolerance, 77.13% of the measured values established are comparable with the manual measurements. Only in 22.87 % of cases are there larger differences. But with which measuring technology are these errors to be found?

In order to find and check possible sources of error, extremely large deviations, in particular, such as differences between 16 and 18 cm were checked once again. The corresponding body scan was checked for quality and the measurements were repeated. The advantage of stored body scans is that these can always be measured again under conditions which can be reproduced 100% accurately. With manual measured values, on the other hand, it is not possible to check the results at a later stage. It is not possible to check whether incorrect measurements were taken, whether the measured value was simply noted down incorrectly, or whether the test subject did not adopt the required posture. The subsequent check indicated that the scan values, at least, contained no errors; it was no longer possible to reproduce the manual measured values, however.

The **source of error** therefore lies primarily with the **manual measurements,** and not with the measurements extracted from the 3D body scan, although it is not possible to accurately determine the order of magnitude of the error.

<u>Comparison of the body measurements: Minimum Leg Girth R</u>

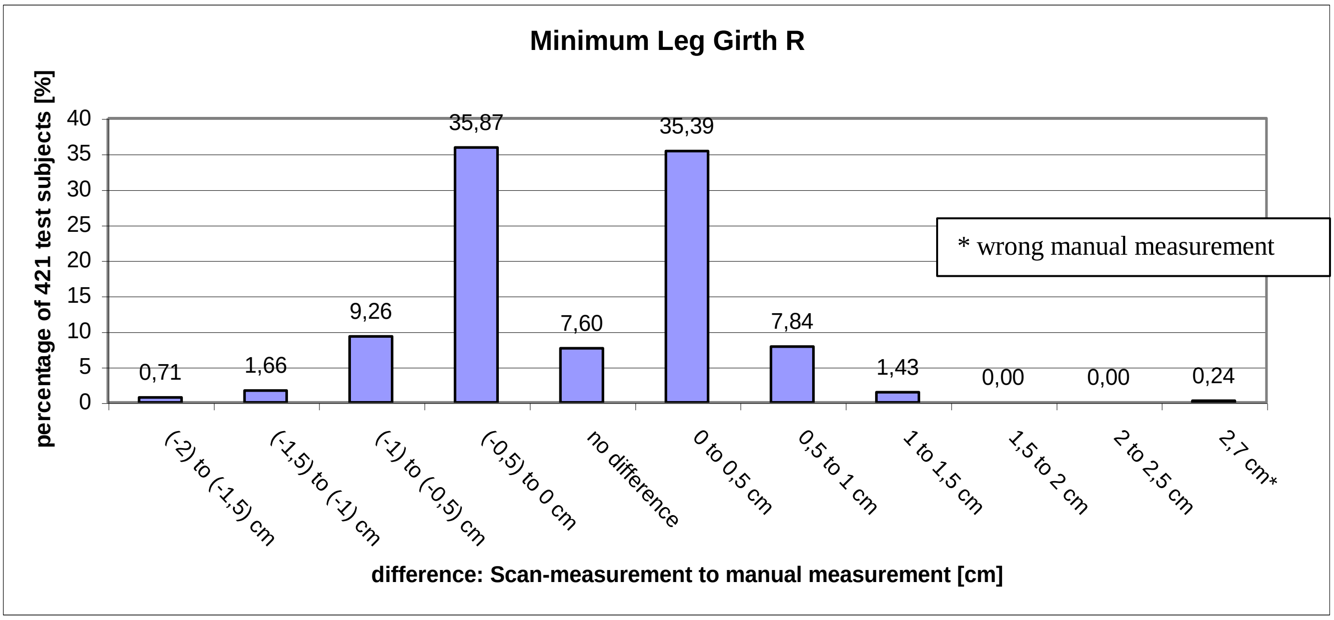


Diagram: Minimum Leg Girth R: Comparison of the scanned measurements to the manual measurements

The differences established by comparing the measured values obtained using the software with the manual measurements are shown in the diagram: Minimum Leg Girth R.

The differences of the "Minimum Leg Girth R" measurement were established in the same way as the differences with "Bust/Chest Girth" and are represented in the same way. The differences below 0.0cm indicate that the scanned measurement is smaller than the manual measurement. A positive difference on the other hand indicates that the scanned value is larger.

The evaluation of the body measurement values of "Minimum Leg Girth R" indicates that there is a greater correspondence of results between the two measuring techniques here than with the "Bust/Chest Girth". 7.60 % of the body measurements compared are identical. And with a tolerance range of +/- 1.0 cm, 95.96 % of the results can be considered good. Even with a tolerance range of +/- 0.5 cm, 78.86 % of the values still correspond.

The better correspondence of body measurements achieved in comparison with the tests on the "Bust/Chest Girth" can be attributed to the fact that the "Minimum Leg Girth R", being a small circumferential measurement, is easy to measure manually. The measuring position above the ankle is easy to define, the tape measure can easily be held in the correct measuring position (no slipping) and the leg can barely be compressed in this place.

In only 4.04 % of cases was no satisfactory result obtained. Here, too, the relevant scans which indicate large deviations in body measurements on comparison were checked and measured once again. In the case of the largest deviation (2.7 cm) it was also unequivocally shown that the error must have arisen during manual measurement, as the quality of the scan is good and the measurement taken, on which this assessment is based, could be easily reproduced.

When comparing the "Minimum Leg Girth" measurement, it should be noted that there may be large differences when using scanner technology, however. It is the small circumferential dimensions that indicate the measuring accuracy of the scanner, which is dependent to a large degree on the point density of the scan. The result from the series of tests at Hohenstein using a laser scanner proved extremely good. However, if a different scanner technology were used, which did not generate the same high point density, the results could prove very different.

Comparison of the measured values: Cervical Height

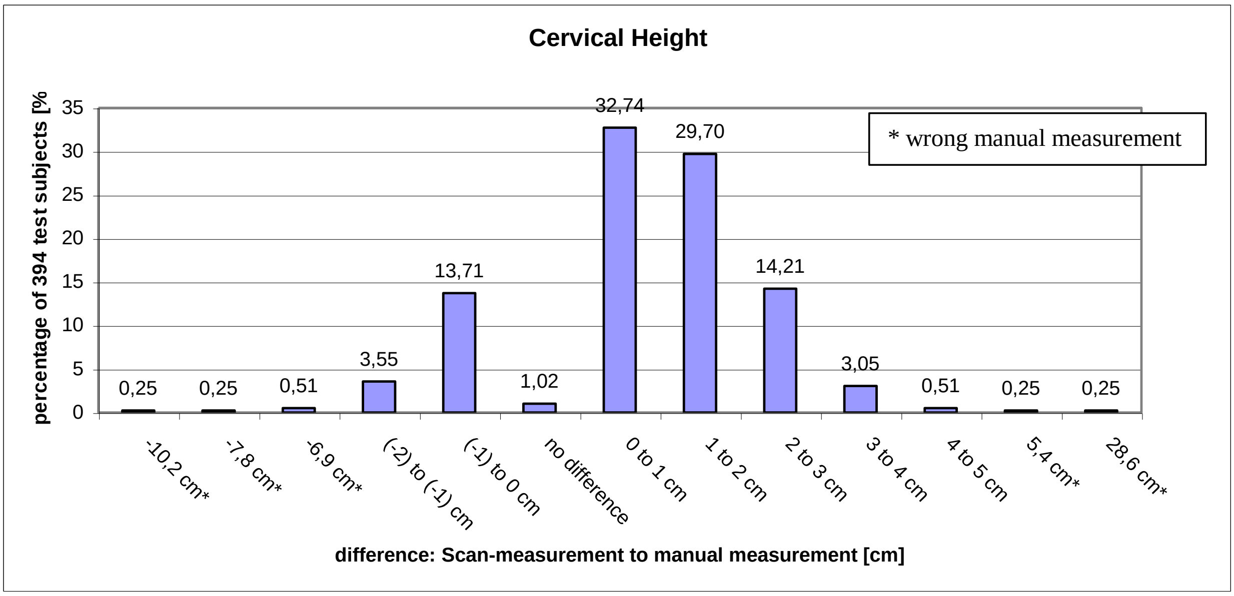


Diagram: Cervical Height: Comparison of the scanned measurements to the manual measurements

The differences established by comparing the automatic measured values obtained using the measurement software with those from manual measurements are shown in the diagram: Cervical Height.

The differences of the “Cervical Height” measurement were established in the same way as the differences with “Bust/Chest Girth” and are represented in the same way. The differences below 0.0cm indicate that the scanned measurement is smaller than the manual measurement. A positive difference on the other hand indicates that the scanned value is larger.

With “Cervical Height”, the measurement is dependent to a large extent on how upright the test subject is standing. The majority of test subjects, in spite of precise instructions from the measuring team, inevitably tend to adopt a different posture in the scanner to their posture when they are being measured manually using the height measuring device. With manual measurements, it can be difficult to determine the correct measuring position on more heavily built individuals either by visual or tactile means.

In spite of this, the evaluation of the “Cervical Height” measurement provided a good result. With a tolerance range of +/- 2.0 cm, the measurements correspond in 80.72% of cases. For 1.51 % of the results, i.e. the largest differences obtained, a subsequent check of the scanned data once again proved unequivocally that the errors which caused the very large differences must have arisen during the manual measurements in every case.

4.6 FIELDS OF APPLICATION OF THREE-DIMENSIONAL BODY DATA

The use of 3D scan data of the human body is not only limited to the development of size charts and clothing. Using the detailed three-dimensional body geometry, the data can also be used to optimise other areas where the dimensions of the human body are used as the basis for product development or for shaping our living space. As well as being used to establish girth and height measurements, the 3D scan data is also used to derive statistical or dynamic human models known as avatars. For ergonomic applications, information relating to the spatial positons of joints can be extracted which are relevant for specific movement sequences. These are just a few examples of ways in which 3D scan data can be used. The list below should provide an indication of the versatility of body scan applications.

<u>E-Commerce:</u>

- Use of scan data to generate personal avatars as the basis for "virtual try-ons" of clothing and for use in computer games

<u>Automobile industry:</u>

- Use of virtual human models to design the interior

<u>Furniture industry:</u>

- Use of virtual human models to ergonomically design seating
- Use of virtual human models to ergonomically design office furniture
- Use of virtual human models to ergonomically design beds

<u>Sports equipment:</u>

- Use of virtual human models to ergonomically design sports equipment

<u>Architecture:</u>

- Use of virtual human models to ergonomically design door dimensions, staircases, banisters etc.

<u>Production lines in all branches of industry:</u>

- Use of virtual human models for ergonomic workplace design.
- Use of the scan data to develop dynamic, animated human models for the virtual simulation of processes

The examples cited demonstrate that due to the wide variety of potential applications of 3D scan data, sizing surveys using 3D scan technology should not only be carried out in the interest of the clothing industry and clothing retailers. In order to fulfil the various requirements, these applications should be taken into consideration when the measurements are being carried out.

4.7 DETAILED DESCRIPTION OF DIFFERENT SCANNER TYPES

4.7.1 Technical data for CYBERWARE - WHOLE BODY - COLOR 3D SCANNER Model WB4

Just as Cyberware revolutionized computer graphics by allowing designers, animators, and researchers to work with true human faces, now Cyberware continues with whole human

Animators, anthropologists, and fashion designers can obtain accurate measurements with the Cyberware Whole Body Color 3D Scanner – creating realistic and detailed alternatives to over simplified or stylized forms.

In as little as 17 seconds, the Cyberware WB4 Whole Body Color 3D Scanner captures the shape and color of the entire human body. The scanner's rapid acquisition speed freezes motion and makes it easy to scan many subjects or to capture different poses appropriate to the application at hand.

To capture the intricacies of the human body in one pass, the Cyberware Whole Body Color 3D Scanner uses four scanning instruments mounted on two vertical towers. Each tower has a linear ball-bearing rail and servo motor assembly that moves the scanning instrument vertically. A platform structure supports the subject, while a separate frame provides alignment for the towers. With a person standing on the scanner's platform, the scanning instruments start at the person's head and move down to scan the entire body. The system is built to withstand shipping and repeated use without alignment or adjustment. A primary goal of the WB4 is to acquire an accurate computer model in one pass. The use of multiple instruments improves accuracy on the sides of the body and in difficult-to-reach areas, such as under a person's arms. While the simple anthropometric pose gives the best results, Cyberware designed the WB4 to handle many different poses for a wide range of applications. The WB4 scans a cylindrical volume 2 meters (79") high with a diameter of 1.2 meters (47"). These dimensions accommodate the vast majority of the human population. For even larger subjects, software enables the user to quickly combine two or more scans into a complete 3D color model.

Color information in 3D digitizing makes available nearly all the information a graphics application needs to fully describe an object. In addition to enhancing realism in graphic models, color denotes boundaries that are not obvious from shape alone. Color indicates surface texture and reflectance. And by marking an object's surface before digitizing, one can use color to transfer ideas from the object to the graphic model. As with Cyberware's other 3D scanners, the WB4 is controlled via Cyberware software running on a graphics workstation (not included in the pricing). This software has been designed to give even non-technical users a quick and easy way to capture the shape of a subject. The software includes tools for automatically aligning and merging scans to create complete 3D models, and tools for editing, modifying, and measuring scanned objects. Graphics tools let the user view the scanned model within seconds after completing a scan. Tools are also provided to translate file formats so that you can take advantage of the many commercially available software packages that work with 3D models.

The Cyberware data format is in the public domain, so it is easy to create your own special-purpose translation routines. Software options include measurement software and a feature extraction tool that prepares 3D models for use in animation, computer-aided design and other applications.

WB4 SCANHEAD
Field of View (cylindrical)
Diameter .... 120cm (47")
Y .... 200cm (79")
Sampling Pitch
Horizontal (X) .... 5mm (0.19")
Vertical (Y) .... Depends upon motion platform
speed; 30 samples per second in Y; typically 2.0mm (0.08")
Depth (Z) .... 0.5mm (0.019")
Sampling Speed
60,000 points per second, digitized to X, Y, Z and R, G, and B components.
Data
8 bits each for red, green, and blue, or luminance
WB4 MOTION SYSTEM
Motion Range
Travel in linear mode:
Y .... 0-200cm (0"-79") Servo Driven
Power Requirements
Input Voltage .... Auto-Selecting 90-135VAC/175-264VAC, 47-63Hz
Power, Maximum 1500W
Size
Width........................... 360cm (144")
Height .... 292cm (117")
Depth .... 300cm (120")
Weight.......................... 450Kg (992lbs)
General
Interface...................... SCSI (4 addresses required)
Light Plane................... Horizontal

Environment .... Normal office or lab conditions

Output Formats:

3D Studio ASCII

Digital Arts (SGI Only) DXF
DXF (3D FACES) IGES 106 110 112 124
IGES 128 NURBS Inventor
MOVIE.BYU (SGI Only) OBJ
PLY Echo
STL VRML
SCR (Mesh & Slice) (SGI Only)

WHOLE BODY COLOR 3D SCANNER SPECIFICATIONS

The WHOLE BODY COLOR 3D SCANNER BUNDLE includes:
Complete Whole Body motion system, four WB optical heads with RGB texture map capability, four SCSI interfaces, power supply, cabling, and online manuals. Also includes node-locked CyDirWB, Decimate, and CyScan scanning software, as well as file format translators. Bundle also includes on-site installation and training, one-year return-to-factory warranty, and technical support and software updates.

Specifications are subject to change without notice. Cyberware and Echo are registered trademarks of Cyberware Laboratory Inc. CySurf and EchoTk are trademarks of Cyberware Laboratory Inc. All other trademarks are property of their respective owners.

Source: cyberware

4.7.2 Technical data for [TC]^2 Body Scanner

Detailed description of [TC]^2 Scanner -An Introduction to theBody Measurement System

Developed by [TC]^2 Textile/Clothing Technology Corporation

4.7.2.1 OVERVIEW

The apparel industry, in order to be more competitive, is driving toward mass customization. This move toward made-to-measure apparel requires underlying technology to facilitate acquiring human body measurements and extracting appropriate critical measurements so that patterns can be altered for the customer. Traditionally, tailors have taken these measurements themselves for their own pattern altering methods. For this reason, tailors' measurements are notoriously inconsistent when compared with other tailors. An accurate data set of the surface of the body is needed in order to develop consistent body measurements.

Several technologies have been employed by researchers for body measurement including 2D video silhouette images, laser based scanning, and white light phase measurement. In order to get a full three-dimensional representation of the body without the use and cost of lasers, [TC]2 chose the white light phase measurement profilometry (PMP) approach. The structured light and PMP application is well suited for body measurement because of the short acquisition time, accuracy and relatively low cost.

4.7.2.2 Body measurement system configuration

System Design

The Body Measurement System (BMS) was designed to achieve unique coverage requirements of the human body. In order to scan the majority of the population, the scanning volume was designed to be 1.1 m wide by 1.0 m thick by 2.0 m in height. The BMS has two frontal views with a 60 degree included angle and a straight on back view as shown in Figure 1. With this configuration, there is overlap between views in areas where detail is needed and minimal overlap on outer edge regions where surfaces are smooth. In order to get adequate height coverage, there are six views in total: three upper views and three lower views.

The system design uses six stationary surface sensors that encompass the body. The sensors are stationary so each must capture an area segment of the surface. The area segments from the sensors are combined to form an integrated surface which covers the critical areas of the body that are needed for making apparel.

4.7.2.3 Sensor Design

Each sensor consists of a projector and an area sensing camera, thus forming a vertical triangulation with the object or body as shown in Figure 2. The camera and projector are separated by a baseline to form the necessary geometry for mapping points onto the surface of the body. The projector contains a two-dimensional patterned grating which is projected onto the body. The pattern varies in intensity sinusoidally in one direction, and is invariant in the perpendicular direction. Both coarse and fine grating patterns are employed. The projected pattern is imaged by an area array charge-coupled device (CCD) camera. See Figure 3.

4.7.2.4 System Hardware Design

The BMS structure is an "erector set" of black anodized aluminum extrusion covered with non-reflective black theater cloth for light tightness. The three viewing angles are achieved by arranging three pods as shown in Figure 1. Each pod contains two of the sensor heads described above to capture the full height of the body.

Each sensor head consists of an aluminum extrusion structure which rigidly holds a custom designed projector, commercial CCD camera and necessary controls for both. The cameras and projectors are controlled by a Pentium 133 personal computer. The computer contains 128 MB RAM, a motion control card, and two frame grabber boards. An electronics enclosure contains additional hardware and wiring necessary to interface the computer to the six sensor heads.

4.7.2.5 System Software Design

The software program was developed in the Microsoft Developer Studio Visual C++ under the Windows NT platform. OpenGL was utilized to create the graphics display tools. The software performs the following functions: graphical user interface, controlling the acquisition sequence, acquiring and storing image buffers, processing acquired images and calculating resulting data points, and displaying graphical output.

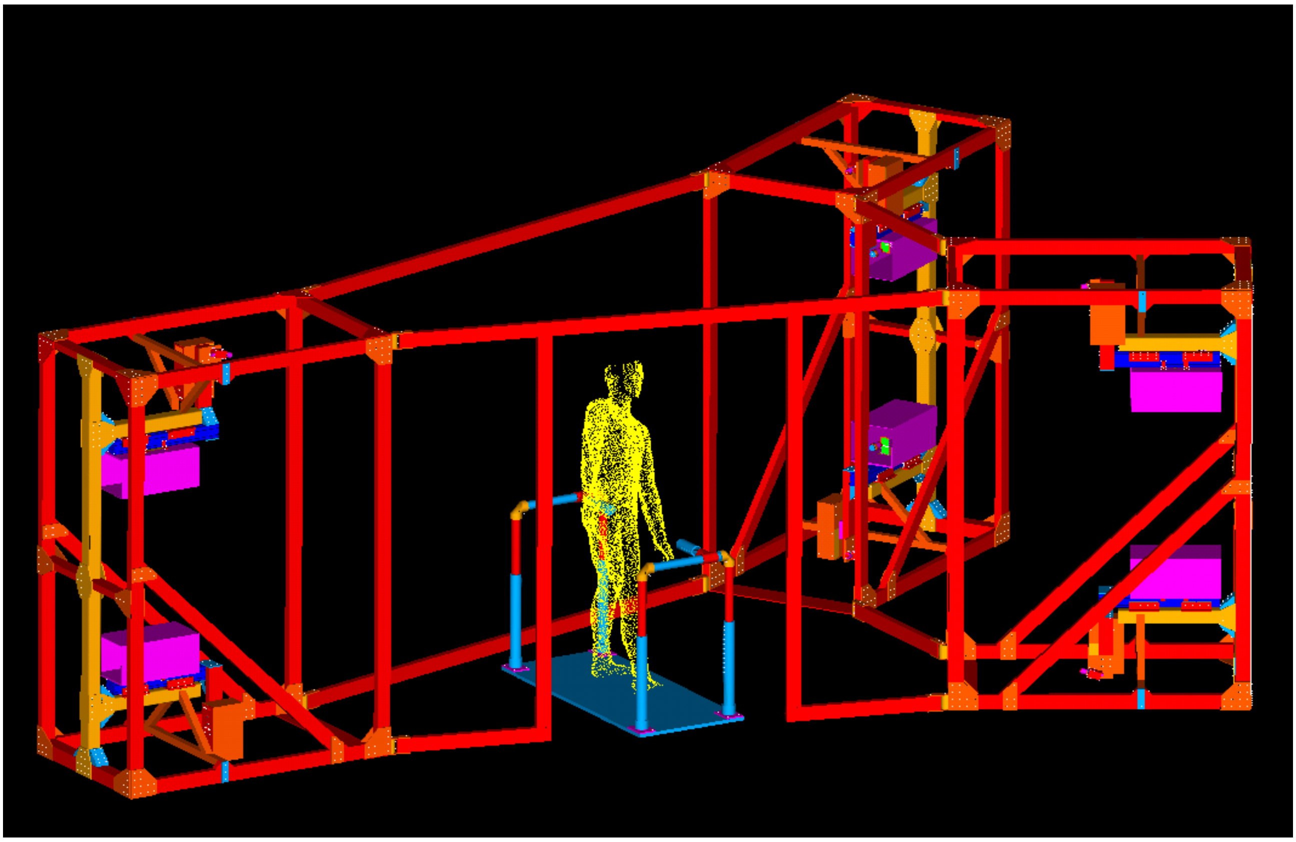


Figure 1 Mannequin positioned in the Body Measurement System for scanning.

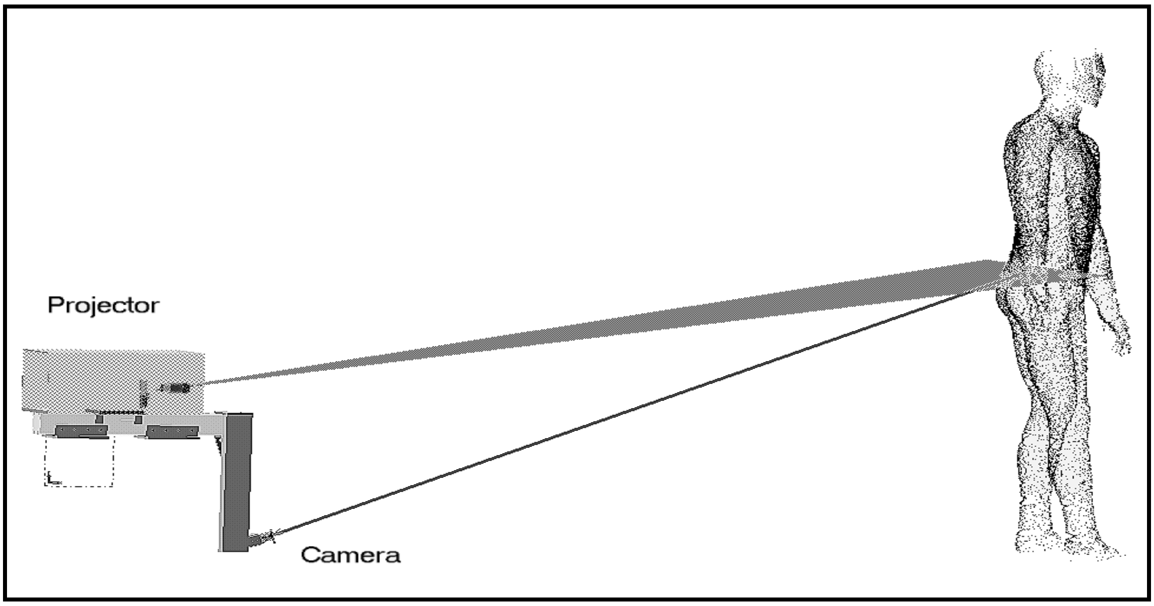


Figure 2 Triangulation between projector camera and target subject.

Figure 3 Camera Images of Sinusoidal patterns from fine and coarse grating projections.

4.7.2.6 Theory of operation

Phase Shifting

The PMP method involves shifting the grating preset distances in the direction of the varying phase and capturing images at each position. A total of four images is taken for each sensor, each with the same amount of phase shift of the projected sinusoidal pattern. Using the four images of the scene, the phase at each pixel can be determined. The phase is then used to calculate the three-dimensional data points. A schematic of the sensor head with a projected plane of constant phase and camera ray is shown in Figure 4.

4.7.2.7 Image Acquisition

As mentioned above, four images per sensor per grating are acquired. Since there are six sensors in the BMS, a total of 48 images are captured. In order to minimize the capture time, the computer acquires the images using a round robin acquisition scheme. In this manner, all of the images of the first grating position are captured in succession. After each sensor's image is acquired, the computer starts shifting the respective grating. When all six sensor images are acquired, the sequence is restarted for the next grating position. This process continues until all 24 images have been acquired for the fine grating. The gratings are then moved to project the coarse grating. The round robin sequence is repeated to acquire 24 images for the coarse grating. In this manner the critical portion of the scan, which occurs during the fine grating acquisition, is captured within 2 seconds.

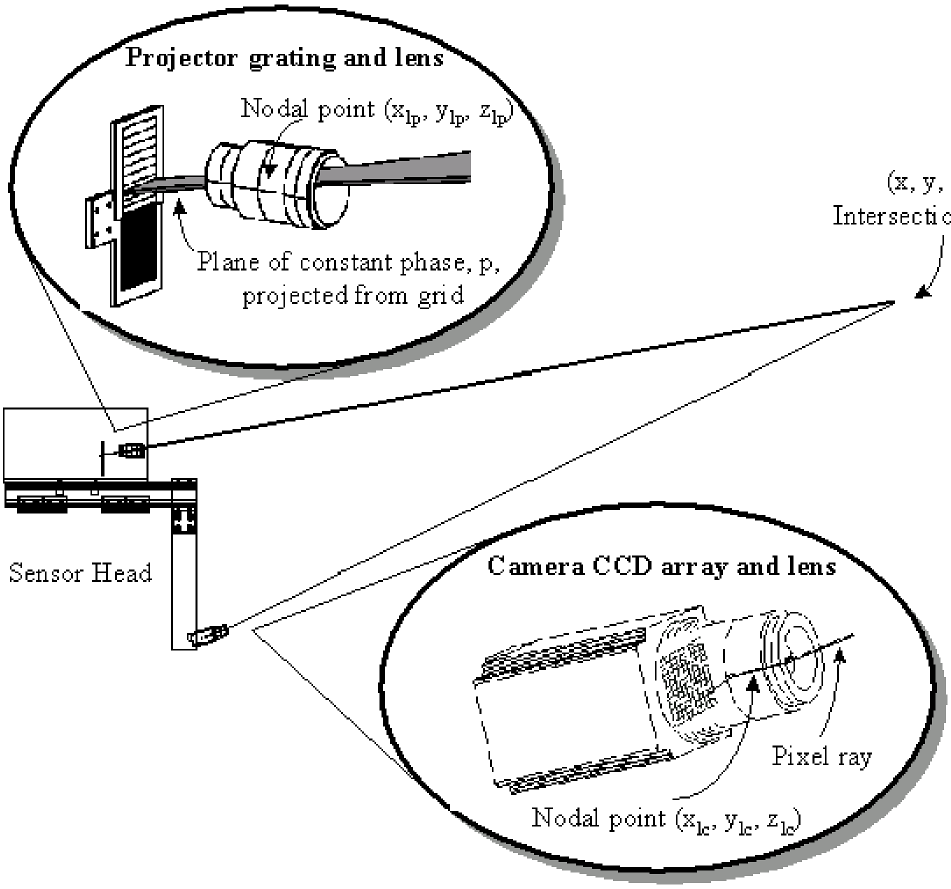


Figure 4 Schematic of sensor head with the projected plane and camera ray.

4.7.2.8 Scanning results

The intermediate output of the PMP process is a data cloud for each of the six views. See Figure 5. The individual views are combined by knowing the exact orientation of each view with respect to one another. Their orientation is derived by scanning a calibration object of known size and orientation. This is known as system calibration. The resultant composite data set is shown in Figure 6. These data points are the raw calculated points without any smoothing or other post-processing.

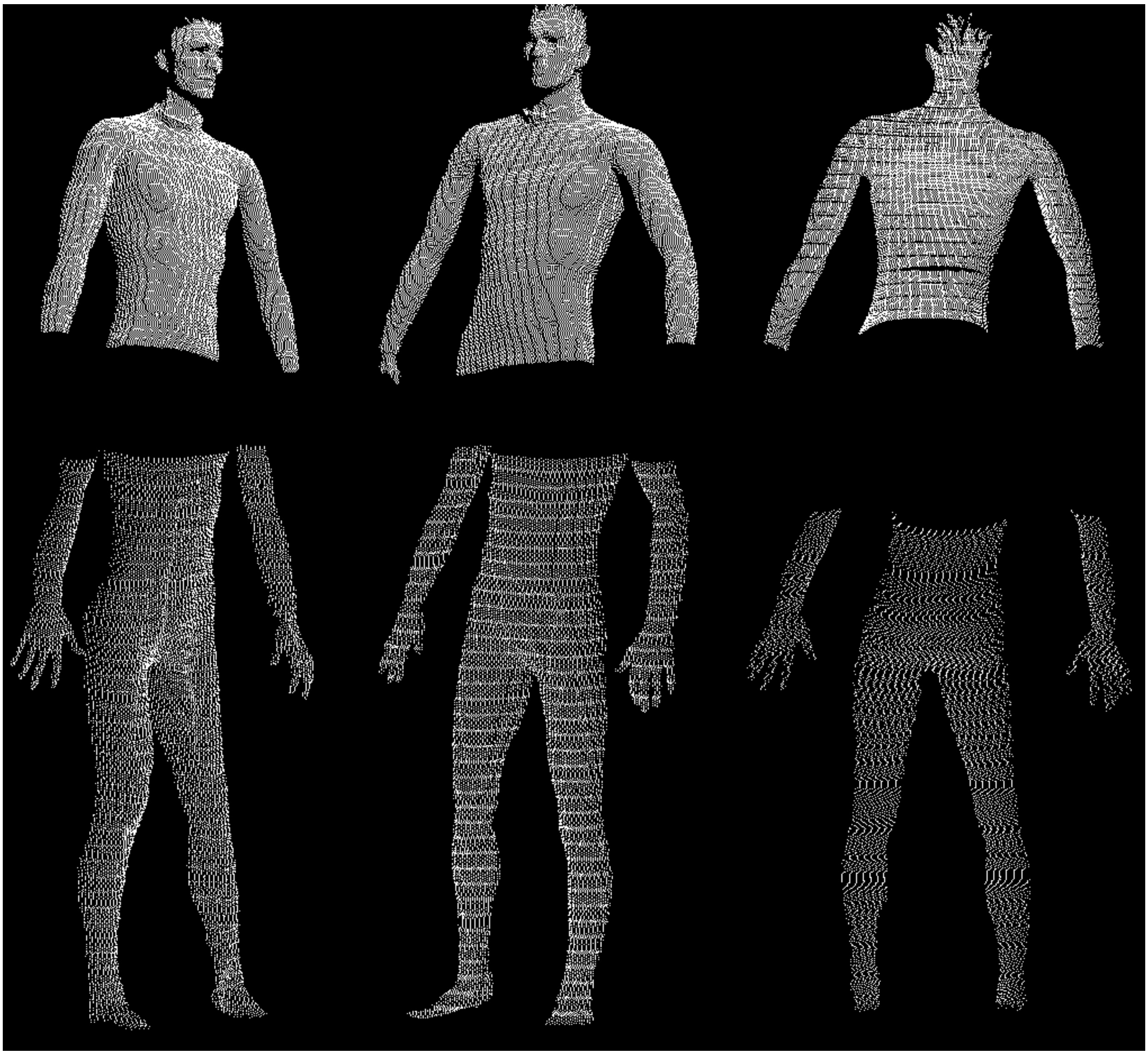


Figure 5 Six Individual Views of 3D Data Points

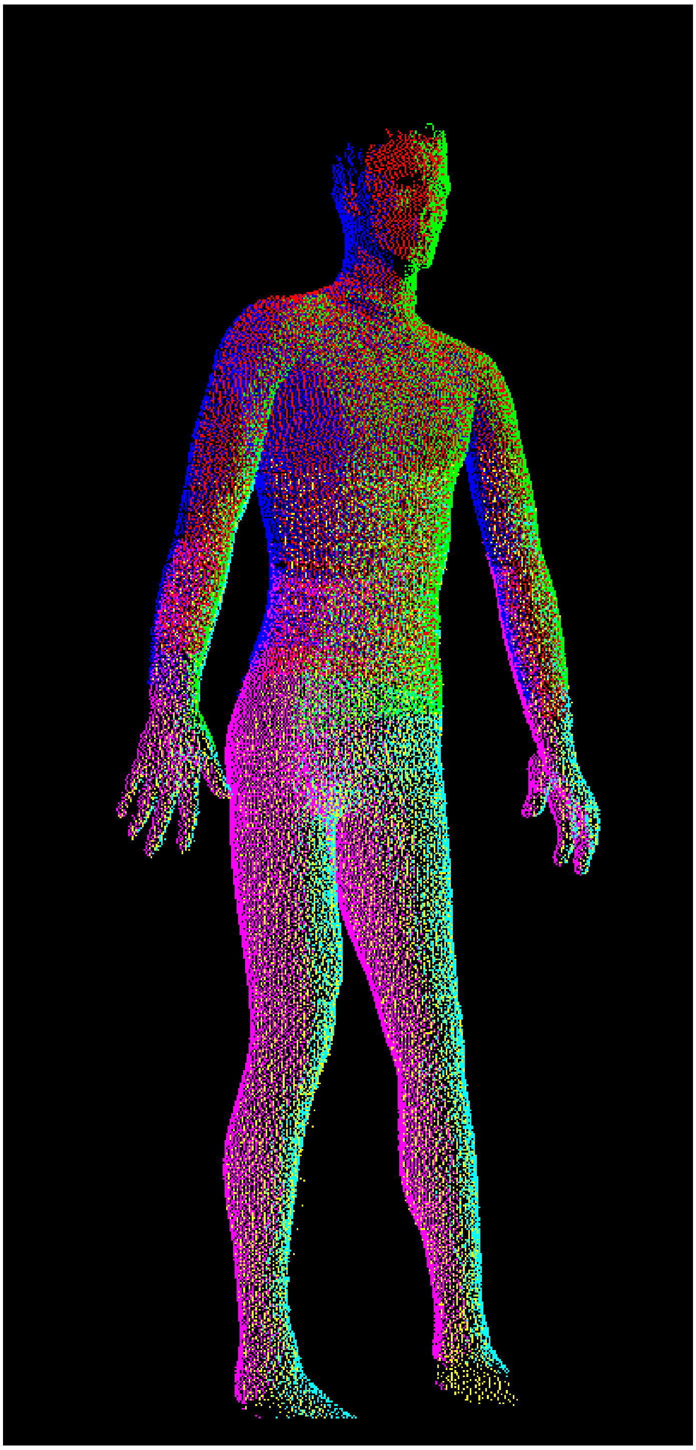


Figure 6. 3D Composite Data Set

Source: TC^2

4.7.3 Technical data for Telmat Symcad Body Scanner

The Scanner booth

4.7.3.1 Automated Body Measurement

- Static or mobile versions, easily transported by
- Automated body measurement without contact
- Not affected by body movements (Instant 3D acquisiton)
- Not affected by underwear colour
- Measurements calculated within less than 30 sec
- Automatic calibration of the measuring space, for a maximum ease of use
- Automatic measurement extraction requiring no human intervention, for a better consistency mid-size van

4.7.3.2 Customization of Body Measurements - Extraction for Made-to-Measure Clothing

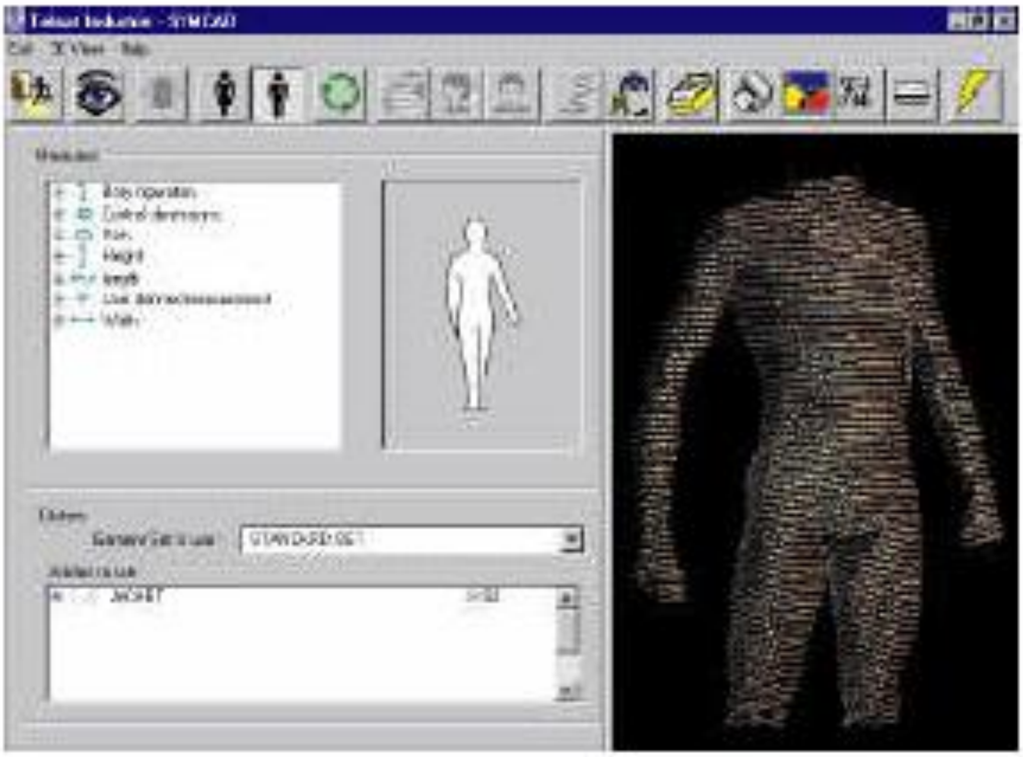
- Automatic determination of required measuring points
- Body shape analysis
- Automatic posture classification
- More than seventy measurements and postures available
- Data export to Made-to-Measure CAD systems

4.7.3.3 Characteristics

SYMCAD uses neither laser nor hazardous rays.

Data capture device is stationary (no moving parts) giving consistent results and easy maintenance.

Patented 3D data acquisition based on light projection technique (white normal light)



Accuracy : ± 2 mm (when measuring a standard 1000 mm perimeter)

Acquisition time : 40 milliseconds

Processing time : < 30 seconds

Data format : IV, VRML (3D) - ASCII (measures)

File Size : < 200 KB compressed

Specifications :

Dimensions (WxLxH) : 1,60 x 3,07 x 2,35 m

Weight : 50 kg (excl.booth)

Electrical requirements : 1 kW - 6A

Source:
TELMAT Industrie

4.7.4 Technical data for Tri Form Scanner Wicks&Wilson Limited

TriForm®

4.7.4.1 3D BodyScanner

TriForm® Is an innovative non-contact 3D image capture system from Wicks and Wilson designed for in-store, field survey and laboratory use.

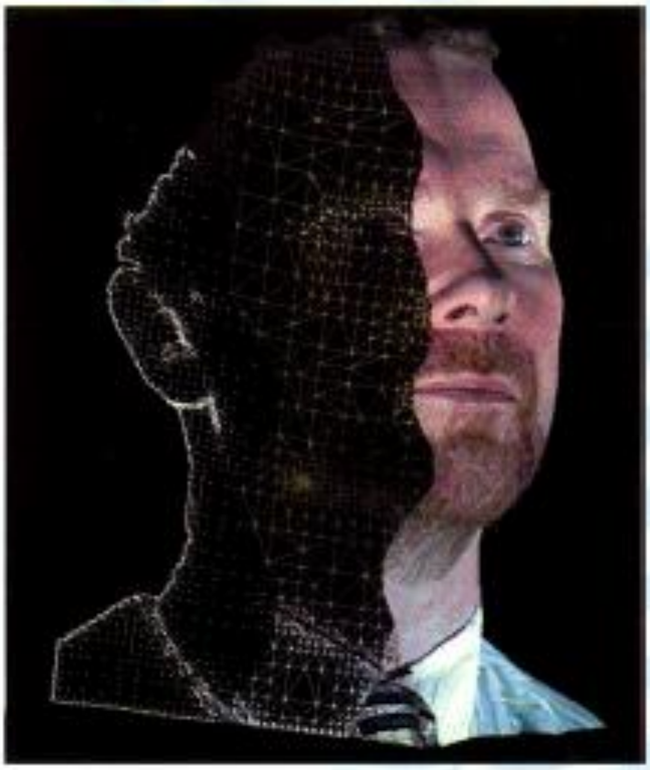
The whole body is captured in a matter of seconds and is then processed to produce a full color three dimensional image which can be displayed, measured or used in a variety of third party software applications.

TriForm® Body Scanner

Simple, speedy and safe. A curtained booth provides privacy for the person being scanned who will ideally be wearing light, form fitting clothing, or underwear. A series of striped light are projected on to the person and a number of images are captured. The image capture and processing technique digitises the surface of the person and converts it into a point-cloud containing up to 1.5M three dimensional co-ordinates and associated color data.

4.7.4.2 Simplicity

The capture technique is simplicity itself. Stand still for a few seconds while structured light patterns capture your body shape then let the automated software build you a complete 3D image – what could be simpler?



4.7.4.3 Speed

Using the TriForm® BodyScanner, a full 360 degree image may be captured in a matter of seconds. The processing of the initial captured data into a point-cloud takes less than one minute, after which the body shape may be viewed and manipulated on screen using viewing software supplied.

4.7.4.4 Safety

The TriForm® BodyScanner uses white light and is, therefore, intrinsically safe. The light used to scan the subject is produced by a normal slide projector type of lamp and is harmless; there are no invisible rays or other radiation.

4.7.4.5 Size

Occupying a footprint of only 2.3mx1.5mx 2.4m high, the TriForm® BodyScanner booth is ideal for point of sale changign room use. The booth is suitable for disabled access and is easily dismantled for transportation.

4.7.4.6 Tools

The TriForm® BodyScanner is supplied with software to meet all the basic capture, alignment, editing and manual measurement requirements. Color viewing software is also provided which can be used to view three dimensional image files.

4.7.4.7 Output

To allow TriForm® images to be used in other application specific software packages, such as animation or automatic measurement extraction, a variety of output options are available. Please refer to the TriForm® BodyScanner specification sheet for the latest output formats.

Source: Wicks&Wilson Limited

4.7.5 Technical data for VITUS/smart 3D Laser Scanner

Technical Goal

Three-dimensional measurement of individuals has to be taken in a fast and cost-effective way combining high precision perception with a high degree of automation.

The VITUS/smart 3D Body Scanner is designed to capture the surface of the human body within a few seconds. It can measure a volume of approximately 2.00 m in height by 0.8 m x 1.0 m in depth and width. The data are stored in binary-files.

4.7.5.1 Environmental Conditions

The VITUS/Smart 3D Laser Scanner must be installed in suitable rooms for measuring human beings. It is designed for use in an air conditioned room (max. humidity 70 %, max. ambient temperature 35° C). In case it is exposed to environmental conditions different from those mentioned above (like vibrations, dust, oil, dampness etc.), the **tecmath AG** must be informed about this prior to ordering the system. The measurement area should not be influenced by bright light sources (e.g. sunlight). Otherwise an efficient shielding needs to be installed by the customer.

Requirements

- Floor space 220cm x 240cm floor space (200cm x 220cm for the scanner itself plus additionally 10 cm on each side)
- 300cm height
- 1 x 220/400watt for the scanner
- 2 x 220/300watt for the PC and monitor
- 2 x 220 the calibration control unit

SYSTEM SET-UP

4.7.5.2 Measurement principle

With the VITUS Laser Scanner, the measurement principle of active optical triangulation is applied. For this purpose, a CCD-Camera with integrated image processing hardware is combined with a laser pointing towards the object to produce images showing a laser line on the object surface. The combination of camera and laser as described is called a laser sensor. The laser illuminating the object is positioned at a fixed angle to the camera. In the resulting camera images, the light line position and shape correlates directly to the distance and shape of the object surface. Based on the known distance and angle between the camera and the laser, co-ordinates of 3D points along the laser line on the scanned object can be calculated from the position and shape of the laser line in an image. This process is called triangulation.

To perform the scanning of a 3D area with a laser sensor, the sensor is moved in linear direction along the object to be scanned, while the camera produces a set of images. From each image, a set of 3D points along the laser line (i.e., x, y and z positions of surface points on the object) is derived by triangulation. By combining the surface points derived from all of the images taken during the scan process, a three-dimensional model of the surface of the scanned object can be formed.

It is, of course, impossible for one sensor to scan an entire body as it can only "see" those parts of the object which face towards the camera. Therefore, several sensors have to be combined to scan the object from different directions. A special set up procedure (calibration) will be performed such that the data delivered by several sensors can be combined to a single three-dimensional model of the scanned object.

Even if combining the output of several laser sensors, there might be parts of the object which cannot be scanned because the cameras do not “see” them. Assume, for example, that a set of laser sensors is arranged around the object and moved linearly from top to bottom during the scanning process. If the lasers point horizontally towards the object and the cameras are fixed above the lasers pointing slightly down to record images showing the object with the laser lines, then it is impossible for the cameras to “see” the area e.g. under the chin of a standing person. To avoid this situation, each sensor head of VITUS/Smart is equipped with two cameras: half of the cameras are located above the lasers pointing slightly downwards, and the other half is mounted underneath the lasers pointing upwards, thus covering the same measuring range. In this way, also areas like on the shoulder or under the chin can be scanned. This measurement method is called double triangulation.

Though VITUS utilizes the double triangulation principle, objects where parts of the surface occlude other parts may not be completely reconstructed. Moreover, only surfaces can be scanned on which the laser line shows clearly. If very dark or specular surfaces (dark clothes, metal, glass) or spotted surfaces with high contrasts are measured, it can happen that gaps or areas of blooming are produced in the measurement signal, falsifying the final result. Limitations to the measurement method are also given by the surface shape. If surfaces which can only be viewed by the sensor at an angle (not perpendicularly) are measured, the specified resolution and accuracy may drop below the given specifications, i.e., the specifications for resolution and accuracy always refer to perpendicular viewing. If the angle between the sensor and the surface increases, the intensity of the light stripe decreases. Therefore the signal can only be recorded up to a limit angle, due to the surface condition.

Figure 1: The VITUS/Smart 3D Body Scanner

4.7.5.3 Mechanical Design

The mechanical set up for a complete 360° scan consists of 4 columns (each containing a double triangulation sensor) placed in approximately 90° angle to each other.

The columns described above can be connected in different combinations and amounts (currently max. 4) to form a multi-sensor system.

4.7.5.4 Sensors

Each column consists of a double triangulation sensor (diode laser with a cylindrical lens in front and two CCD matrix video cameras). The sensors are initially arranged at the same level in each column and move simultaneously from top to bottom in the columns to scan the whole body. Vertical feed as a moving direction was chosen to ensure that small movements of the body have only a minimum effect on the measurement. The lasers are pulsed. Hence, it is not necessary to align the lasers exactly such that all laser lines are in one plane.

4.7.5.5 Measurement

The measuring procedure can be started as soon as the person to be scanned is standing still.

The laser sources are switched on (pulsed) when the measurement begins. During the measurement, the slides travels vertically at a defined speed and almost vibration-free.

The camera signals are acquired during the measuring procedure in real-time as described above. The measuring time and section density (system resolution in the vertical direction) are depending on traveling speed. The measurement takes approx. 10 s, if a resolution of 4 mm is chosen in vertical direction. After acquisition, the scanned data is stored on the hard drive. The scanner is ready for the next scan after approx. 2 min.

The scanner will be able to scan a volume of approx. 2.0 m in height and approx. 1.0 m x 1.0 m in base. Resolution in X, Y and Z should be better than 5 mm in the middle of the scanning base for human subjects.

The raw 3-D data from the sensors is converted from pixels to a metric unit of measurement. The data of all sensors can be combined to one 3D model.

4.7.5.6 Adjusting and Calibrating the Sensors

After the system has been set up or maintained, the sensors have to be adjusted and calibrated. In particular, the cameras and lasers are manually adjusted in X, Y and Z direction. The rest of the calibration procedure takes place semi-automatically. For this purpose, a special calibration tool was developed.

4.7.5.7 Interfaces / Data Output

The result of the scanning process is available as a binary file.

Adaptations with respect to output format or way of providing the results are possible and have to be ordered separately.

The **tecmath AG** reserves the right to make technical improvements without prior notice.

SCOPE OF DELIVERY

4.7.5.8 Hardware

- 3D Whole Body Scanner VITUS/smart, including image-processing hardware (acquisition- and control boards for installation in a PC).
- 4 columns consisting of 8 CCD cameras and 4 lasers in total.
- 1 Platform optionally

4.7.5.9 Software

Scanner control software and scan processing software according to the functionalities described and including operating system and all user licenses for system operation.

4.7.5.10 Documentation

We deliver a detailed system description of the imaging computer and of all delivered peripherals. User manuals with service information are available in German or English language.

4.7.5.11 Requirements to be fulfilled by the customer

The customer has to provide a 230 Volt power supply, all necessary cable laying or other assembly outside of the scanner system, and an adequate room for the scanner with controllable light sources.

4.7.5.12 How mobile is the scanner? How long is the set-up and tear-down process?

The VITUS|smart scanner is designed to be assembled by two people and ready to use in just under 4 hours, disassembled and crated for shipping in less than 2 hours, and able to fit in crates that can be loaded into normal shipping vans. The VITUS|smart scanner has been completely integrated into a fully mobile and independent large truck. Complete information about this scanner can be viewed at the following web site: www.scanliner.com.

Scanliner

5 ORGANISATION OF SIZING SURVEYS

This chapter will examine the experiences gained from two sizing surveys in Great Britain and Germany which differ both in terms of organisation and the way in which the surveys were carried out. The measuring surveys differ in terms of the scanner technology used, the number of measuring stations and people being measured, as well as in the recruitment strategies and the way in which the test subjects were motivated.

Scanner technology used:

Great Britain:	[TC]²
Germany:	Vitus Smart, stationary and in the scan truck (Tecmath)

Recruitment strategy:

Great Britain:	Individuals by clothing size or chest girth in correlation to body height
Germany:	Random sample on the basis of voluntary participation of the test subjects

Motivation of the test subjects:

Great Britain:	Expense allowance in the form of a £20 shopping voucher
Germany:	Motivation by providing the public with extensive information on the intended use and benefits of the measuring results

Number of individuals measured:

Great Britain:	approx. 11,000
Germany:	approx. 3,000

Number of measuring stations:

Great Britain:	eight
Germany:	five – one stationary and four using the scan truck

5.1 SELECTION AND RECRUITMENT FOR REPRESENTATIVE SAMPLES

The selection and recruitment of a representative sample affects how accurately the results will reflect the current distribution of different body proportions in the section of the population studied. A decisive factor in determining the quality of the results is also the number of sample people measured in comparison with the overall proportion of the groups studied within the population. Field research for public opinion polls has confirmed that the error rates decrease as the size of the groups studied increases. Good results were obtained in earlier representative sizing surveys in Germany where approximately 0.3 per thousand of the relevant population group was taken as the basis for the sample in each instance. Applied to the European population distribution, this would equate to the sample sizes for the individual countries listed in the table “Examples of the number of test subjects in the individual European countries”.

Country	**Population female/male**	**Population age 14 to 80 female/male**	**share of 0,3 per thousand entire population**	**share of 0,5 per thousand age 14 to 80 female/male**	**share of 1,0 per thousand age 14 to 80 female/male**
Belgium	10.192.000	8.153.600	3.058	4.077	8.154
Denmark	5.295.000	4.236.000	1.589	2.118	4.236
Germany	82.057.000	65.645.600	24.617	32.823	65.646
Greece	10.511.000	8.408.800	3.153	4.204	8.409
Spain	39.348.000	31.478.400	11.804	15.739	31.478
France	58.727.000	46.981.600	17.618	23.491	46.982
Ireland	3.694.000	2.955.200	1.108	1.478	2.955
Italy	57.563.000	46.050.400	17.269	23.025	46.050
Luxemburg	424.000	339.200	127	170	339
Netherlands	15.654.000	12.523.200	4.696	6.262	12.523
Austria	8.075.000	6.460.000	2.423	3.230	6.460
Portugal	9.957.000	7.965.600	2.987	3.983	7.966
Finland	5.174.000	4.139.200	1.552	2.070	4.139
Sweden	8.848.000	7.078.400	2.654	3.539	7.078
United Kingdom	59.090.000	47.272.000	17.727	23.636	47.272
Suisse	7.096.000	5.676.800	2.129	2.838	5.677
Sum	***381.705.000***	***305.364.000***	***114.512***	***152.682***	***305.364***

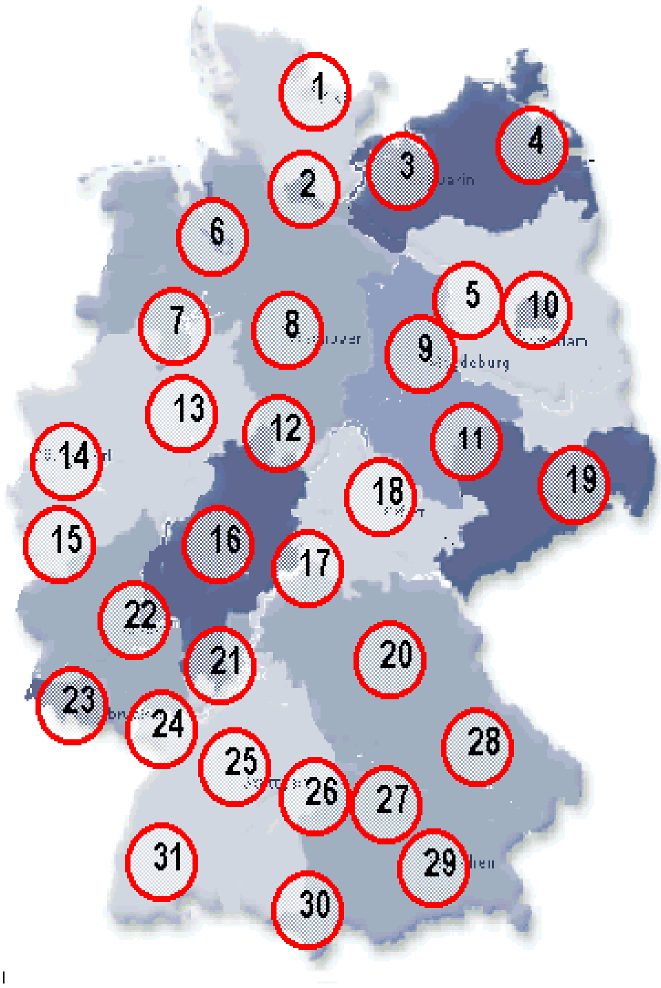
Table: Examples of the number of test subjects in the various European countries

When compiling the representative sample, the following criteria were taken into consideration in Germany:

- Population density in the various regions
- Age structure in the various regions
- Education structure in the various regions
- Professional structure in the various regions
- Economic structure in the various regions

For the manual measuring surveys, the measuring personnel travelled to the selected test subjects, who were generally measured at their homes. In contrast, where measurements were recorded using scanner technology, the test subjects had to travel to the venue where the scan was to take place. This makes it difficult to measure a representative sample. A representative sample can only be guaranteed if it is possible to provide an adequate number of stations to carry out the measurements such that the maximum direct distance which has to be travelled to the scan station is no more than 100 kilometres. (see diagram: Number of measuring stations, using Germany as an example).

Experience from earlier manual sizing surveys has shown that the sample should be doubled, since it was not possible to sample virtually every other test subject for various reasons. For measurements using the body scanner, the success rate is likely to be even lower, as it is not possible to assess to what extent the test subjects selected by representative methods will respond to the appeal, even where they are fully reimbursed for expenses incurred. Consequently, the representative sample should be approximately tripled, in order to obtain the intended number of test subjects.



1	Kiel
2	Hamburg
3	Schwerin
4	Neubrandenburg
5	Brandenburg
6	Bremen
7	Münster
8	Hannover
9	Magdeburg
10	Berlin
11	Leipzig
12	Kassel
13	Bielefeld
14	Düsseldorf
15	Bonn
16	Frankfurt
17	Fulda
18	Erfurt
19	Dresden
20	Nürnberg
21	Mannheim
22	Mainz
23	Saarbrücken
24	Karlsruhe
25	Stuttgart
26	Ulm
27	Augsburg
28	Regensburg
29	München
30	Kempten
31	Freiburg

Diagram: Number of measuring stations using Germany as an example – circles correspond approximately to a diameter of 30 kilometres

Recruiting and measuring a representative sample is extremely costly both in terms of the time involved and the financial outlay. It is possible to reduce the costs when recruiting the test subjects by motivating the public to take part in the measuring survey voluntarily, for example. The sample obtained in this way will then correspond to a random sample. Analyses of opinion polls have shown that there is very little difference between the results from representative quota selections and random samples. In some instances, the results obtained based on the principle of a random sample were actually more accurate than those obtained using a representative survey[1].

[1] Noelle-Neumann, E. ; Petersen,T.: Alle, nicht jeder, München, 1998

In Germany, there have already been positive experiences in recruiting using the principle of voluntary participation, which corresponds to a random sample, for sizing surveys using scanner technology. The majority of participants were happy to take part in the survey free of charge. The only costs incurred were for refreshments for the test subjects and, in some cases, to reimburse travel costs, where this was expressly requested by those taking part.

As mentioned earlier, the size of the sample studied is crucial in ensuring that the underlying population taken as the basis for the survey is represented is as realistically as possible. The statistical standard error (%), which expresses the frequency of a characteristic in the underlying population as a %, decreases as the size of the sample increases. However, this does not mean that if the sample is doubled, the percentage value of the statistical error rate will be halved. Only when the sample is quadrupled is the value halved. In other words, where 100 tests subjects are taken as the basis for the sample and the maximum frequency of a particular characteristic of 50 is 50%, a standard error rate of 5% is to be expected. If the random sample is increased to cover 1000 test subjects, the standard error decreases to 1.58%. If this is applied to the sizing surveys carried out on 2600 women in the last three years in Germany – about 0.07% of the underlying population – and compared with the measurements on 10,000 women – about 0.25% of the underlying population – this means that, where the maximum frequency of the characteristic of 50 is 50%, the standard error rate for 2600 women of 1.12% falls to 0.5% for 10,000 test subjects. It can be seen from this that results which can be applied to the total population can be derived even from studies using a relatively small sample. The error rate for the distribution of body proportions within the total population simply increases by slightly more than the 0.6%.

5.1.1 Recruitment strategy – experiences at HOHENSTEIN

Experiences gained from the sizing surveys in 1999 and 2001/2 in Germany using 3D body scanners on approx. 3000 individuals aged between 14 and 80.

The sizing surveys were carried out using a stationary scanner and a transportable piece of equipment – the scan truck –at five different measuring stations throughout Germany – Table: Scan stations.

Scanner	Bundesland	Scanner location	Number of people measured	Measuring period
Stationary	Baden Württemberg	Hohenstein - Stuttgart	2100	11 months
Stationary/Scan Truck	North Rhine Westfalia	Cologne	500	5 weeks
Scan Truck	Hamburg	Hamburg	100	1 week
Scan Truck	Brandenburg	Falkensee	100	1 week
Scan Truck	Bavaria	Weiden - Oberpfalz	130	1 week

Table: Scan stations

The measurements were carried out by the same experienced team at all locations. In order to keep travel and rental costs to a minimum, relatively short measuring periods were scheduled for the locations where the scan truck was used. This affected the recruitment of the test subjects, as virtually the entire sample had to be available at the very start of the survey.

The sample was composed on the basis of the voluntary participation of the relevant population group in the survey. In order to recruit test subjects, the general public were informed about the problems, the aims and the personal benefits of the sizing survey and an appeal was made for individuals to take part. Various campaigns were initiated in the press, on the radio and on the television in order to publicize the information, including details of contact addresses and telephone numbers. Thanks to the repeated reports in the media, individuals came forward to take part in the sizing survey. The best response was as a result of contributions in regional daily papers, especially in the week following publication (see Chapter 5.2). Where the survey is to be carried out over a fairly long period of time, word of mouth advertising by people who have already taken part in the sizing survey and who have been impressed by the new technology is a particularly effective tool in recruiting larger numbers of test subjects. Where the measurement survey is carried out over shorter periods of time using the scan truck, word of mouth has proved less successful.

As the test subjects come forward, their names and telephone numbers are recorded, and a date is arranged as soon as possible to carry out the measurement. This means that a time schedule for the sizing survey needs to be drawn up beforehand. In order to make the best possible use of the time available, the test subjects are asked to cancel if they are not able to keep an appointment so that the time slot can be reallocated. The appeal to take part in the sizing survey should not be made too long before the survey is scheduled to begin, as otherwise additional costs are incurred in reminding the test subjects of their forthcoming appointment to be measured.

Recruitment for the measuring stations where the maximum number of people possible are to be measured within one week is more problematic as recruitment for long time measurement stations. Here, experience has shown that the information campaigns and appeals should be started well in advance and that measuring appointments should be arranged for virtually the entire sample. The support of commercial partners, for example in the clothing sector, close to where the scanner is to be located, is helpful in terms of recruitment. The support of the recruitment process by campaigns within individual companies to motivate people to take part in the sizing survey increases the willingness of customers to get involved with the survey.

The choice of where to locate the scanner is critical. In highly frequented areas with good travel links, additional test subjects can be reached, who spontaneously make themselves available for the survey. Shopping centres which cover a wide range of goods and services and which are easily accessible by public and private transport are particularly suitable as locations.

5.1.2 Recruitment strategy – SizeUK - NTU

This document will work through NTU's suggestion for recruitment in the main survey. This will be designed with the dual aims of covering a cross section of the population that is representative of the European population as a whole, while keeping the numbers required (and hence the cost of the survey) to a minimum.

At this stage the recruitment model will not include any specific numbers in terms of quota targets. The feedback of the partners is needed before this is possible - national demographics, financial constraints and the specific requirements of the partners must be taken into consideration prior to the recruitment model being finalised. Instead, the document will highlight the issues that will need to be incorporated into the recruitment document, as well as the logistics of how it should be built.

5.1.3 Two-stage recruitment process

For surveys conducted on behalf of high street retailers in the UK, NTU have recruited participants based on dress size for women and chest size for men, both against their height.

People have been specifically targeted to populate a recruitment matrix based on height along one axis and dress size or chest size along the other. This is to fulfil two objectives the retailers have when conducting a sizing survey. These are:

a) To gain information on the body measurements of people from all sizes in the retailers' customer base

b) Keep the numbers recruited, and hence the cost to the consortium, to a minimum

The purpose of the e-tailor project, however, is to populate the European Anthropometric Database (EAD). This requires the size of the European population to be the *outcome* of the survey rather than a variable of recruitment. This means that a recruitment model based on size, as used by NTU for high street retailers, will not fulfil the project objectives.

NTU would therefore suggest a two-stage recruitment process be used, which will satisfy the aims of this project.

The first stage of this would involve recruitment based on factors independent of size, such as age and/or location. This will involve the sample reflecting the European population in terms of accurately ***KNOWN VARIABLES***, with the sizes that fall out, in theory, reflecting the underlying population just as accurately.

The second stage would involve specifically recruiting people of ***SIZES*** underrepresented after the first stage. This serves to boost the numbers in the sample of less "average" sizes, therefore enabling statistically valid analyses across all size ranges. This is of paramount importance to the retailers taking part in the study as it supplies the necessary information from which to produce size charts.

5.1.4 Stage 1

The recruitment model built for stage 1 of the sizing survey will obviously have a huge bearing on the total numbers required for the survey.

As stated previously, at this stage, NTU will not include any figures, as the demographics of the countries taking part and the funds available will form the basis of these.

For this reason, the recruitment models presented within this document will not contain any numbers, but will be displayed as a "skeleton" of the method that NTU would suggest using. For ease of interpretation, this will be split into female and male recruitment models. This document will, however, only demonstrate how the recruitment would be conducted for women, as the men's survey would be identical in terms of method, but simply with "Dress size" replaced by "Chest girth".

5.1.4.1 Women

During stage 1, NTU suggest that women should be recruited by age and geographical location. The same proportions of each age from each location should be used as are present in the underlying population. Data from each of the participant countries' census should be used as the basis for this.

A recruitment model for women based on these parameters would look something like follows:

Age	16-19	20-24	25-34	35-44	45-54	55-64	65-74	75+	**Total**
Region 1	**Known percentages obtained from census data**								
Region 2									
Region 3									
Region 4									
Region 5									
Total									**NUMBERS REQUIRED**

Previous work by H Daanen on the CAESAR project has the shown that in order to get sizing data such as height accurate to 1cm[2] with a 95% confidence level, each sample must contain 188 subjects.

It was determined that height would provide the most conservative estimate (i.e. the estimate that would indicate the most subjects per cell and hence the smallest chance of error). A review of within age group standard deviations measured around the world indicates that 70mm (just under 3”) is a reasonable within cell standard deviation estimate for stature. The desired within cell accuracy was set at 10mm.

Therefore, the within cell sample size becomes:

$$\frac{10 * \sqrt{n_i}}{7} \geq 1.96 \quad \underline{\text{or}}$$

$$n_i = \left(\frac{1.96}{10} * 7 \right)^2 = 188$$

This would mean that a universal 188 subjects per age, per region is required. Using the above age categories this would require 1504 subjects to be recruited per region.

In order to reflect the statistics for the European population as a whole (for instance, if calculating “average sizes” across Europe), however, this figure of 188 will clearly need to be weighted by an appropriate amount.

NTU would, however, suggest that this weighting be carried out during the analysis stage. This ensures that 188 subjects can be recruited per cell regardless of their (the subset of the population represented by the cell) prominence in the underlying European population. Factoring a cell’s results by an appropriate amount means that the weighting of averages is as accurate as possible so as to reflect population trends, but the number of respondents taking part in the survey can be kept to a minimum.

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[2] The accuracy of 1cm refers only to height. Clearly for other measurements this figure would change. For instance, for shoulder length, the required accuracy would be much tighter

5.1.4.2 The need for constant monitoring of Demographics

As well as monitoring size in Stage 1 (to enable Stage 2 to be completed satisfactory), it is important to ensure that the other factors are monitored. To ensure that the participants recruited are representative of the countries population, their socio-economic and employment status must be monitored. The ethnicity of participation must also be observed to ensure the correct ethnic mix is represented.

This is especially true of the e-tailor sizing survey, which has the objective of populating the European Anthropometric database (EAD). The outcome of the survey will be establishing what size the general population of Europe is, and to ensure that the data is statistically valid and representative of all the population.

To follow are three tables taken from the labour survey , created by the Office of National Statistics (ONS) in the UK, from 1999. They provide the current situation within the UK. It is important that all countries taking part in a Europe wide survey provide the same information for their country. The project group can then decide if they wish to monitor demographics by individual country or combine the information to monitor Europe wide.

The first table shows the ethnic distribution within the entire UK of all ages, taken from the Labour Force survey, ONS , showing in 1999/2000 that the total ethnic population for Great Britain is 7%. The table further breaks down the split by region.

Ethnic Distribution (Thousands and %)		**White**	**Black**	**Other**	**Total thousands**
Region 1	London South East Eastern	18,098 88.8%	849 4.2%	1,429 7%	20,376 100%
Region 2	Midlands Wales South West	16,284 95%	200 1.2%	665 3.8%	17,149 100%
Region 3	North East North West Scotland	18,692 96.5%	134 0.8%	541 2.7%	19,367 100%
UK TOTAL		53,074 93.3%	1,183 2.1%	2,635 4.6%	56,892 100%

The second table details socio-economic breakdown of working age.. Again, from the Labour Force survey, ONS of social class of working population, Spring 1999. This table provides information on the UK totals and also the split by region.

	A Professional Occupations	**B** Managerial & Technical	**C1** Skilled occupations (non manua)l	**C2** Skilled occupations (manual)	**D** Partly skilled occupations	**E** Unskilled occupations	**U** Other	**Total ('000s & %)**

Region 1	868 6.8%	3,809 29.9%	2,734 21.4%	1,874 14.7%	1,550 12.1%	474 3.7%	1,450 11.4%	12,759 100%
Region 2	488 4.7%	2,460 23.6%	2,045 19.6%	2,009 19.3%	1,680 16.1%	512 4.9%	1,238 11.8%	10,432 100%
Region 3	536 4.5%	2,722 22.7%	2,422 20.2%	2,176 18.2%	1,842 15.4%	620 5.2%	1,654 13.8%	11,972 100%
UK Total	1,892 5.4%	8,991 25.5%	7,201 20.4%	6,059 17.3%	5,072 14.4%	1,606 4.6%	4,342 12.4%	**35,363** **100%**

The third table, from the Labour Force survey, ONS Spring 1999 shows the employment status for all male and female UK population over the age of 16, including students and pensioners who are termed ‘economically inactive.’

	Full Time	**Part Time**	**Self Employed**	**Unemployed**	**Economically inactive**
Region 1	6,656 41.2%	2,061 12.6%	1,329 8.2%	551 3.5%	5,563 34.5%
Region 2	5,164 37.9%	1,867 13.7%	971 7.2%	509 3.7%	5,128 37.5%
Region 3	5,718 37.2%	2,022 13.2%	865 5.6%	672 4.4%	6,098 39.6%
UK Total	17,538 38.8%	5,950 13.2%	3,165 7%	1,732 3.8%	16,789 37.2%

Although these are not primary recruitment criteria, it is important that these demographics are monitored throughout the recruitment and fieldwork to ensure that there are representative proportions of the each of these criteria. A method for tracking recruitment and ensuring that these demographics are monitored in real time is to use a tracking database. This is covered in more detail within Section 4: Preparation.

5.1.4.3 The need for stage 2

NTU’s experience has found that certain sized people are more likely to come forward for inclusion in a sizing survey than others (unless of course participation is made compulsory). As may be expected, many larger people are more conscious of their body and are therefore more apprehensive about taking part than a more “average” sized person.

To a certain extent this effect is “cushioned” by a reverse phenomenon whereby some larger, body conscious people are willing to come forward as they are pleased that somebody is taking an interest in their body and seeking to provide them with clothes that fit them better, which at the moment they may have problems with.

The net effect is, however, one of under-representation amongst the more extreme sizes. This means that, at the end stage 1 of recruitment (based on age group and region) there are likely to be insufficient numbers of the extreme sizes to enable statistically valid analysis. This means that the goals of the project have not been fulfilled, and the retailers in particular will not have attained the necessary information from which to make better fitting clothes.

Numbers within these under-recruited sizes will therefore need boosting. This boosting forms the basis of stage 2 of a survey.

5.1.5 Stage 2

As stated previously, stage 2 will involve recruiting people based on their size.

Using estimates deduced from previous sizing surveys, it is possible to predict the number of participants that will be required during the second stage of recruitment, given the results of the first stage.

To do this, the subjects from the first stage of recruitment are placed into a matrix with size and height as the parameters along each axis, as shown below. As previously stated, NTU’s experience has shown that dress size for women and chest size for men are the best parameters by which to monitor recruitment by size, as they are the most accurate indicators of a person’s size. Clearly these will need adjusting slightly depending on the country that is conducting that part of the survey.

Please note: the example below is based on UK female’s dress size. This will need adjusting for each country taking part, and a different parameter (recommended to be chest girth) will need to be used for men.

Females												
Height	8	10	12	14	16	18	20	22	24	26	28+	**Total**
Up to 5'2½"	**Cells populated with numbers from stage one of recruitment to show shortfall**											
5'3"-5'6½"												
Over 5'7"												
Total												

Once all respondents from stage 1 have been placed in the appropriate cell in the above matrix, the shortfalls in certain sizes can be quantified.

The question is: how many subjects are required in each of these cells so as to allow statistically valid analysis?

5.1.5.1 Minimum numbers required by height and dress size

The minimum required sample size within each cell of the height against dress size matrix is based upon three key criteria:

- The standard error of the estimate obtained from the known sampling distribution (i.e. when using height as a parameter for recruitment, how accurate is the research upon which the 'assumed' height distribution has been based?)

- The precision desired from the estimate (i.e. when estimating the distribution of height, what accuracy margins should be allowed?)

- The degree of confidence associated with the estimate (which must be balanced against the precision of the estimate)

The need to find a balance between the precision and degree of confidence associated with the estimate can be illustrated by the following statement[3]:

> "A point estimate is a precise estimate in that there are no associated bounds of error; for example, the sample mean indicates that the population mean income is $19,243. This point estimate is also most assuredly wrong, and thus we can have no confidence in it. On the other hand, we can have complete confidence in the following statement: the population mean income is between zero and $1 million. Although we're completely confident about the accuracy of the statement, we must admit that the statement is not particularly helpful, because it tells us next to nothing about the mean income. The statement is simply too imprecise to be of value."

Therefore, a considered approach is required to define the sample size so that neither precision nor confidence is too far in the ascendancy, but instead a combination of the factors are incorporated into the recruitment strategy.

The formula for the calculation of sample size incorporates statistics concerning the variability of the recruitment parameters, the required precision and the confidence intervals, as follows[4]:

$$n = \frac{z^2}{H^2}\sigma^2$$

With 'n' being sample size, 'σ' equating to the standard error of the estimate, 'H' is the precision of the estimate and 'z' is the confidence interval of the estimate.

The next stage is to calculate the required sample size from the available information by inserting the requisite figures into the formula. The following sample size calculation assumes a desire to be 95% confident that the estimates will be true to the actual population. Using height as an example, we expect the average to be around 160cm, a standard error of 7cm and a precision of ± 2cm (i.e. the measure of accuracy on the height and size parameters). Obviously the precision of other body measurements will be in a similar proportion to height with 20mm in 1600mm (e.g. 2mm in a body dimension of 160mm):

$$n = \frac{1.96^2}{\quad} \quad 7^2 \quad = \; 47\;1$$

[3] Gilbert A. Churchill. *Marketing Research: methodological foundations* 7th Ed. (Orlando, FL.: Dryden Press, 1999) p. 550

[4] Nigel Culkin. *Market Research: Part 1 - 2nd Edition* (Leicester Business School: De Montfort University) p.51

2^2

Therefore, with rounding, one would estimate the minimum amount of people required per cell to be around 50. This is the figure NTU would recommend working towards.

5.1.5.2 how does this TWO-STAGE process work in terms of recruitment?

The two stages of recruitment are independent from one another in that stage 2 can commence only upon completion of stage 1.

Stage 1 will involve recruiting members of the public according to their age and location, with the aforementioned 188 being surveyed from each cell.

This is relatively easy to achieve, and can be done in a variety of different ways.

One method of doing this, and the one favoured by NTU, is to use a specialist agency to conduct traditional on street market research-style recruitment by simply approaching people who appear to fit within the criteria being sought.

This method is advantageous in that it can be continued along very similar lines throughout stages 1 and 2. All that needs to be altered is that during stage 2 people will be approached based on their size as against their age.

This method achieves very high percentage response rates and a high level of accuracy in terms of populating the correct cells. It also minimises the risk and disturbance to the project partners as they are, in effect, offloading responsibility for recruitment to a specialist agency.

The downside to this method is that it is very expensive compared to other methods.

An alternative method is to use mail shots to recruit people. The Postal Address File (PAF) information system could be used would involve consulting a database of residents' ages and sending invitations to participate to the households of people who match the required criteria. This satisfies the theoretical requirement for a truly random distribution of participants by size.

This is, however, notoriously difficult to administer. Response rates are very low and this particular method can tend to accentuate the problems with under recruitment of extreme sizes, as people are not having any pressure applied to them to partake i.e. being physically approached and asked in person. In practice, ultimately a persons size will determine their willingness to participate in the survey. This means that a truly random sample is almost impossible to achieve. Short of compulsory participation (as is used in the consensus) there is no perfect solution to the problem.

A final method is to compile a database of potential participants who have agreed in principal to take part. A useful source of this information will be retailer's databases – which are compiled from their customer loyalty cards, where certain information is asked when the participant applies for the loyalty card.

Stored in this database will be people's age, height and size. Unfortunately these sizes will only be the people's self declared perceived size. In NTU's experience it has been found that the shift from perceived to actual size distribution tends to cause a "grouping" effect around the more "average" sizes – i.e. very small people perceive themselves to be larger, very large people perceive themselves to be smaller. This can be overcome to a large extent by way of a dynamic recruitment model, which constantly monitors and feeds back the nature of the recruited sample.

5.1.6 Problems with recruitment

NTU's experience has taught them that it is very difficult to get people to volunteer to take part in a sizing survey without offering them some form of incentive.

For example, during the pilot survey of 200 persons for the e-tailor project, recruiting people was found to be very problematic – until a financial incentive was offered to the participants.

Although NTU have always offered an incentive to members of the public taking part in a sizing survey, for the purpose of the e-tailor pilot, originally NTU attempted to recruit members of staff, hoping their interest in both the project and the university's reputation would prove sufficient for them to come forward for inclusion.

In the event this proved not to be the case, so the decision was made to offer a £10 store voucher (for a UK supermarket chain) to each respondent.

This had a profound effect on recruitment and led to very near full booking on the allocated scanning days.

Participants completing the SizeUK project received a £20 store voucher (€32), that was made available by the retailers involved. It is important to note that the offering of incentives contributes to a considerable percentage of the overall cost of undertaking a sizing survey. The overall cost of offering incentives for participation in the SizeUK was in excess of £200,000.

A very similar recruitment model was used for Size UK as is being recommended by NTU for the e-tailor project. Although this type of model has been used successfully in previous large-scale surveys, there were certain issues and difficulties which came to light during the course of the Size UK fieldwork which may need to be addressed for the European survey.

Whilst the recruitment model NTU proposed was tenable both theoretically and methodically, in practice errors were made in its implementation, leading to various problems.

Whilst the NTU proposal clearly distinguished that there should be a first and second stage – the first stage being size independent, the second stage based on size – in practice this was overlooked in favour of practicalities.

This was, in essence, due to budgetary and temporal restrictions.

These restrictions were manifested in what could be described as a "merging" of stages 1 and 2.

The most obvious digression from the recruitment model's parameters was not using the PAF system.

Instead, a hotline and website were set up from which members of the public could register their interest in partaking in the survey. From the database this created, people were selected for inclusion in the survey based on their age and their place of residence

In this respect the method reflected that suggested quite accurately, but as the PAF (or equivalent) system was not used, an element of "randomness" was taken out of the process.

The method that was used relied on people coming forward for inclusion, whereas the original proposal required approaching people. What this means is that the Size UK sample will be biased towards people who were inherently interested in, and didn't mind taking part in, a sizing survey which involved scanning and measuring people in their underwear.

Initial awareness of the survey and the methods used to promote it served only to provoke interest in participants who had access to the media in which the survey was promoted. Most notably internet users who could log on to the SizeUK site to 'register', this eliminated elder UK residents and lower socio-economic groups who do not have access to a computer and, or internet facilities available to them.

It is also worthy of note that a considerable amount of recruitment was undertaken during the fieldwork, and mainly through local news coverage. Participants were also asked if their peers or family members would like to take part, or just to get people who they thought would be interested to turn up. People were able to take part by registering on the day at the venue and within minutes could be scanned. Although this recruitment was done in a round about away it was extremely successful in capturing participants who would not have otherwise known that the survey was taking place.

These methods go someway to ensuring that the sample is likely to be weighted towards people who are comfortable with their body (i.e. more "normal/average" bodied people) and those who perceive clothing sizing to be a serious issue, and one which warrants their input (i.e. those at the extremes of sizing, who struggle to find clothes that fit them – very tall, very short, very large etc.).

At the time of writing, insufficient analysis has been carried out on the dataset to ascertain how this has affected the composition of the sample. If this information becomes available, NTU will endeavour to provide the e-tailor consortium with it.

5.1.7 Summary

This section of the white paper is produced with the aim of highlighting a number of the issues involved in the recruitment of subjects, and hopefully laying the foundations for the eventual recruitment model.

It is, at this stage, deliberately vague in its level of detail. NTU have compiled this in an attempt to stimulate discussion on the best method of recruitment by hopefully providing a base from which to work.

If, and when it is decided to undertake a European sizing survey all the 'consortium' of involved countries MUST meet to discuss in detail, and reach agreement on the recruitment model to confirm exact numbers of participants that need to be measured. Agreement must be made on the financial budget for a large undertaking such as this and to agree which recruitment method(s) would best suit the target audience required. Logistics would also need to be considered to decide if the survey is to be managed centrally or devolved to each country taking part.

NTU welcome any feedback on the theory behind the above model and would appreciate any national statistics that partners may be able to provide which will help to enrich the level of detail described herein.

5.2 PUBLIC RELATION TO MOTIVATE TEST PERSONS

There are two main aims to the public relations work in the run-up to the sizing survey:

- Providing information on the objectives, purpose and benefits of the survey
- Motivating the general public to take part in the measurement survey and motivating industry and the retail sector to provide financial and organisational support

The press coverage falls into two generic categories. These are:

- Raising awareness of the survey
- Maximising commercial gain from the survey

With something as important to the general public as the size and fit of the clothes they are going to wear, the press and PR opportunities that arise throughout the course of a survey are substantial.

5.2.1 Raising awareness of the survey

This is essential both prior to, and during, the survey. It should be viewed as one of the simplest and least costly forms of recruiting subjects.

Generating public support for a sizing survey will help immeasurably in terms of persuading members of the public to take part in the sizing survey.

A mainstay of this is ensuring there is a “positive spin” on the survey in general, and that the benefits to the consumer are highlighted i.e. clothing that fits them better.

5.2.2 Maximising commercial gain

This aspect of the Press and PR adds great justification for a retailers’ involvement in a sizing survey (although clearly the main priority is to produce better fitting clothes).

A retailer’s inclusion can be seen by the public as an attempt to satisfy their customers by seeking to address their problems.

The other element of this media coverage is that the retailers involved in the project will look to be ahead of their rivals in terms of both customer care, and embracing new technologies and ideas.

This will help portray the company as forward thinking and a market leader. Again, this is a powerful reason for retailers to be involved in the project, and an excellent PR opportunity.

5.2.3 Preparing and success of PR actions

The information can be publicised via the press, radio and television. Leaflets can also be distributed to help provide more in-depth information. These can be sent by post, delivered by hand, or enclosed with newspapers.

In the context of the sizing surveys carried out in Germany, the public relations work by the media – principally in recruiting test subjects – played a crucial role. By providing the public with extensive information on the nature of the problem and explaining why and how the results can contribute to providing a solution, the population was motivated to take part in the sizing survey.

Announcements were made in the daily press and specialist media, and radio and television reports began even in the run-up to the measurements. For up to two weeks following publication of the reports, there was a very high level of response in terms of people coming forward to take part in the sizing survey, which died down gradually after this period. If the measurements are to be carried out over a period of several months, it is therefore vital that PR campaigns are repeated. As well as repeating the information covered in the original campaign, later reports should also include details on the progress of the survey.

It is not always possible to influence the contents of reports in every case. In the case of radio and television reports, in particular, this is only possible to a very limited extent within the context of an interview. It is only possible to control press releases which you have issued yourself. These should therefore be arranged in such a way that the most significant information is contained in the first paragraphs. They should follow the structure outlined below:

- Brief, concise description of the problem outlining why the survey is being carried out
- Details of which groups of individuals are being targeted to take part and why
- Information on the personal and general benefits to be gained as a result of participation and the survey results
- Details of where the measurements are to take place
- Information on who is carrying out the survey - institution
- Contact addresses

If we compare the degree of success of the reports in the various media in recruiting test subjects, experience shows that newspaper reports generate the greatest response. This does not mean that there is no need to continue with radio and television reports, however. These play a crucial role in refreshing the public’s memory and increasing their awareness of the campaign. Interviews with participants have indicated that many of those taking part only became interested in the sizing survey following repeated press coverage and information. As described in the previous section, it is only possible to affect reports on the radio and television to a limited extent. The diagram below, Efficiency of media reports in recruiting test subjects, illustrates which medium had the greatest success in motivating the test subjects to take part.

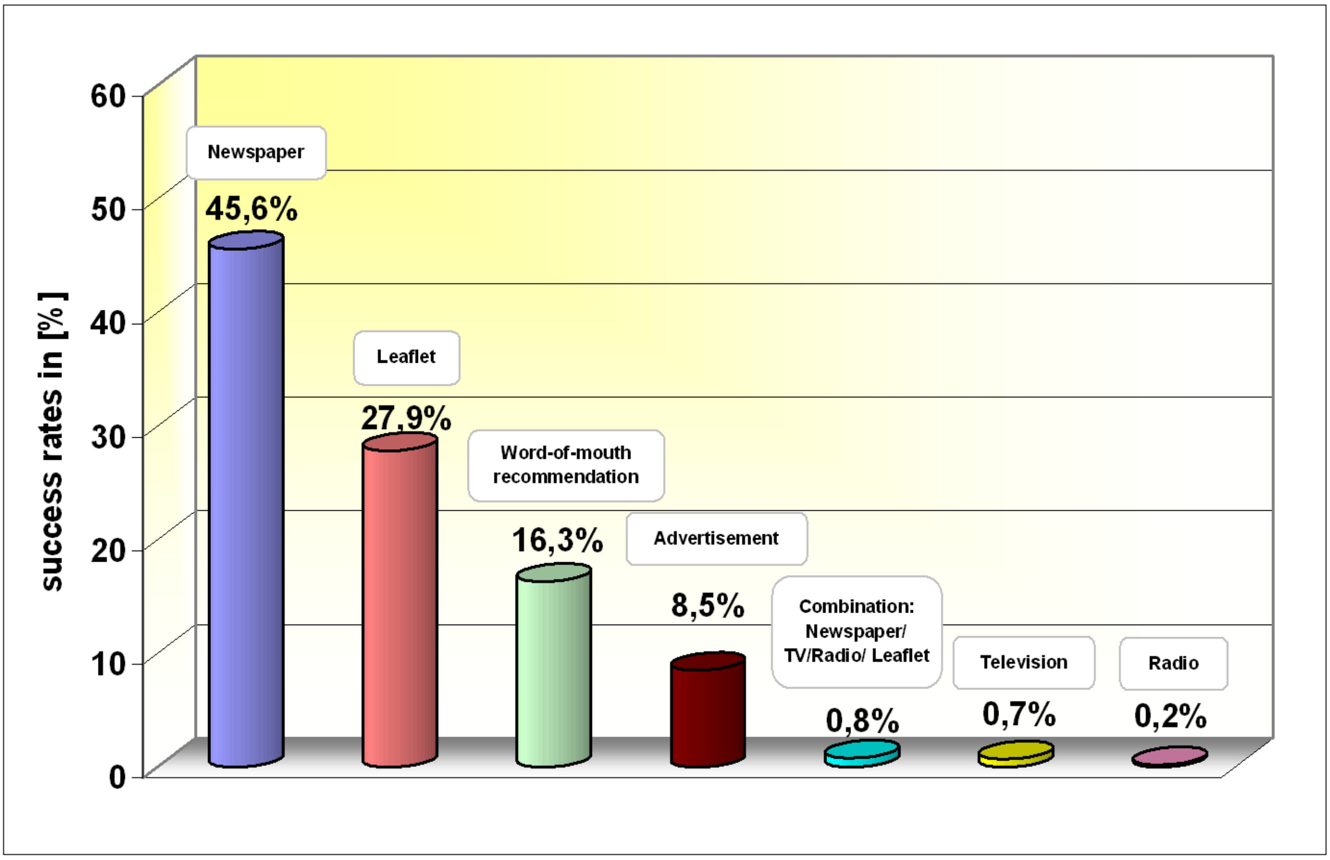


Diagram: Efficiency of media reports in recruiting test subjects

5.3 ORGANISATION OF THE SURVEY

Prior to the actual organisation of the survey, decisions must be made relating to how the sample is to be selected, which scanner technology is to be used, how many scanners are to be used, and the staff required. The measuring environment – waiting area, changing areas, interview and measuring booths and reception area – must also be planned, and the necessary equipment procured.

This chapter shall examine two different scenarios used to carry out sizing surveys. In the first scenario, which was put into practice in Germany, the measurements were carried out at one measuring station with a stationary scanner and at four stations where a scan truck was used. In the second scenario - which was used for Size UK – three stationary scanners were used to take measurements at eight stations. The scenarios also differ in terms of the staff employed. Whereas in Germany, an experienced team of specialists were used to carry out the measurements in all locations, in Great Britain, local teams, who received training in advance, were used at the individual stations. The organisation therefore differs in terms of staffing. In other aspects, the procedure is largely comparable.

Overview of the scenarios:

Germany:

Structure of the survey:	five consecutive measuring periods, relocating the scan truck in each instance
Staffing requirements:	two measuring teams, consisting of experienced specialists

Great Britain:

Structure of the survey:	three parallel measuring stations, three consecutive measuring periods, moving the scanner to a new location
Staffing requirements:	use of eight local measuring teams, generally with no experience in measuring, predominantly trained workers

Both of these procedures to carry out sizing surveys have their advantages. The personnel costs associated with the German method are lower than those related to the British method. By using two experienced teams, continuous results can be achieved which are not affected by differences in the qualifications of the different teams. Measuring at several parallel stations has the advantage that the measuring period is considerably shorter than when consecutive measurements are carried out at the various stations.

The organisation of the sizing survey is divided into eight stages in the order shown below:

1. Definition of the sample
2. Planning the locations of the measuring stations
3. Time management for the individual measuring stations
4. Planning staffing requirements
5. Preparation and launch of PR campaigns
6. Recruiting the test subjects and arranging appointments

7. Preparation for the measurements

8. Carrying out the sizing survey

In detail:

1. The sample is defined in line with the selection principle specified in the preliminary stages of the survey. If the sample is to be compiled on the basis of a random sample, the number of people to be measured for the individual stations should be specified as the point of reference. If a representative sample is to be measured, the sample should be determined on the basis of the distribution of the population group to be recorded and a recruitment plan drawn up.

2. The planning of the measuring stations depends on whether the survey is to be based on the principle of a random sample, or on the basis of a representative sample. In the first instance, it is dependent on the number of planned measuring stations and should be based on significant characteristics of the population distribution and include both urban and rural areas. In the second instance, the planning should be based on the maximum possible number of measuring stations. In an ideal situation, the scanner stations should be designated with a maximum catchment area of 50 kilometres to ensure that the test subjects do not have to travel further than 60 to 70 kilometres to take part.

3. Once the measuring stations have been designated, the time schedules for the individual stations are decided upon. The number of test subjects to be measured within each period is specified. This is based on an analysis and definition of the average time required to interview and measure one test subject.

4. Once the measuring stations have been designated and the duration of the survey at the various locations has been established, planning can begin on staffing requirements. For consecutive measuring periods at the different stations using two measuring teams, a detailed time and travel plan must be arranged for those employed alternately at the individual stations. Alternative arrangements should be made to allow for delays or absences. In order to reduce travel and personnel costs, there is also the option of using one specialist at the individual stations supported by trained assistants (students in related fields). If local measuring teams are used at the individual measuring stations, comprehensive training needs to be organised for the teams in the preliminary stages, as well as scheduling appointments for the survey itself.

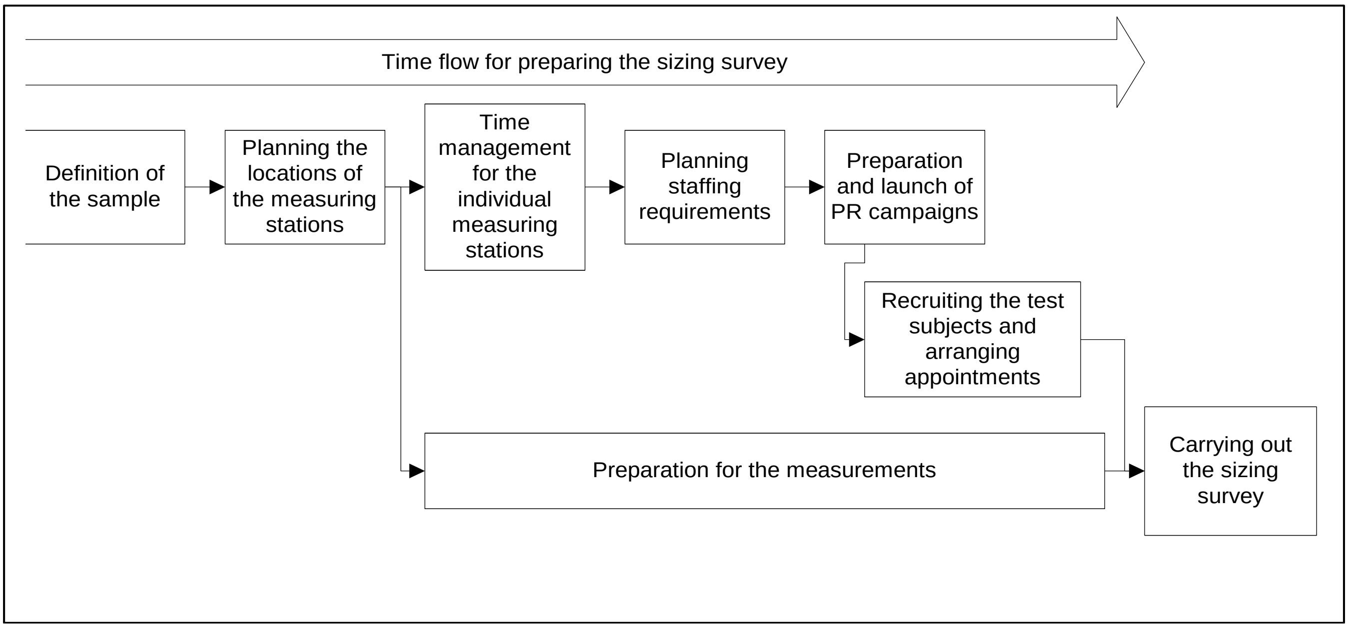
5. Once the time schedule has been established, work can begin on preparing and carrying out the PR campaigns. These should begin several weeks before the actual measuring survey, because experience has shown that it is generally only when information is repeated that it is the most successful, especially for recruiting voluntary test subjects.

6. The recruitment of the sample in line with the random sample principle should begin at more or less the same time as the first PR campaign, as this should form the basis to moti-

vate the test subjects. Appointments to carry out the measurements are made as soon as possible with the test subjects. The time schedule is worked out on the basis of the time scale for each test subject determined in point 3. Recruitment for a representative sample can also begin following the first PR campaign. The population will then already be aware of the sizing survey. The test subjects are selected, contact is made, and appointments are arranged in line with the recruitment plan developed under point 1.

7. Preparations for the measurement survey can begin once the measuring stations and the staffing requirements have been planned. All of the equipment, documents and other materials required for the measurement must be made available. The timing and organisational issues regarding moving the scanners must be planned in the preliminary stages.

8. Once all of the preparations have been completed, the actual survey can begin. In order to monitor the sample targeted and to assess the level of success, a comparison should be drawn between the measuring appointments agreed and those actually carried out. When carrying out the measurements, it is vital that data protection is assured continuously. When allocating the code for the test subject, it is important to ensure that the data recorded manually corresponds with the interview data and scan data.



Timeline for the organisation of sizing surveys

5.3.1 Preparation for a sizing survey

This section of the white paper deals with preparation issues. After planning what measurements are to be taken, where and when the survey will take place and what equipment and consumables are required, it is necessary to prepare the venues where you intend to collect data.

This involves looking at staffing issues, how the site will be set up and how the data is going to be collected and fed back to a central resource for further processing, to enable analysis and monitoring against recruitment requirements.

5.3.1.1 survey staff

It is clear that the on-site team are of paramount importance to the functioning of the survey. They are effectively the “front-end” of all the background work and preparation that goes into a large scale sizing survey. A lot of hard work can be undone very quickly if the team chosen to carry out the measurements and scans are not of sufficient expertise and in possession of a suitable personality and attitude.

It is necessary for the following team to be available on-site during the fieldwork process.

- 1 Site Manager
- 1 Liaison Officer
- 1 Registrar
- 1 On-site recruitment supervisor
- 1 Technical Manager
- 6 Measurers
- 2 Scanning operators

The proposed job descriptions for each are as follows:

5.3.1.2 Job Descriptions

Site Manager

Key responsibilities:

- To control the day-to-day running of the site
- To deal with multi-tasked responsibilities
- To act as the primary contact for NTU
- To allocate the various team break allocations
- To chaperone the candidates through the site
- To deal with all staff issues on site
- To complete all relevant paperwork for the site (detailed in Appendix 1)

Ideal candidate will demonstrate:

- Good managerial skills
- Customer facing abilities
- Good communication skills
- Good delegation skills

Liaison Officer

Key responsibilities:

- To support the Site Manger
- To cover for the registrar in their absence
- To ensure the smooth process of candidates through the site
- To deal with multi-tasked responsibilities

Ideal candidate will demonstrate

- Excellent customer facing abilities
- Good communication skills

Registrar

Key responsibilities:

- To welcome and reassure all candidates
- To input personal data into a data base
- To allocate candidates into various changing rooms
- To promote a very professional image for the whole process
- To allocate the incentive to the candidates and ensure that a signature has been obtained

Ideal candidate will demonstrate

- Sound computer skills
- Very strong customer facing skills
- Ability to juggle responsibilities without ignoring candidates

On-site recruitment supervisor

Key responsibilities:

- To support the Registrar
- To act as the main contact for the recruitment agency
- To keep the site informed as to the daily appointment schedule

Ideal candidate will demonstrate:

- Good organisational skills
- Sound computer skills
- Very strong customer facing skills
- Ability to juggle responsibilities without ignoring candidates

Technical Manager

Key responsibilities:

- To manage all software and hardware issues on site
- To liase with the NTU technical team for all technical issues
- To collate all data from the site on a daily basis and send to the Data Analysis Contractor

Ideal candidate will demonstrate:

- Although full training will be given, a good understanding of computers is essential
- The ability to keep calm under pressure

Measuring Team

Key responsibilities

- To measure accurately both men and women
- To undertake a data inputting role within the measuring cubicle

Ideal candidate will demonstrate

- Very strong customer facing skills
- Ability to relax candidates
- Ability not to respond to deformities or disfigurement of the human body
- Professionalism in handling the male and female body

Scanner operator

Key responsibilities

- To operate scanner hardware and to save the resulting scans
- To perform data archiving of 3D scan data using CDR/DAT media
- To carry out routine maintenance tasks regarding the scanner hardware

Ideal candidate will demonstrate

- Very strong customer facing skills
- Ability to relax candidates
- Ability not to respond to deformities or disfigurement of the human body
- Although full training will be given, a good understanding of computers is essential
- The ability to keep calm under pressure

NTU's experience tells them that both women and men are more comfortable with an all female measuring team. This can mean that the men who take part in the survey often come in groups "for a laugh", but it does ensure that quotas are filled with a minimum of difficulty. Although experience has always deemed this option satisfactory it is important that subjects, especially men are warned that they will be manually measured by a women only team. This should always be part of the briefing note, combined with offering them an option of being measured by a member of the same sex if they object.

As the measuring team will have to be comfortable with handling the human body and acting discreetly towards any deformities, auxiliary nurses have been used by NTU in the past. Again this is the ideal situation but it is far better to recognise a persons attributes and attitudes to the task they are being asked to perform than their profession.

5.3.1.2.1 Working time regulations for the on-site team

The new European Working Directive legislation (as provided by the Department of Trade and Industry) demands the following guidelines be adhered to:

- A worker is limited to an average of 48 hours a week
- A worker is entitled to 11 hours rest per day
- A worker is entitled to one day off a week

5.3.1.2.2 Clothing requirements

In order to gain participants trust and present a professional image, staff uniforms should be allocated. The following criteria should be adhered to when selecting the uniform.

- The uniforms must be flattering to all shapes, sizes and ages
- As the team will be required to work long days, the material for the uniform should be low maintenance - machine washable and easy to iron, whilst remaining presentable throughout the day
- Each candidate should be allocated three of each item of uniform (one to wear, one in the wash and one drying)
- Suggested items of clothing to be allocated are:
    - Three pairs of loose fitting black cotton trousers
    - Three Oxford cotton blouses in one bright colour, or cotton T-shirt’s with the sizing survey branding can be very effective.
    - The team will be expected to provide their own shoes with guidelines being provided to ensure that they comply with Health and Safety Regulations
- In order for the Site Manager to be easily identified by both candidates and participants, it is recommended that an alternative uniform be selected

5.3.1.3 Measuring training

Although the job roles are very specific in their key responsibilities, the team must be multi-functional to cover for breaks and illness. Hence the following people would also be trained to measure:

- Site Manager
- Liaison Officer
- Technical Manager

- Scanning operators

Inclusion of the Site Manager is important to ensure that they feel completely informed and in control of the site and can also act as a key contact for the measuring auditor.

As the manual measurements that need to be taken have been established it is now necessary to train the staff at each venue to take them. it is important that the manual measurements taken are accurate and consistent over all the locations, within countries and from country to country where the project will collect data.

Therefore once the measurements required are established a plan is required detailing how these measurements will be taken, the sequence in which they will be taken in and how the accuracy of the measurements will be measured and controlled.

There are numerous training manuals that have been created during the E-Tailor and E-Cluster projects.

NTU have also developed a training manual This manual also includes a section at the front which details how to prepare a subject for measuring and how to interact with them - how staff interact with subjects is vitally important to ensure that the subject is as relaxed as possible and comfortable in their surroundings.

Again, where on the body the actual measurements are to be taken is a contentious issue but agreement must be made and a single training manual issued that describes in detail ONLY the measurements that are to be taken manually.

Providing a smaller, more defined manual enables a training aid that is easy to understand and definitive in its approach to taking each measurement.

It is important that actual hands on training is made available to all people who will be employed to take measurements. This training should be undertaken by one individual, this ensures that the measurements are accurate and consistent. This allows no measurement to be misinterpreted. A major failure in collecting manual measurements would be made if subjects in France were having their shoulder to wrist measurement being taken from a different starting point than those in the UK. This could show that the French have a longer arm length that people in the UK when in fact the measurements could be the same.

Throughout the sizing survey it is also important to ensure that measurers are continuing to be consistent when they are taking measurements on a daily basis. Regular audits are required to ensure that the measurements are being taken accurately and consistently.

As well as ensuring that the people taking the measurements are consistent between locations it is also vital that the equipment used to take the manual measurements provides consistent and comparable results.

5.3.1.4 Measurment audits

Weekly audits must be undertaken by a trained measuring specialist to ensure that standards are upheld throughout the fieldwork process. The audit standard is a 0.5cm tolerance on the deviance of measurements for the entire team. Whilst the auditor is at the site an audit of the manual measuring equipment must also be taken to ensure that the results are still the same and the equipment is not broken or malfunctioning.

5.3.1.5 Additional training requirements for the team

In order to make the survey a cost effective exercise, and also to build the team's cohesion, the following additional training should be undertaken by the entire team.

The team building exercise should be held over one day with activities and training sessions co-ordinated to run throughout the day.

5.3.1.5.1 Detail of the project

It is vitally important to explain to the team the importance of their role to the functioning of the sizing survey. A short presentation should be given, illustrating:

- How and why the project was started
- What steps have been taken to get to this stage
- Who the key partners are
- What will happen with the results

Other fundamental information will also be detailed in this presentation:

- Their key contacts whilst they are on site
- The reporting structure within the team
- Key roles and responsibilities within the site
- Key rules of the site - for example no chewing gum, smoking or hot drinks

5.3.1.5.2 Customer facing skills

A comprehensive training programme should be undertaken, including role-plays and scenario setting to focus the team and ensure professionalism when faced with a variety of participants.

5.3.1.5.3 Database training

The fieldwork team will be trained to use a centralised data collection facility. The projects technical specialist(s) will initially train the Site Manager then both will train the fieldwork teams.

5.3.1.5.4 Site Management training (role specific)

Training the Site Manager covers intensive man management training including:

- The paperwork that the Site Managers are responsible for – including numbers processed each day and incentives (vouchers) issued with running totals to ensure there are adequate provisions.

- Allocation of breaks
- How to deal with candidate complaints
- How to deal with internal staff problems
- Authorizing payment through the time sheets
- Control of petty cash and gift vouchers

The responsibility for training the Liaison Officer is here passed onto the Site Manager.

5.3.1.5.5 Registrars

The registrar is the first person that the candidates will meet on-site, and hence a good first impression is extremely important.

Although the candidates will have been given an information sheet prior to turning up, many will still be apprehensive about the process.

The registrar must be briefed on the following requirements of their role:

- The importance of putting the candidate before any other task
- How to ask potentially sensitive questions (for example dress size) in a discreet manner
- The necessary paperwork that they need to complete; including the incentive allocation sheets and the retention summary sheet
- How to co-ordinate the recruitment
- Specific training for the database
- The importance of their role in controlling the database

5.3.1.5.6 Scanner operators (specific training)

During all previous survey, scanning performed by NTU, the experience and skills of the scanner operator has been key to ensuring high quality scans. Thus, in order to carry out a successful scanning survey it is important that the scanner operator is fully aware of the key roles and responsibilities required in performing their job. The following sections highlight a number of factors and responsibilities, which NTU has built into the role of scanner operator during past surveys.

The individual given the task of scanner operation must poses highly developed communication skills in order to develop the correct raptor with the subjects. It has become very apparent when using scanners to survey the general public that people have a very mixed perceptions and expectations of the process of being scanned. This can range from fear of being hurt by the scan to wonder and enthusiasm at the technology involved. The scanner operator must be able to react to an individual subject and explain the process in the most appropriate way in order to place nervous subjects at their ease and encourage more enthusiastic subjects so as to enhance their enjoyment of the survey process. The operator must then demonstrate and explain the postures required and then talk the subject through the scanning process as it happens.

Another important role for the operator requiring good communication skills, is that of phoning for technical support should the 3D system malfunction in any way. During a number of scanning surveys performed through NTU, a correctly explained and diagnosed problem with the 3D system has meant the difference between losing and saving days of scanning.

As well as possessing good communication skills, the scanner operator must also have the necessary technical skills to use the scanner software to capture and save the data produced by the scanner to the hard disk of the computer running the scanner software.

During most NTU surveys, the scanner operator has also been responsible for creating data backups at the end of each day of a survey, carrying out basic scanner maintenance and performing regular automated calibration procedures. Previous scanner maintenance tasks, performed by an operator during a survey, have involved:

- Careful cleaning of optical components (using air spays and lens cloths)
- Replacement of blown or degraded bulbs
- Refocusing of cameras and projectors

The specialist training required to use the scanner and perform basic scanner maintenance must be provided by the specific scanner manufacturer. Additional training in the creation of data backups may also be required.

5.3.1.6 Dress rehearsal

A dress rehearsal is fundamental to ensure the smooth running of the process from the on-set of the survey. Although the measurement training is critical, the team must incorporate their newly found skills to fit within the entire site operation. The purpose of the dress rehearsal is:

- To examine how each of the individual processes run together as an integrated system with multiple clients
- To ensure that they are undertaking their allocated tasks to time
- To practise a dialogue that they will use to ensure that all candidates feel comfortable with the process
- To iron out any technical difficulties which may be inherent in the system

Models should be utilised for this activity. It is important that no members of the public see the survey in this preliminary stage, where the process is not well rehearsed.

The timing of the dress rehearsal must be one or two days before the data collection is due to start, and must be as realistic as possible including models who are awkward, shy and embarrassed, to ensure that everything the staff have learnt remains fresh in their minds and this will ensure that they are confident and eager to start the actual data collection.

5.3.1.7 Site planning & set up

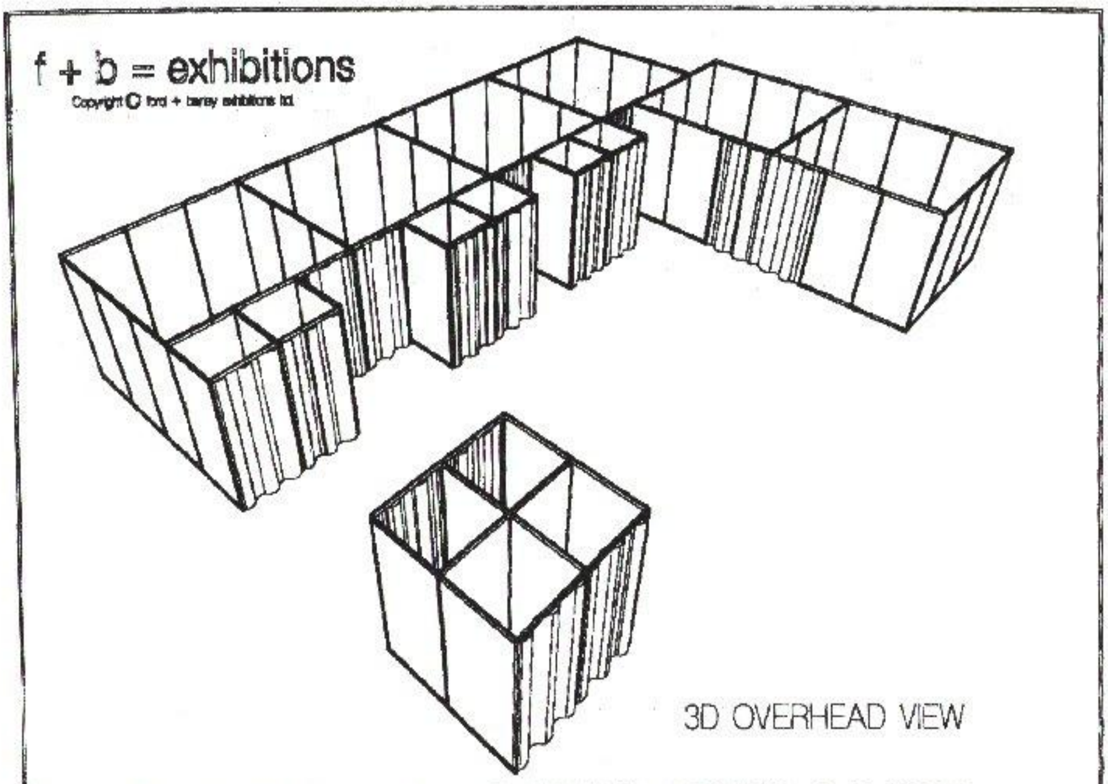
Two different scenarios must be examined here. Firstly, where stationary scanners are used, and secondly, where the scan truck is used. If stationary scanners are used for the measurements, an area for the measurements plus a waiting area must be planned. When the scan truck is used, the measurement area is already integrated into the truck. A waiting area is also available for approx. four people (see Chapter 4.7). An additional waiting buffer located close to the scan truck should also be arranged in order to increase the rate at which the test subjects can be measured.

5.3.1.7.1 The waiting area

The waiting area will be a point of focus. In order to make it as aesthetically pleasing and relaxing, attention must be paid to this area with tea and coffee facilities being provided.

5.3.1.7.2 The measuring and scanning area

In order to ensure that the venue presents the correct image for the project, an exhibition company should be utilised to provide boards to partition the various sections. These boards must provide the necessary privacy for the site.



Example of floor plan for the fieldwork process

5.3.1.7.3 Location & venue

- Once the measurements and market research questions have been established it is important to establish whereabouts data is to be collected. This enables planning and preparation of the site to start.

- For a survey of this size firstly the actual areas and countries must be established. From here the location can be sought that will provide sufficient access to the demographics that you need to attract to ensure recruitment is undertaken that is statistically representative.

- The separate countries need to provide locations – normally north, south and central regions where data can be collected. This ensures that the country as a whole has the correct mix of people from different locations.

- Towns or cities can then be identified that are central to each region (north, south and central). It is important that the town or city will have the correct mix of people located in and around it – in order to match the recruitment model.

- Once a town or city has been identified as a potential area for collecting data a central location must be identified from which the survey can take place.

- The location must be easily accessible to members of the public. It must be in a central location that is well known. The facility must be well maintained and in a desirable area. A series of locations suggested by Nottingham Trent University that was taken up by the SizeUK project was to use facilities at Universities around the UK. Each major city is the UK has a large university campus that is normally centrally located in the city, and is well known to all city residents.

- By involving Universities in the project enabled not only the use of centrally located facilities but also provided a supply of staff that could undertake the fieldwork. This gave both staff and students at each university the opportunity to be involved in a prestigious project.

- This approach worked very well for SizeUK and NTU would recommend that this be considered as an option when deciding on locations for a European sizing survey.

- Another popular location that attracts the public is to have the site located in a shopping centre or mall – in an empty store. The area is already well known to members of the public and they are more likely to want to be involved if they do not have to put themselves out in order to co-operate, by not having to go to another part of the city with which they are not familiar. This approach also works with leisure centres or hotels that are located centrally.

- Renting these properties for a month or so whilst the fieldwork takes place can be expensive but the benefits of having a centrally located site can not be overlooked.

- Once the site has been established the facilities on offer must be appraised. The room used for the survey needs to be a minimum of 150 metre square to ensure that all equipment can be set up, a waiting area can be identified and there is adequate room for storage. There must be toilet facilities nearby and the room must be located near to the entrance of the building so that the public does not need to spend minutes looking for the room.

- The facilities required for a sizing survey are covered in greater detail in the 'Site Set Up' section of this document including the building of measurement and changing areas, but at this stage it is important to know enough about the proposed site to ensure that it at least meets the above criteria.

5.3.1.8 Staffing requirements

- Whilst the locations are being identified and secured as data collection sites it is important to establish how the site is to be managed. This requires identifying who is going to staff the data collection venue. This is again, covered in greater detail in following sections, including proposed job descriptions.
- At this stage the key is identifying if all staff will be employed locally to the site or if a team is to be put together that will travel from site to site, around the country. It is not viable to assume that a team could travel around the countries involved in the survey, due to language, customs and values barriers within each country. There are advantages and disadvantages to both methods. Although a team that collects all the data from each venue will ensure all the measurements will be uniform and collected to the same standard, and due to the time spent collecting would become highly skilled the main disadvantages are the timings and cost required to achieve this.
- If data is to be collected concurrently there will be timing constraints where these people will not be able to be in two places at once, as well as the cost of accommodating these staff whilst they are in places that are not local to them.
- The cost can become huge as these people must be paid wages as well as accommodation and subsistence allowances.
- NTU would recommend, and as demonstrated during SizeUK that teams are recruited that are local to the venue. The most obvious cost benefit to this is that accommodation and subsistence for long periods of time are not required. There is a cost issue during training as each site will have to be trained, so the project will have to train three locations instead of just one but this will be far less than a travelling data collection team. This option also provides the benefit of collecting data concurrently, providing there are no equipment constraints.
- Once this has been established recruitment must begin to take place – as it may take time to recruit the calibre of staff that is required for such an undertaking. If the venue to be used is a University or like establishment, then it is suggested that staff at the University are approached to work at the data collection site. Appropriate degree courses can be targeted to see if they are interested in participating, or if collection is to be made elsewhere temporary staff, from recruitment agencies can be sought.
- Even if people are not actually targeted and given the jobs required at the site there must be firm plans in place to ensure the appropriate provision of staff.

5.3.2 Consumables & incentives

- Once the location and the methods of collecting data have been established it is important to start identifying what else is required for a sizing survey.

5.3.2.1 Consumables

- Consumables are defined, for the purpose of a sizing survey, as all the things that are needed to ensure the smooth running of the site.These can include posters and branding to ensure that the site portrays the correct image. Dressing gowns for clients to wear whilst they are waiting to be scanned and manually measured. Underwear, if people do not turn up in the correct underwear that you have identified as necessary in order to obtain a satisfactory scan.

- Hair clips, for tying hair back so that it is on the top of the head and not over the nape of the neck to ensure the scanner can capture the associated measurements.

- Anti bacterial wipes to ensure that the measurement and scanning area is kept clean between each client, eliminating risk of infections.

- Tea, coffee and water facilities to offer clients a drink whilst they are waiting to be scanned.

- All the necessary paperwork that is required for a survey also comes into this area. A tremendous amount of paper work is required to complete a sizing survey successfully. Each client must sign a confidentiality agreement and be given a marketing questionnaire to complete. On average 10 pages of paper (photocopies) are required per subject and if you are measuring 10,000 people that is over 100,000 photocopies at approx 0.4 euros per page, represents a cost of over 4000 euros.

- Once a definitive list has been identified then these consumable must be procured for the project. As major UK retailers were involved in the SizeUK project many were able to provide consumables from their stores. It must be noted that not all consumables were made available by the retailers, therefore funds from the project must be made available to purchase the consumables required.

5.3.2.2 Incentives

- In all previous sizing surveys carried out by Nottingham Trent University an incentive has been offered to participants. During the E-Tailor pilot NTU tried to recruit subjects without offering any incentive and the response was very limited. The recruitment only picked up when an incentive was offered.

- The incentive offered for the pilot was a £10 (14 euros) store voucher. The SizeUK project also offered vouchers to the value of £20 (28 euros). The benefit to retailers of using vouchers is the additional sales these vouchers attract. Studies of the UK market has shown that a customer with a voucher will typically spend double the amount of the voucher.

- The incentive offered must be established prior to any publicity for the project. Many people will be attracted to the process by the lure of the incentive to do so. As participation in these projects is voluntary the subjects like to think that they are being rewarded with something immediately. Few will see the longer term benefits of being involved in such a survey such as better fitting clothes but many will want the instant gratification in taking part.

- The funding of incentives can be one of the biggest expenses when undertaking a sizing survey so sufficient funds for this must be established and made available early on.

- The management and security of these vouchers can not be overlooked. An appropriate individual must be put in charge of central distribution of the vouchers, ensuring that retailers contributing vouchers have sent their allocated contribution, also they must have responsibility for sending vouchers to the individual vouchers.

- Once the vouchers are at the individual venues they must be held securely, in a safe to prevent theft or loss.

5.3.3 Identifying how long the data collection will take

- Having identified how many manual measurements are required, and how many minutes it will take to take those measurements and how many people can be scanned per day you can start to build up a picture of how long it will take to collect the sizing data.

- There is a model that can be used to establish the optimum amount of people that can be processed in one day, and this is detailed in the 'Site Set Up' section. From NTU's previous experience of sizing surveys and the figures through putted during SizeUK it is best to work with a figure of between 50 to 60 people per day.

- Therefore if 10,000 people are required for a sizing survey to be statistically representative then this equates to 167 to 200 scanning days, which is approximately 33 to 40 weeks (see also chapter 6).

- In order to scan and process 50 – 60 people appointments must be made at five minute intervals throughout a typical day.

- It is assumed that a survey of this size would be collecting data from various sites, and over various European countries, concurrently in order that the collection of data did not take years to complete. This necessitates a number of scanners being made available for use in the project. If there are three regions where fieldwork is taking place then the project requires the use of three scanners, and the same for each country. It will also require three teams of measurers, scanner operators and personnel to staff the venue.

- The amount of preparation and planning that is required in order to ensure that fieldwork is able to take place concurrently is substantial. Therefore Nottingham Trent University would recommend that a project management team is put into place who can co-ordinate the fieldwork. It is necessary that there is also a project team created centrally who can oversee the overall European project, as data collection would be taking place in various countries.

5.3.4 Briefing members of the public

- Once the planning stages of preparing for a sizing survey have been worked through, there will be certain facts that emerge. These facts can be used to brief the public, as they are recruited about the process that you want them to undertake.

- At this stage the consortium will know the scanner manufacturer, and how the machine captures the data. What underwear the public will have to wear to ensure that satisfactory scans are captured.

- The consortium will know how many measurements will need to be taken manually and how long this will take.

- The consortium will have established a market research questionnaire, and how long it will take to complete.

- The consortium will have established what incentive is being offered to the public in order to ‘reward’ them for taking part.

- These facts will enable publicity material to be constructed. More importantly it will provide the basis of a briefing note that can be sent to each person who has registered their interest in taking part.

- It is vitally important that members of the public are educated about what is going to happen when they arrive for their appointment. It is not right to not let people know that they will be scanned, and what that entails and then measured in their underwear. Many people may originally agree to take part in a sizing survey without really realising exactly what they need to do to get their ‘reward’.

- Whilst undertaking the E-Tailor pilot survey Nottingham Trent University sent a briefing note to every person that was interested in taking part (find report I wrote – stating drop out rate!!!)

- This detailed what project we were working on, what would happen to them during the appointment and that if they had any questions prior to their appointment they should just ask.

5.3.5 Manual measuring equipment

5.3.5.1 Introduction

- Having established exactly what manual measurements are required it is now necessary to procure all the manual measuring equipment that is required to take these measurements accurately.

- All measuring manuals produced will contain along with the description of how to take the measurement a description of the equipment required. A list can then be compiled detailing all the equipment required.

- All equipment used in the sizing survey must be calibrated to ensure that it is taking accurate measurements consistently. There are various methods to do this but NTU would suggest that all measuring equipment is purchased new for the project and that the same supplier is used for all locations in all countries. This ensures continuity, which is vital when collecting data from various sites across Europe.

5.3.5.2 Suggested equipment required

The main pieces of equipment that are required for a sizing survey are:

- electronic weight scales. These enable the weight to be read from the scale where dial scales require the measurer to ascertain the weight to the nearest .1 of a kilogram. Reading electronically eliminates assumptions. A good set of scales should cost approximately €70. And two are necessary in each measuring booth in case one fails.

- A height measurer is required to read height, free standing anthropometers can be used to do this they are tricky and can be unreliable if used incorrectly. A floor standing height measure is used for taking front, back and side height measurements. A free standing or hand held anthropometer is used for taking various body depths and widths.

- Hypo-allergenic stickers or eye pencils for identifying landmarks in order to take accurate measurements.

- Tape measures are required to take the majority of measurements. These must be easy to read, unambiguous and from a recognised source. Tape measures can stretch over time so it is important that tape measures are thrown away after two to three days measuring and replaced with new ones. Tape measures with a brass end are also required as this allows the brass end to be placed with minimum embarrassment in hard to reach places such as inside leg.

It is also important to have tape measures over the standard 150cm in length. A supply of 200cm tapes are required to ensure that when you are measuring larger people the tape measure is long enough to fit around them comfortably. It is embarrassing for the subject and the people measuring if they have to put two standard tape measures together to take the measurements, also this method is not proven to be entirely accurate.A good tape measure costs approximately €1.00

- 4 cord elastic is used to tie around bust and hips when locating major girth positions

- A neck chain – made from cotton covered beads or a chain of a similar weight. This is used to locate the base of the subjects neck.

5.3.6 Sources of manual equipment

The following web addresses and contact information provide details of where manual measuring equipment can be purchased:

www.morplan.co.uk
www.anthropometric.com
Chasmore & Son
Camden Town
London NW1 0JH
Tel: 020 7387 2060

Finally when taking manual measurements it is important that people taking the measurements are comfortable with what is required of them. Training the measurers so that they are comfortable and confident with what they are doing is important as this puts the person being manually measured at ease.

5.3.7 Other equipment

In order to equip the venue, in particularly the measuring booths the following equipment is needed in addition to the manual measuring equipment: a table housing a networked computer which allows the data imputer to load the manual measurements taken, another table for all the manual measuring equipment including cleaning equipment to wipe down equipment, 2 chairs - one for the subject the other for the data recorder, waste bin for used labels, tissues and wipes and a laundry bin for used elastic, neck chains and dressing gowns.

In the changing room the set up needs to be very similar to a shop changing room, providing a chair and two coat hangers (1 hanger holding the dressing gown.). During the SizeUK project, subjects left their clothes in the changing room but took their personal possessions with them throughout the process.

5.3.8 Computer equipment

A network of PCs should be used for centralised tracking and collection of data. This network will be composed of PCs running MS Windows NT/2000 and will be further connected to the scanner PCs. A 10Mbps Ethernet should be used within this LAN, running TCP/IP as the network protocol and principally communicating using the SMB protocol.

A printer will be provided for ad-hoc generation of recruitment reports to be faxed each night to the Recruitment Contractor, and other documents that may need to be printed. The Registrar PC will also export a share to be mapped by all PCs for the purposes of the tracking database. There should also be access to a fax, although it is recommended by NTU that as much documentation as possible is sent electronically as this method is far quicker and provides records of transactions and copies where necessary.

A tracking database should be provided which will allow the booking in of clients, and their scheduling throughout the process. This software will help enforce data integrity by centrally storing the ID of the candidate and forcing the operator/measurer to check that the correct person is coming through the process at that point. The system will allow for the input of manually acquired measurements and will force an integrity check at this point also, by doing a bounds check on the data being input.

The system will also prompt the scanner operator on the filename to use for each body scan performed. Output from the system will be available as either a microsoft access .mdb file or as a comma separated value file(.csv).

In the event of network failure the system will log all records to a flat file on the local machine for later recovery to the central database. The central database will reside on the registrar PC.

As valuable equipment and data is stored overnight on site it is important that the site is lockable. Additional security would be provided though siteing the survey within a university/public facility, where security monitoring is practiced.

5.4 DATA PROTECTION AND RIGHT OF OWNERSHIP

The three-dimensional recording of the body using body scanners provides a very realistic virtual model of the scanned person with most scanner types. It is possible to recognise the individual on the basis of the three-dimensional data. Personal data security is therefore crucial, in particular in terms of how the data is managed, utilised and distributed. In this instance, European law states that the data must be formatted in such a way that it is not easy to recognise the individual. In order to meet this requirement, it is usually sufficient to delete the facial information from the 3D data. Only where physical characteristics are particularly pronounced is this insufficient, in which case the test subject should be requested to sign a declaration of consent stating that the data can be utilised.

The issue of proprietary rights and exploitation rights relating to the scan data is also critical. If the test subject is paid for taking part in the survey, this should be regarded as consenting to the data being fully utilised for scientific and economic purposes. This is not the case with voluntary participation. In this instance, the test subject makes him or herself available for a specific purpose, and often assumes that the data will not be passed on for other purposes. For legal purposes, the test subject should be made aware of the possible use that may be made of his data and should sign to confirm he consents to this (see chapter 6.6).

5.4.1 Data Hosting and Protection

It may be necessary for many copies of the data to be made, where its collection has been jointly funded by many partners. Whether the data is hosted independently by each partner or at a central source these same principals of protection and storage will apply. The law is very similar throughout Europe regarding the storage and protection of personal data and much care needs to be taken to ensure these standards are kept for the sake of the individuals concerned.

5.4.2 Physical location of the data

Ideally the data would be held on a high capacity server specified with fast processor and memory due to the size of the data being stored and the number of people likely to require access. This must be housed at a secure location to prevent physical access to the terminal by those not authorised to do so. Anywhere that has restricted access and a 24 hour security surveillance would be ideal, like an academic institution or large corporation.

5.4.3 Security issues to consider when hosting on a publicly networked (inter-networked) computer

The security errata for the operating system on the server must be checked daily, and applied if necessary, to plug any security loop holes found by attackers. It is important to choose an operating system where the manufacturer is not slow to react to serious security flaws and produce patches that a competent technical manager could easily apply.

If a breach occurs before a patch has been released for a particular unidentified exploit firewall software or hardware must be in place to minimise the effectiveness of the attack, and virus protection software installed to prevent known attacks and repeat infection by virulent viruses. Staff must check log files to identify attacks and be ready to disconnect the computer from the network in case of a breach of security or malicious destruction.

The sensitive files must be stored on a drive which is not shared with any other computers but only accessible by users registered on the server. It is always a good idea to hide these files in the directory structure where they would not be immediately apparent to an intruder.

A popular choice for viewing data over the public network these days is to use a secure password-protected web portal. This would require a web server with secure socket layers (SSL) support and applications which could display the data in a coherent fashion. See the section on presenting the results for a view on the kind of tools that are available for presenting and analysing the vast amount of data collected on a large scale sizing survey.

The filenames of the 3D scans should not contain any personal data about the person like date of birth or name. This prevents the scan from being identifiable in its own right. Instead it would normally be named in the form of the unique identification number linking that person to market research data and manual measurements. However it could contain a letter representing sex of the subject, or possibly a digit representing scan order if an individual needs to be scanned multiple times as these are not personally identifiable details.

Generally a scan file will not be of much use without any tools or viewers with which to reconstruct them. Most scanners use their own canonical file format which is very hard to interpret without correct instructions. This is a good reason not to use XML or any published CAD interchange standard as an interchange standard for body file formats, as well as the obvious performance issues.

Depending on the level of anonymity decided during the planning stage and agreed with the subjects the scan may have to be cropped to remove all identifying parts, e.g. hands and head. Again, if colour data is necessary as part of the data capture strategy it must be kept, but in most surveys it will be omitted along with other distinguishing marks like tattoos and birth marks.

5.5 FINANCIAL OUTLAY

This chapter shall examine the cost calculations for a sizing survey, on the basis of examples. The examples can be used to estimate costs for planned projects depending on the size of the sample, number of measuring stations and staffing requirements.

The purchase of a scanner is taken as the basis for the calculation. Rentals were not taken into consideration, as for the measurement of 10,000 people, which is taken as the basis of the calculation, there would be very little difference in the cost of renting or purchasing a scanner. It will be possible to reduce the scanner costs in the future by using devices already installed e.g. in clothes shops etc. Using such equipment could also reduce transport costs associated with relocating the scanner.

Basis of calculation A:

scanners	80.000 Euro	per scanner
personnel specialists	4000 Euro	per month
traveling	200 Euro	per day
other	30 Euro	per person
organisation	20 Euro	per person

Basis of calculation B:

scanners	80.000 Euro	per scanner
personnel specialists	4000 Euro	per month
students - temporary worker	2000 Euro	per month
traveling	10 Euro	per day
other	30 Euro	per person
organisation	20 Euro	per person

Example calculations – using method A as the basis for calculation:

Example 1: Use of non-local measuring teams – Composition: experienced specialists – Throughput **5 people** per hour

			time needed				costs EURO						
Number of scan stations	persons to measure	number of operator	measuring time days	measuring time weeks	measuring time month	average per day - persons	scanner cost	personell cost	traveling cost	other	organsisation	cost summary	cost per person
1	10000	4	285	57	14	40	84.000	228.000	114.000	300.000	22.175	748.175	73
2	10000	8	150	30	8	80	168.000	240.000	120.000	300.000	12.850	840.850	83
3	10000	12	98	20	5	120	252.000	236.000	118.000	300.000	9.775	915.775	91
4	10000	14	73	15	4	160	336.000	203.000	101.500	300.000	8.238	948.738	94
5	10000	16	58	12	3	200	420.000	185.600	92.800	300.000	7.550	1.005.950	100

Example 2: Use of non-local measuring teams – Composition: experienced specialists - Throughput **9 people** per hour

			time needed				costs EURO						
Number of scan stations	persons to measure	number of operator	measuring time days	measuring time weeks	measuring time month	average per day - persons	scanner cost	personell cost	traveling cost	other	organsisation	cost summary	cost per person
1	10000	4	174	35	9	72	84.000	139.111	69.556	300.000	13.842	606.508	59
2	10000	8	94	19	5	144	168.000	151.111	75.556	300.000	8.683	703.350	69
3	10000	12	61	12	3	216	252.000	147.111	73.556	300.000	6.997	779.664	77
4	10000	14	45	9	2	288	336.000	125.222	62.611	300.000	6.154	829.988	82
5	10000	16	36	7	2	360	420.000	114.489	57.244	300.000	5.883	897.617	89

Example 3: Use of local measuring teams – Composition: 3/8 specialists and 5/8 trained assistants – Throughput **9 people** per hour

			time needed				costs EURO						
Number of scan stations	persons to measure	number of operator	measuring time days	measuring time weeks	measuring time month	average per day - persons	scanner cost	personell cost	traveling cost	other	organsisation	cost summary	cost per person
1	10000	8	174	35	9	72	84.000	191.278	13.911	300.000	14.642	603.831	59
2	10000	16	94	19	5	144	168.000	207.778	15.111	300.000	10.283	701.172	69
3	10000	24	61	12	3	216	252.000	202.278	14.711	300.000	9.397	778.386	77
4	10000	32	45	9	2	288	336.000	196.778	14.311	300.000	9.754	856.843	85
5	10000	40	36	7	2	360	420.000	196.778	14.311	300.000	4.683	935.772	93

Example 4: Use of local measuring teams – Composition: 5/8 specialists and 3/8 trained assistants – Throughput **9 people** per hour

			time needed				costs EURO						
Number of scan stations	persons to measure	number of operator	measuring time days	measuring time weeks	measuring time month	average per day - persons	scanner cost	personell cost	traveling cost	other	organsisation	cost summary	cost per person
1	10000	8	174	35	9	72	84.000	179.889	13.911	300.000	14.642	592.442	58
2	10000	16	94	19	5	144	168.000	200.889	15.111	300.000	10.283	694.283	68
3	10000	24	61	12	3	216	252.000	201.889	14.711	300.000	9.397	777.997	77
4	10000	32	45	9	2	288	336.000	202.889	14.311	300.000	9.754	862.954	85
5	10000	40	36	7	2	360	420.000	208.889	14.311	300.000	10.683	953.883	94

6 DATA COLLECTION

The success and quality assurance of the results depends on the measurements being carried out in line with uniform specifications regarding the way in which the measurements are recorded and the posture and clothing of the test subjects during the scanning process. The specifications for this will be defined in this chapter.

The essential requirement for attaining uniform and reproducible scan results is the establishment of rigorous standards for the instruction of the test subjects with regard to posture, breathing condition, muscle tension and the clothing condition of the body. Observance of these standards by the individual partners involved in the implementation of the pilot survey is imperative if data capable of comparison is to be obtained. This document contains descriptions of the conditions necessary for controlling the significant factors of:

- clothing condition
- posture
- breathing condition and muscle tension
- physical exercise

6.1 REQUIREMENTS FOR THE SCANNER ENVIRONMENT

The venue for the measuring process should be easy to find. Signs and posters can be used to indicate where the body scans are to take place. For locations in highly frequented public places, appropriate noise protection must be provided. Care should be taken to ensure that it is not possible to see into the measuring area from the outside in order to guarantee the privacy of the test subjects.

Location plays an important role, in particular where the scan truck, which technically forms a closed measuring unit, is used, as the truck is always positioned outside buildings. The truck should be positioned in a prominent place which can be identified from a distance. It is also useful if e.g. public institutions or businesses close to the truck take part in PR campaigns and draw the attention of visitors or customers to the survey. In the sizing survey carried out using the scan truck by Hohenstein in 2002, interested companies provided waiting areas and staff to look after the test subjects. They benefited from the advertising effect which results from reports in the press, on radio and television associated with such campaigns.

6.2 REQUIREMENTS FOR CLOTHING CONDITIONS

The clothing condition of the test subjects has a decisive influence on the quality of the scan results. In contrast to manual measurement, whereby useful results may be achieved even when wearing outer garments, the recovery of body data by the scanning method while outer clothing is worn is impossible. During manual measurement the clothing is compressed against the skin because the tape measure is applied with tension, thereby making essentially correct measurement of the body possible. In contrast, the scanning process exclusively records and measures the surface of objects. Thus, if comparatively loosely fitting outer garments are worn, it is not the body surface but rather the surface of the clothes which is scanned since the clothing will not be compressed against the skin by the scanner’s contact-free operation.

It follows from this that in order to capture body measurements, the test subjects must be scanned while wearing tight underwear. In order to obtain optimal scan results, light-coloured underwear is recommended because some body scanners can have problems with dark colours.

Most scanners use visible light waves to capture the surface of the body through use of stereo pair photography or striped light techniques. Light will not travel well through clothes so the best way to capture the shape of the body would be to ask the subject to pose without clothes. Due to the nature of 3D body capture and current political climate most people would find it unacceptable to have an image of themselves stored on a computer. It is suggested that wearing only tight fitting undergarments will suffice to give as close an approximation of the surface as possible. This should also produce a higher percentage of subjects willing to go through the process by being more comfortable in this lesser state of undress.

There can be trouble finding the cut off point of the fringes when dark objects are scanned. Dark underwear can be hard to detect but this can be solved by keeping spare undergarments at the measuring venue. In rare cases where dark skin tones present a problem this can be solved by asking the subject to wear a skin tight body suit which is detectable by the scanner. Usually fine tuning by a skilled technician can prevent these problems from occurring in the first instance.

Other scanners using other wave frequencies have been suggested which could scan through clothes, although these have yet to emerge.

- Women must wear a well fitting bra and tight panties – not a vest, a bathing suit, a body or a bustier

- Men must wear tight underpants and not boxer shorts and / or a vest

  Only for men with strong chest hair, it is recommended to wear a <u>tight</u> vest or a T-shirt without any folds.

- The hair of the test subjects must be covered by headgear, e.g. a bathing cap. At least, the hair must be tied in such a way so that the head and also the neck of the subject can be scanned correctly.

- In order to capture body measurements of the feet, the subject must not wear shoes. It is required that the subject goes barefoot or wears light-coloured and <u>tight</u> socks without any folds.

- To ensure the correct measurement of the body, the subjects shouldn't wear any jewellery, especially no watch.

Clothing to be worn during the scanning process

Clothing not to be worn during the scanning process

6.3 REQUIREMENTS ACCORDING THE BODY POSTURES DURING THE SCAN PROCESS

One of the important goals for E-Tailor is the provision in the EAD of body data from several measurement series carried out in various European countries. Use of this data should not be restricted to the areas of textiles and clothing, but should be extended to serve concerns in the fields of medical research, ergonomic design, health, diet, beauty clinics and the pursuit of fitness. In order to meet this wide range of demands, the database will have to be supplied with the necessary information. This means that not merely body measurements are required, but also information concerning the three-dimensional form of the body as well as data permitting bodily kinetics to be elicited, e.g. by deriving the length of partial limb segments.

To meet the needs of textile clothing the scanning process generally makes use only of a standing posture, since all necessary bodily dimensions can be derived from it. However, this position of the subject does not permit derivation of information on the location of joints, the proportions of limbs and so on. Such information can be made available by carrying out a supplementary scan using a suitable posture. Following the CESAR Project, a sitting position is to be used as the posture for the second scan.

The first data capture process is to be conducted using a standing posture. Measurement in each zone of the body is influenced by overall stance, but also by the position of the legs and orientation of the arms, particularly at the shoulders. The arms should be slightly flexed and held sufficiently clear of the torso to make the armpit visible. The legs must be apart in order that the lower extremity of the torso may be seen. The body mass should equally distributed on both legs and with sufficient pressure on the sole to straighten the feet (see: Figure 3).

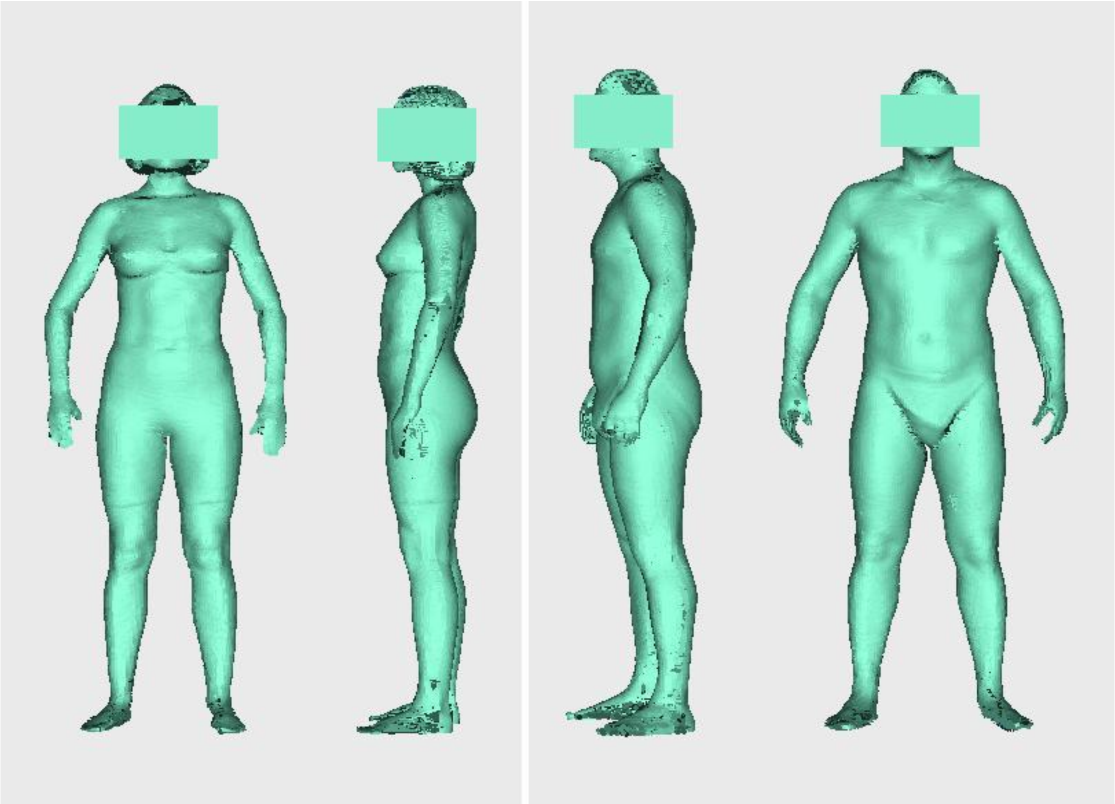


Figure: Scanning posture – standing

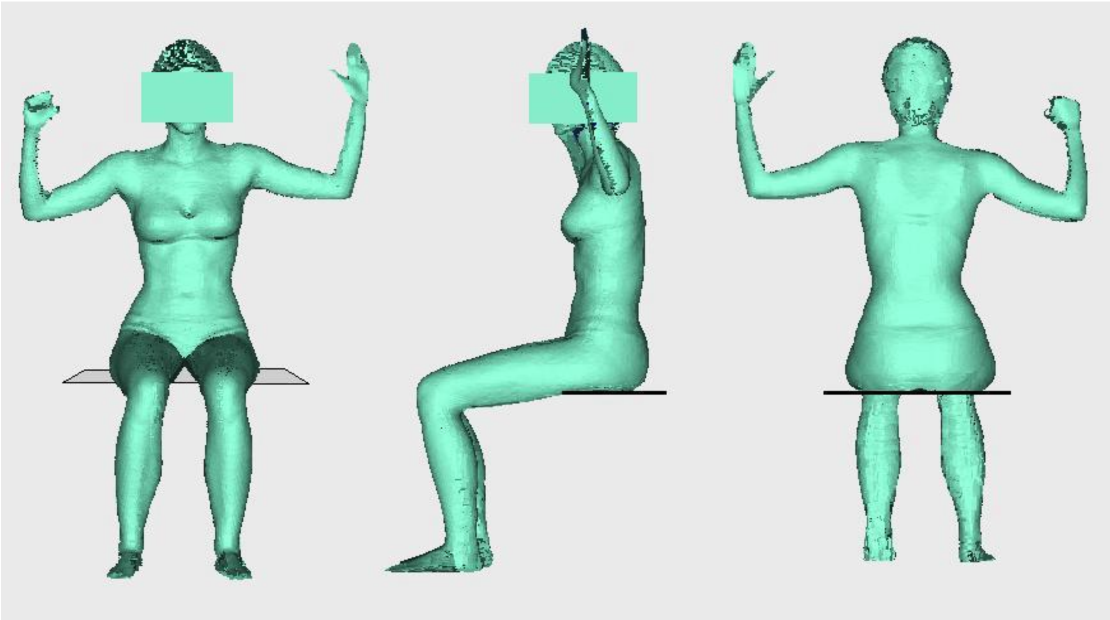


Figure: Scanning posture – seated

The second scanning process is to be conducted using a seated posture. The test subject must be provided with something on which to sit, which should have no back and which should ideally by height adjustable, e.g. a stool. The arms must be held out sideways from the body and raised into a “hands up” position. The right hand must be closed to make a loose fist while the left hand remains open with the fingers together and the thumb extended. The muscles should remain as relaxed as possible (see: Figure - Scanning posture – seated).

Figure - Scanning posture silhouettes- shows factors which are crucial to the scanning postures. Care must be taken in the standing position that the boundaries between the torso and the extremities can clearly be seen at the locations marked.

The legs must be far enough apart for the lower extremity of the torso to be seen (1). The hands must not contact the torso. The distance should be approx. 10 cm (2). The upper arms should be held sufficiently clear of the torso to make the armpits visible (3). The shoulders must not be raised while doing this (4). The arms should be held relaxed and with slightly flexed elbows but without displacing the shoulders, as shown in Figure 6. It is important that the staff make sure the test subject adopts a relaxed posture – the muscles tension should be kept to a minimum. The test subjects should also try to adopt a natural head position and keep their eyes in front of them in a horizontal plane.

When using the seated posture care must be taken to ensure that the test subject sits upright, the arms are not raised too high and the legs are vertical from below the knee.

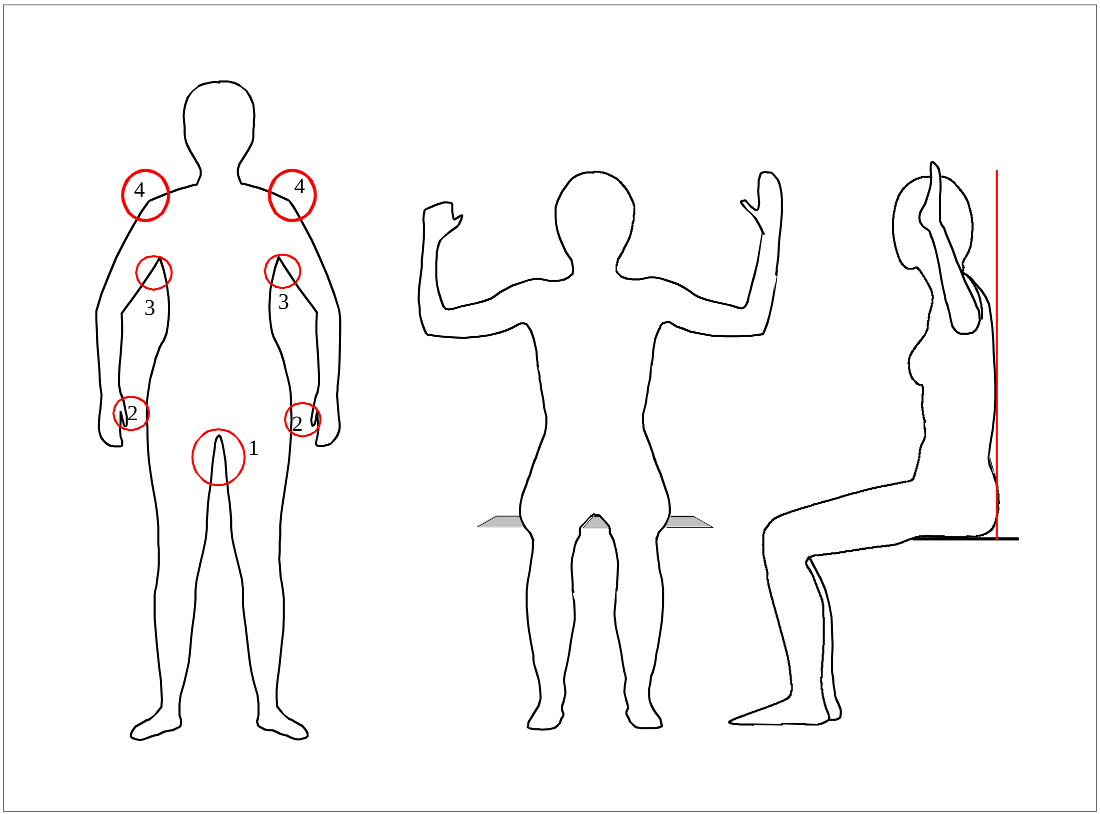


Figure: Scanning posture silhouettes

6.4 PREPARATION OF THE TEST PERSONS

The mental preparation of the test subjects regarding the measuring process forms an essential part of the sizing survey. The quality of the measuring results, both where manual measurements are taken and where physical data is recorded using 3D body scanners, can be significantly affected by the ability of the test subjects to imitate the required posture for the measurements. It can have a negative effect if the test subjects are nervous or tense. The staff taking the measurements must therefore explain the process to the test subjects before the measurements are taken and clarify the technical details if necessary in order to allay any fears and to create a relaxed atmosphere. It would be helpful to speed up the proceedings by showing the test subjects a prepared video in the waiting area to provide them with information on the process.

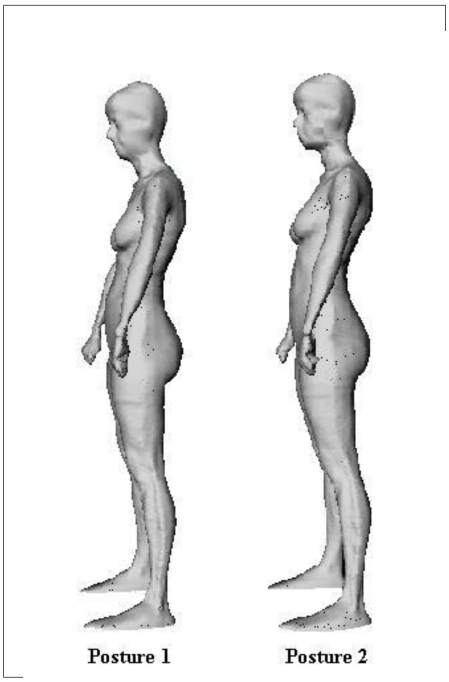
In addition to body posture, breathing condition and muscle tension in the areas of the stomach, seat, arms, shoulder and legs play an important role in determining both the quality and the comparability of the resulting measurements.

- During scanning breathing should be normal and movement of the ribcage should be kept to a minimum.
- During scanning the movements of the body should be kept to a minimum.
- During scanning the muscles of both the stomach and seat should be in a relaxed state (see: Figure: Dependencies between different body condition postures and measurement results).

- Muscle tension in the arms, shoulders and legs should be the minimum required in order to maintain a stable posture.

It will be a helpful preparation for the test subjects if those doing the measuring first demonstrate the posture to be assumed.

To avoid excessive muscle tension in the chest, back and upper arms, the test subjects should move their arms slightly away from their sides, allowing them to hang loosely, and then turn the elbows a little outwards (see: Figure: Scanning posture – standing).



Posture 1: relaxed posture of the test subject

Posture 2: muscle tension in the areas of the shoulders, arms, stomach, seat and legs.

Differences between both postures

	Posture 1	Posture 2	Difference
Bust Girth	90,8	93,8	3,0
Underbust Girth	75,9	78,0	2,1
Waist Girth	69,0	71,4	2,4
Hip Girth	100,2	100,9	0,7

Figure: Dependencies between different body condition postures and measurement results

6.5 THE SCANNING PROCESS

Although modern scanner technology is already sufficiently sophisticated that it can reproduce a model of the human body to a very high degree of accuracy, it is not yet in a position to extract exact measurements on the head, for example, around the hair. During the scanning process, the body surface is recorded, including the hair surface on the head, which could considerably distort the measuring results, depending on the volume in question. It was therefore specified within E-TAILOR and eT-CLUSTER projects that body measurements which could be distorted as a result of hair should also be recorded manually. This relates to a minimum of two body measurements – height and head circumference, together with the weight of the test subject. This means that manual measurements must also be taken into consideration, as well as the scanning process.

In this section, the timing and organisation of two different variants shall be considered.

Variant 1:

- Manual measurement of height and head circumference plus weight – duration approx. 5 minutes
- Extensive questioning of the test subject by the measuring personnel at the PC – duration approx. 15 minutes
- Scanning the test subject in two different postures – duration approx. 10 minutes

  → **Overall duration of the measurement process: approx. 30 minutes**

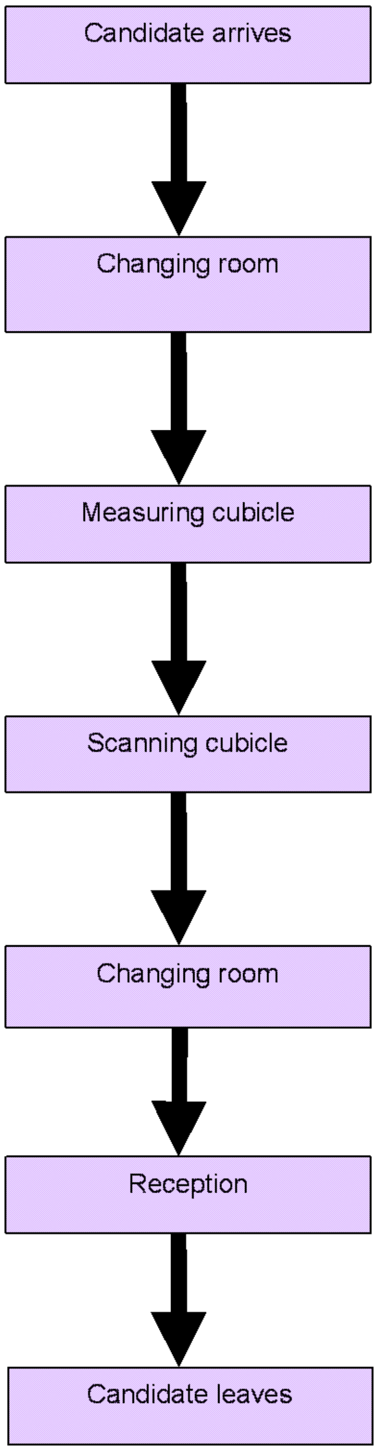
Variant 2:

- Manual measurement of a large number of body measurements – duration approx. 20 minutes
- Questioning the test subject using a questionnaire to be completed by the test subject themselves – not time relevant
- Scanning the test subject in a single measurement posture – duration approx. 10 minutes

  → **Overall duration of the measurement process: approx. 30 minutes**

6.5.1 Flow chart of the data collection process- Overview

The following diagram represents the flow of a candidate through each of the individual processes, which are required to collect the measurement and scan data during a survey.



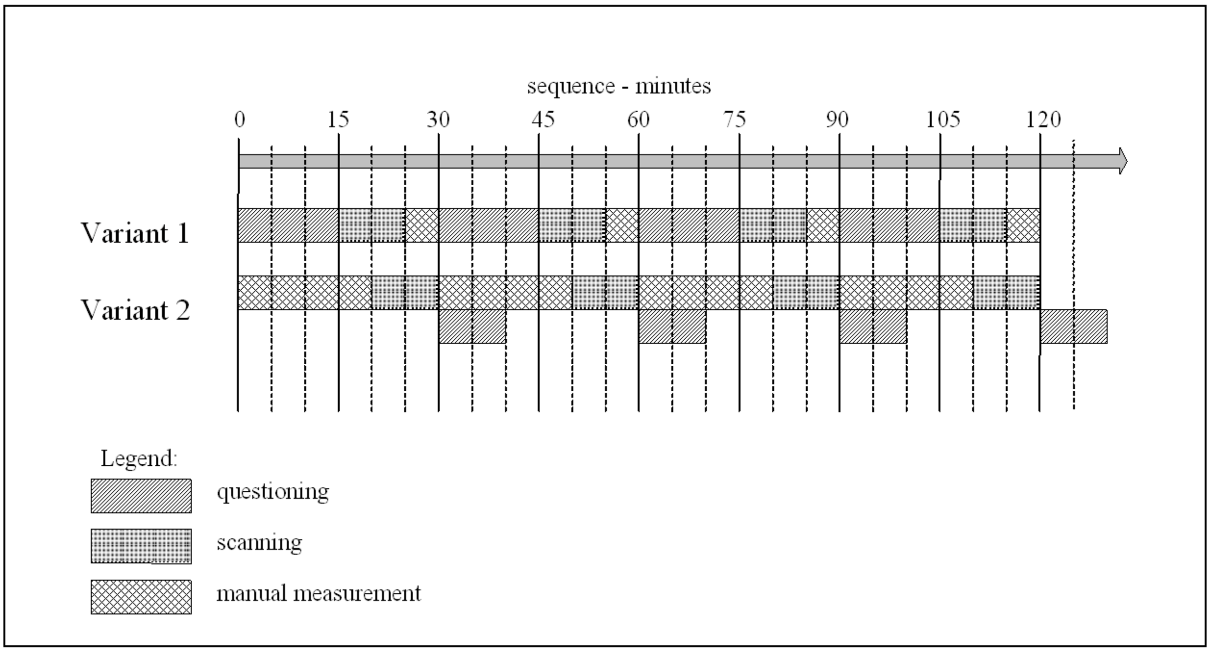
- Candidate registers
- Key info is given to the registrar
- An ID number is allocated for the entire process
- A market research questionnaire is given

- The site manager/Liaison Officer allocates a changing room
- The candidate strips down to their underwear and puts on the dressing gown provided

- Key poses are captured
- Scan data is processed and saved

- The candidate is returned to the changing room where they get re-dressed

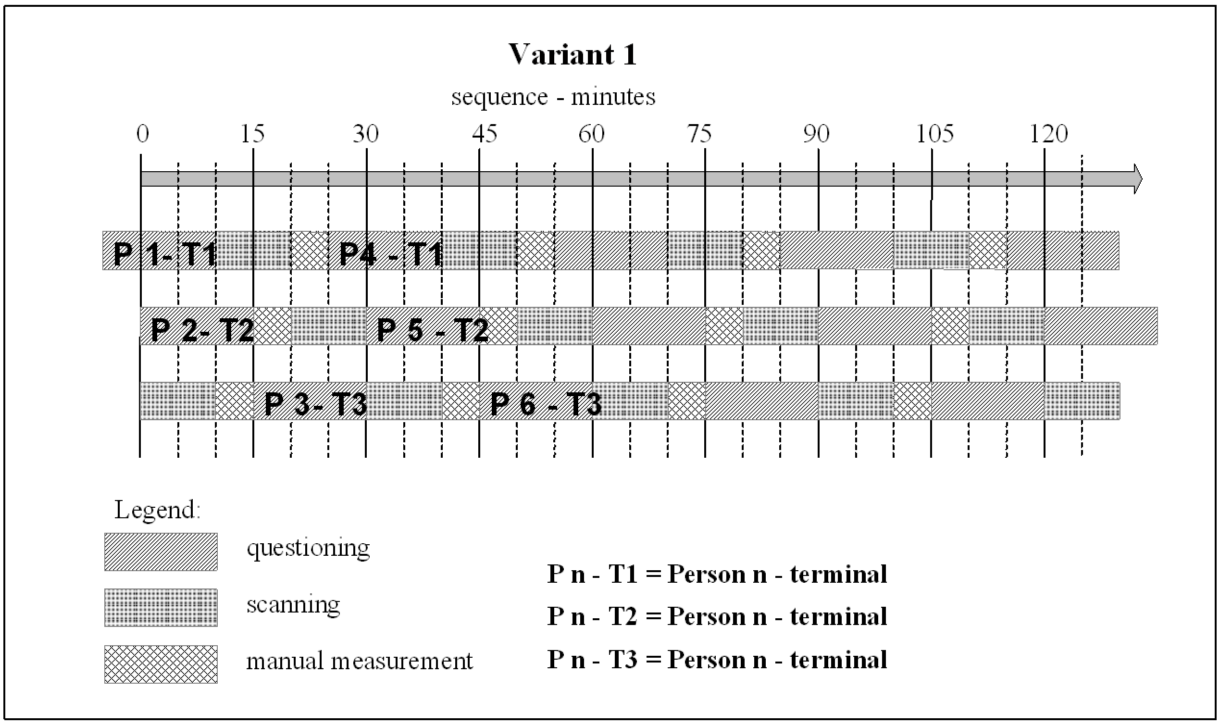
- The candidate completes the questionnaire
- Registrar allocates gift vouchers



Chronological order of the measurement process for the individual test subjects for the different Variants 1 and 2

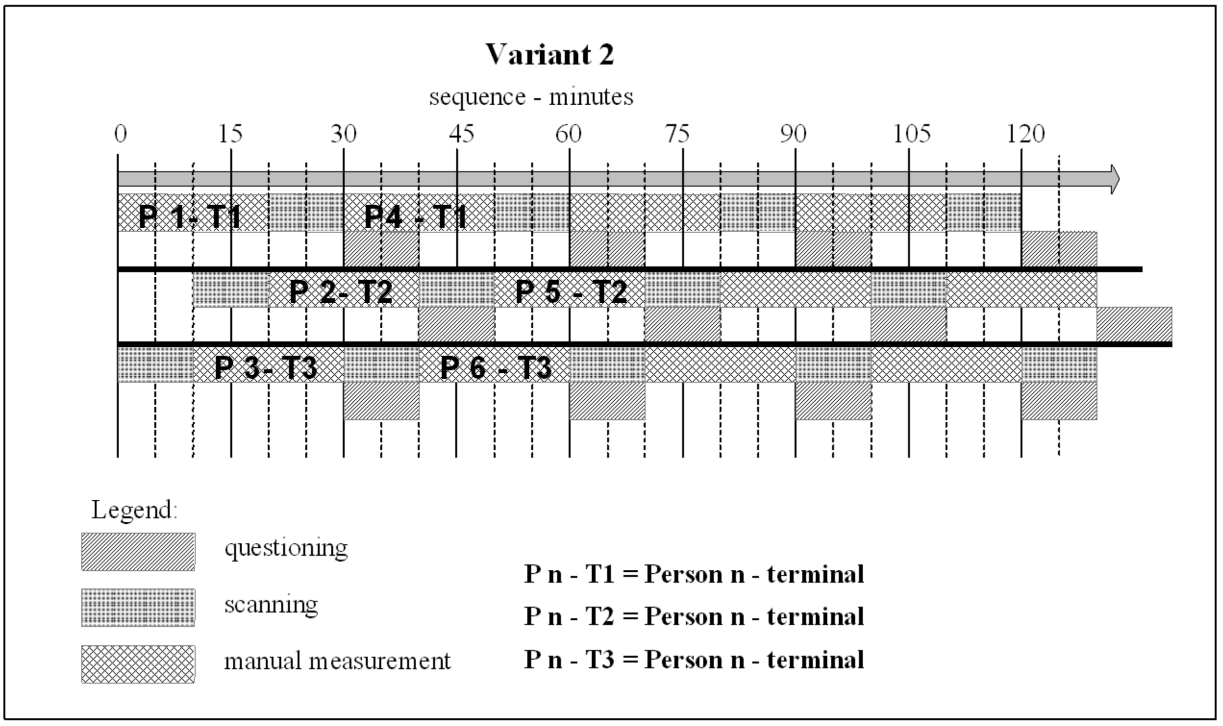
6.5.2 Flow chart variant 1

The number of test subjects sampled per hour is dependent on the number of measuring and interview booths. In both scenarios, where one scanner is used, the time required for the scanning process is the decisive factor in determining the maximum number of people who can be measured per day/hour. In the first variant, a maximum of six people per hour can be processed where three interview booths are used. This is shown in the diagram below.



6.5.3 Flow chart variant 2

As with the first variant, the time required for the scanning process is the factor which determines the maximum number of measurements possible per hour/day where the second variant is used. However, in this instance, the time spent questioning the test subjects is not relevant, as this is carried out independently of the measuring process. Where three manual measuring terminals are used, it is also possible to process six people per hour. This can be seen from the diagram below.



6.5.4 Necessary paperwork for data collection

As the flow diagram shows on the previous page there are a number of processes that the subject will go through during a sizing survey. In order that they can complete the survey there is some necessary paperwork required.

6.5.4.1 Appointment log

The recruiter will advise the site each day of how many people are going to turn up that day. The only information the site will know is the subjects first name and the allocated ID number that has been given to them by the recruiter. This is the identification number that will follow them through the process – and the number that their scan will be saved under, their manual measurements entered in under and the market research questionnaire will also need this identification number on.

6.5.4.2 Consent form

In order for the subjects to take part in the sizing survey it is important that each subject signs a consent form. This provides the project with signed authorization that the subject understands that they are going to be scanned and that the information is being gathered as part of a sizing survey. It authorizes the project to use the scan and the associated data – such as the market research questionnaire. It also provides the individual taking part with guarantees that no personally identifiable data will be used and that their addresses and personal details will not be sold to other companies, and will be kept separately to their scans.

The content of the consent form will vary from country to country as legislation regarding what can and can not be saved together differs from country to country.

A copy of the consent form used by NTU in the e-tailor pilot sizing survey is included in the appendix section

6.5.4.3 Market Research Questionnaire

Each person taking part in the survey will be required to complete a market research questionnaire. The ID number must be placed at the top of the questionnaire in the boxes provided along with the person's first name. From our experience of SizeUK and the subsequent matching of scan, measurement and market research data it would also be of benefit to include the date the person attended the appointment, as this date is included in the recruitment database and makes it a little easier to bond information together.

6.5.4.4 Contingency Forms

These forms will be required if there are any computer breakdowns. These allow the survey to continue with the minimum disruption to subjects. Once the computer problem has been rendered then the information can then be added to the database.

Probably the most likely thing that may need contingency forms will be the manual measurements. If there are problems with the database the measurements can still be taken but recorded on paper and then up loaded to the database in bulk. During SizeUk the decision was taken to record all manual measurement on paper and then to enter them into a database en masse. This also has the effect of ensuing there is a back up against computer failure. If any computer failure does occur it is necessary to contact the technical manager at the site or to phone the technical support team to try to resolve the issues without loosing people who can not stay for their appointment because of the delay.

6.5.4.5 Attendees and Incentive records

It is necessary to confirm each day to the recruiter exactly who turned up, and if there were people who did not who these people were. It is only necessary to track how many incentives have been issued to subjects. Paperwork is required at each venue to accurate track how many people have been scanned and how many incentives have been issued.

6.5.5 Integrity checking

The data integrity checker attempts to detect and rectify anomalous data. The process is two-fold: First identify outliers, which represent potentially spurious measurements; then investigate the validity of the outlying data.

Detecting outliers

The diagram below shows the program interface for the Integrity Checker. The steps are as follows:

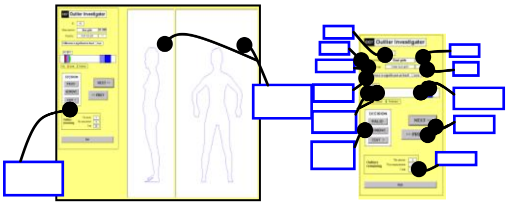
- Select database containing the measurements. Having selected the database, the “Fields not checked” box appears: this displays those measurements that currently have insufficient information defined.
- Run program. At the end of the program, the number of records affected and the total number of outliers is updated. The results of the program are stored in the “Measurement errors” table
- Investigate>>>. Activate program for investigating outliers.

Investigating outliers

The diagram below shows the program interface for the Outlier investigator. This enables the user to scan through the outliers in order to distinguish between those that are valid and those that are genuine outliers.

It provides a combination of numerical information with a diagram of the individuals’ silhouettes. The main bar indicates how the measurement value for the current individual compares with the distribution of measurements for the entire population. It also indicates the disparity between the actual measurement and the predicted value (Using a correlated measurement as a predictor).

The Outlier Investigation toolbox The information area shows data that can be used to determine the validity of a particular outlier. It also provides the capability to change the outlier.



The following information and commands are available:

- Basic information is displayed regarding the ID; measurement value; the value of the variable used as a predictor; and the significance level of the disparity between actual and predicted value.

- Information bar. This indicates how the measurement value for the current individual compares with the distribution of measurements for the entire population. It also indicates the disparity between the actual measurement and the predicted value. The dark blue band at the left indicate the [0.1,1] percentiles, the light blue band is the [1, 5] percentiles for the distribution. Similarly on the right hand side the [95,99] and [99,99.9] percentiles are illustrated.

- Decision commands. The user can then treat the outlier in one of 3 ways:

1. Accept as valid. This decision is then logged in the database, so that future running of the outlier detector program will not repeatedly flag this outlier.

2. Remove. Simply deletes the measurement, leaving the field blank.

3. Edit. A separate box pops-up allowing the user to enter a new value for this measurement.

- Next, Previous. Moves on to the next or previous outlier.

The program will loop through all measurements in the database to determine outliers.

Two criteria are used:

1. Compare each measurement with a priori information on the distribution of the measurement, determined from a large dataset. If the measurement is less than the 1st percentile or greater than the 99th percentile, this is cause for further examination.

2. Compare measurements against a model of predicted values. The correlation between measurements has been assessed in “data integrity.xls” and used to create a predictive model for each measurement.

For example, “Under bust girth” is highly correlated with “Bust girth” therefore a reasonable predictive model for “Bust girth” is:

Bust Size = **a** x Under bust girth + **b**

In addition, a tolerance is computed at different levels of severity. The 95th, 99th and 99.9th percentiles for the residual values are used. For example, for “Bust girth” we expect 99% of the measurements to be within 16 cm of the predictive model.

Database considerations

The program assumes that the database of measurements contains certain components relating to measurement data and shape information. See the document “Implementing fieldwork data into shape viewer” which illustrates the format of the database required before data integrity checking can be performed. Also ensure that two empty tables are included in the database for “Measurement outliers” and “Measurement outliers validated”

6.6 MARKET RESEARCH – INTERVIEW

For the statistical evaluation of a sizing survey, additional information to supplement the body measurements is required. A survey of those taking part should therefore always be carried out in parallel to the measurements.

Additional information such as the place of origin and age of the volunteers being recorded are vital in order to confirm that the results represent a fair cross-section. Such surveys fulfil an important function in the statistical evaluation of body measurement data, in particular for developing sizing systems and to determine market share.

The information contained in the survey can also be used for marketing and product planning as well as company-specific evaluations. Evaluations, combined with the body measurement data of the people questioned, can be used in a number of ways to help resolve problems specific to various target groups in terms of fit, function and customer requirements. Data on social status is also of particular interest when determining market shares for market analysis. The physical demands of the volunteers both at work and in their leisure time represents another important aspect, as this has a significant influence on the development and changes in physique.

The place of origin of those being questioned is highly significant in determining to what extent the statistical evaluation is representative. The ethnic groups within Europe do not only differ in terms of their nationality; significant differences in body proportions can also be identified in some instances. Due to the large population mixes found in all European states, it is therefore not enough to simply ask someone’s nationality; information which determines the place of origin also needs to be provided. For the statistical evaluation needed to develop a sizing system, it is important that the various body proportions are not combined, as this would lead to the statistical average being distorted.

6.6.1 Scope and content of the survey

The list of questions may vary considerably in terms of its scope and the subject matter covered depending on the client’s objective. However, as a basis to confirm the general validity of the results, the following personal details need to be recorded.

- Scanner type
- Scan date
- Sex
- Date of birth
- Place of residence or the first two letters of the postcode, together with the country code
- Place of birth (of parents)
- Ethnic origin

The place of birth of those taking part only plays a minor role, in particular when recording the body measurement data. The parents’ backgrounds play a much more significant role in determining body proportions. The origin of the parents should therefore be included in the study.

Because of national data protection guidelines, not all the information may be sought in each and every country.

In order to safeguard the anonymity of those taking part, no addresses or other personal data which could enable the individuals to be identified must be recorded. Each data record should be allocated an identification number to enable the body scan to be compared and evaluated in conjunction with the corresponding questionnaire.

Although the focus of the survey is determined to a large extent by the objective of the client, the scope is limited by time constraints and the receptiveness of those being questioned, a consideration which is particularly important for the elderly. Some of those taking part also lose patience and the willingness to respond as honestly as possible for far too many questions. The survey should therefore always be adapted to fit in with the relevant time frame and the way in which the measuring process is organised, as experience has shown that the interview takes longer than the actual measurement.

6.6.2 Carrying out the survey

In order to evaluate the list of questions, the data should be available in electronic form. It is therefore recommended that the survey is carried out directly on a PC using a database, and is not in the form of a questionnaire which needs to be completed by hand. If those taking part are questioned directly by an interviewer at a PC, this avoids hand-written questionnaires having to be entered into spreadsheet programs at a later stage in a time-consuming process, with the risk of errors arising as the data is transferred. If there are any problems in understanding the content of a question, the interviewer can immediately clarify the question, giving the person being questioned the opportunity to provide a correct answer quickly.

In order to optimise the evaluation, the possible answers should be available in the form of multiple-choice criteria, if the wording of the question allows this. The interviewer is then able to simply select the required answer in the database. This ensures that the data is consistent and means that the time required both for the survey itself and for the subsequent evaluation can be significantly reduced.

Open-ended questions are very difficult to evaluate, as the responses first need to be categorised. As there are so many different ways of formulating an answer, this is not always easy, especially as each individual has their own way of expressing themselves. Possible spelling mistakes which can occur time and again when an answer is not specified can make evaluation using spreadsheet programs even more complicated.

If for organisational reasons it is not possible to question those taking part directly at the PC and hand-written questionnaires have to be used, the data must not be transferred manually into the PC; it should be read in using a scanner. This will both reduce the time involved and prevent errors arising when transferring the data. The scanner mentioned here is described in more detail in the chapter “Questionnaire Input” by NTU.

6.6.3 Legal protection

Guidelines for data protection vary considerably within the European Union, however, they all state that in order to safeguard the sphere of privacy of the individual, body measurement data and personal data must not be utilised publicly without the consent of the individual involved.

The utilisation of personal data from the E-Tailor Pilot Survey, with the aim of establishing a European database for anthropometrical data, is in this sense deemed to be public, for example. Therefore, for this and similar use of the personal data, those taking part must give their consent for the data to be passed on and used. In Germany, the volunteer is simply required to sign a relevant form. Each state must determine and regulate how this is to operate in their own country.

In order to safeguard the anonymity of the individuals, the scans should be stored in general form without facial information. The data records for the survey should not contain any information relating to the address or other personal data which could enable the individual to be identified.

Before the declaration of consent is made, those taking part should be made aware that their scan and the data from the survey will only be stored and used in depersonalised form.

Example of a standard text:

I hereby give permission that my scan data (without facial information) together with other information serving purely demoscopic purposes may be made available for use by the European Database.

In order to ensure that the measuring process runs quickly and smoothly, it is recommended that the interviewer explains the data protection guidelines to the volunteers and asks for them to give their consent immediately after the survey.

If the volunteers are taking place in the sizing survey voluntarily, rather than being paid for this, it is not necessary to draw their attention to the need for them to give their consent at the recruitment stage. This deters a large number of people, and may put them off taking part in the measurement and survey altogether. The topic of data protection is much easier to discuss and explain in a personal conversation. Experience has shown that those being measured are unlikely to refuse to give their signature in consent if they have been fully informed that their data will be stored in anonymous form and if they have been assured of the respectability of the institutes and companies involved.

The situation is quite different for people who are paid for taking part. It is essential that such individuals are provided with detailed information concerning their rights and obligations before they are recruited.

6.6.4 Marketreseaarch proposal -Hohenstein questionnaire for the E-tailor pilot survey

Those taking part were questioned directly at a PC using a database in parallel to the measurement process. The aim of the survey was to provide additional information on the social background and purchasing patterns of those taking part and to ascertain how they felt about the fit of clothing available on the market at the present time. The questionnaire covered 39 questions relating to the areas listed above and was subdivided into four main criteria:

- General information

  This covered details on place of origin, age, social background, profession and physical activity. This information was required primarily for statistical purposes.

- Basic information

  In this section, the volunteers were questioned on general topics such as their preferred style of clothing and wearing habits.

- Purchasing patterns

  The purchasing patterns of those taking part were ascertained by questions on where they buy their clothes, how much they spend on clothing, and the most significant factors which influence clothing purchases.

- Fit

  This section covered questions on general assessment of fit and problems finding the correct sizes.

The results of the survey provide an important basis on which to represent origin, age structure and customer requirements.

Please see An overview of the scope and content of the database in appendix.

6.6.5 MARKET RESEARCH PROPOSALS - Questionnaire of NTU

This section outlines NTU's suggestions for the market research questionnaires, which are to accompany the sizing survey.

They are based on NTU's considerable experience in the field of body size and clothing fit related market research. These suggestions should not, however, be deemed exhaustive as partners may have specific questions that they would like to see included in the questionnaire. These can be added at a later date if approved by the other partners.

Please note, however, that the questionnaire must cater for all partners, so they must show flexibility when the questions are being finalised.

NTU envisage that the market research questionnaire will be completed by participants at the survey site, after they have been scanned and measured.

6.6.5.1 Unique opportunity

NTU would like to emphasise the fact that this project represents a unique opportunity to collect a wealth of previously unavailable data on a large scale, Europe wide basis.

This is a chance that should not be missed or under utilised.

6.6.5.2 Aims of the section

This section will aim to provide a comprehensive list of questions that ***could*** be included in the final questionnaire. The questions are split into the following five sections:

- Health and fitness issues
- Self-perception
- Clothing and shopping issues
- Personal details
- Survey satisfaction

For each of these sections the proposed questions are listed along with the possible answers. Also included is whether this information is better collected by a registrar (at point of arrival at fieldwork setting), or by questionnaire, and NTU's recommendation as to whether or not the question should be included in the final version.

NTU's suggestion as to whether a question should be included in the final version is based on their experience from previous surveys. Certain questions that may be deemed important will not, in reality, garner any useful information – this may be due to frequent misinterpretation by the respondent, ambiguity in people's perception of the question's meaning, or simply a lack of relevance.

Whilst NTU could justify their support or rejection of each question, this would be an extensive, and ultimately largely irrelevant, process.

6.6.5.3 Linking responses to body measurements

Linking a person's body measurements to their market research responses provides hitherto unavailable insight into exactly who is satisfied or dissatisfied with the fit of clothing.

This is particularly useful for the retailers in the survey as it can provide them with characteristics, both in terms of demographics and body measurements, of those who are unhappy with their current fit offer.

For example, it may transpire that only women of over 5'5" (approximately 1.65metres) tall, with a waist of over 30" (approximately 76cm) and legs of over 30" (76cm) are satisfied with your current size offer. This is clearly only a very small part of the market and would indicate that your fit offer may need altering. Linking this to the demographics of a retailer's customer base adds yet further value.

This information can provide retailers especially with incredibly strong justification for taking part in the project.

6.6.5.4 Considerations

Although a sizing survey is a superb opportunity to collect as much information as possible about fit and clothing related issues, it is misjudged to assume that gathering as much information as possible per se is the most appropriate course of action.

The respondents will have very little time in which to answer the questions, especially if they are to be guided through the questionnaire by an employee of the project, who will have strict limits on the amount of time they have to spare per participant.

As a result, the questionnaire must be a compromise between taking advantage of an opportunity to collect as much information as possible, and the limits of the participants' concentration and time constraints.

With this in mind, partners are asked to choose carefully which of the following questions they would like to see included. NTU would strongly recommend that 25-30 questions is an appropriate number of questions, which will take approximately 10 minutes for a participant to complete (which is deemed to be an acceptable time period). Any more than this and the respondent's concentration is likely to start to wane, and therefore the quality of responses will quickly start to diminish.

Please see An overview of the scope and content of the questionnaire in appendix.

6.6.5.5 Questionnaire input

The e-tailor project should note that questionnaire results need to be available in electronic spreadsheets. Inputting the completed questionnaires from hand written responses into electronic databases can be an arduous and lengthy task.

A contractor should be arranged for this task before the field work is underway, as the sheer volume of respondents ensures that it is difficult to keep up with the flow of incoming questionnaires, let alone catch up if inputting has fallen behind. Obviously data can not be analysed until all the data is available. It is necessary to ensure that questionnaires are inputted quickly so as to monitor demographics such as socio class and working status. All other criteria such as age, dress size, location and ethnicity can be asked at the point of recruitment, so are easier to monitor in real time.

NTU have access to a questionnaire scanner, which can "read" responses and significantly reduce the amount of time required to input the data. Depending on the length and complexity of the questionnaire (e.g. how many questions requiring hand-written open-ended responses are there? How many are "tick-box"? etc) the scanner can "read" and transfer to a database (either CSV, Access, Excel or other statistical package) anything between 250 and 500 a day – this is assuming a "standard length" questionnaire which takes around 7-10 minutes to complete.

The cost of a questionnaire scanner is approximately £10,000 (€16,000), and an approximate cost of inputting questionnaires is approximately £2 (€3) per response (mainly labour costs), coupled with photocopying the questionnaire and any transportation costs equals a total of €3.50 per questionnaire.

Manually inputting the responses would reduce this figure to somewhere between 75 and 150 a day.

In order to enable the scanner to read the questionnaires in as short a time as possible, the questionnaire must be appropriately designed. This involves minimising the number of open-ended questions in favour of tick boxes.

Another element of this is the use of number boxes, instead of asking for hand written numbers. For instance, if asking a respondent to complete their ID number, a series of boxes can be used for them to fill in as appropriate. This enables them to be read by the scanner, without the need for human intervention (as there would be with hand-written responses).

For example:

☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
0	1	2	3	4	5	6	7	8	9

NTU formulated a questionnaire for use during the e-tailor pilot survey, all participants – male and female were asked to complete the questionnaire. A copy of the woman's questionnaire is enclosed within the Appendix section of this document.

6.6.5.6 market research summary & findings

The market research questionnaires used for the projects NTU have been involved with have, on the whole, been well received by both the project partners and the members of the public who completed them.

Response rates were high, as were the levels of understanding amongst the respondents, although it must be noted that older people found some of the questionnaires difficult to relate to – such as questions on brand and label awareness. The best way to ascertain if there is adequate understanding of the questionnaire is to allow it to be filled in by a wide age range of people, prior to the survey to see how long it takes them and if they have any queries from it.

Of particular interest is the analysis of the respondents' "perceived versus actual" measurements and body dimensions. This will give invaluable insight into the relationship between what size people *think* they are, compared to what size they are buying, as well as showing what dimensions people associate with different clothing sizes.

For SizeUK having a sample of nearly 11,000 people clearly means that numerous statistically significant results can be produced.

The proposed questions above are a guide only and should be considered a base from which to build a comprehensive questionnaire that satisfies as many partners as possible.

NTU require the partners' feedback in order to include questions specific to each of them.

In previous sizing surveys of the nature of the e-tailor project, NTU have had difficulty in balancing the requirements of all the partners, who have very different ideas about what should and should not be included in the questionnaire.

For this reason NTU would appreciate understanding from the partners as some may not feel the questionnaire accurately represents their needs. We will endeavour to be as fair as possible in the allocation of questionnaire space, but all parties must exercise a little co-operation.

7 STANDARDISED DEFINITION OF BODY MEASUREMENTS AND MEASURING TECHNIQUES

One important prerequisite which must be met in order for comparisons to be made between the data from different national sizing surveys is the use of uniform definitions for body measurements and measuring methods. The standardised description of the body measurements means that a uniform designation should be used for each body measurement. Thereby misinterpretations and confusion arising from the use of different names for one and the same body measurement are avoided. The standardised description of measuring techniques for the individual body measurements forms the basis for the extraction of comparable data, both where automatic measurements using the 3D body scan are used, and when the human body is measured using manual techniques.

Standards were created within the E-TAILOR and ET-CLUSTER project in cooperation with international specialists.

7.1 STANDARDISATION OF THE MEASURING DEFINITIONS AND MEASURING TECHNIQUES - OBJECTIVES

Standardisation for the measurement of the human body is based on 4 fundamental objectives:

1. The uniform designation of the individual body measurements

2. The definition of the minimum necessary primary and secondary measurements for the development of sizing systems

3. The description of the relevant reference points on the body in order to clearly define the position of the measuring section on the body

4. The description of a uniform measuring technique as the basis for manual measuring and the automatic derivation of body measurements based on 3D body scan data.

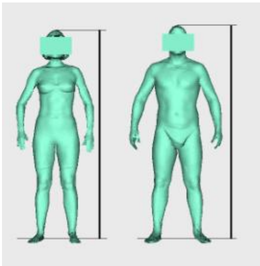
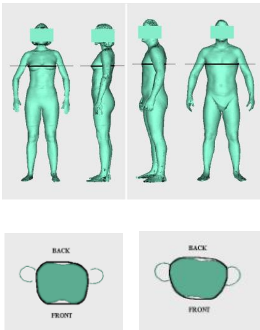
In addition to the verbal description of the individual measuring sections, the document prepared in the context of the two projects mentioned above contains a pictorial representation to help clarify the descriptions in order to address the first objective.

The body measurements are divided into three groups:

- Primary Measurements – used for sizing
- Secondary Measurements – used for MTM
- Additional Measurements – for general use, pattern making and shape analysis

The Primary Measurements contain eight body measurements and represent the essential basis for the development of sizing systems and for the size allocation of different clothing products. They consist of body height, bust girth, underbust girth, waist girth, hip girth, inside leg length, arm length and neck girth. The group of Secondary Measurements contains a further fifty three body measurements. Another approximately one hundred body measurements are described in the group of additional body measurements.

The description of the measuring techniques consists of the definition of the body landmarks, the description of the measuring process and the pictorial representation of the respective body measurement using a three-dimensional figurine. Examples are shown in the table below.

No.	Body Dimensions	Body Landmarks	Body Location	Picture	Women	Men	COMMENTS
	Weight		Weight recorded in kilograms				
1	Height	Highest point of skull	Vertical distance between the crown of the head and the ground		Y	Y	the measurement shall be taken manually.
2	Bust/Chest Girth at Maximum Prominence	Maximum projection of the bust/chest	Horizontal girth measured under the armpits (without arms) and at the level of the maximum projection of the bust / chest		Y	Y	

Extract of eT-Cluster document to standardised measurement definitions

7.2 STANDARDS FOR THE MEASUREMENT OF THE HUMAN BODY (ET-CLUSTER)

The full document comprises 66 pages, and extracts can be found in the appendix.

8 STANDARDISED DATA FORMATS

Against the background of the progressive globalisation of the market, the objective behind national sizing surveys should be the readiness to exchange data on an international level. To this end, the European Anthropometric Database was developed within the E-TAILOR project. This is intended to be used as a tool for the primary international management of measuring data obtained from various national or European sizing surveys.

A prerequisite for the use of this tool is the use of uniform, standardised data formats for the measured data, the 3D body data and the additional information obtained from the questionnaires.

The appropriate data formats for this were specified within E-TAILOR. A rough overview of the data formats specified is outlined in the sections below. Detailed information can be obtained from the ATC.+

8.1 DATA FORMATS FOR THE 3D BODY REPRESENTATION

A VRML file format was defined for the exchange of 3D body data. Scan data which is to be made available in the EAD must be converted into this data format. A specific requirement, in particular if the data is to be used to generate avatars from the scan data, is that this must be in what is known as water-tight form, in other words, there should be no gaps in the body surfaces.

The XML-files which contain the measuring data and personal information for the data record, are also used to transfer the VRML files.

Detailed information on standardised data formats for the 3D body representation can be obtained from the ATC.

8.2 DATA FORMATS – MEASUREMENT DATA

XML files, which enable data to be exchanged without any problems, were developed to transfer the measurement data.

Several xml files have been developed in E-tailor for the exchange of data. Two of them involve transferring measurement data. The first primarily involves the exchange of personal and body measurement data. The second is more general purpose and includes customer measurement data, as part of the order data transferred from the POS to the manufacturing site. An extract from the details of these files is given below:

- <measurements>
- <record>
<measurementcode>1</measurementcode>
<measurementname>**Height**</measurementname>
<measurementvalue>**182.3**</measurementvalue>
</record>
- <record>
<measurementcode>2</measurementcode>
<measurementname>**Neckgirth**</measurementname>
<measurementvalue>**37.0**</measurementvalue>
</record>
- <record>
<measurementcode>3</measurementcode>
<measurementname>**Chest / Bustgirth**</measurementname>
<measurementvalue>**95.2**</measurementvalue>
</record>
- <record>
<measurementcode>4</measurementcode>
<measurementname>**Underbustgirth**</measurementname>
<measurementvalue>**89.9**</measurementvalue>
</record>
- <record>
<measurementcode>5</measurementcode>
<measurementname>**Waistgirth**</measurementname>
<measurementvalue>**75.8**</measurementvalue>
</record>
- <record>
<measurementcode>6</measurementcode>
<measurementname>**Armlength**</measurementname>
<measurementvalue>**66.3**</measurementvalue>
</record>
- <record>
<measurementcode>7</measurementcode>
<measurementname>**Hipgirth**</measurementname>
<measurementvalue>**94.5**</measurementvalue>
</record>
- <record>
<measurementcode>8</measurementcode>
<measurementname>**Ins.LegLength**</measurementname>
<measurementvalue>**84.3**</measurementvalue>
</record>
</measurements>
</person>
</file>

Example to E-Tailor xml file for exchange of standard data (8 primary measurements)

9 ANALYSING OF THE DATA

The results of the sizing survey include both physical data and additional information on the participants, compiled as part of a market research interview. Just how detailed this additional information is depends on the aim and scope of the interview (see chapter 6.6). In terms of data analysis, this means that the evaluation can be divided into two sections, one covering the demographic evaluation and, if appropriate, a market analysis, and the other covering the evaluation of the physical data. By integrating the information from the two areas, the results become meaningful.

9.1 EVALUATION OF THE MARKET RESEARCH INTERVIEW

The evaluation and economic use of the market research interview is largely dependent on the contents of the survey. If the questions merely cover the basic information required (see chapter 6.6), it will only be possible to obtain information on the scan technology used, when the data was recorded, and a demographic breakdown by age, social status, ethnic origin, region and sex of the participants. If the interview covers additional questions, e.g. on sporting activities, purchasing habits, style preferences etc. a more in-depth evaluation is possible, the results of which can be used to provide the clothing industry and retail sector with valuable information on customer profiles and market requirements.

There are two possible methods of analysing the data:

1. analysing the questionnaire without reference to the physical measurements of the participants

2. analysing the questionnaire taking into consideration the key body measurements: height, chest girth, waist and hip girth

With the minimal questionnaire, using the first method means that only global information can be extracted, as detailed above. If on the other hand, the second method is used, it is also possible to derive information on the breakdown e.g. of body proportions etc. classified by age, region or other criteria.

With the extended questionnaire, the first method of data analysis provides fundamental information on the additional topics covered. However, the significance of the responses which specifically relate to the fit of clothing do not reflect a realistic market situation if they do not correspond to body measurements or sizes. For optimal evaluation of this topic, the second method should be used. By combining the answers with the data on the body proportions of those being questioned, it is possible to define specifically whether, e.g. problems with fit relate merely to specific body measurements or whether they are a global phenomenon. The results enable clothing manufacturers to counter any problems in a targeted manner. They also provide the retail sector with detailed information to optimise or extend their range of products and sizes.

The next two sections provide an overview of the contents and procedure to follow for data analysis for each method of evaluation.

9.1.1 Primary analyses

Key percentage responses per question

Response frequency charts

Comparison of trends

Demographic research and commentary on recruited sample

Regional analysis

Summary of top-level findings

9.1.2 Cross-reference analysis

- Statistical interpretation of correlation and bivariate analysis results (i.e. the inherent association between different responses)
- Examination of the nature of key relationships between response variables
- Build profiles of different consumer segments
- Define types of behaviour attitude from shoppers by demographics e.g. age, region etc.
- Summary of key relationships and consumer profiles

9.1.3 Applied analysis – merged body measurement data is required for this section of analysis

- Comparative assessment of perceived versus actual dress size/bra size/chest girth/waist girth/inside leg/height etc., where applicable
- Highlight the key areas of satisfaction/dissatisfaction with current retail offer for garments
- Illustrate demographic breakdown by size, region, age and other parameters where necessary
- Additional retailer-specific statistics

9.2 ANALYSIS OF MEASUREMENT DATA

The analysis of the measurement data is a very complex process. A distinction should be made between two different objectives:

- Analysis of the body measurement data as the basis for drawing up size charts
- Analysis of the body measurement data to determine market share

This document will predominantly concentrate on the subject matter. More detailed information can be obtained from NTU and Hohenstein, who have many years of experience in carrying out and analysing sizing surveys.

One of the most significant conditions for the correct evaluation of data is the quality of the measurement data. In particular when analysing manually recorded data, the data records must be checked for possible errors in measuring and transferring the data. However, it is also necessary to check the measurement data from body measurements which have been automatically extracted from a body scan (see chapter 4).

The checked data records together with the results from the market research questionnaire represent the basis for the analysis.

The principal tasks for data analysis are described in the sections below.

9.2.1 Data preparation

- Checking the data records compiled from the manual and automatic measurements and the market research interview for consistency and completeness
    - Content of the data fields must be identical (unit of measurement, method etc.)
    - The required minimum personal data must be included
    - As a minimum, each data record must contain the eight primary dimensions as described in chapter 7
- Complete investigation of data quality with feedback addressing any specific measurement problems discovered during the fieldwork stage (e.g. problems with measuring equipment; validity range checks; completeness of data)
    - Checking the data for plausibility in order to exclude incorrect measurements or errors arising when transferring the data (defining maximum and minimum values for the individual measurements relating to the corresponding measures (e.g. inside leg must always be smaller than the measurement waist to the ground by a given amount etc.)
    - Checking the individual measurements/data field contents for extremely implausible differences between the individual data records
- An assessment of conformance to the target sample parameters, totals of men and women by age group, region; adherence to target checks for representative randomness [socio-economic, ethnic, employment status, size/height spread]

- Preparation of datasets for analysis e.g. by gender, age, height, and size-related parameters.

  Structuring the database as appropriate for the planned evaluation. When developing size charts, the data needs to be divided into the following categories: babies, children, young people (male and female), women and men.

  Although proposals have been developed in various standardising committees regarding the classification of the people groups described above, these are always related to the specific field of application of the standard in question (e.g. safety etc.). In EN 13402, no specifications have been defined for the classification of the various target groups (babies, children, young people and adults).

  The following classification is recommended for the data analysis with reference to clothing:

  - Babies under 2
  - Children up to approx. 12
  - Young people aged between 12 and 18
  - Adults over 18 (full height has been reached)

  For the evaluation of the data for market analyses, the data must be divided as appropriate for the specified aim. If market shares for specific standard sizes for a defined age group are to be identified, the applicable criteria for filtering the appropriate data records are the desired age range and the corresponding fields for size-determining body measurements.

9.2.2 Basic analysis of the measurement data

The basis for the detailed analysis of the data to develop size charts and market share tables is a more in-depth basic evaluation of the measurement data. At this stage of the analysis, correlations between the individual body measurements are determined and/or confirmed. The global statistical analysis serves to provide average body measurements and standard deviations from the primary dimensions of the entire sample, without taking standard garment sizes into consideration. The results of this basic analysis also form the basis for determining ranges which are used to designate secondary dimensions related to the primary dimensions using relevant correlations.

Given the increasing Europeanisation or globalisation of the economy and politics, the evaluation and economic use of the data should not be biased towards national objectives. The advantages of making national data available for international usage outweigh the disadvantages for foreign competitors caused by information being available on an international level.

- Calculation of population averages, modes, and ranges for all recorded measurements with percentiles, descriptions, standard deviations, etc. The length of this process depends on the number of measurements available.

- Correlation and regression analyses to assess the association between specific variables (which variables best relate to others) for up to 20 key measurements. Scatter diagrams to be produced where appropriate, though this is likely to be considerably less than the 400 possible combinations of correlation

- Assessment and interpretation of statistics by age group for average bust, waist, hip girth and height for the population, and how this relates to preconceptions
- Critique of the relationship between bust/chest, waist and hip, investigating how these proportions change by age, body volume and height
- Regional analysis of body measurements
- Visual guide to levels of confidence associated with different parts of the database

9.2.3 Data analysis for developing body measurement/size charts

The data analysis for developing size/body measurement charts for clothing requires a different approach to that of current statistical evaluations due to the special way in which the charts are structured. The clothing sizes are based on a combination of the four body measurements: chest girth, waist girth, hip girth and height. The other body measurements are analysed on the basis of predefined average values and intervals relating to a primary dimension. The primary and secondary dimensions and the related intervals have been elaborated by an expert committee and documented in EN 13402-3 (see extract from EN 13402-3). The mean values and intervals for chest girth, waist girth, hip girth and height are specified in this standard. The combination of chest girth, waist girth, and hip girth is variable. Examples of different combinations are shown in the diagram “possible variations”. The values ascertained in the standard for the chest girth should be adopted unchanged to develop an international uniform sizing table. The values defined for waist and hip girth serve as guidelines and can be modified in accordance with the results of the analysis.

Primary and secondary dimension	Girth measurements of women (bust 76 to 104) in cm								Interval in cm
Bust girth	76	80	84	88	92	96	100	104	4
Waistgirth	60	64	68	72	76	80	84	88	4
Hip girth	84	88	92	96	100	104	108	112	4

Primary and secondary dimension	Girth measurements of women (bust 104 to 152) in cm									Interval in cm
Bust girth	104	110	116	122	128	134	140	146	152	6
Waistgirth	88	94	100	106	112	118	124	130	136	6
Hip girth	112	117	122	127	132	137	142	147	152	5

Extract from EN 13402-3

The chest girth measurement is taken as the reference measurement which is used as the basis for determining the standard sizes for both men and women. This means that mean values and intervals relating to the chest girth form the basis for a sizing system and are not altered; the tolerance range is simply extended upwards or downwards as required. Height, waist girth and hip girth are additional size-determining primary or secondary dimensions which define figure types and height ranges.

Correlations between these three additional primary/secondary dimensions in relation to the chest girth are determined and analysed and this information is then used as the principal basis on which to develop size charts. While the waist and hip girth are directly related to the chest girth, there is no direct correlation between the chest girth and height. The height particularly influences length-related body measurements such as waist to sole of foot, or arm length etc.

The combination of the primary dimensions for individual sizes is variable, in other words, a large number of size variations can be derived from the different combinations of the primary dimensions chest girth, waist or hip girth and height. A range of possible body measurement combinations is covered by the variety of different dimensions, even including extreme deviations. In order to limit these infinite combinations to a certain extent, preferred primary dimension combinations and standard deviations have been defined within the standards (see example Fig. Possible variations).

Preferred Choices (in cm) – Example:

	Preferred	**Preferred**
Bust	**88 cm**	**104 cm**
Waist	72 cm	88 cm
Hip	96 cm	112 cm
Standard Hip		

Possible variations:

Flexible use of measurements and ranges (in cm) - Example

Bust	**88**	**88**	**104**	**104**
Waist	68	76	84	94
Hip	92	100	108	117

Flexible use of Hip measurements for different Hip types:

Bust	**88**	**88**	**88**	**88**
Waist	72	72	72	72
Hip	88	92	100	104
Hip type	Hip 8 cm smaller than preferred	Hip 4 cm smaller than preferred	Hip 4 cm larger than preferred	Hip 8 cm larger than preferred

In order to obtain comparable international sizing systems, the average values specified in the standards for chest girth and height, together with the related intervals should be used as the basis for the data analysis.

The intended use for the size charts to be developed is significant when deciding on the methodology to be used and the scope of the data analysis. A distinction should be made between four different objectives:

- Generally applicable, product-independent size charts to be used to communicate sizes within industry and the retail sector
- Generally applicable, product-specific size charts, e.g. for jeans, foundation garments etc.
- Generally applicable size charts, based on the individual target groups, which represent a specific age or customer group, e.g. the elderly
- Company-specific size charts which are aimed at the target groups of specific companies

The procedures involved in developing general/official size charts are comparable and only differ in the choice of which data is taken as the basis. The development of company-specific size charts follows the same principles, but there is more flexibility in the combination of primary dimensions and the designation of secondary dimensions.

9.2.4 Procedure

The eight body measurements for sizing specified in E-Tailor and eT-CLUSTER serve as the basis to describe the procedure to be used for the data analysis:

Height
Bust girth
Under bust girth
Waist girth
Hip girth
Inside leg height/length
Arm length
Neck column girth

1. **Definition of the body measurements which correlate to the primary dimensions chest girth and height in relation to the critical change as the primary dimensions increase** (see example Fig. Example of the correlation chest girth – waist girth – hip girth).

Primary dimension	Direct correlation	Indirect correlation
Bust/chest girth	Under bust girth, waist girth, hip girth, neck column girth	Arm length
Height	Inside leg height/length, arm length	

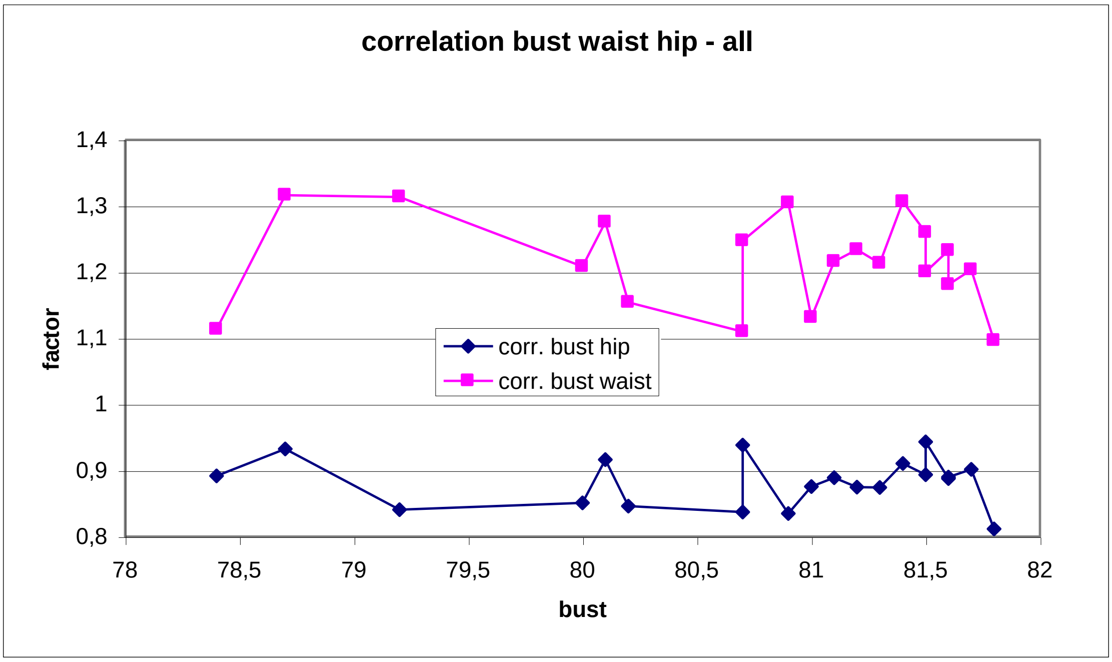


Fig.: Example of the correlation chest girth – waist girth – hip girth

2. Classification of the data records in line with the average values specified for the chest girth and intervals for the sizes

In the second stage, the data records are divided into size groups by chest girth. The average values specified in EN 13402-3, with a tolerance range based on half the interval above and below the average, serves as the basis for classification (see size ranges for chest girth and example for the classification of the data). This division of the data records forms the basis for the analysis of the body measurements with direct correlation to the bust/chest girth.

Size ranges for the chest girth:

Average Bust/chest	**84**	**88**	**92**	**...**	**110**	**116**	**...**
Interval	4	4	4		6	6	..
Bust/chest range	**82 to < 86**	**86 to < 90**	**90 to < 94**		**107 to < 113**	**113 to < 119**	**...**

Example for the classification of the data:

Code	Body height	**bust girth**	waist girth	hip girth
6030	175	**87**	71	93
6013	163	**88**	70	94
6014	166	**88**	72	104
6002	169	**88**	76	96
6010	170	**89**	66	97
6046	170	**93**	78	101
6050	164	**93**	83	94
6007	163	**95**	79	105
6000	156	**95**	84	94
6029	171	**96**	78	97
6020	166	**97**	82	92
6040	152	**97**	87	98

3. Determining the average values for all body measurements with direct correlation to the chest girth

Based on the classification carried out as described in point 2, the average values of the body measurements which directly correlate with the chest girth, i.e. the waist and hip girth, are determined for each size range. These form the basis for developing the average figure type for the body measurement table. When determining the average figure type, it is essential that the most common measurement correlation between chest, waist and hip girth is taken into consideration for each chest girth range. If only the mean value of the measurements is used, this will not always correspond to the body proportions of the majority of those measured (see example for the definition of the average figure type). The mean values in accordance with the example given below must equate to a chest girth of 82 cm, a waist girth of 66.8 cm and a hip girth of 91.5 cm. On the basis of the most common correlation of the three body measurements (cells highlighted in grey), the waist girth of the average figure type should be taken as 62 cm, however.

	bust	waist	hip	corr. bust waist	corr. Bust hip	corr. Hip waist
	77	80	101	0.96	0.76	1.26
	79	80	97	0.98	0.81	1.21
	77	62	93	1.23	0.83	1.49
	81	78	96	1.03	0.84	1.24
	78	66	93	1.19	0.84	1.41
	81	70	95	1.16	0.86	1.35
	81	70	94	1.16	0.86	1.34
	82	78	94	1.04	0.87	1.21
	79	61	91	1.30	0.87	1.50
	80	62	92	1.29	0.87	1.48
	80	62	91	1.29	0.88	1.47
	82	68	93	1.20	0.88	1.36
	81	63	92	1.29	0.88	1.46
	81	62	91	1.31	0.90	1.46
	82	62	89	1.31	0.91	1.44
	80	62	88	1.29	0.91	1.42
	82	70	90	1.17	0.91	1.28
	82	65	88	1.26	0.93	1.35
	82	62	87	1.32	0.93	1.41
	81	60	84	1.35	0.96	1.41
	81	60	83	1.35	0.97	1.39
Average	***80.3***	***66.8***	***91.50***	***1.21***	***0.88***	***1.37***

Example for the definition of the average figure type

Following the analysis of waist and hip girth, the other body measurements which are directly related to the chest girth are analysed using the same principle.

4. Determining the average values for all body measurements directly correlating to height

The body measurements relating to length are analysed following the same procedure as outlined in point 3.

5. Smoothing the size-specific mean values with the aim of establishing linear intervals between the individual sizes as far as possible

The mean values of the body measurements which correlate to the chest girth or height should be modified to ensure that there are linear intervals between the individual size groups as far as possible (see diagram: smoothing the mean values). In order to ensure that the modified mean values for the body measurements correspond to the average proportions of the sample recorded, checks should be carried out to ascertain what percentage is covered. If the figure is below 30%, the smoothing parameters must be adjusted.

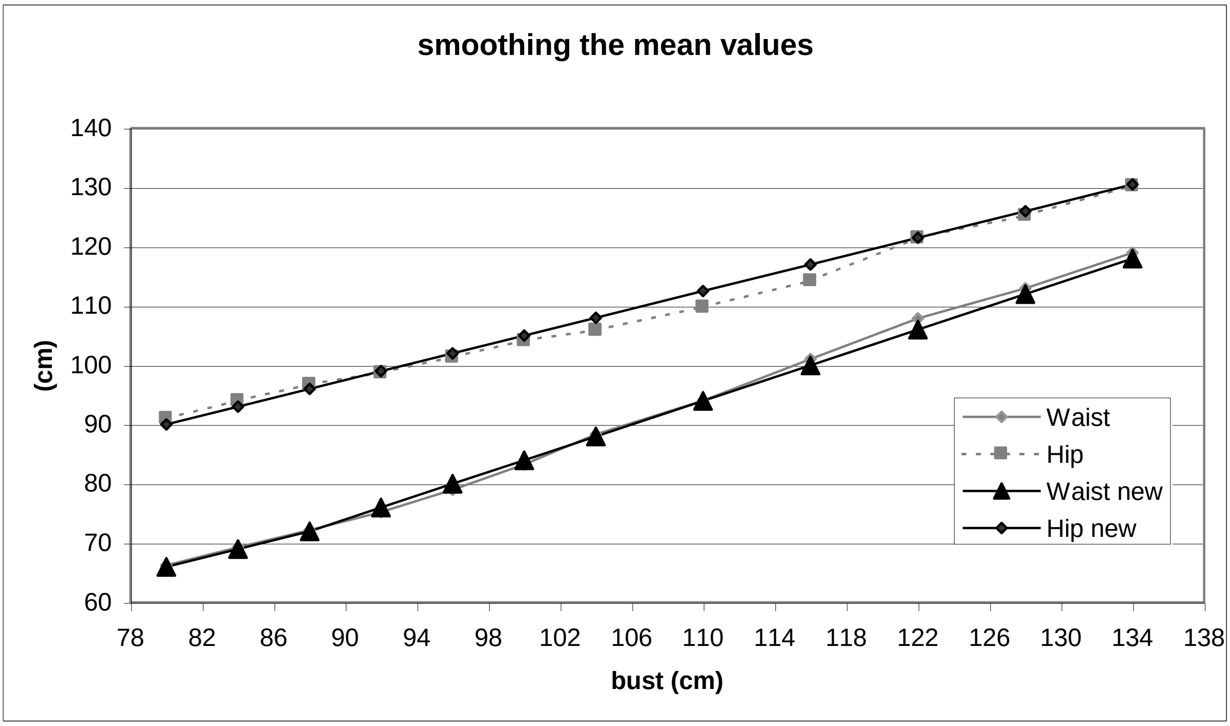


Diagram: Smoothing the mean values

6. Developing additional figure types and height ranges

The mean values for the sizes of additional figure types and height ranges are analysed in the same way as the average figure type and the average size range are developed. The intervals specified in EN 13402-3 for the waist or hip girth and height can be used as guidelines for the intervals of the average sizes for the additional figure types/height ranges. It is essential that these specifications are taken into consideration when developing size charts for the international market in order to achieve sizing harmonisation in the future.

To summarise, the fundamental aspects which should be taken into consideration are as follows:

- Compare the new size chart with current National Standards
- Compare the new size chart with current European Standards
- Construct a size chart based on existing European conventions of sizing / labelling with 4/6 cm girth intervals

- Construct a new, exploratory size chart. This can be non-linear and is unconstrained, but targeted at maximum coverage of the population with minimum numbers of sizes, to achieve ‘reasonable’ fit
- Description of the methodology behind size chart construction to form part of a “User’s guide”

9.2.5 Extraction of market shares for sizes

The extraction of market shares can only begin when analysis of the size/body measurement charts has been completed and the body dimension combinations for the sizes have finally been determined. The analysis takes into consideration the body measurements chest girth, waist and/or hip girth and height. In the first stage, the validity ranges of the body measurements for the individual sizes need to be determined (see example – validity range of the sizes). These are based on the intervals between the sizes, figure types and height ranges. Using the validity ranges of the sizes, the individual data records are designated to the appropriate sizes and the percentages calculated from this. In addition to a general evaluation without taking into consideration specific features such as age group, region etc., it is possible to derive additional information on the breakdown of the sizes with reference to demographics such as age or region by extending the analysis. In addition to the four relevant body measurements, the related criteria, such as the age of the people being measured, must be taken into consideration when filtering the data for the purposes of designating sizes.

Example ranges of validity of sizes: - Bust -

Bust	***76***	***80***	***84***
Interval - figure types	0	0	0
Interval - sizes	4	4	4
Interval - height ranges	0	0	0
Ranges of validity	**74 to 77.9**	**78 to 81.9**	**82 to 85.9**

Example ranges of validity of sizes: - Hip -

Hip	***90***	***93***	***96***
Interval - figure types	4	4	4
Interval - sizes	3	3	3
Interval - height ranges	0	0	0
Ranges of validity	**88 to 91.9**	**92 to 94.9**	**95 to 97.9**

9.2.6 Size charts

As yet, there are still no universally accepted standards governing the way in size charts are presented. However, for the purposes of harmonising sizes on an international level, a uniform layout would be sensible. This would make it considerably simpler to compare the different national charts and minimise sources of error. In connection with the European Anthropometic Database, the eight body measurements specified for sizing in eT-cluster have been listed in the order specified within this document. Additional body measurements can be listed after these. This essentially provides a uniform basis for the international marketing of ready-made clothing.

The body measurements should be used as row designators, and the size codes as column designators (see example for the construction of size charts):

Example for the construction of size charts:

	Size code			
Body measurement	code1	code2	code3	code....
Height				
Bust girth				
Under bust girth				
Waist girth				
Hip girth				
Inside leg height/length				
Arm length				
Neck column girth				

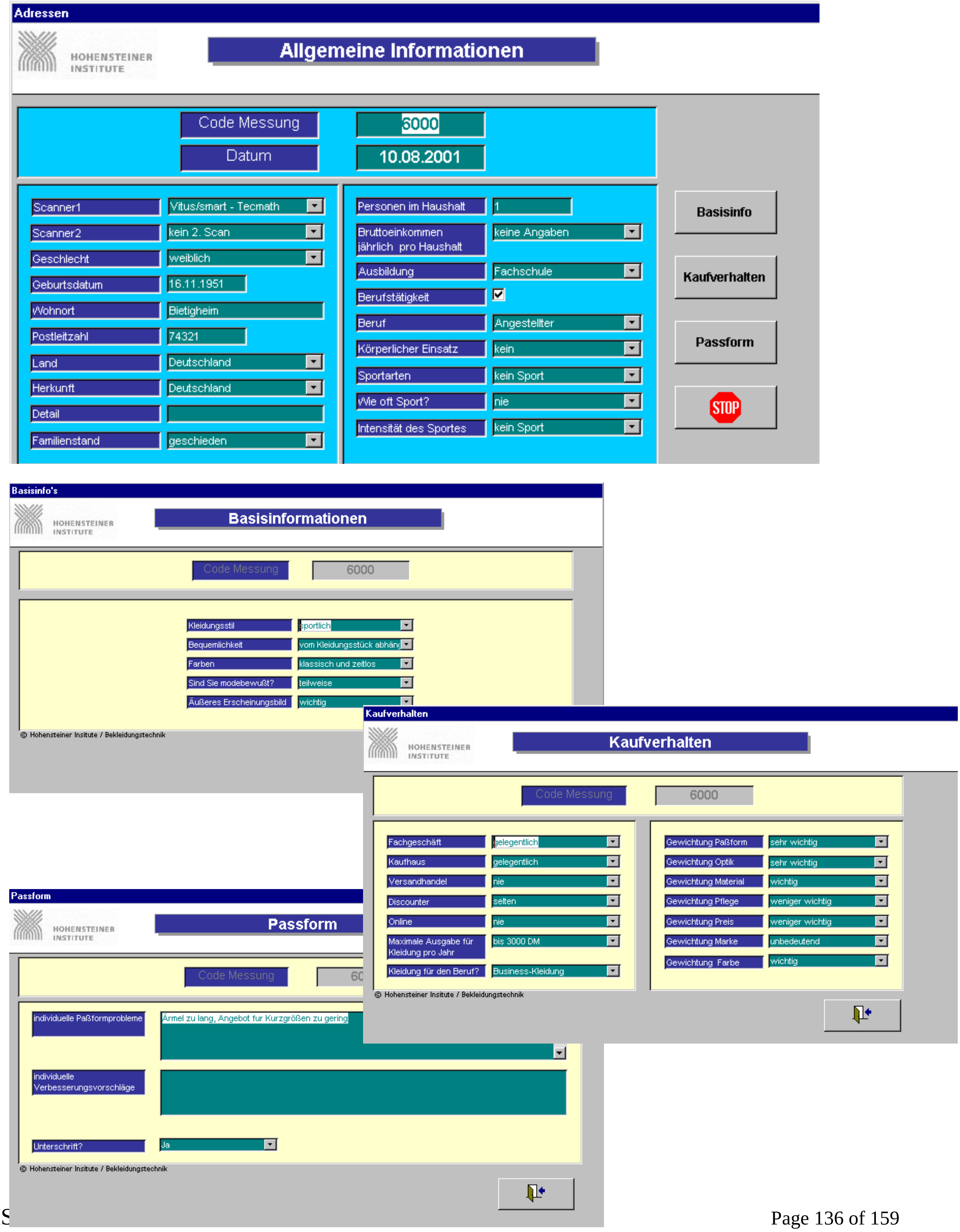
9.2.7 Shape analysis

Shape analysis requires specialist software tools, some of which may be available with a 3D scanner, others may be available from other sources at an additional cost. Some applications of shape analysis tools are listed below.

- 3D data analysis and CAD models for dress stand design
- Creation of average body models based on actual 3D data of subjects close to a specific set of measurement criteria
- Create average models for each size option from an agreed size chart
- Average cross-sections for each measurement
- Identification of shape measurements that affect clothing fit, e.g. seat prominence, through-rise distribution, breast volume, etc.
- Creation of shape chart corresponding to agree size chart cells
- Identification of shape classifications and the distribution of people within these groups
- Identification of posture classifications and the distribution of people within these groups

10 APPENDIX

10.1 QUESTIONAIRE – HOHENSTEINQUESTIONNAIRE „E-TAILOR PILOT SURVEY“



QUESTIONNAIRE "E-TAILOR PILOT SURVEY"	
Code No.	Numbered consecutively
Date of scanning	DD/MM/YYYY

10.1.1 Personal details			
QUESTIONS		**POSSIBLE ANSWERS**	**MANDATORY**
1.	Scanner - Type	kind of scanner	**X**
2.	Gender	→ male → female	**X**
3.	Birth Date	DD/MM/YYYY	**X**
4.	Place of residence	e.g. Stuttgart	
5.	Postal Code	e.g. 70_ _ _ (first two digits are enough)	**X**
6.	Country	→ Germany → Austria. → Switzerland. → Turkey → etc. ...	**X**
7.	Place of Birth (of parents)	→ Germany → Austria. → Switzerland. → Turkey → etc. ...	**X**
8.	Ethnicity	→ White → Black-African → Black-Caribbean → Black-Other → Asian-Chines → Asian-Indian → etc. ...other, please specify	**X**
9.	Marital Status	→ married / common-law marriage → single → divorced → widowed	
10.	Number of persons in house-hold	X persons	

10.1.1 Personal details			
QUESTIONS		**POSSIBLE ANSWERS**	**MANDATORY**
11.	Combined gross income per annum per household	→ no statement → no income → less than 25.000 € → 25.000 - 50.000 € → 50.000 - 75.000 € → 75.000 - 100.000 € → more than 100.000 €	
12.	Education	→ no education → Hauptschule (German school system) → Realschule (German school system) → Abitur (German school system) → technical school → university → polytechnic → other education	
13.	Working ?	→ yes → no	
14.	Job profile	→ housewife → pensioner → official → employee → worker → self-employed → student → trainee → military / civilian service	
15.	Level of manual work which is necessary for the job	→ high → medium → low → no manual work	
16.	Kind of sport	→ no sport → bodybuilding → gymnastics /Aerobics → stamina training (e.g. jogging) → tennis, football, hockey, (European) handball... → serious / competitive sports	
17.	How often sport ?	→ regular → not regular → rarely → never	

10.1.1 Personal details			
QUESTIONS		**POSSIBLE ANSWERS**	**MANDATORY**
18.	Level of intensity of sport	➔ high ➔ medium ➔ low ➔ no sport	

10.1.2 Clothing issues		
QUESTIONS		**POSSIBLE ANSWERS**
19.	Preferred style of everyday clothes	➔ classic ➔ elegant ➔ functional, practical ➔ casual ➔ folkloristic ➔ combined
20.	Preferred comfort of clothes	➔ rather tight ➔ comfortable ➔ rather wide ➔ depends on the garment
21.	Preferred colour	➔ classical colours - black, white, grey, dark blue etc. ➔ fashionable and colourful colours
22.	Are you fashion-conscious?	➔ yes ➔ no ➔ sometimes
23.	Importance of your looks	➔ very important ➔ important ➔ less important ➔ unimportant

10.1.3 Shopping issues		
QUESTIONS		**POSSIBLE ANSWERS**
	The favourite shops for buying clothes:	
24.	Specialist shop, boutique	➔ very often ➔ often ➔ sometimes ➔ rarely ➔ never

10.1.3 Shopping issues		
QUESTIONS		**POSSIBLE ANSWERS**
25.	Department store	➔ very often ➔ often ➔ sometimes ➔ rarely ➔ never
26.	Mail-order business	➔ very often ➔ often ➔ sometimes ➔ rarely ➔ never
27.	Discount store	➔ very often ➔ often ➔ sometimes ➔ rarely ➔ never
28.	Internet shopping	➔ very often ➔ often ➔ sometimes ➔ rarely ➔ never
29.	Maximum clothing expenditure per annum (without shoes)	➔ less than 250 € ➔ to 500 € ➔ to 1000 € ➔ to 1500 € ➔ more than 1500 € ➔ more than 2500 €
30.	Are special clothes for the job necessary?	➔ not necessary ➔ business - clothes ➔ working clothes
Most important influence when buying clothes:		
31.	Importance of the garment fit	➔ very important ➔ important ➔ less important ➔ unimportant
32.	Importance of design / optical effects	➔ very important ➔ important ➔ less important ➔ unimportant

10.1.3 Shopping issues

QUESTIONS		POSSIBLE ANSWERS
33.	Importance of material	→ very important → important → less important → unimportant
34.	How to wash, to clean ?	→ very important → important → less important → unimportant
35.	Importance of the price	→ very important → important → less important → unimportant
36.	Importance of the brand / label	→ very important → important → less important → unimportant
37.	Importance of the colour	→ very important → important → less important → unimportant

10.1.4 Garment fit

QUESTIONS		POSSIBLE ANSWERS
38.	Individual garment fit	Open-ended question
39.	Suggestion for improvement to the clothing industry and/or trade	Open-ended question
40.	Signature ? I hereby give permission that my scan data (without face)together with other anonymous information serving purely demoscopic purposes may be made available for use by the European Database.	→ yes → no

10.2 QUESTIONAIRE –QUESTIONNAIRE SIZE UK – NTU

10.2.1 Example for fieldwork Schedule

ID	name	Changing room	Terminal	Arrival time	Manual measuring (20 minutes)		Scanning (10 mins)		Market research
1	[name]	1	1	8:30 AM	8:40 AM	9:00 AM	9:00 AM	9:10 AM	V
2	[name]	2	2	8:40 AM	8:50 AM	9:10 AM	9:10 AM	9:20 AM	A
3	[name]	3	3	8:50 AM	9:00 AM	9:20 AM	9:20 AM	9:30 AM	R
4	[name]	4	1	9:00 AM	9:10 AM	9:30 AM	9:30 AM	9:40 AM	I
5	[name]	5	2	9:10 AM	9:20 AM	9:40 AM	9:40 AM	9:50 AM	A
6	[name]	6	3	9:20 AM	9:30 AM	9:50 AM	9:50 AM	10:00 AM	B
7	[name]	7	1	9:30 AM	9:40 AM	10:00 AM	10:00 AM	10:10 AM	L
8	[name]	8	2	9:40 AM	9:50 AM	10:10 AM	10:10 AM	10:20 AM	E
9	[name]	1	3	9:50 AM	10:00 AM	10:20 AM	10:20 AM	10:30 AM	
10	[name]	2	1	10:00 AM	10:10 AM	10:30 AM	10:30 AM	10:40 AM	V
11	[name]	3	2	10:10 AM	10:20 AM	10:40 AM	10:40 AM	10:50 AM	A
12	[name]	4	3	10:20 AM	10:30 AM	10:50 AM	10:50 AM	11:00 AM	R
13	[name]	5	1	10:30 AM	10:40 AM	11:00 AM	11:00 AM	11:10 AM	I
14	[name]	6	2	10:40 AM	10:50 AM	11:10 AM	11:10 AM	11:20 AM	A
				Break					B
15	[name]	7	3	11:00 AM	11:10 AM	11:30 AM	11:30 AM	11:40 AM	L
16	[name]	8	1	11:10 AM	11:20 AM	11:40 AM	11:40 AM	11:50 AM	E
17	[name]	1	2	11:20 AM	11:30 AM	11:50 AM	11:50 AM	12:00 PM	
18	[name]	2	3	11:30 AM	11:40 AM	12:00 PM	12:00 PM	12:10 PM	V
19	[name]	3	1	11:40 AM	11:50 AM	12:10 PM	12:10 PM	12:20 PM	A
20	[name]	4	2	11:50 AM	12:00 PM	12:20 PM	12:20 PM	12:30 PM	R
21	[name]	5	3	12:00 PM	12:10 PM	12:30 PM	12:30 PM	12:40 PM	I
22	[name]	6	1	12:10 PM	12:20 PM	12:40 PM	12:40 PM	12:50 PM	A
23	[name]	7	2	12:20 PM	12:30 PM	12:50 PM	12:50 PM	1:00 PM	B
24	[name]	8	3	12:30 PM	12:40 PM	1:00 PM	1:00 PM	1:10 PM	L
25	[name]	1	1	12:40 PM	12:50 PM	1:10 PM	1:10 PM	1:20 PM	E
26	[name]	2	2	12:50 PM	1:00 PM	1:20 PM	1:20 PM	1:30 PM	
				Lunch					V
27	[name]	3	3	1:50 PM	2:00 PM	2:20 PM	2:20 PM	2:30 PM	I
28	[name]	4	1	2:00 PM	2:10 PM	2:30 PM	2:30 PM	2:40 PM	A
29	[name]	5	2	2:10 PM	2:20 PM	2:40 PM	2:40 PM	2:50 PM	B
30	[name]	6	3	2:20 PM	2:30 PM	2:50 PM	2:50 PM	3:00 PM	L
31	[name]	7	1	2:30 PM	2:40 PM	3:00 PM	3:00 PM	3:10 PM	E
33	[name]	8	2	2:50 PM	3:00 PM	3:20 PM	3:20 PM	3:30 PM	V
34	[name]	1	3	3:00 PM	3:10 PM	3:30 PM	3:30 PM	3:40 PM	A
35	[name]	2	1	3:10 PM	3:20 PM	3:40 PM	3:40 PM	3:50 PM	R
36	[name]	3	2	3:20 PM	3:30 PM	3:50 PM	3:50 PM	4:00 PM	I
37	[name]	4	3	3:30 PM	3:40 PM	4:00 PM	4:00 PM	4:10 PM	A
38	[name]	5	1	3:40 PM	3:50 PM	4:10 PM	4:10 PM	4:20 PM	B
39	[name]	6	2	3:50 PM	4:00 PM	4:20 PM	4:20 PM	4:30 PM	L
40	[name]	7	3	4:00 PM	4:10 PM	4:30 PM	4:30 PM	4:40 PM	E
41	[name]	8	1	4:10 PM	4:20 PM	4:40 PM	4:40 PM	4:50 PM	
				Break					V
42	[name]	1	2	4:30 PM	4:40 PM	5:00 PM	5:00 PM	5:10 PM	A
43	[name]	2	3	4:40 PM	4:50 PM	5:10 PM	5:10 PM	5:20 PM	R
44	[name]	3	1	4:50 PM	5:00 PM	5:20 PM	5:20 PM	5:30 PM	I
45	[name]	4	2	5:00 PM	5:10 PM	5:30 PM	5:30 PM	5:40 PM	A
46	[name]	5	3	5:10 PM	5:20 PM	5:40 PM	5:40 PM	5:50 PM	B
47	[name]	6	1	5:20 PM	5:30 PM	5:50 PM	5:50 PM	6:00 PM	L
48	[name]	7	2	5:30 PM	5:40 PM	6:00 PM	6:00 PM	6:10 PM	E
49	[name]	8	3	5:40 PM	5:50 PM	6:10 PM	6:10 PM	6:20 PM	
50	[name]	1	1	5:50 PM	6:00 PM	6:20 PM	6:20 PM	6:30 PM	
51	[name]	2	2	6:00 PM	6:10 PM	6:30 PM	6:30 PM	6:40 PM	
52	[name]	3	3	6:10 PM	6:20 PM	6:40 PM	6:40 PM	6:50 PM	

10.2.2 Section 1: health and fitness

Question title	Question	Possible answers	Registrar or questionnaire	NTU recom-mended?
Exercise	On average, how many hours a week do you spend exercising?	1) None 2) Some, but less than 1 hour 3) 1-2 hours 4) 3-5 hours 5) 6-8 hours 6) 9+ hours	Questionnaire	Yes
Alcohol	How many units of alcohol do you drink in a typical week? Note: approximate units are: 1 pint beer = 2-3 units Single spirit = 1-1.5 units 1 glass of wine = 1 unit	1) None 2) 1-5 units 3) 6-10 units 4) 11-20 units 5) 21-30 units 6) 30+ units	Questionnaire	Yes
Smoking	How often do you smoke cigarettes/cigars?	1) I don't smoke 2) Fewer than 10 per week 3) 10-49 per week 4) 50-99 per week 5) 100+ per week	Questionnaire	Yes
Diet	Have you been on a calorie-controlled diet within the last 6 months?	1) Yes 2) No	Questionnaire	Yes

10.2.3 Self-perception

Question title	Question	Possible answers	Registrar or questionnaire	NTU recom-mended?
Measurement classification	What are your measurements for the following areas of your body? 1) Height 2) Waist 3) Bra size 4) Inside leg 5) Hip 6) Shoe size length 7) Dress size	1) Metres or feet and inches 2) Cm or inches 3) Bra back (inches) & cup size (adjust as per country's protocol) 4) Cm or inches (S/R/L/XL) 5) Cm or inches 6) Full and half sizes 7) 8/10/12 etc (or individual country sizes)	Questionnaire	Yes
Heel size	What size heels do you generally wear during the 1) Day and 2) Night?	1) Inches or cm 2) Inches or cm	Questionnaire	Dependent on partners' wishes
Petite definition	A) Are you petite? B) How would you define the term "petite"?	A) Yes/No B) Height related (feet & inches) C) Size related (dress size) D) Height **and** size related	Questionnaire	Yes
Height perception	How tall are you compared to the rest of the population?	Very short/Short/Average/Tall/Very tall/ Prefer not to say	Questionnaire	Yes
Size perception	How do you view your dress size in relation to the rest of the population?	Very small/Small/Average/ Large/Very large/Prefer not to say	Questionnaire	Yes

10.2.4 Clothing and shopping issues

Question title	Question	Possible answers	Registrar or questionnaire	NTU recom-mended?
Overall fit	In general, do you find it easy to select clothes that fit you well?	Yes/No	Questionnaire	Yes
Specific fit	Are there any areas of your body where it is difficult to find clothes that fit you well? **Please mark as many as apply**	Waist/Hips/Bust/Foot/Trouser length/Sleeve length/Thigh/Shoulder	Questionnaire	Yes
Clothing ex-penditure	How much do you spend on clothes in a typical month?	1) £0-£19 2) £20-£39 3) £40-£59 4) £60-£79 5) £80-£99 6) £100-£199 7) £200+	Questionnaire	Yes
Influence	What is the most important influence on you when buying clothes?	Open-ended question to overcome problems of prompting	Questionnaire	Yes
Last measured	Can you put a rough timescale on the last time you were measured for…? A) Clothes B) Lingerie	1) Within the previous month 2) In the last year 3) In the last 5 years 4) In the last 10 years 5) Never been measured	Questionnaire	Yes
Internet shop-ping	Have you ever bought clothing over the Internet?	Yes/No	Questionnaire	Yes

Question title	Question	Possible answers	Registrar or questionnaire	NTU recom-mended?
Rating Internet Shopping	For the following characteristics, how would you rate your experience of buying clothing over the Internet? 1) Fabric quality 2) Garment quality 3) Garment fit 4) Service quality 5) Value 6) Convenience	Using Likert Attitude Rating scales from Very good through to Very poor (5 point scale), with additional "Don't know" option	Questionnaire	Yes
General fit statements	How strongly do you agree or disagree with the following statements? Please mark only **ONE** answer for each statement 1) I enjoy buying clothes 2) I follow the latest fashions 3) More expensive clothes fit me better 4) I would be confident of buying a good fit from a catalogue or website 5) I buy most of my clothes from one store 6) I would like to see a universal sizing system introduced 7) I know my body measurements well 8) I tend to select clothes that emphasise my figure	Using Likert Attitude Rating scales from Strongly Agree to Strongly Disagree (5 point scale), with additional "Don't know" option	Questionnaire	Yes

10.2.5 Personal details

Question title	Question	Possible answers	Registrar or questionnaire	NTU recom-mended?
ID	ID number	4 digit number	Both	Yes, on all docu-mentation
Ethnicity	Which of the following ethnic groups do you consider your-self to belong to?	1) White 2) Black-Caribbean 3) Black-African 4) Black-Other 5) Asian-Chinese 6) Asian-Indian 7) Asian-Pakistani 8) Asian-Bangladeshi 9) Asian-Other 10) Mixed race 11) Other, please specify	Questionnaire	Yes
Age	What is your date of birth?	e.g. 03/11/1962	Registrar	Yes
Housing tenure	Which of the following best describes the ownership of your current place of residence?	1) Owner occupied 2) Privately rented 3) Housing association 4) Local authority owned	Questionnaire	No

Question title	Question	Possible answers	Registrar or questionnaire	NTU recom-mended?
Working status	Which of the following best describes your working status?	1) Full time (30+ hrs/week) 2) Part-time (8-29 hrs/week) 3) Student 4) Retired 5) Unemployed 6) Not working	Questionnaire	Yes
Combined income	What is the combined income of your household?	1) < £10,000 2) £10,000-£14,999 3) £15,000-£19,999 4) £20,000-£29,999 5) £30,000-£49,999 6) £50,000+	Questionnaire	Yes
No. of children	How many children do you have?	1) None 2) One 3) Two 4) Three 5) Four or more 6) Prefer not to say	Questionnaire	Yes
Age of children	How old are your children?	Spaces for up to 6 children	Questionnaire	Yes

Question title	Question	Possible answers	Registrar or questionnaire	NTU recom-mended?
General questions	1) The information given about the survey was: 2) The changing room facilities were:	Using Likert Attitude Rating Scales from "Excellent" through to "Unsatisfactory" (5 point scale)	Questionnaire	Yes
Manual measuring process	1) The explanation about being measured was: 2) The instructions for being measured were: 3) The guidance given by staff was: 4) Your experience of being measured was:	Using Likert Attitude Rating scales from "Excellent" through to "Unsatisfactory" (5 point)	Questionnaire	Undecided (may be covered by other questions)
3D scanner process	1) The explanation about the scanning process was: 2) The "instructions for being measured" poster was: 3) The guidance given by the operator was: 4) Your experience of being scanned was:	Using Likert Attitude Rating scales from "Excellent" through to "Unsatisfactory" (5 point)	Questionnaire	Undecided (may be covered by other questions)
Other	Please add any further comments, concerning any issues relevant to this survey, where necessary	Open-ended question	Questionnaire	Yes

10.3 EXTRACT OUT OF ET-CLUSTER DOCUMENT

eT - CLUSTER

“Developing Common Standards for the Integration of 3D Body Measurement, Advanced CAD,

and Personalised avatars in the European Fashion Industry ”

DELIVERABLE DOCUMENT D7

PROPOSED HUMAN BODY MEASUREMENTS STANDARD

Confidential document

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TELMAT Industrie (F), TECMATH AG (D), EURATEX (B), UCL (UK)

DOCUMENT STRUCTURE:

- Introduction
- Referred Documents
- Lists of Measurements
- Sizing
- MTM
- Additional
- Vertical Distances
- Horizontal Distances
- Circumference Dimensions
- Hand & Foot Measurements
- Other Seated Measurements
- Special Contoured Measurements
- Derived Measurements

INTRODUCTION

The goal of this document is to initiate the attempt for standardisation of the definitions of body measurements used for clothing design in Europe.

The list of measurements and their definition has been built by gathering input and feedback from the e-T Cluster partners, and work is currently fo-cused on achieving agreement upon the structure and content of this list.

The measurements are divided in the following 3 categories:

- Primary Measurements – used for Sizing
- Secondary Measurements – used for MTM
- Additional Measurements – for general use, pattern making and shape analysis

This document refers to the contribution of Hohenstein to T3.3 " Uniform Body Representations" which was presented at the eT-Cluster Body Meas-urement Meeting in London on April 2nd, 2001.

The definitions of the "Primary Measurements" and the "Secondary Measurements" have been updated according to the measurement definitions dis-cussed and adopted at the eT-Cluster Meetings.

The purpose of endeavouring to achieve a set of clear, precise and undisputable measurement definitions is to define ulimately a standard that covers the **needs** of the European clothing industry. It is desirable, through the e-T cluster project, to promote the use of 3D scanning technologies for clothing design and manfacturing. However, the attempt is focused on adapting and improving these technologies in order to meet current needs, rather than re-adjusting the perceived needs of the industry in order to match the capabilities of 3D scanning technologies in general, and the capabilites of the product of a specific scanner manufacturer in particular. Each measurement has been included or excluded from the list not according to how easy or possible it is to extract it using current scanning technology, but according to how important it is for the production of garments. This is in order to enable hardware and software de-velopers to steer their development towards technologies that may meet the specifications proposed here. It is desirable, as a follow-up of this work, to pro-ceed to standardising the software used for automatically locating landmarks and extracting measurements described in this specification. However, it is still too early to address the issue of standardising the software, and such an issue is outside the scope of this document

body measurements were identified that are important for clothing design

2. an unambiguous description is given of these scan derived body measurements

3. the detectability of the 3D-scanning technique is incorporated in the description

4. the measurements are as close as possible to ISO 8559 and ISO 7250. Some of the measurements in the ISO standards require palpation of bony points before the measurements. 3D scanning offers the advantage of untouched size determination and therefore palpation is not desired. Deviation of the ISO

standards therefore occur for these measurements.

Clothing

It is generally accepted that measurements are taken with the subject in close fitting underwear. This assumption has been taken into account in the definition of measurements where applicable (e.g. women's measurements in the breast area), if the natural shape of the body is significantly dis-torted by the use of underwear. However, the precise type of clothing to be worn during measuring/scanning has yet to be defined.

Postures

It is generally assumed that measurements are taken with the subject in a standard anthropometric posture unless otherwise stated. However, each one of the project partners has a slightly different understanding of that posture. Therefore, the precise definition of the "standard anthropometric posture" and/or any other postures used in this work is an issue that is yet to be addressed.

Definitions of basic concepts

(please note that this list may grow from version to version of this document)

longitudinal axis: vertical line through the center of the head through the torso midway between the feet

frontal axis: horizontal line through the middle front of the chest through the back

transversal axis: horizontal line from left to right through the chest

midcoronal plane: plane through the longitudinal and transversal axis

midsagittal plane: plane through the longitudinal and frontal axis

midtransversal plane: plane through the frontal and transversal axis

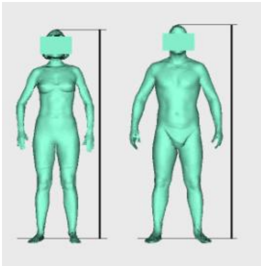
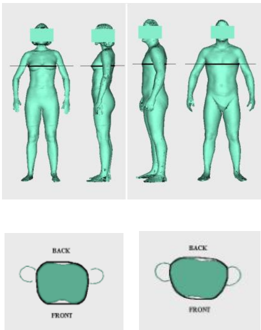
Numbering.

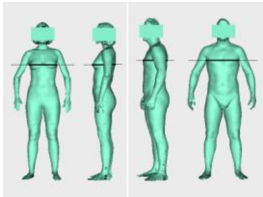
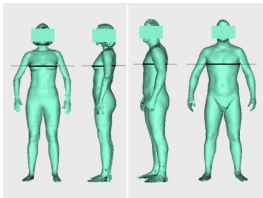
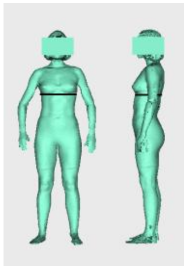
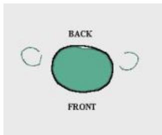
The reader may note that in this version of the document, the numbering of measurements is neither consistent nor linear. The reason for that is that the list is still subject to some minor restructuring, prior to which it is pointless to attempt to finalise the numbering. That would only cause confusion by introducing problems with the referencing of measurements. Therefore, a decision has been made to keep the original numbering of the measure-ments as they appear on the original list provided by Hohenstein, no matter how these measurements are moved around the document. If a measure-ment is thereafter deleted, its number falls into disuse to avoid confusion. If a new one is added, it will either remain un-numbered or it will be as-signed a temporary number if it needs to be refered to somewhere else in the document. Once the list is finalised, it will be fully renumbered in a lin-ear manner, and all cross-references will be updated.

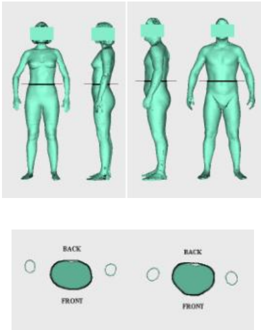
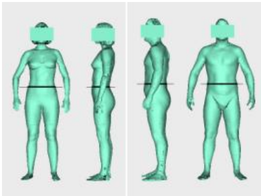
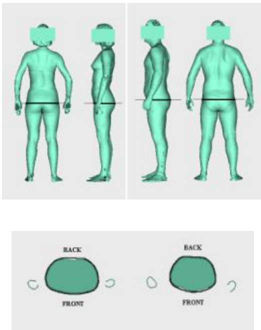
Miscellaneous Notes

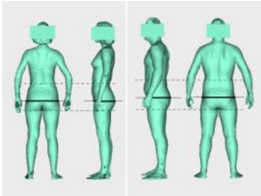
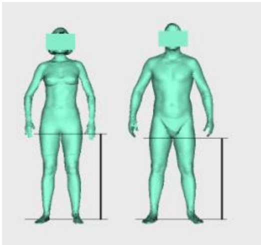
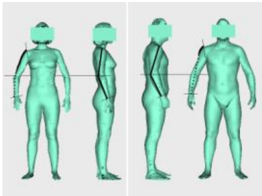
 If a measurement can be taken on either side of the body, and a side is not specified, the right side is assumed. For example, “Arm Length” im-plies “Right Arm Length”. The only exception to this rule is the case of amputated subjects, where obviously it is the intact side that gets meas-ured.

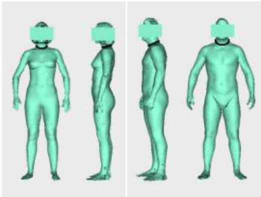
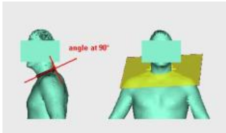
SECTION 1: PRIMARY MEASUREMENTS – USED FOR SIZING

No.	Body Dimensions	Body Landmarks	Body Location	Picture	Women	Men	Comments
	Weight		Weight recorded in kilograms				
1	Height	Highest point of skull	Vertical distance between the crown of the head and the ground		Y	Y	Diagram must be modified to show feet together 1b, 1c and 1d We should add the information, that the measurement shall be taken manually. It is to discuss if we take instead the 7 cervical height
2	Bust/Chest Girth at Maximum Prominence	Maximum projection of the bust/chest	Horizontal girth measured under the armpits (without arms) and at the level of the maximum projection of the bust / chest		Y	Y	

No.	Body Dimensions	Body Landmarks	Body Location	Picture	Women	Men	COMMENTS
2b	Maximum Bust/Chest Girth		Maximum circumference of the trunk at bust / chest height				The definition of landmark is very flexible. For persons which are very corpulent it is not possible to set the correct measurement position For uniform sizing we only should use one definition. Additional measurements shall put into the area body shape information
2c	Bust/Chest Girth at Nipple Height		Nipples				Same as 2b
3	Underbust Girth (women only)	Breast base which is lower down the body	Horizontal girth of the body immediately below the breasts. The measurement position is determined by the breast (breast base) that is lower down the body.	 	Y		JLR: Perhaps we should add in the description that the female subject must be wear fitting bras so that the underbust line is not hidden by her breasts

No.	Body Di-mensions	BODY LANDMARKS	BODY LOCATION	PICTURE	WOMEN	MEN	COMMENTS
4a	Anthropo-metric Waist Girth	Deepest point of the spinal curve at the tangential change, closer to the buttocks	Horizontal girth at waist height From the side view: The waist level is determined by the deepest part of the spinal curve or rather by the point of tangential change		Y	Y	For uniform sizing we should use this measurement. It is the product independent definition of waist girth
4b	Waist girth at Navel	Navel	Horizontal Circum-ference of the Trunk at the Navel				This measurement should put into the body shape information area
5a	Hip Girth at Maximum Prominence	Maximum projection of the buttocks in body profile	Horizontal girth of the trunk measured at hip height From the side view: The position of the measurement is determined by the fullest part of the buttocks		Y	Y	

No.	Body Di-mensions	BODY LANDMARKS	BODY LOCATION	PICTURE	WOMEN	MEN	COMMENTS
5b	Maximum Hip Girth	Level of Maximum Circumference between Crotch Level and Waist Level					This measurement should put into the body shape information area
6	Inside Leg Height	Crotch level	Vertical distance between the crotch level at middle of thigh at the and the ground (how is centre of body identified?)		Y	Y	If we add the measurement distance between feet, we don’t need to define a fixed distance Distance between feet neeeds to be specified.
7	Arm Length – Bent	Acromion extremity, outside elbow joint, wrist bone	Distance from the armscye / shoulder line intersection (acromion) over the outside elbow joint to the far end of the prominent wrist bone (ulna) in line with the small finger		Y	Y	The detection of acromion is difficult for scanners. Therfore we should define the upper point as intersection point to a vertical axis to armpits on the highest point of shoulder

No.	Body Dimensions	Body Landmarks	Body Location	Picture	Women	Men	Comments
8	Neck Column Girth (Need to differentiate between 8 and 20)	Centre Base Neck (close to the 7th cervical vertebra, but easier to locate) it is t he point midway between the neck-rise points on the front silhouette.	Girth of the neck column measured from the Centre Base Neck The measuring line is determined by a plane which is perpendicular to the back neck contour viewed from the side.	 	Y	Y	Neck Base Girth is a different measurement Definition of Centre Base Neck!