

IEEE-SA Industry Connections White Paper

**IEEE Industry Connections (IEEE-IC)  
Landmarks and Measurement Standards  
Comparison in 3D Body-model Processing**

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# IEEE Industry Connections (IEEE-IC) Landmarks and Measurement Standards Comparison in 3D Body-model Processing

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## Abstract

This white paper reviews the current standards landscape for three-dimensional body scanning, body landmarking, and measuring. International standards are compared and recommendations are made for a minimal set of landmarks and measurements (L&M) needed for several industrial use cases of 3D Body Processing such as fit and size estimation, retail, clothing manufacturing, CAD tool developers, and body model storage and service.

## 1. Introduction

Human body structure is made up of 206 bones and 230 moveable and semi-movable joints in adults [1], and its outer body surface can range from an average of 2205 cm<sup>2</sup> at birth (50 cm, 3.5 kg) to 25,000 cm<sup>2</sup> for a 300 kg, 190.5 cm obese adult [19]. Three-dimensional (3D) scanners enable the fast, safe, and cost-effective acquisition of body surface geometry in 3D. Since their appearance, 3D models of the human body (or body parts) have been in use for various applications and are becoming ubiquitous in industries such as apparel manufacturing and retail. The increase in availability of body scanning equipment that are able to digitize body surface in combination with the expected proliferation of applications that use body models, justify efforts to standardize some of the interactions concerning 3D body models and associated data.

The 3D Body Processing (3DBP) initiative aims to improve interoperability between producers and consumers of 3D body models and associated services. In turn, standardization will ease the development of innovative solutions using body models and accelerate scaling of 3D body-model-based applications.

One of the common usages for 3D body models is the extraction of body measurements from the model since it is an efficient alternative to traditional anthropometry. These measurements are used in a range of applications such as ergonomic design, garment construction, mass customization, health or physical fitness. These measurements include distances, heights, widths, lengths, or girths. Measurements thus constitute an important metadata that should be kept along the 3D data processing pipeline, described in first white paper published by the 3DBP Industry Connections group [24].

In traditional anthropometry, human measurers locate the anatomical body references (designated as landmarks) by palpation of bony prominences. These landmarks are used as reference points when taking manual measurements (e.g., by measuring the distance between landmarks). Measurements are made using traditional tools such as calipers and measuring tape (Kouchi, et al. [17]). The digital extraction of measurements from a 3D body model relies on the same steps (i.e., landmarking and then measuring) but the definition of the landmarks is based on searches on the body surface geometry because no palpation is possible of the digital data. Some scanning solutions offer both the physical scan capture as well as a post-processing stage to calculate body measurements. In other cases, measuring software is offered as standalone software that accepts 3D body models from different scanners.

Measurement definitions, postures, anatomical body references, instruments, procedures, and attire are standardized for different purposes (i.e., ergonomic design of products and environments, health and physical activity) by different independent organizations such as ISO<sup>1</sup>, ISAK<sup>2</sup>, IEC<sup>3</sup>, CEN<sup>4</sup> or ASTM<sup>5</sup>. In garment construction, there are also definitions provided by the different patternmaking methods (Aldrich [1], Armstrong [3], Beazley [5]) However, there are discrepancies among measurement definitions leading to, for instance, different definitions for the same designations (e.g., waist girth). Even though body scanners are presented as alternative measuring instruments in the latest versions of standard (ISO 8559-1:2017 [9]; ISO 7250-1:2017 [8]), for these applications, definitions are still based on manually palpated landmarks and do not consider the particularities and advantages of the digital methods. This means that each measuring software developer creates a different interpretation and implementation of the same measurements and landmarks. To address this issue, new standards have been recently released providing body measurements, landmarks, body part and joint definitions from a natively digital perspective for digital fashion applications (ISO 18825-1:2016 [10], ISO 18825-2:2016 [11]). Despite the fact that these standards constitute an important step forward, these definitions are conceived to work with digital human models rather than with actual body scans of people. Additionally, none of the previously mentioned standards considers a procedure for defining new measurements, which is common practice among body scanner and measuring software suppliers.

Regarding quality, in the case of manual measurements, the skill of measurer strongly affects the reliability of manual measurements (Kouchi, et al. [17]); moreover, compatibility among manual measurements is often compromised due to systematic errors between differently skilled measurers. Analogously, in the case of digitally elicited measurements, the quality of the 3D scans has a strong influence on the reliability of measurements; moreover, the compatibility among digital measurements is often compromised due to differences in the interpretation and implementations of different measuring software.

The main benefit of 3D scanners is that they provide the whole surface of the body, i.e., 3D body model, which cannot be provided by traditional anthropometry. The accuracy of the raw scan point cloud (or surface) acquired by a body scan of a rigid object is also addressed by ISO 20685-2:2015 [12] and by proprietary procedures developed by manufacturers. However, it is not resolved for measuring living humans, which are soft and articulated. Moreover, the surface manipulations along the processing pipeline from the raw scan to the 3D body model is neither tracked nor quantified.

Within 3DBP initiative, the quality sub-group intends to provide methods, tools, benchmarks, resources, and testing procedures to define and quantify the quality of 3D models, as well as the quality of the critical metadata for use cases, such as body landmarks and measurements. Quality quantification is intended to be part of the quality-related metadata, which will provide complementary information about what the user receives and to what extent it is reliable, accurate, and trustworthy. Among the different steps within the 3D body processing pipeline (Figure 1), the sub-group is initially focused on (A) 3D scanning, (B) mesh surface reconstruction,

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<sup>1</sup> International Standards Organization

<sup>2</sup> International Society for the Advancement in Kinanthropometry

<sup>3</sup> International Electrotechnical Commission

<sup>4</sup> Comité Européen de Normalisation

<sup>5</sup> American Society for the Advancement in Kinanthropometry

(C) digital landmarking, and (D) digital measuring since they are the more relevant for the considered use cases.

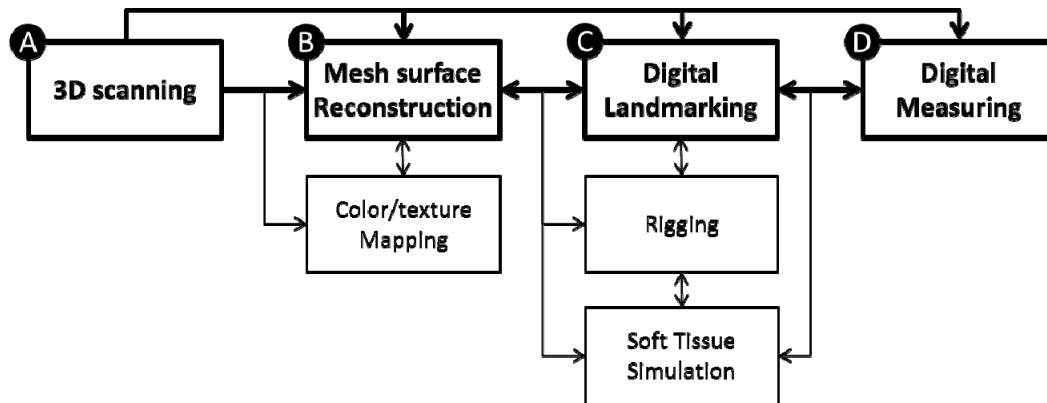


Figure 1 : 3D Body Data Processing Pipeline (McDonald [20])

Within these four processes, the quality attributes considered so far are related to the following:

- Descriptive information about the process, e.g., scanner supplier, scanner specifications, software version, scanning pose, or scanning attire.
- Qualitative descriptors and quantitative metrics for the processed 3D surfaces related to noise, artifacts, redundancies, holes, smoothing, and surface reconstruction.
- Reliability of body measuring software.
- Compatibility of digital body measuring and landmarking to methods dependent upon different digital software and/or traditional methods.

This white paper provides some examples of the role of measurements in 3DBP use cases as well as discusses the current landscape of standards related to body measurements and landmarks, and identifies the gaps not covered by them. Moreover, it provides a shortlist of measurements and landmarks that will be used within the initial use cases considered by 3DBP initiative; i.e., fit and size estimation, retail, clothing manufacturing, CAD tool developers, and body model storage and service.

## 2. The role of landmarks and measurements in 3DBP applications

As noted in the first paper published by the 3DBP Industry Connections group [24], there are different building blocks that can make up a 3DBP solution, such as the following:

- a. Scanning or acquisition of the 3D surface data
- b. 3D Model generation
- c. Landmarks and measurements (L&M) identification
- d. Digitization of objects (e.g., clothing, furniture)
- e. Aggregation of data from various sources
- f. Processing and integration of the data
- g. Presentation/display/output the results



An application may contain all or some of the previous building blocks. (Each of the blocks were described in detail in the first paper by the 3DBP group.) This paper focuses on landmarks and measurements (L&M) identification. Within this block, L&M are estimated by software that receives a body scan or a body model as an input. This software is not necessarily tightly coupled to the model generation step and can run on body models regardless of the scanner used to create them. Recognition and isolation of body parts may take place in this step as well. Some restrictions may apply. For example, the code may be expecting the subject to be scanned in a certain pose.

The following subsections give examples for how a 3DBP solution uses L&M. Implicit in the given examples is the understanding that certain landmarks and measurements must be provided with a model to make the use case possible.

### CAD clothing design

The general procedure for constructing 3D garments with 3D-CAD software can be broken down into the following steps:

1. Create patterns in 2D space
2. Position 2D-patterns around the 3D-body (avatar)
3. Virtually stitch of the 3D-pattern
4. Simulate garment

In step 1, the accuracy of landmarks is of vital importance since 2D-patterns are being drafted based on the measurements/sizes of the target body to achieve a good fit. These measurements (body lengths and depths) are based on landmarks, whose maximum allowable error between extracted value and traditionally measured value should be within  $\pm 5$  mm (ISO 20685:2010 [12]). Body circumferences should be within  $\pm 4$  mm to 9 mm.

In step 2, the landmarks on a 3D-avatar are used as reference locations for selecting arrangement points around a 3D-body. The accuracy of landmark placement is less important if the CAD software can drape clothing correctly over the avatar even when the initial positioning of the clothing is not that accurate. Note that this applies only to certain CAD software; some applications do require accurate landmark placement to provide good draping results.

### CAD footwear design and fitting

Another example for the use of L&M is footwear fitting. The main concern is the positioning of the foot while being scanned to achieve appropriate information. The foot can be in a fully weighted state (standing with body weight on one foot, or full-weight bearing, FWB) or an unweighted state (sitting or with foot in the air; or non-weight bearing, NWB). ISO/TS 19408 [15] states that measurements should be taken in an evenly weighted position between the two feet (half weight bearing, HWB). However, that may not be the best position for all use cases in footwear, especially if the underside of the foot should not be compressed. The foot measurements maximum allowable error between extracted value and traditionally measured value should be within  $\pm 2$  mm (ISO 20685:2010 [12]). This is in the same order of magnitude as the differences between the different weight-bearing conditions for different foot measurements, which can range from 3–7 mm depending on the measurement (Houston, et al. [6], Oladipo [21], Telfer and Woodburn [22], Tsung, et al. [23], Xiong, et al. [25]). Additional critical factors affecting L&M include the following:

- Whether the foot is shod or unshod
- Whether the foot is fleshy or bony, i.e., soft tissue
- Whether the foot is wrapped, e.g., wearing a sock or in a cast
- Whether the arch of the foot is raised or flattened, i.e., the windlass mechanism

3D CAD software for footwear design is different from CAD software for clothing design as the whole process is based on the shoe last and not directly based on the human body. Shoe lasts are not the 3D representation of the ideal foot that fits the shoe, but rather a constructive component of shoe manufacturing. Shoe lasts are used to define the final shape of the shoes, are impacted by the intended usage of the shoes, and are directly related to shoe fit. The use of lasts for shoe development dictates two approaches for foot scanning. The foot is either scanned with the intent of creating a last for product development or creating a model of the foot for product fitting. Scanning to create a model for fitting is further complicated by the dynamic change in foot shape with flexing and movement.

The shape of the shoe is not based on static criteria. Foot dynamics, inner structure, and soft tissue wrapping/compression play an important role in shoe design and must be accounted for in the foot scan.

### 3. Landscape of existing standards

Independent organizations such as ISO, ASTM, and ISAK have already developed standards that are related to these topics, which cover partially the objectives of the 3DBP use cases. In particular:

- ISO 8559-1:2017 [9] and ASTM D5219-15 [4] provide body measurement designations and definitions for garment construction
- ISO 7250-1:2017 [4] provides body measurement designations definitions for ergonomic design
- ISAK [7] provides body measurement designations and definitions for shape tracking in health, sports and fitness
- ISO/TS 19408 [15] provides foot measurements designations and definitions
- ISO 18825-1 [10] and ISO 18825 2 [11] provide measurement and landmark definitions for virtual models used in fashion applications
- ISO 20685 [12] and ISO/DIS 20685-1 [13] provide 3D body scanning attire, compatibility thresholds between traditional and digital body measurements
- ISO 20685-2 [14] provides testing and reporting procedures for spatial quality of unanimated objects (sphere), as well as procedures for landmark repeatability of life-size human dummies and determination of hidden areas.

This white paper focuses on the differences and gaps of the landmarks and measurements mentioned in the standards shown in Figure 2 and Table 1. Any gaps in testing methods, thresholds, reference values, and test bench datasets may be addressed in future white papers.

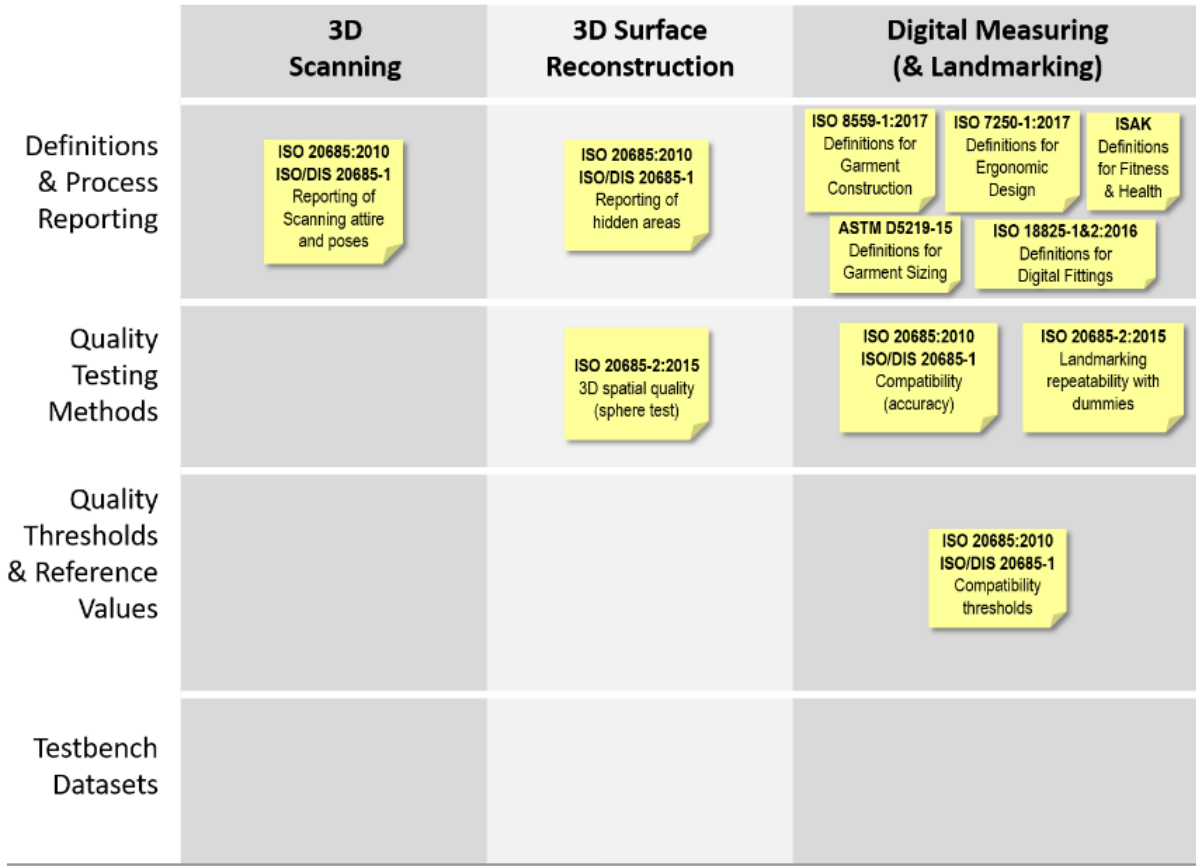


Figure 2 : Map of current coverage of existing standards and gaps to be covered by the Quality Sub-group, McDonald [20]

Table 1 : Lists of reviewed standards

ISO 8559-1:2017 and ASTM D5219-15	<ul style="list-style-type: none"> <li>Body measurement and landmarks definitions for garment construction (traditional perspective)</li> </ul>
ISO 7250-1:2017	<ul style="list-style-type: none"> <li>Body measurement and landmark definitions for ergonomic design (traditional perspective)</li> </ul>
ISAK	<ul style="list-style-type: none"> <li>Body measurement definitions for health, sports and fitness</li> </ul>
ISO 18825-1:2016 and ISO 18825-2:2016	<ul style="list-style-type: none"> <li>Body measurement and landmark definitions for virtual models (digital perspective)</li> </ul>
ISO 20685:2010 (ISO/DIS 20685-1)	<ul style="list-style-type: none"> <li>3D body scanning attire</li> <li>Compatibility thresholds between traditional and digital measurements</li> </ul>
ISO 20685-2:2015	<ul style="list-style-type: none"> <li>Procedures for evaluating spatial accuracy of 3D body scanners</li> <li>Procedures for landmarking repeatability of objects (life-size human dummies)</li> <li>Reporting of hidden areas in 3D scanning of human bodies</li> </ul>

Appendix A summarizes each of the standards listed in Table 1. Appendix B provides the full list of designations of L&M used in each of the standards. The list includes L&M of full body and body parts, namely head, feet, and hands.

Within 3DBP initiative, the quality sub-group makes use of the existing definitions, procedures, and thresholds, and aims at filling the gaps required for regulating the 3DBP use cases that are not currently covered by them. Thus, the main aims are as follows:

- Defining a procedure for reporting user-defined measurements beyond standard definitions enabling their interoperability.
- Defining procedures for qualifying and/or quantifying 3D quality of digitized bodies of living human bodies.
- Defining procedures for quantifying reliability of body measurements and landmarks extracted from digitized bodies.
- Defining procedures for quantifying compatibility across body measuring methods including both the digital and traditional methods.
- Generating resources and reference quality data (benchmarks) related to the reliability and compatibility of 3D surfaces, measurements, and landmarks of living humans.
- Establishing acceptability thresholds of reliability and compatibility for the different applications and industry use cases.

#### **4. Detailed comparison of preferred landmarks and measurements from use cases**

L&M are basic building blocks for designs that are based on the human body. It is therefore critical for interoperability that all practitioners in the field agree on a small standardized set of landmarks and measurements for use in conjunction with 3D body models. This includes definitions of L&M (the location on the human body) as well as the use of a common terminology (one set of names) for each landmark and measurement.

While there is a general agreement about landmarks and measurements between the standards, the actual names or locations given these items may differ. Additionally, some items exist in one standard and not in another.

The intention is to leverage the work done leading up to the current standards (mainly ISO 7250-1 [8] and ISO 8559-1 [9]) for the definition of L&M to be supported by preferred definitions.

The members of the 3DBP group are companies involved in 3D body processing (size recommendations, virtual fit, apparel CAD tools, body simulation, etc.). Together, the group reviewed many use cases and arrived at a list of twenty-six landmarks for full body scanning as a minimum set needed to allow the reviewed use cases. Those landmarks are used to generate corresponding body measurements or for other goals (e.g., garment simulation).

The recommended landmarks and measurements are applicable to the use cases of retail, product development, and CAD developers. Further L&M may be added as additional use cases are explored.

Based on current practices of landmark identification in industry, as well as a comparison of ISO 7250-1 [8] and ISO 8559-1 [9], we concluded that ISO 8559-1 is a more appropriate information source than ISO 7250-1 [8], especially when it comes to 3D body processing. The

recommendation of this white paper is to follow ISO 8559-1 [9] definitions unless otherwise specified. We decided to use ISO 8559-1 [9] for the majority of L&M because of the following:

- The designations used in ISO 7250-1 [8] are based on anthropometric terminologies.
- The designations used in ISO 8559-1 [9] are easier to understand or make more sense for people without any knowledge in medical anatomy nomenclature. Additionally, ISO 8559-1 [9] contains more detailed information with updated figures.

Some landmarks needed to support the use cases are defined in only one of the standards. In most instances, more landmarks are defined in ISO 8559-1 [9].

- Six landmarks defined in ISO 8559-1 are not included in ISO 7250-1.
- Only one landmark (vertex) in ISO 7250-1 is not defined in ISO 8559-1. This landmark is used for height measurement.

Landmarks are defined differently in the ISO standards. Twelve landmarks are defined identically but have different names; other landmarks share the same names but have varied levels of differences in their definitions.

### Required landmarks from use cases for full body

The standards compared have the L&M determined by traditional methods as explained in the introduction. The following tables provide details of twenty-seven landmarks that are being recommended by the 3DBP group contributors from CLO, Gerber, Browzwear, TC<sup>2</sup>, Zelus, and Intel for full body scanning. Table 2 describes the comparison between the standards and recommendation. Table 3 contains measurements that utilize the landmarks in the same format as Table 2. This is repeated for Table 4, Table 5, and Table 6 for body regions of head, foot and hand.

If there is no further comment within the table cells, the definitions of a landmark in ISO 7250-1 and ISO 8559-1 are identical, even though the actual terminology/name may be different. A table cell marked with an asterisk (\*) indicates a difference from the definition of ISO 8559-1.

Any landmark or measurement that is noted as “(L & R)” must be determined bilaterally. Those that can be measured or marked in one side only are noted as “(L or R)”; in such cases, it is recommended to use the largest or highest side and record which side is utilized.

**PLEASE NOTE: There are known discrepancies between standard definitions. Where direct comparisons between these standards could not be found, definitions with a close correlation were chosen.**

**Table 2 : List of landmarks and reference to the standard describing the definition**

	Terminology <sup>6</sup>	Recommended standard	ISO 8559-1	ISO 7250-1	ISAK
1	Armpit Back Fold Point (L & R)	ISO 8559-1:2017, 3.1.14	3.1.14 Armpit back fold point	NA	NA
2	Armpit Front Fold Point (L & R)	ISO 8559-1:2017, 3.1.13	3.1.13 Armpit front fold point	NA	NA
3	Back Neck Point	ISO 8559-1:2017,	3.1.6 Back neck	5.3 Cervicale	NA

*Table continues*

<sup>6</sup> (L & R) indicates that the landmark should be located at the Left and Right sides of the body. (L or R) indicates that the Landmark can be located at either the Left or Right sides of the body.

	Terminology <sup>6</sup>	Recommended standard	ISO 8559-1	ISO 7250-1	ISAK
		3.1.16	point		
4	Bust Point (L & R)	ISO 8559-1:2017, 3.1.11 (females), ISO 7250 -1:2017, 5.17, Thelion (males)	3.1.11 Bust point	5.18 Thelion	NA
5	Centre Point of Kneecap (L or R)	ISO 8559-1:2017, 3.1.17	3.1.17 Centre point of kneecap	5.17 Surprapatella, sitting*	Anterior patella*
6	Elbow Point (L or R)	ISO 8559-1: 2017, 3.1.10	3.1.10 Elbow points	5.12 Olecranon*	Radiale*
7	Front Neck Point	ISO 8559-1:2017, 3.1.8	3.1.8 Front neck point	NA	NA
8	Highest Point of the Hip Bone (L & R)	ISO 8559-1:2017, 3.1.16	3.1.16 Highest point of the hip bone	5.7 Illiospinale anterius*	Illospinale*
9	Hip Level	ISO 8559-1:2017, 3.1.25	3.1.25 Hip Level	NA	Gluteal*
10	Inside Leg Level	ISO 8559-1:2017, 3.1.26	3.1.26 Inside leg level	5.4 Crotch level*	NA
11	Lowest Rib Point (L & R)	ISO 8559-1:2017, 3.1.15	3.1.15 Lowest rib point	5.8 Lowest point of the rib cage	NA
12	Waist Level	ISO 8559-1:2017, 3.1.22	3.1.22 Waist level	6.4.11 Waist circumference	Waist* <sup>7</sup>
13	Side Neck Point (L or R)	ISO 8559-1:2017, 3.1.7	3.1.7 Side neck point	NA	NA
14	Shoulder Point (L & R)	ISO 8559-1:2017, 3.1.1	3.1.1 Shoulder point	5.2 Acromion	Acromiale
15	Wrist Point <sup>8</sup> (L or R)	ISO 8559-1:2017, 3.1.19	3.1.19 Wrist point	5.21 Ulnar Stylium*	NA
16	Under Bust Level (L & R)	ISO 8559-1:2017, 3.1.20	3.1.20 Under bust level	NA	NA
17	Akropodion <sup>9</sup> (L or R)	ISAK, Section 2.2	NA	NA	Akropodion
18	Centre Chest Point	ISO 8559-1:2017, 3.1.12	3.1.12 Centre chest point	5.10 Mesosternale	Mesosternale
19	Centre Point of Brow Ridge	ISO 8559-1:2017, 3.1.2	3.1.2 Centre point of brow ridge	5.6 Glabella	Glabella
20	Dactylion <sup>10</sup> (L or R)	ISAK	NA	NA	Dactylion
21	Lowest Point of Chin	ISO 8559-1:2017, 3.1.5	3.1.5 Lowest point of chin	5.9 Menton	NA
22	Orbitale <sup>11</sup> (L or R)	ISO 8559-1:2017, 3.1.4	3.1.4 Orbitale	5.13 Orbitale	Orbitale
23	Outer Ankle Point (L or R)	ISO 8559-1:2017, 3.1.18	3.1.18 Outer ankle point	NA	NA
24	Sellion <sup>12</sup>	ISO 7250-1:2017, 5.14	NA	5.15 Sellion	NA

*Table continues*

<sup>7</sup> The level is measured at the narrowest point between 10th rib border and the iliac crest

<sup>8</sup> Wrist point at outside, close to pinky finger

<sup>9</sup> The tip of the longest toe

<sup>10</sup> The tip of the middle finger

<sup>11</sup> Lowest point of the lower border of the orbital margin (lower edge of the eye socket)

<sup>12</sup> Center of the lowest part of nose-bridge. Point of greatest indentation of the nasal root depression, in the midsagittal plane, while the head is held in the Frankfurt plane

	Terminology <sup>6</sup>	Recommended standard	ISO 8559-1	ISO 7250-1	ISAK
25	Radial Styliion <sup>13</sup> (L or R)	ISO 7250-1:2017, 5.15	NA	5.16 Styliion (Radial Styliion)	Styliion
26	Tragion <sup>14</sup> (L or R)	ISO 8559-1:2017, 3.1.3	3.1.3 Tragion	5.20 Tragion	Tragion
27	Vertex <sup>15</sup>	ISO 7250-1 :2017, 5.21	NA, but mentioned as the highest point of head.	5.22 Vertex (top of head)	Vertex

**PLEASE NOTE:** There are known discrepancies between standard definitions. Where direct comparisons between these standards could not be found, definitions with a close correlation were chosen.

**Table 3 : List of measurements and reference to the standard describing the definition**

	Terminology	Recommended standard	ISO 8559-1	ISO 7250-1	ISAK
1	Across Back Shoulder Width	ISO 8559-1:2017, 5.4.3	5.4.3 Across back shoulder width	NA	NA
2	Arm Length (L or R)	ISO 8559-1:2017, 5.7.8	5.7.8 Arm Length	NA	#25+ #26*
3	Back Neck Point to Waist	ISO 8559-1:2017, 5.4.5	5.4.5	NA	NA
4	Body Mass	ISO 8559-1:2017, 5.6.1	5.6.1	6.1.1	Section 3.2-1
5	Bust/Chest Girth	ISO 8559-1:2017, 5.3.4	5.3.4	6.4.10	#18*
6	Inside Leg Height	ISO 8559-1:2017, 5.1.15	5.1.15	NA	NA
7	Diagonal Trunk Girth	ISO 8559-1:2017, 5.3.27	5.3.27	NA	NA
8	Elbow-Wrist Length (L or R)	ISO 8559-1:2017, 5.4.15	5.4.15	NA	#26*
9	Knee Girth (L or R)	ISO 8559-1:2017, 5.3.22	5.3.22	NA	NA
10	Hip Girth	ISO 8559-1:2017, 5.3.13	5.3.13	NA	#20
11	Neck Girth	ISO 8559-1:2017, 5.3.2	5.3.2	6.4.9	#13*
12	Stature	ISO 8559-1:2017, 5.1.1	5.1.1	6.1.2	Section 3.2-2*
13	Thigh Girth (L or R)	ISO 8559-1:2017, 5.3.20	5.3.20	6.4.13	#21
14	Total Crotch Length	ISO 8559-1:2017, 5.4.18	5.4.18	NA	NA
15	Upper Arm Girth (L or R)	ISO 8559-1:2017, 5.3.16	5.3.16	NA	#14*
16	Waist Girth	ISO 8559-1:2017, 5.3.10	5.3.10	6.4.11	#19*
17	Wrist Girth (L or R)	ISO 8559-1:2017, 5.3.19	5.3.19	6.4.12*	#17*
18	Under Bust Girth	ISO 8559-1:2017, 5.3.8	5.3.8	NA	NA
19	Across Back Width	ISO 8559-1:2017, 5.4.4	5.4.4	NA	NA
20	Across Front Width	ISO 8559-1:2017, 5.4.7	5.4.7	NA	#36*
21	Calf Circumference (L or R)	ISO 8559-1:2017, 5.3.24	5.3.24	6.4.14	#23
22	Elbow Circumference (L or R)	ISO 8559-1:2017, 5.3.17	5.3.17	NA	NA
23	Elbow Height, standing (L or R)	ISO 7250-1:2017, 6.1.5	NA	6.1.5	NA
24	Foot Breadth (L or R)	ISO 8559-1:2017, 5.5.6	5.5.6	6.3.8	NA
25	Foot Length (L or R)	ISO 8559-1:2017, 5.5.5	5.5.5	6.3.7	#32
26	Front Neck Point to Waist	ISO 8559-1:2017, 5.4.8	5.4.8	NA	NA
27	Upper Hip Girth	ISO 8559-1:2017, 5.3.11	5.3.11	NA	NA
28	Top Hip Girth	ISO 8559-1:2017, 5.3.12	5.3.12	NA	NA
29	Illiatic Spine Height, standing	ISO 7250-1:2017, 6.1.6	NA	6.1.6	#28
30	Neck Point to Breast Point (L & R)	ISO 8559-1:2017, 5.4.12	5.4.12	NA	NA

*Table continues*

<sup>13</sup> Wrist point at inside, close to thumb

<sup>14</sup> Point of the notch just above the tragus (the small cartilaginous flap in front of the ear hole)

<sup>15</sup> Top of the head in the midsagittal plane while the head is held in the Frankfurt plane

	Terminology	Recommended standard	ISO 8559-1	ISO 7250-1	ISAK
31	Neck Point to Breast Point to Waistline (L & R)	ISO 8559-1:2017, 5.4.13	5.4.13	NA	NA
32	Outside Leg Length (L or R)	ISO 8559-1:2017, 5.4.22	5.4.3	NA	#30 + #31*
33	Scye Depth	ISO 8559-1:2017, 5.4.6	5.4.6	NA	NA
34	Back Shoulder Width	ISO 8559-1:2017, 5.4.2	5.4.2	NA	#34*
35	Shoulder Height (L or R)	ISO 7250-1:2017, 6.1.4	NA	6.1.4	NA
36	Shoulder Length (L or R)	ISO 8559-1:2017, 5.4.1	5.4.1	NA	NA
37	Side Waist to Hip	ISO 8559-1:2017, 5.4.21	5.4.21	NA	NA
38	Knee Height (L or R)	ISO 8559-1:2017, 5.1.16	5.1.16	NA	#31*
39	Back Neck Point to Ground (contoured)	ISO 8559-1:2017, 5.4.23	5.4.23	NA	NA

\*Definition is different from that of ISO 8559-1:2017.

## Body regions

In addition, improvement and/or clarification is needed especially for body regions such as head, foot, and hands. Added tables for these regions are listed in the following section in the same format as the full body scanning requirements. Landmarks and measurements are combined in 0 through Table 6 for body regions of head, foot and hand. Since the foot is covered in more detail in ISO/TS 19408 [15], this standard is used for comparison with ISO 8559-1 [9] and the INFOOT system by I-Ware Laboratory [16].

**PLEASE NOTE: There are known discrepancies between standard definitions. Where direct comparisons between these standards could not be found, definitions with a close correlation were chosen.**

**Table 4 : Basic anthropometric measurements for head**

	Terminology	Recommended standard	ISO 7250-1	ISO 8559-1	ISAK
1	Head length	ISO 7250-1:2017, 6.3.9	6.3.9	NA	NA
2	Head breadth	ISO 7250-1:2017, 6.3.10	6.3.10	NA	NA
3	Face length	ISO 7250-1:2017, 6.3.11	6.3.11	NA	NA
4	Head circumference	ISO 7250-1:2017, 6.3.12	6.3.12	5.3.1	#12
5	Inter-pupillary breadth, (L & R)	NA	NA	NA	NA
6	Face breadth zygomatic breadth	NA	NA	NA	NA
7	Fore-aft distance from the ears to the bridge of the nose	NA	NA	NA	NA

**Table 5 : Basic anthropometric measurements for hands**

	Terminology	Recommended standard	ISO 8559-1	ISO 7250-1	ISSK
1	Hand length (L or R)	ISO 8559-1:2017, 5.5.2	5.5.2	6.3.1*	#27*
2	Palm length perpendicular (L or R)	ISO 8559-1:2017, 5.5.3	5.5.3	6.3.2*	NA
3	Hand girth (L or R)	ISO 8559-1:2017, 5.5.1	5.5.1	6.3.3*	NA
4	Middle finger length (L or R)	NA	NA	NA	NA

\*Definition is different from that of ISO 8559-1:2017.



**PLEASE NOTE: There are known discrepancies between standard definitions. Where direct comparisons between these standards could not be found, definitions with a close correlation were chosen.**

**Table 6 : Basic anthropometric landmarks and measurements for feet**

	Terminology	Recommended standard	ISO 8559-1	ISO/TS 19408	I-Ware
1	Foot length (L or R)	I-Ware 0	5.5.5	2.1.4	0
2	Ball girth circumference (L or R)	I-Ware 1	5.5.7	2.1.8	1
3	Foot breadth	I-Ware 2	5.5.6*	2.1.10	2
4	Instep circumference	I-Ware 3	NA	NA	3
5	Heel breadth	I-Ware 4	NA	NA	4
6	Instep length	I-Ware 5	NA	NA	5
7	Fibulare Instep length	I-Ware 6	NA	NA	6
8	Height of Top of Ball Girth	I-Ware 7	NA	NA	7
9	Height of Instep†	I-Ware 8	NA	2.1.7	8
10	Sphyrion Fibulare	I-Ware 14	NA	NA	14
11	Heel circumference	I-Ware 20	NA	2.1.16*	20

\*Definition is different from that of the recommended standard.

†Landmark

### Required digital landmarks from use cases for full body

The following tables provide details of the same L&M that were determined by traditional methods and are now determined by digital methods. The locations and values of L&M may be different between the traditional and digital methods. A comparison between the traditional L&M and the digital L&M locations and values will be presented in a future white paper.

**PLEASE NOTE: There are known discrepancies between standard definitions. Where direct comparisons between these standards could not be found, definitions with a close correlation were chosen.**

**Table 7 : Lists of landmarks and reference to the standard describing the definition**

	Terminology <sup>16</sup>	Recommended standard	ISO 8559-1	ISO 18825-2
1	Armpit Back Fold Point (L & R)	ISO 8559-1:2017, 3.1.14	3.1.14 Armpit back fold point	2.1.8 Virtual front axillia point
2	Armpit Front Fold Point (L & R)	ISO 8559-1:2017, 3.1.13	3.1.13 Armpit front fold point	2.1.9 Virtual back axillia point
3	Back Neck Point	ISO 8559-1:2017, 3.1.16	3.1.6 Back neck point	2.1.5 Virtual back neck-base point
4	Bust Point (L & R)	ISO 8559-1:2017, 3.1.11 (females), ISO 7250 -1:2017, 5.17, Thelion (males)	3.1.11 Bust point	2.1.10 Virtual bust point
5	Centre Point of Kneecap (L or R)	ISO 8559-1:2017, 3.1.17	3.1.17 Centre point of kneecap	2.1.22 Virtual knee point

*Table continues*

<sup>16</sup> (L & R) indicates that the landmark should be located at the Left and Right sides of the body. (L or R) indicates that the Landmark can be located at either the Left or Right sides of the body.

	Terminology <sup>16</sup>	Recommended standard	ISO 8559-1	ISO 18825-2
6	Elbow Point (L or R)	ISO 8559-1: 2017, 3.1.10	3.1.10 Elbow points	2.1.17 Virtual elbow point
7	Front Neck Point	ISO 8559-1:2017, 3.1.8	3.1.8 Front neck point	2.1.3 Virtual front neck-base point
8	Waist Level	ISO 8559-1:2017, 3.1.22	3.1.22 Waist level	2.1.12 Virtual side waist point
9	Highest Point of the Hip Bone (L & R)	ISO 8559-1:2017, 3.1.16	3.1.16 Highest point of the hip bone	NA
10	Hip Level	ISO 8559-1:2017, 3.1.25	3.1.25 Hip Level	2.1.15 Virtual hip point
11	Inside Leg Level	ISO 8559-1:2017, 3.1.26	3.1.26 Inside leg level	2.1.16 Virtual crotch point
12	Lowest Rib Point (L & R)	ISO 8559-1:2017, 3.1.15	3.1.15 Lowest rib point	NA
13	Side Neck Point (L or R)	ISO 8559-1:2017, 3.1.7	3.1.7 Side neck point	2.1.4 Virtual side neck-base point
13	Shoulder Point (L & R)	ISO 8559-1:2017, 3.1.1	3.1.1 Shoulder point	2.1.6 Virtual shoulder point
14	Wrist Point <sup>17</sup> (L or R)	ISO 8559-1:2017, 3.1.19	3.1.19 Wrist point	2.1.18 Virtual wrist point
15	Under Bust Level (L & R)	ISO 8559-1:2017, 3.1.20	3.1.20 Under bust level	2.1.11 Virtual underbust point
16	Akropodion <sup>18</sup> (L or R)	ISAK, in Section 2.2	NA	NA
17	Centre chest point	ISO 8559-1:2017, 3.1.12	3.1.12 Centre chest point	NA
18	Centre Point of Brow Ridge	ISO 8559-1:2017, 3.1.2	3.1.2 Centre point of brow ridge	Table 5, row 3, Virtual centre eyebrow point
19	Dactylion <sup>19</sup> (L or R)	ISAK	NA	2.1.19 Virtual middle finger tip point
20	Lowest Point of Chin	ISO 8559-1:2017, 3.1.5	3.1.5 Lowest point of chin	Table 5, row 7, Virtual jaw point
21	Orbitale <sup>20</sup> (L or R)	ISO 8559-1:2017, 3.1.4	3.1.4 Orbitale	NA
22	Outer Ankle Point (L or R)	ISO 8559-1:2017, 3.1.18	3.1.18 Outer ankle point	2.1.25 Virtual outside ankle point
23	Sellion <sup>21</sup>	ISO 7250-1:2017, 5.14	NA	Table 5, row 2, Virtual Sellion point
24	Radial Styli <sup>22</sup> (L or R)	ISO 7250-1:2017, 5.15	NA	NA
25	Tragion <sup>23</sup> (L or R)	ISO 8559-1:2017, 3.1.3	3.1.3 Tragion	Table 5, row 6, Virtual Tragion point

*Table continues*

<sup>17</sup> Wrist point at outside, close to pinky finger

<sup>18</sup> The tip of the longest toe

<sup>19</sup> The tip of the middle finger

<sup>20</sup> Lowest point of the lower border of the orbital margin (lower edge of the eye socket)

<sup>21</sup> Center of the lowest part of nose-bridge. Point of greatest indentation of the nasal root depression, in the midsagittal plane, while the head is held in the Frankfurt plane

<sup>22</sup> Wrist point at inside, close to thumb

<sup>23</sup> Point of the notch just above the tragus (the small cartilaginous flap in front of the ear hole)

	Terminology <sup>16</sup>	Recommended standard	ISO 8559-1	ISO 18825-2
26	Vertex <sup>24</sup>	ISO7250-1 :2017, 5.21	NA, but mentioned as the highest point of head	2.1.1 Virtual top head point

**PLEASE NOTE:** There are known discrepancies between standard definitions. Where direct comparisons between these standards could not be found, definitions with a close correlation were chosen.

**Table 8 : List of measurements and reference to the standard describing the definition**

	Terminology	Recommended standard	ISO 8559-1	ISO 18825-2
1	Across Back Shoulder Width	ISO 8559-1:2017, 5.4.3	5.4.3 Across back shoulder width	2.2.8 Virtual shoulder width
2	Outer Arm Length (L or R)	ISO 8559-1:2017, 5.7.8	5.7.8 Outer arm length	2.2.10 Virtual arm length
3	Back Neck Point to Waist	ISO 8559-1:2017, 5.4.5	5.4.5	2.2.9 Virtual back waist length
4	Body Mass	ISO 8559-1:2017, 5.6.1	5.6.1	NA
5	Bust/Chest Girth	ISO 8559-1:2017, 5.3.4	5.3.4	2.2.18 Virtual bust girth
6	Inside Leg Height	ISO 8559-1:2017, 5.1.15	5.1.15	2.2.5 Virtual crotch height, virtual inside leg length
7	Diagonal Trunk Girth	ISO 8559-1:2017, 5.3.27	5.3.27	NA
8	Elbow-Wrist Length (L or R)	ISO 8559-1:2017, 5.4.15	5.4.15	NA
9	Knee Girth (L or R)	ISO 8559-1:2017, 5.3.22	5.3.22	2.2.25 Virtual knee girth
10	Hip Girth	ISO 8559-1:2017, 5.3.13	5.3.13	2.2.22 Virtual hip girth
11	Neck Girth	ISO 8559-1:2017, 5.3.2	5.3.2	2.2.11 Virtual neck girth
12	Stature	ISO 8559-1:2017, 5.1.1	5.1.1	2.2.1 Virtual height
13	Thigh Girth (L or R)	ISO 8559-1:2017, 5.3.20	5.3.20	2.2.23 Virtual thigh girth
14	Total Crotch Length	ISO 8559-1:2017, 5.4.18	5.4.18	NA
15	Upper Arm Girth (L or R)	ISO 8559-1:2017, 5.3.16	5.3.16	2.2.14 Virtual upper arm girth
16	Waist Girth	ISO 8559-1:2017, 5.3.10	5.3.10	2.2.20 Virtual waist girth
17	Wrist Girth (L or R)	ISO 8559-1:2017, 5.3.19	5.3.19	2.1.16 Virtual wrist girth
18	Under Bust Girth	ISO 8559-1:2017, 5.3.8	5.3.8	2.2.19 Virtual underbust girth
19	Across Back Width	ISO 8559-1:2017, 5.4.4	5.4.4	NA
20	Across Front Width	ISO 8559-1:2017, 5.4.7	5.4.7	NA
21	Calf Circumference (L or R)	ISO 8559-1:2017, 5.3.24	5.3.24	2.2.26 Virtual calf girth

*Table continues*

<sup>24</sup> Top of the head in the midsagittal plane while the head is held in the Frankfurt plane

	Terminology	Recommended standard	ISO 8559-1	ISO 18825-2
22	Elbow Circumference (L or R)	ISO 8559-1:2017, 5.3.17	5.3.17	2.2.15 Virtual elbow girth
23	Elbow Height, standing (L or R)	ISO 7250-1:2017, 6.1.5	NA	NA
24	Foot Breadth (L or R)	ISO 8559-1:2017, 5.5.6	5.5.6	NA
25	Foot Length (L or R)	ISO 8559-1:2017, 5.5.5	5.5.5	NA
26	Front Neck Point to Waist	ISO 8559-1:2017, 5.4.8	5.4.8	NA
27	Upper Hip Girth	ISO 8559-1:2017, 5.3.11	5.3.11	NA
28	Top Hip Girth	ISO 8559-1:2017, 5.3.12	5.3.12	NA
29	Iliac Spine Height, standing	ISO 7250-1:2017, 6.1.6	NA	NA
30	Neck Point to Breast Point (L & R)	ISO 8559-1:2017, 5.4.12	5.4.12	NA
31	Neck Point to Breast Point to Waistline (L & R)	ISO 8559-1:2017, 5.4.13	5.4.13	NA
32	Outside Leg Length (L or R)	ISO 8559-1:2017, 5.4.22	5.4.3	NA
33	Scye Depth	ISO 8559-1:2017, 5.4.6	5.4.6	NA
34	Back Shoulder Width	ISO 8559-1:2017, 5.4.2	5.4.2	NA
35	Shoulder Height (L or R)	ISO 7250-1:2017, 6.1.4	NA	NA
36	Shoulder Length (L or R)	ISO 8559-1:2017, 5.4.1	5.4.1	NA
37	Side Waist to Hip	ISO 8559-1:2017, 5.4.21	5.4.21	NA
38	Knee Height (L or R)	ISO 8559-1:2017, 5.1.16	5.1.16	2.2.6 Virtual knee height
39	Back Neck Point to Ground (contoured)	ISO 8559-1:2017, 5.4.23	5.4.23	NA

## Digital body regions

In addition, improvement and/or clarification is needed especially for body regions such as head, foot, and hands. Added tables for these regions are listed in the following section in the same format as the full body scanning requirements. Landmarks and measurements are combined in Table 9 through Table 11 for body regions of head, foot and hand. Since the foot is covered in more detail in ISO/TS 19408 [15], this standard is used for comparison with ISO 8559-1 [9] and I-Ware [16].

**PLEASE NOTE: There are known discrepancies between standard definitions. Where direct comparisons between these standards could not be found, definitions with a close correlation were chosen.**

**Table 9 : Basic anthropometric measurements for head**

	Terminology	Recommended standard	ISO 7250-1	ISO 18825-2
1	Head length	ISO 7250-1:2017, 6.3.9	6.3.9	Table 6, row 7, Virtual Head Depth
2	Head breath	ISO 7250-1:2017, 6.3.10	6.3.10	Table 6, row 4, Virtual Head Width
3	Face length	ISO 7250-1:2017, 6.3.11	6.3.11	Table 6, row 2, Virtual Face Length
4	Head circumference	ISO 7250-1:2017, 6.3.12	6.3.12	Table 6, row 3, Virtual Head Girth
5	Inter-pupillary breadth, (L & R)	NA	NA	Table 6, row 6, Virtual Eyeball Width

*Table continues*

	Terminology	Recommended standard	ISO 7250-1	ISO 18825-2
6	Face breadth zygomatic breadth	NA	NA	NA
7	Fore-aft distance from the ears to the bridge of the nose	NA	NA	NA

**PLEASE NOTE: There are known discrepancies between standard definitions. Where direct comparisons between these standards could not be found, definitions with a close correlation were chosen.**

**Table 10: Basic anthropometric measurements for hands**

	Terminology	Recommended standard	ISO 8559-1	ISO 18825-2
1	Hand length (L or R)	ISO 8559-1:2017, 5.5.2	5.5.2	Table 10, row 1, Virtual Hand Length
2	Palm length perpendicular (L or R)	ISO 8559-1:2017, 5.5.3	5.5.3	Table 10, row 2, Virtual Palm Length
3	Hand girth (L or R)	ISO 8559-1:2017, 5.5.1	5.5.1	Table 10, row 4, Virtual Hand Width
4	Middle finger length (L or R)	NA	NA	Table 10, row 13, Virtual Middle Finger Length

Digital definitions for feet are not mentioned in ISO 18825-2.

**PLEASE NOTE: There are known discrepancies between standard definitions. Where direct comparisons between these standards could not be found, definitions with a close correlation were chosen.**

**Table 11: Basic anthropometric landmarks and measurements for feet**

	Terminology	Recommended standard	ISO 8559-1	I-Ware
1	Foot length (L or R)	I-Ware 0	5.5.5	0
2	Ball girth circumference (L or R)	I-Ware 1	5.5.7	1
3	Foot breadth	I-Ware 2	5.5.6	2
4	Instep circumference	I-Ware 3	NA	3
5	Heel breadth	I-Ware 4	NA	4
6	Instep length	I-Ware 5	NA	5
7	Fibulare Instep length	I-Ware 6	NA	6
8	Height of Top of Ball Girth	I-Ware 7	NA	7
9	Height of Instep	I-Ware 8	NA	8
10	Sphyrion Fibulare	I-Ware 14	NA	14
11	Heel circumference	I-Ware 20	NA	20

## 5. Summary and recommendations

This white paper is the second in a series of papers that describes the 3D Body-model Processing (3DBP) Industry Connections group recommendations to the IEEE P3141, Draft Standard for 3D

Body Processing Committee. The first paper gave the rationale for a 3DBP standard as well as an overview of the possible benefits to the industry.

This white paper provided a review of existing standards that are relevant to the 3DBP initiative. Landmark and measurement definitions in many standards were compared and a short list of twenty-seven landmarks and thirty-nine measurements were recommended for inclusion in 3D body model files. The L & M definitions and terminology are mostly based on ISO 8559-1 and use other sources when needed landmarks and measurements are not defined in ISO 8559-1. These L&M that are based off of traditional methods were then compared to the digital definitions in ISO 18825-2 [11].

Current 3D body-model files do not contain information that can help assess the accuracy of the model they represent. The 3DBP group is investigating possible ways to deal with this issue. A discussion of model accuracy and what (if anything) can be said about model accuracy is the topic of another white paper, intended to be published later in 2018. Along with accuracy, the other topics to be presented in future white papers are as following:

1. Dealing with user-defined measurements from a purely digital perspective (from 3D body models) beyond standard definitions, which is the case of most body, foot, and head/face scanner manufacturers. In addition, a recommended procedure on how to report the measurements for interoperability will be presented.
2. Dealing with 3D quality of digitized body shapes of living human subjects, addressing both accuracy/validity and precision/reliability. The basis for calculation for precision, reliability, and accuracy will be proposed so that the error ranges are defined in universal recognized methods.
3. Dealing with tracking reliability of measurements and landmarks—this is the consistency of repeated measurements from the same person scanned at different instants. The basis for calculation for precision and reliability will be proposed so that the error ranges are defined in universal recognized methods
4. Dealing with compatibility and interoperability between measurements taken with different methods/sources, both between manual to digital and among digital thereby improving traceability. In addition, a recommended procedure on how to gather and report reference data will be presented.

## 6. Citations

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## Appendix A

### Summary of content of 3DBP-related standards

#### ISO 7250-1 (2017)

*Basic human body measurements for technological design—Part 1: Body measurement definitions and landmarks*

The 2017 version defines 21 landmarks and 62 body measurements. The standard provides the following:

- Reference to measurement conditions and the type of equipment used
- Landmark definitions
- Body measurement definitions:
  - While subject stands, a Standing subject
  - While subject sits, a Seated subject
  - Measurements on specific body segments
  - Functional measurements

#### ISO 8559-1 (2017)

*Garment construction and anthropometric surveys—Body dimensions*

The standard contains definitions for 93 body dimensions in the garment industry. Some of these coincide with body measurements defined in ISO 7250-1, while others are specific to measurements of garments.

The standard provides the following:

- Landmark and level definitions
- Line and plane definitions
- Some reference to measuring conditions and apparatus
- Body measurement definitions:
  - Vertical measurements
  - Breadth, width and depth measurements
  - Girth measurements
  - Distance measurements
  - Hand and foot measurements
  - Calculated measurements

#### ISO 20685:2010

*3-D scanning methodologies for internationally compatible anthropometric databases*

- Defines how to measure people and verify the accuracy of the data, so that results are valid for human body measurement databases.
- Refers to ISO 7250-1 for the definition of measurements

- Defines four positions of the human subject (e.g., A-pose; sitting)
- Defines the maximum mean difference allowed between the scanner results and the anthropometrist results, to be considered sufficiently accurate.
- Defines the sample size of scanned people to meet a 95% confidence interval for the mean difference between measured and scanned measurements.
- Lists recommended clothing to use while scanning.
- Provides a protocol for evaluating the comparability between manual and scan-derived measurements.

## ISO 20685-2:2015

*Ergonomics—3-D scanning methodologies for internationally compatible anthropometric databases—Part 2: Evaluation protocol of surface shape and repeatability of relative landmark positions*

This part of ISO 20685 addresses protocols for testing of 3-D surface-scanning systems in the acquisition of human body shape data and measurements.

The standard applies to the landmark positions determined by an anthropometrist. It does not apply to landmark positions automatically calculated by software from the point cloud.

The tests are aimed at verifying:

- The intrinsic accuracy of the scanner using a known-size ball placed at various locations in the scan volume
- The repeatability of landmark placement when the subject stands at slightly different positions within the scan volume

## International Society for the Advancement of Kinanthropometry (ISAK)

*International Standards for Anthropometric Assessment (a guide)*

ISAK created a comprehensive anthropometric guide. They offer anthropometrist training classes and certifications at a number of levels.

## I-Ware Laboratory

Four pages of diagrams for foot landmarks and measurements

## ISO/TS 19408:2015

*Footwear—Sizing—Vocabulary and terminology*

This technical specification defines terms commonly used for measuring feet and lasts and for determining the size of footwear.

Refers to ISO 19407 Footwear—Sizing—Conversion of major sizing systems and ISO 19952, Footwear—Vocabulary

Section 2.1 defines Foot dimensions and shoe sizing and Section 2.2 defines Last dimensions

## Appendix B

### Landmarks and measurements from the existing standards

#### Landmarks from all standards

##### ISO 7250-1: 2017

5.2 Acromion	5.13 Orbitale
5.3 Cervicale	5.14 Opisthocranium
5.4 Crotch level	5.15 Sellion
5.5 Ectocanthus	5.16 Stylium (radial)
5.6 Glabella	5.17 Suprapatella, sitting
5.7 Illiospinale anterius	5.18 Thelion
5.8 Lowest point on rib cage	5.19 Tibiale
5.9 Menton	5.20 Tragion
5.10 Mesosternale	5.21 Ulnar Stylium
5.11 Nuchale	5.22 Vertex (top of head)
5.12 Olecranon	

##### ISO 8559-1:2017

3.1.1 Shoulder point	3.1.16 Highest point of the hip bone
3.1.2 Centre point of brow ridge	3.1.17 Centre point of knee-cap
3.1.3 Tragion	3.1.19 Wrist point
3.1.4 Orbital	3.1.20 Under bust level
3.1.5 Lowest point of chin	3.1.21 Midriff level
3.1.6 Back neck point	3.1.22 Waist level
3.1.7 Front neck point	3.1.23 Upper hip level
3.1.8 Front neck point	3.1.24 Top hip level
3.1.9 'Adam's apple' point	3.1.25 Hip level
3.1.10 Elbow point	3.1.26 Inside leg level
3.1.11 Bust point	3.2.1 Neck base line
3.1.12 Centre chest point	3.2.2 Shoulder line
3.1.13 Armpit front fold point	3.2.3 Armscye line
3.1.14 Armpit back fold point	3.2.4 Midsagittal plane
3.1.15 Lowest rib point	3.2.5 Frankfurt plane

##### ISO 20685-2:2015 (these are the same as in ISO 7250-1)

1 Vertex	14 Thelion, right
2 Tragion, right	15 Thelion, left
3 Tragion, left	16 Illiocristale, right
4 Infraorbitale, right	17 Illiocristale, left
5 Infraorbitale, left	18 Anterior superior iliac spine, right
6 Glabella	19 Anterior superior iliac spine, left
7 Sellion	20 Stylium, right
8 Menton	21 Stylium, left
9 Opisthocranium	22 Ulnar stylium, right
10 Cervicale	23 Ulnar stylium, left
11 Acromion, right	24 Tibiale, right
12 Acromion, left	25 Tibiale, left
13 Mesostenale	26 Lateral malleolus, right

27 Lateral malleolus, left  
28 Suprapatella, right  
29 Suprapatella, left  
30 Neck shoulder point, right  
31 Neck shoulder point, left  
32 Front neck point  
33 Anterior axilla point, right  
34 Anterior axilla point, left  
35 Posterior axilla point, right  
36 Posterior axilla point, left  
37 Omphalion

38 Trochanterion, right  
39 Trochanterion, left  
40 Buttock point, right  
41 Buttock point, left  
42 Radiale, right  
43 Radiale, left  
44 Mid patella, right  
45 Mid patella, left  
46 Sphyrion, right  
46 Sphyrion, left

#### ISAK Guide

Acromiale  
Radiale  
Mid-acromiale-radiale  
Styilion  
Mid-styilion  
Subscapulare  
Mesosternale  
Illiocristale  
Iliospinale  
Trochanterion  
Tibiale laterale

Mid-trochanterion-tibiale laterale  
Tibiale mediale  
Sphyrion tibiale  
Akropodion  
Anterior patella  
Dactyilion  
Glabella  
Orbitale  
Ptemion  
Tragion  
Vertex

#### I-Ware Laboratory

0 Pternion  
1 Landing points  
2 The most medial point of medial malleolus  
3 Sphyrion  
4 The most lateral point of lateral malleolus  
5 Sphyrion fibulare  
6 Navicular  
7 Tuberosity of 5<sup>th</sup> metatarsalis  
8 Metatarsale tibiabile  
9 Metatarsale fibulare

10 Toe #1 joint  
11 Toe #2 joint  
12 Toe #4 joint  
13 Toe #5 joint  
14 Head of second metatarsal  
15 Tentative junction point  
16 Highest point of #1 metatarsal head  
17 Cuneiform  
30 Inside heel born point

#### ISO/TS 19408:2015

2.1.7 Instep point of foot

#### ASTM D5219-15

None listed

#### ISO 18825-2:2016

2.1.1 Virtual top head point  
2.1.2 Virtual neck point  
2.1.3 Virtual front neck-base point  
2.1.4 Virtual side neck-base point  
2.1.5 Virtual back neck-base point  
2.1.6 Virtual shoulder point

2.1.7 Virtual axillia point  
2.1.8 Virtual front axillia point  
2.1.9 Virtual back axillia point  
2.1.10 Virtual bust point  
2.1.11 Virtual underbust point  
2.1.12 Virtual side waist point

2.1.13 Virtual back waist point  
 2.1.14 Virtual abdomen point  
 2.1.15 Virtual hip point  
 2.1.16 Virtual crotch point  
 2.1.17 Virtual elbow point  
 2.1.18 Virtual wrist point  
 2.1.19 Virtual middle finger tip point

2.1.20 Virtual gluteal fold point  
 2.1.21 Virtual mid-thigh point  
 2.1.22 Virtual knee point  
 2.1.23 Virtual calf point  
 2.1.24 Virtual lower leg point  
 2.1.25 Virtual outside ankle point  
 2.1.26 Virtual landing heel point

Table 5

1<sup>st</sup> row Virtual top head point  
 2<sup>nd</sup> row Virtual sellion point  
 3<sup>rd</sup> row Virtual centre eyebrow point  
 4<sup>th</sup> row Virtual eyeball point  
 5<sup>th</sup> row Virtual side head point

6<sup>th</sup> row Virtual trigion point  
 7<sup>th</sup> row Virtual jaw point  
 8<sup>th</sup> row Virtual top neck point  
 9<sup>th</sup> row Virtual back head point  
 10<sup>th</sup> row Virtual back head-base point

Table 9

1<sup>st</sup> row Virtual wrist centre point  
 2<sup>nd</sup> row Virtual hand inside point  
 3<sup>rd</sup> row Virtual hand outside point  
 4<sup>th</sup> row Virtual index finger thumb crease point  
 5<sup>th</sup> row Virtual thumb root point  
 6<sup>th</sup> row Virtual thumb first point  
 7<sup>th</sup> row Virtual thumb tip point  
 8<sup>th</sup> row Virtual index finger root point  
 9<sup>th</sup> row Virtual index finger first point  
 10<sup>th</sup> row Virtual index finger second point  
 11<sup>th</sup> row Virtual index finger tip point  
 12<sup>th</sup> row Virtual middle finger root point

13<sup>th</sup> row Virtual middle finger first point  
 14<sup>th</sup> row Virtual middle finger second point  
 15<sup>th</sup> row Virtual middle finger tip point  
 16<sup>th</sup> row Virtual ring finger root point  
 17<sup>th</sup> row Virtual ring finger first point  
 18<sup>th</sup> row Virtual ring finger second point  
 19<sup>th</sup> row Virtual ring finger tip point  
 20<sup>th</sup> row Virtual pinky finger root point  
 21<sup>st</sup> row Virtual pinky finger first point  
 22<sup>nd</sup> row Virtual pinky finger second point  
 23<sup>rd</sup> row Virtual pinky finger tip point

## Measurements from all standards

### ISO 7250-1:2017

6.1.1 Body mass (weight)  
 6.1.2 Stature (body height)  
 6.1.3 Eye height  
 6.1.4 Shoulder height  
 6.1.5 Elbow height  
 6.1.6 Iliac spine height, standing  
 6.1.7 Crotch height  
 6.1.8 Tibial height  
 6.1.9 Chest depth, standing  
 6.1.10 Body depth, standing  
 6.1.11 Chest breadth, standing  
 6.1.12 Hip breadth, standing  
 6.2.1 Sitting height (erect)  
 6.2.2 Eye height, sitting  
 6.2.3 Cervicale height, sitting  
 6.2.4 Shoulder height, sitting  
 6.2.5 Elbow height, sitting  
 6.2.6 Shoulder-elbow length  
 6.2.7 Shoulder (biacromial) breadth  
 6.2.8 Shoulder (bedeltoid) breadth

6.2.9 Elbow-to-elbow breadth  
 6.2.10 Hip breadth  
 6.2.11 Popliteal height, sitting  
 6.2.12 Thigh clearance  
 6.2.13 Knee height, sitting  
 6.2.14 Abdominal depth, sitting  
 6.2.15 Thorax depth at the nipple  
 6.2.16 Buttock-abdomen depth, sitting  
 6.3.1 Hand length (stylium)  
 6.3.2 Palm length  
 6.3.3 Hand breadth at metacarpals  
 6.3.4 Index finger length  
 6.3.5 Index finger breadth, proximal  
 6.3.6 Index finger breadth, distal  
 6.3.7 Foot length  
 6.3.8 Foot breadth  
 6.3.9 Head length  
 6.3.10 Head breadth  
 6.3.11 Face length (menton-sellion)  
 6.3.12 Head circumference

- 6.3.13 Sagittal arc
- 6.3.14 Bitragion arc
- 6.3.15 Thumb length
- 6.3.16 Thumb breadth
- 6.3.17 Hand thickness
- 6.3.18 Hand breadth including thumb
- 6.3.19 Arm circumference flexed
- 6.3.20 Forearm circumference flexed
- 6.4.1 Wall-acromion distance
- 6.4.2 Grip reach; forward reach
- 6.4.3 Elbow-wrist length

- 6.4.4 Elbow-grip length
- 6.4.5 Fist (grip axis) height
- 6.4.6 Forearm-fingertip length
- 6.4.7 Buttock-popliteal length (seat depth)
- 6.4.8 Buttock-knee length
- 6.4.9 Neck circumference
- 6.4.10 Chest circumference
- 6.4.11 Waist circumference
- 6.4.12 Wrist circumference
- 6.4.13 Thigh circumference
- 6.4.14 Calf circumference

#### ISO 8559-1:2017

- 5.1.1 Stature
- 5.1.2 Recumbent length
- 5.1.3 Chin height
- 5.1.4 Front neck height
- 5.1.5 Back neck height
- 5.1.6 Chest height
- 5.1.7 Bust height
- 5.1.8 Under-bust height
- 5.1.9 Midriff height
- 5.1.10 Waist height
- 5.1.11 Upper hip height
- 5.1.12 Top hip height
- 5.1.13 Hip height
- 5.1.14 Maximum hip girth height
- 5.1.15 Inside leg height
- 5.1.16 Knee height
- 5.1.17 Outer ankle height
- 5.1.18 Back neck height (sitting)
- 5.2.1 Hip breadth
- 5.2.2 Neck base width
- 5.2.3 Bust point width
- 5.2.4 Armscye front to back width
- 5.2.5 Chest depth
- 5.2.6 Bust depth
- 5.2.7 Abdomen/hip depth
- 5.3.1 Head girth
- 5.3.2 Neck girth
- 5.3.3 Neck base girth
- 5.3.4 Bust girth
- 5.3.5 Bust girth contoured
- 5.3.6 Chest girth (at axilla)
- 5.3.7 Upper chest girth
- 5.3.8 Under-bust girth
- 5.3.9 Midriff girth
- 5.3.10 Waist girth
- 5.3.11 Upper hip girth
- 5.3.12 Top hip girth
- 5.3.13 Hip girth
- 5.3.14 Maximum hip girth (seat measure girth)

- 5.3.15 Armscye girth
- 5.3.16 Upper arm girth
- 5.3.17 Elbow girth
- 5.3.18 Elbow girth (arm bent)
- 5.3.19 Wrist girth
- 5.3.20 Thigh girth
- 5.3.21 Mid-thigh girth
- 5.3.22 Knee girth
- 5.3.23 Lower knee girth
- 5.3.24 Calf girth
- 5.3.25 Minimum leg girth
- 5.3.26 Ankle girth
- 5.3.27 Diagonal trunk girth
- 5.3.28 Centre trunk length
- 5.4.1 Shoulder length
- 5.4.2 Back shoulder width
- 5.4.3 Across back shoulder width (through back neck point)
- 5.4.4 Across back width
- 5.4.5 Back neck point to width
- 5.4.6 Scye depth length
- 5.4.7 Across front width
- 5.4.8 Front neck point to bust point
- 5.4.9 Side waist length
- 5.4.10 Side neck point to bust point
- 5.4.11 Side neck point to waist level
- 5.4.12 Back neck point to bust level
- 5.4.13 Back neck point to waist level
- 5.4.14 Upper arm length (shoulder to elbow, elbow bent)
- 5.4.15 Lower arm length (elbow to wrist, elbow bent)
- 5.4.16 Underarm length
- 5.4.17 Back neck point to wrist
- 5.4.18 Total crotch length
- 5.4.19 Front crotch length
- 5.4.20 Back crotch length
- 5.4.21 Side waist to hip
- 5.4.22 Outside leg length

5.4.23 Back neck point to ground (contoured)  
5.5.1 Hand girth  
5.5.2 Hand length (wrist crease)  
5.5.3 Palm length perpendicular  
5.5.4 Index finger length  
5.5.5 Foot length  
5.5.6 Foot width  
5.5.7 Foot girth  
5.6.1 Body mass

5.6.2 Shoulder slope  
5.7.1 Contoured centre trunk length  
5.7.2 Back neck point to knee  
5.7.3 Torso height  
5.7.4 Straight body rise  
5.7.5 Thigh length  
5.7.6 Inside leg length  
5.7.7 Bust cup size  
5.7.8 Outer arm length

#### ISO 20685-2:2015

None listed

#### ISAK Guide

Body mass  
Stature  
Sitting height  
Head girth  
Neck girth  
Arm relaxed girth  
Arm flexed and tensed girth  
Forearm girth  
Wrist girth  
Chest girth  
Waist girth  
Thigh girth  
Mid-thigh girth  
Calf girth  
Ankle girth

Acromiale-radiale length  
Radiale-styilion length  
Midstyilion-dactyilion length  
Illiospinale height  
Trochanterion height  
Trochanterion-tibiale length  
Tibiabile laterale length  
Foot length  
Tibiale mediale-sphyrion tibiale  
Biacromial breadth  
Biilliocristal breadth  
Transverse chest breadth  
Anterior-posterior chest depth  
Biepicondylar humerus width  
Biepicondylar femur width

#### I-Ware Laboratory

0 Foot length  
1 Ball girth circumference  
2 Foot breadth  
3 Instep circumference  
4 Heel breadth  
5 Instep length  
6 Fibulare instep length  
7 Height of top of ball girth  
8 Height of instep  
9 Toe #1 angle  
10 Toe #5 angle  
11 Toe #1 height  
12 Toe #5 height

13 Height of navicular  
14 Height of sphyrion fibulare  
15 Height of sphyrion  
16 Height of the most lateral point of lateral malleolus  
17 Height of the most medial point of medial malleolus  
18 Arch length  
19 Angle of heel bone  
20 Heel girth circumference  
21 Horizontal ankle circumference  
22 Calf circumference

#### ISO/TS 19408:2015

2.1.1 Central line of foot  
2.1.4 Foot length  
2.1.6 Inside tangent  
2.1.7 Instep point of foot

2.1.8 Joint girth of the foot, anatomic ball girth of the foot  
2.1.10 Linear width (of the foot, of the last)  
2.1.13 Stick width of the foot (or linear width)  
2.1.15 Tread width of ball area foot

- 2.1.16 Long heel girth of foot
- 2.1.17 Ankle girth
- 2.1.18 Calf girth

**ASTM D5219-15**

- Across back shoulder width
- Across front shoulder width
- Ankle girth
- Ankle height
- Arm length
- Armscye girth
- Back width
- Body weight
- Calf girth
- Center back waist length
- Center front waist length
- Cervicale height
- Cervicale to crotch height
- Cervicale to knee height
- Cervicale to wrist length
- Chest/bust point to bust point
- Chest/ bust girth
- Crotch height
- Crotch length
- Elbow girth
- Foot length
- Foot width
- Forearm girth
- Front chest width
- Hand girth
- Hand length
- Hand width
- Head and neck height
- Head girth
- Height
- High-hip girth
- High-hip height
- High hip length
- Hip height
- Hip/seat girth

**ISO 18825-2:2016**

- 2.1.1 Virtual height
- 2.1.2 Virtual bust height
- 2.1.3 Virtual waist height
- 2.1.4 Virtual hip height
- 2.1.5 Virtual crotch height; virtual inside leg length
- 2.1.6 Virtual knee height
- 2.1.7 Virtual calf height
- 2.1.8 Virtual shoulder width
- 2.1.9 Virtual back waist length
- 2.1.10 Virtual arm length

- 2.1.19 Under knee girth
- 2.1.20 Short heel girth of foot

- Hip/seat height
- Hip/seat length
- Knee girth
- Knee height
- Mid-neck girth
- Mid-thigh girth
- Neck base girth
- Neck to chest/bust point
- Rise height
- Scye depth
- Shoulder and arm length
- Shoulder drop
- Shoulder girth
- Shoulder length
- Shoulder slope
- Shoulder to elbow length
- Side waist length
- Thigh girth
- True Rise
- Trunk Length (total vertical girth)
- Underarm length
- Under-chest/ bust girth (missy special case)
- Upper- arm girth
- Upper-back girth
- Upper-chest girth
- Upper-front chest width
- Waist girth
- Waist height
- Waist length
- Waist to hip/ seat length
- Waist to hip/ seat height
- Waist to knee height
- Waist to knee length
- Wrist girth

- 2.1.11 Virtual neck girth
- 2.1.12 Virtual neck base girth
- 2.1.13 Virtual armscye girth
- 2.1.14 Virtual upper arm girth
- 2.1.15 Virtual elbow girth
- 2.1.16 Virtual wrist girth
- 2.1.17 Virtual chest girth
- 2.1.18 Virtual bust girth
- 2.1.19 Virtual underbust girth
- 2.1.20 Virtual waist girth
- 2.1.21 Virtual abdomen girth



2.1.22 Virtual hip girth  
2.1.23 Virtual thigh girth  
2.1.24 Virtual mid-thigh girth  
2.1.25 Virtual knee girth

2.1.26 Virtual calf girth  
2.1.27 Virtual lower leg girth  
2.1.28 Virtual ankle girth

Table 6

1<sup>st</sup> row Virtual head height  
2<sup>nd</sup> row Virtual face length  
3<sup>rd</sup> row Virtual head girth  
4<sup>th</sup> row Virtual head width  
5<sup>th</sup> row Virtual tragon width

6<sup>th</sup> row Virtual eyeball width  
7<sup>th</sup> row Virtual head depth  
8<sup>th</sup> row Virtual top neck point  
9<sup>th</sup> row Virtual back head point  
10<sup>th</sup> row Virtual back head-base point

Table 10

1<sup>st</sup> row Virtual hand length  
2<sup>nd</sup> row Virtual palm length  
3<sup>rd</sup> row Virtual thumb hand width  
4<sup>th</sup> row Virtual hand width  
5<sup>th</sup> row Virtual hand girth  
6<sup>th</sup> row Virtual hand depth  
7<sup>th</sup> row Virtual thumb length  
8<sup>th</sup> row Virtual thumb width  
9<sup>th</sup> row Virtual thumb girth  
10<sup>th</sup> row Virtual index finger length  
11<sup>th</sup> row Virtual index finger width

12<sup>th</sup> row Virtual index finger girth  
13<sup>th</sup> row Virtual middle finger length  
14<sup>th</sup> row Virtual middle finger width  
15<sup>th</sup> row Virtual middle finger girth  
16<sup>th</sup> row Virtual ring finger length  
17<sup>th</sup> row Virtual ring finger width  
18<sup>th</sup> row Virtual ring finger girth  
19<sup>th</sup> row Virtual pinky finger length  
20<sup>th</sup> row Virtual pinky finger width  
21<sup>st</sup> row Virtual pinky finger girth

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