3D RC
3D Retail Coalition

Digital Fabric Physics Interoperability

3DRC Innovation Sub Committee

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1. Project Brief

1.1 Problem Statement

Users of 3D design technologies face several key challenges in consistent use of digital fabrics, including:

- Multiple 3D apparel software solutions are used by retailers, brands and manufacturing vendors and each software has a proprietary way to test and measure fabric physics
- Lack of interoperability of the digital fabrics test results across multiple 3D apparel software solutions means one fabric must be tested multiple times to support the data input needs of each solution
- Low confidence in accuracy of the digital fabric physics results in lower adoption of 3D technologies

1.2 Project Goals

Find/recommend the most accurate methods to measure fabric physics for the key parameters which impact simulation and accurate representation of the physical fabric.

Find/recommend a solution to "measure fabric physics once and use the data in any 3D apparel software solution" for interoperability.

1.3 Project Scope

The 3D software solutions included in the fabric measurement assessment (in alphabetical order):

- Assyst/Vidya
- Browzwear
- CLO3D
- Gerber
- Optitex

To compare fabric test results, three fabric types were tested on each of the 3D apparel software solution's preferred testing device, either standard laboratory textile testing equipment (Assyst/Vidya, Gerber, Optitex) or solution-specific testing kits (Browzwear, CLO3D).

All the project team members worked together from their respective locations, leveraging video conferencing and meeting technologies, from January to September, 2020.

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1.4 Project Success Criteria

Achievement of one or more of the below success criteria will deem the project to be successful:

1. Digital fabric physics conversion: Ability to convert the fabric physics values measured from one testing kit to equivalent and compatible fabric physics values for more than one 3D apparel software solution

2. Measure fabric physics at source: To be able to recommend a process/tool for correct fabric physics measurement so that fabric mills and fabric testing labs can test the physics and provide the fabric physics data along with the swatch

3. Grouping fabrics to measure a representative: To be able to find/recommend a method to group fabrics so that testing the fabric physics of one fabric in the group may be representative of the entire group, within acceptable tolerance limits

2. Project Approach

2.1 Tests and Samples

GOAL 1 - Find/recommend the optimal methods to measure fabric physics for the key parameters which impact simulation and accurate representation of the physical fabric.

2.1.1 Key Fabric Physics Tests

WHAT WE DID - We interviewed key software partners (Browzwear, Optitex, Gerber Technology) and analyzed the key parameters used to measure fabrics. Data was verified from the available white papers of each company.

OUTCOME - Alignment on the Tests

Based on our interviews and 3D software solution whitepapers, many different fabric properties are used by the various 3D software solutions as well as from company to company (e.g. fabric type (woven or knit), composition, density, friction, folding behavior, etc.). The team aligned on the following five tests as common to all solutions and the most important to determine fabric physics:

- Bend
- Stretch/Elongation
- Shear/Diagonal Stretch
- Weight
- Thickness

2.1.2 Key Fabric Samples

WHAT WE DID – We agreed on using 100% cotton fabrics because the team had access to sufficient quantities to provide to team members doing the testing. Samples of a specific fabric style taken from the same roll was important to ensure consistency when testing on different machine.

Choice of sample fabrics for the project and reasons for limiting the scope: The key goal was to test the concept of ‘test once and use everywhere.’ The team agreed to start small to prove success. Once this path is established, each organization or other teams can take this learning and apply for specific fabrics as needed.

OUTCOME - Alignment on Fabric Samples Tested

The following fabrics were used on each of the fabric testing devices:

- 310 g/m², 9.14 oz/yd² Twill, 100% Cotton
- 210 g/m², 6.19 oz/yd² Jersey, 100% Cotton
- 125 g/m², 3.69 oz/yd² Poplin, 100% Cotton

2.2. Testing Procedure

GOAL 2 - Find/recommend a solution to provide interoperability in fabric physics testing, supporting the goal of "measure fabric physics once and use the data in any 3D apparel software solution."

WHAT WE DID – For every 3D apparel software solution in scope, we identified a team member with access to its preferred fabric testing device(s). Samples of the same three fabrics were sent to each of the identified team members. Team members conducted their fabric testing and recorded their results in a spreadsheet for comparison. In some cases, the method for measuring needed further investigation. Team members followed up with software vendors to fully understand their methods for testing fabric physics. Test results were compared and analyzed.

OUTCOME – The fabric physics test results recorded indicate a high correlation among the various testing devices to support the goal of "measure it once and use it in any 3D design software." The tests for Weight, Thickness, and Bend can be converted using formulas (e.g. metric to imperial). Stretch/Elongation and Sheer require a curve to be established which identifies how a fabric stretches at increasing rates of force. Once the curve is established, each of the software solution's required input(s) can be derived (see Exhibit 3 – Stress Strain Curve below).

3. Project Findings – Summary

3.1 Findings – Interoperability

Based on our research and tests, we concluded that it is possible to measure a fabric using standard fabric testing devices and calculate or derive values needed for the 3D apparel software solutions in scope.

3.2 Findings – Fabric Grouping and Tolerance

During discussion with 3D apparel software companies we found that for the time being it does not make sense to group the fabrics for the purpose of fabric digitization; they are too different from each other. Development of the detailed methods for the testing of fabrics is the fact that grouping is not possible. Even with one substrate, the dyeing and finishing processes and compositions could render the same fabric different from a physics perspective.

Though there is no consistent and aligned view on grouping different fabrics so that "fabric physics of one fabric from a group is representative of the entire group, within acceptable tolerance limit", below is a summary of different findings by this project team on the topic.

- 3D apparel software solutions group by Knits and Wovens
- 3D apparel software solutions are aligned in that they do not recommend grouping fabrics based on similar weight. They recommend testing the physics of every fabric
- Some retailers and brands use a tolerance such as (+/-) 5-10% weight, based on other industry standard tests for weight with the exception of elastane content. All retailers and brands test any fabric with elastane independently
- Some Retailers and brands test the physics of each fabric

4. Project Findings – Fabric Physics Test Details

4.1 Mass per Unit Area

Weight in g/m2 is a standard textile measurement. There is no need for a conversion.

4.2 Thickness

For the measurement of thickness there are several gauges available in the market. Some machines use an international standard, some do not. The results are very similar (see Exhibit 1 below). With this measurement, there is no need for a conversion.

Exhibit 1 – Fabric Thickness Comparison

Fabric	Thickness [cm] with Optitex gauge	Thickness [cm] with CLO Kit tool	Thickness [cm] with lab thickness tool
Jersey Single (Cotton)	0,06	0,06	0,05
Twill (Cotton)	0,04	0,05	0,04
Poplin (Cotton)	0,02	0,02	0,02

Exhibit 2 – Fabric Thickness Testing Gauges

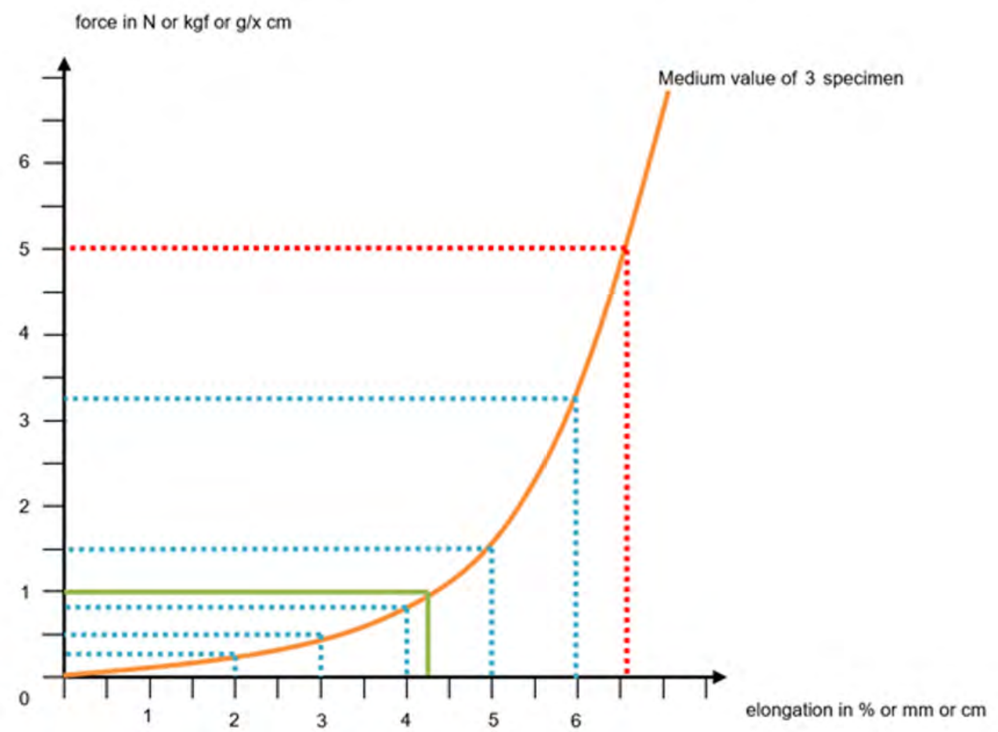
4.3 Elongation and Shear

Shear is diagonal elongation.

For four of the five 3D apparel software solutions, one or several specimens are stretched once to a certain force per testing direction. Only Browzwear performs a set of four force and relaxation cycles.

At one or several defined points of elongation per force, a corresponding value of force/elongation is determined. The complete curves are interpreted in the software (see graph in Exhibit 3 below).

Exhibit 3 – Stress-Strain Curve



▪▪▪ (red dotted)	GERBER [elongation in cm at 500 g]	Used specimen width 7,6 cm	
···· (blue dotted)	CLO3D [5 data pairs to simulate a stress strain curve mm/kgf]	Used specimen width 3 cm	Max. force: 20 N; no defined speed
— (green)	VIDYA [elongation in % at 20 N/m = 1N/5cm]	Used specimen width 5 cm	Max. force : no; principle of testing: CRE [100 mm/min]
— (orange)	OPTITEX [give complete data set]	Used specimen width 2,5 cm	Max. force 25 N; principle of testing: CRE [100 mm/min] Need data of complete test
— (orange)	BROWZWEAR [add a relaxation curve to sketch and 3 more cycles]	Used specimen width 5 cm	Max. force of load cell 10N, need data of complete test, used max. force 500 g

Note: By using a classical dynamometer for fabric testing (like one from James Heal or Mark10), the elongation and shear data needed for all the in-scope 3D apparel software solutions can be measured at the same time.

Trials were successfully done by taking the elongation data measured with a Titan4 universal testing machine and using it in the Optitex software.

Despite unit and specimen size variations, results can be converted. Testing speed also may differ but does not influence the result (see Exhibit 4 below, a high degree of correlation found). Maximum forces put on the specimen are very low and similar and are mostly determined by the maximum capacity of the testing apparatus' load cell.

Exhibit 4 – CLO vs. Titan4 Elongation Test Result Comparison

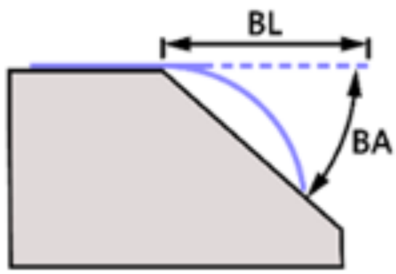
Warp Results Popeline						
Specimen		*1,00 mm (CLO)*	2,00 mm (CLO)	*3,00 mm (CLO)*	4,00 mm (CLO)	*5,00 mm (CLO)*
1			0,16		0,55	
2			0,15		0,51	
3			0,16		0,46	
Mean Titan4 HUGO BOSS		**0,05**	**0,15**	**0,31**	**0,50**	**0,80**
Std Dev			0,01		0,05	
ConfLimits			±0,0187		±0,113	
CoeffOfVar			0,05		0,09	
CLO Kit data TARGET		**0,07**	**0,14**	**0,27**	**0,47**	**0,72**
Weft Results Popeline						
Specimen		*1,00 mm (CLO)*	2,00 mm (CLO)	*3,00 mm (CLO)*	4,00 mm (CLO)	*5,00 mm (CLO)*
1			0,14		0,37	
2			0,14		0,38	
3			0,15		0,41	
Mean Titan4 HUGO BOSS		**0,00**	**0,14**	**0,26**	**0,39**	**0,53**
Std Dev			0,01		0,02	
ConfLimits			±0,0182		±0,0592	
CoeffOfVar			0,05		0,06	
CLO Kit data TARGET		**0,08**	**0,15**	**0,24**	**0,32**	**0,49**
Bias Results Popeline						
Specimen		*1,00 mm (CLO)*	2,00 mm (CLO)	*3,00 mm (CLO)*	4,00 mm (CLO)	*5,00 mm (CLO)*
1			0,02		0,04	
2			0,01		0,03	
3			0,01		0,03	
Mean Titan4 HUGO BOSS		**0,01**	**0,01**	**0,02**	**0,03**	**0,04**
Std Dev			0,00		0,01	
ConfLimits			±0,0119		±0,0206	
CoeffOfVar			0,32		0,27	
CLO Kit data TARGET		**0,01**	**0,01**	**0,02**	**0,03**	**0,03**

4.4 Bending

Cantilever

Three software companies (Assyst/Vidya, Gerber and Optitex) test for bending according to the Cantilever principle. Measuring the overhang length (BL), one can calculate either the bending stiffness or the flexural rigidity of a fabric.

Exhibit 5 – Cantilever Principle



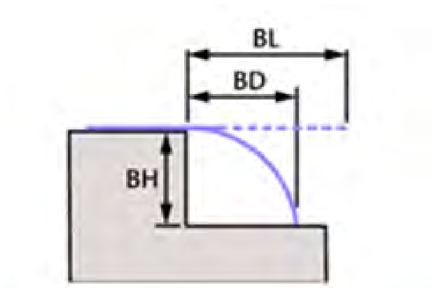
BL – Bending Length

BA – Bending Angle

Other Systems

CLO3D works with a height/distance system. These values can be measured with a specifically prepared Cantilever machine.

Exhibit 6 – Height Distance System



BL – Bending Length

BH – Bending Height

BD – Bending Depth

Browzwear operates with the folding loop principle. Additional information is needed to determine conversion possibilities.

5. Conclusion and Next Steps

This project team concluded that it is possible to measure the main five fabric physics attributes once, using one standard fabric testing kit, and derive the equivalent physics values for multiple 3D apparel software solutions. This conclusion resolves one of the biggest challenges faced for 3D adoption, which is the need to test the same fabric multiple times for each 3D apparel software solution.

This team also recommends that fabric suppliers and fabric testing labs do the testing for fabric physics while they are performing other standard industry tests such as abrasion, seam slippage etc. so that all retailers and brands can receive consistent fabric physics data along with the swatch, providing one source of truth. This practice would help achieve a high level of confidence among users and create consistency across 3D apparel software solutions.

Measure fabric physics once, use for multiple 3D apparel software solutions			
Fabric Physics	Interoperability	How	Supplier
Mass (Weight)	Measure for data, convert for CLO	Use standard measurement is g/m^2. EXCEPT CLO (*) needs to convert from the 3 specimen rolled to universal g/m^2.	Mathematical conversion
Thickness	Measure for data	Convert unit of measurement (i.e., cm, mm).	
Bend	Measure for data	Use Cantilever method. (*) CLO 3D uses height/distance system. These values can be measured with a specifically prepared Cantilever machine. Browzwear operates with the folding loop principle. Additional data is needed to determine conversion possibilities.	Supplier can test and measure this physics value and convert for multiple 3D apparel software solutions
Stretch (Elongation)	Measure to establish curve, identify needed value(s) for each 3D apparel software solution	Use stress-strain curve (see Exhibit 3 above).	Use industry standard equipment such as Titan or Mark 10 and the strain curve to derive the equivalent value(s) needed by each 3D apparel software solution
Shear (Bias)			

(*) CLO 3D – For bend, we recommend CLO update their weight test to the universal standard of g/m2 or supplier can convert mathematically.

6. Future – Standard Operating Procedure (SOP)

The project team intends to prepare standard operating procedures for all five fabric physics characteristics defining necessary information (e.g. specimen sizes, forces, testing speed, formulas, number of specimens per testing direction) to enable fabric suppliers to perform the testing. Once this SOP is published, fabric mills and fabric testing labs could provide the standard digital fabric physics data along with the swatch. Any user would then be able to use the fabric physics data for their specific 3D apparel software solution. This process will help the apparel industry reduce the fabric testing bottleneck and provide the data needed as inputs for any 3D apparel software solution.

7. Acknowledgements

The 3DRC Digital Fabric Physics Interoperability project team is grateful to all the individuals and companies who have participated in this project and helped the team with our findings and results. Thank you very much for your kind support.

7.1 3D Software Companies we interviewed

Representative	Company
Sharon Lim	Browzwear Solutions Pte Ltd.
Renate Eder	Vizoo GmbH
Matt Bakhoum	Gerber Technology
Archady Tseytlin	Optitex
Amit Ben Sheffer	Optitex
Emanuel Sepulveda	Optitex
Dr. Martin Lades	Assyst GmbH

7.2 3DRC Digital Fabric Physics Standardization project team

Representative	Company
Sarah Pierson	Kalypso, A Rockwell Automation Company
Michelle Greenhouse	Target Corporation
Anja Sick	Hugo Boss AG
Chris Okazaki	Li & Fung
Yvonne Johnson	Cotton Incorporated
Emily Croneberger	Cotton Incorporated
Joshua Young	VF Corporation
Peter Goodwin	James H Heal and Co. Ltd.
Matt Bakhoum	Gerber Technology
Giulietta Camarda	Perry Ellis International
Abinash Sahoo	Target Corporation

7.3 3DRC Innovation Subcommittee members

Representative	Company
Dominic Sluiter	STITCH 3D
Claire Wu	Under Armour, Inc.
Chris Hillyer	Deckers Outdoor Corporation
Sandra Kuijpers	AMFI
Hans Scheurer	Adidas
Christiane Luible	Kunstuniversitaet Linz
Rudi Schubert	IEEE
Sarah Pierson	Kalypso, A Rockwell Automation Company
Abinash Sahoo	Target Corporation

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About the 3DRC

Mission Statement

The 3D Retail Coalition (3DRC), is a collaborative group of global retailers and brands, working together to advance 3D technology for the apparel, accessories, and footwear designers, retailers, manufacturers and supply chains. Our mission is to provide direction, resources, and networking opportunities to help members unlock and accelerate the potential value of 3D digital transformation, while maximizing positive impact within their organizations and the industry.

The 3D.RC organization brings together one voice for collective influence. The group is open to any retailer/brand currently using (or planning to use) 3D technology.

The logistical affairs of the 3DRC are managed by its Board of Directors: PI Apparel, Target and Kalypso.

Learn More

http://3drc.pi.tv/

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