JTC 1 Opening remarks

Tony Holland
About JTC 1

Joint Technical Committee of IEC and ISO

- "Standardization in the field of Information Technology"
- Consistent IT deliverables across IEC and ISO
- Building blocks for global markets that respond to the needs of businesses, consumers, governments, other organizations

40 P-members and 62 O-members

Organized in 23 Subcommittees and 5 JTC 1 Working Groups

More than 4500 active participants currently developing around 500 standards; more than 3300 published
JTC 1 Focus

Horizontal by design, JTC 1 develops information technology standards that are applicable across domains

- Emphasis on initiating new areas of work at the right time, delivering high quality standards that respond to market trends
- Track record of acceptance by global markets

Work together with other IEC and ISO TCs and other organizations that are utilizing information technology to develop domain-specific standards

- More than 400 liaisons (JTC 1 and its SCs)
- 18 approved submitters of Publicly Available Specifications
- Emphasis on effective cooperation/collaboration
Technical areas

Coded character sets
Telecommunications and information exchange between systems
Software and systems engineering
Cards and security devices for personal identification
Programming languages
Digitally recorded media
Computer graphics, image processing
Interconnection of IT equipment (home electronics)
IT security techniques
Office equipment (printing)
Coding of audio, picture, multimedia (JPEG, MPEG)
Automatic ID and data capture (RFID)

Data management
Document description, processing
User interfaces
IT for learning, education, training
Biometrics
Cloud computing
IT Sustainability
IT governance
Internet of Things and Digital Twin
Artificial Intelligence
IT for smart cities
3D printing and scanning
Trustworthiness
Quantum Information Technology
Brain-Computer Interface
3D Printing Standardization for Medical Devices

Kohei MURASE
ISO/TC150 JWG1
Center for Industry-University Collaboration, Graduate School of Engineering Science, Osaka University
JAPAN

3D Printing and Scanning (ISO/IEC JTC 1/WG 12 - Online Workshop)
2023-Dec.12
My profile

- Graduate School of Engineering Science. **Osaka University**
  - Special Appoint Professor, **Center for Industry-University Collaboration**, Computational Engineering Laboratory for **Medical Instruments and Devices**, Member of JSME, JSCB
- Convener of Joint ISO/TC150(Implant for Surgery) – 261(Additive Manufacturing) ‘**Additive manufacturing in surgical implant applications**’ (TC150 JWG1)
- Liaison Officer between ISO/TC106 (Dentistry) and ISO/TC206 (Fine Ceramics)
Est. 1971.

Standardization in the field of

- implants for surgery and their required instrumentation,
- covering terminology,
- specifications and methods of tests for all types of implants, and for the materials both basic and composite used in their manufacture and application.

ISO/TC 150
Implants for surgery

175
Published ISO standards
of which 17 under the direct responsibility of ISO/TC 150

49
ISO standards under development
of which 4 under the direct responsibility of ISO/TC 150

24
Participating members

- ISO/TC 106 (Dentistry)
- ISO/TC 150 (Implants for surgery)
- ISO/TC 194 (Biological and clinical evaluation of medical devices)
- ISO/TC 198 (Sterilization of health care products)
- ISO/TC 210 (Quality management and corresponding general aspects for medical devices)
- ISO/TC 261 (Additive manufacturing)
- ISO/TC 276 (Biotechnology)
- ASTM F04 (Medical devices)
- ASTM F42 (Additive manufacturing)

and JTC 1/WG 12 !!
Today’s Topics

- Needs in Orthopaedics with AM (Additive Manufacturing = 3D printing) standardization.
- Introduction of ISO TC 150/JWG1 (Joint Working group with ISO TC261)
- Scope and currently work in TC150/JWG1 - ‘Additive manufacturing in surgical implant applications’
Artificial joint replacement (in Asia)

- Reported by Japanese Society for Replacement Arthroplasty*
  - 22,935 cases* for Hip joint replacement a year,
  - 25,892 cases* for Knee joint replacement a year,
  - About 130 cases a day!
- 3 times increasing for 5 years (2012 to 2017)
- Increasing “revision surgery”
- Increasing a variety of replacement
  - Spine, Shoulder, etc…
- Patient-Specified-Instrument (PSI : Custom-made)

Additive Manufacturing is the **key** of medical devices.
What’s required in International standard?

- After Medical operation, Medical implants works for 15~20 years.
- $=5 \times 10^6 \sim 2 \times 10^7$ cycle works under $200 \sim 2,300N$
  
  (3~5 times of bodyweight)
- Mechanical strength is very important for medical implants

Medical implants in human body needs mechanical durability.

We need the ‘Golden methods’ to estimate the performance of each devices. = International Standard
Surgical Guides

- Effective instruments for “quickly” / “accurate” operations.
- Potential for use in minor areas (ankle / shoulder)
Who is Stakeholder?

- Scanning
- Designer
- Manufacturer
- Doctor
- Patient

- To standardization, which categories do we belong to?
**ISO/TC150 JWG1**

**Convenor:**
- Kohei Murase (TC150)
- Lim Wonbong (TC261)

**Manager:**
- Klaus Zeier (DIN)

<table>
<thead>
<tr>
<th>Member from</th>
<th>2023-01-17</th>
<th>2023-02-08</th>
<th>2023-03-22</th>
<th>2023-05-08</th>
<th>2023-07-12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>(14)</td>
<td>(19)</td>
<td>(14)</td>
<td>(13)</td>
<td>(9)</td>
</tr>
<tr>
<td>Brazil</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>3</td>
<td>2</td>
<td>6</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Italy</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Republic of Korea</td>
<td>2</td>
<td>2</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>United Kingdom</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>United State</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>2023-01-17</th>
<th>2023-02-08</th>
<th>2023-03-22</th>
<th>2023-05-08</th>
<th>2023-07-12</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) Industry and commerce: Manufacturers, Suppliers, Trade associations</td>
<td>6</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>(B) Government: Government organizations, Regulatory authorities</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>(C) Consumers: Patients, Healthcare centers, Surgeons</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>(D) Labour: Trade unions, Employees</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>(E) Academic and research bodies: Academic and research communities</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>(F) Standards application: Testing facilities, Accreditation bodies</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>(G) Non-governmental organization; Government independent organizations</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>
Considerations for medical AM implants

I. Introduction and Scope

FDA has developed this guidance to provide the Agency’s initial thinking on technical considerations specific to devices using additive manufacturing, the broad category of manufacturing encompassing 3-dimensional (3D) printing. Additive manufacturing (AM) is a process that builds an object by sequentially building 2-dimensional (2D) layers and joining each to the layer below, allowing device manufacturers to rapidly produce alternative designs without the need for retooling and to create complex devices built as a single piece. Rapid technological advancements and increased availability of AM fabrication equipment are encouraging increased investment in the technology and its increased use by the medical device industry. The purpose of this guidance is to outline technical considerations associated with AM processes, and recommendations for testing and characterization for devices that include at least one additively manufactured component or additively fabricated step.

- In 2017, FDA (U.S.) announced ‘Technical consideration for AM Medical Devices’
- For Medical use, we have to pass the (Very severed) certifications from each country.
Scope of ISO/TC150 JWG1 (9 items)

1. **Qualifications of machine operators** of AM Machines used in surgical implant applications
   
   e.g., *powder bed fusion, stereolithography, fused filament fabrication, liquid-based extrusion machines*,

2. **Calibration, Validation and Re-validation** for acceptance of AM Machines used in surgical implant applications,
   
   e.g., *powder bed fusion, stereolithography, fused filament fabrication, liquid-based extrusion machines*,
Scope of JWG1 (cont.)

6. Physical and mechanical test methods or considerations to address risks associated with AM of surgical implants,

7. Addressing each of the above items also in the use or incorporation of biological, cellular, or tissue-based products in AM.

8. Biological considerations of final devices taking into account manufacturing residues, cleanliness, sterilization, biocompatibility

9. Labeling considerations
   - Data Format, Security, Voxel modeling, etc.
3. **Specifications for materials** used in AM of surgical implant applications,
   - e.g., *virgin and reused powders/starting materials,*

4. **Process specifications and quality considerations** including, e.g., *design* (standard or patient-matched from *medical imaging*), software workflow, printing/build, and post-printing/build validation,

5. **Identification of risks**
   - including, e.g., *variability in quality, geometry, surface finish, tolerances, microstructure, chemistry,*
To estimate 3D quality of ‘real’ product…

To estimate 3D quality of ‘real’ product…

- Resolution of CT image
- Slice thickness
- X-ray Strength (kV)
- Specification of AM machine.
- Material specification
- Necessarily of metal-use for hole and cutting space.
- Posture during Scanning
- …

Guide must be fitted to the bone shape!!
Currently work in JWG1

- Identified gaps with respect to AM in existing implant specific standards.

- Provide a list of references to existing / currently developed relevant standard documents in TC150, TC261, ASTM F04 and F42

- JWG1 is working on ISO/CD 5092, “Additive manufacturing for medical – General principles – Additive manufacturing of non-active implants”.

- The RoV and comments of ISO/CD 5092 received on 2023-11-03 and the next meeting will be held on January 2024.

- We request participate you to discuss AM for medical use!!
Summary

- **Additive Manufacturing (3D Printing and Scanning)** is a powerful tool to develop the future medical devices (=Patient-Specified Instruments: PSI).

- In medical application of AM, it is important to **establish the international standards** for:
  - Modeling,
  - Measurement (Scanning),
  - Material constitution, etc.

  Collaborate with many other fields (categories).

- Collaborations of AM & computer modeling will grow up to ease / agree with orthopaedics.

Thank you for your attention!
murase.kohei.es@osaka-u.ac.jp
Digital Twin projects around ISO/ TC184/ SC4/ JWG16
ISO/IEC JTC 1

ISO/IEC JTC 1/SC 41
Internet of things and digital twin

ABOUT
Undergoing Projects in WG6:

- ISO/IEC WD 30186 Digital twin – Maturity model and guidance for a maturity assessment
- ISO/IEC WD 30188 Digital Twin - Reference Architecture
- PWI JTC1-SC41-6 Guidance for IoT and Digital Twin use cases
- PWI TR JTC1-SC41-11 Digital Twin - Correspondence measure of DTw twinning
- PWI TR JTC1-SC41-16 Digital Twin – Extraction and transactions of data components

Published;
ISO/IEC TR 30172:2023 Internet of things (IoT) - Digital twin - Use cases
ISO/IEC 30173:2023 Digital twin - Concepts and terminology
ISO/IEC AWI 30173
Digital twin — Concepts and terminology

General information

Status: Under development
Edition: 1

Technical Committee: ISO/IEC JTC 1/SC 41 Internet of things and digital twin
Differentiate human twins?
Correspondence measure

5 similarity measures

- Euclidean distance: physical distance
- Manhattan distance: topology distance (number of metro stations)
- Minkowski distance: hybrid distance
- Cosine Similarity: angle
- Jaccard Similarity:

https://dataaspirant.com/five-most-popular-similarity-measures-implementation-in-python/
Integrated metrology process with QIF standard
Unwanted surface gaps of CAD models (PDQ)
Onion model of correspondence measure

Behavior 1 (performance)

Function

Motion 1 (animation) (dynamic, time dimension)

3D shape (descriptor) (static, spatial dimension)

Motion 2 (flight)

Behavior 3 (acoustic)

Behavior 2 (structural)
ISO/TC 184
Automation systems and integration

About
Secretariat: AFNOR
Committee Manager: Mr Skander Ben Yaha
Chairperson (until end 2023): M Patrick Lamboley
ISO Technical Programme Manager [TPM]: Ms Laura Mathew
ISO Editorial Manager [EM]: Ms Claudia Lueje
Creation date: 1983

Structure

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO/TC 184/SC 1</td>
<td>Industrial cyber and physical device control</td>
</tr>
<tr>
<td>ISO/TC 184/SC 4</td>
<td>Industrial data</td>
</tr>
<tr>
<td>ISO/TC 184/SC 5</td>
<td>Interoperability, integration, and architectures for enterprise systems and automation applications</td>
</tr>
<tr>
<td>ISO/TC 184/AG 2</td>
<td>Digital Twin</td>
</tr>
</tbody>
</table>
Ed. 2 is in ballot process 2023

ICS › 25 › 25.040 › 25.040.40

ISO/TR 24464:2020
Automation systems and integration — Industrial data — Visualization elements of digital twins

가시화 없이 DTw가 가능할까?
ISO 23247-1:2021
Automation systems and integration — Digital twin framework for manufacturing — Part 1: Overview and general principles

Abstract

This document provides an overview and general principles of a digital twin framework for manufacturing including:

— terms and definitions;

— requirements of the digital twin framework for manufacturing.
Digital Twin Framework for Manufacturing ISO 23247

- Part 1 — Overview
- Part 2 — Reference Architecture
- Part 3 — Data examples
- Part 4 — Network protocols

ISO/AWI 23247-5 Digital twin framework for manufacturing
Part 5: Digital thread for digital twin
ISO/AWI 23247-6 Digital twin framework for manufacturing
Part 6: Digital twin composition
ISO TC/184/SC5/WG13: EBC

ISO 16400 – Equipment behavior catalogues for virtual production system

Part 1: Overview
Part 2: Formal description of catalogue template
Part 3: Guideline for construction of equipment instance model
Part 4: Application method
Part 5: Integration of EBC templates in production system design & operation
Part 6: An EBC enhanced with machine learning techniques
JTC 1/SC 24 Standards and Projects for the Metaverse

ISO/IEC Workshop: Standards for the Metaverse

2023-06-26

Myeong Won Lee, JTC 1/SC 24 Chair

https://www.iec.ch/system/files/2023-06/presentations_0.pdf
Project: IEC 63278-1 ED1
Asset Administration Shell for industrial applications - Part 1: Asset Administration Shell structure

Related documents:
SMB/7507A/INF
428 kB
Soonhung Han (韓淳興)

**Current**
- iCAD laboratory, Mechanical and Ocean Systems engineering, KAIST, [https://sites.google.com/view/icadlab/home](https://sites.google.com/view/icadlab/home)
- Korea STEP center: ISO standard for exchange of engineering design [www.kstep.or.kr](http://www.kstep.or.kr)
- Convener of JWG16 of ISO/TC184/SC4, [https://committee.iso.org/home/tc184sc4](https://committee.iso.org/home/tc184sc4)
- ICT convergence network: Industry 4.0 in Korea, [https://kicon.org/](https://kicon.org/)

**Study**
- PhD in Ship CAD, University of Michigan, USA
- MS in Ship Design, Newcastle upon Tyne, UK
- Naval Architecture, Seoul National University, Korea

**Work**
- Ship and ocean research institute, [www.kriso.re.kr](http://www.kriso.re.kr)
- Society of CAD/CAM Engineers (Korea) [www.cde.or.kr](http://www.cde.or.kr)
- Start up [www.PartDB.com](http://www.PartDB.com)
- Design committee for ships and ocean plants (Korea)
- Society for e-business studies (Korea)
ISO/TC 106/SG 9
Scanning & 3D Printing on Digital Dentistry

12th, Dec. 2023

Seoul National University
School of Dentistry
WG 3 ILT project leader
WG 7 Secretary

Prof. Ji-Man Park
<table>
<thead>
<tr>
<th>TC/SC/WG</th>
<th>Title</th>
<th>Mon Sep 17</th>
<th>Tues Sep 18</th>
<th>Wed Sep 19</th>
<th>Thurs Sep 20</th>
<th>Fri Sep 21</th>
<th>Meeting Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC 1/WG 1</td>
<td>Plenary</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>08:30-12:00</td>
</tr>
<tr>
<td>TC 1/WG 3</td>
<td>Dental implants</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>08:30-12:00</td>
</tr>
<tr>
<td>SC 8/WG 3</td>
<td>Implantable materials</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>08:00-12:00</td>
</tr>
<tr>
<td>SC 8/WG 4</td>
<td>Mechanical testing</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>13:00-17:00</td>
</tr>
<tr>
<td>SC 8/WG 6</td>
<td>Pre-clinical performance requirements</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>08:00-12:00</td>
</tr>
<tr>
<td>SC 8/WG 7</td>
<td>Evaluation of Connective Interfaces of Dental Implant Assemblies</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>08:00-12:00</td>
</tr>
<tr>
<td>SC 9/WG 2</td>
<td>Terminology</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>08:00-10:00</td>
</tr>
<tr>
<td>SC 9/WG 3</td>
<td>Digitizing devices</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>08:00-12:00</td>
</tr>
<tr>
<td>SC 9/WG 4</td>
<td>Interoperability</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>10:30-12:30</td>
</tr>
<tr>
<td>SC 9/WG 5</td>
<td>Machined devices</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>13:00-17:00</td>
</tr>
<tr>
<td>SC 9/WG 6</td>
<td>Machinable blanks</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>13:00-17:00</td>
</tr>
<tr>
<td>CAG</td>
<td>Chairman’s Advisory Group (CAG)</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>17:00-19:00</td>
</tr>
</tbody>
</table>

*SC 9/WG 6 invites SC 2/WG 1 members to a meeting
**CAG Meeting on Thursday is tentative meeting, if required
Working group 3

Digitizing devices
Accuracy specification based on ISO 12836
## Materials and Methods

<table>
<thead>
<tr>
<th>List</th>
<th>Item</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scanner model</td>
<td>IDENTICA Hybrid</td>
<td>ID</td>
</tr>
<tr>
<td></td>
<td>CS3650</td>
<td>CS</td>
</tr>
<tr>
<td></td>
<td>TRIOS</td>
<td>TR</td>
</tr>
<tr>
<td></td>
<td>E4scan</td>
<td>EZ</td>
</tr>
<tr>
<td>Material of test specimen</td>
<td>Resin for 3D Printing</td>
<td>3D</td>
</tr>
<tr>
<td></td>
<td>Improved Stone</td>
<td>IS</td>
</tr>
<tr>
<td>Surface treatment of test specimen</td>
<td>No treatment</td>
<td>NO</td>
</tr>
<tr>
<td></td>
<td>Powders</td>
<td>PO</td>
</tr>
<tr>
<td></td>
<td>Sandblast</td>
<td>SB</td>
</tr>
<tr>
<td>Shape of test specimen</td>
<td>Crown form of ANSI/ADA 32 Standard</td>
<td>#1</td>
</tr>
<tr>
<td></td>
<td>Inlay form of ANSI/ADA 32 Standard</td>
<td>#2</td>
</tr>
<tr>
<td></td>
<td>Inlay form of ISO 12836 Standard</td>
<td>#3</td>
</tr>
<tr>
<td></td>
<td>Bridge form of ISO 12836 Standard</td>
<td>#4</td>
</tr>
</tbody>
</table>

Ex) TRIOS로 짜은 표면 처리하지 않은 것과 ISO12836 인레이 모델 → TR IS NO #3

![Results](image)

### ISO 12836 인레이 표준 시편(#3)

<table>
<thead>
<tr>
<th>Surface</th>
<th>IDENTICA</th>
<th>CS3650</th>
<th>TRIOS</th>
<th>Ez-iscan</th>
</tr>
</thead>
<tbody>
<tr>
<td>No treat</td>
<td>![Image]</td>
<td>![Image]</td>
<td>![Image]</td>
<td>![Image]</td>
</tr>
<tr>
<td>Powder</td>
<td>![Image]</td>
<td>![Image]</td>
<td>![Image]</td>
<td>![Image]</td>
</tr>
<tr>
<td>Sandblast</td>
<td>![Image]</td>
<td>![Image]</td>
<td>![Image]</td>
<td>![Image]</td>
</tr>
<tr>
<td>Stone</td>
<td>![Image]</td>
<td>![Image]</td>
<td>![Image]</td>
<td>![Image]</td>
</tr>
</tbody>
</table>

### Reproducibility

<table>
<thead>
<tr>
<th>Level</th>
<th>Reproducibility</th>
<th>Explanatory notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>100 %</td>
<td>스팬어의 위치 기의 안정한 형태를 표현하는 경우</td>
</tr>
<tr>
<td>B</td>
<td>75 %</td>
<td>절단 합성 표면에서만 빠졌거나 응집되는 형태가 있는 경우</td>
</tr>
<tr>
<td>C</td>
<td>50 %</td>
<td>절단 데코로 표면이나 제대로 표면형상을 표현하지 못하는 경우</td>
</tr>
</tbody>
</table>

A : ID-3D-NO-#3, ID-3D-PO-#3, ID-IS-NO-#3
B : CS-3D-NO-#3, CS-3D-PO-#3, ID-3D-SB-#3, CS-3D-SB-#3, CS-IS-NO-#3, TR-IS-NO-#3, EZ-3D-SB-#3
C : TR-3D-NO-#3, TR-3D-PO-#3, TR-3D-SB-#3, EZ-3D-NO-#3, EZ-3D-PO-#3, EZ-3D-IS-#3
Consideration for intraoral scanner

: Arch distortion
Test methods are developed & introduced

# Intraoral scanners introduced at IDS 2019

<table>
<thead>
<tr>
<th>IOS Brand</th>
<th>Manufacturer</th>
<th>Special feature</th>
<th>Demo with Human or Model</th>
<th>Arch Distortion</th>
<th>Scan speed</th>
<th>Wand size &amp; weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aoralscan</td>
<td>Shining 3D</td>
<td>Newcomer (Nothing special)</td>
<td>Model</td>
<td>4</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Condor</td>
<td>Condor</td>
<td>Smallest scanner tip</td>
<td>Human</td>
<td>4</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>CS3700</td>
<td>CanaStream</td>
<td>Ergonomic design/Shade matching algorithm</td>
<td>Human</td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Emerald 5</td>
<td>Planmeca</td>
<td>Small scanner tip/Transillumination tip</td>
<td>Human</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>i500</td>
<td>Medit</td>
<td>Subgingival margin - Add Impression scan</td>
<td>Human</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>iTero Element 5D</td>
<td>Align Technology</td>
<td>NIR (Near-Infrared Imaging); proximal caries detection without Transillumination tip</td>
<td>Model</td>
<td>1</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>KaVo X Pro</td>
<td>KaVo</td>
<td>Newcomer (Nothing special)</td>
<td>Model</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Primescan</td>
<td>Denitsply Sirona</td>
<td>Improved speed/Wide monitor/Touchpad</td>
<td>Human</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Trios 4</td>
<td>3Shape</td>
<td>Surface caries detection/Transillumination tip</td>
<td>Human</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>V-IOS</td>
<td>VOCO</td>
<td>Subsurface scanning (Digital Holography)</td>
<td>Not yet introduced</td>
<td>No information</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Virtuo Vivo</td>
<td>Dental Wings</td>
<td>Small wand (Pen-grip)/Wide window</td>
<td>Human</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

*The smaller the number, the higher the performance.*

Various intraoral scanners were introduced in IDS 2019. I have evaluated these intraoral scanners and organized them in a table. My subjective opinion may be included, so please consider it.

Last year, I compared 9 intraoral scanners and published at J Prosthet Dent. [https://gooogle/fgakP4] Now I feel a little impatient thinking that I need to give objective data again with the newly introduced intraoral scanners.

I usually use intraoral scanners in my daily practice. There ... 계속 읽기
ILT Protocol circulation (Feb 2023)

Protocol of ILT for ISO WD 20896-1 (Ed 2)

I. Background

This protocol is proposed for an inter-laboratory (ILT) test for methods specified in ISO WD 20896-1 (Ed 2). It is part of a series of inter-laboratory tests for Annexes A to G currently being evaluated. For Annex A to G, the number of projects based on the procedures described in Annex C of ISO WD 20896-1 (Ed 2) based on the results of TC 118/FDAWG 3 meeting held in Berlin.

NOTE 1 ILT project manager can be the model test object of Annexes A to G on request of the participating laboratory and must be reviewed at the end of the ILT. Also, the test object of Annex A is not to be provided on request.

NOTE 2 The ILT test and part methods mentioned in Annexes A to G are based on the data of the ILT project manager and will be supplied centrally.

II. Test Method Procedures

1 Long edentulous ridge of Annex B

1.1 General

This and evaluates the distortion. The test for measuring a long edentulous ridge with an interlaboratory model (ILM) phantom was fabricated by attaching four markers for distortion evaluation to the long edentulous model (insert attached molar, panel dental phantom, and scan with a desktop scanner (Epson 8800)). The model was printed from a 3D printer using a resin (inert to the model with a layer thickness of 0.12). Volume data should be obtained by scanning the test object using a desktop scanner with minimal distortion. For distortion evaluation, the centers of each marker are used as measurement points, and the distance between them are evaluated at the pre-defined points.

Figure 1 — A complete arch test object showing the placement and the sequential designation of four gauge balls. Points a, b, c, and d designate gauge balls.
Delivery of test objects (Feb-Mar 2023)
Delivery of test objects (Feb-Mar 2023)
Hands-on videos for scanning
Hands-on videos for measurement (Geomagic Control X)
Hands-on videos for measurement (Gom Inspect)
Annex B (Long edentulous ridge)

**Measurement**

Measurement software: Geomagic Control X or GOM Inspect

Four measurement points (a, b, c, d): reverse engineered at sphere centers

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>distance from a to b</td>
</tr>
<tr>
<td>2</td>
<td>distance from b to c</td>
</tr>
<tr>
<td>3</td>
<td>distance from c to d</td>
</tr>
<tr>
<td>4</td>
<td>distance from d to a</td>
</tr>
<tr>
<td>5</td>
<td>distance from a to c</td>
</tr>
<tr>
<td>6</td>
<td>distance from b to d</td>
</tr>
<tr>
<td>7</td>
<td>a to distance between point a and a plane defined by the three points b, c, and d</td>
</tr>
<tr>
<td>8</td>
<td>d to distance between point d and a plane defined by the three points a, b, and c</td>
</tr>
</tbody>
</table>
How-to-measure Video (Annex B)
Comments from Participants

Comments

1. Sphere Geometry Issues: Data Excludes Problematic Areas at Sphere Bottom (UK)
   : Complete Sphere Scanning with each Scanner’s Full Functionality

2. Scanning Issues with Primescan: Difficulty Scanning Test Object (Japan)
   : Primescan’s Robust AI Requires Complete Data for Scanning
   : For Better Recognition, Scan Along Buccal Side of Alveolar Ridge (Canine to Molar Area)

3. Color & Recognition Issues with Primescan: Dark Color Causes Scanning Issues (Japan)
   : Scan Initiated when a Skin-colored Object (Finger) was Included
   : Scan Continued even After Removing Finger
   : Primescan's performance issues, Not solely due to Color, But also its Strong AI algorithms in Edentulous Areas
### Measurement

Measuring Liquid Distortion:
1. SW: Geomagic Control X or GOM Inspect
2. Determine **depth from top to deepest sulcus**.
3. Create section lines from top plane in scan data.
4. Gradually lower section plane, until the lowest point (red arrow)
5. Measure shortest distance from **point to top plane**.

#### Key measurement items

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Arid</td>
<td>distance between the deepest point and top plane without artificial saliva</td>
</tr>
<tr>
<td>2</td>
<td>Wet 1/3</td>
<td>distance between the deepest point and top plane when 1/3 submerged in artificial saliva</td>
</tr>
<tr>
<td>3</td>
<td>Wet 2/3</td>
<td>distance between the deepest point and top plane when 2/3 submerged in artificial saliva</td>
</tr>
</tbody>
</table>
How-to-measure Video (Annex C)
Annex D (Translucency)

Distortion Measurement Method:
- SW: Geomagic Control X or GOM Inspect
- Measure distortion of two conditions \((h_1, h_2)\)
- Simulate difference between IOS scan data and actual surface position

Translucent Tooth Surface Measurement Process:
- Select mesh on top face of translucent layer.
- Create reverse-engineered dentin surface plane.
- Form body part surface with 1.5 mm deep translucent resin.
- Measure distance between created planes to calculate height difference between simulated enamel-dentin and dentin-only part.
- Repeat process for incisal part with 3 mm deep translucent resin

Key measurement items

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(h_1)</td>
<td>Displacement at body part (dentin/enamel): 1.5 mm deep translucent resin on the upper step</td>
</tr>
<tr>
<td>2</td>
<td>(h_2)</td>
<td>Displacement at incisal part (enamel): 3 mm deep translucent resin on the lower step</td>
</tr>
</tbody>
</table>
How-to-measure Video (Annex D)
### Key Measurement Items

<table>
<thead>
<tr>
<th></th>
<th>( m_{su} )</th>
<th>Sum of clearly discernable margin line length at supra-gingival margin tooth</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>( m_{eq} )</td>
<td>Sum of clearly discernable margin line length at equi-gingival margin tooth</td>
</tr>
<tr>
<td>2</td>
<td>( m_{sb} )</td>
<td>Sum of clearly discernable margin line length at sub-gingival margin tooth</td>
</tr>
</tbody>
</table>

- **SW**: Geomagic Control X or GOM Inspect

---

**Create line at margin level**

**Delete polygon if margin line encroaches certain portion**

**Keep polygon if margin line & polygon outer edge line overlaps**

**Measure total length of kept margin with remaining polygons**
How-to-measure Video (Annex E)
Comments from Participants

Comments (HongKong U)

1. Subjective Judgement in Measuring 'Sharp and Identifiable Margins' Causes Inconsistency
   → Developing Automation Software with Clear Margin Criteria

![Image of 3D model with highlighted margins]

Fig. 37 Measurement of the total length of sharp and identifiable margins by evaluation of polygons forming the margin line in the 3D model. In the above example, the portion of the margins in red circle was left because it could be clearly distinguished by the edge of the polygon, while the portion of the margins in yellow circle was deleted because it appeared as a polygon face. The distinction between these two involved subjective judgements and was disputable.
Annex F (Arch distortion)

Measurement
The amount of distortion shall be measured using industrial 3D analysis software, such as Geomagic Control X. Five measurement points (A, B, C, D, and E) shall be created. The following are the measurement items:

<table>
<thead>
<tr>
<th>Horizontal</th>
<th>Angular</th>
</tr>
</thead>
<tbody>
<tr>
<td>posterior inter-block width</td>
<td>$\angle$ACE total arch convergence angle</td>
</tr>
<tr>
<td>anterior inter-block width</td>
<td>$\angle$CBA Lt. anterior convergence angle</td>
</tr>
<tr>
<td>Lt. anterior circumferential length</td>
<td>$\angle$CDE Rt. anterior convergence angle</td>
</tr>
<tr>
<td>Rt. anterior circumferential length</td>
<td></td>
</tr>
<tr>
<td>Lt. posterior circumferential length</td>
<td>$A$- Lt. vertical distortion</td>
</tr>
<tr>
<td>Rt. posterior circumferential length</td>
<td>$E$- Rt. vertical distortion</td>
</tr>
</tbody>
</table>
Annex F  (Arch distortion)

Method

Three planes forming the corners corresponding to points shall be obtained by reverse-engineering and intersecting the three planes to set the measurement points. The perpendicular distance of the posterior reference points at either side from the plane shall be defined by the rest of the three reference points.
**Annex G** (Inlay, onlay, and crown preparation)

Measurement
The amount of distortion is measured using industrial 3D analysis software, such as Geomagic Control X. The following are the measurement items:

<table>
<thead>
<tr>
<th>Inlay</th>
<th>Crown</th>
</tr>
</thead>
<tbody>
<tr>
<td>h1 height of block 1</td>
<td>h2 height of block 2</td>
</tr>
<tr>
<td>d1 onlay floor depth of block 1</td>
<td>w2 buccolingual width of block 2</td>
</tr>
<tr>
<td>w6 mesiodistal width of block 6</td>
<td>d2 lingual inlay base depth of block 2</td>
</tr>
<tr>
<td>h6 buccal base height of block 6</td>
<td>h3 height of block 3</td>
</tr>
<tr>
<td>h7 height of block 7</td>
<td>h4 height of block 4</td>
</tr>
<tr>
<td>w7 mesiodistal width of block 7</td>
<td>d4 recess depth of block 4</td>
</tr>
<tr>
<td>w8 buccolingual width of block 8</td>
<td>h5 height of block 5</td>
</tr>
<tr>
<td>d8 distal groove depth of block 8</td>
<td>d5 groove depth of block 5</td>
</tr>
</tbody>
</table>
Method
For height, measure the height of the plane at the base of the test object and the top plane of each block. For depth, measure the depth from each block's top plane to the other planes of the block. For width, measure each block's mesiodistal width or buccal lingual width.
How-to-measure Video (Annex G)
Working group 7

Additive manufacturing
ISO TC 106 SC9/WG7
Virtual meeting 2020

ISO - DTR 5015
Dentistry – Accuracy of CAD/CAM 3D printed dental products
Numerous dental 3D printers are introduced
Dental 3D printing materials are also competitively introduced.
Importance of co-work between Material & Device parts

Material
- Dispersion state
  - Particle size
- Refinement of filler particle size, dispersion of particles
- High dispersion
- High flow
- Maximizing light sensitivity
- Development of high dispersion material technology
- Increase of interlayer bonding power

Device
- Pixel size
- Axis movement
- Reflection rate
- Wavelength
- Curing time
- Viscosity
- Light source power

Light source spectrum analysis
- Optimal wavelength selection
- Speed up material supply
- Securing large area uniformity through pixel stitching
### Physical property measurement of printed products according to printing conditions

<table>
<thead>
<tr>
<th>Verification drawing for printing condition</th>
<th>Microscopic image</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Verification drawing" /></td>
<td><img src="image2" alt="Microscopic image" /></td>
</tr>
</tbody>
</table>

### Printing condition
- **Line width:** 50, 100, 150, 170 μm
- **Layer Thickness:** 50, 100 μm
- **Expose time:** 4~10 sec
- **UV Power:** 10~60

Confirm printing condition by line width discrimination performance.

- Printing grid patterns of various line widths
- Check the expose time that shows optimal line width

### Standard specimen specification

<table>
<thead>
<tr>
<th>Vickers hardness test specimen</th>
<th>Compressive strength measurement specimen</th>
<th>Flexural strength measurement specimen</th>
<th>Casting pattern (ISO 15854)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 X 15 X 15 mm (ISO 14233)</td>
<td>20 X 40 mm (ISO 6873)</td>
<td>4 X 10 X 80 mm (ISO 178)</td>
<td></td>
</tr>
</tbody>
</table>
Design of reference data
3D printed models

- FDM
- DLP 1
- DLP 2
- Polyjet
- SLA
Measurement protocol
Result of coordinate study
Surface texture of 3D printed models
Surface texture of 3D printed models
SEM comparison of 3D printed models
Test Objects

- Test object one: All-in-one specimen (crown/inlay/long distance evaluation)
- Test object two: Cross model with drill sleeves
Test object one: The six-cylinder specimen for long distance evaluation
Importance of evaluating light uniformity of vat
Cross with base
- horizontal setting

Cross without base
- 45 degrees setting

Five models in case of 1:1 build platform (SLA)

Six models in case of 16:9 build platform (DLP)
Opinions from Japan

Accuracy Validation Print

Benchmark print
Opinions from Germany

Denture base

Model with fixed angles

Drill sleeves

Splints

Impression tray
Bracket positioner
Crown & bridge (w/ different wall thickness)
Inlay & onlay
Dental cast
Aligner
Opinions from Korea

Crown restoration

Bridge restoration

Measurement areas

A: intaglio occlusal
B: intaglio lateral
C: margin
D: external lateral
E: external occlusal
Technical report -> Technical specification (Berlin 2022)
DTS discussed & began ILT (Sydney 2023)
Test objects of DTS 5105 (Under ILT project, Project leader: Park JM)

(Annex A) Accuracy validation specimen

(Annex B) Complete-arch dental model with single inlay and crown dies

(Annex C) Drill sleeve model with fixed angles

(Annex D) Crown and bridge restorations

(Annex E) Full denture
Thank you for your attention!
Mandate of the SYC on Bio-digital convergence

Systems level standardization activities in the domain of bio-digital convergence for the IEC, including ISO/IEC JTC 1.

- Facilitate outreach and influence the work on bio-digital convergence with ISO, other SDOs, and industry consortia, in collaboration with relevant IEC entities and thus facilitate the advancement and coordination of bio-digital convergence standardization.

- Identify and assess potential new forthcoming bio-digital convergence topics and problematics that may become relevant to IEC activities and recommend to the SMB an appropriate course of action to meet the needs of the global community.
Bio-digital Convergence

convergence of engineering, nanotechnology, biotechnology, information technology and cognitive science

Note 1 to entry: convergence means the creative union of sciences, technologies, engineering and peoples, focused on mutual benefit; this is a process requiring increasing integration across traditionally separate disciplines, areas of relevance, and across multiple levels of abstraction and organization.

Bio-digital Convergence - a ~20 years old concept!

In the context of BioDigital convergence, ‘The phrase “convergent technologies” refers to the synergistic combination of four major “NBIC”(Nano-Bio-Info-Cogno) provinces of science and technology, each of which is currently progressing at a rapid rate: (a) nanoscience and nanotechnology; (b) biotechnology and biomedicine, including genetic engineering; (c) information technology, including advanced computing and communications; and, (d) cognitive science, including cognitive neuroscience.’ [1]

Also in DOI : 10.1007/978-94-017-0359-8
IT has changed a lot in the last 20 years

Moore's Law: The number of transistors on microchips doubles every two years

Moore's law describes the empirical regularity that the number of transistors on integrated circuits doubles approximately every two years. This advancement is important for other aspects of technological progress in computing—such as processing speed or the price of computers.

<table>
<thead>
<tr>
<th>Transistor count</th>
</tr>
</thead>
<tbody>
<tr>
<td>50,000,000,000</td>
</tr>
<tr>
<td>10,000,000,000</td>
</tr>
<tr>
<td>5,000,000,000</td>
</tr>
<tr>
<td>1,000,000,000</td>
</tr>
<tr>
<td>500,000,000</td>
</tr>
<tr>
<td>100,000,000</td>
</tr>
<tr>
<td>50,000,000</td>
</tr>
<tr>
<td>10,000,000</td>
</tr>
<tr>
<td>5,000,000</td>
</tr>
<tr>
<td>1,000,000</td>
</tr>
<tr>
<td>500,000</td>
</tr>
<tr>
<td>100,000</td>
</tr>
<tr>
<td>50,000</td>
</tr>
<tr>
<td>10,000</td>
</tr>
<tr>
<td>5,000</td>
</tr>
<tr>
<td>1,000</td>
</tr>
<tr>
<td>500</td>
</tr>
<tr>
<td>100</td>
</tr>
<tr>
<td>50</td>
</tr>
<tr>
<td>10</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>1</td>
</tr>
</tbody>
</table>

![Moore's Law Diagram](https://techcrunch.com/2023/06/05/apple-announces-the-m2-ultra-with-up-to-192gb-of-memory/)


https://techcrunch.com/2023/06/05/apple-announces-the-m2-ultra-with-up-to-192gb-of-memory/
Reverse Engineering of Life

Living Systems:

Descriptive:
- Genomics
- Transcriptomics
- Proteomics
- Metabolomics
- Epigenetics
- Microbiomics

Systems integration
- Metagenomics
- Physiology

‘Life-cyle’
- Epigenetics
- Developmental biology
- Evolution

Environment and biologic system of systems:
- Metagenomics
- Exposomics
- Ecosystems
- Ecosystem Evolution
- Gaia

https://en.wikipedia.org/wiki/Metabolomics
https://civilaspirant.in/levels-of-organisation-in-ecology/
https://evolution.berkeley.edu/evolution-101/
How much information?

For a human

• Genome: \(~3 \times 10^9\) base pairs, \(~700\) MB of very complex programming - need a cellular factory to ‘decode’ and additional ‘instructions’ to ‘execute’
  \(~22\ 000\) genes
  – + mitochondrial DNA \((\sim 17\ 000\) base pairs)  
• Proteome: \(~20\ 000\) proteins (encoded in about 1% of the human genome) 
• Metabolome: \(~+110\ 000\) molecules 
• Microbiome: \(~+316\ 000\ 000\) genes.

http://biosoft.kaist.ac.kr/
Human Augmentation Technologies

Human Augmentation Technologies

Phase 1. Recovering, repairing the existing impaired human physiological functions. Most assistive technologies in this phase, e.g., rehabilitation exoskeleton, focuses on rehabilitation scenarios in hospitals and at home.

Phase 2. Replicating, substituting human functions and organs. Power augmentation Exoskeletons (rehabilitation exoskeleton excluded) and artificial organs are common examples at Phase 2. External devices that supplement the daily life living, e.g., smart watches and VR glasses, are also considered as typical use cases.

Phase 3. Enhancing, outperforming human capabilities. Applications aiming at exceeding human abilities are performed using emerging technologies from biomechanical engineering to genetic engineering.

Source: Preliminary findings of IEC SEG 12/WG4

Global Human Augmentation Market - By Region (2019-2027)


Human Geometry (e.g., Limb Malformation) → Personalized Modular Prosthetic Component → Low-cost Prostheses with Sensor-integrated AHMI → Spatial Pressure Sensing

1) 3D Scanning → 2) Bio-CAD → 3) 3D Printing → 4) Testing

Projector, Camera, Camera, Camera

Anatomical Human-Machine Interface (AHMI)

Conformal Electrodes

Human Subject

http://3dprintingireland.com/portfolio/pharmaceutical-medical/attachment/scanmain/


3D Printing Electronics and Sensors Directly on Skin [video]

by Bruce Brown | May 23, 2018 | Enabling Tech, General News | 0 comments


https://doi.org/10.1039/D1TB01335A
14

Physical organ model
- Replicating the Shape and structure
- Mimicking the mechanical properties
- Without biological activity

Real organ

Bioactive Tissue model
- Simulating tissue microenvironment
- Imitating tissue structure
- Biological active

3D printing 3D bioprinting

purpose
- Doctor-patient Communication
- Intraoperative navigation
- Performing experiments
- Preoperative planning
- Simulating operations
- Medical education
- Device testing
- Training skills

Engineering field

Medical field
- Cell reactions
- Cell therapy
- In situ detection
- Drug screening
- Local tissue filling
- Tissue regeneration
- Organ transplantation

purpose
Zoom in: decomposing


3(4)D Scanning and printing applications
History and Status of the SyC BDC

Precursor - Standards Exploratory Group (SEG) 12:
• Created in April 2021
• 7 Working Groups, 125 members
• Report issued to SMB in May 2023
• Technical Report to be published IQ2024

SyC BDC
• Created at the October 2023 IEC SMB Meeting
• Chair and Secretariat assigned
• Kick-Off Plenary in April 2024
• SMB resolution inviting ISO for collaboration through a possible joint structure
SEG 12 Structure & Topics

- WG1 - Communications, Synthesis and Edition of Report
- WG2 - Reverse Engineering of Living Systems
- WG3 - Life systems and Bioengineering
- WG4 - Human Augmentation Technologies
- WG5 - Agricultural Bioengineering
- WG6 - Environmental Bioengineering
- WG7 - Biodigital Social, Risks and Ethical Aspects
- AG8 - Convener Advisory Group
SyC BDC

As an IEC systems committee, the SyC BDC can have:

- **Vice-chair(s)** (See 1.8.2 of the IEC Supplement)
- **Working groups** (Cannot develop standards unless a project is specifically authorized by the SMB)
- **Joint Working Groups, Joint Project Teams** (with IEC or ISO TCs or SCs)
- **Registered (R) Members** (Essentially enhanced liaisons with IEC or ISO TCs or SCs as well as other Standards Developing Organizations - SDOs)
- **Pool(s) of Experts** (from NBs and R Members)
- **Open Forum(s) - open (like a SEG) to any self-nominated experts**
- **Advisory Groups**

For more details, see [https://syc-se.iec.ch/home/what-a-system-committee-does/](https://syc-se.iec.ch/home/what-a-system-committee-does/) and Annex SO of the IEC Supplement.
• Kick-off Plenary (virtual) in April 2024
• Agree on a initial structure
• Review and implement SEG 12 recommendations to the SMB
• As requested by the SMB, come with recommendations for a course of action on ethical issues
• Do whatever is necessary to initiate standardization activities (with IEC and ISO TCs) identified by IEC / SEG 12. This includes the draft bio-digital vocabulary elaborated by SEG 12
• etc…
SyC BDC - how to participate

- Nomination through a National Body
- Nomination through future liaisons or ‘R’ liaisons
- Joining (a) future(s) open forum(s)
Thank You

Brief Introduction of JTC 1/WG 12
3D Printing and Scanning

JTC 1/WG 12 workshop, virtual
(2023-12-12, 1100-1400 UTC)

Kyu Won Shim, MD, PhD
Convenor of JTC 1/WG 12

Co-convenor of JTC 1/WG 12/AHG 3 3D scanning
Status of JTC 1/ WG 12

- **Established at**
  - the 32\textsuperscript{nd} JTC 1 Plenary in Vladivostok, Russia in 2017 conditionally

- **Activated from**
  - 2018-08-15 with the approval of NP 23510

- **Officers**
  - WG 12 Convenor: Prof. Kyu-Won Shim
  - WG 12 Secretary: Ms. Yaeseul Park

- **Members**
  - 74 members from 11 NBs, 5 Liaisons and SIF facilitator (December 2023)
F2F Seoul Meeting for ISO/IEC JTC 1 Study Group on 3D Printing and Scanning, May 24 to 26, 2017
F2F Montreal Meeting for ISO/IEC JTC 1 Study Group on 3D Printing and Scanning,
Ecole de technologie superieure, Department of Software and IT Engineering,
August 29 to 31, 2017
Terms of Reference

- Serve as a focus of and proponent for the JTC 1 standardization program on 3D Printing and Scanning
- Develop ICT related foundational standards for 3D Printing and Scanning upon which other standards can be developed
- Develop other 3D Printing and Scanning standards that are built upon the foundational standards when relevant ISO and IEC committees that could address these standards do not exist or are unable to develop them
- Identify gaps and opportunities in 3D Printing and Scanning standardization
- Develop and maintain liaisons with all relevant ISO and IEC committees as well as with external organizations that have interests in 3D Printing and Scanning
- Engage with 3D Printing and Scanning communities to raise awareness of JTC 1 standardization efforts and provide an open platform for discussion and further cooperation
- Develop and maintain a list of existing 3D Printing and Scanning standards produced and standards development projects underway in ISO TCs, IEC TCs and JTC 1
<table>
<thead>
<tr>
<th>No.</th>
<th>National Body</th>
<th>Number of Experts</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Australia</td>
<td>1</td>
<td>Committee Member</td>
</tr>
<tr>
<td>2</td>
<td>China</td>
<td>6</td>
<td>Committee Member</td>
</tr>
<tr>
<td>3</td>
<td>Canada</td>
<td>1</td>
<td>Committee Member</td>
</tr>
<tr>
<td>4</td>
<td>France</td>
<td>3</td>
<td>Committee Member</td>
</tr>
<tr>
<td>5</td>
<td>Germany</td>
<td>1</td>
<td>Committee Member</td>
</tr>
<tr>
<td>6</td>
<td>India</td>
<td>1</td>
<td>Committee Member</td>
</tr>
<tr>
<td>7</td>
<td>Israel</td>
<td>5</td>
<td>Committee Member</td>
</tr>
<tr>
<td>8</td>
<td>Italy</td>
<td>1</td>
<td>Committee Member</td>
</tr>
<tr>
<td>9</td>
<td>Japan</td>
<td>5</td>
<td>Committee Member</td>
</tr>
<tr>
<td>10</td>
<td>Korea</td>
<td>26</td>
<td>Committee Member</td>
</tr>
<tr>
<td>11</td>
<td>Luxembourg</td>
<td>1</td>
<td>Committee Member</td>
</tr>
<tr>
<td>12</td>
<td>Nigeria</td>
<td>1</td>
<td>Committee Member</td>
</tr>
<tr>
<td>13</td>
<td>UK</td>
<td>2</td>
<td>Committee Member</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>53</strong></td>
<td></td>
</tr>
</tbody>
</table>
• **Subgroups (2)**
  - AHG 1 on 4D Printing
  - AHG 3 on 3D scanning for 3D printing

• **Liaisons**
  - JTC 1/SC 24, 29 and 42
  - Khronos Group

• **Collaborate with other committees**
AHG 1 on 4D Printing

JTC 1/WG 12 agrees to reconstitute AHG 1 on 4D Printing with the following

Terms of Reference:

1) Continue to update the description of key concepts and terminology related to 4D Printing.
2) Assess the current state of standardization activities relevant to 4D Printing in other relevant ISO and IEC TCs, in other SDOs and in consortia.
3) Identify and propose how JTC 1 could address ICT standardization needs of 4D Printing.
4) Provide a progress report to the 11th JTC 1/WG 12 Meeting including recommendations for further study and/or potential NWIPs.

Membership in the AHG 1 is open to:

- JTC 1/WG 12 registered experts and Category C liaisons with JTC 1/WG 12;
- Appointed experts from JTC 1/SCs, JTC 1/WGs, relevant ISO and IEC TCs;
- Invited standards setting organizations that are engaged in 4D Printing standardization as approved by the AHG.

JTC 1/WG 12 reappoints Mr. Adin Stern (IS) as the Convenor with the following membership: Prof. François Coallier (CA), Dr. Byoung Nam Lee (KR), Mr. Dongyub Lee (KR), Prof. Hwanyong Lee (KR), Prof. Jumyung Um (KR), Dr. Atsuhiko Onuma (JP), Prof. Kyu-won Shim (KR), and Prof. Yonghui Liu (CN).

JTC 1/WG 12 requests the AHG 1 Convenor to report the AHG 1 activity no later than 2024-01-15.
AHG 3 on 3D Scanning for 3D printing

JTC 1/WG 12 agrees to reconstitute AHG 3 on 3D scanning for 3D printing with the following Terms of Reference:

1) Investigate current market and technical status related to 3D scanning for 3D printing.

2) Investigate and assess the current status of standardization activities relevant to 3D scanning in other relevant ISO and IEC TCs, in other SDOs, and in consortia.

3) Investigate the future impact of new ICT technology (e.g. digital twin, metaverse) to JTC 1 with 3D scanning for 3D printing.

4) Provide gap analysis for standardization opportunities related to 3D scanning for 3D printing.

5) Identify and propose how JTC 1 could address ICT standardization needs of 3D scanning for 3D printing.

6) Propose, if appropriate, new work items related to 3D scanning and 3D replications (onestop continuous processing that started from 3D scanning to 3D printing).

7) Provide a progress report to the 12th JTC 1/WG 12 Meeting including recommendations for further study and/or potential NWIPs.

Membership in the AHG 3 is open to:

- JTC 1/WG 12 registered experts and Category C liaisons with JTC 1/WG 12;
- Appointed experts from JTC 1/SCs, JTC 1/WGs, relevant ISO and IEC TCs;

JTC 1/WG 12 reappoints Prof. Kyu-won Shim (KR) and Dr. Jason Dowling (AU) as the Co-Convenors with the following membership: Dr. Byoung Nam Lee (KR), Mr. Jonghong Jeon (KR), Mr. Dongyub Lee (KR), Prof. Hwanyong Lee (KR, JTC 1/SC 24 and Khronos Group), Prof. Jumyung Um (KR, ISO/TC 184), Prof. Ji-Man Park (KR, ISO/TC 106), Mr. Yusuke Yasuda (JP), Adin Stern (IS), and Prof. Yonghui Liu (CN).

JTC 1/WG 12 requests the AHG 3 Co-Convenors to report the AHG 3 activity no later than 2024-01-15.
ICT Aspects of 3D Scanning

7.1 Data acquisition: 3D scanners use various technologies such as structured light, laser, or stereo vision to capture the surface geometry of an object or a person. The data captured by the scanner is typically stored in a digital format and can be processed, analyzed, and transmitted using ICT.

7.2 Data processing: After data acquisition, the raw data is typically processed using specialized software to create a 3D model. This process involves a variety of tasks such as data alignment, registration, and meshing.

7.3 Data storage and management: The 3D models generated by scanning process can be large and complex, so they require efficient storage and management. Cloud-based storage and remote access solutions can be used to store and share 3D models, enabling collaboration among multiple users.

7.4 Data visualization: 3D models can be visualized using specialized software, and can be used to generate 2D images, animations, and interactive simulations. This can be done locally or remotely and can be accessed by multiple users.

7.5 Remote access and control: With advancements in ICT, it is possible to remotely control and operate 3D scanners and software, enabling remote data acquisition and processing. This can be useful for applications such as telemedicine or remote monitoring.
Pertinent Standardization activities

10.1 General

<table>
<thead>
<tr>
<th>1. Object</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1 Target object</td>
<td>What is the target object for scanning? (e.g: human body, car, building, city...)</td>
</tr>
</tbody>
</table>

2. Acquisition methods

<table>
<thead>
<tr>
<th>2.1 Scanning device</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the name of the scanning device? (e.g: CT, MRI, intra oral scanner ...)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2.2 Distance</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scanning distance (e.g: contact, short-range, mid-range, long-range...)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2.3 Device Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scanning device type (e.g: fixed, handheld, ...)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2.4 Scan style</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3D scanning method (e.g: LASER triangulation, Structured light, Photogrammetry, Contact-based, LASER pulse-based, ...)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2.5 Raw Data</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw data format or type</td>
<td></td>
</tr>
</tbody>
</table>

3. Segmentation

<table>
<thead>
<tr>
<th>3.1 Segmentation required</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do it require a segmentation technique? If yes, what kind of segmentation techniques are required?</td>
<td></td>
</tr>
</tbody>
</table>

4. 3D model generation

<table>
<thead>
<tr>
<th>4.1 3D reconstruction</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>What 3D (object) reconstruction methods are used? (e.g. from point clouds, models, a set of 2D slices, laser scans, photographs ...)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4.2 3D representation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>What 3D representation methods are used? (e.g.: Raw data(point cloud, range image, polygon soup), Solids (Voxels, BSP tree, CSG, Sweep), Surfaces (Mesh, Subdivision, Parametric, Implicit), High-level structures (Scene graph, Skeleton, Application specific))</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4.3 Format</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>What kind of 3D model format is used?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4.4 Compression</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is standardized compression technology used?</td>
<td></td>
</tr>
</tbody>
</table>

5. Application

<table>
<thead>
<tr>
<th>5.1 Registration</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are registration techniques used?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5.2 Size/Scale</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the size and scale level?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5.3 Error range</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the acceptable range of error?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5.4 Level of Details</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the acceptable range of error?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5.5 Application</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application category (e.g.: space experiments, construction industry and civil engineering, design process, entertainment, 3D photography, Law enforcement, reverse engineering, real estate, virtual/remote tourism, cultural heritage, Medical CAD/CAM, quality assurance and industrial metrology...)</td>
<td></td>
</tr>
</tbody>
</table>

6. Standardization

<table>
<thead>
<tr>
<th>6.1 Related Standards</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>List of related standards (finished and under development)</td>
<td></td>
</tr>
<tr>
<td>Organization/Committee</td>
<td>Description</td>
</tr>
<tr>
<td>------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>ISO/TC 106</td>
<td>Dentistry</td>
</tr>
<tr>
<td>ISO/TC 150</td>
<td>AM in surgical implant applications</td>
</tr>
<tr>
<td>ISO/TC 171/SC 2</td>
<td>Document file formats, EDMS systems and authenticity of information</td>
</tr>
<tr>
<td>ISO/TC 215</td>
<td>Health informatics</td>
</tr>
<tr>
<td>ISO/TC 261</td>
<td>Additive Manufacturing</td>
</tr>
<tr>
<td>ISO/TC 184/SC 1</td>
<td>Automation systems and integration – physical device control</td>
</tr>
<tr>
<td>ISO/TC 184/SC 4</td>
<td>Automation systems and integration – industrial data</td>
</tr>
<tr>
<td>ISO/IEC JTC 1/SC 24</td>
<td>Computer graphics, image processing and environmental data representation</td>
</tr>
<tr>
<td>ISO/IEC JTC 1/SC 29</td>
<td>Coding of audio, picture, multimedia and hypermedia information</td>
</tr>
<tr>
<td>ISO/IEC JTC 1/SC 42</td>
<td>Artificial intelligence</td>
</tr>
<tr>
<td>Khronos Group</td>
<td>3D graphics, Virtual and Augmented Reality, Parallel Computing, Machine Learning, and Vision Processing</td>
</tr>
</tbody>
</table>
Current Activities

Projects

• Published Standards (2)
  - ISO/IEC 3532-1:2023, Information technology — Medical image-based modelling for 3D printing — Part 1: General requirements

• Under development (5)
  - ISO/IEC FDIS 3532-2, Information technology — Medical image-based modelling for 3D printing — Part 2: Segmentation
  - ISO/IEC CD 8801, Information Technology — 3D Printing and Scanning — 3D scanned and labeled data Standard Operating Procedure (SOP) for evaluation of modelling from 3D scanned data
  - ISO/IEC CD 8803, Information Technology — 3D Printing and Scanning — accuracy and precision evaluation process for modeling from 3D scanned data
  - ISO/IEC CD 16466, Information Technology — 3D Printing and scanning — Assessment methods of 3D scanned data for 3D printing model
  - ISO/IEC AWI 23955, Information Technology — 3D Printing and scanning — Technical requirements for product data protection of Additive Manufacturing Service Platform (AMSP)
Errors in modeling tasks determine overall quality.

Total Error/Inaccuracy
Scope of Items

Image acquisition Phase
- Imaging Equip.
  - Evaluate/validate optimal image quality and protocol optimization for 3D printing

Segmentation Phase
- 3D Design SW (Segmentation)
  - Evaluate/verify segmentation performance (precision/accuracy/error)

3D modelling Phase
- 3D Design SW
  - Evaluate/verify 3D modeling performance (precision/accuracy/error)
Scope

- This document describes a standard operating procedure (SOP) of a test data for the evaluation of modelling from 3D scanned data. And the test data consists of 3D scanned data and its corresponding label data.

- This document classifies the main task phases and defines the required tasks in each phase on 3D scanned and labeled data SOP.

- This document defines essential requirements of test data for evaluating modelling from 3D scanned data and describing how to check them.
Scope

- This document defines a standardized accuracy and precision evaluation process for modelling from 3D scanned data. The set of processes, activities and tasks described in this document provides a common framework for evaluating quality factors such as accuracy and precision for the modelling from 3D scanned data.

- This document is not intended to evaluate the 3D printed product itself.
Scope

- This document specifies the assessment methods of 3D scanned data for 3D printing model for the accuracy and precision in the total 3D printing life cycle.

- This document focusses mainly on 3D scanned data from computed tomography. Computed tomography can acquire the informations of internal structures, regional density, orientation and/or alignment of scanning objects as well as shape and appearance.

- This document is not intended to evaluate the 3D printed product itself.
Meeting Records

- **Study Group**
The 1st SG 3 F2F Meeting was held in May 24-26, 2017 in Seoul, Korea
The 2nd SG 3 F2F Meeting was held in August 29-31, 2017 in Montreal, Canada

- **Working Group**
The 1st WG 12 F2F Meeting was held in October 15-17, 2018 in Seoul, Korea
The 2nd WG 12 F2F Meeting was held in February 26-28, 2019 in New York, United State
The 3rd WG 12 F2F Meeting was held in August 27-29, 2019 in Dublin, Ireland
The 4th WG 12 Meeting was held with hybrid mode of F2F and Virtual in March 3-5, 2020 in New York, United State (COVID-19 Pandemic)
The 5th WG 12 Meeting was held fully virtually in August 25-27, 2020
The 6th WG 12 Meeting was held fully virtually in March 8-12, 2021
The 7th WG 12 Meeting was held fully virtually in August 16-20, 2021
The 8th WG 12 Meeting was held fully virtually in February 14-17, 2022
The 9th WG 12 Meeting was held fully virtually in August 29-September 1, 2022
The 10th WG 12 F2F Meeting was held with remote participants in March 14-16, 2023 in Tel Aviv, Israel
The 11th WG 12 F2F Meeting was held with remote participants in August 29-September 1, 2023 in Seoul, Korea
The 1st F2F Meeting for ISO/IEC JTC 1/WG12 in Seoul Korea (15-17 October, 2018)
Current Activities

Meetings

2nd NY, USA

3rd Dublin, Ireland

2020. 03 4th NY, USA -> COVID-19 Pandemic
### Current Activities

#### Meetings

- **March 2023**
  - 10th WG 12 F2F Meeting
  - Tel Aviv, Israel
- **August 2023**
  - 11th WG 12 F2F Meeting
  - Seoul, Korea
- **March 2024**
  - 12th WG 12 F2F meeting
  - Sydney, Australia
- **August 2024**
  - 13th WG 12 F2F meeting
  - TBD, China
JTC 1/AG 21 or "JTC1 strategic direction,"

- the strategic direction and operational structure of JTC 1.
- addressing future environmental changes and adapting JTC 1's operations accordingly.
ISO/IEC JTC 1 "Information technology"
Secretariat: ANSI
Committee manager: Rachell Lisa Mrs.

AG 21 Interim Report

<table>
<thead>
<tr>
<th>Document type</th>
<th>Related content</th>
<th>Document date</th>
<th>Expected action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project / Other</td>
<td>Meeting: Berlin (Germany) 13 Nov 2023</td>
<td>2023-09-21</td>
<td>COMMENT/REPLY by 2023-10-16</td>
</tr>
</tbody>
</table>

Description
This document is circulated for review and consideration at the November 2023 JTC 1 Plenary.
## JTC 1 entities by technical areas

<table>
<thead>
<tr>
<th>Technical Areas</th>
<th>ISO/IEC JTC 1 (Information Technology) Subcommittees and Working Groups</th>
</tr>
</thead>
</table>
| Application Domains Technologies & IT Integration    | SC 27 - Information security, cybersecurity and privacy protection (JWG 6)  
SC 36 - Learning Technology  
SC 41 – Internet of Things and Digital Twin (WG 5, WG 7, JWG 17, JWG 24, JWG3)  
SC 42 - Artificial Intelligence (JWG 3)                                                                 |
| Cultural and Linguistic Adaptability and User Interfaces| SC 02 - Coded Character Sets  
SC 22/WG 20 – Internationalization  
SC 35 - User Interfaces                                                                 |
| Data Capture and Identification Systems              | SC 17 - Cards and Personal Identification  
SC 31 - Automatic Identification and Data Capture Techniques                                                                 |
| Data Management and Governance                       | SC 32 - Data Management and Interchange  
SC 42 - Artificial Intelligence (WG2)  
SC 40 – IT Governance and IT Management (ISO/IEC 38505-2 & 3)  
SC 07 - Software and System Engineering (ISO/IEC 25012)                                                                 |
| Document Description Languages                       | SC 34 - Document Description and Processing Languages                                                                                     |
| Information Interchange Media                        | SC 23 - Optical Disk Cartridges for Information Interchange                                                                                   |
| Multimedia and Synthesis                             | SC 24 - Computer Graphics and Image Processing  
SC 29 - Coding of Audio, Picture, and Multimedia and Hypermedia Information  
WG 12 - 3D Scanning and Printing  
SC 41 – Internet of Things and Digital Twin (WG6)                                                                 |
JTC 1 entities technology maturity map

- Emerging:
  - WG 14
  - SC 43

- Maturing:
  - WG 11, WG 12
  - SC 27, SC 37, SC 41, SC 42

- Deploying:
  - SC 36, SC 38, SC 39, WG 13
  - SC 6, SC 7, SC 17, SC 25, SC 29, SC 31, SC 32, SC 35, SC 40
  - SC 22, SC 23, SC 24, SC 25, SC 28, SC 34

- In production:
  - SC 2

- Legacy:

- Obsolete:

SC 41 Chair contribution to JTC 1/AG21 - v 1.2
Formal cooperative work with non-IT sectors entities: SC 27, SC 41, SC 42, JTC 1 (WG 11), SC 25.

SC 36, SC 7, SC 17, SC 31, SC 35, SC 37, SC 38, WG12, WG 13.

SC 24, SC 27, SC 43, SC 28, SC 40.

IT sector facing:

<table>
<thead>
<tr>
<th>Institution</th>
<th>Names</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. Army Combat Capabilities Development Command (DEVCOM) Armaments Center</td>
<td>Peter Canales, Ryan Carpenter, Erin Hardmeyer, Elias Jelis, John LaBar, Mishail Sharma</td>
</tr>
<tr>
<td>U.S. Army DEVCOM Army Research Laboratory</td>
<td>Matthew Feurer, William Lum, Wayne Ziegler</td>
</tr>
<tr>
<td>U.S. Army DEVCOM Ground Vehicle Systems Center (GVSC)</td>
<td>Aaron LaLonde, Eric Niemasz</td>
</tr>
<tr>
<td>U.S. Department of Defense (DoD) Defense Advanced Research Projects Agency (DARPA)</td>
<td>Andrew Detor</td>
</tr>
<tr>
<td>U.S. Department of Defense (DoD) Defense Innovation Unit (DIU)</td>
<td>Travis DeMeester, Joel Van Brunt</td>
</tr>
<tr>
<td>U.S. Department of Defense (DoD) Defense Logistics Agency (DLA)</td>
<td>Jesse Chambers, Tony Delgado, Kyle Hedrick</td>
</tr>
<tr>
<td>U.S. Department of Defense (DoD) DLA Aviation</td>
<td>David Anderegg, Jorge Bentacourt, Matthew Borsinger</td>
</tr>
<tr>
<td>U.S. Department of Defense (DoD) Manufacturing Technology (Man Tech) Program</td>
<td>Brett Conner, Tracy Frost</td>
</tr>
<tr>
<td>U.S. Department of Energy (DOE)</td>
<td>Blake Marshall</td>
</tr>
<tr>
<td>U.S. Food and Drug Administration (FDA)</td>
<td>James Coburn, Matthew Di Prima, Xiaofei Liu, Kirstie Snodderly</td>
</tr>
<tr>
<td>U.S. Marine Corps</td>
<td>Bill Baker</td>
</tr>
<tr>
<td>U.S. Marine Corps Advanced Manufacturing Operation Cell (AMOC)</td>
<td>Douglas McCue</td>
</tr>
<tr>
<td>U.S. Navy</td>
<td>Ling Xu, Molly Zantow</td>
</tr>
<tr>
<td>U.S. Nuclear Regulatory Commission (NRC)</td>
<td>Amy Hull, Shah Malik</td>
</tr>
<tr>
<td>University of Louisville</td>
<td>Li Yang</td>
</tr>
<tr>
<td>University of North Dakota</td>
<td>Surojit Gupta</td>
</tr>
<tr>
<td>Vibrant Corporation</td>
<td>Eric Biedermann</td>
</tr>
<tr>
<td>Victrex</td>
<td>Silvia Berretta, Patrick Clemensen, Robert McKay, Michael Wallick</td>
</tr>
<tr>
<td>Virginia Commonwealth University</td>
<td>Barbara Boyan</td>
</tr>
<tr>
<td>Volume Graphics GmbH</td>
<td>Philip Sperling</td>
</tr>
<tr>
<td>Weatherford</td>
<td>Robert Badrak</td>
</tr>
<tr>
<td>Wentworth Institute of Technology</td>
<td>Serdar Tumkor</td>
</tr>
<tr>
<td>Wichita State University, National Institute for Aviation Research (NIAR)</td>
<td>Rachael Androlonis, Mark Shaw</td>
</tr>
<tr>
<td>Wohlers Associates, powered by ASTM International</td>
<td>Shane Collins</td>
</tr>
<tr>
<td>Xerox</td>
<td>Farhan Khan</td>
</tr>
<tr>
<td>Yongsei University, Seoul, Korea</td>
<td>Kyu Won Shim</td>
</tr>
</tbody>
</table>

Prepared by the America Makes & ANSI Additive Manufacturing Standardization Collaborative (AMSC)
2.3.7.2 Data Output from Imaging Sources

Patient-specific data can be acquired by a variety of medical imaging modalities, including CT scan, MRI, and ultrasound. The Digital Imaging and Communications in Medicine (DICOM) standard is overseen by the Medical Imaging & Technology Alliance (MITA), a division of the National Electrical Manufacturers Association (NEMA). The DICOM standard applies to communication and management of medical imaging information and related data. The standard facilitates interoperability of medical imaging equipment by specifying protocols for network communication, syntax and semantics of commands, media storage, and file format structure. DICOM is the standard used by all manufacturers of X-ray, CT scan, and MRI imaging equipment. However, the ability to capture radiological output data varies depending on the manufacturer.

Published Standards, etc.

- **ISO/ASTM TR 52916:2022, Additive manufacturing for medical — Data — Optimized medical image data**
- **ISO/IEC 3532-3, Information technology — Medical image-based modelling for 3D Printing — Part 1: General requirements**

In-Development Standards

- **ISO/IEC CD 8803, Information Technology — 3D Printing and Scanning — Accuracy and precision evaluation process for modeling from 3D scanned data (ISO/IEC JTC 1)**

2.3.7.3 Data Acquisition for 3D Modelling: Imaging Protocols

The issue here is multifaceted:

- Diagnostic CT and MRI image data is routinely acquired for the CAD file or modelling application used to create the 3D file for use in the additive manufacturing process. However, the metadata that describes the accuracy, precision, and quality of the source files may not meet the needs of 3D printed patient-matched medical devices.
- Different imaging equipment has different protocols and many patient-matched medical device manufacturers require specialized protocols.
- There is a clinical balance between image quality and patient exposure.

Published Standards

- **ISO/ASTM TR 52916:2022, Additive manufacturing for medical — Data — Optimized medical image data**
- **ISO/IEC 3532-3, Information technology — Medical image-based modelling for 3D Printing — Part 1: General requirements**

In-Development Standards


2.3.7.13 Quality, Verification, and Validation of Medical Product 3D Models

3D models are typically created for a region of interest (ROI). Image processing therefore entails functions such as data segmentation (determining ROI), deleting (eliminating artifacts, noise, and non-RK), smoothing, texturing, (better visualization, surface finishing), and reducing post-processing time. Models are transferred back and forth between image processing and graphic software to create the best model.

Published Standards

- **ISO/IEC 3532-2, Information technology — Medical image-based modelling for 3D Printing — Part 1: General requirements**

In-Development Standards

- **ISO/IEC CD 8803, Information Technology — 3D Printing and Scanning — Accuracy and precision evaluation process for modeling from 3D scanned data (ISO/IEC JTC 1)**

2.6 Data

2.6.1 Introduction

At a digital production process, the formatting, extraction, transfer, integration, security and interoperability of data is critical along the entire additive manufacturing value chain. Data will impact the design, testing, validation, qualification, and quality assurance of parts and systems in nearly all industry sectors. Standards which support data management will help inform decision making in AM production. The following links provide more background regarding how data and data management support AM:

- **Data Driven Decision Support for Additive Manufacturing**
- **A Collaborative Data Management System for Additive Manufacturing** standards, for example under ASTM F42,08 and in cooperation with ISO have published ISO/ASTM 52901-2021, Additive manufacturing — General principles — Overview of data processing. This section may also include domain specific data needs, such as:

- **ISO/IEC 22000-1, Information technology — Security techniques — Information security management systems — Overview and vocabulary**

2.6.9.2 Medical AM Quality Management Systems

The FDA is proposing to expand regulation of hospitals and other "point of care" medical facilities conducting additive manufacturing of medical devices to include individual, patient specific medical devices. This will require point of care facilities to comply with FDA guidance governing manufactured medical devices. A critical requirement within this regulatory "framework" is the creation and use of a quality management system (QMS) that will facilitate validation of each medical device's quality by the

Published Standards

- **ISO/ASTM TR 52916:2022, Additive manufacturing for medical — Data — Optimized medical image data**
- **ISO/IEC 3532-1, Information technology — Medical image-based modelling for 3D Printing — Part 1: General requirements**

In-Development Standards

- **IEEE P3333.3.2, Standard for Three-dimensional (3D) Medical Data Management**

2.4.3.2 3D Image Quality Indicators (IQI)

Published Standards

- **ASTM B889-23, 2023 X-Ray Computed Tomography (CT) Performance Evaluation provides guidance for performance evaluation for users of the machine to assess.**
- **ASTM E1499-2011 Standard Test Method for Measurement of Computed Tomographic (CT) System Performance**
- **ASTM E1441-10, Standard Guide for Computed Tomography (CT)**

In-Development Standards

- **ISO/IEC CD 8803, Information Technology — 3D Printing and Scanning — Accuracy and precision evaluation process for modeling from 3D scanned data (ISO/IEC JTC 1)**
Challenges and Opportunities

3D Printing and 3D Scanning are two distinct industries with significant overlap. These industries are growing rapidly, are being utilized in an increasing array of applications, and are facing many significant challenges.

There is a risk that a large number of collaborator/partners in the same industry can act as a competitor in some situation. It is necessary to communicate and discuss closely at all times so that the cooperative relationship is maintained well.

- ISO/TC 261/WG 4 addresses ‘Data and design’, it does not fully cater to ICT standards.
- ISO/TC 150/JWG 1 focuses on medical 3D printing, but it does not encompass the ICT perspective of data processing and the implant design process itself.

Maintaining a healthy relationship with both ISO/TC 150/JWG 1 and ISO/TC 261, despite their competitive and cooperative dynamics, is indeed crucial.

We should carry out 'open communication, mutual respect, collaboration, conflict resolution and shared goals'.

Many existing groups are already working on underlying technologies and standards, which will provide an opportunity to work closely together to accomplish the needs of the industry and the start-up.
3D Printing and 3D Scanning are inherently cyber-physical systems.

As such, many standardization opportunities cannot be addressed from a strictly ICT point-of-view.

Collaboration with other standards bodies with complementary areas of expertise will be required in many cases. For each opportunity, the following approaches will be considered:

1. If the standardization opportunity is clearly a foundational ICT enabler for 3D printing or 3D scanning, then WG 12 will take the initiative and lead in developing that standard. Examples include but are not limited to underlying broadly applicable file formats, protocols, or cyber-security mechanisms.

2. If the standardization opportunity requires both ICT expertise and domain expertise in another area, then WG 12 will investigate collaborative development opportunities with other entities within ISO and/or IEC, and externally with other appropriate standards bodies. Examples include but are not limited to, specific applications of file formats and protocols, information management policies, data quality standards.

For those 3D printing and scanning related standardization activities with significant ICT concerns currently underway, WG 12 will seek a collaborative arrangement with the standards bodies responsible for the work.
ISO/IEC 3532 series
JTC 1/WG 12 workshop, virtual
(2023-12-12, 1100-1400 UTC)

Kyu-Won Shim, MD, PhD.
Convenor of JTC 1/WG 12

Project leader of ISO/IEC 3532-1:2023, ISO/IEC CD 16466
3D Printing Medical Devices Market is estimated to reach $2.77 billion by 2025; growing at a CAGR of 16.8% between 2017 and 2025. (@profsharemarketresearch)
Market and Technology

• By 2021, IDC expects worldwide spending to be nearly $20.0 billion with a five-year compound annual growth rate (CAGR) of 20.5%.

• **The two use cases of 3D printing** that will see the fastest spending growth – tissue/organ/bone (56.6% CAGR) and dental objects (36.9% CAGR) – will also be driven by healthcare provider spending.
ISO/IEC JTC 1/SG 3
3D Printing and scanning
Convenership: KATS (Korea, Republic of)

Document type: Other document (Open)
Title: Wrap-up report for cranial implant
Status: 
Date of document: 2017-05-26
Source: Leader of Editing group 2
Expected action: INFO
Email of convenor: b.n.lee@etri.re.kr
Committee URL: http://isotc.iso.org/livelink/livelink/open/jtc1sg3
3D implant Workflow

IEC TC62
DICOM
2D File Format
DICOM from CT or MRI data

ISO TC261 WG4
Materialise Mimics
3D File Format
STL
3D modeling

CAD
ISO TC150
Materialise 3-matics

ISO TC184
Machine Code File Format
G-Code
3D Printing (EBM machine)

ISO TC150
Application

ISO TC261 WG3
Q/C
Reverse Engineering

Post-processing, sanding, cleaning,
ISO TC261 JG58
Postprocessing
ISO/IEC FDIS 3532-2
ISO/IEC CD 8803, 8801, 16466
JTC 1/SC 41 Digital twin
JTC 1/SC 24 Computer graphics
JTC 1/SC 42 AI
ISO/TC 261/WG 4
STL, AMF, 3D file format
ISO/IEC 23510 AMSP
JTC 1/SC 24
IEC TC 62D
IEC SEG 12 BioDigital convergence
JTC 1/SC 7 Software
ISO/TC 150/JWG 1
ISO/TC 106
ISO/TC 184, ISO/TC 184/SC 4,
ISO/TC 184/SC 4/WG 15
ISO 10303-21: STEP, STEP-NC
Cyber-physical control
Digital manufacturing
ISO/TC 261
ISO/TC 184/SC 4
ASTM F42
Cyber-physical
control
Machine control
G-code
ISO 13485
ISO/TC 150/JWG 1
ISO CD 5092
ISO/TC 261/WG 3
Reverse engineering
NDT, DICONDE
ISO/TC 261/WG 2/JG
58, ISO/ASTM 52908
# Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreword</td>
<td>iv</td>
</tr>
<tr>
<td>Introduction</td>
<td>v</td>
</tr>
<tr>
<td>1  Scope</td>
<td>1</td>
</tr>
<tr>
<td>2  Normative references</td>
<td>1</td>
</tr>
<tr>
<td>3  Terms, definitions and abbreviated terms</td>
<td>1</td>
</tr>
<tr>
<td>3.1  Terms and definitions</td>
<td>1</td>
</tr>
<tr>
<td>3.2  Abbreviated terms</td>
<td>4</td>
</tr>
<tr>
<td>4  Overview of image processing for the medical industry</td>
<td>5</td>
</tr>
<tr>
<td>4.1  Process flow</td>
<td>5</td>
</tr>
<tr>
<td>4.1.1  3D printing process for medical applications</td>
<td>5</td>
</tr>
<tr>
<td>4.1.2  Explanation of a typical use case (cranial implant case)</td>
<td>5</td>
</tr>
<tr>
<td>5  General requirements</td>
<td>6</td>
</tr>
<tr>
<td>6  Requirements of data processing</td>
<td>7</td>
</tr>
<tr>
<td>6.1  Medical image data flow</td>
<td>7</td>
</tr>
<tr>
<td>6.2  Medical image acquisition/computed tomography scan</td>
<td>8</td>
</tr>
<tr>
<td>6.3  Segmentation</td>
<td>9</td>
</tr>
<tr>
<td>6.4  3D reconstruction and visualization</td>
<td>11</td>
</tr>
<tr>
<td>6.5  Calibration and validation of 2D and 3D conversion</td>
<td>12</td>
</tr>
<tr>
<td>6.6  File format</td>
<td>13</td>
</tr>
<tr>
<td>Annex A (informative) Reporting</td>
<td>14</td>
</tr>
<tr>
<td>Bibliography</td>
<td>15</td>
</tr>
</tbody>
</table>
1 Scope

This document specifies the requirements for medical image-based modelling for 3D printing for medical applications. It concerns accurate 3D data modelling in the medical field using medical image data generated from computed tomography (CT) devices. It also specifies the principal considerations for the general procedures of medical image-based modelling. It excludes soft tissue modelling from magnetic resonance image (MRI).

ISO/IEC 3532-1:2023 touching on CT Scan Data through to image optimization, and with the Point Cloud XYZ format and DICOM data.

ISO/IEC 3532-1:2023 is applicable to NDT or related technology based on CT.
F2F Seoul Meeting for ISO/IEC JTC 1 Study Group on 3D Printing and Scanning, 24 ~ 26 May, 2017

ISO/IEC JTC 1/SG 3
3D Printing and scanning
Convenership: KATS (Korea, Republic of)

Document type: Other document (Open)
Title: Wrap-up report for IEEE 3D Based Medical Application and 3D Printing and Digital Dental Clinic
Status:
Date of document: 2017-05-26
Source: Leaders of Editing Group 1 and 3
Expected action: INFO
Email of convener: b.n.lee@etri.re.kr
Committee URL: http://isotc.iso.org/livelink/livelink/open/jtc1sg3
Proposed Generic Workflow View for 3D Printing and Scanning Processes

- Simulation
  - IEEE-SA P3333.2.4: Simulation
  - ISO TC106

- Geometrical Data
  - IEEE-SA P3333.3.2: Visualisation

- Modelling
  - Education: ISO/IEC JTC1 SC36

- 3D Scan Data
  - IEEE-SA P3333.2.1: Modelling

- Data
  - QC
  - 3D Print: ISO TC261, ASTM F42
  - ISO 17296: AM General Principles

- Machine Control
  - CAD data format: ISO 52915 AMF
  - ISO 13485: Quality control of medical instrumentation
  - ISO/TC184/SC4

- Starting point / End result
  - QC

- ISO 9001: General quality control
  - IEEE-SA P3333.2.5: Printing
  - Health Informatics: ISO/TC215
Proposed Generic Workflow View for 3D Printing and Scanning Processes V2.0

ISO/IEC 23510 AMSP

ISO/TC 261
ISO/TC 184/SC 4
ISO/TC 150/JWG 1
ISO/TC 261/JWG 10
ASTM F42
Cyber-physical control
Machine control
G-code

ISO/TC 184, ISO/TC 184/SC 4,
ISO/TC 184/SC 4/WG 15
ISO 10303-21: STEP, STEP-NC
Cyber-physical control
Digital manufacturing

JTC 1/SC 24
Web3D
Khronos group: ANARI
IEEE P3333.2.4


Data

3D scanned data
DIOM, DICONDE, STL, OBJ, PLY, X3D, FBX, glTF
JTC 1/SC 24
IEC TC 62D
IEC SEG 12 BioDigital convergence
JTC 1/SC 7 Software
ISO/TC 150/JWG 1
ISO/TC 106
ISO/TC 184, ISO/TC 184/SC 4,
ISO/TC 184/SC 4/WG 15
ISO 10303-21: STEP, STEP-NC
Digital manufacturing

3D printing

Starting Point/End results

Modelling

Geometrical data

Simulation

Visualization

Slicing

ISO/TC 184/SC 4/JWG 16
Web3D: X3D

ISO/IEC CD 8803, 8801, 16466
JTC 1/SC 41 Digital twin, JTC 1/SC 24 Computer graphics
STL, AMF, 3D file format, glTF
Errors in modeling tasks determine overall quality.

Total Error/Inaccuracy

- Issue 1
- Issue 2

Modeling Task:
- Image acquisition phase
- Segmentation phase
- 3D modeling phase
- 3D Printing phase

Printing Task:
- Post-processing phase
- QC phase

Application Task:
- Clinical application and review phase
- Post-market phase

Modeling Task vs. Printing Task vs. Application Task
Figure 1 — overall process flow of segmentation
Annex A
(informative)

CT scanning conditions for orbital bone segmentation

High-quality CT scanning is one of the key preconditions in obtaining accurate human bone segmentation. Table A.1 shows the CT scanning parameters and conditions for segmentation of the orbital bone and how to acquire the medical image data. These CT scan conditions are the minimum recommendations considered for the most difficult orbital bone segmentation and, in the cases of other human bones, can be adjusted to appropriate values.

Table A.1 — CT scanning conditions (minimum recommendations)

<table>
<thead>
<tr>
<th>Term</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic conditions</td>
<td></td>
</tr>
<tr>
<td>Region of interest</td>
<td>For orbital bone, the whole head can be scanned, and an optimal ROI can be extracted from 1 cm above the supraorbital foramen to infraorbital foramen.</td>
</tr>
<tr>
<td>Bony position</td>
<td>Supine position</td>
</tr>
<tr>
<td>Image resolution</td>
<td>At least 512 x 512</td>
</tr>
<tr>
<td>Scanning conditions</td>
<td></td>
</tr>
<tr>
<td>Tube voltage</td>
<td>80 kV to 120 kV (100 kV recommended)</td>
</tr>
<tr>
<td>Tube current</td>
<td>250 mA to 400 mA (CT-AEC recommended)</td>
</tr>
<tr>
<td>Scan slice thickness</td>
<td>Below 1.0 mm</td>
</tr>
<tr>
<td>Scan (rotation) time</td>
<td>0.5 s to 1.5 s</td>
</tr>
<tr>
<td>Reconstructing conditions</td>
<td></td>
</tr>
<tr>
<td>FOV</td>
<td>100 mm to 150 mm</td>
</tr>
<tr>
<td>Slice thickness</td>
<td>Below 1.25 mm</td>
</tr>
<tr>
<td>Slice spacing</td>
<td>Below 1.0 mm</td>
</tr>
<tr>
<td>Reconstruction kernel</td>
<td>Standard</td>
</tr>
<tr>
<td>Output format</td>
<td>DICOM (Digital Imaging and Communications in Medicine) format, as most medical 3D modeling software is compatible with the DICOM format.</td>
</tr>
</tbody>
</table>

NOTE ISO 19233-1 recommends CT scanning conditions for the orthopedic joint prosthesis [21].
<table>
<thead>
<tr>
<th>Brief Description</th>
<th>General</th>
<th>Anatomical Modelling</th>
<th>Surgical Planning</th>
<th>Personalized/Precision Prosthetics</th>
<th>Permanent Implants</th>
<th>Active &amp; Wearable Devices</th>
<th>Bioprinting/Tissue Fabrication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-personalized, instruments or prototypes</td>
<td>Patient-matched anatomical models from medical imaging studies (CT/MRI)</td>
<td>Templates, guides, and models after preparing a patient-specific surgical plan in a software environment (the 3D printed items are brought into operating room)</td>
<td>Patient-matched prosthetics or orthotics</td>
<td>“Off-the-shelf” (ability to create fine details easily, such as porous structures/shapes) and patient-matched implants</td>
<td>Devices that include electronics or other active element</td>
<td>3D printing of materials that incorporate living cells or living cells</td>
<td></td>
</tr>
</tbody>
</table>

Examples of What is 3D Printed:
- Simple instruments: plastic or metal
- Specialized metals (other instruments for hospitals/surgical use: e.g., plate bending)
- Testing pieces built with new materials
- Prototypes for iterative design process
- Models for surgical preparation, training, and simulation (e.g., pediatric cardiac, conjoint twins)
- Models for teaching or training purposes ("off-the-shelf" models)
- Models for communicating with patients, patient and colleagues (e.g., realistic models)
- Simulation/Training models to test fit and fixation of a device (e.g., stent deployment, implant seating)
- Guides that mark without cutting or injection: Examples:
  - Surgical marking guide
  - Implant placement guide (i.e., guiding placement of "off-the-shelf" total joint replacement components for total hip and knee arthroplasty)
  - Radiation shields
  - Imaging frames
- Cutting/drilling guides for surgical injection/instrumentation: examples:
  - Guiding osteotomies in the bone
  - Surgical saw guides
  - Surgical drill guide
- Patient-Matched Prosthetics/Orthotics:
  - Direct Contact with Non-Mucosal Surface (e.g., glasses, body lenses, hearing aids, prosthetic limbs and attachments, etc.)
  - Direct Contact with Mucosal Surface (i.e., dental and orthodontic applications)
- Assistive devices:
- Serialized implants
  - Metallic implants (e.g., titanium, stainless steel, cobalt chrome alloy)
  - PEAK/PEEK implants
  - Temporary or Permanent Implants
- Patient-Matched Reconstructive Implants:
  - Small Quantity Cases (e.g., limb amputations, hip fractures)
  - "Everyday" type of implants (e.g., knee replacements)
  - Temporary (or Removable) implants (i.e., nail matrix)
- Permanent Implants: Non-Dissolvable (e.g., tissue ingrowth or osseointegrated implants (e.g., dental implants))
- Wearable sensors
- Lab on a chip
- Microfluidics
- Electronics for active devices
- Tissues or scaffolds used for regenerative engineering, drug delivery, drug discovery, tissue engineering, etc.
- Organ on a chip
- Tissue and bone scaffolds

Where:
- All
- All, with emphasis on point-of-care

Technology:
- 3D Printing
- Materials
- 3D Printing/Additive Manufacturing
- Image Processing Software
- Materials
- 3D Printing
- Biocompatibility
- Design Software
- Materials
- Surgical Planning Software
- Templating
- 3D Printing
- Design Software
- Digitizing Anatomy
- Manufacturing Workflows
- Materials
- Scanning
- Additive Manufacturing (DMIS, EBDM, SLS)
- Materials
- Telemetrics
- 3D Printing
- Materials
- 3D Printing

Standards:
- Aging
- Cleaning and Sterilization
- Material Properties
- Re-Use
- Cleaning and Sterilization
- Color
- Imaging
- Material Properties
- Cleaning and Sterilization
- Material Properties
- Porous Material Evaluation

Issues of Importance:
- Material Properties
- Re-Use
- Reuseable Misuse (e.g., device which was designed as a holding aid to be left or stuck with a mallet during use, etc.)
- Automation of Software
- Biocompatibility
- Cleaning and Sterilization
- Model Accuracy
- Multi-Materials
- Point of Care Issues
- Biocompatibility (including the debris from drilling/cutting)
- Efficiency
- Forreseeable Misuse
- Proving it Matters (Reimbursement)
- Automation of Design
- Biocompatibility
- Cleaning and Sterilization
- Forreseeable Misuse
- Model Accuracy
- Part Strength
- Secondary Post Processing
- Shell Life
- Workflows and Efficiency
- Biocompatibility
- Build Orientation
- Cleaning and Sterilization (including cleaning porosity)
- Part Strength
- Point of Care Issues
- Process Control
- Secondary Post-Processing
- Shelf Life
- Speed and Reliability to Cost
- Validations
- Verification and Inspection
- Biocompatibility
- Cell Survival
- Material
- Point of Care Issues
- Sterility

©SME Medical Additive Manufacturing/3D Printing Workgroup
This utilization of 3D printing in the medical field has led to numerous advancements, including the production of customized medical devices, surgical models, prosthetics, and even tissue and organ printing.

These technologies have the potential to revolutionize healthcare by enabling personalized treatments and improving patient outcomes.

"Medical applications of 3D printing" refers to the extensive use of 3D printing technology in the field of healthcare and medicine. The market share for these applications is substantial, accounting for over 35-45% of the overall market.

Therefore, it is crucial to explore common technological elements that can be applied from an Information and Communication Technology (ICT) perspective.

Furthermore, any technology standards derived from this exploration should be designed to be applicable in both medical and non-medical contexts, as suggested by JTC 1/AG 21.
The role of JTC 1/WG 12

- JTC 1/AG 21 is known for its role in standardizing 3D printing and scanning across various fields in a horizontal and versatile manner. The specific group responsible for this role is “JTC 1/WG 12,” which promotes international standardization for 3D printing and scanning, defines standardized procedures and terminology, and supports the broader utilization of 3D printing and scanning technology across various application areas.

- From an ICT perspective, ISO/IEC 3532-1:2023 outlines the process of creating the most commonly used 3D model, a standard deemed essential for 3D printing.

- ISO/IEC 3532 series were designed to include horizontal details about the needs of each related TCs since JTC 1/SG 3, with the concept and basic needs originating from the medical industry.
Nondestructive, 3D Scanning of Internal and External Geometries

Benefits of CT Scanning:

- Non-destructive inspection of your parts; line of sight or visual access to any surface is not required for CT scanning, yet 100% of the surface data is captured. Your object, material or system will not be compromised or impaired, so its future usefulness is kept intact.
- CT Scanning can provide accuracy on small parts of +/-0.010mm and on larger parts of +/-0.025mm (depending on size of part).
- Parts with small, complex, and fine geometry from the medical and electronics industries benefit especially from this technology, since they are very difficult to measure using even the most advanced, laser-based scanning or CMM technologies.
- Customizable two- and three-dimensional inspections of small- to medium-sized objects generate 3D XYZ scan data in standard file format outputs for inspection and reverse engineering applications.
- CT scanning helps you capture all surfaces, both external and internal, of complex and free-form parts without damage to the object.
Nondestructive, 3D Scanning of Internal and External Geometries

The Laser Design 3D Scanning Team has been busy! Besides a busy lab (that is also ITAR certified) we've also been to the World Trade Center, the new U.S. Bank Stadium, Space Needle, Miami Airport, ships in Korea, the Mirage volcano and more! We have the experience and know-how to tackle your next project whether it's a small hearing aid or an entire ship! Check out our gallery of CT scanned photos.
Nondestructive, 3D Scanning of Internal and External Geometries

CT Scanning Case Studies

4 Easy Steps to NURBS Surface Modeling in Geomagic Design X
Case Study – Using EasyTom CT Scanner and Volume Graphics Analysis Software for Defect Detection
Case Study – CT Scanning Baseballs
Merit Medical Gains R&D Efficiencies with 3D Scanning
Just what the Doctor Ordered: Innovative Medical Applications of Non-Contact 3D Scanning
Verifying Assemblies Using CT Scans and Geomagic

Laser Design adds EasyTom Industrial CT Scanner to Services Division
Application Story – Medical Device 3D CT Scanning

Nondestructive, 3D Scanning of Internal and External Geometries | Laser Design
Nondestructive, 3D Scanning of Internal and External Geometries

- CT scanner captures all surfaces, both external and internal, of complex free-form parts and assemblies without harming the object. Parts made of plastic, ceramics or composite materials, as well as magnesium, aluminum and steel, can be measured and efficiently evaluated. A very long service life is enabled by the open X-ray tube technology and it has a measurement range of 11.8" x 13.8" (300 mm x 350 mm). The CT system can also be equipped with a higher resolution detector to make very fine part structures visible, and the enlarged detailed view can be measured with extremely high accuracy.

- Processing the CT scan data through Volume Graphics, the 3D model is then loaded into Geomagic Qualify where the assembly is compared to either original CAD design data or to scan data of another known working product. Geomagic Qualify quickly and automatically measures and assesses deviations between the new scan data and the comparison assembly model, making measurement on known tolerances, identifying deviations in the assembly based on unanticipated forces between parts. Geomagic Qualify then automatically produces a custom report for the production engineers in PDF, so it can be viewed by all concerned parties.
This use of additive manufacturing is interesting for several reasons.

1. Material is added to an existing part rather than to a base plate or table.

2. The build direction may well not be constant.

3. The material added may not be in planar sections – Directed Energy Deposition (DED) has been proposed for the repair of turbine blade edges, for example.

The same technique may also be used to add manufacturing features where, say, milling cannot be used because there is no tool access.

The most important knowledge for this case comes from accurate scanning of the broken shape including very small complex geometry and balancing the ratio between the shape removed before 3D printing and the shape filled by the 3D printing process.
Needs for the New Standard

• Information technology — 3D Printing and Scanning — Image-Based Modelling from 3D scanned Data
  • ISO/IEC 3532-1 : General Requirement
  • ISO/IEC 3532-2 : Segmentation
  • ISO/IEC 8803 : Accuracy and precision evaluation process for modeling from 3D scanned data
  • ISO/IEC 16466 : Assessment methods of 3D scanned data for 3D printing model
  • ISO/IEC 8801 : 3D scanned and labeled data Standard Operating Procedure (SOP) for evaluation of modelling from 3D scanned data
  • NWIP : Phantom-based evaluation methods for 3D printing modeling software
Scope of NWIP

- Defines **Phantom-based assessment procedure of 3D Modeling Software for 3D Printing** in the **Total 3D Printing Life cycle**, and especially focuses on the image-based modelling of 3D scanned data from CT scanner, industrial and medical.

---

**1. Image Acquisition Phase**

**2. Segmentation Phase**

**3. 3D Modelling Phase**

**4. 3D Printing Phase**

**5. Post-processing Phase**

**6. QC Phase**

**7. Clinical Application & Review Phase**

**8. Post-market Phase**

---

**Phases:**

1. **Image acquisition Phase**
2. **Segmentation Phase**
3. **3D Modelling Phase**
4. **3D Printing Phase**
5. **Post-processing Phase**
6. **QC Phase**
7. **Clinical Application & Review Phase**
8. **Post-market Phase**
Scope of NWIP

**Image acquisition Phase**
- Imaging Equip.

**Segmentation Phase**
- 3D Design SW (Segmentation)

**3D modelling Phase**
- 3D Design SW

**Phantom for 3D scanning & printing**

- Evaluate/validate optimal image quality and protocol optimization for 3D printing
- Evaluate/verify segmentation performance (precision/accuracy/error)
- Evaluate/verify 3D modeling performance (precision/accuracy/error)
1. Scope

- This document defines the test procedure and test methods for the accuracy and precision evaluation of 3D modeling software used for 3D printing parts/devices using well-designed phantom.

- This document is not intended to evaluate the 3D printed product itself.
5 Phantom Design Requirements

5.1 General

The requirements for the design of the well-designed phantom used in the accuracy and precision evaluation of the 3D modeling software, including material requirements, size and shape requirements, and any other relevant physical characteristics.

Unlike conventional 3D printing, architectural 3D printing models buildings and structures from design images. Design images have errors due to resolution, image noise, etc., when acquired, and have difficulty in accurately representing the boundaries of buildings and structures with complex geometric shapes due to resolution limitations. In particular, the former area has structural features such as curves, correct surfaces, small sizes, and this part is composed of different materials and colors, making it difficult to segment images of design images. Due to the inaccurate information of the design image, it is difficult to verify whether the result of the modeling process, which processes through image acquisition, segmentation, STL file generation, 3D printing, design, etc., is accurate with the original design. To verify and correct the modeling process, a phantom that can measure and compare evaluations is required. The architectural phantom should not only reflect the geometric characteristics of the design being simulated and provide spatial (3D) information for verifying the accuracy and precision of the modeling process.

5.2 Requirements

5.2.1 It shall reflect the physical characteristics (such as specific dimensions and characteristic shapes, RGB values of the constituent materials in design images, etc.) of the size and structural target parts of the customized products.

5.2.2 It shall distinguish between the customized target region of interest (ROI) and non-region of interest (non-ROI).

5.2.3 It shall describe the design, production material, and production method of the phantom.

6 Assessment Procedure

6.1 General

The procedure for the accuracy and precision evaluation of the 3D modeling software, including the steps involved in preparing the well-designed phantom, using the 3D modeling software to create a 3D model of the phantom, and measuring the accuracy and precision of the 3D model using the well-designed phantom.

- Prepare the basic required for the test.
- Set the software to be tested to the optimal environment according to the manufacturer’s recommendations.

6.2 Assessment Procedure

6.2.1 Retrieving the phantom CT data corresponding to the phantom elements specified in Annex B from the 3D modeling software.

6.2.2 Segmentation function accuracy/precision test

6.2.2.1 Split the CT phantom into individual components using segmentation in 3D modeling software.

6.2.2.2 Select the key test measurement locations specified in Annex B for each segmented assessment target.

6.2.2.3 Measure the length, height, angle, and radius of each major key test measurement position using the measurement functions provided by the 3D modeling software.

6.2.2.4 Record the measurements obtained from the 3D modeling software in the test results table.

6.2.2.5 Compare the measurements obtained from the 3D modeling software with the values in the measurement reference table.
Q & A

shimkyuwon@yuhs.ac
I. Market and Technology

II. What is an AMSP?

III. Needs for the Standards

IV. Investigation and Analysis of Typical AMSPs

V. Introduction to NP23955

VI. Plan of NP 23955
Worldwide revenues from AM products and services were about $18.027 billion in 2022, with an increase of 18.3%. 1) Revenues from AM products were $7.289 billion, with an increase of 17%. 2) Revenues from AM services were $10.738 billion (about 60%), with an increase of 19.1%.

(Source: Wohlers Report 2023)
Additive Manufacturing Service Platform (AMSP) uses additive manufacturing technology and information technology to provide services according to users’ requirements.
What is an AMSP?

- AMSP can satisfy different 3D printing needs from different fields through the Internet very easily, especially those who do not have 3D printers or cannot design.
AMSP has created a new business model and also brought about the need for standardization.

a) Traditional business model

b) New business model based on AMSPs
What is an AMSP?

Figure 1 — Typical AMSP workflow
What is an AMSP?

Figure 2 — Interaction among stakeholders including an AMSP, users, designers and AM centres.
In October, 2021, the first AMSP standard, ISO/IEC 23510: 2021 Information technology — 3D printing and scanning — Framework for an Additive Manufacturing Service Platform (AMSP) proposed was successfully published.
Based on ISO/IEC 23510, a new draft standard related to AMSP entitled *Information technology — 3D Printing and Scanning — Technical requirements for product data protection of Additive Manufacturing Service Platform (AMSP)* is proposed in 2022.

### 7.1 Copyright protection

An AMSP allows users to upload or create personalized 3D models online in a convenient manner. The data of 3D models is usually easily spread or stolen illegally through the transmitting procedure over the internet. Meanwhile, 3D models are also easily printed without permission, which can cause a loss to the designer or model provider. Therefore, the data security of the 3D model during the data storage, transmission and printing are ensured and the intellectual property of designers and model providers needs to be protected.

---

**Table 1 (continued)**

<table>
<thead>
<tr>
<th></th>
<th>Resource layer</th>
<th>Technical support layer</th>
<th>Engine layer</th>
<th>Platform integration operating environment layer</th>
<th>Tool layer</th>
<th>Access layer</th>
<th>User layer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Security management</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operation monitoring</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

7.2 Quality inspection

The performance requirements and inspection methods of the final objects/parts delivered to the user from the AMSP should meet the requirements of ISO 17296-3 and ISO/ASTM 52901.
3D design model is the core of additive manufacturing for the application of 3D printing on an AMSP, which embodies the great efforts and wisdom of a designer.

However, many AMSPs lack the mechanism of product data information protection, limiting the commercialization of excellent design works combined with additive manufacturing technology.

According to statistics, about 80% of designers are not willing to share their designs on an AMSP for fear of theft.
Needs for the Standards (3) ...

- Open application program interface requirements for AMSP
Investigation and Analysis of Typical AMSPs

Liu Yonghui
28 Dec. 2022, Qingdao, China
Introduction to NP23955

- **Title**
  Technical requirements for product data protection of Additive Manufacturing Service Platform (AMSP)

- **Purpose and justification of the proposal**
  ① This standard was developed in response to the needs of product data protection so as to promote the mass customization of additive manufacturing technology by taking full advantage of information and communication technology (ICT).
  ② This standard can protect the product data information of designers and stimulate their innovation enthusiasm.
  ③ Moreover, it can provide guidance for the establishment and operation of an AMSP, and promote the healthy development of the new industry of providing additive manufacturing services by AMSP.
Introduction to NP23955

- Normative references
  - ISO/ASTM 52900, Additive Manufacturing — General Principles — Fundamentals and vocabulary
  - ISO/ASTM 52901, Additive manufacturing — General principles — Requirements for purchased AM parts
  - ISO/IEC 27001, Information security management
Introduction to NP23955

Terms and definitions (which can be cited)
- additive manufacturing service platform
  AMSP
- user
- designer
- additive manufacturing centre
  AM centre
Introduction to NP23955

Terms and definitions (which are new)

- **product data information on AMSP**: information related to 3D model that can be processed by the application software of AMSP in the process of providing additive manufacturing products and relevant services.
- **provider of 3D model**: individual or organization that provides 3D model data to AMSP and has the ownership of 3D model data or obtains partial or all of rights and interests after being legally authorized by the owners of 3D design data, mainly including users and designers.
- **receiver of 3D model**: individual or organization that receives 3D model data from AMSP for the manufacturing purposes, usually referring to AM centres.
Introduction to NP23955

- Classification of product data information on AMSP

Figure 2 Categories of product data information on AMSP

- Product identification information
  - (Product name, etc.)

- Product attribution information
  - (Store name, etc.)

- Product geometric information
  - (Geometric file, etc.)

- Product manufacturing information
  - (Material, color, etc.)

- Product transaction information
  - (Price, etc.)

Figure 1 — Property types of a product on AMSP

- Geometry-related properties: shape, size, etc.
- Manufacturing-related properties: surface roughness, printing time, cost, etc.
According to the importance of different categories of product data information, three protection levels can be divided, which are level I, level II and level III.

- Level I is the strictest protection level.

<table>
<thead>
<tr>
<th>Categories</th>
<th>Main contents</th>
<th>Protection level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product identification information</td>
<td>Product name, trademark and/or brand, product type, product description, etc.</td>
<td>Level III</td>
</tr>
<tr>
<td>Product attribution information</td>
<td>Uploader and/or designer (or design owner), etc.</td>
<td>Level II</td>
</tr>
<tr>
<td>Product attribution information</td>
<td>Store name</td>
<td>Level III</td>
</tr>
<tr>
<td>Product geometric information</td>
<td>Product shape, size, geometric file and format type, sliced file and format type, etc.</td>
<td>Level I</td>
</tr>
<tr>
<td>Product manufacturing information</td>
<td>Manufacturing materials, manufacturing process and/or equipment, product color, post-processing (like surface roughness), etc.</td>
<td>Level III</td>
</tr>
<tr>
<td>Product transaction information</td>
<td>Product quotation, lead time, delivery method, etc.</td>
<td>Level III</td>
</tr>
<tr>
<td></td>
<td>Quantity of purchased products, transaction value, etc.</td>
<td>Level II</td>
</tr>
</tbody>
</table>
Technical requirements for product data information protection at different stages

- The processing of product data information on AMSP mainly involves four stages, i.e. data collection, data display, data transfer and data deletion, and the protection of product data information should be carried out throughout all the four stages.
Responsibilities and obligations assumed by different entities

All stakeholders including 3D model providers, 3D model receivers and AMSPs have the responsibilities and obligations to protect product data information.

- Responsibilities and obligations of 3D model providers
- Responsibilities and obligations of 3D model receivers
- Responsibilities and obligations of AMSPs
Plan of NP 23955

- The voting process has finished before 2023-11-07
- Proposed Standard Development Track: 36 months
- Proposed date for first meeting: 2024-01-05
- Proposed TARGET dates for key milestones
  - Circulation of 1st Working Draft (if any) to experts: 2024-06-15
  - Committee Draft consultation (if any): 2024-11-15
  - DIS submission*: 2025-07-15
  - Publication*: 2026-08-15

We need the participation from YOU!
Thank you!

Your advices are highly appreciated

12 Dec. 2023, Online Workshop

Prof. Yonghui Liu, Member of ISO/IEC WG12, and SAC/TC 562
+86 13963988206, yonghui_liu_sd@126.com
Ocean University of China/ShanDong CharmRay Laser Technology Co.,Ltd
No.238, Songling Road, Laoshan District Qingdao, China
gltf for 3D Scan Data Format

Hwanyong Lee, Ajou University
Member of Korean National Body of JTC 1/WG 12
Liaison Representative of WG12-Khronos Group

CC-BY Khronos Group 2023
This work is licensed under a Creative Commons Attribution 4.0 International License
Contents

• Introduction to glTF
• glTF ecosystem
• 3D Commerce
• 3D Scanning and glTF
**glTF 2.0 Scene Description Structure**

- **.gltf (JSON)**
  - Node hierarchy, PBR material textures, cameras

- **.bin**
  - Geometry: vertices and indices
  - Animation: key-frames
  - Skins: inverse-bind matrices

- **.png, .jpg, .ktx2**
  - Textures

**Texture based PBR materials**

**Mandatory Metallic-Roughness Materials**

**Optional Specular-Glossiness Materials**
glTF

- ISO/IEC 12113:2022

**Authoring Formats**

- Interchange
- Dilation
- Distillation

**Authoring Tools**

- Import
- Remixing
- Export
- Publish

**Transmission Format**

- Optimization
- Verification, Editing

**glTF Tools**

**Viewers / Engines**

**Tools**

- glTF
- USD
- NVIDIA MDL
- MATERLX
- FBX

© Khronos® Group Inc. 2019 - Page 4
glTF - The JPEG of 3D!

<table>
<thead>
<tr>
<th>Audio</th>
<th>Video</th>
<th>Images</th>
<th>3D</th>
</tr>
</thead>
<tbody>
<tr>
<td>MP3</td>
<td>H.264</td>
<td>JPEG</td>
<td>glTF</td>
</tr>
</tbody>
</table>

Efficient, reliable transmission
Bring 3D assets into 1000s of apps and engines

Compact to Transmit ✔
Simple and Fast to Load ✔
Describes Full Scenes ✔
Runtime Neutral ✔
Open and Extensible ✔

glTF 1.0 - December 2015
Primarily for WebGL
Uses GLSL for materials

glTF 2.0 - June 2017
Native AND Web APIs
Physically Based Rendering
Metallic-Roughness and Specular-Glossiness

glTF spec development on open GitHub - get involved!
https://github.com/KhronosGroup/glTF
Draco glTF Mesh Compression Extension

- Library for compressing and decompressing 3D geometric meshes and point clouds
  - Draco designed and built for compression efficiency and speed - great fit with glTF!
    - https://github.com/google/draco

- Draco glTF extension launched in February 2018
  - https://github.com/KhronosGroup/gltf/blob/master/extensions/2.0/Khronos/KHR_draco_mesh_compression/README.md

- Google has released Draco encoders and decoders in open source
  - C++ source code encoder to compress 3D data
  - C++ and JavaScript decoders for the encoded data
    - https://github.com/google/draco/tree/gltf_2.0_draco_extension

- glTF/Draco compression already in use
  - Blender, three.js, BABYLON.JS, Adobe Dimension, glTF pipeline, FBX2glTF, AMD Compressorator and glTF sample models

![Mesh Compression Ratios Chart]

© Khronos® Group Inc. 2019 - Page 7
Universal Textures for glTF

- Fragmentation of GPU texture formats is significant issue for developers
  - Binomial’s ‘Basis Universal’ technology enables JPEG-sized texture assets
  - Transcodable on-the-fly to natively supported compressed GPU formats

- glTF Universal Texture extension uses KTX2 as a flexible container
  - Precisely defined specification for consistent, cross-vendor generation and validation
  - Can contain wide range of texture formats used in Vulkan/DirectX/Metal
  - Supports streaming and full random access to MIP levels
  - Subset of full KTX2 - mandating supercompressed textures using Basis Universal technology

*ASTC support in development
Physics

- Collision geometry
- Motions
- Materials
- Joints
- Filters
PBR in glTF

- Clearcoat
- Sheen
- Transmission
- Volume
- Index of Refraction
- Specular

Metal / Rough

© Khronos® Group Inc. 2019 - Page 10
Geospatial

Expand the capabilities of glTF and related technologies to better address the needs and requirements for transmission and display of 3D models, scenes, and interfaces for geospatial applications.

- Liaison with Open Geospatial Consortium (OGC)
- Very large data sets
- Specialized data handling (Hierarchical Level of Detail - HLOD)
3D Scanning Data Format Based on glTF
3D Scanned Data

Geometry: Vertex and Mesh
Texture Mapping: UV Coords
Textures: Materials
glTF 2.0 Scene Description Structure

.glTF (JSON)
- Node hierarchy, PBR material textures, cameras

.bin
- Geometry: vertices and indices
- Animation: key-frames
- Skins: inverse-bind matrices

.png
- Textures

.jpg
- Textures

.ktx2
- Textures

Mandatory Metallic-Roughness Materials

Optional Specular-Glossiness Materials
Why glTF for 3D Scanning

• Efficiency - Directly import/export 3D asset for GPU
  - No need to conversion - binary data of Geometry, Image (Texture)
  - GPU import / export tools available with open source

• Usefulness
  - Asset can be used in tremendous tools for editing, visualization, compression, metaverse and commerce etc.
  - Annotation (PDF), Presentation (MS PowerPoint), Documentation (MS Word), Rich Media (MPEG)

• It is an international standard!
  - ISO/IEC 12113:2022
  - Can be used as a reference standard
Thank you

Hwanyong Lee, Ajou University

hwanyong.lee@gmail.com / hwan@ajou.ac.kr
Proposal for NWIP overview and vocabulary for 3D scanned data

JTC1 WG12 Online workshop, 2023-12-09
Korean experts

Presenter: Prof. Jumyung UM
JTC1 WG12 & ISO TC184 SC1
Kyung Hee University
Contents

• Motivation
  ① Advanced features
  ② Advanced scanning technology
  ③ Advanced visualization method

• Use cases
  ① Legacy methods
  ② Quality control
  ③ Reverse engineering
  ④ Robot programming
  ⑤ Digital factory
  ⑥ Construction yards
  ⑦ Retail applications
  ⑧ Medical applications

• Working draft
  ① Introduction
  ② Scope
  ③ Related standards
  ④ General procedure
  ⑤ Table of Contents
  ⑥ Plan

• QnA
• modern 3D scanner have advanced features
  • What is Base Color, F0, Normal, Metalness, Roughness and Scattering?
  • Who can define them precisely?

Image courtesy from DGG and ZEISS
Motivation > Advanced scanning technology

• How can we evaluate 3D scanned quality?
  • Can we separate skin color and shadow?
  • Resolutions of color and geometry.
New visualization methods for 3D scanned images are feasible
  - for instance, Direct Volume Rendering - rendering without iso-surface detection
  - need definition
    - drawing params
    - technical features
Use cases > Legacy methods of traditional manufacturing

• Legacy metrology and inspection processes are using touch probing to measure selected points on the surface of final products
• Limitations: Single point measurement, Part accessibility, Surface finish sensitivity, Material compatibility, Tool deflection

→ 3D scanning method
Advanced assembly factories are employing new quality control methods of welding surface with whole plates by using 3D scanning.

There is use cases of mobile robots inspecting assembly results visually by using 3D camera attached in the end of its head.

Source: https://www.hyundai.com/worldwide/en/company/newsroom/detail/0000000363
“Overhaul and Repair” is evolving by using 3D scanning technologies. Dense scanning data and Deep learning methods let the process enhance the speed and the accuracy.

By comparing scanned data with the original shape, repair process optimizes the time and cost.

Various 3D scanning methods are used. In particular, metal parts are more challenging but new technologies overcome the limitation.

• Since collaborative robots (Cobots) are introduced in shop floors, Camera sensors are widely used to recognize positions of parts as well as to detect possible hazardous situation such as collision with human operators.
• Legacy robot programming is off-line way, but Cobot control requires for synchronizing with 3D scanning data during the robot are running.

Building digital twin of factories give the opportunities of asset management, layout planning, Safety analysis, Training operators, Real-time monitoring, etc.

In essence, 3D scanning data forms the foundation for creating detailed and accurate digital twins of factory environments, enabling a wide range of applications.
• Leveraging 3D scanning data in constructing digital twins of construction yards significantly improves safety measures by providing simulations, real-time monitoring, training opportunities, and proactive hazard identification and mitigation strategies.

• Visualizing Safety Protocols, Emergency routes, Worker monitoring and tracking, Dynamic Safety Assessment, Collaborative Safety Planning, etc
• 3D scanning is a widely used solution in various industries, including fashion, retail, and retail. It allows for accurate body measurements for tailored apparel and allows shoppers to try on new clothes using their 3D avatars. Virtual fitting rooms also provide new opportunities for in-store and online shopping, allowing customers to view results in 360 degrees.

https://www.iphone3dscanner.com/solutions
• 3D scanning technology plays a pivotal role in improving patient care by enabling personalized treatments, precise surgical planning, enhanced medical education, and the development of innovative medical devices and interventions.

• WG12 is standardizing a data procedure of Medical Image-Based Modelling as ISO/IEC 3532-1.
This document provides an overview of 3D printing and scanning along with a set of terms and definitions. The purpose of this document is to provide foundational standards for better understanding and for developing key ideas and practices on the Information and Communication Technology (ICT) aspect of 3D printing and scanning.

This document places an emphasis on the ICT aspects of terms used for 3D scanning. It clarifies and enhances definitions for generic workflows for 3D printing and scanning to emphasize the ICT perspective that aligns with the work scope of JTC 1. The definitions include terms related to 3D scanning devices, data, process, and its applications.
• This document provides an overview of the ICT aspects of 3D scanning and its applications along with a set of terms and definitions.

• This document also related with the following processes: visualization, machining, inspection, product design, reverse engineering, and 3D printing.

• New terms from the future work within ISO/IEC JTC 1/WG 12 will be included in upcoming amendments of this document.
<table>
<thead>
<tr>
<th>Title</th>
<th>Group</th>
<th>Link</th>
</tr>
</thead>
</table>
3D scanning is a precise and efficient method for accurately determining an entity’s surface or volume in a three-dimensional space.

It captures real-world information, aiding in visualization and measurement, and can be utilized for comparative analysis or design changes in new products.
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Scope</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>Normative references</td>
<td>8</td>
</tr>
<tr>
<td>3</td>
<td>Terms and definitions</td>
<td>8</td>
</tr>
<tr>
<td>3.1</td>
<td>General terms relating to 3D scanning</td>
<td>8</td>
</tr>
<tr>
<td>3.2</td>
<td>Terms relating to attributes</td>
<td>12</td>
</tr>
<tr>
<td>3.3</td>
<td>processing 3D scanned data</td>
<td>13</td>
</tr>
<tr>
<td>3.4</td>
<td>Abbreviated terms</td>
<td>15</td>
</tr>
<tr>
<td>4</td>
<td>Overview of 3D scanning process</td>
<td>15</td>
</tr>
<tr>
<td>4.1</td>
<td>3D Scanning process</td>
<td>15</td>
</tr>
<tr>
<td>4.2</td>
<td>Process to end user application</td>
<td>16</td>
</tr>
<tr>
<td>5</td>
<td>Applications and use cases</td>
<td>16</td>
</tr>
<tr>
<td>5.1</td>
<td>Engineering and manufacturing</td>
<td>16</td>
</tr>
<tr>
<td>5.2</td>
<td>Medical Application</td>
<td>17</td>
</tr>
<tr>
<td>5.3</td>
<td>Retail business</td>
<td>18</td>
</tr>
</tbody>
</table>
• terms used in 3D asset scanning, manipulation and visualization.
• no redundant definition!
• only new terms and difference usage in 3D asset (not listed in ISO terminologies)
• terms and overview for evaluation of 3D scanning and 3D asset manipulation and visualization

• Schedule - In the end of 2023 - NWIP and first draft will be provided by KNB
Thank You
ISO/IEC JTC1/WG12
AHG 3 on 3D Scanning for 3D Printing

12th Dec 2023: 3D Scanning for 3D Printing Webinar

Jason Dowling, Ph.D.
Principal Research Scientist, CSIRO
Brisbane, Australia

Jason.Dowling@csiro.au
AHG 3 3D SCANNING FOR 3D PRINTING: TERMS OF REFERENCE

01 Investigate current market and technology status related to 3D scanning for 3D printing

02 Investigate/assess status of relevant standardization activities in other ISO/IEC TCs; SDOs, and consortia

03 Investigate future impact of new ICT technology (e.g. digital twin, metaverse) to JTC1.

04 Provide gap analysis for standardization opportunities

05 Identify and propose how JTC 1 could address ICT standardization needs

06 Propose, if appropriate, new work items related to 3D scanning and 3D replications
AHG 3 HISTORY

16 Jun 2022
1ST JTC 1/WG 12 AHG 3 MEETING VIRTUAL. 15 PARTICIPANTS, 2.5 HOURS (N520)

7 Jul 2022
2ND JTC 1/WG 12 AHG 3 MEETING VIRTUAL. 8 PARTICIPANTS; 2 HOURS

31 Aug 2022
3RD JTC 1/WG 12 AHG 3 MEETING VIRTUAL

16 Feb 2023
4TH JTC 1/WG 12 AHG 3 MEETING ON 3D SCANNING FOR 3D PRINTING. VIRTUAL 4 PARTICIPANTS; 1 HOUR 45 MINUTES.

14 Mar 2023
5TH JTC 1/WG 12 AHG 3 MEETING TEL AVIV, ISRAEL F2F MEETING WITH REMOTE PARTICIPATION.
<table>
<thead>
<tr>
<th>Name</th>
<th>Country</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prof. Kyu won Shim</td>
<td>KR</td>
<td>Co-Convenor</td>
</tr>
<tr>
<td>A/Prof Jason Dowling</td>
<td>AU</td>
<td>Co-Convenor</td>
</tr>
<tr>
<td>Dr. Byoung Nam Lee</td>
<td>KR</td>
<td></td>
</tr>
<tr>
<td>Mr. Jonghong Jeon</td>
<td>KR</td>
<td></td>
</tr>
<tr>
<td>Mr. Dongyub Lee</td>
<td>KR</td>
<td></td>
</tr>
<tr>
<td>Prof. Hwanyong Lee</td>
<td>KR</td>
<td>JTC 1/SC 24</td>
</tr>
<tr>
<td>Prof. Jumyung Um</td>
<td>KR</td>
<td>ISO/TC 184</td>
</tr>
<tr>
<td>Prof. Ji-Man Park</td>
<td>KR</td>
<td>ISO/TC 106</td>
</tr>
<tr>
<td>Mr. Yusuke Yasuda</td>
<td>JP</td>
<td></td>
</tr>
<tr>
<td>Adin Stern</td>
<td>IS</td>
<td></td>
</tr>
<tr>
<td>Prof. Yonghui Liu</td>
<td>CN</td>
<td></td>
</tr>
</tbody>
</table>
HIGH LEVEL ICT ASPECTS OF 3D SCANNING

- **Data acquisition** (structured light, laser, stereo vision, etc)
- **Data processing** (data alignment, registration, meshing, etc)
- **Data storage and management** (3D models require efficient storage and management)
- **Data visualization** (generate 2D images, animation, interactive simulations, etc)
- **Remote access and control of 3D scanners** (eg. remote monitoring)
SAMPLE 3D SCANNING APPLICATIONS

- Cultural heritage
- Construction industry and civil engineering
- Engineering design process
- Entertainment
- 3D photography
- Law enforcement
- Reverse engineering
- Real estate
- Virtual remote tourism
- Circumvention of shipping costs and tariffs
- Medical
APPLICATIONS: CULTURAL HERITAGE

- Recording and preserving historical sites and artifacts
- Restoration and conservation
- Archaeology
- Digital preservation
- Education
APPLICATIONS: ENGINEERING DESIGN PROCESS

1. 3D scanning of object
2. Data processing (e.g., convert point cloud to mesh)
3. Design (import mesh into CAD or BIM software)
4. Simulation and analysis (in virtual environment)
5. Fabrication (3D print, CNC machining, etc.)
6. Inspection (Compare 3D scan result with original design)

Neptune 3D CT scan of Moka Express Coffee maker.
https://www.scanofthemonth.com/scans/coffee

APPLICATIONS: MEDICAL

• 3D scanning (e.g. CT and MRI) can acquire data for detailed digital models of human anatomy, which can be used in medical research and education, as well as in the planning of surgeries.

• 3D scans of a patient’s external surface can be acquired through 3D scanning technologies

Scanned (Artec Leo); Modelled (Autodesk Meshmixer); and 3D printed (Ender 5) bolus for radiation therapy treatment.

**EMERGING TECHNOLOGIES**

<table>
<thead>
<tr>
<th>Technology</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Handheld 3D scanning</strong></td>
<td>Quickly and easily capture 3D data of objects and environments. Lightweight, portable and easy to use</td>
</tr>
<tr>
<td><strong>Multi-modal 3D scanning</strong></td>
<td>Combines different 3D scanning technologies, such as laser scanning and photogrammetry, to capture data from different perspectives and in different lighting conditions</td>
</tr>
<tr>
<td><strong>Active illumination 3D scanning</strong></td>
<td>Uses structured light or laser to project a pattern of light onto an object, and then captures the deformation of the pattern using a camera. Can improve the accuracy and resolution of 3D scanning in certain situations</td>
</tr>
<tr>
<td><strong>Deep learning for 3D scanning</strong></td>
<td>Use deep learning techniques to improve the quality of 3D scans by making the process more automated, faster, and more accurate</td>
</tr>
<tr>
<td><strong>Mobile 3D scanning</strong></td>
<td>Uses a combination of 3D scanning, GPS and computer vision to capture 3D data while moving. Useful for mapping and surveying large areas, such as cities, mines or archaeological sites</td>
</tr>
<tr>
<td><strong>Terrestrial Laser Scanners</strong></td>
<td>Uses lasers to scan a wide area quickly and accurately, and can be used for large-scale mapping and surveying, such as for construction and civil engineering projects; and digital twins</td>
</tr>
</tbody>
</table>
## Standardization Activities: Gap Analysis

### DRAFT FRAMEWORK FOR STANDARDIZATION GAP ANALYSIS

#### Modeling Task
- **Image acquisition phase**
- **Segmentation phase**
- **3D modeling phase**
- **3D Printing phase**
- **Post-processing phase**

#### Printing Task
- **QC phase**
- **Clinical application and review phase**
- **Post-market phase**

#### Application Task

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ISO/IEC JTC 1/SC 15 WG 12 (3D Printing and scanning)</td>
<td>CT, MRI</td>
<td>y</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. ISO/TC 190 (Dentistry)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. ISO/TC 181 (Automation systems and integration)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. ISO/TC 190/SC 14 (Implants for surgery)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. ISO/IEC JTC 1/SC 24 (Computer graphics)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. ISO/IEC JTC 1/ISO 41 (Internet of things and digital twin)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. ISO/TC 159 (Ergonomics)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Minos Group</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. ISO/TC 133 (Cloud printing systems)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. ASTM Committee E57 on 3D Imaging System</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. DDS point cloud</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. MPES point cloud compression</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. IEEE 3A 3D Body Processing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Niras</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
AHG 3 wants to focus on opportunities for horizontal standardization which align with other ISO/IEC committees.

Membership in the AHG 3 is open to:

- JTC 1/WG 12 registered experts and Category C liaisons with JTC 1/WG 12
- Appointed experts from JTC 1/SCs, JTC 1/WGs, relevant ISO and IEC TCs
- We welcome more diverse active membership from a wide range of application domains.
ISO/IEC JTC1/WG12
AHG 3 on 3D Scanning for 3D Printing

12th Dec 2023: 3D Scanning for 3D Printing Webinar

Jason Dowling, Ph.D.
Principal Research Scientist, CSIRO
Brisbane, Australia

Jason.Dowling@csiro.au