The Printer Working Group

May 4, 2017
Working Draft

PWG 3D Print Job Ticket and Associated Capabilities v1.0 (PJT3D)

Status: Stable

Abstract: This document describes the PWG Semantic Model Print3D service schema for embedded Job Tickets. The schema is based on the IPP 3D Printing Extensions v1.0 (3D) and suitable for data exchange and embedding within common 3D file formats such as 3MF and 3D PDF documents so that user intent is preserved regardless of the transport or workflow used.

This document is a Working Draft. For a definition of a "Working Draft", see: http://ftp.pwg.org/pub/pwg/general/pwg-process30.pdf

This document is available electronically at:

http://ftp.pwg.org/pub/pwg/ipp/wd/wd-smpjt3d10-20170504.docx
http://ftp.pwg.org/pub/pwg/ipp/wd/wd-smpjt3d10-20170504.pdf

Title: *PWG 3D Print Job Ticket and Associated Capabilities v1.0 (PJT3D)*

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About the IEEE-ISTO PWG

The Printer Working Group (or PWG) is a Program of the IEEE Industry Standards and Technology Organization (ISTO) with member organizations including printer manufacturers, print server developers, operating system providers, network operating system providers, network connectivity vendors, and print management application developers. The group is chartered to make printers and the applications and operating systems supporting them work together better. All references to the PWG in this document implicitly mean “The Printer Working Group, a Program of the IEEE ISTO.” In order to meet this objective, the PWG will document the results of their work as open standards that define print related protocols, interfaces, procedures and conventions. Printer manufacturers and vendors of printer related software will benefit from the interoperability provided by voluntary conformance to these standards.

In general, a PWG standard is a specification that is stable, well understood, and is technically competent, has multiple, independent and interoperable implementations with substantial operational experience, and enjoys significant public support.

For additional information regarding the Printer Working Group visit:

http://www.pwg.org

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About the Internet Printing Protocol Workgroup

The Internet Printing Protocol (IPP) workgroup has developed a modern, full-featured network printing protocol, which is now the industry standard. IPP allows a print client to query a printer for its supported capabilities, features, and parameters to allow the selection of an appropriate printer for each print job. IPP also provides job information prior to, during, and at the end of job processing.

For additional information regarding IPP visit:

http://www.pwg.org/ipp/

Implementers of this document are encouraged to join the IPP mailing list in order to participate in any discussions of the document. Suggested additions, changes, or clarification to this document, should be sent to the IPP mailing list for consideration.

Table of Contents

List of Figures

1. Introduction

The IPP 3D Printing Extensions v1.0 [PWG5100.21] defines an extension to the Internet Printing Protocol (IPP) that supports printing of physical objects by Additive Manufacturing devices such as three-dimensional (3D) printers. This document defines an XML schema representing the semantic elements and values of the IPP 3D model, allowing conversion of IPP Job Tickets and Printer Capabilities into an XML format suitable for data exchange and embedding within common 3D file formats such as 3MF [3MF] and 3D PDF [ECMA363] [ISO14739] [ISO32000].

The Print3D schema [SCHEMA] is automatically generated from the IANA IPP registry by the IPP Registry project's [IPPREGISTRY] "regtosm" tool. This schema is based in part on the PWG Print Job Ticket and Associated Capabilities Version 1.0 (PJT) [PWG5108.07] which defines an XML schema for the IPP 2D model.

1.1 Output Intent Versus Device Process and Control

As with [PWG5108.07], the focus of 3D printing using the Print3DService schema defined in this document is the specification of output intent and not the processes or device control needed to produce a given output. Clients can specify general material selections (“red PLA”, “brown wood PLA”, “clear ABS”, etc.), print preferences and quality, and whether supports and rafts should be printed. Printers then use implementation specific device control and (ordered) processes to satisfy the Client-supplied output intent when processing the Job.

Besides enabling simpler, easier to use Client software that is less likely to fail due to minor implementation differences, this model also prevents the Client from providing dangerous device control instructions that exceed safe operating parameters or disable critical safety interlocks.

2. Terminology

2.1 Printing Terminology

Normative definitions and semantics of printing terms are imported from IETF Printer MIB v2 [RFC3805], IETF Finisher MIB [RFC3806], and IETF Internet Printing Protocol/1.1: Model and Semantics [RFC8011].

Document: An object created and managed by a Printer that contains the description, processing, and status information. A Document object may have attached data and is bound to a single Job.

Intent: The preferences for the processing and description properties of a Job or Document.

Job: An object created and managed by a Printer that contains description, processing, and status information. The Job also contains zero or more Document objects.

Job Receipt: A data object that contains information on the actual values of processing Elements used when a Job was processed.

Job Ticket: A data object that contains the Job-level Intent (processing and description Elements).

Printer: A print Service or hardware device that supports 3D printing.

Service: A program that accepts and processes requests to create, monitor and manage Jobs. The Service accepts and processes requests to monitor and control the status of the Service itself and its associated Resources. A Service may be hosted either locally or remotely from the Printer.

2.2 Other Terminology

Element: A term used to convey structure and relationships in XML Document instances. An Element can contain both content and Elements. Complex Elements are composed, at least in part, of other Elements.

2.3 Acronyms and Organizations

3D PDF Consortium: http://www.3dpdfconsortium.org/

3MF Consortium: 3D Manufacturing Format Consortium, http://www.3mf.io/

ISO: International Organization for Standardization, http://www.iso.org/

ODL: Object Definition Language

PWG: Printer Working Group, http://www.pwg.org/

3. Rationale for the PWG 3D Print Job Ticket and Associated Capabilities v1.0 (PJT3D)

Existing specifications define the following:

1. The IPP 3D Printing Extensions v1.0 (3D) [PWG5100.21] defines an extension to the Internet Printing Protocol (IPP) that supports printing of physical objects by Additive Manufacturing devices such as three-dimensional (3D) printers;
2. The W3C XML Schema Definition Language (XSD) 1.1 Part 1: Structures [XSD11-1] specifies the XML Schema Definition Language, which offers facilities for describing the structure and constraining the contents of XML documents, including those which exploit the XML Namespace facility;
3. The W3C XML Schema Definition Language (XSD) 1.1 Part 2: Datatypes [XSD11-2] defines facilities for defining datatypes to be used in XML Schemas as well as other XML specifications;
4. The 3D Manufacturing Format Core Specification & Reference Guide v1.1 [3MF] defines an XML schema and file format for describing 3D objects with one or more materials;
5. The Universal 3D File Format [ECMA363] defines a binary format for 3D objects embedded in PDF files;
6. Document management -- 3D use of Product Representation Compact (PRC) format -- Part 1: PRC 10001 [ISO14739] defines a binary format for 3D objects embedded in PDF files; and
7. Document management — Portable document format — Part 1: PDF 1.7 [ISO32000] defines a binary file format that supports embedded 3D objects with one or more materials.

Therefore, this PWG 3D Print Job Ticket and Associated Capabilities document should define an XML schema that represents the IPP attributes and values needed to support embedding of Job Tickets in 3D document files, data exchange of Printer capabilities, Printer status, Job Receipts, Job Status, and Job Tickets, and workflows utilizing XML data models.

3.1 Use Cases

3.1.1 Web-Based Submission of 3MF File

Jane has a 3D model she wishes to print using a commercial 3D printing provider. The provider supports 3MF files but only allows submission using a HTML form on their web site. Jane uses the software on her Client device to select the materials and required dimensional accuracy, and then exports the 3D model to a 3MF file with an embedded Job Ticket. She then submits the file for printing by the provider.

3.1.2 Job Accounting using Receipts

A print provider needs to produce machine-readable records of every Job that is printed that are provided to customers to report what work has been performed, the billing department to determine the cost of each Job, and the operations group to track when to order supplies and perform maintenance. The receipts need to record the amount and type of materials used, the total processing time, and any issues that were encountered during printing. The provider generates a standalone file for each Job, providing copies to the customers, billing department, and operations group.

3.2 Out of Scope

The following are considered out of scope for this document:

1. Reporting of actual monetary values associated with Jobs.

3.3 Design Requirements

The design requirements for this document are:

1. Define PWG Semantic Model elements and values that correspond to their IPP counterparts; and
2. Define a named PWG Semantic Model schema incorporating the elements and values so that Job Tickets and their associated capabilities can be exchanged.

4. The Print3D Schema

The Print3D schema defines a PWG Semantic Model schema for an abstract 3D printing Service based on the IPP 3D Printing Extensions v1.0 (3D) [PWG5100.21]. The "Print3DServiceType" and "Print3DJobType" types define the abstract data models for the Service and its Jobs. The "Print3DJobTicketType" type defines the abstract data model for the Job Ticket that is typically embedded in a 3D document file.

The schema itself is organized into four schema description ("XSD") files:

"Print3DService.xsd": This file defines the Print3D service types and includes all of the other files.

"PwgCommon.xsd": This file defines the elements mapped from IPP attributes.

"PwgTypes.xsd": This file defines the base IPP types.

"PwgWellKnownValues.xsd": This file defines the well-known values of registered IPP enum and keyword attributes.

The schema namespace URL is "http://www.pwg.org/schemas/smpjt3d10".

4.1 Print3DServiceType

Figure 1 shows the "Print3DServiceType" type which describes an instance of the abstract 3D printing service and contains the capabilities, configuration, description, status, and Jobs list.

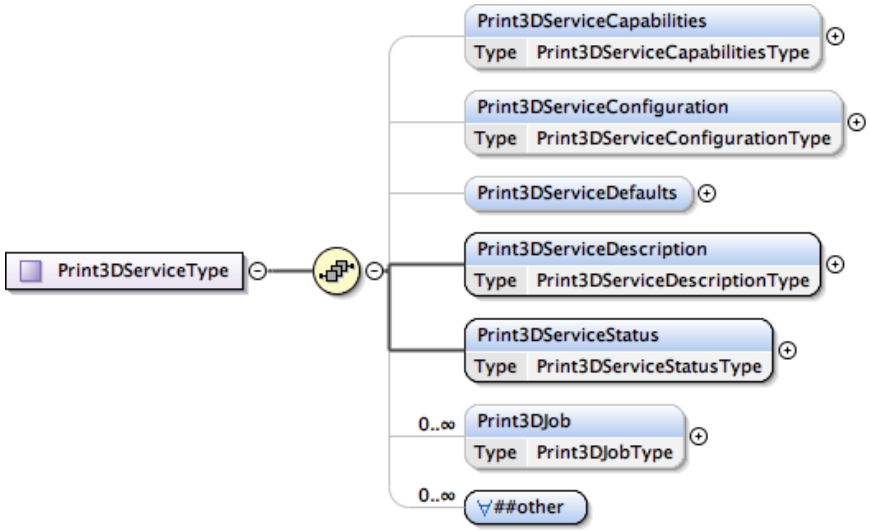

Figure 1 - Print3DServiceType Schema

4.1.1 Print3DServiceCapabilities

This Element contains the supported and "ready" values for each of the Job Ticket elements. Ready values are those that the Printer can use without operator intervention.

4.1.2 Print3DServiceConfiguration

This Element contains information about the Printer sub-units.

4.1.3 Print3DServiceDefaults

This Element contains the default Job Ticket values for the Printer.

4.1.4 Print3DServiceDescription

This Element contains descriptive values for the Printer, including its name and owner.

4.1.5 Print3DServiceStatus

This Element contains state values for the Printer.

4.1.6 Print3DJob

This Element contains the list of active and previously completed 3D print Jobs.

4.2 Print3DJobType

Figure 2 shows the "Print3DJobType" type which describes an instance of the abstract 3D print Job and contains the Job Receipt, Job Ticket, Job status, and Documents list.

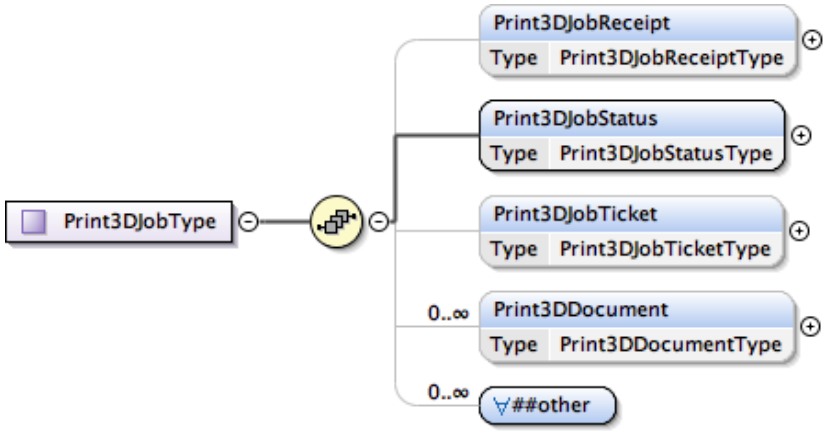

Figure 2 - Print3DJobType Schema

4.2.1 Print3DJobReceipt

This Element contains the Job Receipt for a completed Job.

4.2.2 Print3DJobStatus

This Element contains the Job status information.

4.2.3 Print3DJobTicket

This Element contains the Job Ticket for the Job.

4.2.4 Print3DDocument

This Element contains the list of Documents associated with the Job.

4.3 Print3DJobTicketType

Figure 3 shows the "Print3DJobTicketType" type which contains the Job name and processing intent.

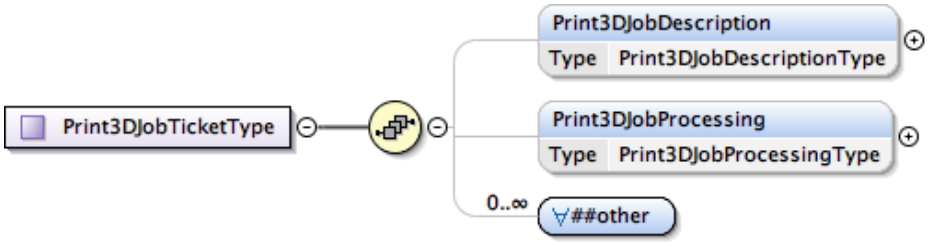

Figure 3 - Print3DJobTicketType Schema

4.3.1 Print3DJobDescription

This Element contains the Job name and any billing information that was supplied.

4.3.2 Print3DJobProcessing

This Element contains the Job processing intent, including the list of materials to use, required print accuracy, and so forth.

5. Internationalization Considerations

For interoperability and basic support for multiple languages, conforming implementations support:

1. The Universal Character Set (UCS) Transformation Format -- 8 bit (UTF-8) [STD63] encoding of Unicode [UNICODE] [ISO10646]; and
2. The Unicode Format for Network Interchange [RFC5198] which requires transmission of well-formed UTF-8 strings and recommends transmission of normalized UTF-8 strings in Normalization Form C (NFC) [UAX15].

Unicode NFC is defined as the result of performing Canonical Decomposition (into base characters and combining marks) followed by Canonical Composition (into canonical composed characters wherever Unicode has assigned them).

6. Security Considerations

The security considerations for this document are the same as those described in the IPP 3D Printing Extensions v1.0 (3D) [PWG5100.21].

7. References

[3MF] "3D Manufacturing Format Core Specification & Reference Guide v1.1", http://www.3mf.io/specification

[ECMA363] "Universal 3D File Format", ECMA-363

[IPPREGISTRY] "ISTO-PWG IPP Registry Repository", https://github.com/istopwg/ippregistry

[ISO10646] "Information technology -- Universal Coded Character Set (UCS)", ISO/IEC 10646:2014

[ISO14739] "Document management -- 3D use of Product Representation Compact (PRC) format -- Part 1: PRC 10001", ISO 14739-1:2014

[ISO32000] "Document management — Portable document format — Part 1: PDF 1.7", ISO 32000-1:2008

[PWG5100.21] M. Sweet, "IPP 3D Printing Extensions v1.0 (3D)", PWG 5100.21-2017, http://ftp.pwg.org/pub/pwg/candidates/cs-ipp3d10-20170210-5100.21.pdf

[PWG5108.07] P. Zehler, "PWG Print Job Ticket and Associated Capabilities Version 1.0 (PJT)", PWG 5108.07-2012,

http://ftp.pwg.org/pub/pwg/candidates/cs-sm20-pjt10-20120801-5108.07.pdf

[RFC5198] J. Klensin, M. Padlipsky, "Unicode Format for Network Interchange", RFC 5198, March 2008, http://tools.ietf.org/html/rfc5198

[RFC8011] M. Sweet, I. McDonald, "Internet Printing Protocol/1.1: Model and Semantics", RFC 8011, January 2017, http://tools.ietf.org/html/rfc8011

[SCHEMA] "PWG Print3D Schema", http://ftp.pwg.org/pub/pwg/sm3/schemas/smpjt3d10-20170420.zip

[STD63] F. Yergeau, "UTF-8, a transformation format of ISO 10646", RFC 3629/STD 63, November 2003, http://tools.ietf.org/html/rfc3629

[UAX15] Unicode Consortium, “Normalization Forms”, UAX#15, June 2014, http://www.unicode.org/reports/tr15/tr15-41.html

[UNICODE] Unicode Consortium, "Unicode Standard", Version 9.0.0, June 2016, http://www.unicode.org/versions/Unicode9.0.0/

[XSD11-1] "W3C XML Schema Definition Language (XSD) 1.1 Part 1: Structures", April 2012, https://www.w3.org/TR/2012/REC-xmlschema11-1-20120405/

[XSD11-2] "W3C XML Schema Definition Language (XSD) 1.1 Part 2: Datatypes", April 2012, https://www.w3.org/TR/2012/REC-xmlschema11-2-20120405/

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9. Sample Print3DJobTicket

The following 3D print job ticket specifies four copies of an object printed with two materials - blue PLA for the object and a dissolvable PLA for the supports - at normal quality with supports and rafts:

```
<?xml version="1.0" encoding="UTF-8"?>
<pwg:Print3DJobTicket xsi:schemaLocation="Print3DService.xsd"
  xmlns:pwg="http://www.pwg.org/schemas/smpjt3d10"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  <pwg:Print3DJobProcessing>
    <pwg:Copies>4</pwg:Copies>
    <pwg:MaterialsCol>
      <pwg:MaterialColor>blue</pwg:MaterialColor>
      <pwg:MaterialPurpose>InFill</pwg:MaterialPurpose>
      <pwg:MaterialPurpose>Shell</pwg:MaterialPurpose>
      <pwg:MaterialType>pla</pwg:MaterialPurpose>
    </pwg:MaterialsCol>
    <pwg:MaterialsCol>
      <pwg:MaterialPurpose>Base</pwg:MaterialPurpose>
      <pwg:MaterialPurpose>Support</pwg:MaterialPurpose>
      <pwg:MaterialType>pla-dissolvable</pwg:MaterialPurpose>
    </pwg:MaterialsCol>
    <pwg:PlatformTemperature>60</pwg:PlatformTemperature>
    <pwg:PrintBase>Raft</pwg:PrintBase>
    <pwg:PrintSupports>Material</pwg:PrintSupports>
    <pwg:Quality>Normal</pwg:Quality>
  </pwg:Print3DJobProcessing>
  <pwg:Print3DJobDescription>
    <pwg:DocumentMetadata>creator=Jane Doe</pwg:DocumentMetadata>
    <pwg:DocumentMetadata>date=2017-03-27T12:34:56Z</pwg:DocumentMetadata>
    <pwg:JobName>Sample 3D Print Job</pwg:JobName>
  </pwg:Print3DJobDescription>
</pwg:Print3DJobTicket>
```

10. Sample Print3DServiceCapabilities

The following 3D print service capabilities describe a printer that supports up to two materials simultaneously and has blue PLA and dissolvable PLA loaded:

```
<?xml version="1.0" encoding="UTF-8"?>
<pwg:Print3DServiceCapabilities xsi:schemaLocation="Print3DService.xsd"
  xmlns:pwg="http://www.pwg.org/schemas/smpjt3d10"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">

  <!-- Support millimeters and nanometers for accuracy -->
  <pwg:AccuracyUnitsSupported>Mm</pwg:AccuracyUnitsSupported>
  <pwg:AccuracyUnitsSupported>Nm</pwg:AccuracyUnitsSupported>

  <!-- Support 1 to 999 copies -->
  <pwg:CopiesSupported>
    <pwg:LowerBound>1</pwg:LowerBound>
    <pwg:UpperBound>999</pwg:UpperBound>
```



```
        </pwg:CopiesSupported>

        <!-- Support 3MF and STL -->
        <pwg:DocumentFormatSupported>model/3mf</pwg:DocumentFormatSupported>
        <pwg:DocumentFormatSupported>application/sla</pwg:DocumentFormatSupported>

        <!-- Material amounts in grams -->
        <pwg:MaterialAmountUnitsSupported>G</pwg:MaterialAmountUnitsSupported>

        <!-- 2.85mm filaments -->
        <pwg:MaterialDiameterSupported>
          <pwg:LowerBound>2850000</pwg:LowerBound>
          <pwg:UpperBound>2850000</pwg:UpperBound>
        </pwg:MaterialDiameterSupported>

        <!-- Supported purposes -->
        <pwg:MaterialPurposeSupported>All</pwg:MaterialPurposeSupported>
        <pwg:MaterialPurposeSupported>Base</pwg:MaterialPurposeSupported>
        <pwg:MaterialPurposeSupported>InFill</pwg:MaterialPurposeSupported>
        <pwg:MaterialPurposeSupported>Shell</pwg:MaterialPurposeSupported>
        <pwg:MaterialPurposeSupported>Support</pwg:MaterialPurposeSupported>

        <!-- Supported rates -->
        <pwg:MaterialRateSupported>
          <pwg:LowerBound>1</pwg:LowerBound>
          <pwg:UpperBound>250</pwg:UpperBound>
        </pwg:MaterialRateSupported>
        <pwg:MaterialRateUnitsSupported>Ml_second
          </pwg:MaterialRateUnitsSupported>

        <!-- Shell thickness -->
        <pwg:MaterialShellThicknessSupported>
          <pwg:LowerBound>0</pwg:LowerBound>
          <pwg:UpperBound>4000000</pwg:UpperBound>
        </pwg:MaterialShellThicknessSupported>

        <!-- Temperatures -->
        <pwg:MaterialTemperatureSupported>
          <pwg:LowerBound>180</pwg:LowerBound>
          <pwg:UpperBound>260</pwg:UpperBound>
        </pwg:MaterialTemperatureSupported>

        <!-- Supported types -->
        <pwg:MaterialTypeSupported>nylon</pwg:MaterialTypeSupported>
        <pwg:MaterialTypeSupported>pet</pwg:MaterialTypeSupported>
        <pwg:MaterialTypeSupported>pla</pwg:MaterialTypeSupported>
        <pwg:MaterialTypeSupported>pla-conductive</pwg:MaterialTypeSupported>
        <pwg:MaterialTypeSupported>pla-dissolvable</pwg:MaterialTypeSupported>
        <pwg:MaterialTypeSupported>pla-stone</pwg:MaterialTypeSupported>
        <pwg:MaterialTypeSupported>pla-wood</pwg:MaterialTypeSupported>

        <!-- Support Blue, Orange, Red, and Dissolvable PLA -->
        <pwg:MaterialsColDatabase>
          <pwg:MaterialColor>blue</pwg:MaterialColor>
          <pwg:MaterialDiameter>2850000</pwg:MaterialDiameter>
          <pwg:MaterialKey>pla-blue</pwg:MaterialKey>
```



```
      <pwg:MaterialName>Blue PLA</pwg:MaterialName>
      <pwg:MaterialPurpose>All</pwg:MaterialPurpose>
      <pwg:MaterialTemperature>
        <pwg:LowerBound>210</pwg:LowerBound>
        <pwg:UpperBound>235</pwg:UpperBound>
      </pwg:MaterialTemperature>
      <pwg:MaterialType>pla</pwg:MaterialPurpose>
    </pwg:MaterialsColDatabase>
    <pwg:MaterialsColDatabase>
      <pwg:MaterialColor>orange</pwg:MaterialColor>
      <pwg:MaterialDiameter>2850000</pwg:MaterialDiameter>
      <pwg:MaterialKey>pla-orange</pwg:MaterialKey>
      <pwg:MaterialName>Orange PLA</pwg:MaterialName>
      <pwg:MaterialPurpose>All</pwg:MaterialPurpose>
      <pwg:MaterialTemperature>
        <pwg:LowerBound>210</pwg:LowerBound>
        <pwg:UpperBound>235</pwg:UpperBound>
      </pwg:MaterialTemperature>
      <pwg:MaterialType>pla</pwg:MaterialPurpose>
    </pwg:MaterialsColDatabase>
    <pwg:MaterialsColDatabase>
      <pwg:MaterialColor>red</pwg:MaterialColor>
      <pwg:MaterialDiameter>2850000</pwg:MaterialDiameter>
      <pwg:MaterialKey>pla-red</pwg:MaterialKey>
      <pwg:MaterialName>Red PLA</pwg:MaterialName>
      <pwg:MaterialPurpose>All</pwg:MaterialPurpose>
      <pwg:MaterialTemperature>
        <pwg:LowerBound>210</pwg:LowerBound>
        <pwg:UpperBound>235</pwg:UpperBound>
      </pwg:MaterialTemperature>
      <pwg:MaterialType>pla</pwg:MaterialPurpose>
    </pwg:MaterialsColDatabase>
    <pwg:MaterialsColDatabase>
      <pwg:MaterialColor>clear-white</pwg:MaterialColor>
      <pwg:MaterialDiameter>2850000</pwg:MaterialDiameter>
      <pwg:MaterialKey>pla-dissolvable</pwg:MaterialKey>
      <pwg:MaterialName>Dissolvable PLA</pwg:MaterialName>
      <pwg:MaterialPurpose>All</pwg:MaterialPurpose>
      <pwg:MaterialType>pla-dissolvable</pwg:MaterialPurpose>
    </pwg:MaterialsColDatabase>

    <!-- Red and Dissolvable PLA are loaded -->
    <pwg:MaterialsColReady>
      <pwg:MaterialColor>red</pwg:MaterialColor>
      <pwg:MaterialDiameter>2850000</pwg:MaterialDiameter>
      <pwg:MaterialKey>pla-red</pwg:MaterialKey>
      <pwg:MaterialName>Red PLA</pwg:MaterialName>
      <pwg:MaterialPurpose>All</pwg:MaterialPurpose>
      <pwg:MaterialTemperature>
        <pwg:LowerBound>210</pwg:LowerBound>
        <pwg:UpperBound>235</pwg:UpperBound>
      </pwg:MaterialTemperature>
      <pwg:MaterialType>pla</pwg:MaterialPurpose>
    </pwg:MaterialsColReady>
    <pwg:MaterialsColReady>
      <pwg:MaterialColor>clear-white</pwg:MaterialColor>
```



```
      <pwg:MaterialDiameter>2850000</pwg:MaterialDiameter>
      <pwg:MaterialKey>pla-dissolvable</pwg:MaterialKey>
      <pwg:MaterialName>Dissolvable PLA</pwg:MaterialName>
      <pwg:MaterialPurpose>All</pwg:MaterialPurpose>
      <pwg:MaterialType>pla-dissolvable</pwg:MaterialPurpose>
    </pwg:MaterialsColReady>

    <!-- Maximum number of materials per job -->
    <pwg:MaxMaterialsColSupported>2</pwg:MaxMaterialsColSupported>

    <!-- Supported platform temperatures -->
    <pwg:PlatformTemperatureSupported>
      <pwg:LowerBound>40</pwg:LowerBound>
      <pwg:UpperBound>100</pwg:UpperBound>
    </pwg:PlatformTemperatureSupported>

    <!-- Brims, Rafts, and Skirts are supported -->
    <pwg:PrintBaseSupported>Brim</pwg:PrintBaseSupported>
    <pwg:PrintBaseSupported>None</pwg:PrintBaseSupported>
    <pwg:PrintBaseSupported>Raft</pwg:PrintBaseSupported>
    <pwg:PrintBaseSupported>Skirt</pwg:PrintBaseSupported>

    <!-- Supported supports -->
    <pwg:PrintSupportsSupported>Material</pwg:PrintSupportsSupported>
    <pwg:PrintSupportsSupported>None</pwg:PrintSupportsSupported>
    <pwg:PrintSupportsSupported>Standard</pwg:PrintSupportsSupported>

    <!-- Supported qualities -->
    <pwg:QualitySupported>Draft</pwg:QualitySupported>
    <pwg:QualitySupported>High</pwg:QualitySupported>
    <pwg:QualitySupported>Normal</pwg:QualitySupported>
  </pwg:Print3DServiceCapabilities>
```

11. IPP Mapping

The mapping of the IPP 3D Printing Extensions to the PWG 3D Print Job Ticket and Associated Capabilities follows the mapping defined in section 21 of the PWG Print Job Ticket and Associated Capabilities Version 1.0 [PWG5108.07].

In addition:

1. Similar to the handling of "media-color" and "media-type", IPP "material-color" and "material-type" keyword values are preserved (hyphenated lowercase) instead of converting them to TitleCase; and
2. IPP attributes using the 1setOf syntax are mapped to unbounded elements instead of an element containing an unbounded sequence.

12. Change History

12.1 May 4, 2017

1. Updated references to 3MF and ISO 10646

12.2 April 20, 2017

1. Status: Stable
2. Section 1.1: device control commands
3. Section 2.1: remote from the printer
4. Section 9: Fix MaterialColor, MaterialKey, and MaterialType values
5. Section 10: Fix MaterialColor, MaterialKey, and MaterialType values
6. Section 11: Drop operations (item 3)

12.3 March 27, 2017

1. Section 1: Reference the PJT and talk about output intent
2. Section 2: Define Service
3. Section 4: Added a list of the files in the schema ("roadmap") and the namespace URL.
4. Section 8: Added acknowledgements
5. Added appendices with sample job ticket, capabilities, and the IPP mapping strategy.

12.4 March 3, 2017

1. Updated acronym to "PJT3D", filename to "smpjt3d10"
2. Global: Print3d -> Print3D
3. Global: Element as a defined term.
4. Global: Updated all schema figures to reflect new service name.
5. Abstract: "... suitable for data exchange and embedding within common 3D file formats such as ..."
6. Section 1: Made it clear the schema is generated from the IANA IPP registry.
7. Section 2.1: Added Intent, Job Receipt, and Job Ticket, Printer
8. Section 2.2: Replaced "Protocol Terminology" with "Other Terminology", define Element
9. Section 3: Dropped "1.1" from "XML 1.1 schema".
10. Section 3.1.1: Fixed wording.
11. Section 7: Added link to IPP 3D spec.

12.5 February 19, 2017

Initial revision.

599

