Annex 3 X3D Graphics for CAD, 3D Printing and 3D Scanning

The following point paper was provided to ISO/IEC JTC-1/SC 24 and this JAG for this report.

The Web3D Consortium is an international, non-profit, industry/academia/agency/individual member-supported Standards Development Organization (SDO). Web3D Consortium members create and promote open standards for real-time 3D communication. The Web3D Consortium builds and maintains widely applicable standards through well-coordinated Liaison Partnerships with International Standards Organization (ISO), Open Geospatial Consortium (OGC), World Wide Web Consortium (W3C) and other organizations. Web3D Consortium membership is fully open to industry, government agencies, academia and individual professionals. All Web3D standardization efforts also receive public scrutiny and comment as milestone requirements prior to formal ISO approval as International Standards. Web3D has a Category A liaison with ISO, providing all technical updates to the X3D family of standards for ISO/IEC JTC 1/SC 24.

The X3D Graphics standards include full functional capabilities of the Virtual Reality Modeling Language (VRML) 97 International Standard, ISO/IEC 14772-1:1997 and ISO/IEC 14772-2:2004. Backwards compatibility with VRML syntax is also maintained for all versions of X3D through the X3D Classic VRML Encoding, ISO/IEC 19776-2. A great many tools and applications continue to support VRML import/export and modification, so X3D/VRML consistency provides valuable capabilities for printing 3D models.

The X3D standard includes a CADGeometry Component which supports representation of product assembly structure and face features in X3D scenes. The CADInterchange Profile defined in the X3D standard supports distillation of computer-aided design (CAD) data to downstream applications. Multiple conversions routes from STEP (ISO 10303) exchange files to X3D scenes have been identified, including standalone translation software and web based applications. Commercial CAD applications commonly support export to VRML file format which is a subset of X3D and readily converted to X3D files in Classic VRML or XML encoding. Broad X3D support for Web-based CAD usage continues to be reported regularly during SC24 liaison efforts with ISO/TC 184/SC4.

A recent workshop at the Web3D 2016 Conference has demonstrated consensus on the suitability of creating a combined X3D Profile for CAD, 3D Printing and Scanning. Functional compatibility with other related formats (such as STL, PLY, AMF, and 3MF) provides important design guidelines for this work. Building converters to demonstrate full compatibility is an important part of this work, with many tools already available (e.g. Blender, Okino NuGraf and dozens of other software resources). Current estimates indicate that over 80% coverage is already available for use, and that most additions are refinements to existing capabilities.

Given the broad capabilities of X3D, we are finding that a number of other related technologies are pertinent. Brief descriptions follow.

- Two distinct types of compression are being established for X3D models. The Shape Resource Container (SRC) work by Fraunhofer IGD provides a variety of geometric compression schemes (polygonization efficiencies, quantization, etc.) in concert with progressive-mesh streaming. Through cooperative work between Web3D Consortium and the Khronos Group, SRC is being fully aligned with binary glTF.
- Additionally, cooperative work with the World Wide Web Consortium (W3C) is applying the Efficient XML Interchange (EXI) schema-based compression standard to the X3D XML Encoding. Together these composable approaches are expected to provide unprecedented levels of data compaction and decompression performance, in turn minimizing memory requirements and maximizing processor performance.
- Additional cooperative work with W3C has already applied XML Security capabilities to X3D, including

both XML Encryption for privacy and XML Digital Signature for authentication. Of interest is that these standards can each be applied either in whole or in part to an X3D scene document. Current EXI working group efforts include consideration of compatibly applying XML Security standards to X3D scenes that are first reduced using SRC and then compressed using EXI. Such comprehensive capabilities appear feasible and are expected to support a wide range of use cases for secure 3D printing of X3D models.

- X3D includes a document metadata model matching HTML, and also includes a Metadata component which enables embedding of strongly typed metadata anywhere within an X3D scene graph. Current working group efforts are examining addition of a potential Annotation component to facilitate sharable markup and situated display of user metadata annotations. Implementation efforts are especially keen to demonstrate effective integration of ISO metadata libraries suitable for 3D printing, CAD and medical applications.
- Another recent Web3D 2016 Conference workshop has clearly demonstrated the applicability of 3D printing to medical applications, with many models and illustrative examples online as part of the U.S. National Institutes of Health (NIH) 3D Print Exchange (http://3dprint.nih.gov). Current work, performed in part with the DICOM medical imaging standards organization, includes investigation into the suitability of including printable medical X3D models as part of patient electronic health records.
- Of interest is that joint work between SC 29 and SC 24 Working Group 9 on the ISO/IEC JTC1 Joint Ad hoc Group (JAhG) Mixed Augmented Reality (MAR) Reference Model, draft ISO/IEC 18039, which includes the possible use of 3D printed markers and physical objects within MAR spaces.
- The X3D standard is currently in use in the consumer 3D printing market through its adoption in online tools and archives aimed at 3D Printing. 3D printing services offer online uploading of user design files to be printed in a variety of materials. Several of these services, including Shapeways, support submitting user designs as X3D files. X3D offers the advantage over STL format in that it supports multiple colors on a single model; and multiple color printing is now being offered in the consumer market. Online solid modellers now allow consumer users to prepare 3D printing designs using browser-based application, and several of these including TinkerCAD and Clara.io, support exporting a user's design file in X3D format for submission to a 3D printing service. A third component of the 3D printing market is online archives of design files; one popular archive, Thingiverse, directly supports X3D format files.
- The X3D Specifications include language bindings for JavaScript and Java, as well as a newly demonstrated X3D Encoding for JavaScript Object Notation (JSON). Formalization of further language bindings for C++ and Python are under consideration. Current work includes autogeneration of exemplar open-source code for the X3D Scene Access Interface (SAI). We expect that such production of strongly typed application programming interfaces (APIs) for X3D across multiple programming languages, with the likelihood of tuning for small-footprint applications like printers and scanners, is likely to further facilitate the use and interoperability of X3D for printers and scanners.

The Web3D Consortium, through its working groups, public meetings, and open publication of the X3D standards documents, is supporting development of workflows and software conversion and authoring tools to increase adoption of X3D as a standard allowing interchange of 3D content for visualisation on desktop and mobile device screens and for connections with the physical world with 3D Printing and Scanning.

All of these efforts are able to continue progressing coherently thanks to deliberate coordinated efforts by Web3D Consortium participants in concert with formal ISO/IEC JTC1/SC 24 review. Continuing and expanded participation with related ISO/IEC JTC 1 activities is welcome and provides excellent mutual benefit.