

Web3D 2016 Workshop on CAD, Additive Manufacturing, 3D Printing and 3D Scanning

When and Where. Friday 22 July 2016, Web3D 2016 Conference, Web3D 2016, Anaheim California USA

Motivation. Determine how a combined, harmonized approach to "CAD, Additive Manufacturing, 3D Printing and 3D Scanning" makes best sense as an X3D Profile. Determine requirements and next steps.

Goals

- Briefly review state-of-the-art progress in four fast-moving but related, overlapping fields
 - Computer-Aided Design (CAD) modeling and Additive Manufacturing (AM) processes
 - 3D Printing and 3D Scanning, possibly 3D model search/comparison and archiving
- Workshop attendees will present, propose, compare and collate goal requirements for X3D.
- Important workflow and technology checkpoint: feasibility of a single common X3D Profile for CAD, AM, 3D Printing and 3D Scanning.
- If needed, outline a Call for Contributions to address any expected gaps.
- Workshop results will serve as basis for focusing next-step efforts by X3D CAD Working Group.

Participation

- Expect 10-20 people. Single session, no breakouts, single projector, forum-style seating.

References

- X3D Computer Aided Design (CAD) Working Group
 - <http://www.web3d.org/working-groups/computer-aided-design-cad>
- Web3D Calls for Contributions, <http://www.web3d.org/call-contributions>
- NIH 3D Print Exchange, <http://3dprint.nih.gov>

Workshop preparations

- CAD Working Group prepares initial list of requirements for such an X3D Profile
- Show examples about scanning and point clouds: EDF, Smithsonian, Fraunhofer, Bit Management, DotProduct scanner, and Synergy Software Design (SSD).
- Review related work in ISO TC184/SC4 and elsewhere on 3D printing & scanning
- Draft ISO Technical Report on these topics (Hyokwang Lee, Brutzman)

Planned schedule

- 15 minutes: participant introductions and agenda (Marchetti, Brutzman), purpose of an X3D profile (Puk)
- 1 hour: overviews of CAD (Marchetti), Additive Manufacturing AM (Brutzman someone), 3D Printing (Marchetti and Gordon Fisher?), 3D Scanning (Brutzman, Russalesi). Include demos!
- 30 minutes overview: Related standards such as ISO STEP AP242 standard (Mouton), STL/AMF/3MF (Brutzman and Marchetti, possibly NIH and/or Alan Hudson).
- 30 minutes discussion. Participants review overall required capabilities list, highlight additions needed in new profile, then outline go-forward strategy for technology and tools.

Bridge to Related Follow-on Workshop. Multiple interests are shared with other working groups. We are adding a 1-hour overlapping session with a paired workshop on Medical and H-Anim visualization. Topics of mutual interest include:

- 30 minutes. Metadata, compression, compatible digital signature and encryption, summary of SRC geometry compression and EXI data compression (Brutzman).
- 30 minutes. NIH 3D Print Exchange showcase (Coakley-McCarthy, Hurt)

X3D Profile for CAD/printing/scanning

Agenda and Issues List

CAD Working Group and contributors
Web3D Consortium
Anaheim California
22 July 2016

Agenda

0900 Welcome, introductions	1300 National Institutes of Health (NIH) 3D Print Exchange
0915 X3D CAD overview	
1000 Specification Development	1400 Medical Working Group
1010 Printing Workflow	
1030 break	1500 Web3D Consortium Town Hall Meeting
1045 Scanning Workflow	
1100 Profile Requirements	
1130 SRC Compression	
1150 Next Steps	
1200 Lunch	

Multiple documents for this workshop session

1. This slideset defines workshop structure
2. Primary topics slideset
 - X3D Graphics Standard for World Wide Web Interoperability – Additive Manufacturing (AM) and Virtual Environments (VEs)
3. Workflow Diagrams - X3D CAD Printing Scanning
4. Background details slideset
 - X3D Graphics Support for Computer Aided Design (CAD)
5. Gap analysis: feature comparison for CAD, printing, scanning
 - Table of nodes and attributes
6. Technical Report: [Remote Collaborative 3D Printing](#), Cody Reese NAVFAC

Discussion: important next steps. Reactions please:

- What X3D needs that aren't being addressed
 - Sharing, Archiving, Collaboration
 - —
- Tell us what you need that isn't here yet
 - —
- Tell us what you think we should do next
 - —

Issue: point definitions

- Point cloud (unordered)
- Point mesh (ordered, regular)
- Polygon mesh (ordered, regular, uniform?)
- Relation to volumes

Issue: Point visualization

- Point size
- Color per
- Alternate techniques: texture splats / sprites / ParticleSets
- Do other standards exist?

Issue: differencing

Quantifying the lossiness of virtual – physical roundtripping

- Quality of mesh ('as designed')
- Quality of print ('as built') re-scanned
- View both at the same time
- Metrics and tolerances
- Encoding output results in model metadata

Issue: X3D is very big!

- Profiles provide an answer
 - Defines needed subset for software and hardware tools
 - Enabling step for simple workflow processes by users
- Nevertheless some pieces missing
 - Gap analysis table helps show what still needs to be added to X3D

Issue: Software tools don't always follow profile, what to do? (from Seva)

Compare existing ways of doing things

Provide resources

- Example X3D scenes to test
- Example X3D players to render and present
- Example tools to modify scenes
- Showcase good examples
- Document successful work flows
- Rinse, lather, repeat...

Issue: what else?

- Questions, suggestions and additions all welcome

Contact

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New X3D Profile: Common Capabilities and Requirements for 3D Printing, 3D Scanning and CAD

New X3D Capabilities	3D PRINTING	3D SCANNING	CAD	notes
Point Cloud (unordered, overlapping)	?	<input checked="" type="checkbox"/>	<input type="checkbox"/>	
“Point Mesh”? (ordered, distinct)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	superposition
“Polygon Mesh”? (ordered, well defined)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	for comparison
<ul style="list-style-type: none"> PointProperties node 				
<ul style="list-style-type: none"> closed solid (watertight) attribute 	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	
<ul style="list-style-type: none"> closed solid, except for bottom? 	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
<ul style="list-style-type: none"> Informational (post-tool) or directive? 				
<ul style="list-style-type: none"> wall thickness 	likely		?	
<ul style="list-style-type: none"> Normals used for curved triangles (as defined in AMF) 	<input checked="" type="checkbox"/>			Are they identical?
LineSet, IndexedLineSet	Support struts?	Scan Boundaries?	Help guides and callouts	
<ul style="list-style-type: none"> LineProperties 			<input checked="" type="checkbox"/>	
Advanced materials, lighting	<input checked="" type="checkbox"/> Varying use	<input checked="" type="checkbox"/> Scan properties	<input checked="" type="checkbox"/> Bill of materials	Possibly solved with metadata
Non-Uniform Rational B-Splines (NURBS)				
Volumetric data	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		
Metadata standards for <ul style="list-style-type: none"> Creation pedigree (materials, etc.) IPR and usage rights Addition of supports, etc. 	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Allow external standards
Metadata display and callouts: draft X3D Annotation Component	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
Progressive mesh streaming (SRC)			<input checked="" type="checkbox"/>	
Geometric Compression (SRC)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
Data Compression (EXI)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
Digital Signature for Authentication	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
Encryption for Privacy, Access Control	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
Layer or plating of physical material (e.g. paint or coating)				External surface

TODO: continue reviewing/refining “X3D version 4.0 Development:Candidate capabilities” list at

http://www.web3d.org/wiki/index.php/X3D_version_4.0_Development#Candidate_capabilities

Fleet mishap vignette: actions afloat + ashore

- Deployed LCS 3D prints new UAV
- Launcher mishap hurts sailor
- Material failure catastrophic
- Cause unclear: UAV, launcher?

• Ship sends CASREP, OPREP, photos, 3D scans, narrative

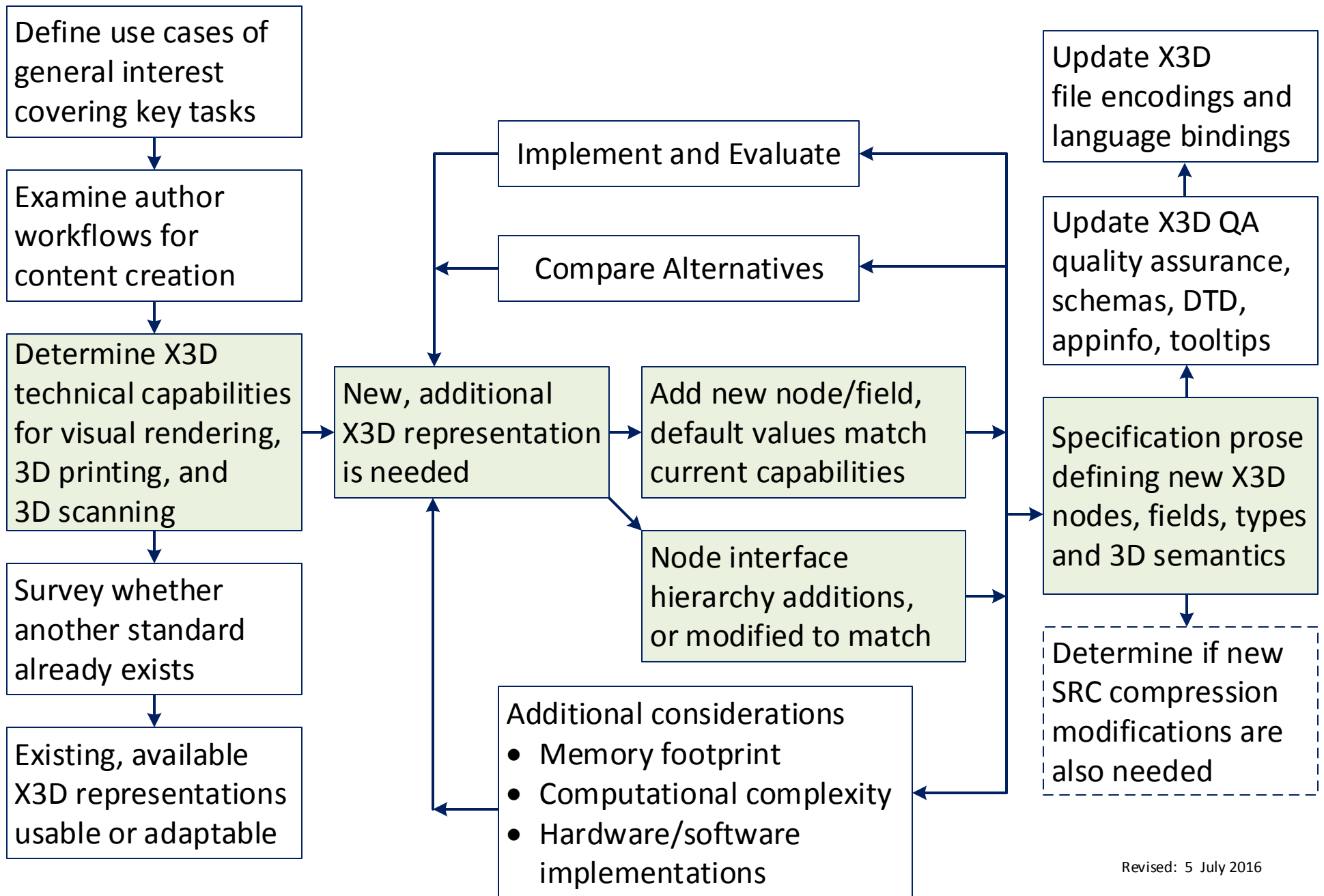
- Custom 3D splint treats sailor
- Ship, fleet commander await...

• Ship prints fixes, resumes ops

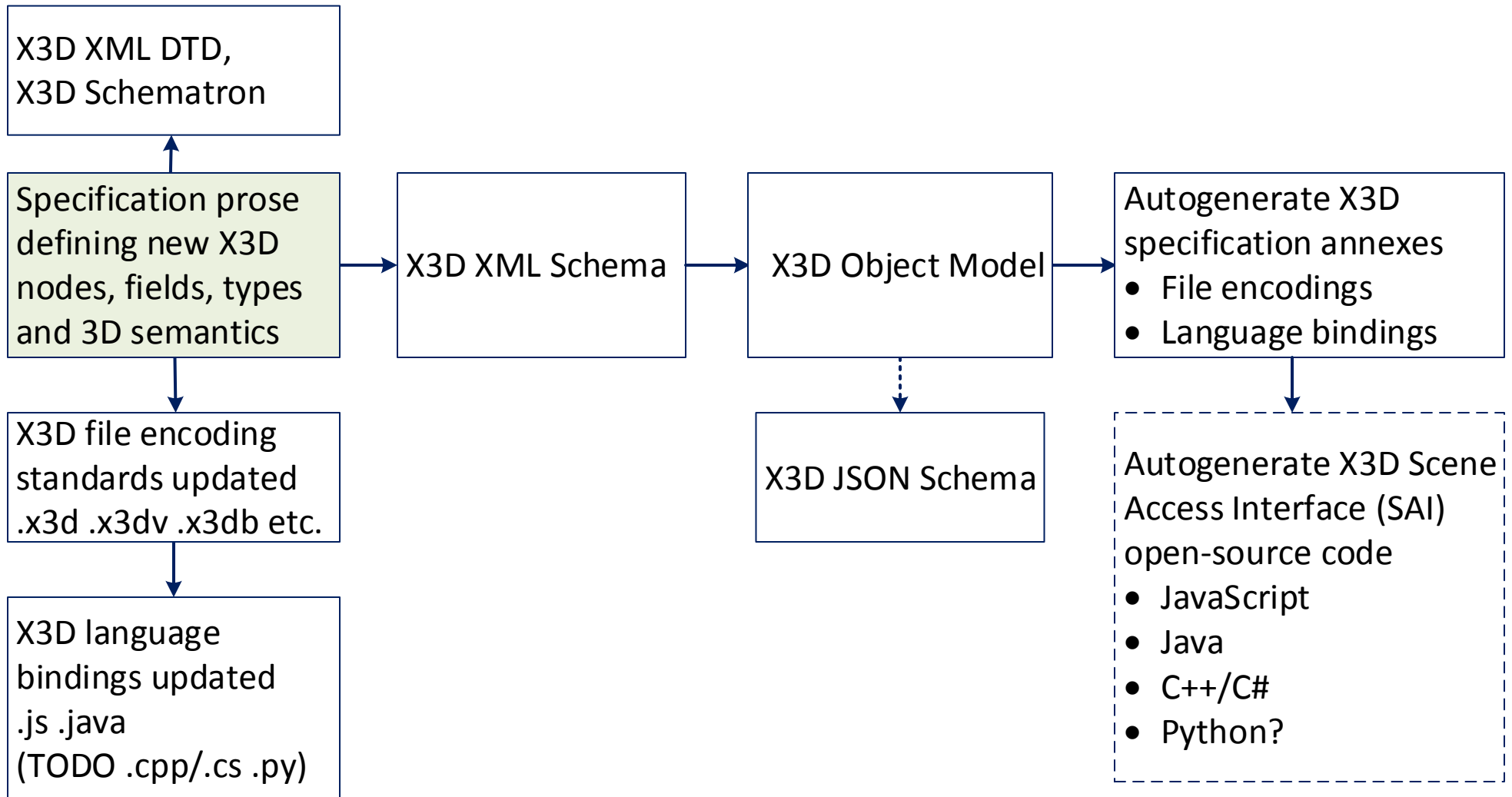
- LCS in different ocean also updated

- Warfare and safety centers alerted
- NAVAIR, NAVSEA engineers find unexpected system interactions
- UAV model design adjusted, tested
- Launcher safety guard also added
- Safety center reviews tests & fixes
- 3D mods certified in DT repository
- Leadership stakeholders approve
- Lessons-learned database updated

Specification design process for new capabilities



X3D Object Model Creation and Autogeneration



X3D Specification Implementation & Evaluation

Mailing list discussions

Working group focus, projects, papers

X3D specifications

Specification comments

Version control of examples: SourceForge

Web3D Strategy

Mantis issue tracker

Version control of specifications: GitHub

ISO, W3C, OGC specs

Example X3D scenes

Example X3D implementations

Quality Assurance (QA)

- .x3d as master version
- X3D Validator (all tests)
- XML well-formed
- XML DTD validation
- XML Schema validation
- XML Schematron rules
- X3D Regular Expressions (regexes) for numeric values
- X3D Canonicalization (C14N) for comparability
- Autotranslation into multiple X3D encodings
- JSON Schema validation

Open Source, Commercial Codebases

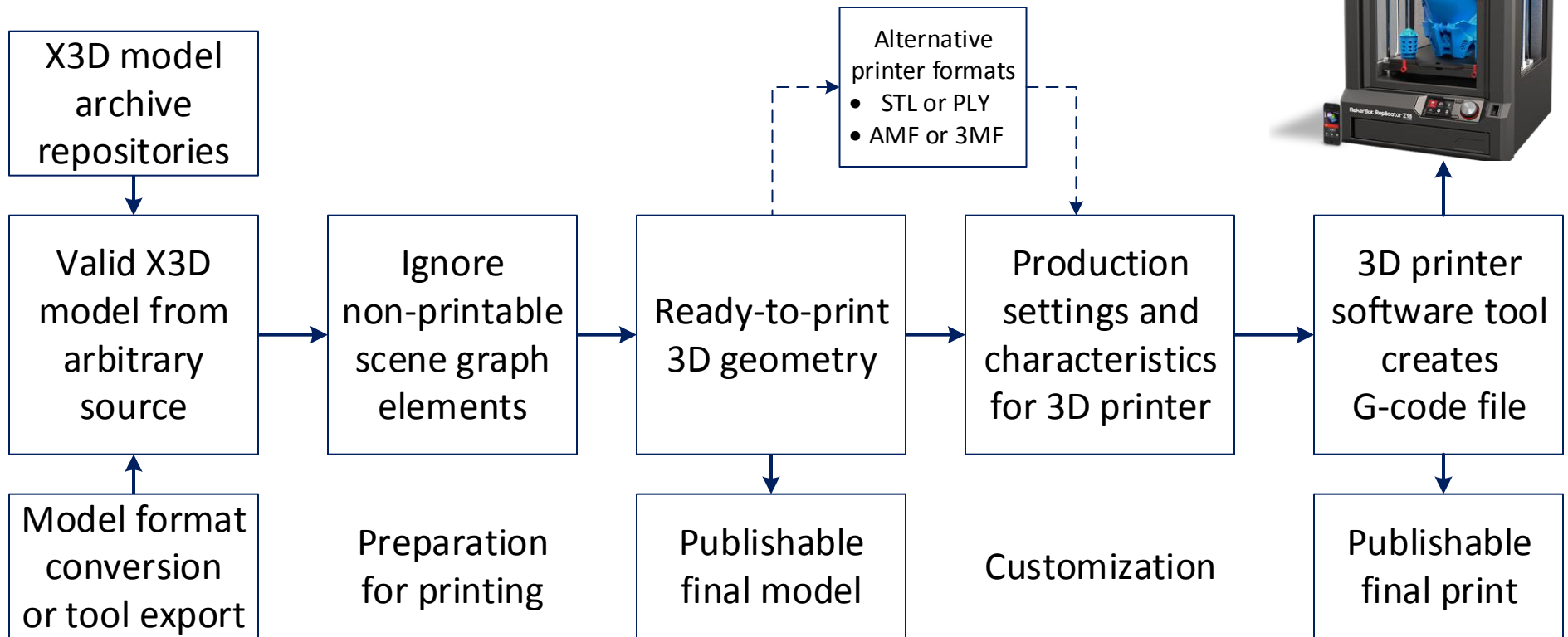
- X3D players
- X3D authoring tools, workflow support
- X3D converters and translators
- X3D import, export support by independent tools
- X3D Scene Access Interface (SAI) in JavaScript, Java, C++/C#, Python?

- HTML5, CSS, SVG, Efficient XML Interchange (EXI), MathML, Security
- Open Web Platform
- JavaScript, Java
- KML, CityGML, etc.

Possible additions

- Conformance test suite certification
- SRC compression, streaming tests
- 3D print tests

Workflow: 3D Printing for X3D Models



- X3D Resources: Conversion Tools
- Native support for X3D, VRML in tools
- Open-source SAI APIs for X3D Scene Authoring Interface (autogenerated, work in progress) in Java, C++, JavaScript

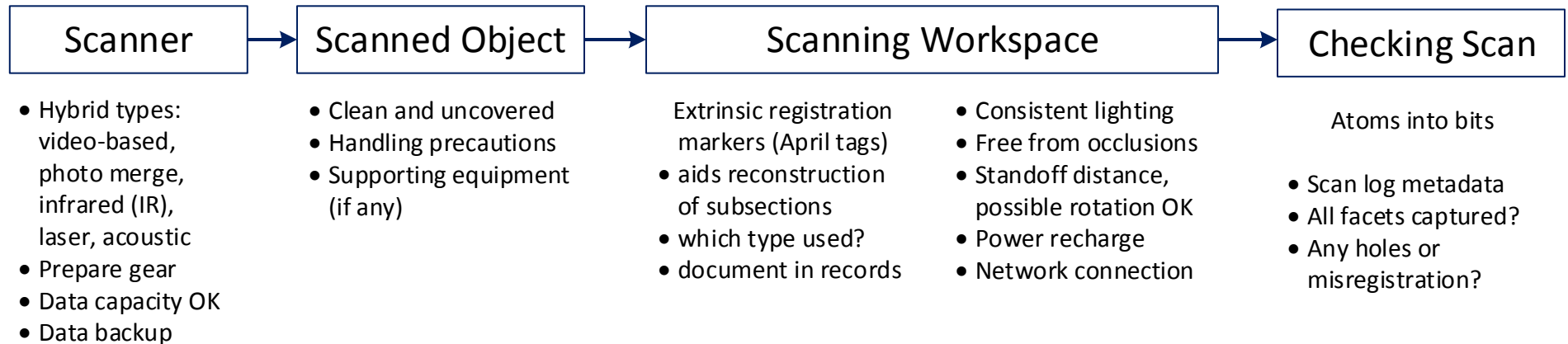
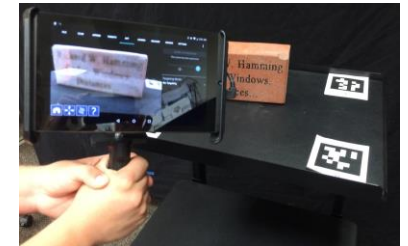
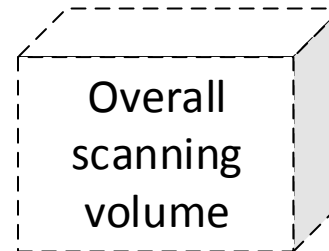
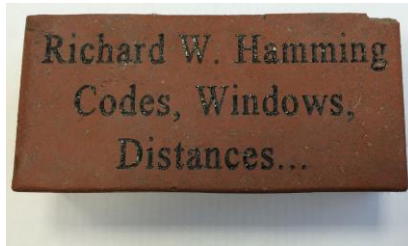
- Retain all metadata
- Retain full spatial transformation hierarchy of all 3D component shapes
- Retain all 3D shapes OR
- Retain only chosen, printable 3D shapes

Publication options

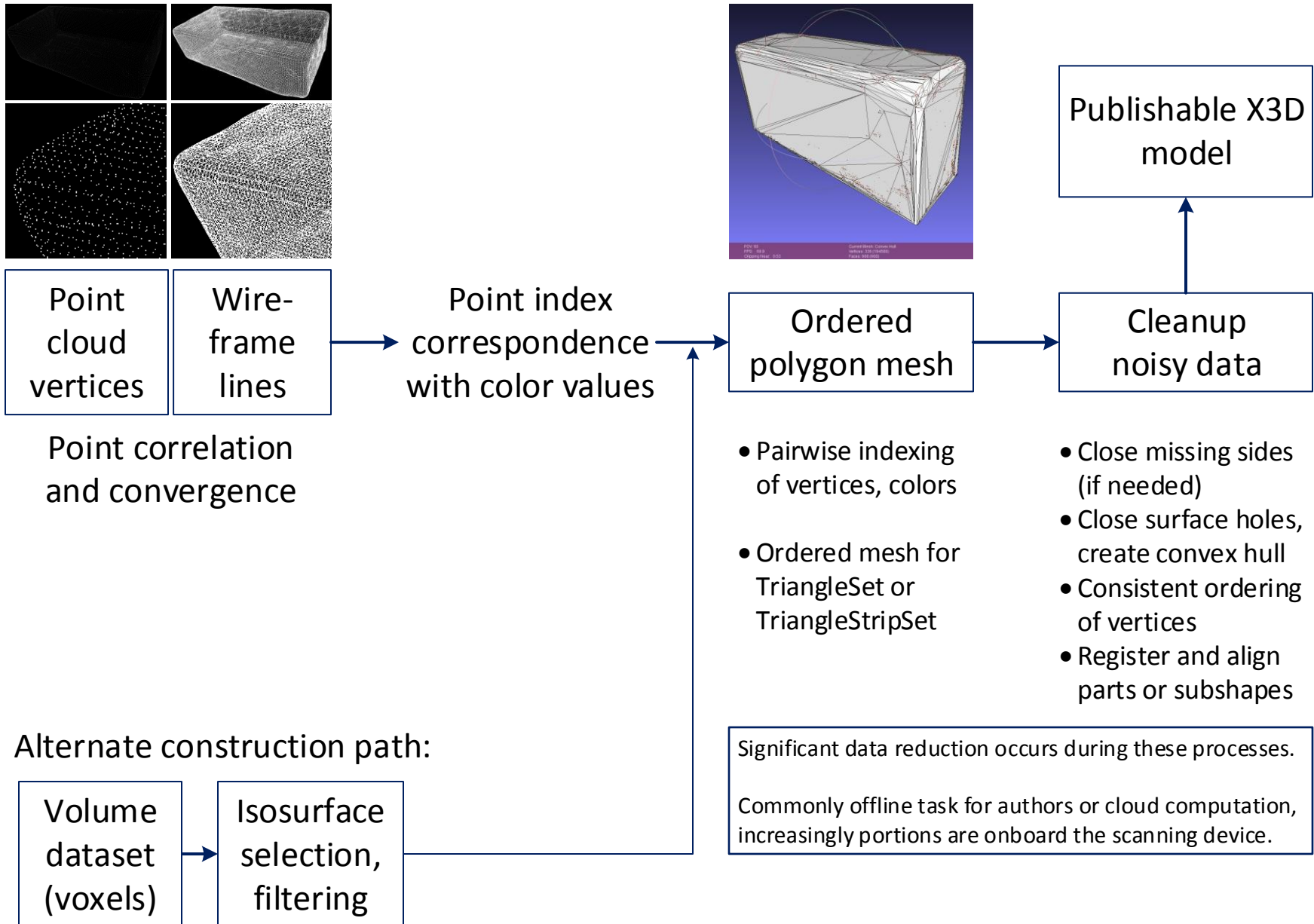
- **Metadata** annotated information
- **Compression** of data and 3D geometry
- **Authentication** (digital signature)
- **Encryption** (in whole or parts)

- Model size
- Model orientation
- Material(s)
- Thickness
- Support struts
- plus
- Specialized printer settings

Workflow: Scanning Shapes for 3D Mesh Data



Workflow: Scan Post-Production to Build Mesh



X3D Model Repository: Capabilities and Structure

User Access,
Authentication



- Public or private webserver
- Community portal
- Model database
- Converter engine (e.g. Blender)
- Network security
- Information assurance (IA)
- Usage statistics
- Model export to collaboration and simulation systems

View, Discuss



- Browse, discover
- Search using metadata terms
- Shape-based query
- Documentation
- Online training
- Maintenance, routine and repair
- Trouble reports
- Lessons learned
- Availability and alternatives

Download, Print



- Selected models
- Modified models
- Licensed models
- Converted models
- Tutorials and guides
- Technical support
- Online 3D printer services for special capabilities

Upload



- New models with original CAD plans
- Model updates and modified versions
- 3D scans for model comparison
- Import, convert alternate formats
- Validation, cleanup, QA quality assurance
- Metadata, photos
- Usage and repair information
- Case studies, new training resources

Publication options



- **Metadata** annotated information



- **Compression** of data and 3D geometry

John Blumcraft

- **Authentication** (digital signature)



- **Encryption** (in whole or parts)

Model Repository: Data at Rest

Secure system boundary

Product data family

- Functional capability model
- Engineering design model
- Material requirements and alternatives
- 3D printing guidelines
- Acceptance test criteria

Process data family

- Business processes
- Intellectual property rights (IPR) terms and usage
- Logistics requirements
- Contract requirements
- Additional restrictions

Information Infrastructure

- Heterogeneous databases for 3D models, scans and related assets
- Data validation capabilities via reference schemas
- Authoritative metadata
- Distribution restrictions
- Maintenance logs
- Quality Assurance (QA) records
- Usage accountability
- Trouble reports
- Safety considerations

Publication options



- **Metadata** annotated information



- **Compression** of data and 3D geometry

John Hancock

- **Authentication** (digital signature)



- **Encryption** (in whole or parts)

Cybersecurity

- Certified software
- Certified systems
- Certified network

Access

- Trusted employee
- Trusted contractor
- Trusted partner
- Public

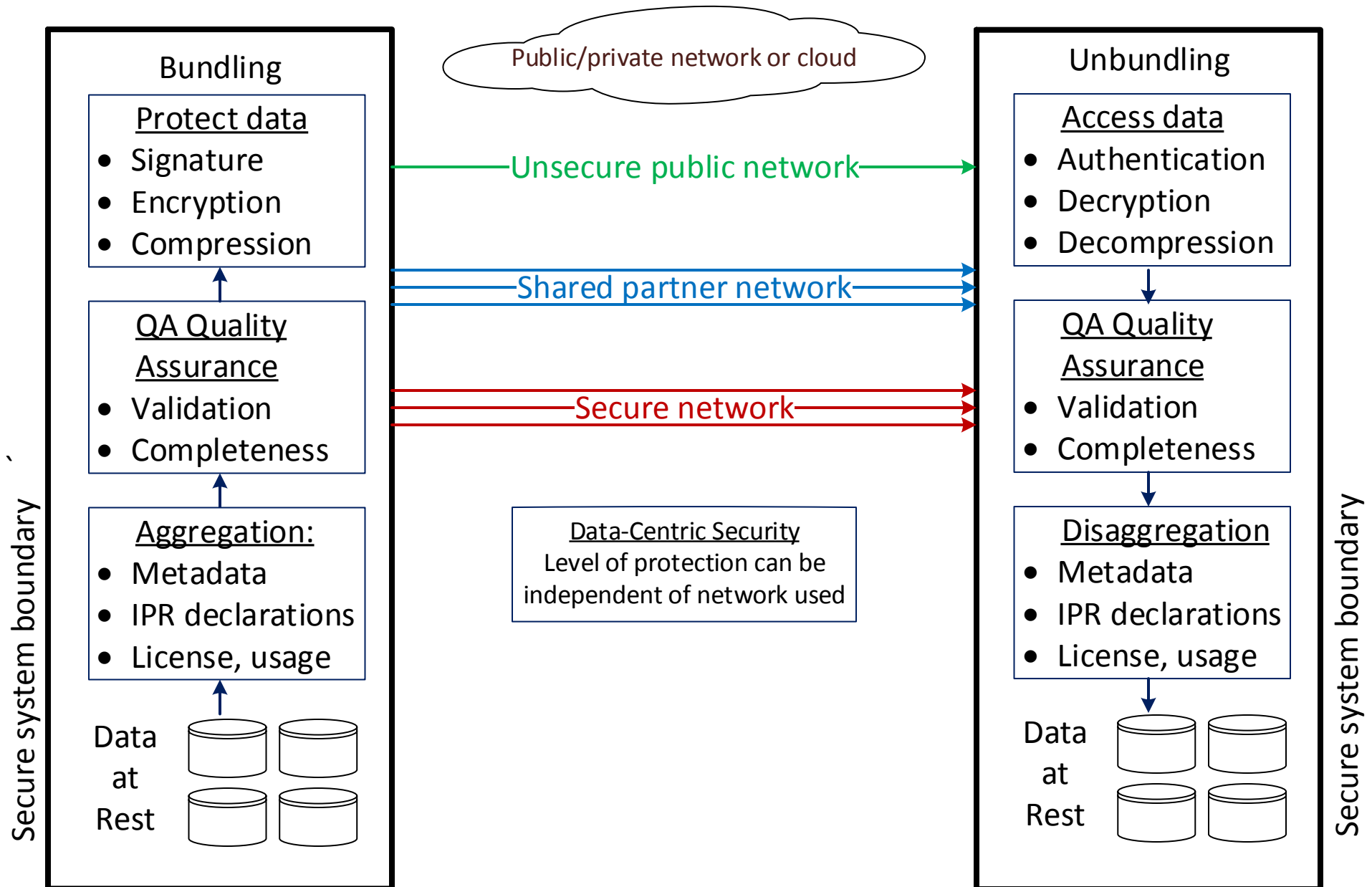
Data-Centric Security

- In general, all data is maintained compressed, signed and encrypted for maximum security throughout the product lifecycle.
- Only data “in active use” by applications needs to be decrypted and protected by software. Note: many applications are themselves distributed, so application usage can be a form of “data in motion.”

Secure system boundary

Secure system boundary

Model Repository: Data in Motion

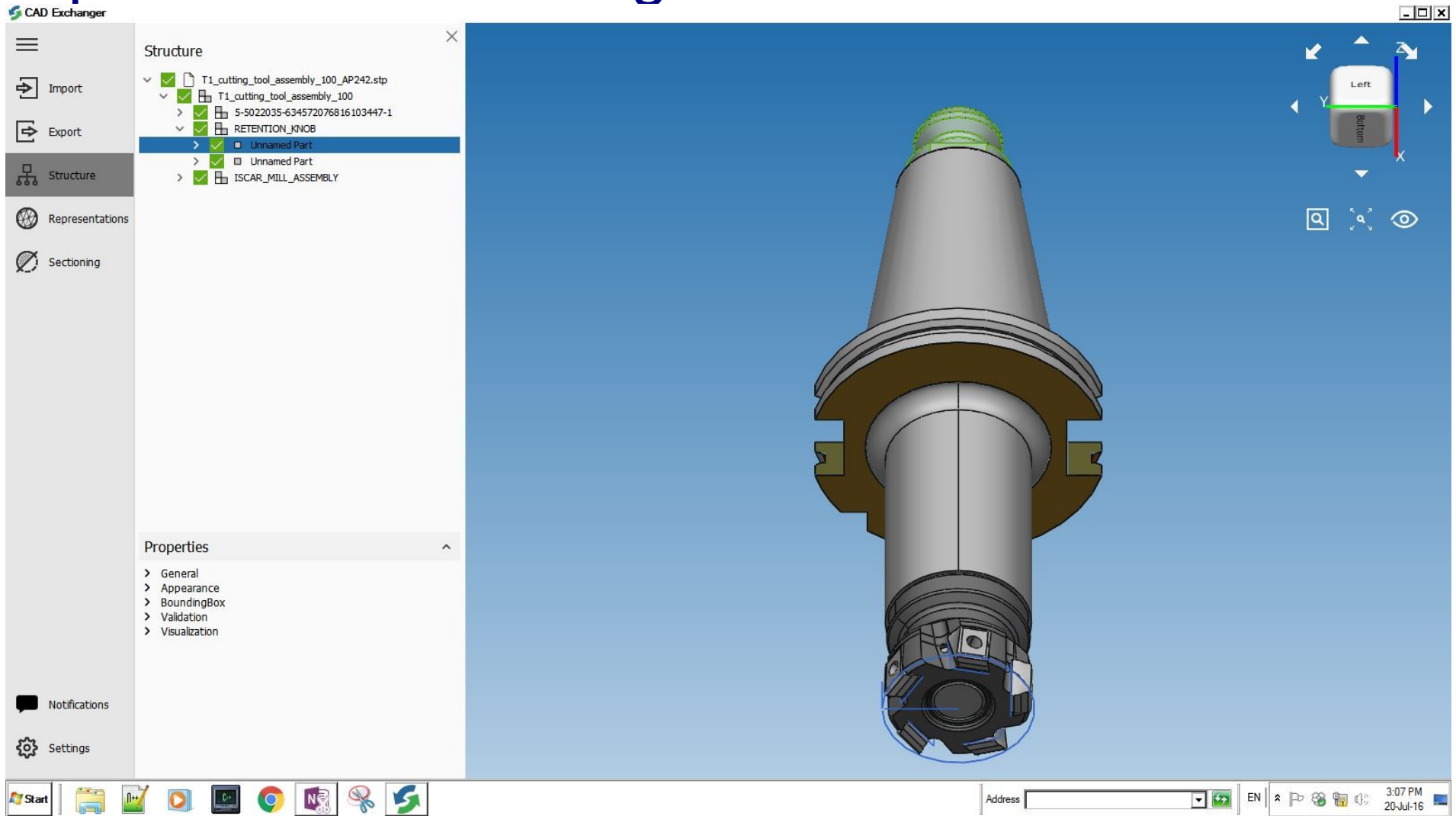


STEP to X3D conversion routes.

1. CADEXchanger v3.2 : Commercial product, Windows, Linux, Mac
2. PythonOCC: Python scripting of the C++ OpenCascade open source geometry engine.
3. SPRI web application: Online STEP file browser with options of viewing geometry in X3DOM or Cobweb, and downloading X3D file.

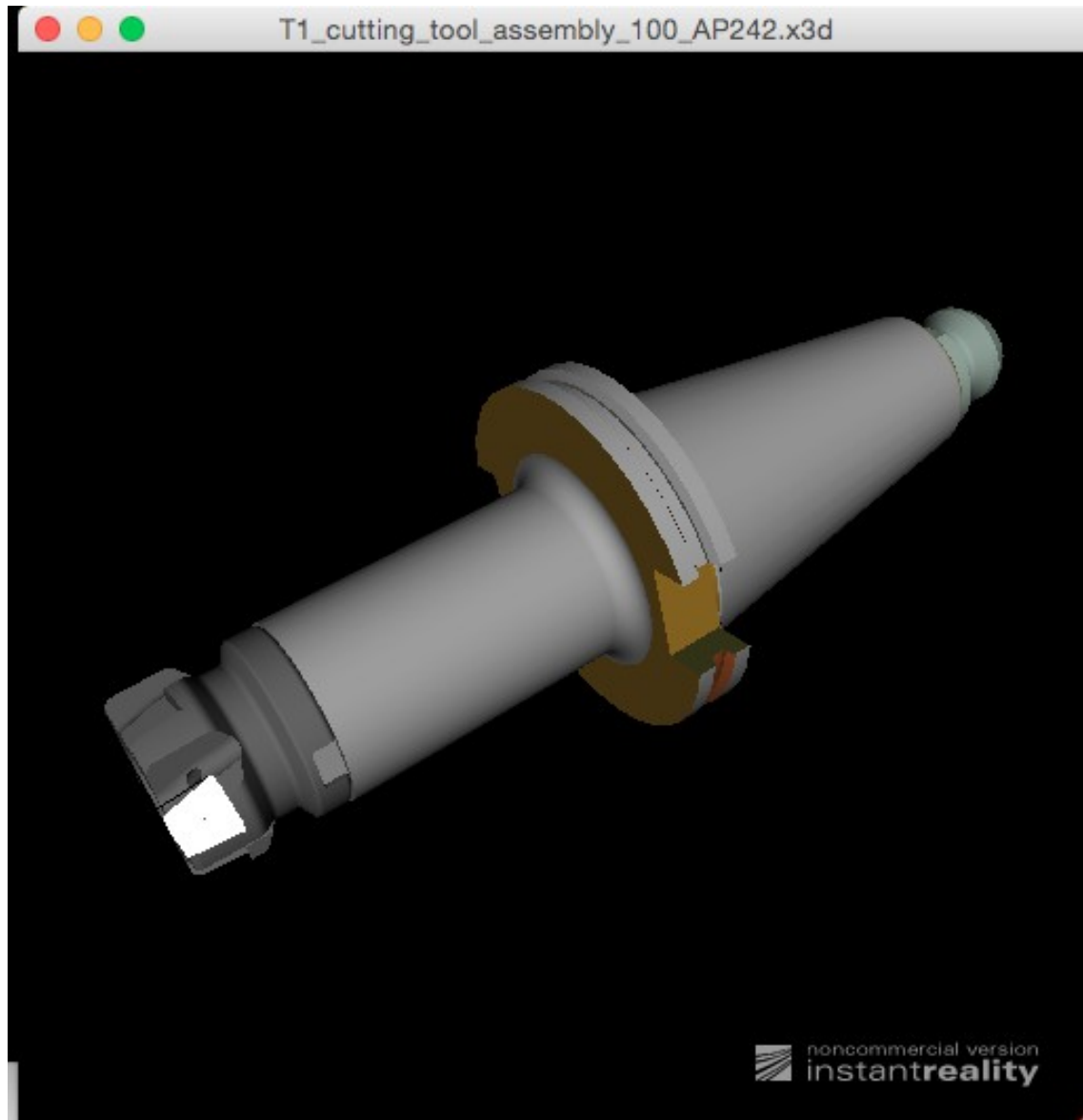
CAD Exchanger

<http://www.cadexchanger.com>



Screenshot after reading STEP file (AP 242). Parts and faces defined in the original STEP file

Result of CAD Exchanger export to X3D



PythonOCC: Python interface to OpenCascade geometry engine

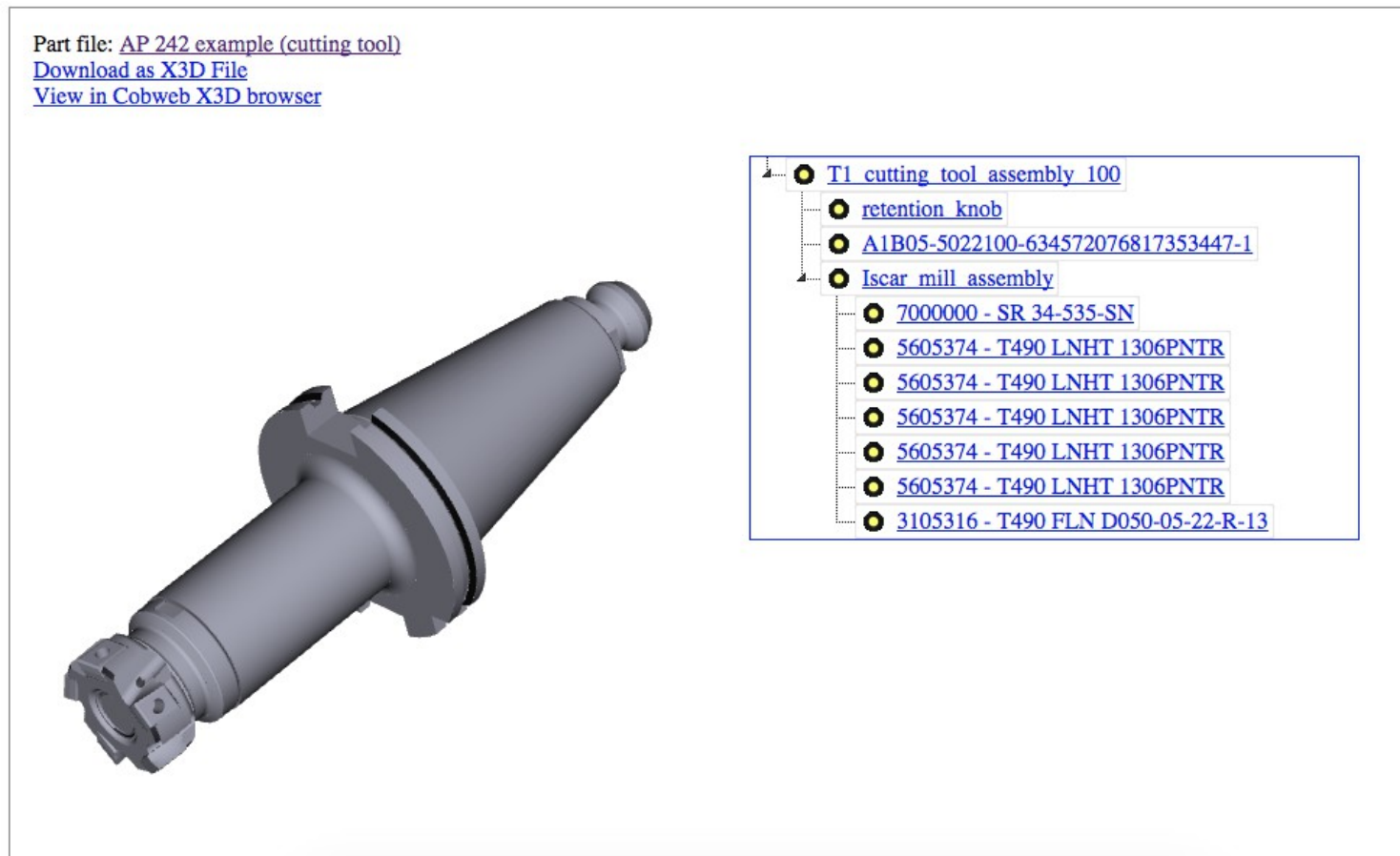
- Open Cascade open source geometry engine, in C++:
<http://www.opencascade.com>
- PythonOCC: <http://www.pythonocc.org>
- STEP to X3D Python script available on Web3D CAD public wiki:
http://www.web3d.org/wiki/index.php/STEP_X3D_Translation



X3D conversion result

SPRI web application

- Start at webpage <http://spri.kshell.com> to upload STEP file.



Result page: <http://spri.kshell.com/xt/shape/x3dom/f6hb20ckz8e5/23323738>

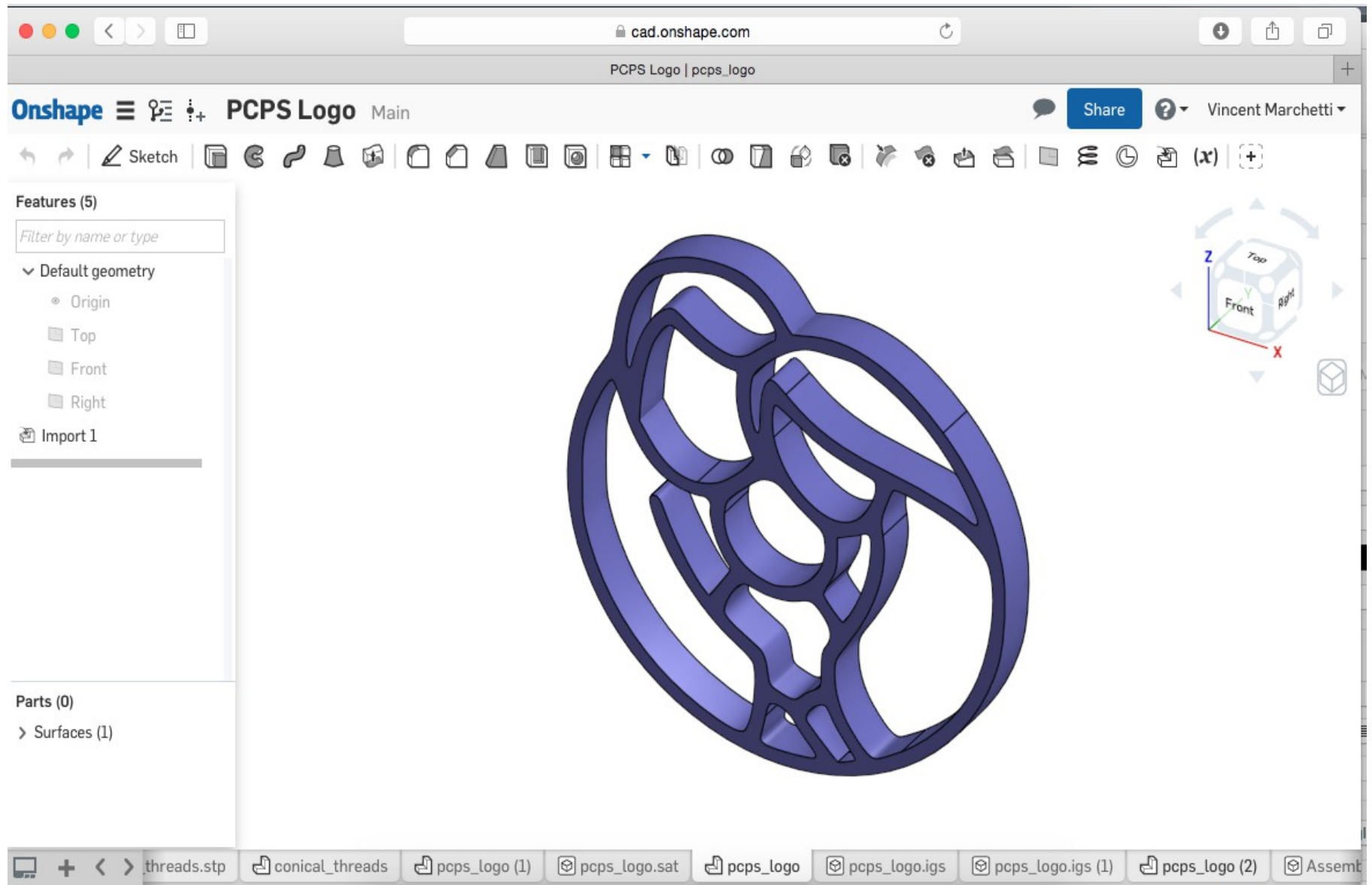
Comparison of STEP → X3D conversion capabilities

	CADEXchanger	PythonOCC	SPRI
AP 203, AP214, AP242 [CAD]	●	●	●
AP 238 [CAM]	●*		●
Colors from STEP file	●		
Preserve Assembly	●		●
Preserve Faces			●
Use CADGeometry component			●

* CADEXchanger does not separate multiple models in one file

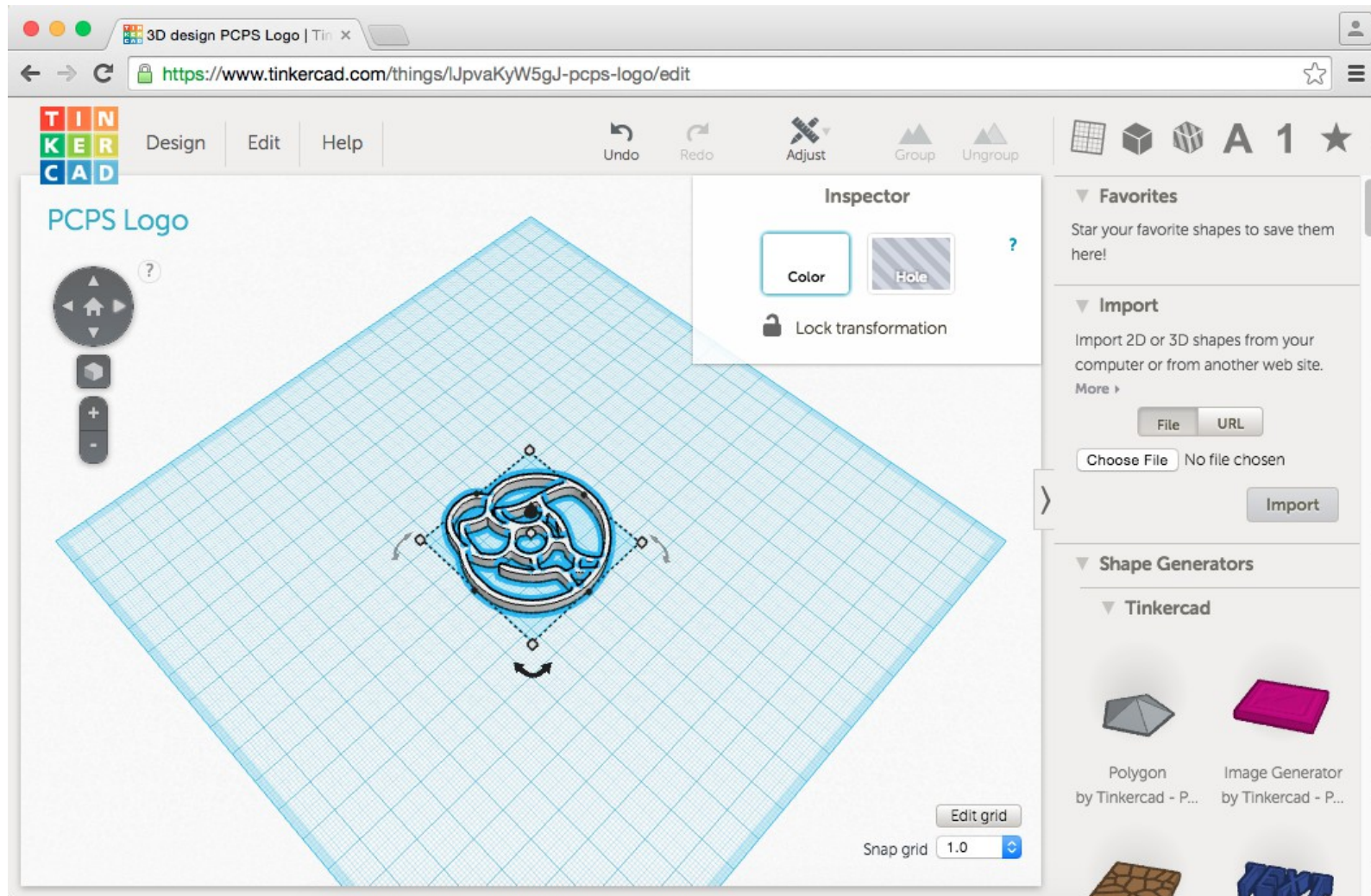
Online CAD modelers

OnShape <http://www.onshape.com>



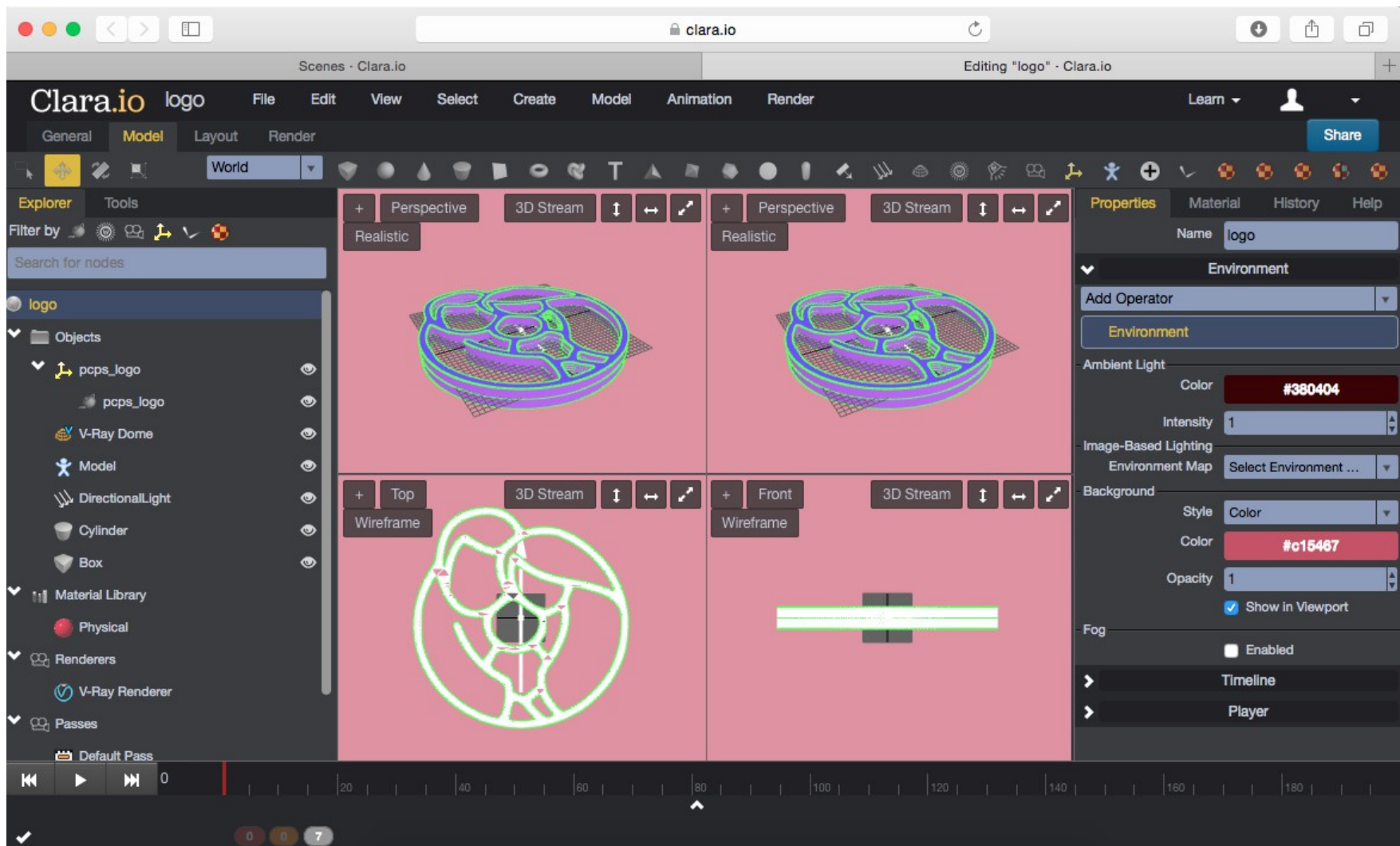
Exports to STEP (AP 214), exports assemblies and colored faces

TINKERCAD <https://www.tinkercad.com>



Has option to “Download for 3D Printing” as “X3D Colors”. Result is an X3D file in Interchange profile, with a single IndexedFaceSet colored by triangle

Clara.io <https://clara.io/>



Supports a “File > Export > Web eXtensible 3D” option, gives an X3D Immersive profile