

Learn X3D !

With Cases Studies and Examples

Web3D Webinar 8/4/2020

Nicholas F. Polys, PhD
Virginia Tech



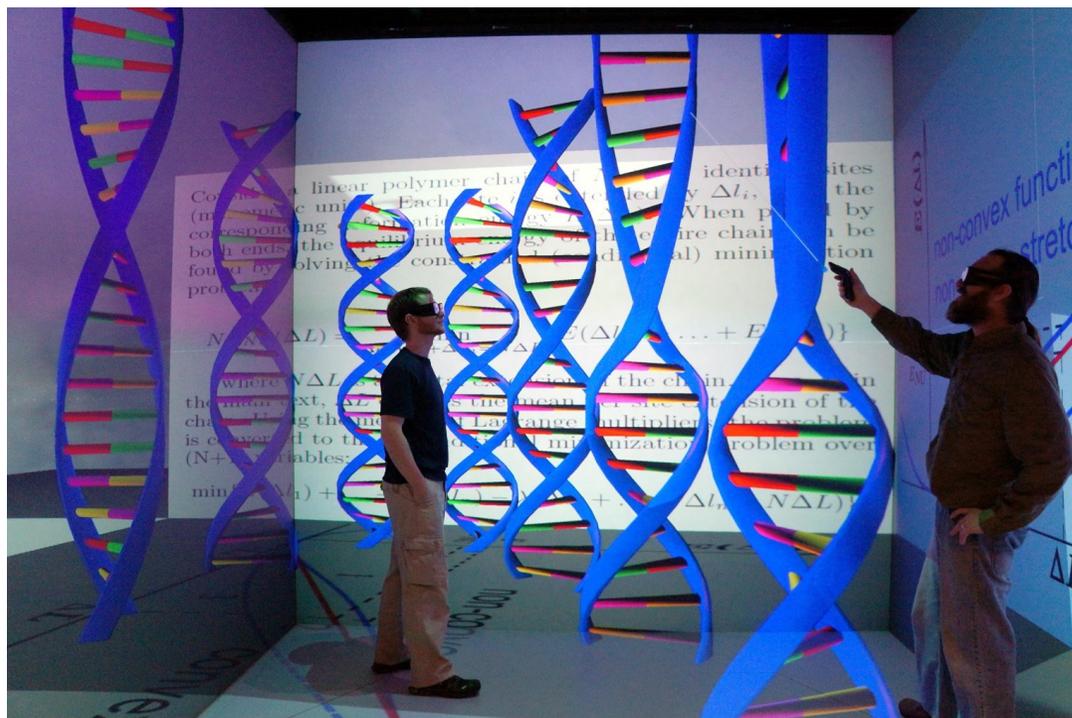
Acknowledgements

Evolving material since 2018 with :

Johannes Behr

Timo Sturm

Uwe Woessner



The Web is Wide

Many Domains ... data



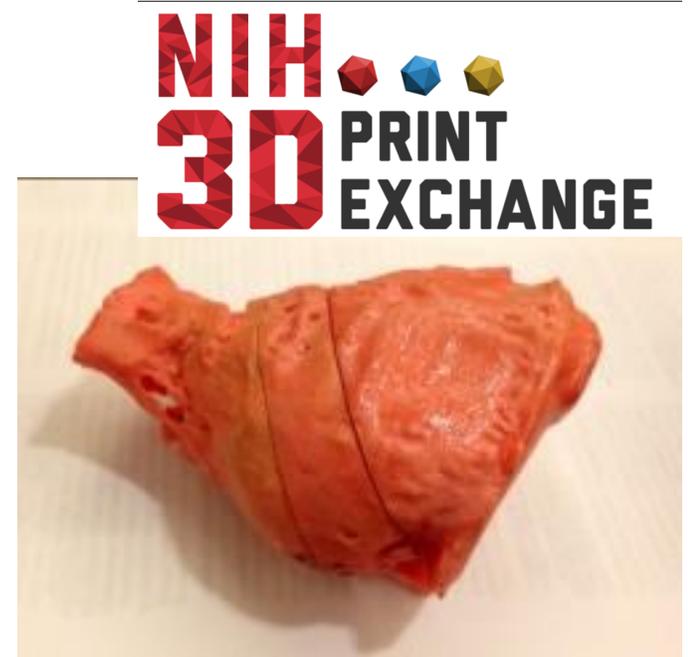
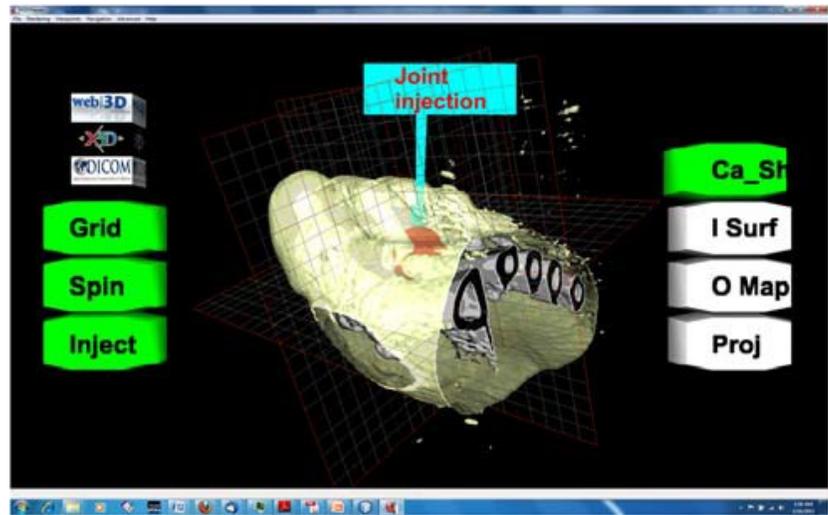
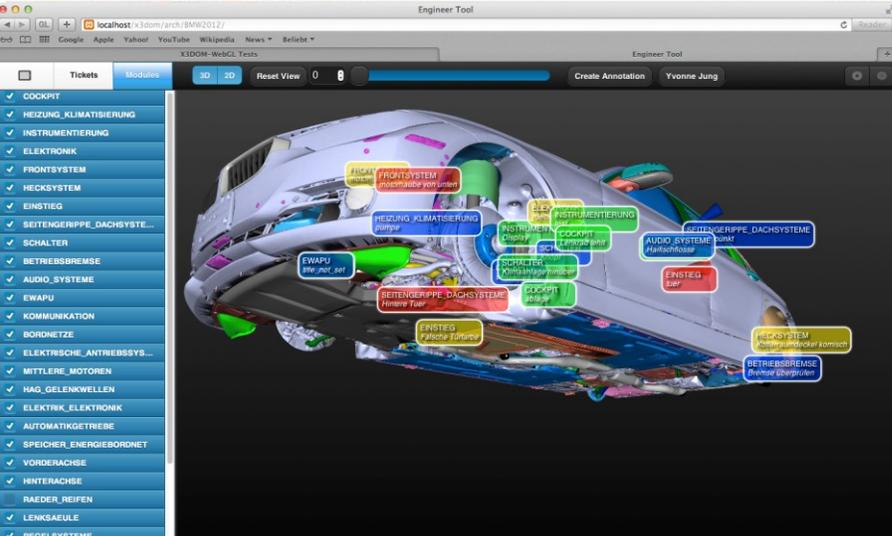
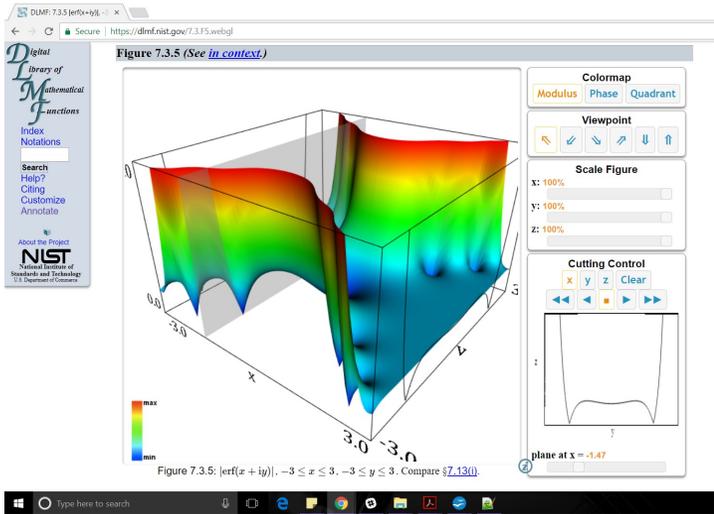
people.cs.vt.edu/~poly/...
 Click and Drag your mouse to examine (left button) or zoom (right button) ; Pg-Up and Pg-Down Jumps you to viewpoints.

Computing stretched DNA

An international team of researchers led by CS faculty A. Oamfrif proposed a general mechanism of strong stretching of polymers. When stretching of individual units (monomers) of the polymer is described by a convex energy-extension curve, the entire polymer chain extends uniformly in response to the pulling force. In contrast, when the energy-extension function is non-convex, the stretched polymer consists of two distinct phases. Some biological polymers such as the DNA exhibit this type of two-phase stretching, which leads to many peculiar phenomena such as the existence of a regime in which further extension of the polymer proceeds without increase in the pulling force. The work is now published in the Proceedings of the National Academy of Sciences, USA.

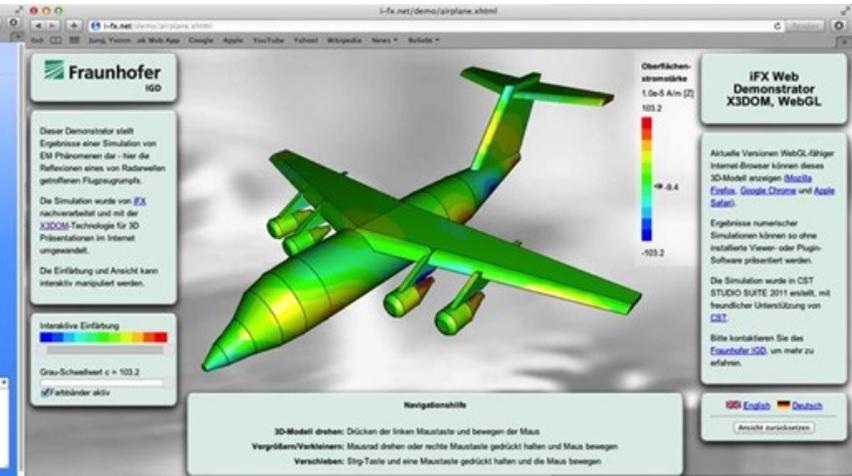
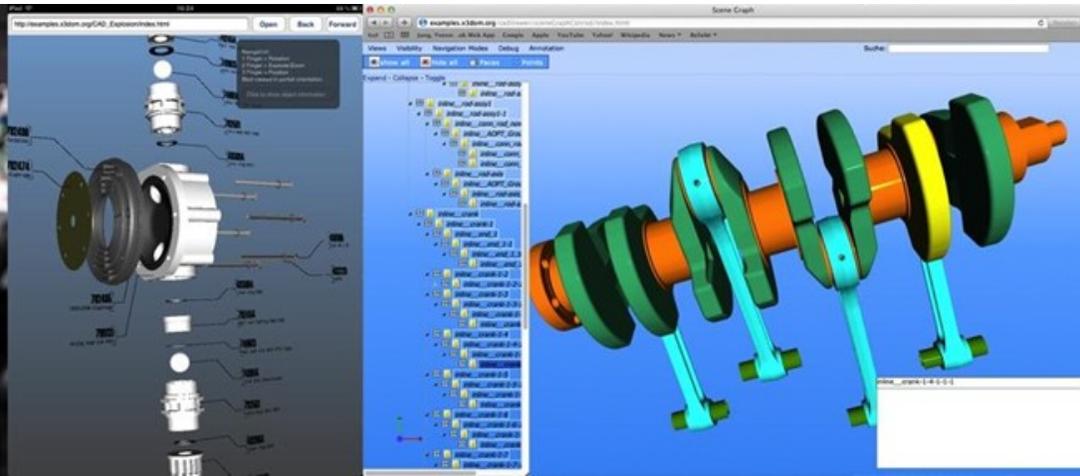
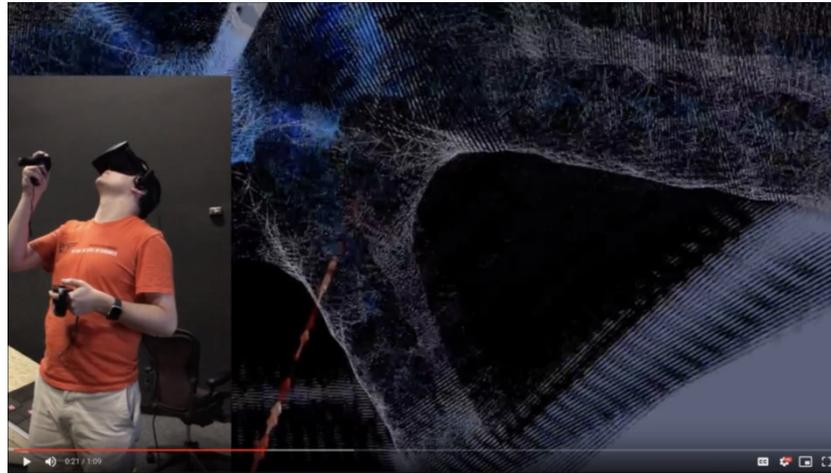
<http://www.ncbi.nlm.nih.gov/pubmed/23378631>

Images and Vis courtesy of Virginia Tech Research Computing: Nicholas Polys, Andrew Wood, Alexey Oamfrif

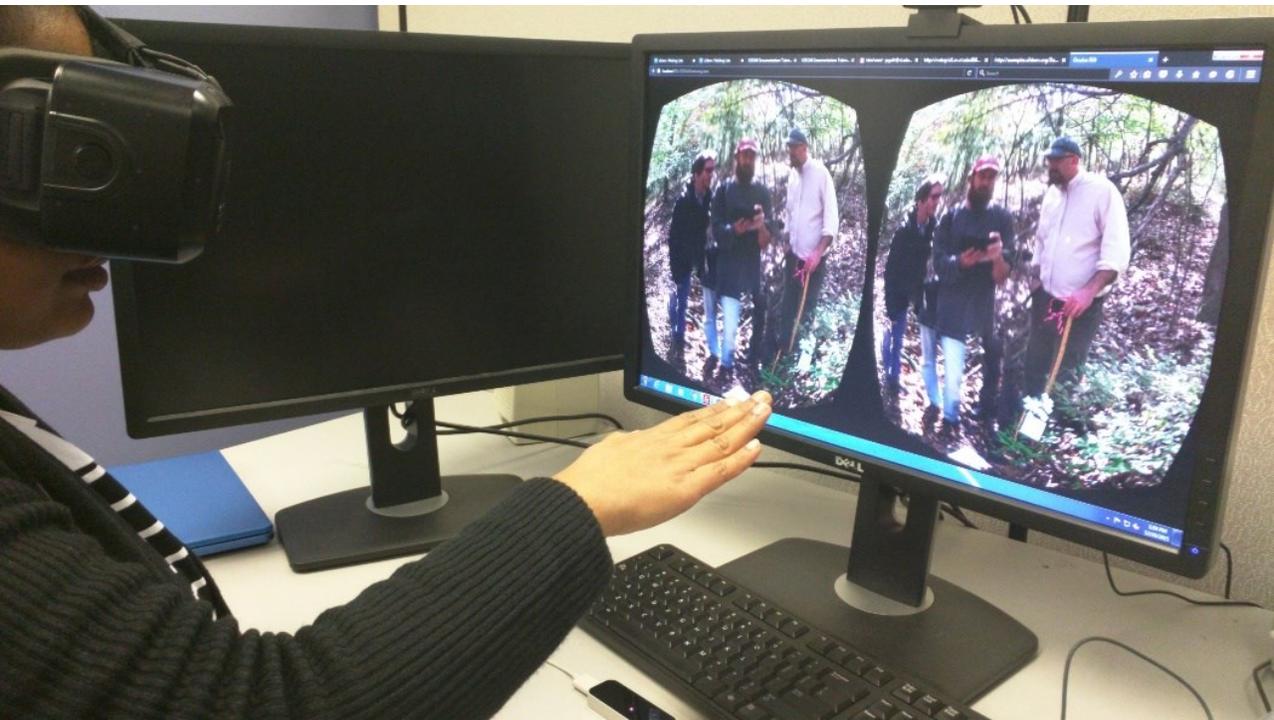


The Web is Deep

Open worlds linked can composed by URL



Interactive 3D Graphics



+ WWW

= Web3D

web|3D
CONSORTIUM

A Rising Tide Lifts All Boats

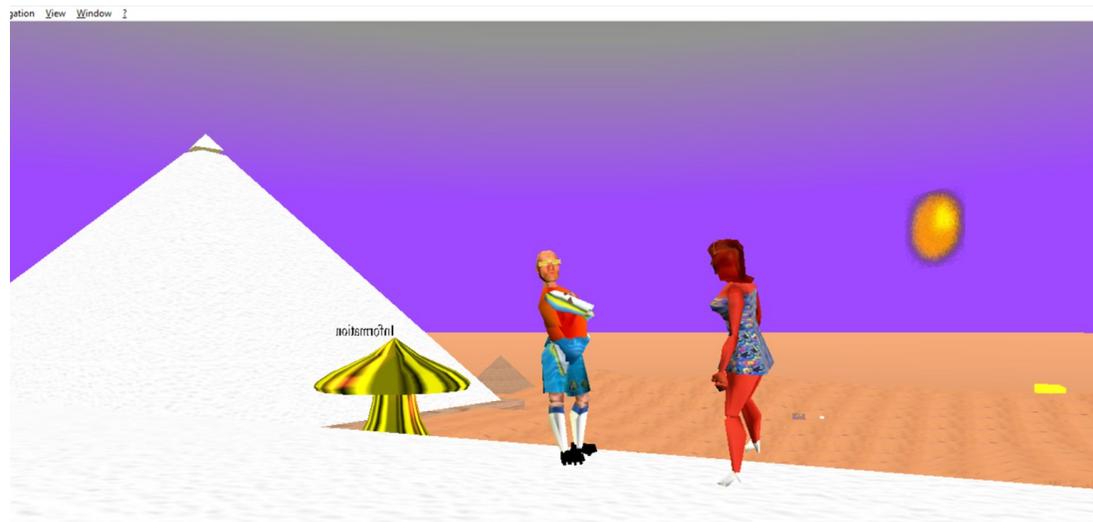
Web3D Standards:

- 25 years of interactive 3D Graphics Innovation
(& ACM SIGGRAPH Conference)
- A world-wide community
- Researchers Innovate
- Content & Applications Survive

VirtuWorlds Giza (1998-2020)

Early searches into 3D and Virtual Reality:

- ***Epistemology***
- ***Metaphysics***
- ***The Web***
- ***Archival 3D***



How it Works

- **International Standards Organization** (ISO.org)
 - **National bodies ratify technology**
- **World Wide Web Consortium** (W3C.org)
 - **Members ratify technology**
- **Web3D Consortium** (Web3D.org)
 - **Members ratify technology**



Open Standards for Real-Time 3D Communication

- HOME
- NEWS & EVENTS
- CREATE X3D
- PARTICIPATE
- STANDARDS
- ABOUT

modelRoot > modelRoot-1 > 2_Cylinder_Engine > 2_Cylinder_Engine-1

tree

Graph Metadata Annotation

X3D Product Design

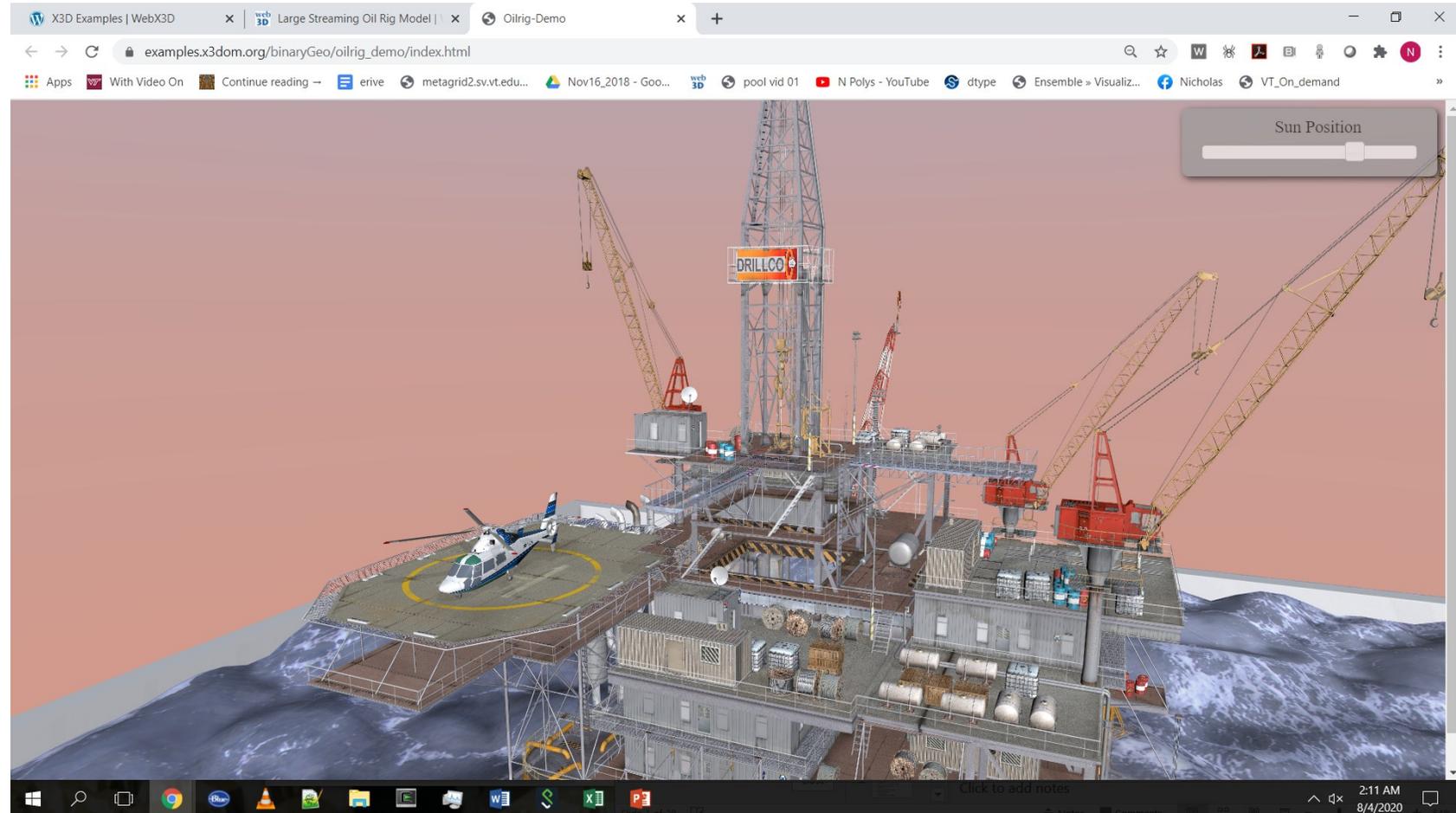
X3D
VERSION 4

X3D 4.0 development is the center of discussion among Web3D working groups and community. We encourage members to participate in these important discussions as we extend X3D to make native authoring and use of X3D models fully integrated with HTML5.

- News
- Uncomina Events
- Web3D Tweets

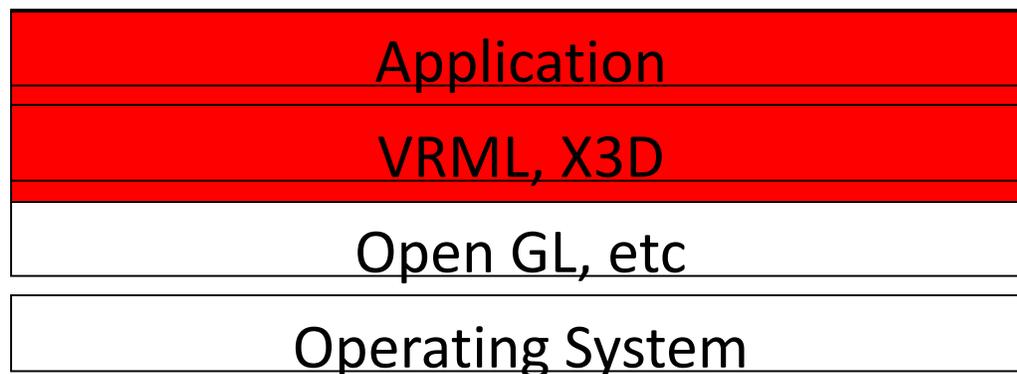
www.web3d.org

- Globe & Weather
- Banner Worlds
- Case Studies



Foundations

- ISO standard, openly published and royalty-free
- A layer above media and rendering libraries
- Multiple implementations including open source codebases
- X3D Scene graph includes the *Transformation graph* and the *Behavior graph*



A Hypertext Markup for 3D: Extensible 3D (X3D)

- Like HTML, X3D has a content model that enables the spatial layout of media elements (images, audio, video, text) and links
- Like HTML, X3D is platform - independent
- Like HTML, X3D can be scripted with JavaScript
- Like XML, X3D XML uses a DTD and Schema

Scene Graph

- Lives above the rendering library
- Specifies object and environmental properties:
 - Lights
 - Camera
 - Transformation and Grouping of Shapes (parent - child)
 - Geometry and Appearance (materials, textures, shaders)
 - Environmental effects (e.g. Fog, Backgrounds)
- Manifests animation and interaction behaviors
- Is 'traversed' for drawing



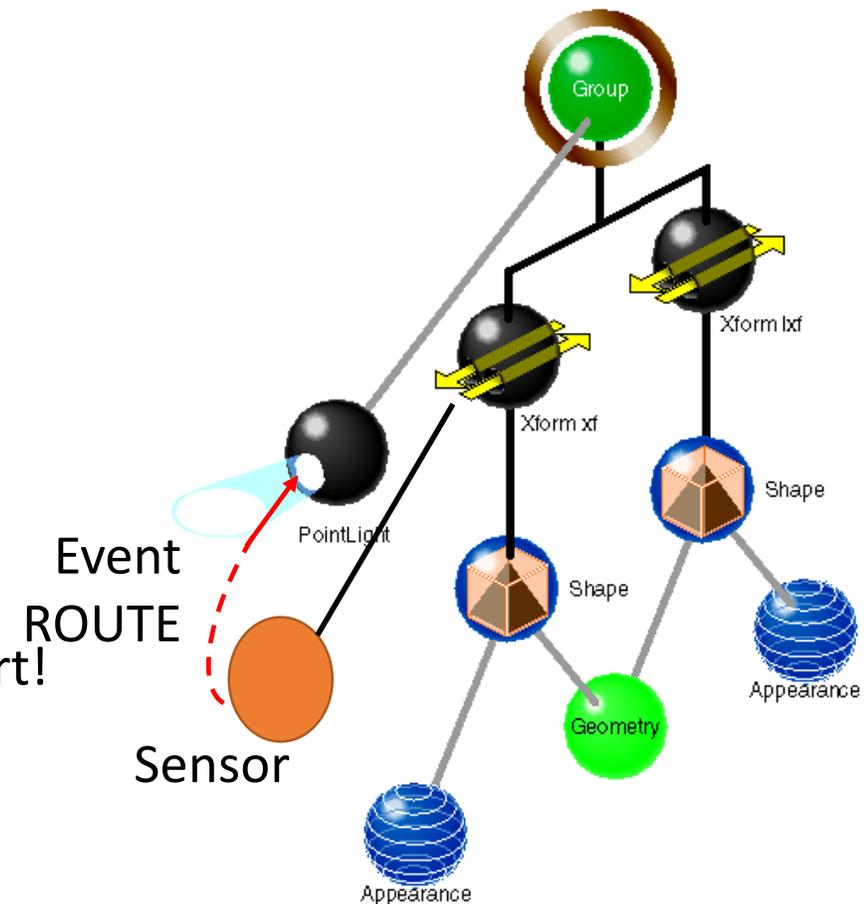
ISO-IEC Standard Scope

Scene graph for real-time interactive delivery of virtual environments over the web:

- Meshes, lights, materials, textures, shaders
- Integrated video, audio
- Animation
- Interaction
- Behaviors
- Scripts
- Application Programming Interfaces

3.3 examples for Medical Imaging, CAD and Geospatial support!

<https://www.web3d.org/standards>



Resources

March 12, 2020:

'X3D'

yields 20,700 documents in Google Scholar and 8,450 in Semantic Scholar

'VRML'

yields 87,100 documents in Google Scholar and 24,000 in Semantic Scholar.

X3D Scene graph

Resources & International Community

www.web3d.org



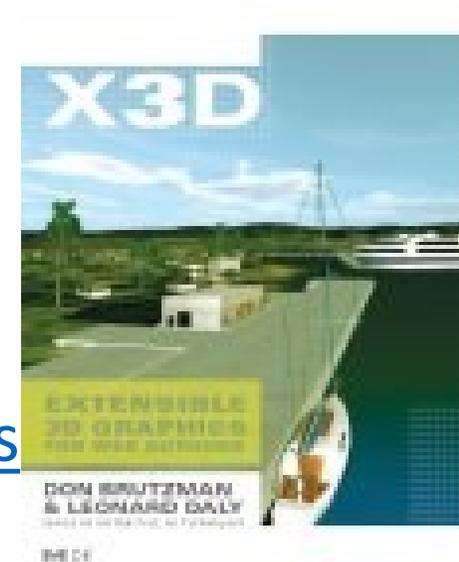
<http://www.web3d.org/documents/specifications/19775-1/V3.3/index.html>

Book:

<http://x3dgraphics.com/>

Online Slides: <http://x3dgraphics.com/slidesets/index.php>

Online Examples: <http://www.web3d.org/x3d/content/#Examples>



Playing Well on the Web

No spaces in file names!

X3D4 supports GLTF and PBR !!!

<https://www.web3d.org/blog-integrating-x3d-and-gltf>

Scenegraph

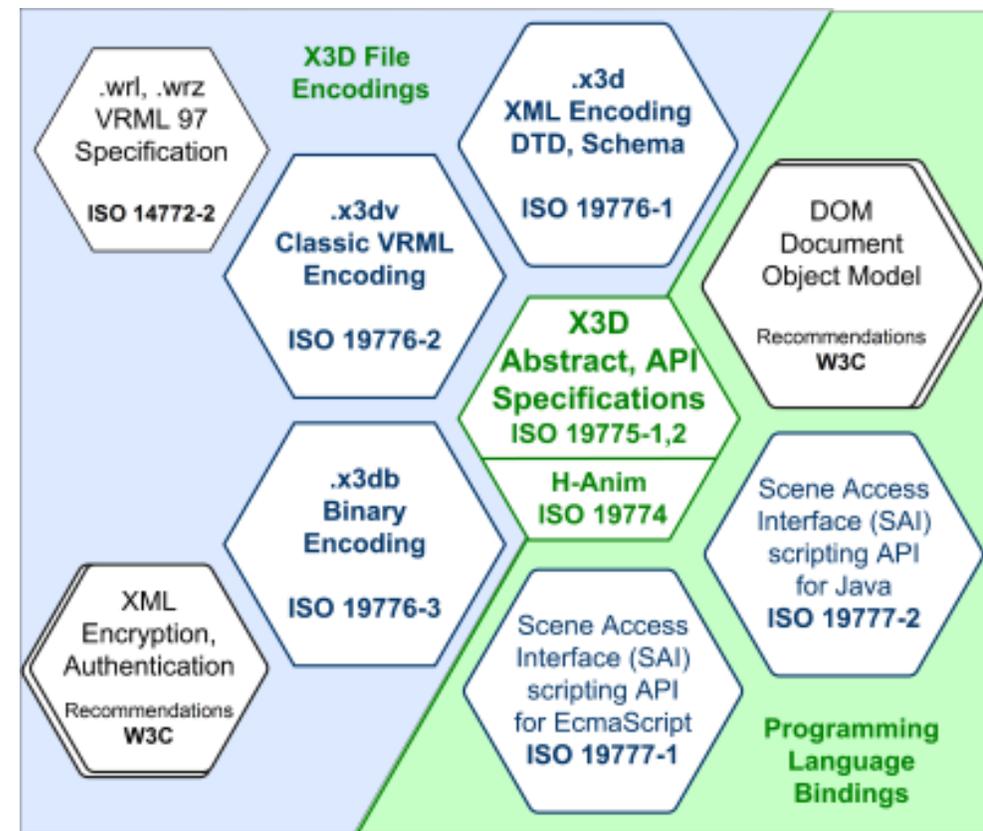
Lots of tools export:

- Virtual Reality Modeling Language (VRML)
- Extensible 3D (X3D)

... lots of other proprietary formats ;
can be converted with
commercial translation tools,
open source tools,

or your own Scripts !

***Target X3D Profiles and Components for different node sets
(functionality)***



Tons of Tools...

- Blender
- MeshLab
- 3DS Max
- Maya
- Rhino
- Paraview
- Agisoft
- ARCScene
- Creoform
- PointFuze
- ...

- Titania (Linux)
<http://create3000.de/>
- X3D-Edit
<https://savage.nps.edu/X3D-Edit/>
- AOPT (w/
InstantPlayer)
- XML &
stylesheets
- ...

export me!

- 3DPrint Exchange
- POSTGIS
<https://postgis.net/>
- ...
- Okino Polytrans
- Safe Software
- ...

X3D Engines (installed)

(July 2020)

- Instant Reality
- Covise/OpenCover
- V-slam.org (Unity, Hololense)
- Castle Game Engine
- FreeWRL
- H3D (Haptics, py)
- Octaga
- Xj3D
- BS Contact
- Coin3D
- ...

HTML5 + WebGL Javascript Polyfills:

- X3DOM
- X_ITE
- NIH 3D Viewer

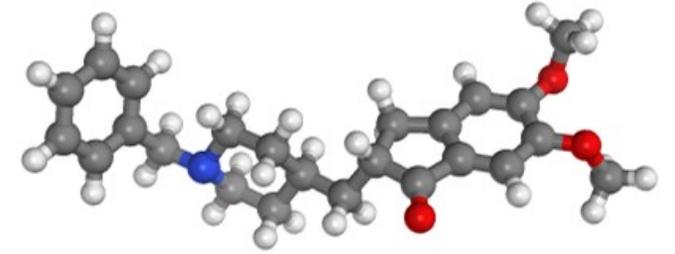
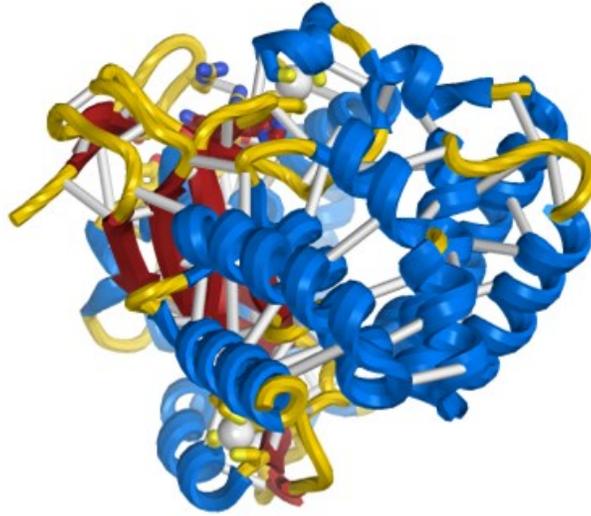


...

Molecules

- Chimera
- VMD
- *Mol
- CML

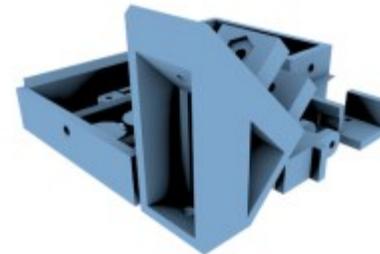
...



3dprint.nih.gov



- **Molecules**
- **Cells & tissues**
- **Anatomical models**
- **Prosthetics**
- **Labware**
- ...



3D Printing Support

- CURA,
- Netfab,
- Shapeways,
- ...

*Can always convert to-
from **STL** with tools
like:*

- Blender
- Meshlab,
- 3DPrintExchange
- ...

Native support of
X3D for 3D Printing

(including color and metadata)!



**High spatial and
temporal resolution
body scans**

www.3dmd.com

OBJ is not enough-
need for rich metadata

X3D Authentication &
Encryption

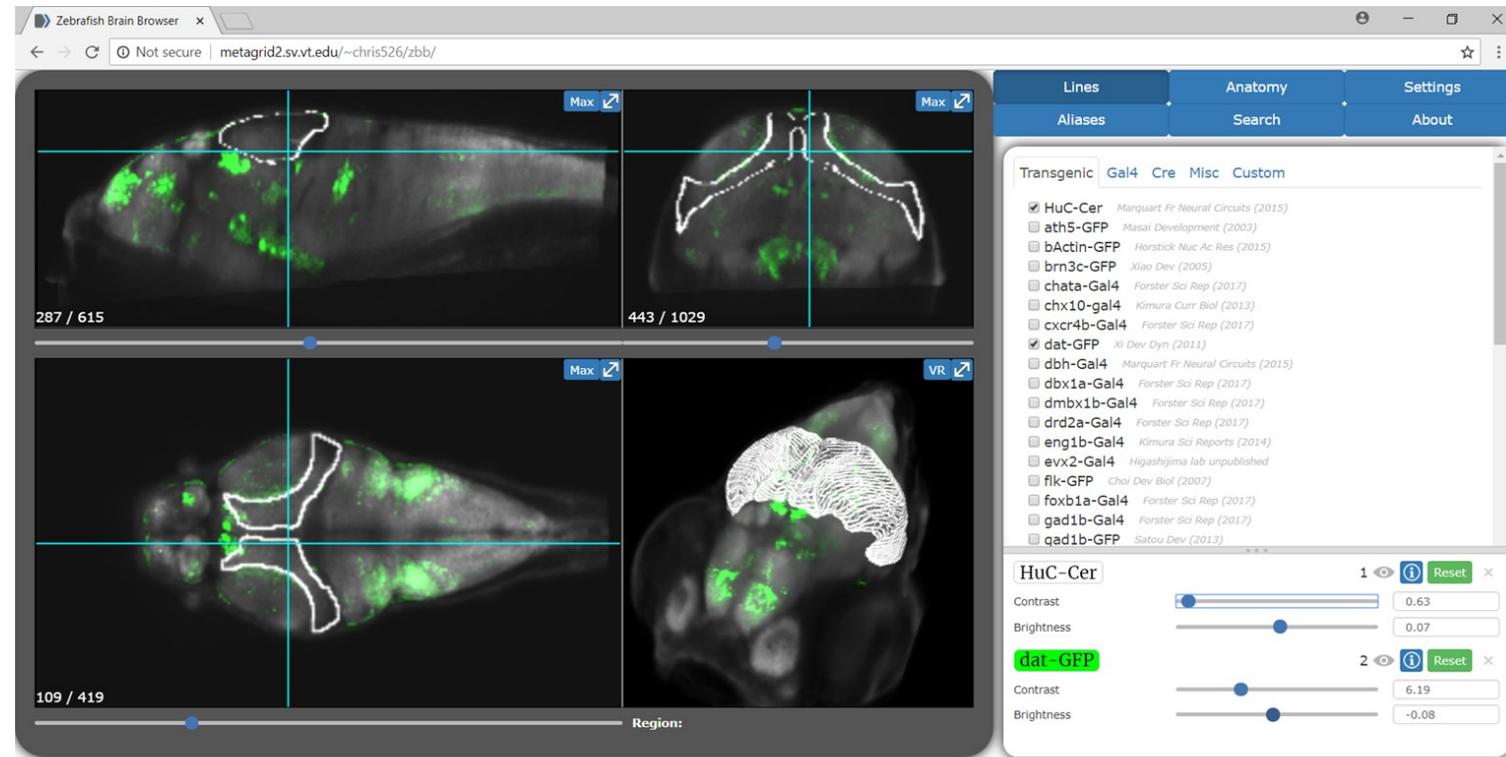


Zebrafish Brain Browser

- NIH and the Burgess Lab
- VT Undergrad Interns

***Zebrafish genetic
and neuro atlas:***
zbbrowser.com

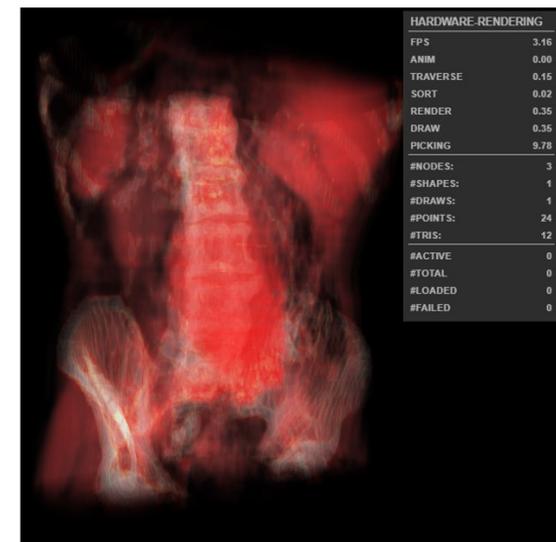
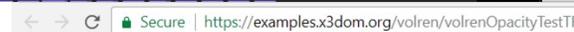
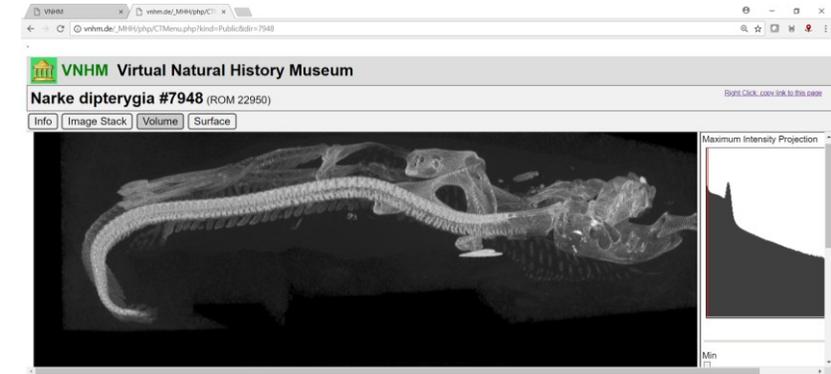
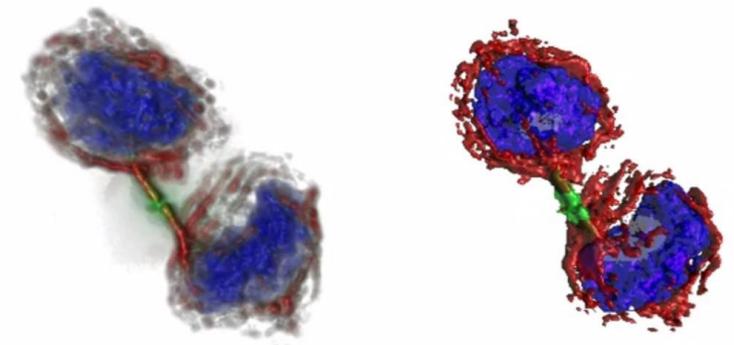
- [clip plane](#)
example



Volume data

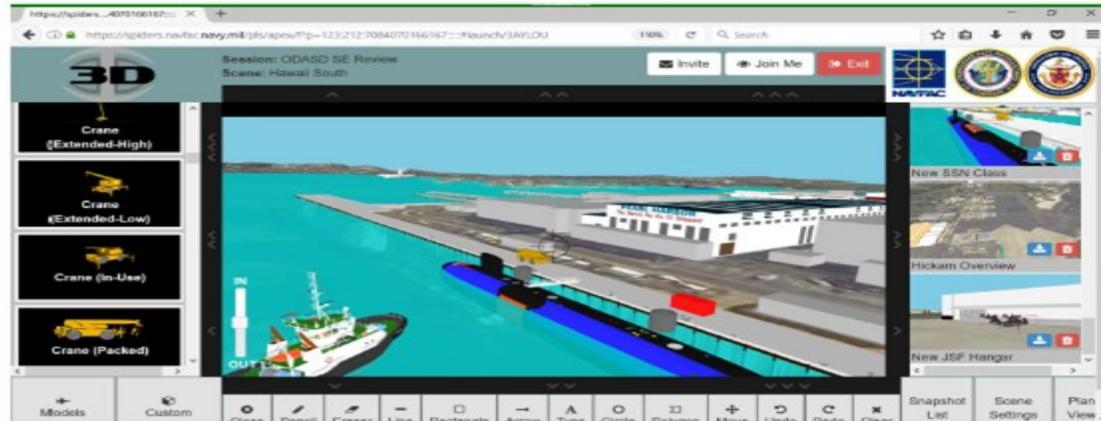
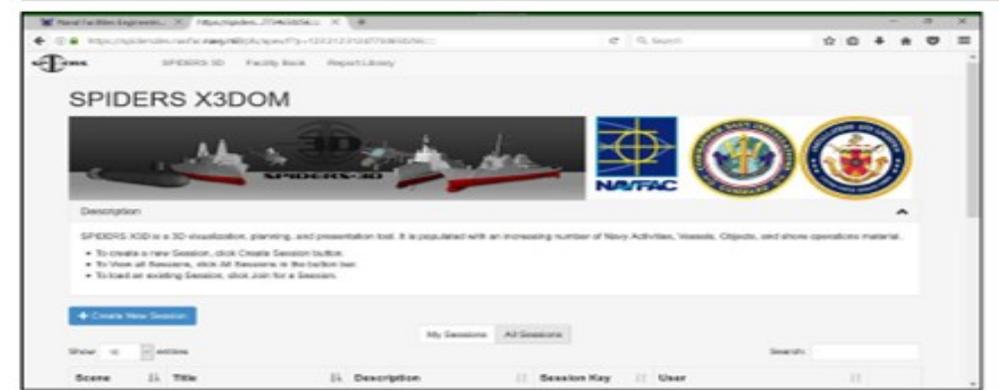
- Cell Image library
- Fossils (CT)

- Zoology (Prof Hoffmann, Bonn)
 - <http://vnhm.de/>
- VICOMTech:
 - MIRROR4All
 - <https://github.com/VolumeRC/AtlasConversionScripts>



US Navy Facilities: Worldwide

- X3D Database
- X3DOM client
- Video Link on Web3D.org case studies!!



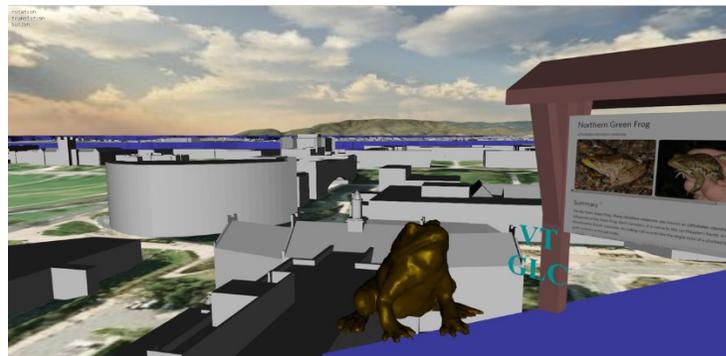
✓ Interactive 3D Models in Geospatial Context
✓ High Velocity Group Learning Environment



X3D Blacksburg

Environmental Awareness E.g. <https://youtu.be/ZIXbsR4KSzc>

- Terrain
- Imagery, openstreetmap
- Town buildings
- Campus buildings
- Sketchup buildings
- Frog scans
- ...



3D Blacksburg Collaborative Planning



Nicholas Polys, Cecile Newcomb, Todd Schenk, Thomas Skuzinski, and Donna Dunay. (2018). "The value of 3D models and immersive technology in planning urban density". In Proceedings of the 23rd International ACM Conference on 3D Web Technology (Web3D '18). ACM, New York, NY, USA, Article 13, 4 pages. DOI: <https://doi.org/10.1145/3208806.3208824>



Appalachian Trail

Remote site

Photosphere

viewsheds

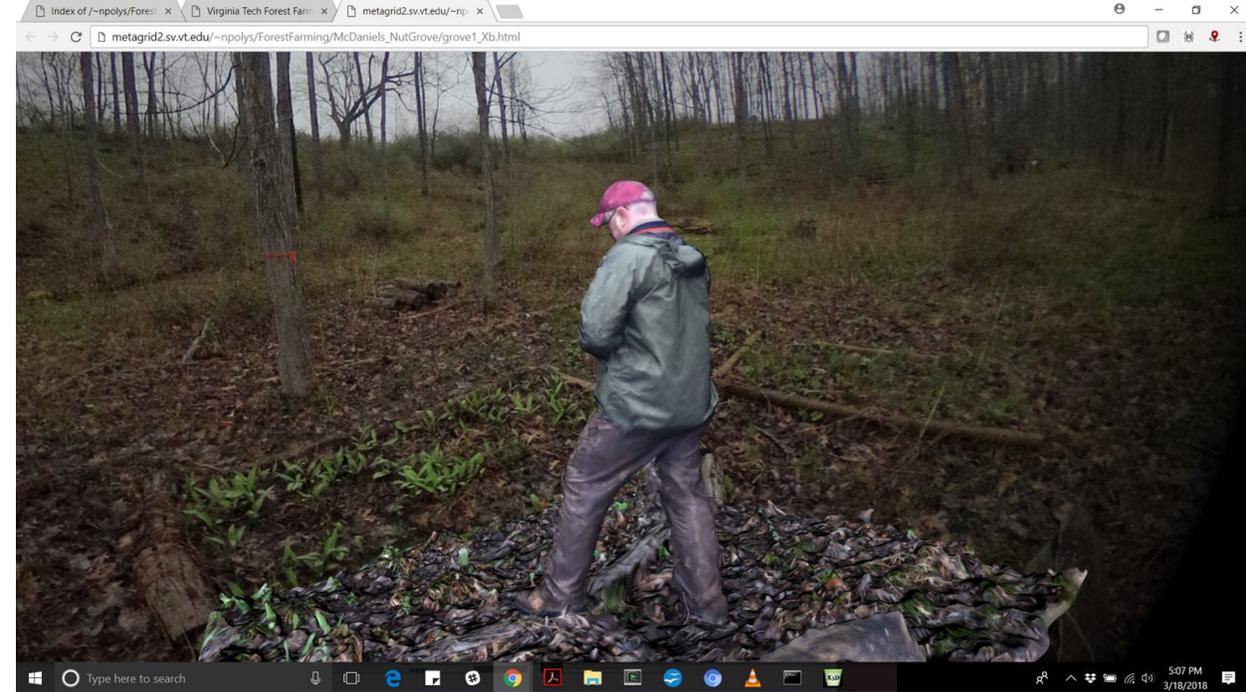


Remote site visits



Design & Planning II

- Virtual Tours
 - photospheres
 - Structure.io scans
- Town Planning (Sketchup + X3D Blacksburg)



http://metagrid2.sv.vt.edu/~npolys/ForestFarming/McDaniels_NutGrove/grove1_Xb.html

http://metagrid2.sv.vt.edu/~npolys/3DBBurg/Cecile/Dec5/BBurg_AlleyV4_aopt_bin_Newnew.html



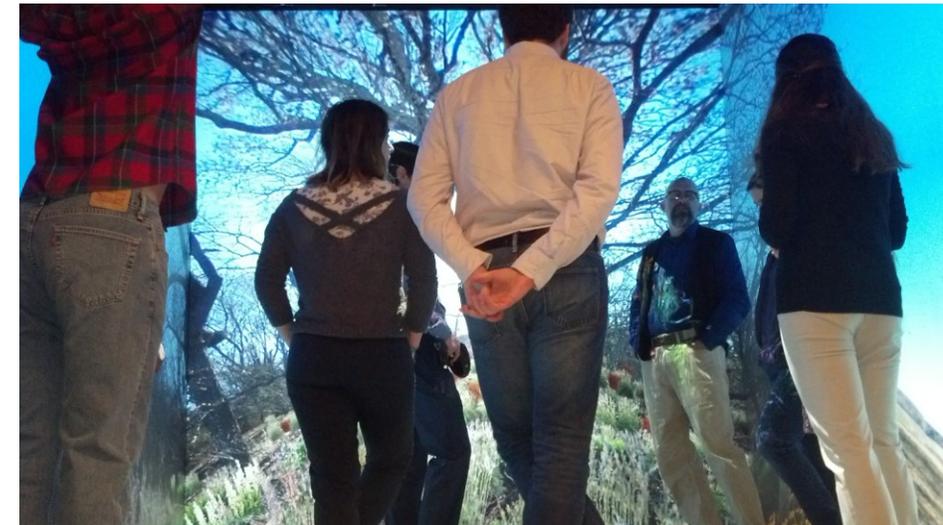
Design & Planning examples

<https://vimeo.com/visionarium2018>

Exhibits

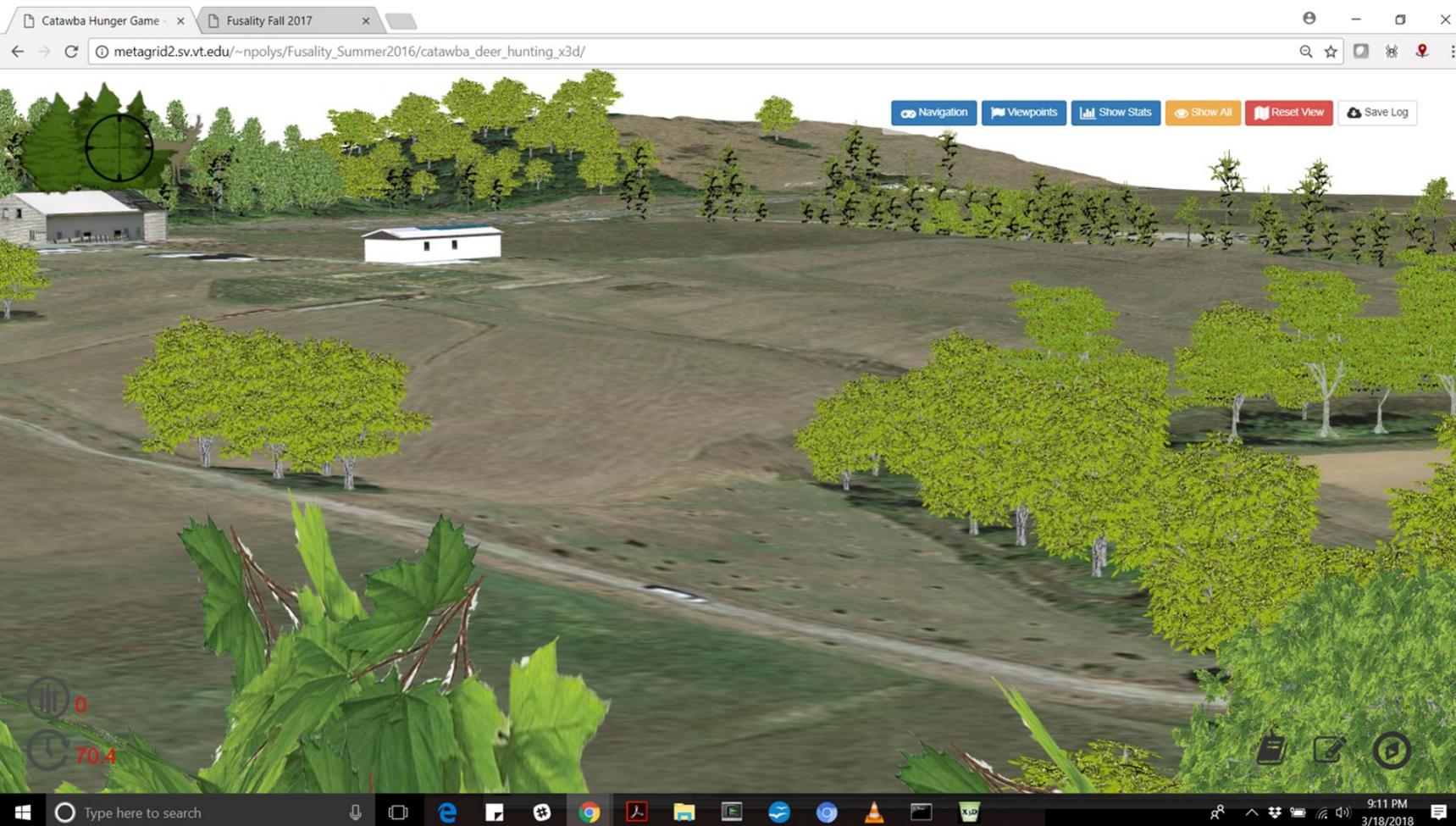


Landscapes



Catawba GIS & tree LOD

http://metagrid2.sv.vt.edu/~npolys/Fusality_Summer2016/catawba_deer_hunting_x3d/



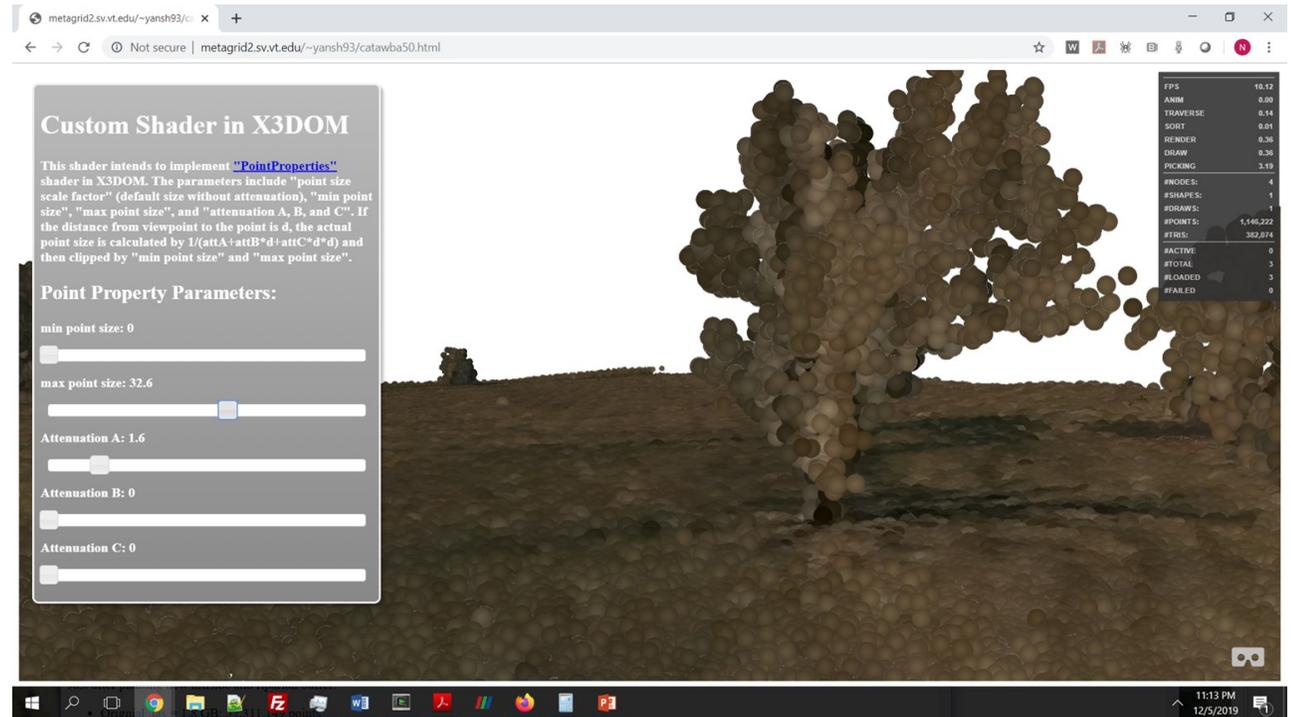
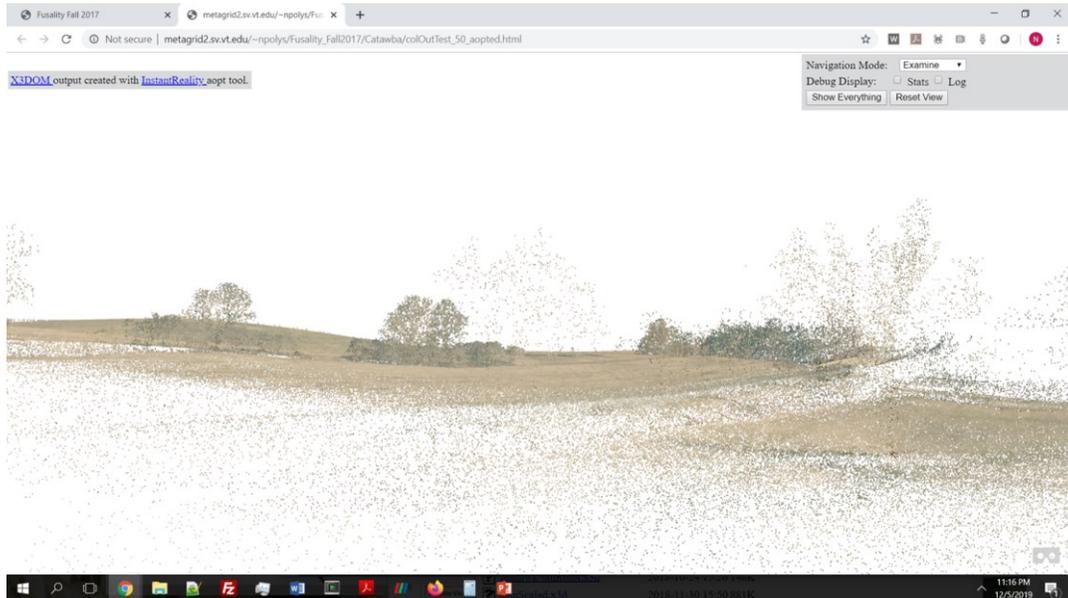
Haitao Wang, Xiaoyu Chen, **Nicholas Polys** and Peter Sforza (2017). "A Web3D Forest Geo-Visualization and User Interface Evaluation". In *Proceedings of the 22nd International Conference on 3D Web Technology (Web3D '17)*. ACM, New York, NY, USA.

PointClouds and X3D Rendering

PointProperties in X3D 4.0

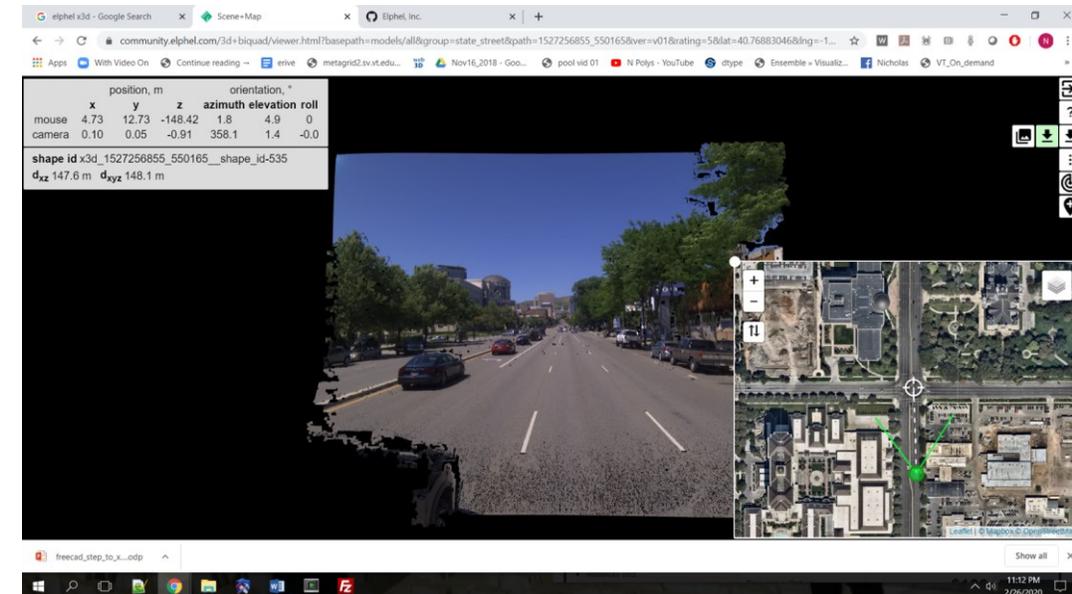
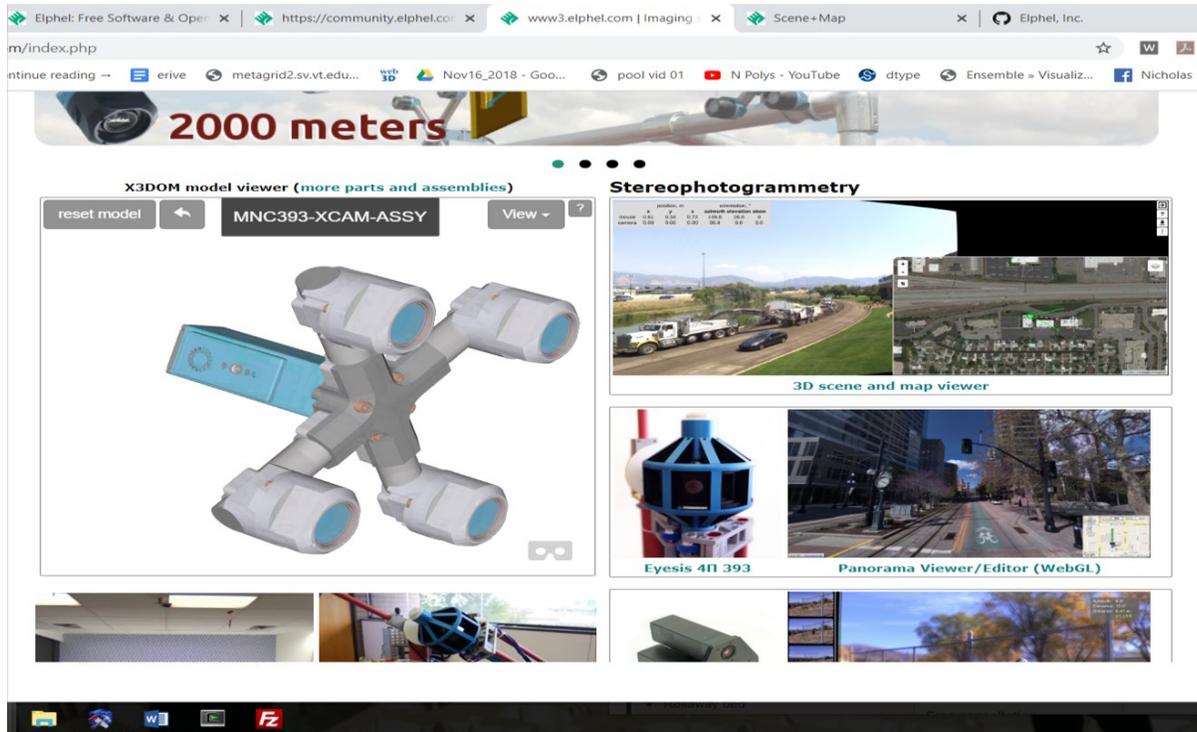
http://metagrid2.sv.vt.edu/~yansh93/archimedes_pp.html

http://metagrid2.sv.vt.edu/~yansh93/catawba_pp.html



More Cool examples

[Elphel](#) using open standards and open source!
Cameras : Product Catalog & [media products](#) in X3D!~



eTrout Citizen Science

w/ USGS & WebVR VideoSpheres - count the trout!

http://metagrid2.sv.vt.edu/~npolys/eTrout/AI/index_sphere.html

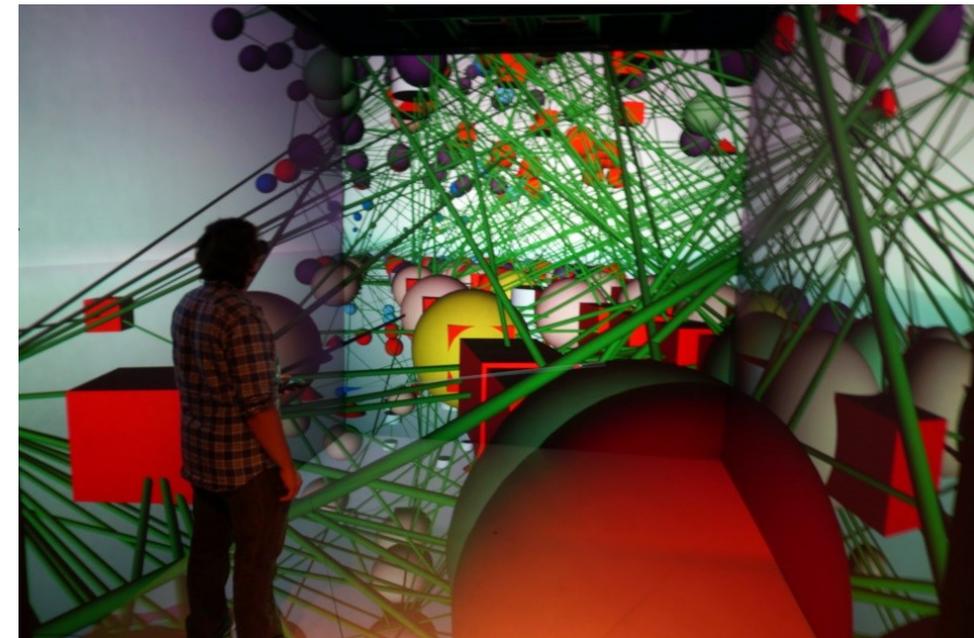
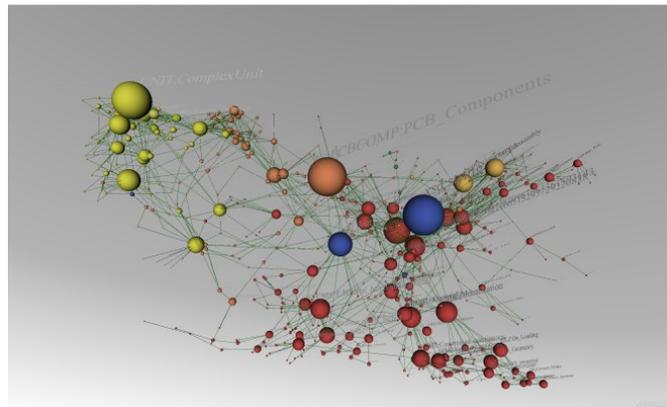
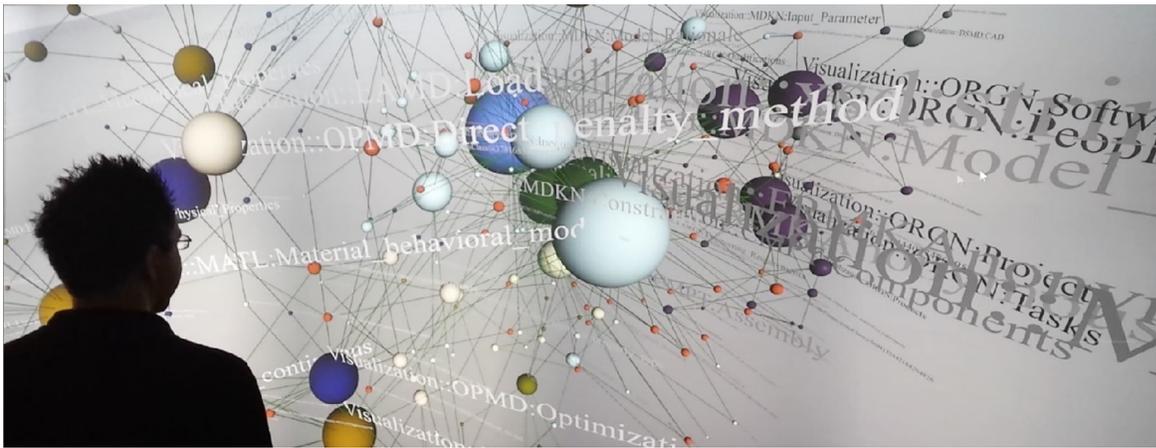
https://viriniatech.qualtrics.com/jfe/form/SV_3KmmcAZmpC2Yw29

- Hitt, N.P., C. Snyder, J. Young, K. Rogers, **N. Polys**, and C.A. Dolloff. *New approaches linking trout abundance to headwater stream flow*. American Fisheries Society Annual Meeting 2019. Reno, NV. Invited presentation.
- Hitt, N.P., K. Rogers, C. Snyder, **N. Polys**, and C.A. Dolloff. *New method for trout abundance estimation with video sampling*. East Coast Trout VI (2019), Frostburg, MD. Contributed presentation.



BioPax Ontology Vis

Peter J. Radics, **Nicholas F. Polys**, Shawn P. Neuman, and William H. Lund. "OSNAP! Introducing the open semantic network analysis platform". *Proceedings of Visualization and Data Analysis*, IS&T/SPIE Electronic Imaging; 2015.



<http://vis.arc.vt.edu/projects/osnap/home.html>

Particle Physics

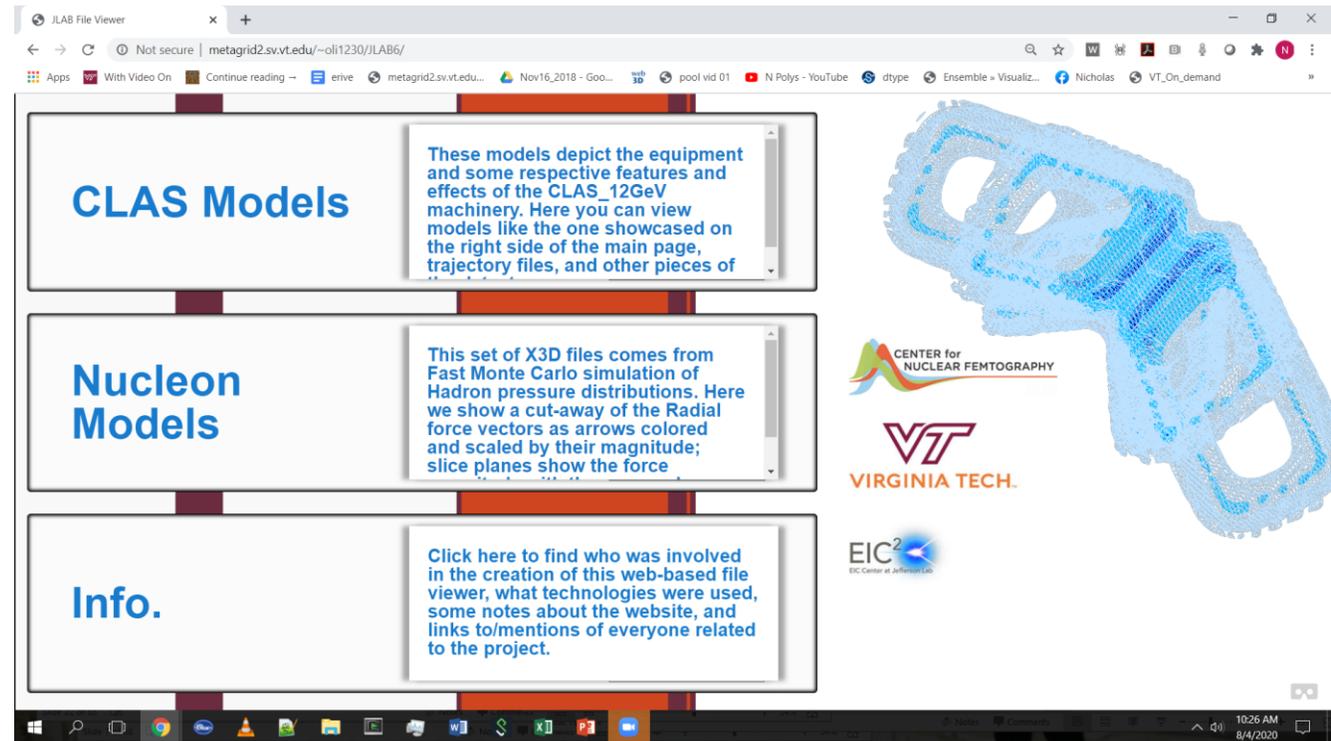
Jefferson National Lab,

Center for Nuclear Femtography

CLAS-12 Instrument & Trajectories

<https://youtu.be/TkrAqSFBgTE>

<http://metagrid2.sv.vt.edu/~oli1230/JLAB6/>



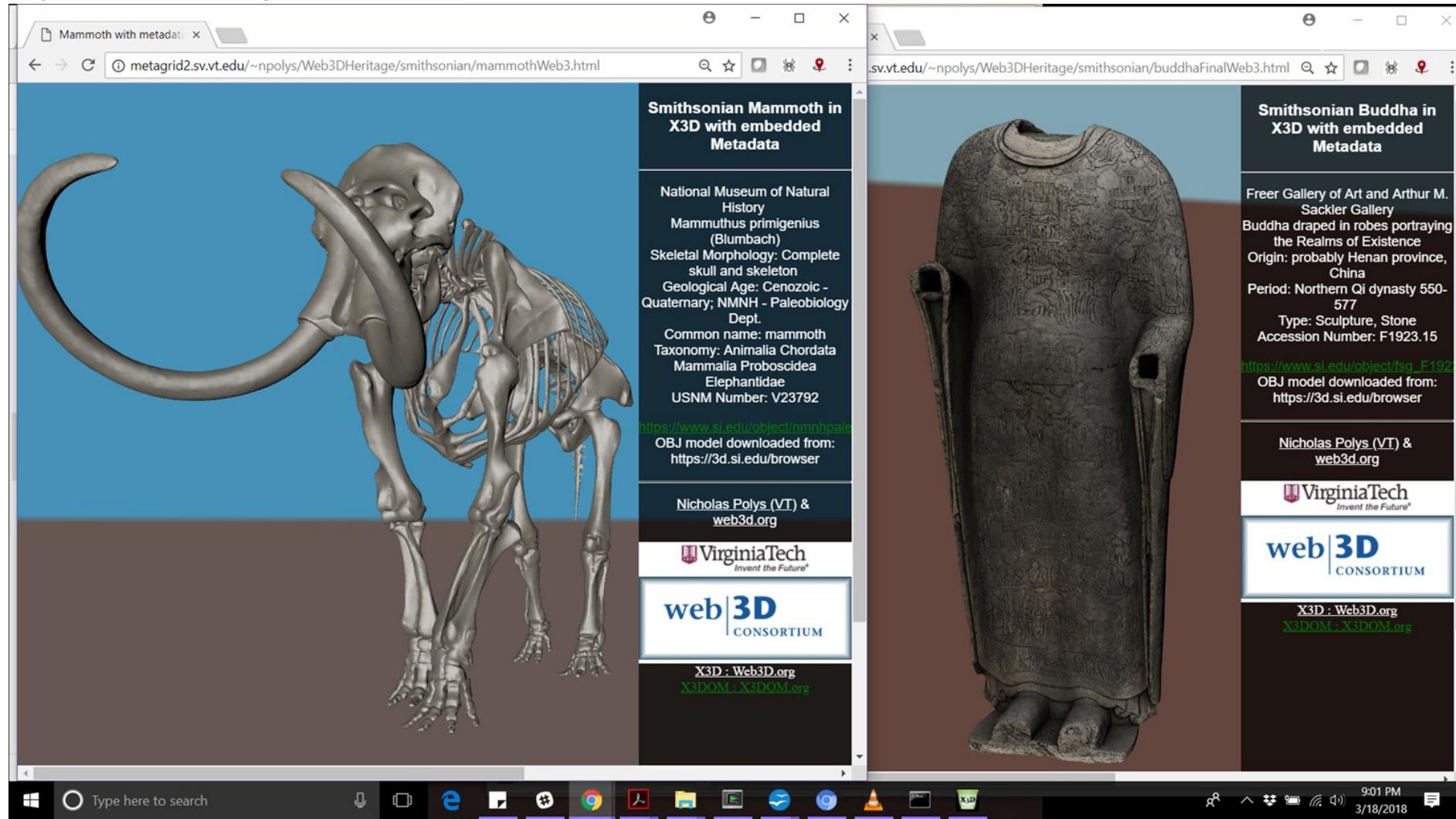
The screenshot shows a web browser window titled "JLAB File Viewer" with the address bar displaying "metagrid2.sv.vt.edu/~oli1230/JLAB6/". The browser's address bar also shows "Not secure". The page content is organized into three main sections on the left, each with a title and a description:

- CLAS Models**: "These models depict the equipment and some respective features and effects of the CLAS_12GeV machinery. Here you can view models like the one showcased on the right side of the main page, trajectory files, and other pieces of..."
- Nucleon Models**: "This set of X3D files comes from Fast Monte Carlo simulation of Hadron pressure distributions. Here we show a cut-away of the Radial force vectors as arrows colored and scaled by their magnitude; slice planes show the force..."
- Info.**: "Click here to find who was involved in the creation of this web-based file viewer, what technologies were used, some notes about the website, and links to/mentions of everyone related to the project."

On the right side of the page, there is a large 3D model of the CLAS-12 instrument, rendered in blue and white. Below the model, there are logos for the "CENTER for NUCLEAR FEMTOGRAPHY", "VT VIRGINIA TECH.", and "EIC² EIC Center at Jefferson Lab". The browser's taskbar at the bottom shows various application icons and the system tray with the time "10:26 AM" and date "8/4/2020".

Smithsonian Heritage + metadata in X3D

<http://metagrid2.sv.vt.edu/~npolys/Web3DHeritage/smithsonian/>



The image shows two browser windows side-by-side. The left window displays a 3D model of a mammoth skeleton with a large tusk. The right window displays a 3D model of a Buddha statue in robes. Both windows have a dark sidebar on the right containing metadata and logos.

Smithsonian Mammoth in X3D with embedded Metadata

National Museum of Natural History
Mammuthus primigenius (Blumbach)
Skeletal Morphology: Complete skull and skeleton
Geological Age: Cenozoic - Quaternary; NMNH - Paleobiology Dept.
Common name: mammoth
Taxonomy: Animalia Chordata Mammalia Proboscidea Elephantidae
USNM Number: V23792
<https://www.si.edu/object/nmnhpale>
OBJ model downloaded from: <https://3d.si.edu/browser>

Nicholas Polys (VT) & web3d.org

VirginiaTech
Invent the Future®

web|3D CONSORTIUM

X3D : Web3D.org
[X3DOM - X3DOM.org](https://www.x3dom.org/)

Smithsonian Buddha in X3D with embedded Metadata

Freer Gallery of Art and Arthur M. Sackler Gallery
Buddha draped in robes portraying the Realms of Existence
Origin: probably Henan province, China
Period: Northern Qi dynasty 550-577
Type: Sculpture, Stone
Accession Number: F1923.15
https://www.si.edu/object/fsq_F1923.15
OBJ model downloaded from: <https://3d.si.edu/browser>

Nicholas Polys (VT) & web3d.org

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web|3D CONSORTIUM

X3D : Web3D.org
[X3DOM - X3DOM.org](https://www.x3dom.org/)

Natural & Cultural Heritage

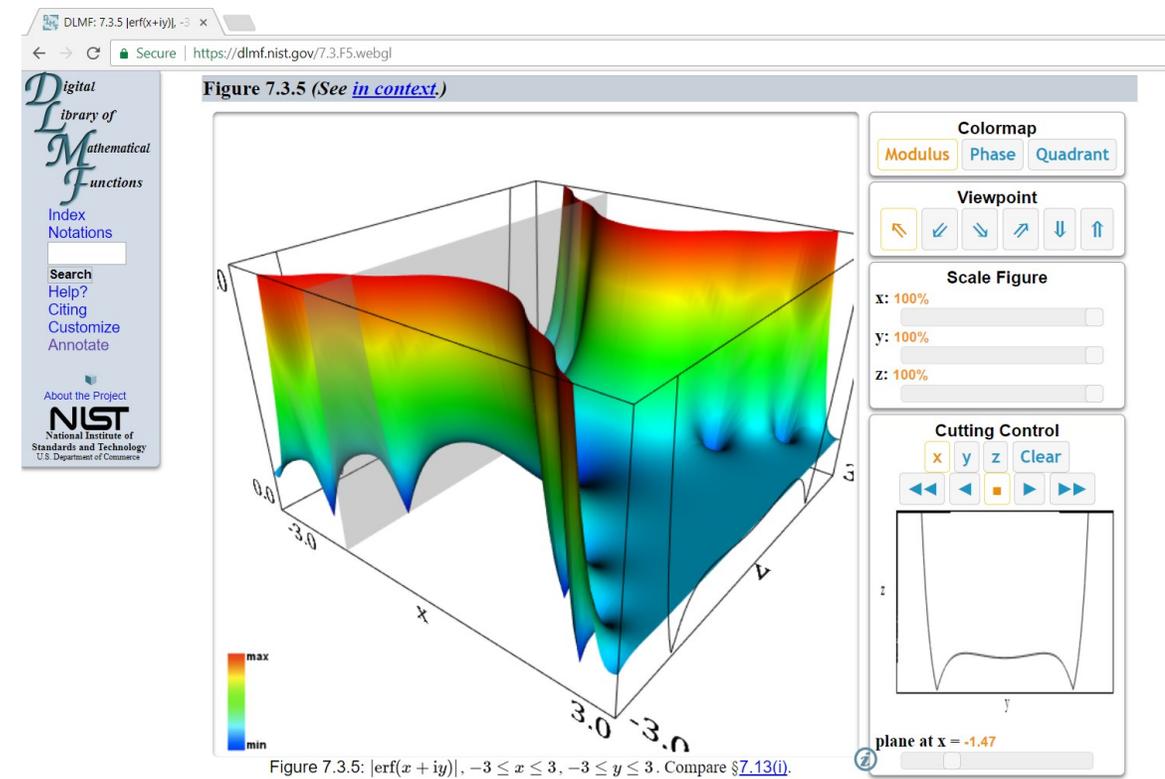
- [Virginia Tech Insect Collection v.1](#)
- [Smithsonian Tests](#)
- **Virtual Natural History Museum:** <http://vnhm.de>

- **Australian National Insect Collection**
 - <https://www2.ala.org.au/chuong/>
 - [https://data.csiro.au/dap/landingpage?pid=csiro:8289&recsysp=2&recsyst=csiro:8316&recsysl=similar&recsyslo=\[csiro:8290,%20csiro:8289,%20csiro:8310,%20csiro:8309\]](https://data.csiro.au/dap/landingpage?pid=csiro:8289&recsysp=2&recsyst=csiro:8316&recsysl=similar&recsyslo=[csiro:8290,%20csiro:8289,%20csiro:8310,%20csiro:8309])

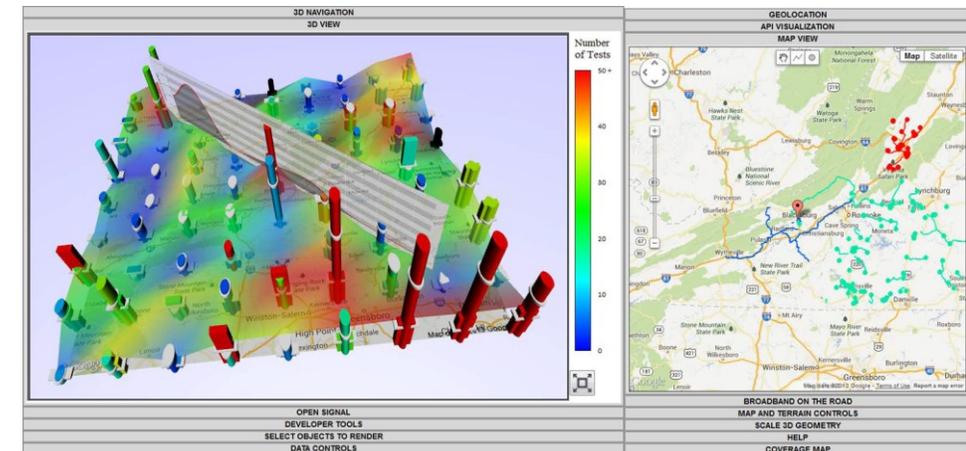
- **ICONS of Greece**
 - <http://www.ceti.gr/~akoutsou/3dicons/showall.php>

Interactive X3D Graphing

<https://dlmf.nist.gov/>

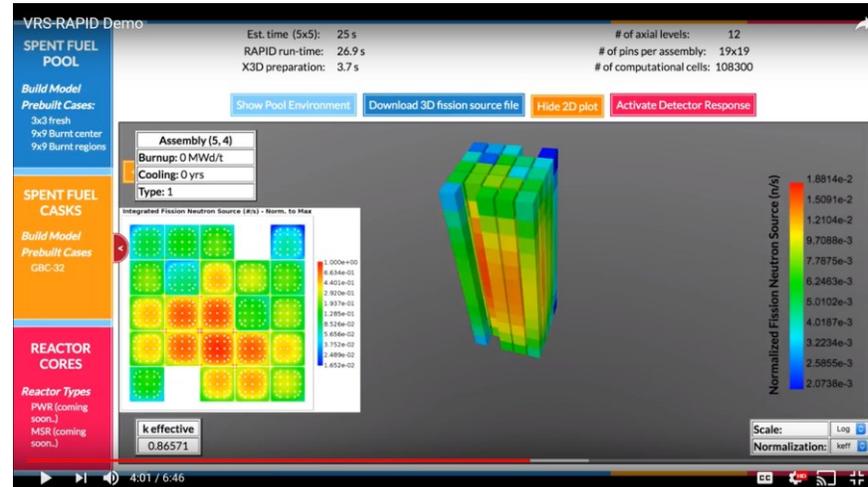


Nikita Sharakhov, **Nicholas Polys**, and Peter Sforza. (2013). “SpeedSpy: a mobile Web3D platform for visualizing broadband data”. In *Proceedings of the 18th International Conference on 3D Web Technology (Web3D '13)*. ACM, New York, NY, USA, pg. 208.



Online Vis + Sim Services

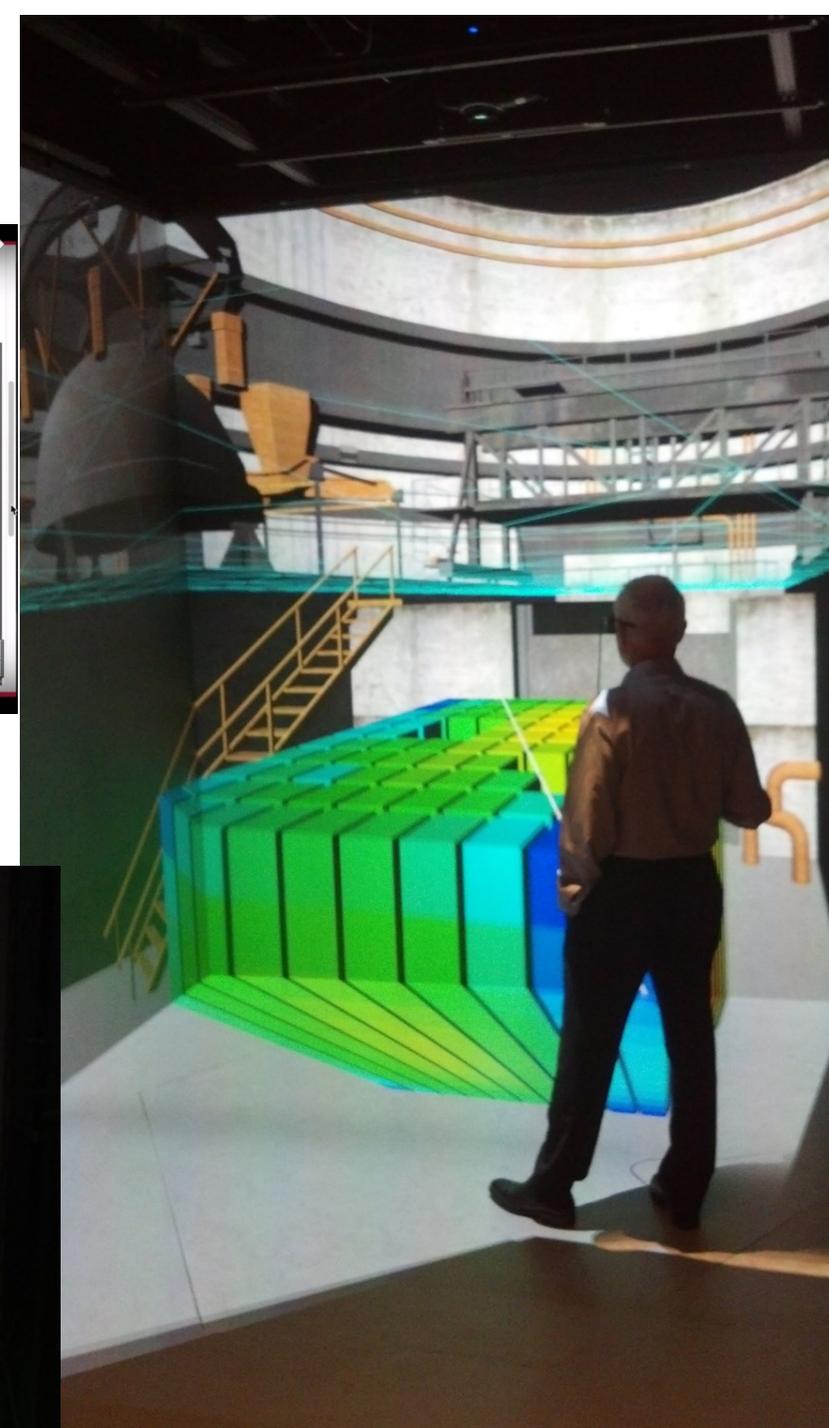
VRS - RAPID



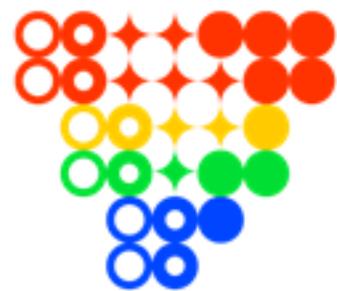
<https://www.youtube.com/watch?v=1Q2ytjBrmXc&t=1s>

Valerio Mascolino, Alireza Haghigat, **Nicholas Polys**, Nathan J. Roskoff, and Srijith Rajamohan. (2019). "A Collaborative Virtual Reality System (VRS) with X3D Visualization for RAPID". In *The 24th International Conference on 3D Web Technology (Web3D '19)*. ACM, New York, NY, USA, 1-8. DOI:

<https://doi.org/10.1145/3329714.3338135>

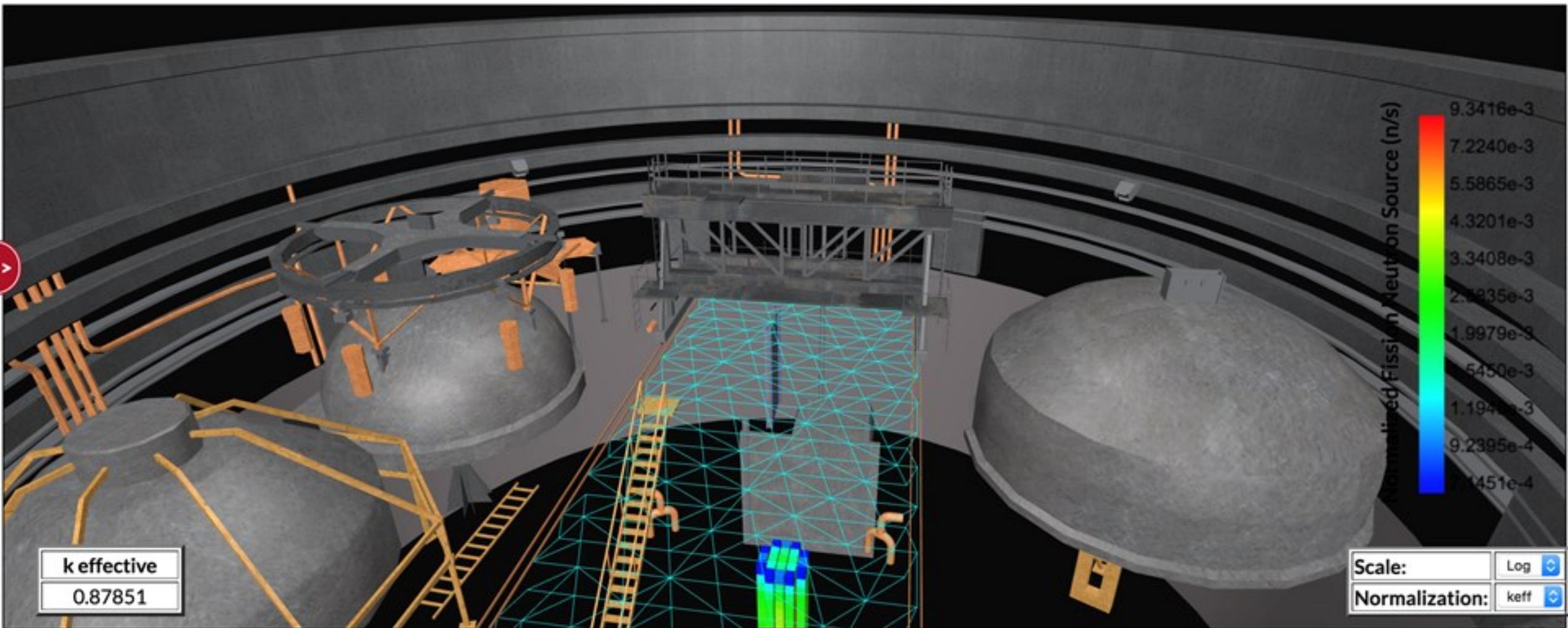


- **VRS-RAPID** is a collaborative, interactive, and 3D virtual-reality **web-application** for real-time simulation of nuclear systems
- Users connect to VRS-RAPID to collaborate **on modeling and simulation** of e.g., nuclear reactors
- Valuable tool for nuclear industry operators and regulators, educators and students, and continuing and professional training



VRS
Rapid





Going Immersive @ VT

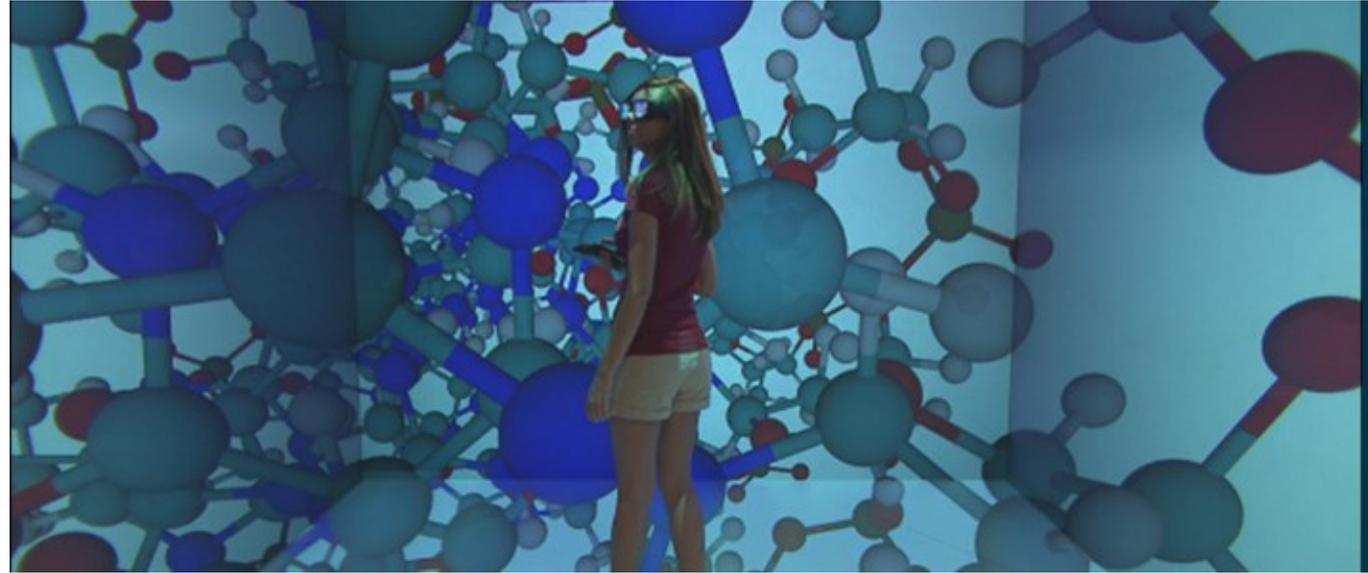
Instant Player Engine files:

- Stereo Windows and Screens
- 3DUI as Javascript

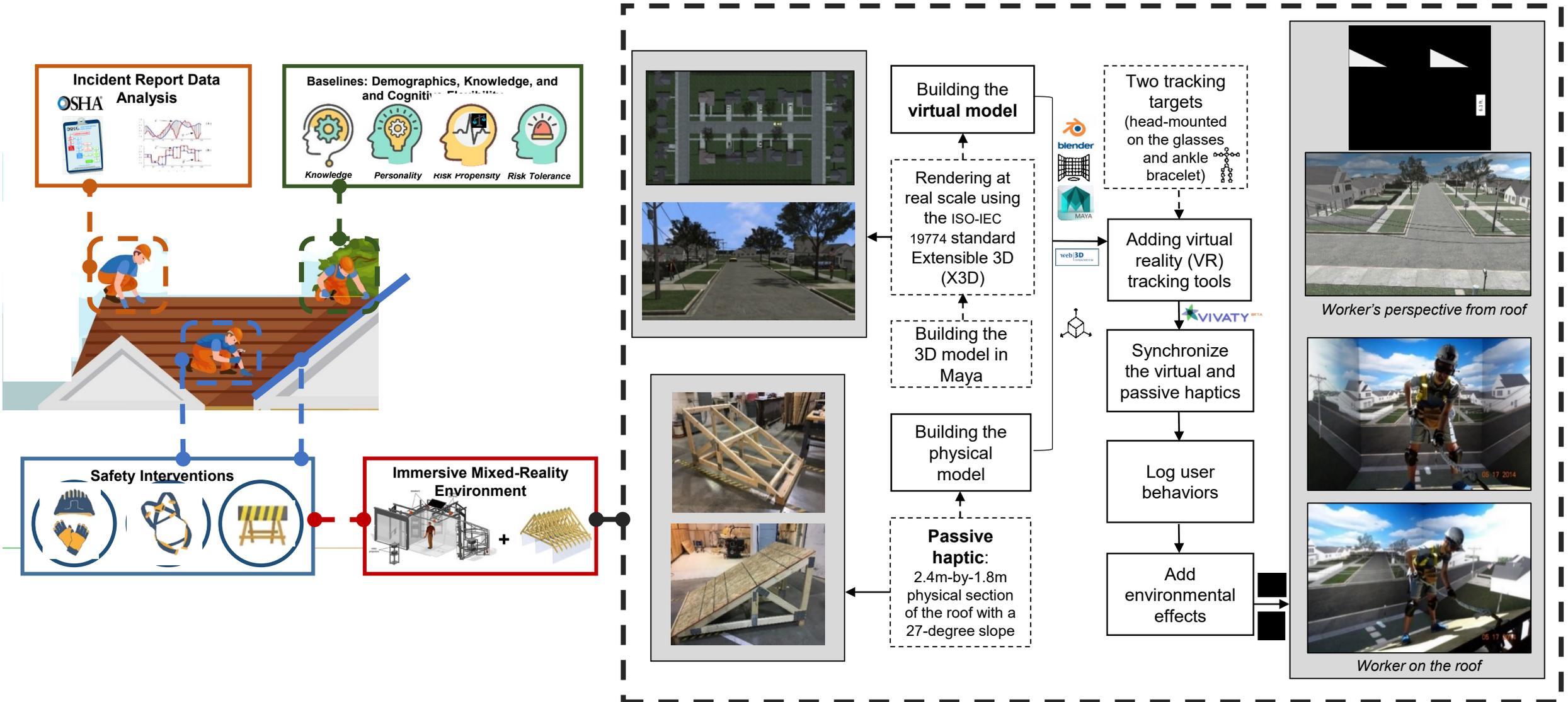
InstantIO components:

- ART head, wand data
- DTK/TrackD (Intersense)
- Navigator

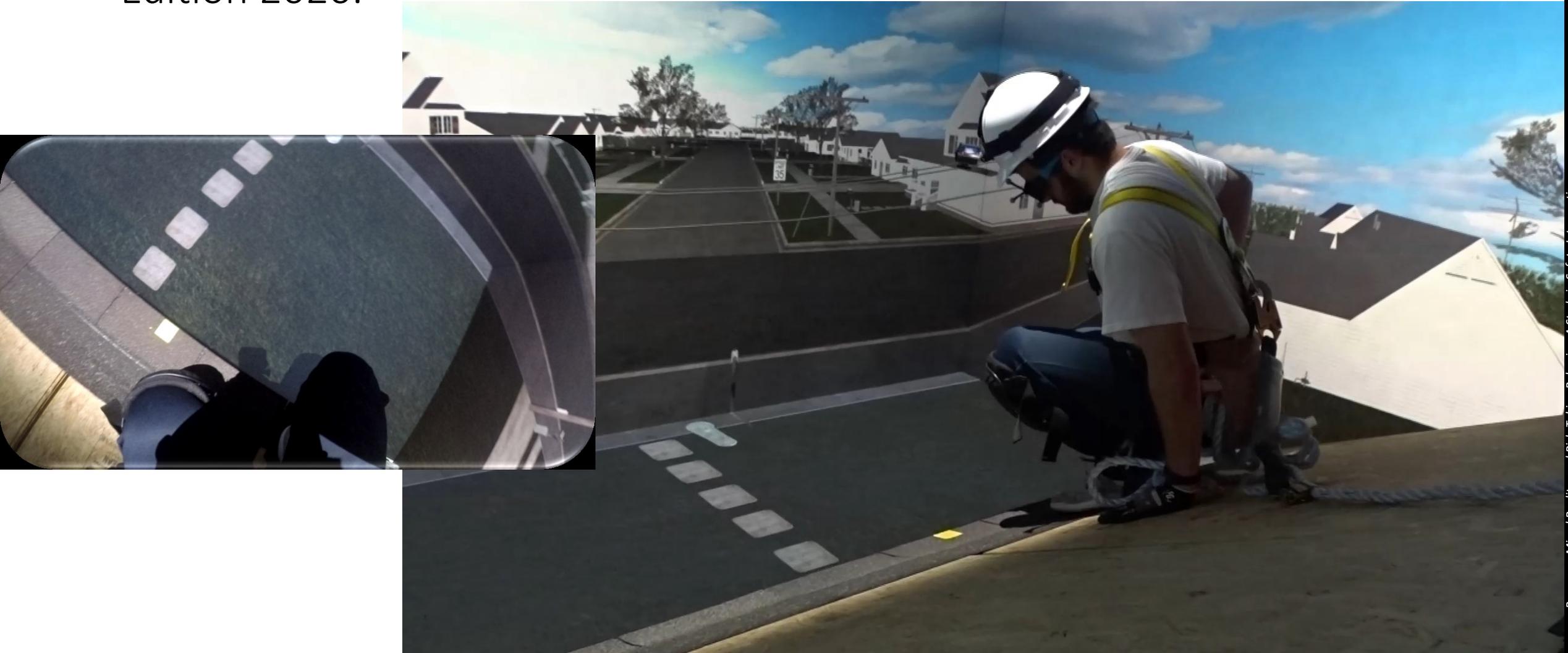
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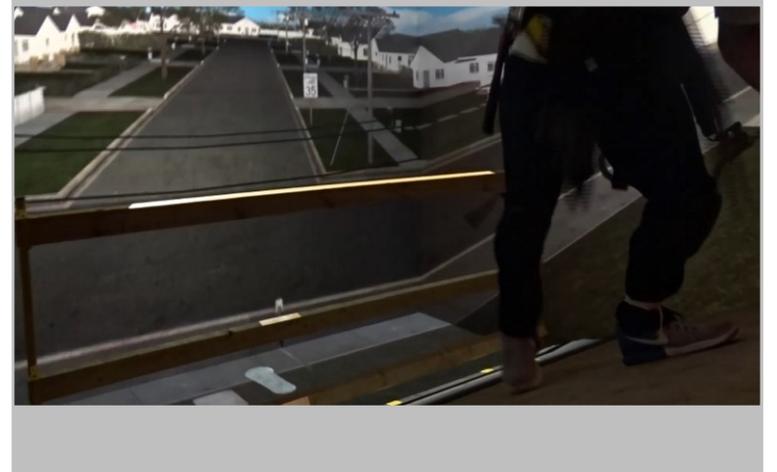
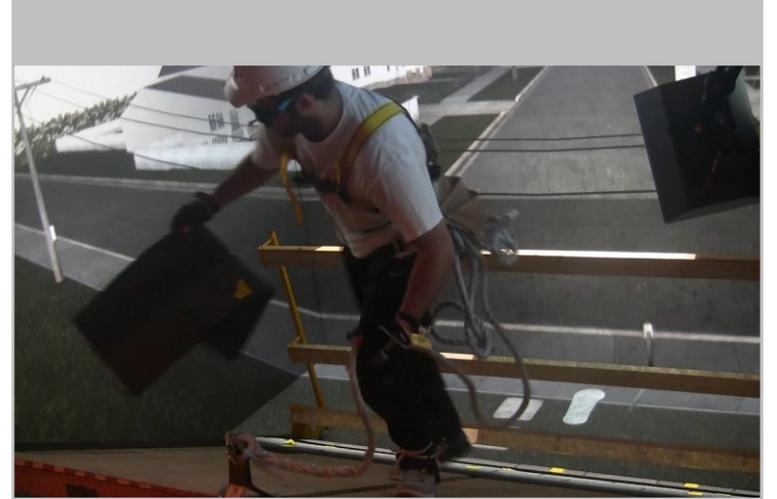
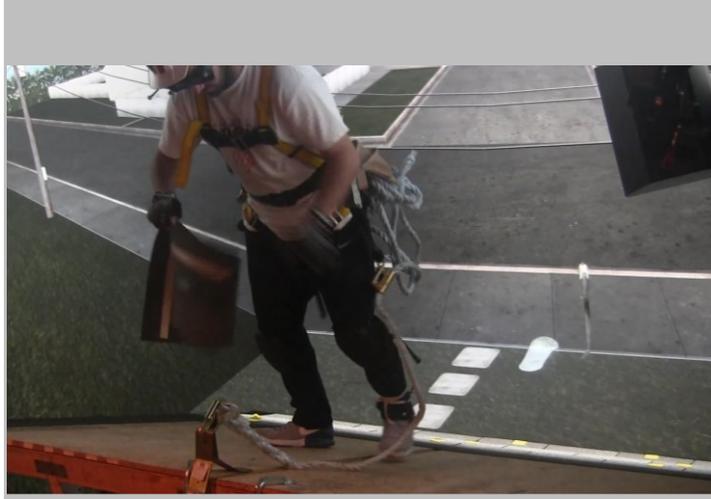
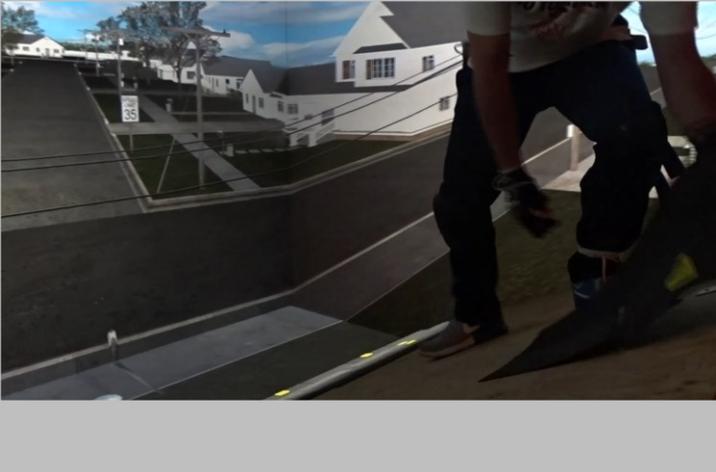


Experimental Design



Hasanzadeh, Sogand; **Polys, Nicholas**, et al (2020). “Presence, Mixed Reality, and Risk-Taking Behavior: A Study in Safety Interventions”. Transactions on Visualization and Computer Graphics. IEEE VR Journal Edition 2020.





Engage!

- Standards make it work!
- Members drive features and Standards
- Expert Community
- Early Access to specifications
- Outreach opportunities

www.Web3D.org