X3D Graphics Standard for World Wide Web Interoperability

Additive Manufacturing (AM) and Virtual Environments (VEs)

This X3D slideset has tons of detail!
Enjoy – at your leisure. ☺

Today's goal: quick fly-by of recent development efforts, then get to **discussion our group's broad needs.**
All feedback welcome.

Don Brutzman
Naval Postgraduate School
brutzman@nps.edu

22 July 2016

Topics

- What is X3D?
  - Capabilities and opportunities
  - Navy business case
- Additive Manufacturing (AM)
  - 3D printing
  - 3D scanning
- Virtual Environments (VEs)
  - Interoperability among diverse technologies

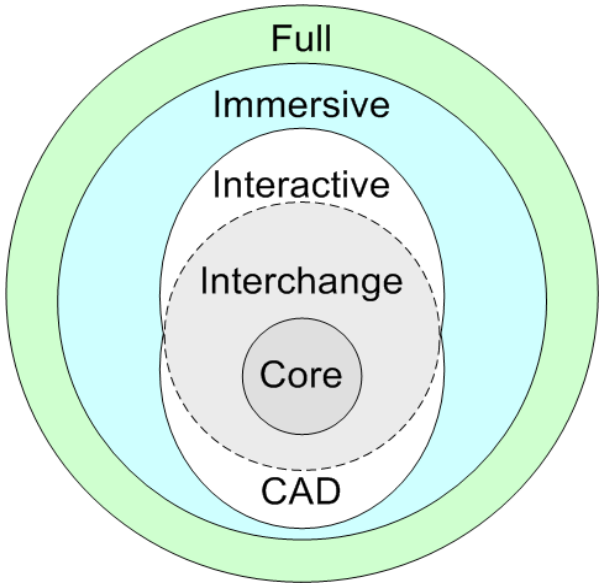
What is Extensible 3D (X3D) Graphics?

X3D is a royalty-free open-standard file format

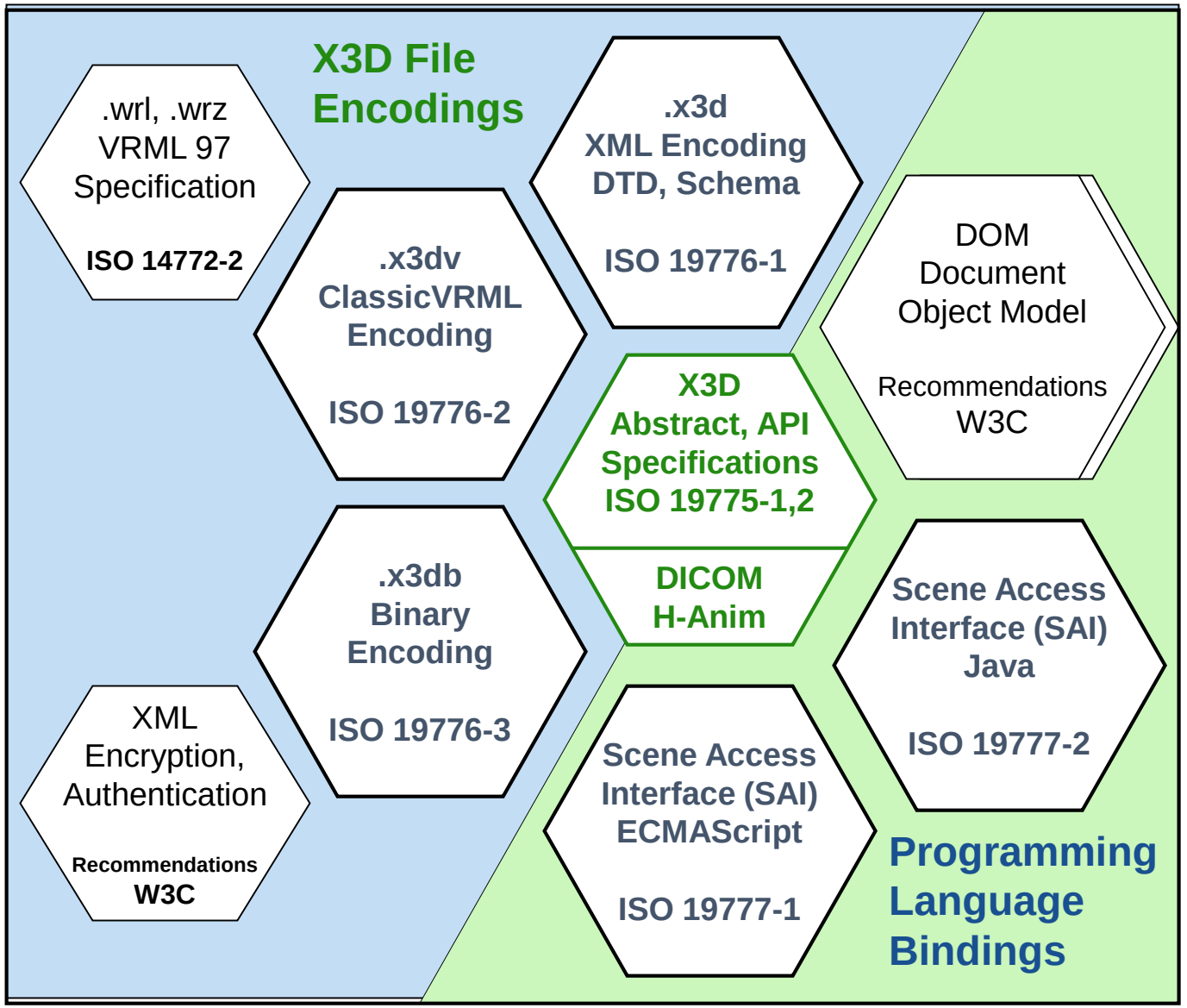
- Communicate animated 3D scenes using XML, in Web pages or separate
- Run-time architecture for consistent user interaction
- ISO-ratified standard for storage, retrieval and playback of real-time 3D graphics content
- Enables network communication of 3D data across applications, and provides archival publishing format for 3D models on the Web
- Rich set of componentized features for engineering and scientific visualization, CAD and architecture, medical visualization, training and simulation, multimedia, entertainment, education, and more

Multiple encodings, common basis

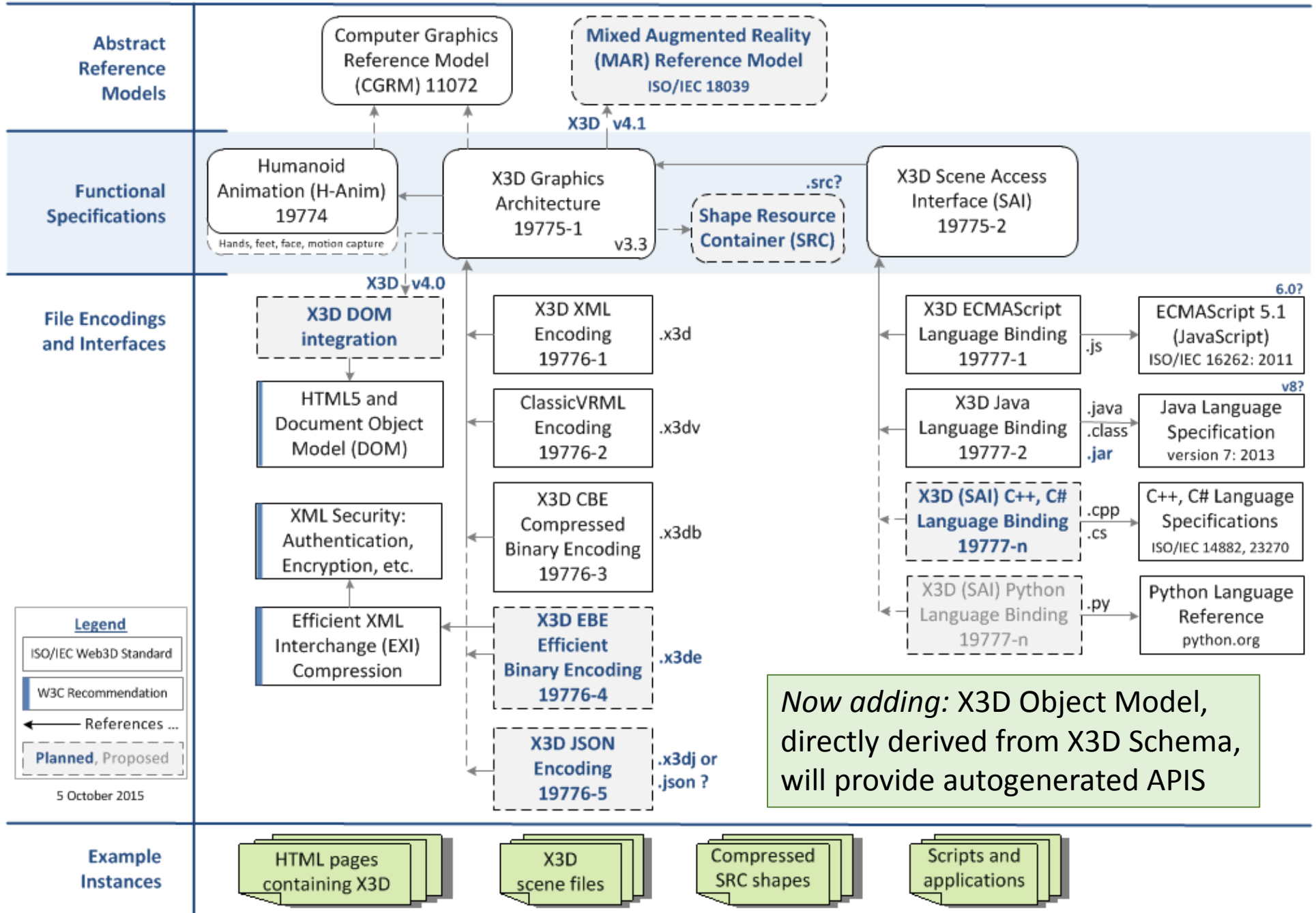
Family of standards for X3D on the Web



Composable and adaptable structures to simplify extensions and special use cases



X3D Graphics Standards: Specification Relationships



Web3D Consortium www.web3D.org

- Web3D Consortium founded in 1998 to protect, support and advance the Virtual Reality Modeling Language (VRML) specification

Continued efforts on new technology by multiple working groups led its successor, Extensible 3D (X3D) Graphics International Standard

Non-profit organization ensures that X3D remains royalty free, relevant

- Partnership of industry, agency, academic and professional members
- Many stakeholders with archival stability and “staying power”

Liaison relationships with key standards organizations worldwide

Web3D process: proven path for success

- Community Groups
  - Collectively explore topic, report best practices

X3D Working Group + Specialty Working Groups

- Define goals, requirements, use cases
- Build examples, implement, evaluate effectiveness
- Two X3D players, X3D authoring, example scenes
- Use wiki, then write draft specification prose
- Web3D members and board of directors approve

International Organization for Standardisation (ISO)

- In-depth review, voting, approval, publication

Interoperability - what's the difference?

Multiple paths, but often confused as equal

- *Standard:* proven process for content interoperability, scalability, compatibility, licensing, growth, success
- *Specification:* Algorithm descriptions, necessary detail
  - But: might hide royalty problems, such as GIF imagery debacle in 1990s

Open source software: pile of (maybe repeatable) code

- But: usage licensing is not same as source-code licensing

Market share dominance: biggest competitor wins?

- Companies (or at least investors) hope to "own" 3D
- But: many defunct companies, dead-end technologies
- Everyone ends up with much smaller market than the Web

Intellectual property rights (IPR)

- Web3D and W3C have similar policies
- Any known patented technology must be declared by members prior to consideration in safe haven of working groups
- Any patented technology contributions must be licensed on a royalty-free (RF) basis for inclusion in an openly used Web standard http://www.web3d.org/membership

Caveat: any legal problem can be solved, but only in advance!

X3D is inoculated against patent problems

How Important is Stability?

- 3D graphics authors create wonderful content, but it tends to "time out" and break after 2-3 years, simply becoming no longer usable due to software changes, company acquisitions/shutdowns, etc.
- Creating quality 3D content is expensive, both in time and software costs
- Something just as expensive: recreating that same 3D content when the underlying commercial technology no longer works
- Especially true for Navy with much longer life cycles than industry. We must be smart about our requirements and purchasing power.

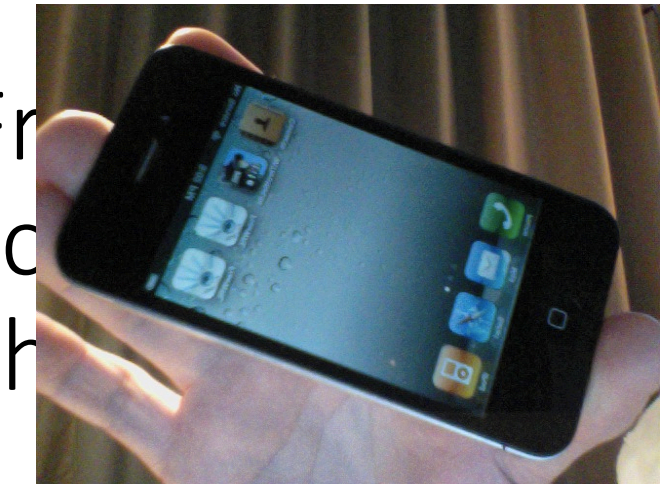
Mixed Augmented Reality (MAR)

X3DOM player, Google Cardboard

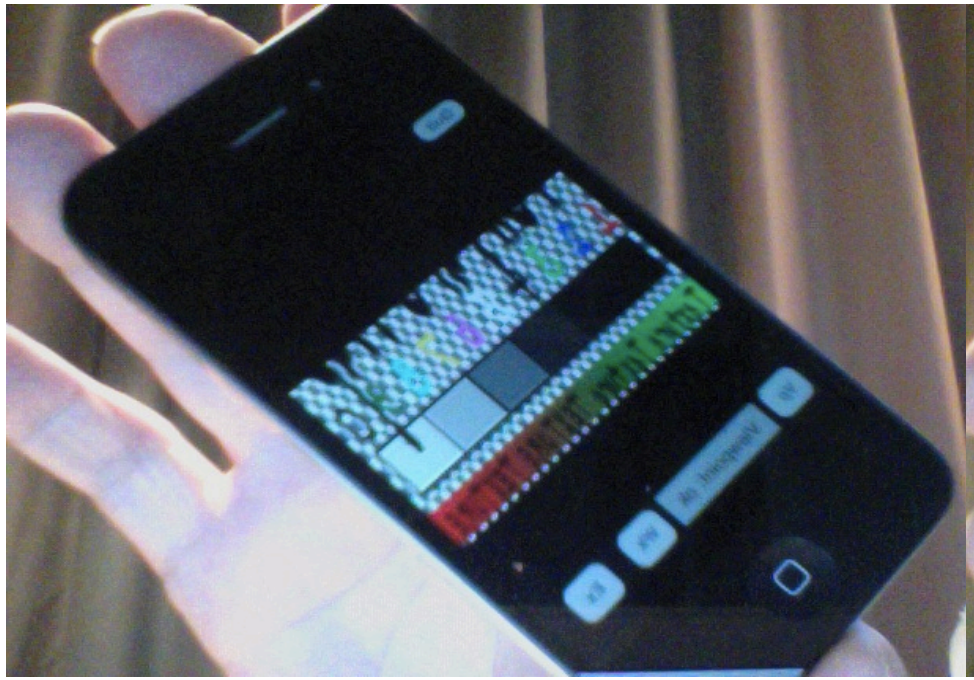
ISO Mixed Augmented Reality (MAR) Reference Model

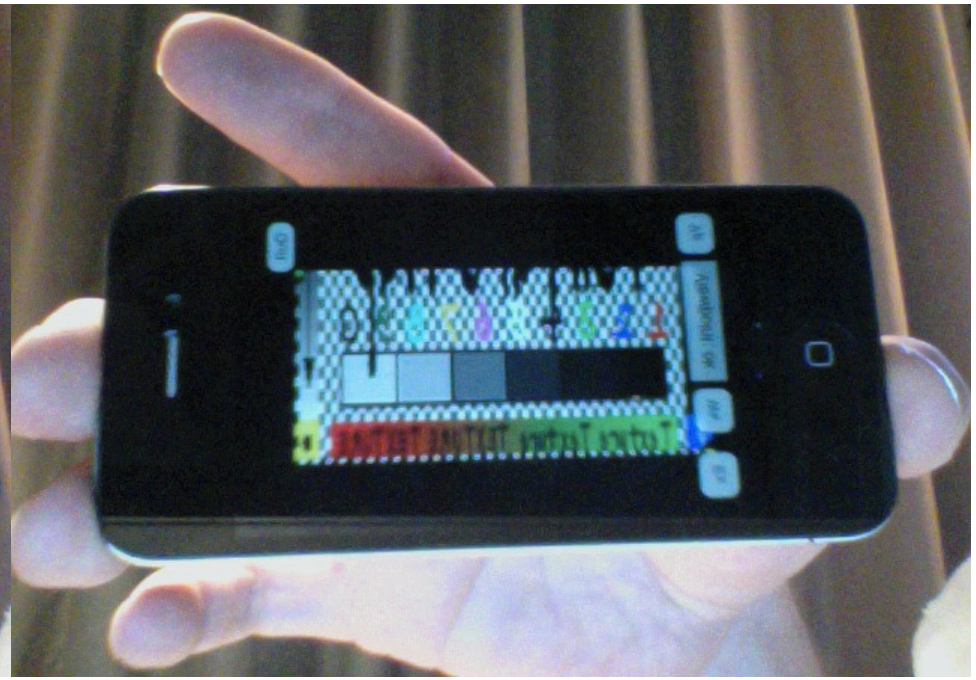
- Collaborative joint ad hoc group (JAHG) between ISO SC24, 29
- Describes common terminology, use cases, baseline technologies, and architectural commonalities for all MAR applications
- X3D version 4.0 is aligning, then X3D version 4.1 will adopt

Fr
so
sh



http://freewrl.sourceforge.net





X3DOM.org implementation

- Open Source
- Javascript / WebGL based
- Needs Firefox/WebKit nightly builds
- Runs without any plugin
- Can be easily modified while evolving
- Needs XHTML encoded data
- One line script per XHTML

Also runs on Apple Safari and Google Chrome
current developmental browsers supporting WebGL

Single file, no plugin

HTML5

X3D

HTML5

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Stric
    "http://www.w3.org/TR/xhtml1/DTD/xhtml1-strict.d
<html xmlns="http://www.w3.org/1999/xhtml">
    <head>
        <meta http-equiv="Content-Type" content="te
        <title>Simple attribute update</title>
        <style>          p.case { clear: both; border-to
        </style>
    <link rel="stylesheet" type="text/css" href="x3dom.
    </head>

<body>
  <h1>Simple attribute update</h1>

    <p class="case">
        <X3D xmlns="http://www.web3d.org/specificat
showStat="false" showLog="false" x="0px" y="0px" wid
height="400px" altImg="helloX3D-alt.png">
      <Scene>
        <Viewpoint position='0 0 10' />
        <Shape>
          <Appearance>
            <Material diffuseColor='1 0 0.5' />
          </Appearance>
          <Box DEF='box'/>
        </Shape>
      </Scene>
    </X3D>
    </p>

    <script type="text/javascript"><![CDATA[

    var solid = true;
    function toggleRendering()
    {
        var button = document.getElementById("color

        solid = !solid;

        if (solid)
            button.value = "Blue";
        else
            button.value = "Red";

        var mat = document.getElementsByTagName("
        var i = 0, n = mat.length;

        var aMat = mat[0];
        aMat.setAttribute("diffuseColor", (!solid ? "0 0
```

about

X3DOM (pronounced X-Freedom) is an experimental open source runt
support the ongoing discussion in the Web3D and W3C communitie
an integration of HTML5 and declarative 3D content could look like. It
fulfill the current HTML5 specification for declarative 3D content and
including X3D elements as part of any HTML5 DOM tree.

The goal here is to have a live X3D scene in your HTML DOM, which
you to manipulate the 3D content by only adding/ removing or changin
elements. No specific plugin or plugin interface (like SAI) are needed.
supports some of the HTML events (like "onclick") on 3D objects. The
integration model is still evolving and open for discussions.

We hope to trigger a process similar to how the SVG in HTML5 inte
evolved:

- Provide a vision and runtime today to experiment with and furth
develop an integration model for declarative 3D in HTML5
- Get the discussion in the HTML5 and X3D communites going and
the system and integration model
- Finally it would be part of the HTML5 standard and supported by
major browser natively

More architectural and background information can be found
X3DOM-paper (published at the Web3D symposium 2009).

Alternatively you, as web-developer, can also just utilize the system to
build web-pages and applications, which include declarative (X)3D
that will be rendered hardware accelerated (thanks to WebGL) with
need for using any plugin.

X3DOM oil rig

Browser plugins no longer required
Applications can also re-use models

Cobweb X3D Browser

Cobweb is an X3D Browser entirely written in JavaScript and uses WebGL for 3D rendering. Authors can publish X3D source within an HTML5 page that works with Web browsers **without** prior plugin installation.

Please note: For now Cobweb only runs in fresh installs of Firefox as Cobweb uses functions from the upcoming JavaScript 6 standard and this standard is currently only supported by Firefox either on your desktop computer or on your modern smartphone.

Examples

Chomp!
Smashing Boxes
The Secret Labyrinth
Backyard Soccer
Astronomy
Arcadia
4 Pong
Foldup
Mediafacade Berlin
Lust For Life
Lost Cathedral
Huey Huey
Approach
Terrain
Old Leipzig Rathaus
Magic Mushrooms
Treasure Island
World Trade Center
Helicopter Simulation

Random World

>> Next Page

Toggle Fullscreen

Cobweb 1.19

WebGL X3D Browser

Something special, something more!

On this page

Additive Manufacturing (AM), 3D Printing and 3D Scanning

Interoperability with X3D

Common Basis

- 3D software companies often utilize proprietary formats to provide special features which may change over time
- This also tends to “lock in” customers with a particular product line
- Meanwhile 3D hardware has many common-denominator capabilities

- X3D is based on 3D scene graph concepts, which are well established and good match for structure of Web pages and declarative models
- X3D has patterned user interaction in ways that match HTML pages
- Many import/exportxconverters make X3D good for interoperability

X3D CAD Working Group

X3D CAD Working Group is now in third generation development effort. We are developing and demonstrating best practices for exporting any CAD model to X3D for Web applications.

The X3D CAD Working Group develops and demonstrates best practices for exporting Computer-Aided Design (CAD) models into X3D to support Web applications.

Computer Aided Design (CAD)

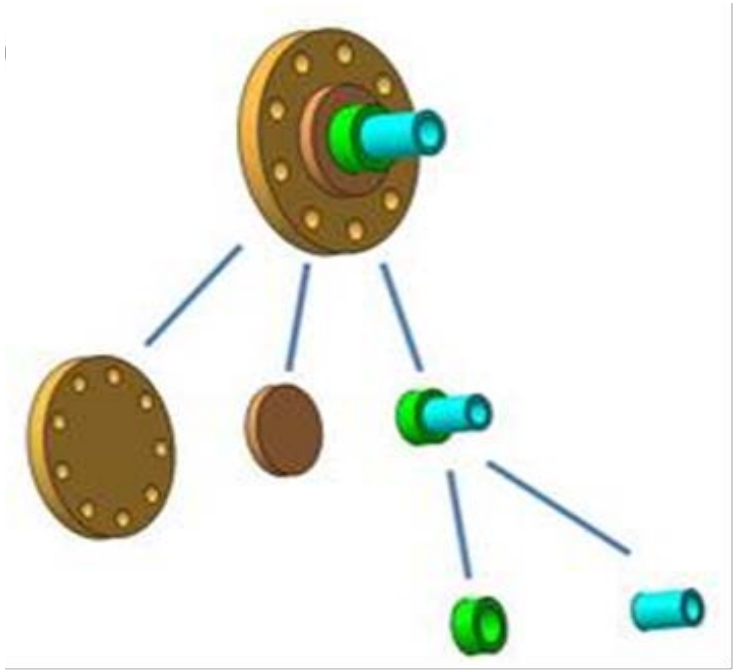
The X3D CAD Working Group develops and demonstrates best practices for exporting Computer-Aided Design (CAD) models into X3D to support Web applications.

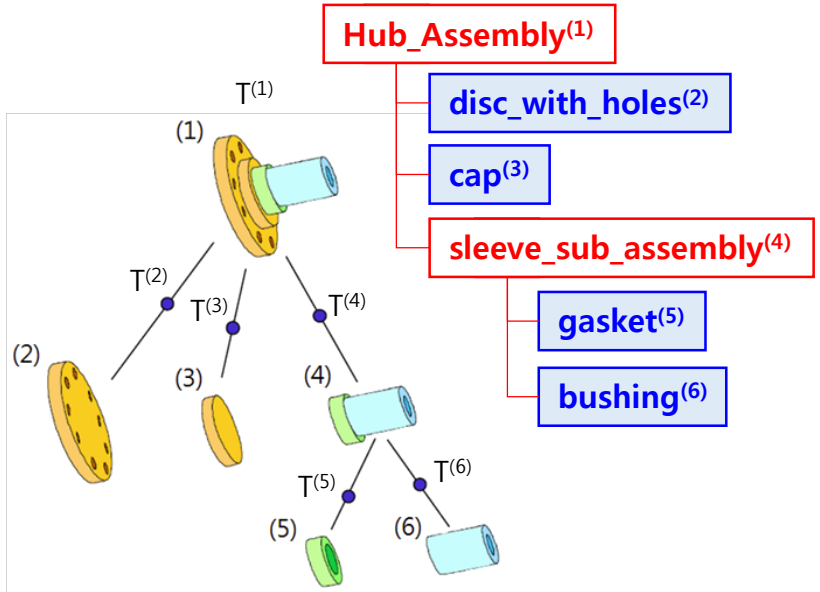
Billions of dollars are invested in CAD and technical product information. But 3D data created with CAD applications, is difficult to share with other users across the enterprise. Integrating 3D data, such as CAD engineering files, into other applications for sales & marketing or training is time consuming and difficult.

The open standards X3D CAD initiative lets customers access and repurpose complex 3D and technical data and seamlessly integrate it into other common desktop applications across the enterprise. Professionals outside of CAD and engineering will be able to access this graphical data, including animation, materials and textures, to increase productivity, cut costs and generate new revenue streams. This increases the value of the CAD data and reduces costs in other areas. Applications include customer visualization, design communication, training, technical documentation, sales and marketing, and customer support.

The CAD3D Working Group has a defined a file format and data transfer process. The format, CAD Distillation Format (CDF), enables translation of CAD data to an open format for publishing and interactive media. The process includes an open framework pipeline that incorporates tools for decimation of surfaces to constructs that are more common in the non-CAD environments.

Hub Assembly Product Structure in X3D





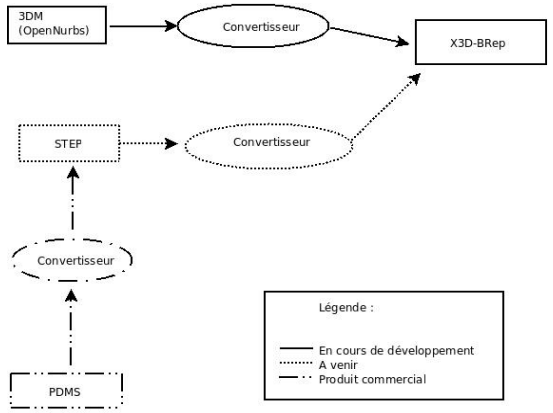
CATIA* Hub Assembly
(6 Files)

* CATIA : Dassault Systemes' CAD/CAM/CAE commercial solution, http://www.3ds.com/products-services/catia/

CAD export to X3D for interoperability

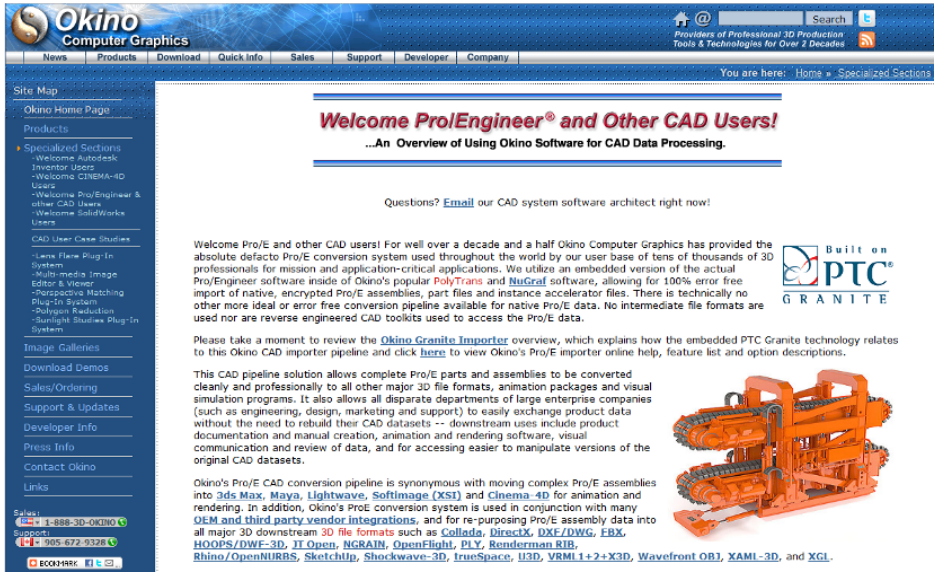
Tool support continues to grow

- Kshell
- PartDB
- Xj3D, X3D-Edit
- Okino Polytrans
- CAD Exchanger
- X3D Resources Conversions and Translation Tools maintained online



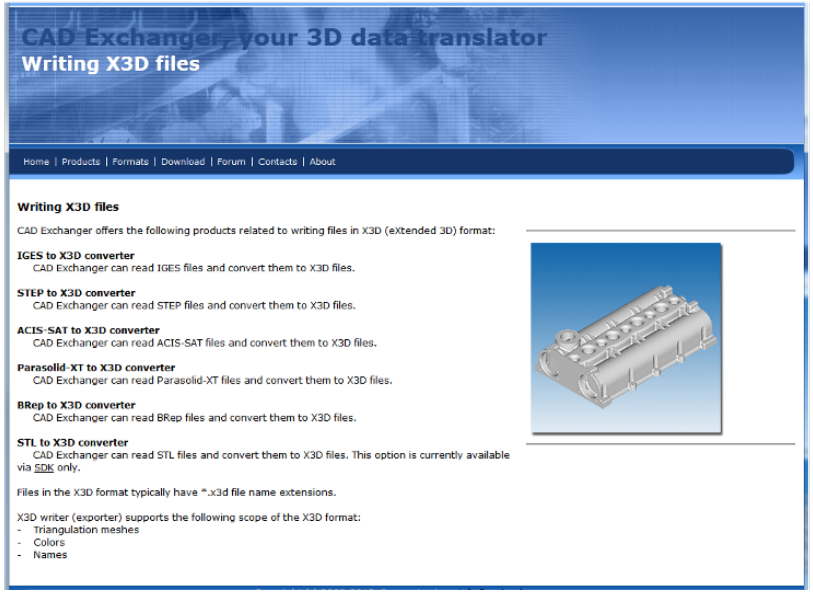
Okino Polytrans converter

http://www.okino.com



CAD Exchanger

http://www.cadexchanger.com



X3D archival considerations

X3D scenes can embed strongly typed metadata

- Metadata strategies analogous to video, cinema efforts can be similarly established, pursued

X3D specification has maintained backwards and forwards compatibility through 5 generations!

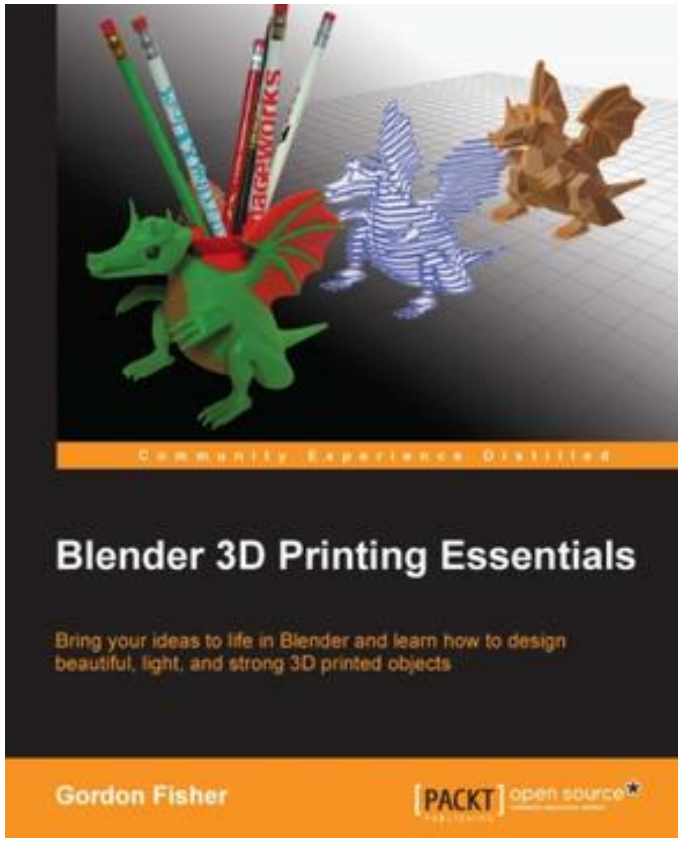
- VRML97, X3D v3.0, 3.1, 3.2, 3.3
- Going forward on 4.0 and efficient compression updates

We are steadily meeting all our stated goals, evolving and not breaking this proven architecture. Thus investments are fully protected & stable.

Emerging Recognition of 3D Print Potential

Book: *Blender 3D Printing Essentials*

by Gordon Fisher, PACKT press, 2015



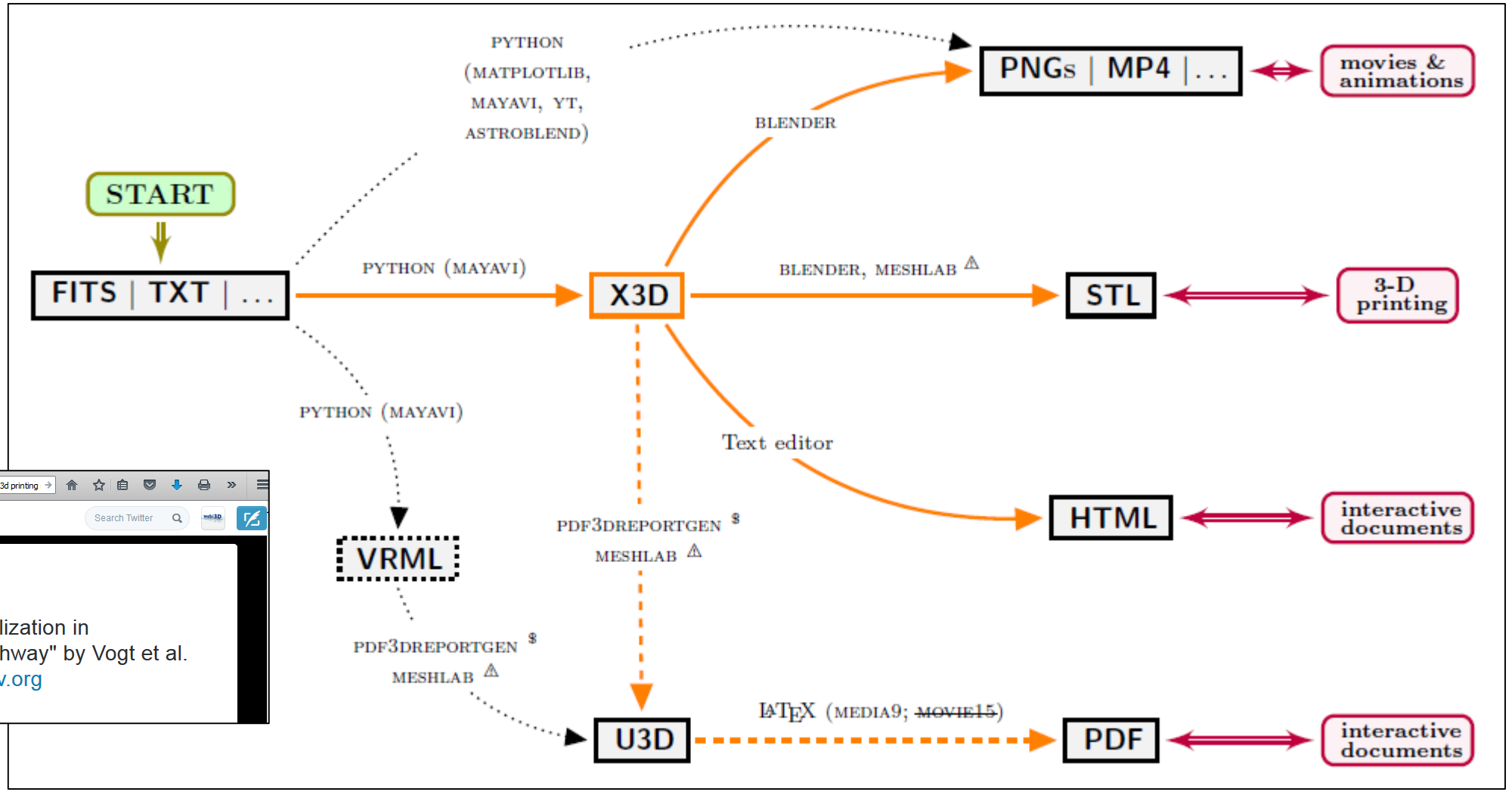
Exporting your 3D object

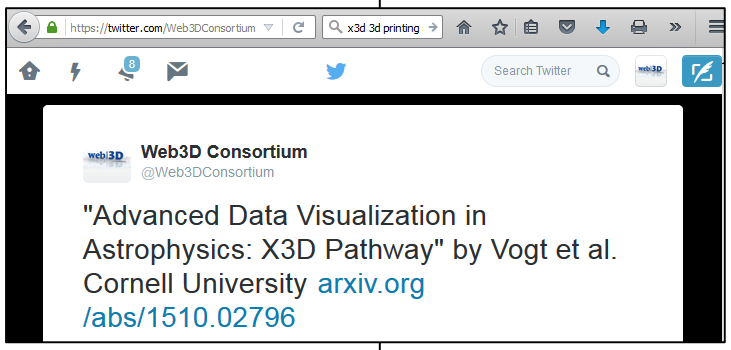
There are two kinds of files for exporting Blender objects to be printed in 3D; STL files and X3D files.

A few 3D printer companies offer plugins that export Blender files to their website as well. STL files do not carry any color information. Your color comes from the color material that is chosen as I mentioned in Chapter 1, *Designing Objects for 3D Printing*. The pencil cup is an example of this. No material was ever specified. It takes its red color from the plastic chosen for printing.

X3D files are really interactive 3D file formats; they carry color information and 3D printing bureaus accept them for printing.

Journal paper: X3D central to 3D printing





X3D Profile for 3D Printing and Scanning

- New work by Web3D Consortium has commenced
  - Initial drafting stage, now determining requirements
  - Today's workshop, X3D Profile 3D Printing and Scanning
- Recognize 3D printers are a "vertical" capability domain of end users, tool developers, hardware systems, workflows
- Recognition that 3D scanning is a rapidly emerging complement with overlapping technical requirements
- How big an overlap?
  - 3D printing is *bits into atoms*
  - 3D scanning is *atoms into bits*

X3D Compressed Binary Encoding (CBE) 2007

Combination of technologies

- XML canonicalization (C14N) format, allows consistent security through digital signature and encryption
- Fast Infoset (FI) data compression of XML documents
- Java3D geometry compression to eliminate 3D redundancies and further reduce file size

Efficient Binary Encoding: 2016 update

Combination of updated technologies

- Efficient XML Interchange (EXI) W3C Recommendation for even smaller, faster data compression – always meets/beats gzip, zip
- Fraunhofer Shape Resource Container (SRC) for exceptionally smaller, faster geometric compression.
- Retained full compatibility with XML Security
- Royalty free (RF) for any use
- Full round-trip support for any X3D model

THE MOVES INSTITUTE
NAVAL POSTGRADUATE SCHOOL
LT Sheldon L. Snyder

EFFICIENT XML INTERCHANGE (EXI) COMPRESSION AND PERFORMANCE BENEFITS: DEVELOPMENT, IMPLEMENTATION AND EVALUATION

<MOTIVATION>

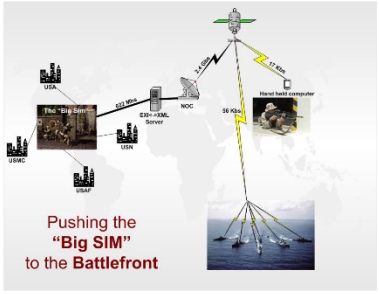
Compact & Efficient XML

Better Compression than other Techniques with Binary Data Binding

http:// http://exificient.sourceforge.net/

Bandwidth Maximization / Deepening The Web

Extends XML use to Low-bandwidth, High- Volume Domains



Standardization and Interoperability

World Wide Web Consortium Member Created

"Best of Breed Solution"

W3C Ubiquitous Web domain

Application To DoD

- DoD is Heavily Invested in XML
- DoD Files are often Numerically Intensive
- DoD Files are often Very Large
- Next Generation of Devices Supported
- DoD Tactical Networks are Bandwidth Limited

<PROBLEM STATEMENT>

Network Edge Devices Unable To Process Native XML Format (Battery, CPU, Bandwidth)

- XML is VERBOSE
- XML is Text Only = Computationally Expensive
  - String to Numeric Conversions
  - Memory Intensive
  - Power Demanding

Net-Centric Warfare Requires XML

- Every Sailor and Soldier is a Sensor (Low Bandwidth mobile edge)
- System of Systems Interoperability (the DoD Information Warfare vision)

Why Not GZip

- Because it Doesn't Address Processing Efficiencies
- Better Compression can be Achieved for XML

<SOLUTION>

Standardized Compact And Efficient Binary Xml Format: Efficient XML Interchange (EXI)

- Both commercial and open-source implementations available

efficient XML

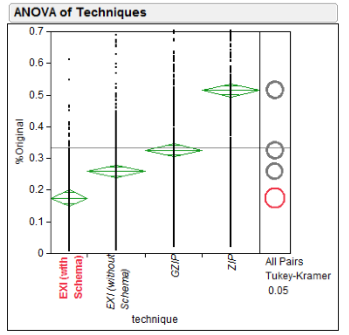
http://www.agiledelta.com/product_efx.html

W3C Endorsed

- Up to Hundreds of Times Smaller, Faster than Native XML
- 100% Compatible with XML, Including Schema-based, Free Form or Multiple-Namespace Hybrid XML

<CONCLUSIONS>

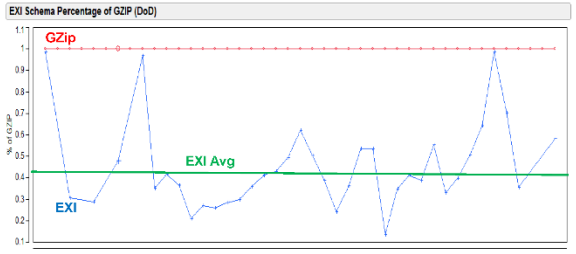
EXI Deliver Statistically Significant XML Improvements



773 XML examples compared in the W3C EXI Test Corpus hosted at NPS

Analysis of Common Compression Techniques at 95% alpha factor
EXI (schema and schemaless) deliver statistically smaller files

EXI has DoD Specific Expectation of Doubling Bandwidth Potential



EXI compared to GZip (standard compression) in the long run average is 42% of GZip = 116% increase in bandwidth potential for DoD

Passes The Litmus Test Of Technology Development

- **More -** Deeper network penetration with all the benefits of XML
- **Better** – Usage with what you already have transparently
- **Faster** – Information exchange

<!-- FURTHER INFORMATION -->

Contacts:
Don Brutzman, brutzman@nps.navy.mil, 831.656.2149
Sheldon L. Snyder, slsnyder@nps.edu

Data-centric security

- Files that include metadata and digital signatures can
  - Record and observe restrictions on usage of proprietary contracted models
  - Allow fleet forces to ensure they have latest/greatest/approved versions
- Files that can be digitally signed, encrypted and compressed can be transported securely over any digital channel
- Opportunity to both utilize, decouple from network-specific requirements
- Powerful business model is possible for Navy
- Ideas emerged in Additive Manufacturing (AM) and Data Dilemma (dd) MMOWGLI crowd-sourcing games
  - Trusting Software and Trusting Data, Don Brutzman, 12 April 2015

Many new use cases expected

- 3D models for operations, training, watch standing, maintenance, repair
  - Many variations possible, they will occur rapidly once in the hands of the fleet
- Part repair scenario
  - Bearing collar breaks on feed pump while at sea
  - Partial engine-room shutdown, retrieve part, determine breakage mode
  - Intermediate maintenance activity sends printable 3D model to check
  - Ship's force prints, fits, adjusts, rescans modified part, sends bits back to IMA
  - IMA constructs corrected part from right material, ships or available on return
  - One or more ship days are saved
- Eventually enough ship days are saved to equal… a whole ship-year!

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

Virtual Environments (VEs)

Interoperability with X3D

Grand challenges are becoming actionable

- Numerous “walled gardens” that cannot share content or interoperate are counterproductive and not useful to Navy
- The key to gaining advantage is long-term stability and Web usage
- This is not a “highlander” approach that picks a single “winner” but rather an opportunity to take advantage of standards
  - Protecting investments
  - Building capabilities
  - Providing insight in real world
  - Allowing innovation to occur at any level
- Exemplars follow

Navy POAM for Naval Modeling + Simulation, Virtual & Simulated Environment Assessment (NVEA)

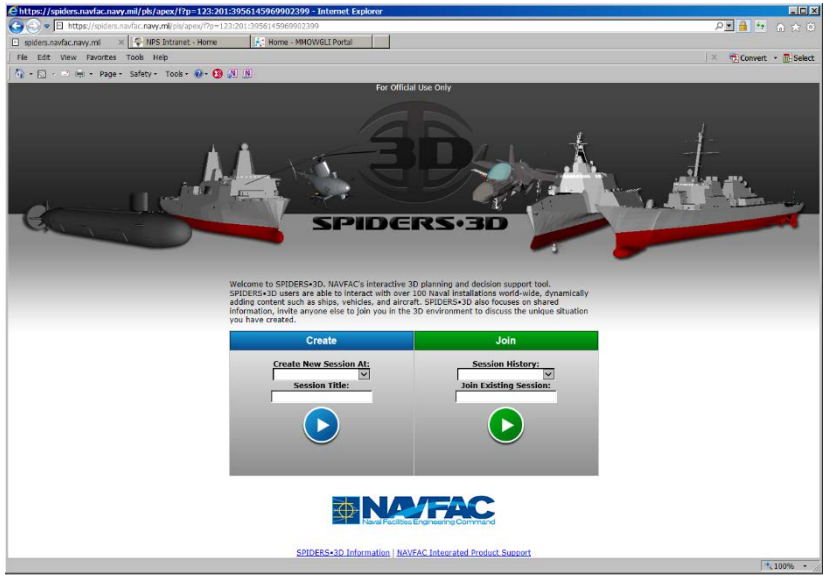
TASK NAME	DESCRIPTION
Identify VE use, value and identify gaps with existing capabilities **X3D Graphics Standard for Interoperability Using the Web**	○ Categorize types of VEs • Game Environments (GE) • Virtual World Environment (VW) • Live, Virtual, Constructive Environments (LVC) • Design & Development Environments (DDE) • Augmented Reality • Immersive First-Person • Through the window • Mirror world ○ Identify how Industry and PEOs are using Virtual Environments ○ Where and under what conditions Virtual Environments demonstrate value ○ Identify known VE limitations and gaps

Savage tool suite for faculty/student research

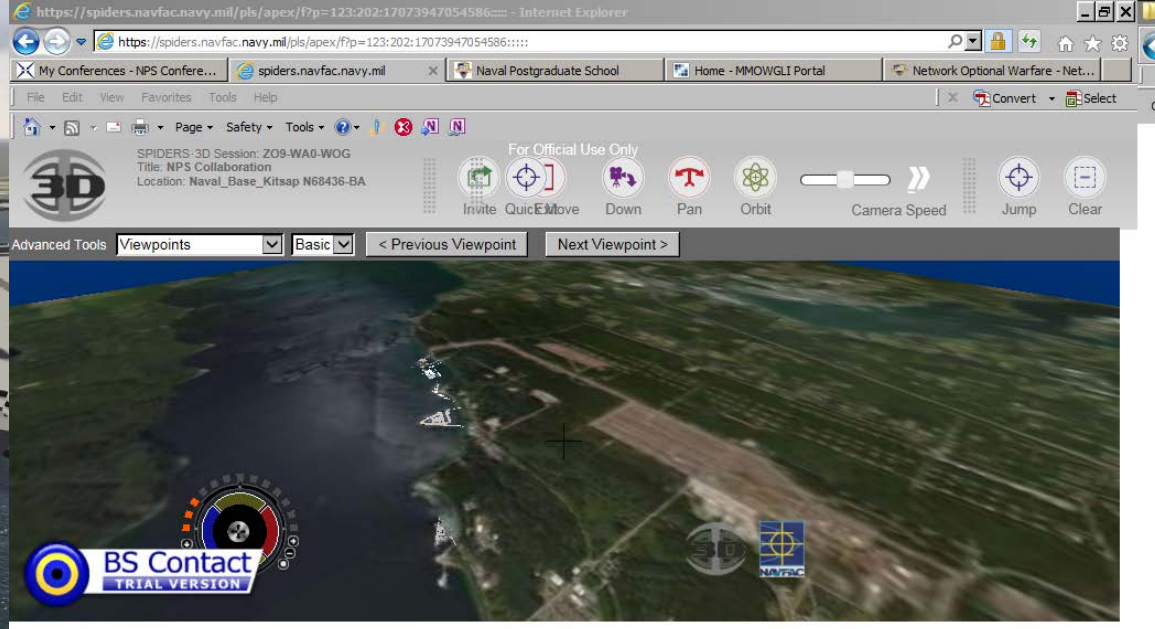
- Scenario Authoring and Visualization for Advanced Graphics Environments (SAVAGE) and SavageDefense (FOUO)
- Open-source software and models are all in version control
- Savage, SavageDefense X3D Models Archives
- X3D-Edit authoring tool, Xj3D player for X3D
- Viskit visual programming for Discrete Event Simulation (DES)
- Scenario Modeling and Analysis Language (SMAL) metadata scheme
- SavageStudio composition tool for DES-driven analytic 3D simulations

SPIDERS3D Virtual Environment

- Ports, piers, pilings for Navy ships world wide
- Diverse up-to-date databases exported to X3D in Web Browser
- Runnable on NMCI computers or open Internet, CAC card access
- Remote collaboration enabled among diverse individuals, locations
- Forerunner/exemplar of Web-based Navy VE
- X3D models are easily “mashed up” together




NAVFAC
SPIDERS

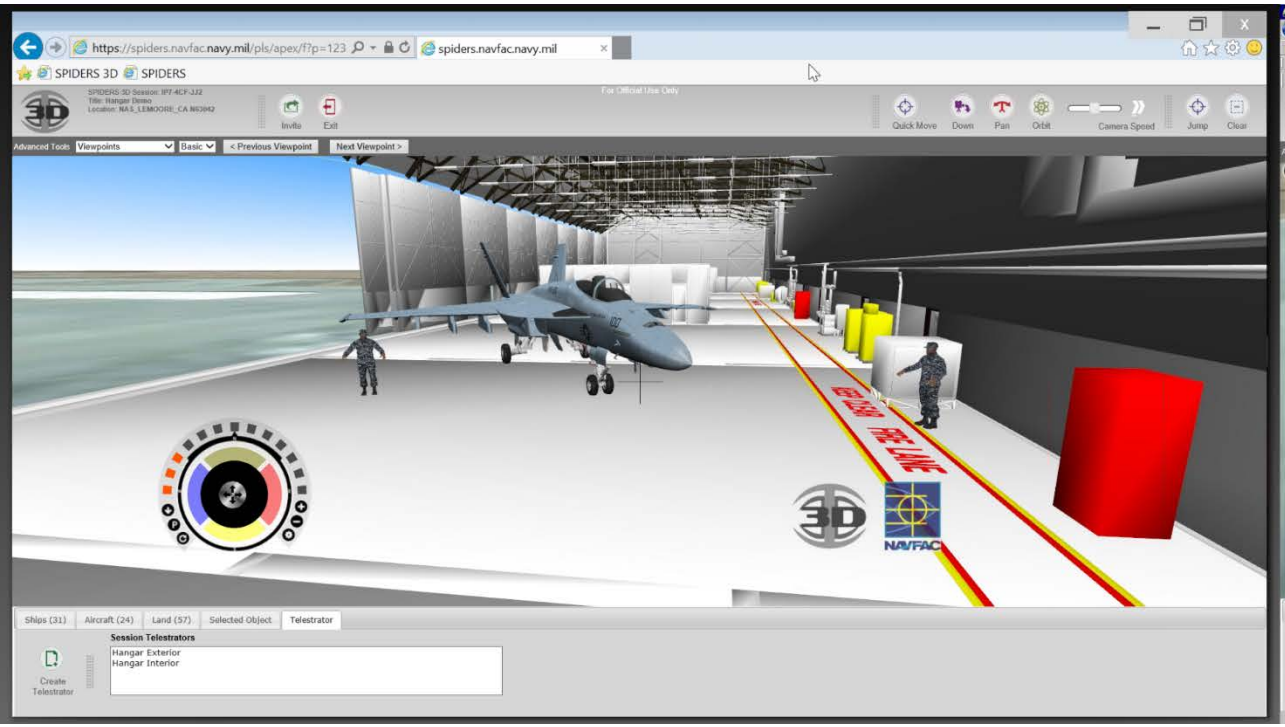

https://spiders.navfac.navy.mil/pls/apex/f?p=123:202:17073947054586:::: - Internet Explorer
https://spiders.navfac.navy.mil/pls/apex/f?p=123:202:17073947054586::::
My Conferences - NPS Confere...
spiders.navfac.navy.mil
Naval Postgraduate School
Home - MMOWGLI Portal
Network Optional Warfare - Net...
File Edit View Favorites Tools Help
Convert
Select
Page
Safety
Tools
SPIDERS 3D Session: ZO9-WA0-WOG
Title: NPS Collaboration
Location: Naval_Base_Kitsap N68436-BA
For Official Use Only
Invite
Quick Exit
Move
Down
Pan
Orbit
Camera Speed
Jump
Clear
Advanced Tools
Viewpoints
Basic
< Previous Viewpoint
Next Viewpoint >
BS Contact
TRIAL VERSION

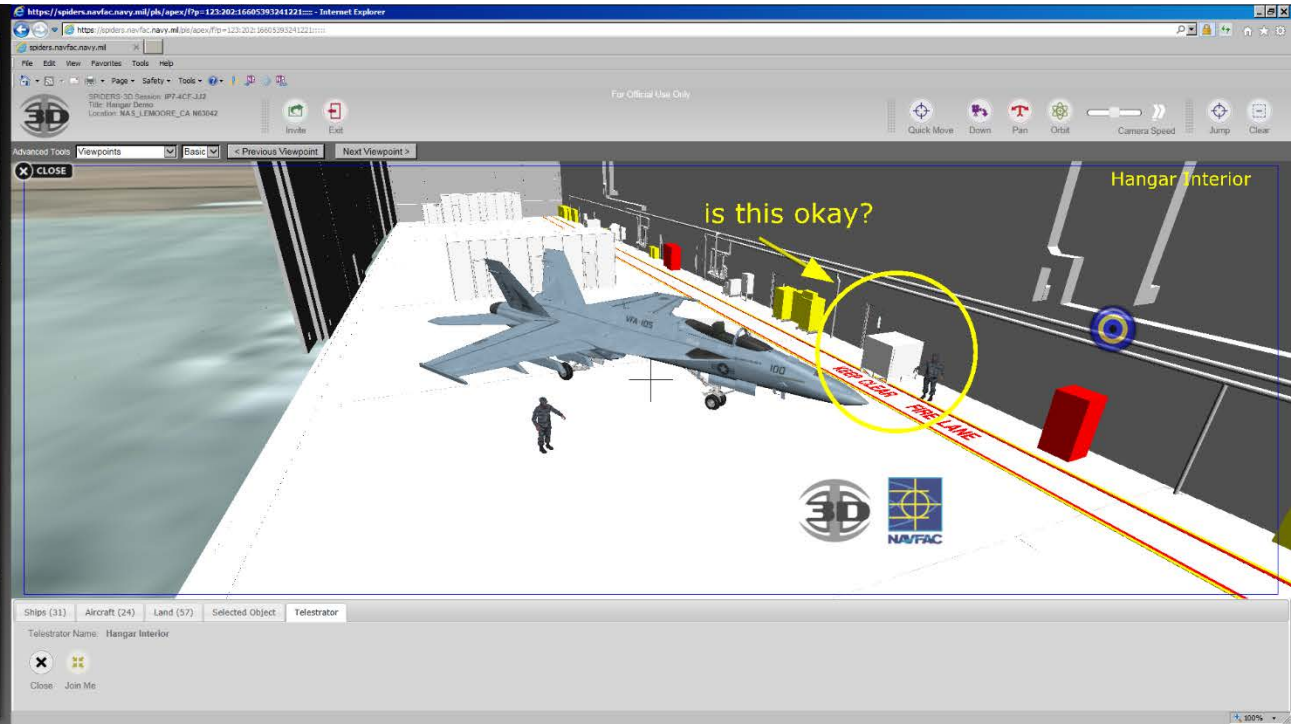

Ships (31)
Aircraft (24)
Land (57)
Selected Object
Telestrator
Quick Help
About Our Models
Previous
Next
(1) USS Nimitz (CVN-68)
(2) USS Gerald R. Ford (CVN-78)
(3) USS Gerald R. Ford (CVN-


Loading 67/68 resources
Title: NPS Collaboration
Location: Naval_Base_Kitsap N68436-BA
Camera: ..loading..
Elev: ..loading.. Head: ..loading..
Invite
Exit
Down
Pan
Orbit
Camera Speed
Jump
Clear
CLOSE
ALEX_VIANA No. 1 - Bangor Waterfront Overview
New EHW 2
EHW 1
Marginal Wharf
Delta Pier
Ships (29)
Aircraft (24)
Land (29)
Selected Object
Telestrator


DANGER
STAND OFF
1000 YARDS
Ammo Pier South

NAVAIR Hangar Redesign Virtual Walkthrough





Morning 16 DEC 2016: group visit to actual site, review effectiveness of virtual event

Manifesto: technical parallels for AM and VEs

- Interoperability through data exchange rather than software/hardware defining winners/losers,
- Compatibility among models that are shared for fleet needs, despite "walled gardens" of product suites and corporate functionality,
- Data integrity with respect to digital signature/encryption/intellectual property rights (IPR)/compression,
- Physical cybersecurity to ensure that produced models receive quality assurance (QA) and access control to avoid catastrophic failure,
- Navy requirements for use lasting across ship lifecycles rather than quarterly corporate reports,

Manifesto: technical parallels for AM and VEs

- Ability to collaborate and visualize 3D models "in the small" or "in the large" for people working together around the globe,
- Ability to improve training and compatibly integrate simulation for both preventative & corrective maintenance,
- Changing Ao operational availabilities through better coordination of harbor planning, fewer repair transits, and less in-port time,
- Ability to reduce deployment loadouts via changes in materials, just-in-time construction modes, and distributed virtual inventories,
- Ability to design and deploy smaller/different vessels and aircraft as the logistic chain refactors, Etc. etc. etc.

Why does Navy care? Building a business case.

- Navy buys lots of equipment, computers and software
- We need to utilize it for long life cycles
- Navy contracts need to allow of interchange interoperability
  - Which is much simpler than engineering reconstruction rigor
- Business case analysis (BCA) needed, both specific fleet scenarios and “in the large” for acquisition process.
- Best metrics for progress (A_o etc.) since “you get what you measure”
- Availability of these capabilities will improve competitiveness and help avoid life-cycle lockin by small set of large vendors

Conclusions about X3D Capabilities

- Web-based X3D interoperability reconciles diverse functionality in complementary ways
  - X in X3D = extensibility, supporting stable growth
  - Royalty-free standardization protects investments

Meaningful production, distribution, re-use of high-end X3D graphics can be commonplace
  - Enabling important work on the bigger challenges

X3D architecture + extensibility mechanisms provide baseline framework for broad interoperability using the Web

Opportunity!

Recommendations

- More common overlaps exist than contrary differences. X3D helps.
- Allow diverse systems to “do what they are good at” while interconnecting and informing each other via Web standards
- Show multiple exemplars of working systems of direct use to Navy
- Spiral development of infrastructure
- Establish contract guidelines for program managers to continue growing a re-usable infrastructure for 3D printing and simulation
- Etc. etc. etc. etc.

  Etc. etc. etc. etc.

  There is one way to do things: we do them. Let’s go!

Contact

Don Brutzman, Ph.D.

brutzman@nps.edu

http://faculty.nps.edu/brutzman

Code USW/Br, Naval Postgraduate School
Monterey California 93943-5000 USA
1.831.656.2149 work