FULL MOTION VR

Refining Verification Approaches for Nuclear Arms Control

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PRINCETON UNIVERSITY

Revision 3b

BUILDING FROM LIVE EXERCISES

➤ **UK-Norway Initiative**

UKNI Managed Access exercises took place in Norway in 2008 and 2009, and in the UK in 2010. The exercises were underpinned by a framework which included a hypothetical Treaty between two fictitious countries: the NWS 'Torland' and the NNWS 'Luvania'. The Luvanian Inspectors deployed a number of techniques and processes, including radiation monitoring, tags and seals, digital photography of the tags and seals, CCTV cameras, and an information barrier system for gamma measurements.

➤ **UK-US Cooperation**

From 2002 through 2011, the United Kingdom and United States conducted four major managed access exercises, concluding with an extensive Warhead Monitored Dismantlement exercise.
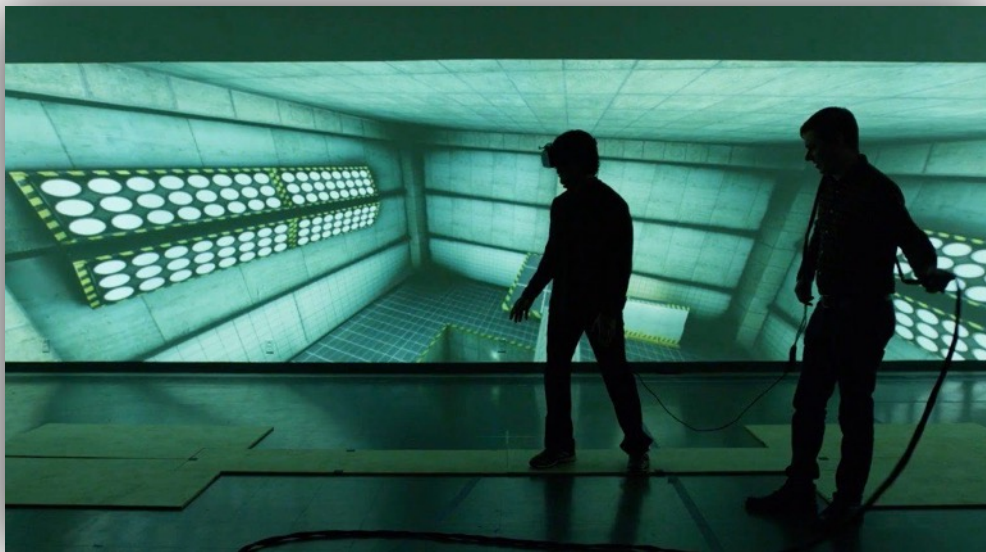

Images from the UK-Norway Initiative
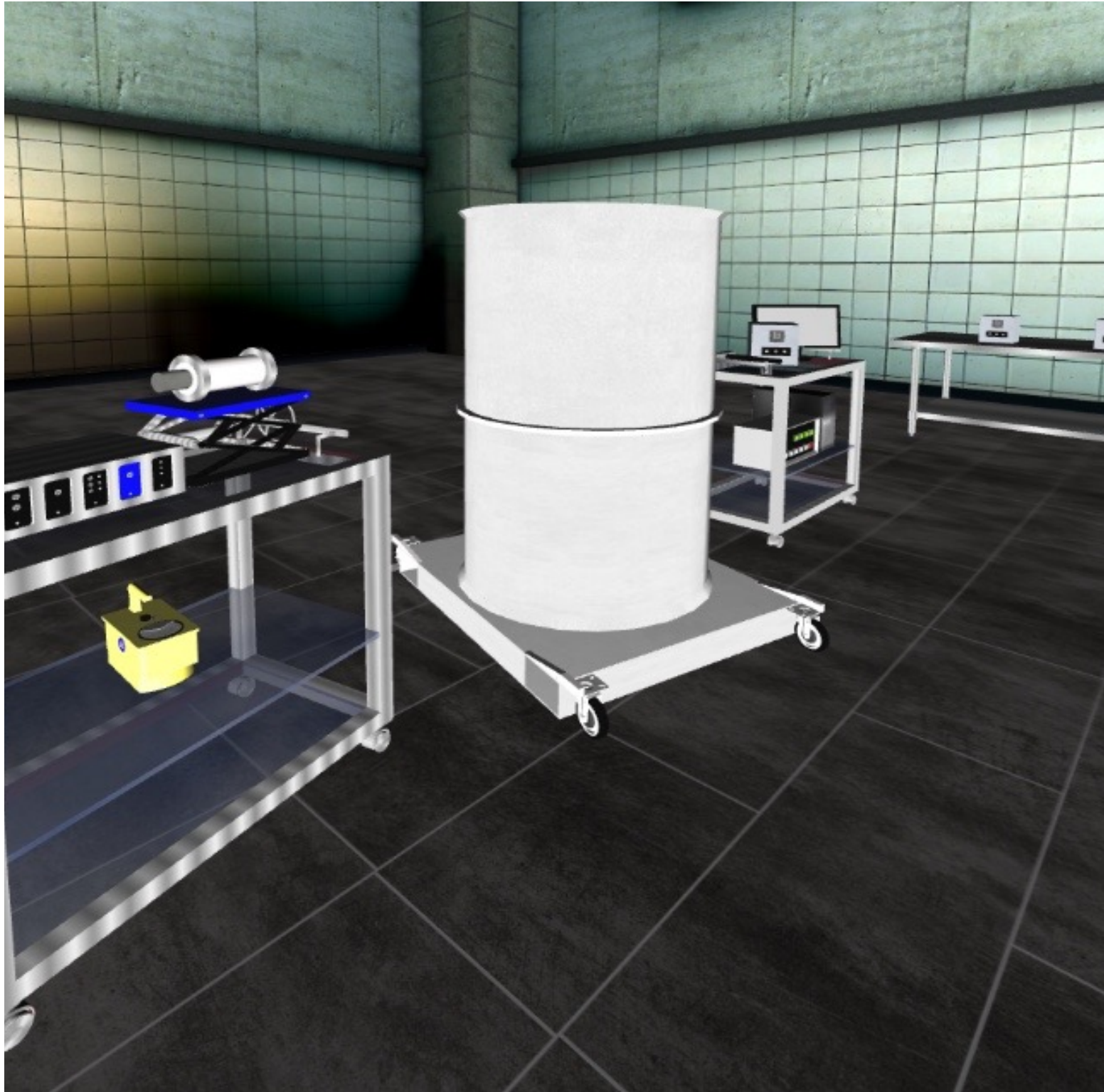
"FMVR provides a flexible and powerful way to extend the research community's ability to examine larger numbers of options and technology combinations for verification approaches."
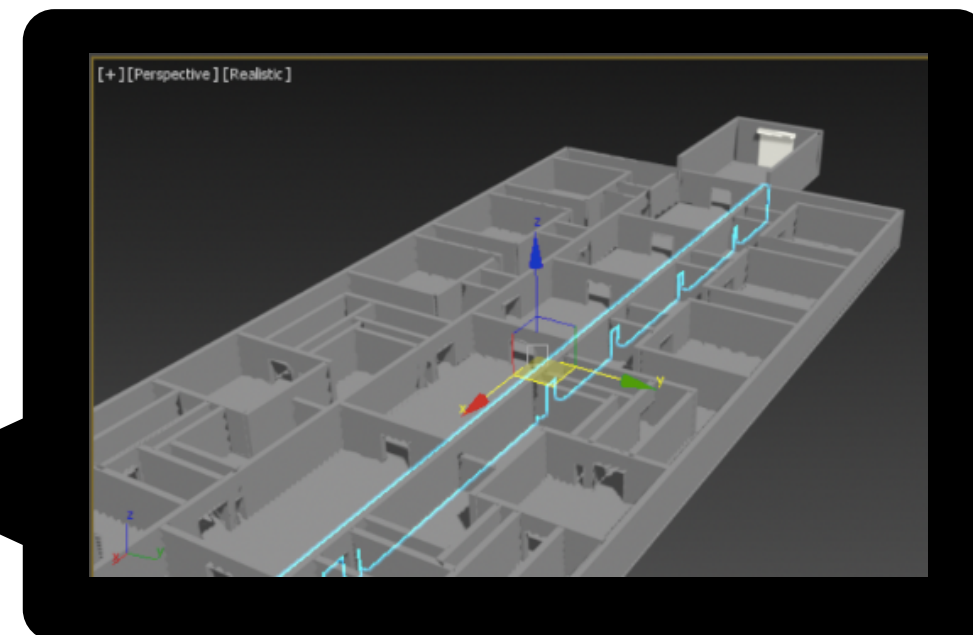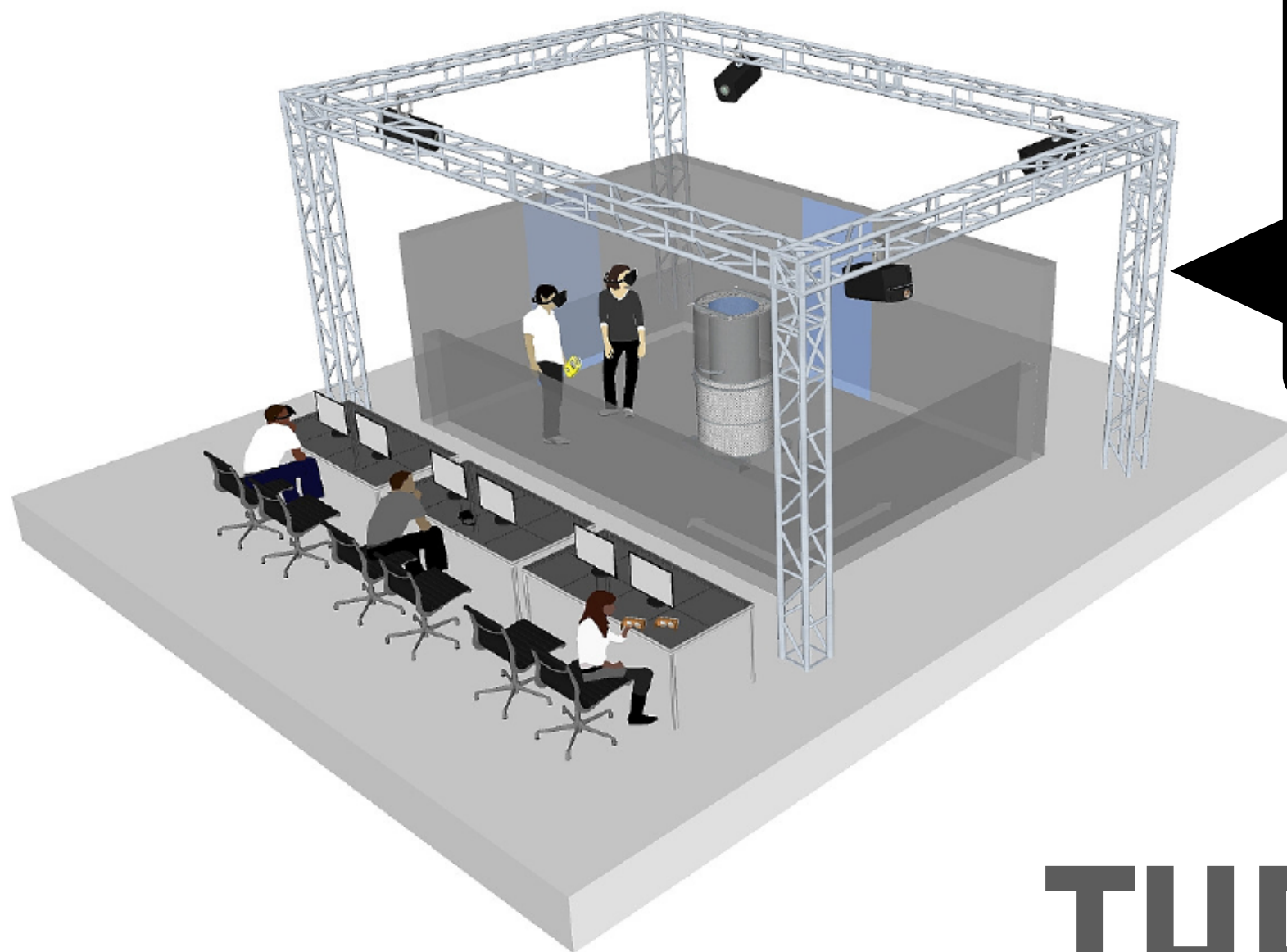
" The brain doesn't much care if an experience is real or virtual.

Jim Blascovich and Jeremy Bailenson
Infinite Reality: The Hidden Blueprint of Our Virtual Lives

More to explore: www.youtube.com/watch?v=9jx2YWzxvbs

THE SYSTEM

WorldViz Walking Virtual Reality System

QUESTION SETS FOR VR

➤ **1. ARCHITECTURE**

  ➤ Existing versus dedicated facility?

  ➤ Should the structure prioritize disassembly efficiency or verification?

  ➤ How "integrated" can inspectors be in the facility?

➤ **2. VERIFICATION TECHNOLOGY**

  ➤ Differences in protocols for different technologies (e.g. templates vs attributes)

  ➤ Chain of custody technology: how to track weapons and components?

➤ **3. MANAGED ACCESS**

  ➤ How can hosts grant inspector confidence without revealing classified information?

  ➤ How can inspectors gain confidence without gathering any proliferation-sensitive information?
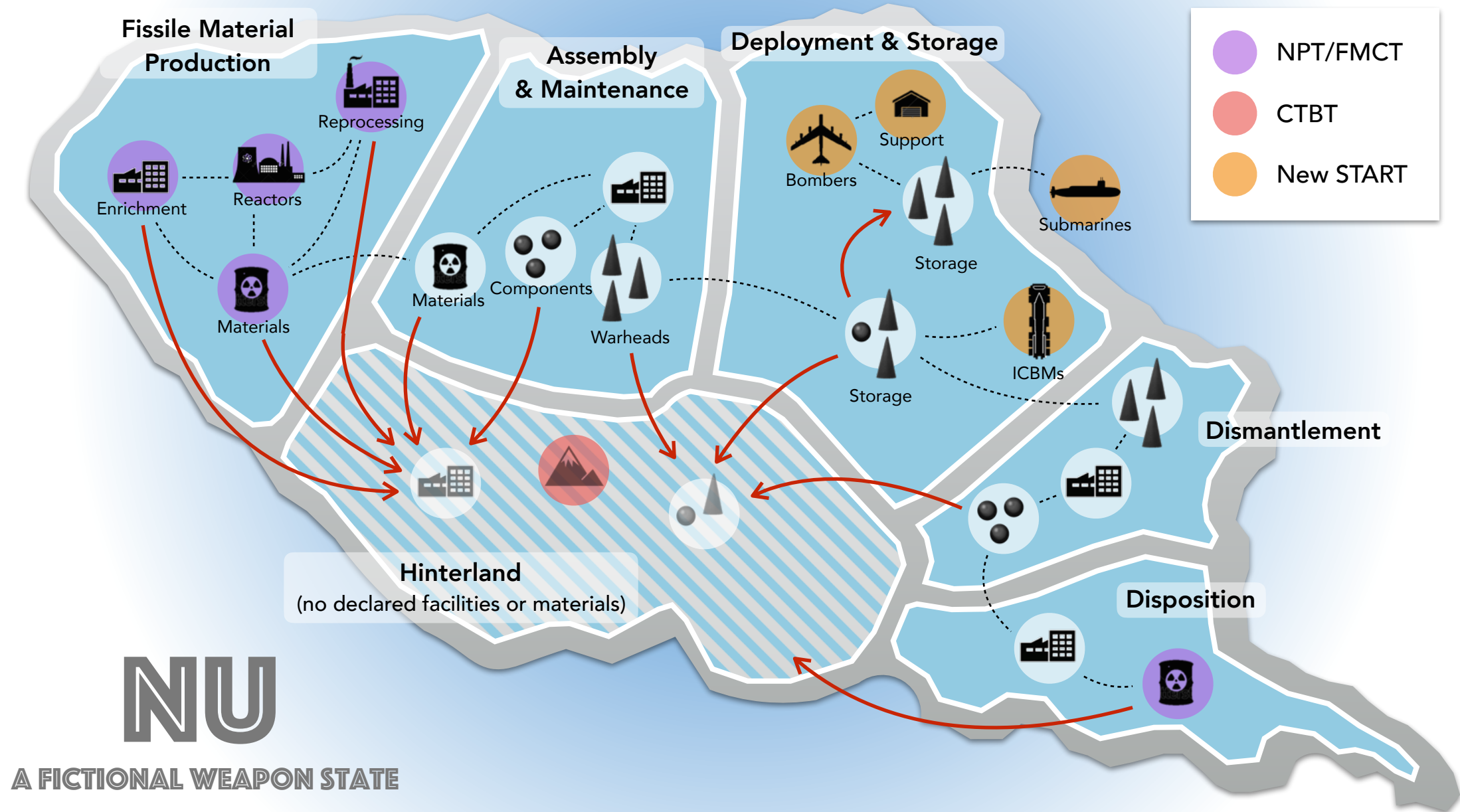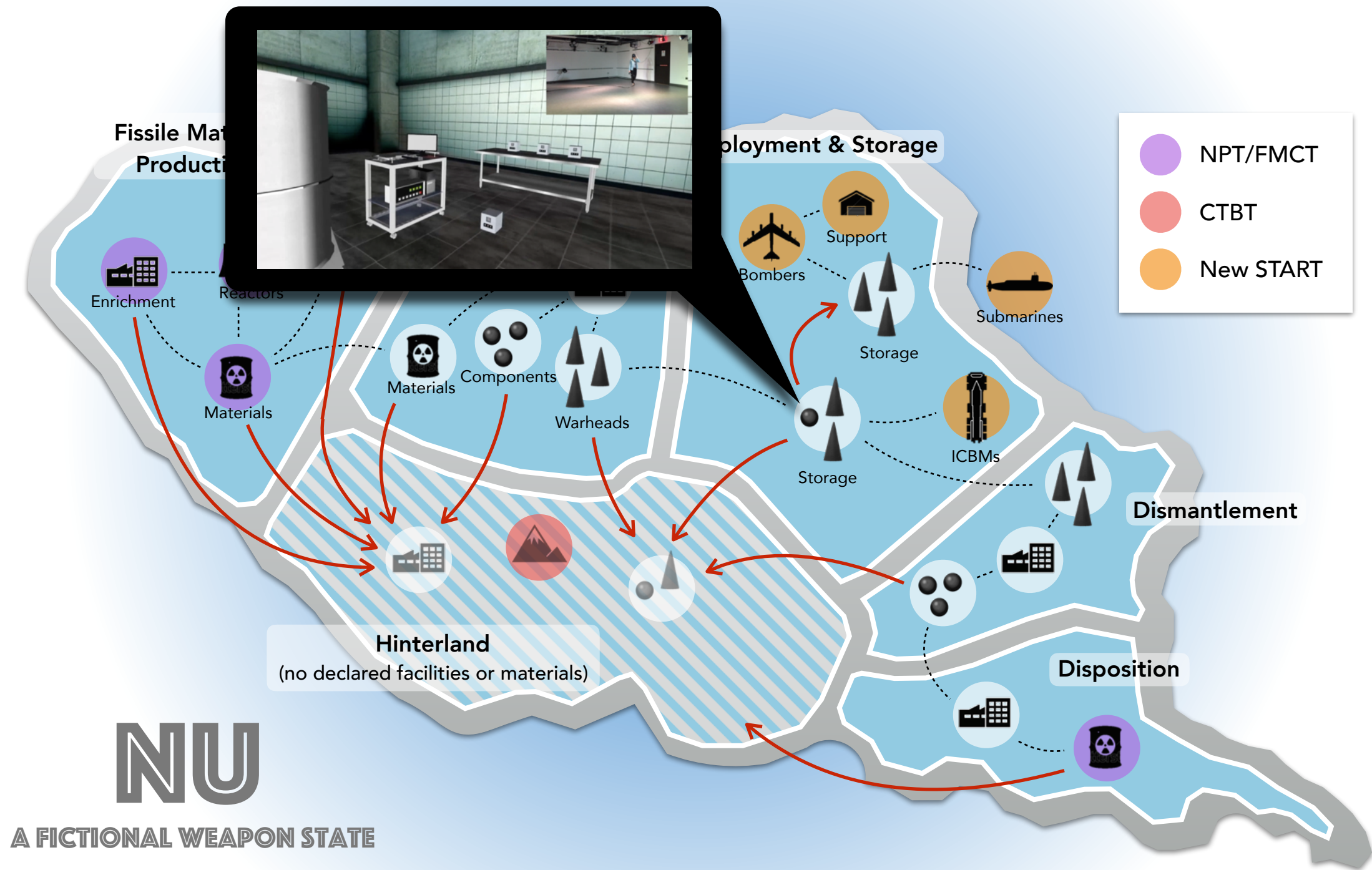
Elements of a

CASE STUDY

Refining a Verification Approach

| Nu Map Site	Verification Task	Time Period	Technology	Violation mechanisms addressed	Violation mechanisms unaddressed
Deployment	Item accountancy	T1, T2	Buddy tag	D, UAO	F, UAH
Maintenance	Item accountancy	T1, T2	Buddy tag	D, UAO	UAH
	Warhead confirmation	T1	PG/IB	F	
	UID confirmation	T1, T2	Modal testing		
Storage (non-deployed)	Item accountancy	T1, T2	Buddy tag	D, UAO	UAH
	Warhead confirmation	T1	PG/IB	F	
	UID confirmation	T1, T2	Modal testing		
Dismantlement	Warhead confirmation	T2	PG/IB	F	UAH
	UID confirmation	T2	Modal testing		
	Continuity of knowledge	T2	Room sweeping Room portal monitor	D	
	New UID on pit container	T2	Modal testing	D	
Waste storage	UID confirmation	T2	Modal testing	D	UAH
	Secure long-term storage	T2, T3	Room portal monitor	D	
Hinterland	Absence of undeclared weapons	T2	Challenge inspections	UH, UCP	None from framework

VIDEO

nuclearfutures.princeton.edu/vr

SCENE 1
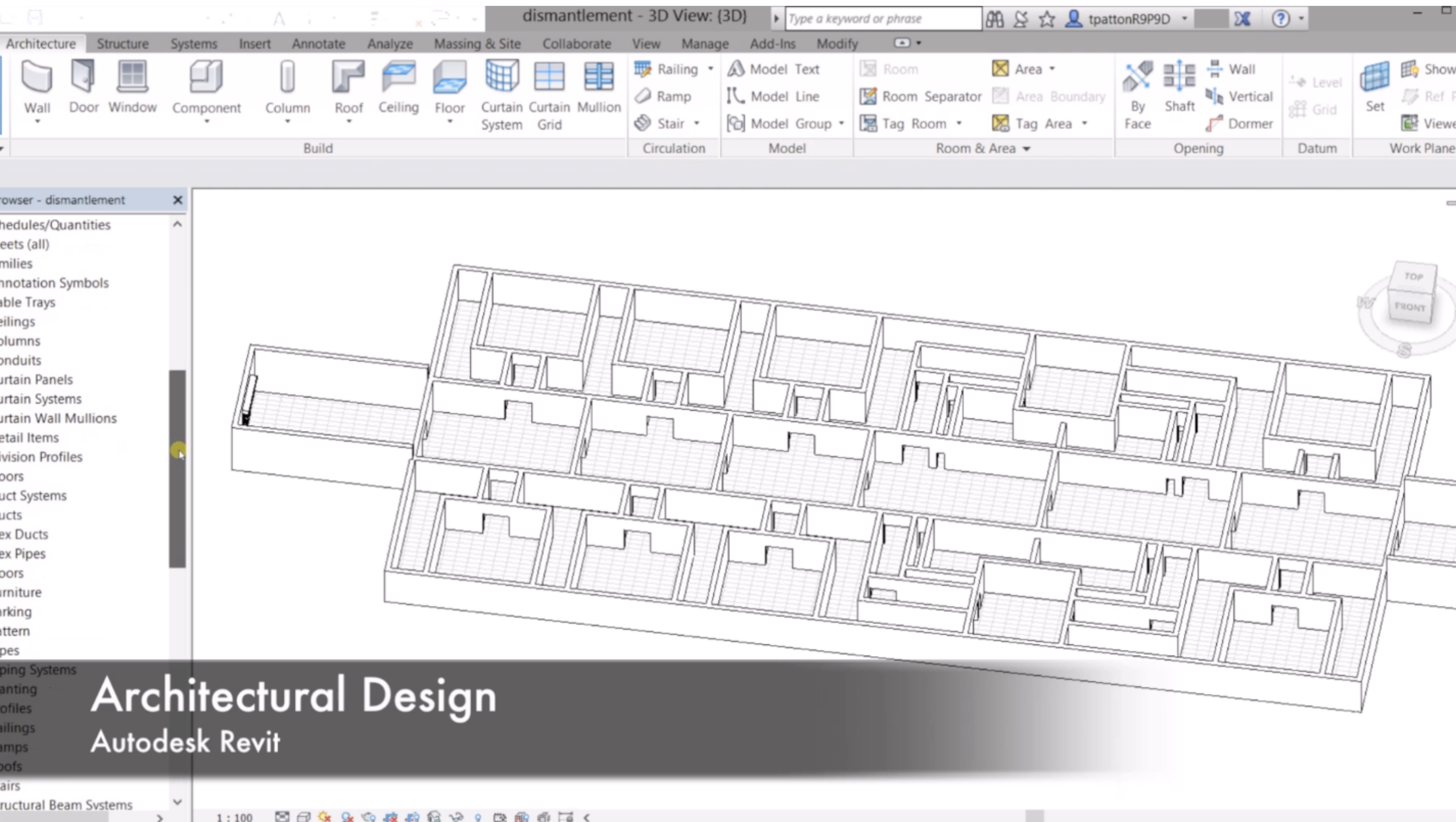
Buddy tags at a storage site
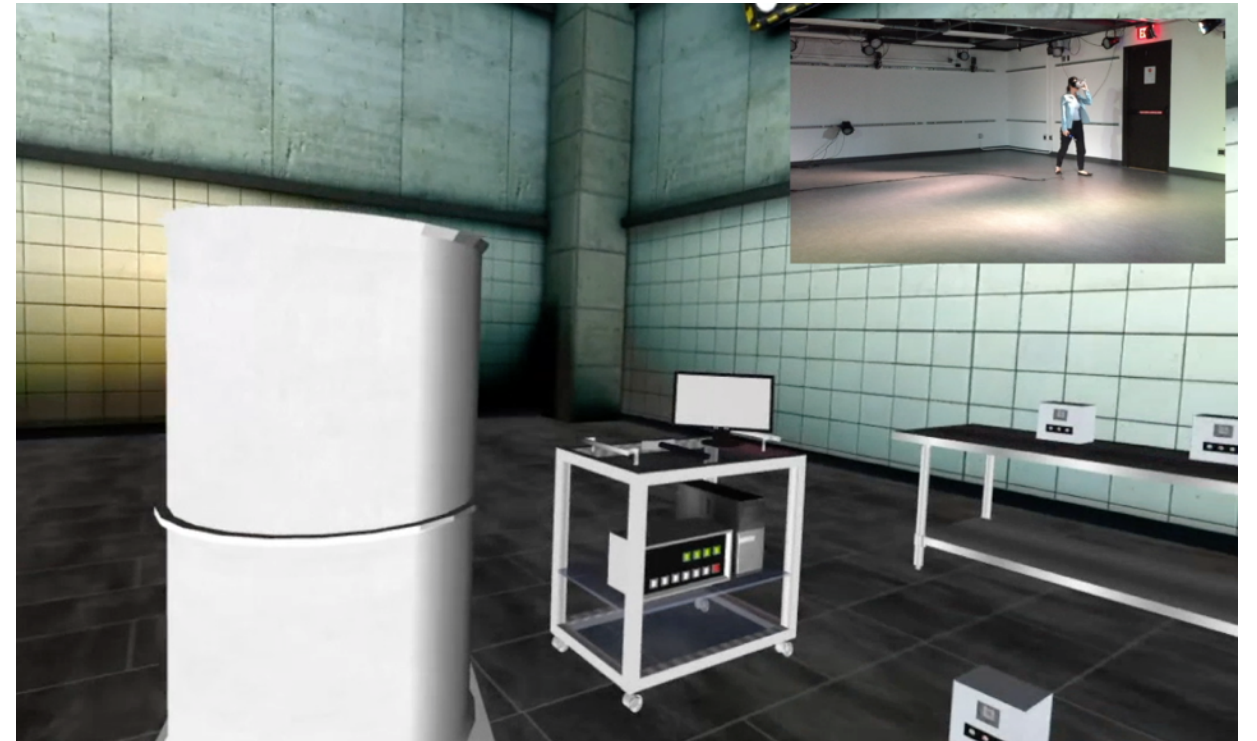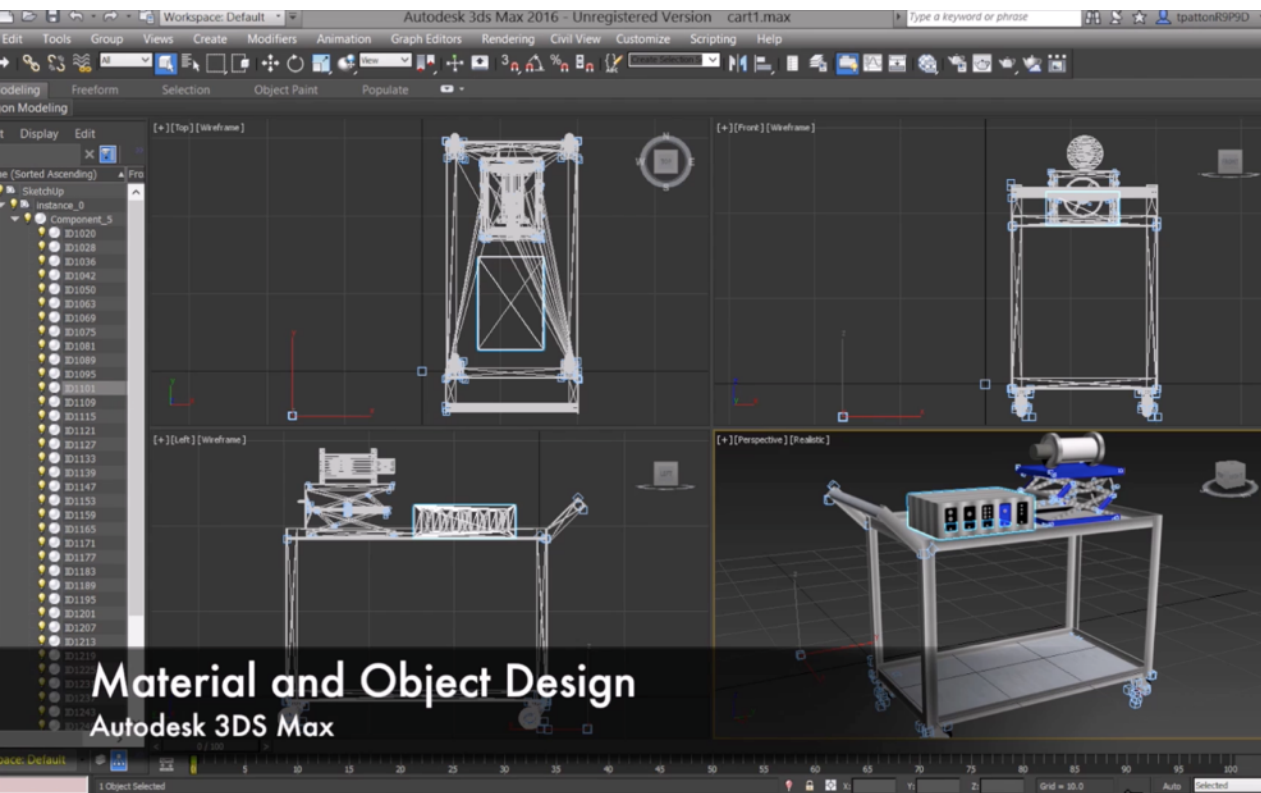

SCENE 2

Buddy tags with a possible UID system

www.youtube.com/watch?v=AMSvrxg-at4 (silent) and www.youtube.com/watch?v=PVR-ioOoOhg (sound)

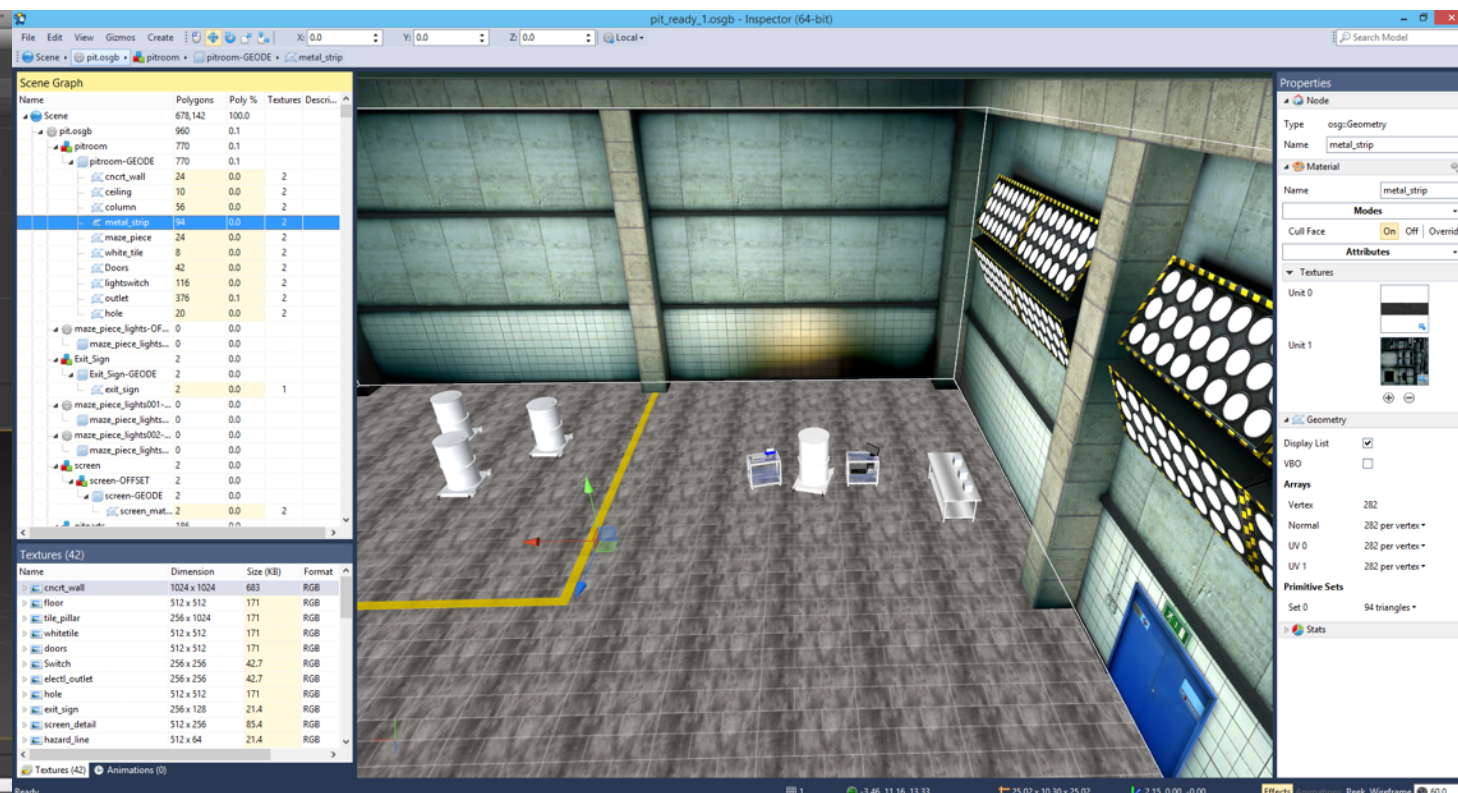# CONSTRUCTION PROCESS AND FUTURE DEVELOPMENT

Architectural Design
Autodesk Revit

CONSTRUCTION PROCESS AND FUTURE DEVELOPMENT

Artwork

Physics & Interactivity

3D Modeling

Autodesk 3DS Max

Game Engine

Vizard with Python

VR RADIATION RESEARCH

Source: Halden Virtual Reality Centre (HVRC) Institute for Energy Technology"
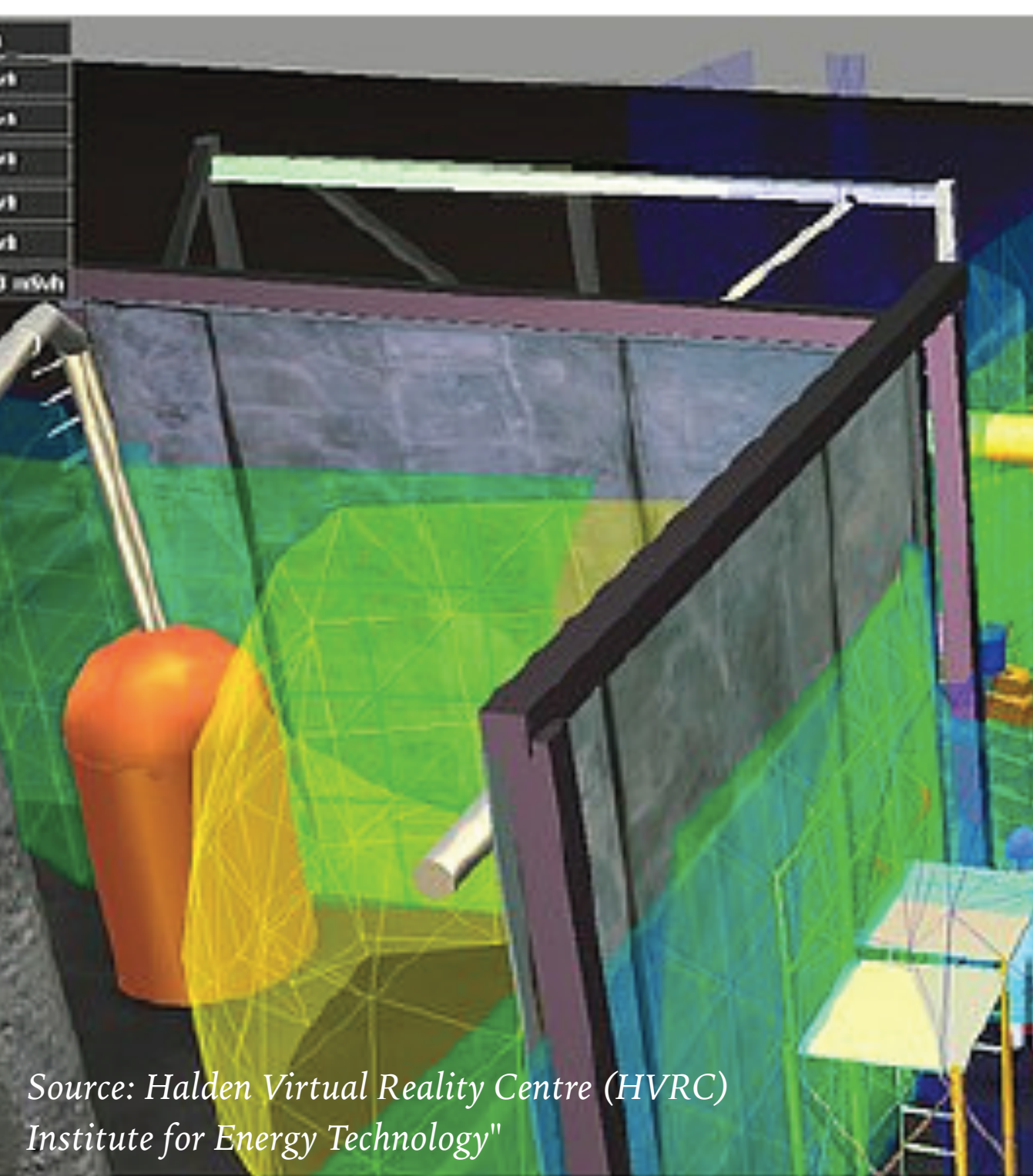
➤ 2006 - Making an "Impact" on Modernizing Nuclear Materials Safeguards and Security, Benny Martinez, Los Alamos National Laboratory

➤ 2007 - Use Of Virtual Reality To Estimate Radiation Dose Rates In Nuclear Plants, Silas C. Augusto, Instituto De Engenharia Nuclear

➤ 2010 - Virtual Reality Technologies for Nuclear Safeguards and Security, Emilio Ruiz Morales, European Commission, Joint Research Centre

➤ 2013 - Real-time, Accurate Radioactive Source Representation for Virtual Reality based Training on Radiation Detection, Teófilo Moltó Caracena, European Commission - Joint Research Centre

➤ Virtual Education and Research Laboratory (VERL) in the Department of Nuclear, Plasma, & Radiological Engineering at the University of Illinois at Urbana-Champaign

$$C \approx \sum_{i,j} S_{i,j} \frac{1}{4\pi r_i^2} \exp\left(-\sum_k \mu_{k,j} d_{k,i}\right)$$
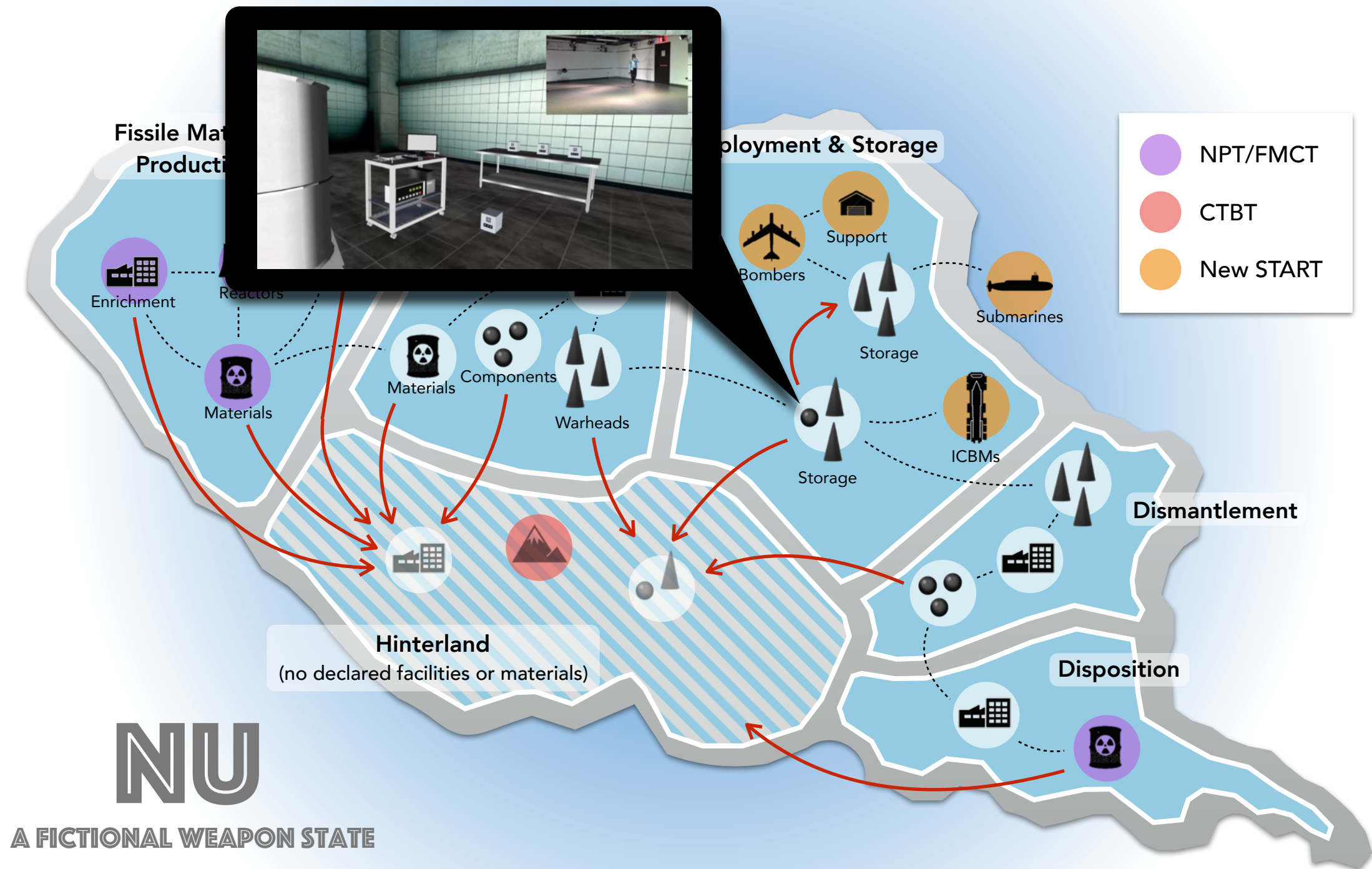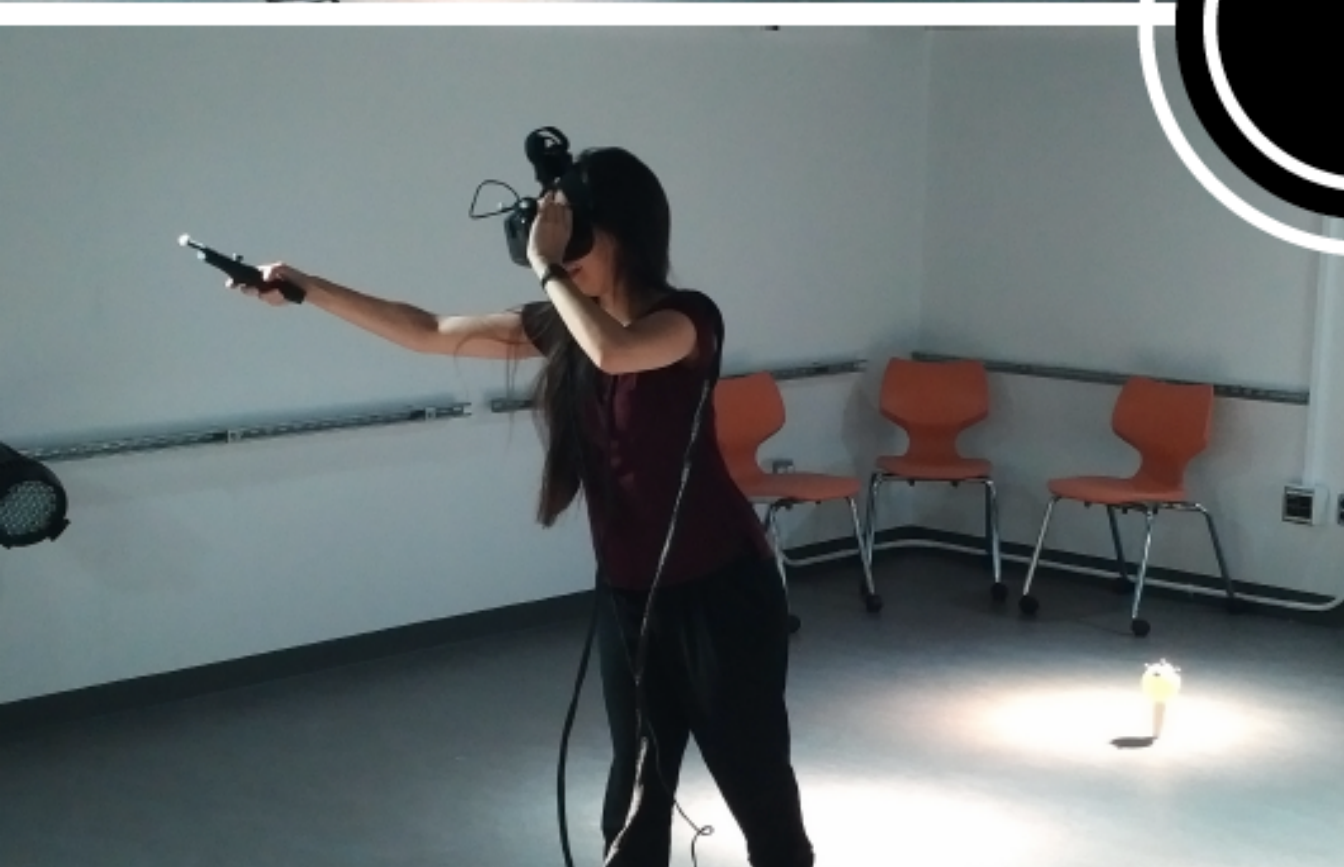
Counts

VIRTUAL RADIATION

➤ Radiation signatures of materials are relevant for many aspects of nuclear verification, and it is therefore important to include radiation in our models.

➤ Goal: Quasi real-time treatment of nuclear radiation

➤ Our first implementation uses a (simple) point-kernel method for gamma radiation (i.e., direct radiation from the source is treated as a collection of rays originating from one or more radiation sources reaching a point of interest).

MAPPING NUCLEAR VERIFICATION

Fissile Materials Production

Enrichment

Reactors

Materials

Materials

Components

Warheads

Deployment & Storage

Bombers

Support

Storage

Submarines

Storage

ICBMs

Dismantlement

Disposition

Hinterland
(no declared facilities or materials)

Legend:
- NPT/FMCT
- CTBT
- New START

NU

A FICTIONAL WEAPON STATE

Live Demo

CVT 2016

Move through the
virtual world at a
1:1 scale with the
physical world.

VizMove Walking VR System Components.

MORE

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nuclearfutures.princeton.edu/vr
www.verification.nu (coming soon)
cvt.engin.umich.edu