

A 3D Digital Twin of the CERN Accelerator complex using NVIDIA Omniverse

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Digital Twin?

- ❑ A parallel digital representation of a real object
- ❑ Contains data from and influence decisions made with the real object

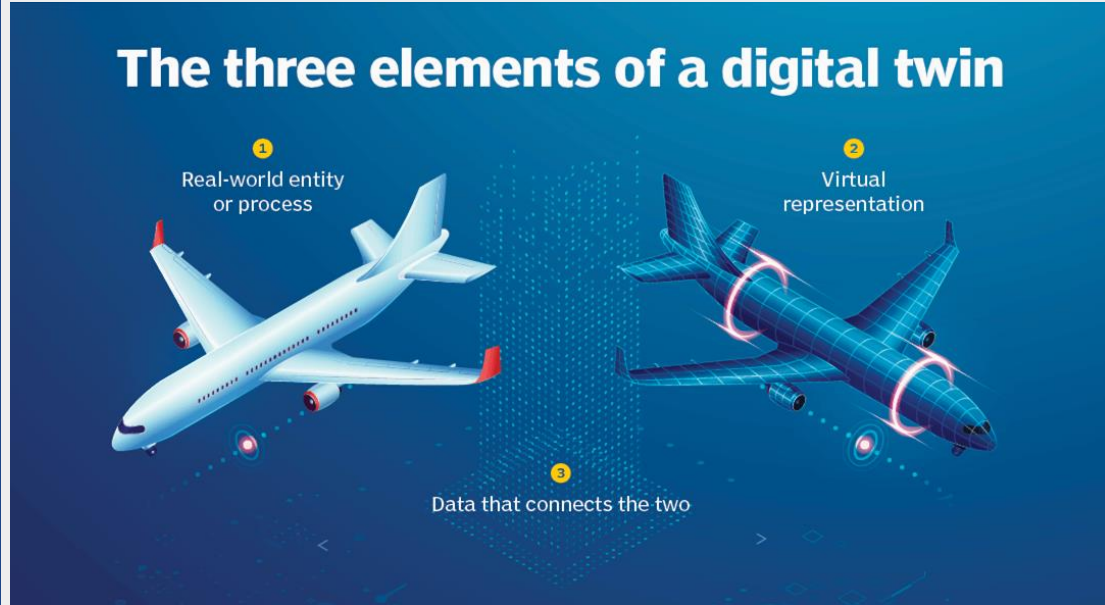


Image source: TechTarget

At CERN?

- ❑ CERN's Accelerator complex is constantly monitored and maintained
- ❑ A 3D digital twin is useful for management, maintenance, and creating media

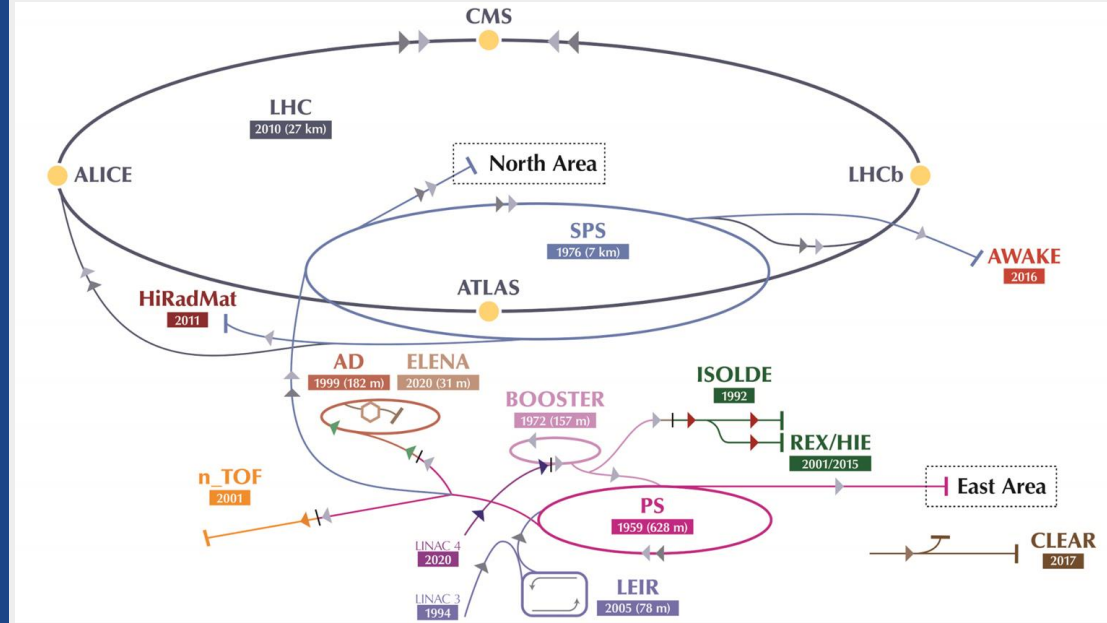


Image source: CERN

NVIDIA Omniverse

Why this choice of software?

- ❑ Particular support by NVIDIA for digital twins
- ❑ Robust and simple extension and development platform
- ❑ Universal Scene Descriptors

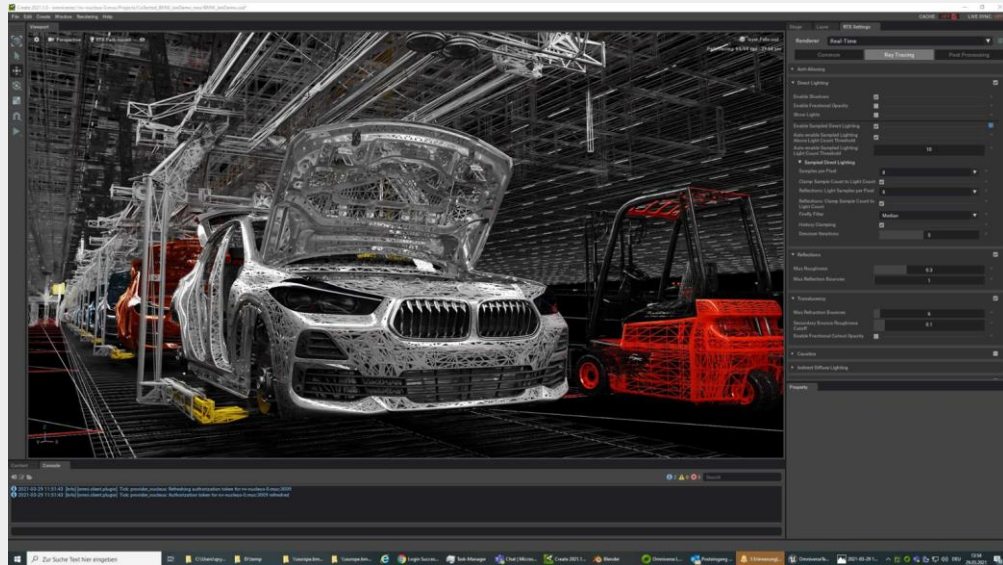


Image source: NVIDIA

Universal scene descriptor (USD)

- ❑ CERN uses several CAD formats that must be stored; USD could unify these with less file conversion
- ❑ Open-source & compatible with a wide and growing variety of programs



USD

```
#usda 1.0
(
  defaultPrim = "hello"
)

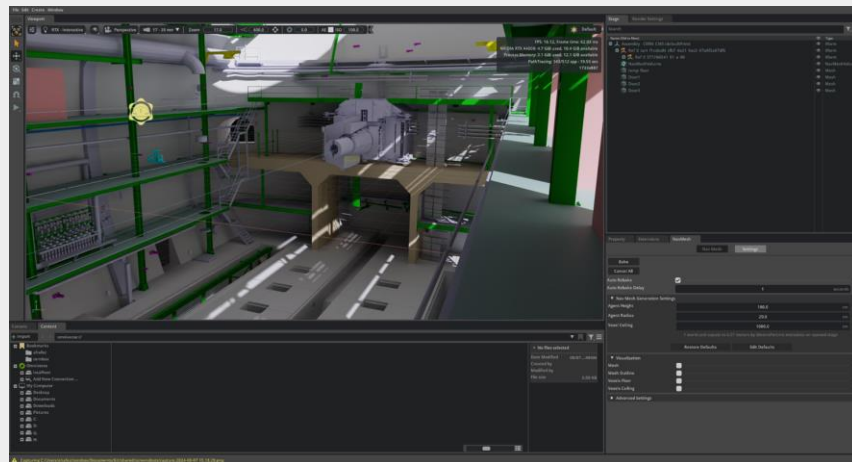
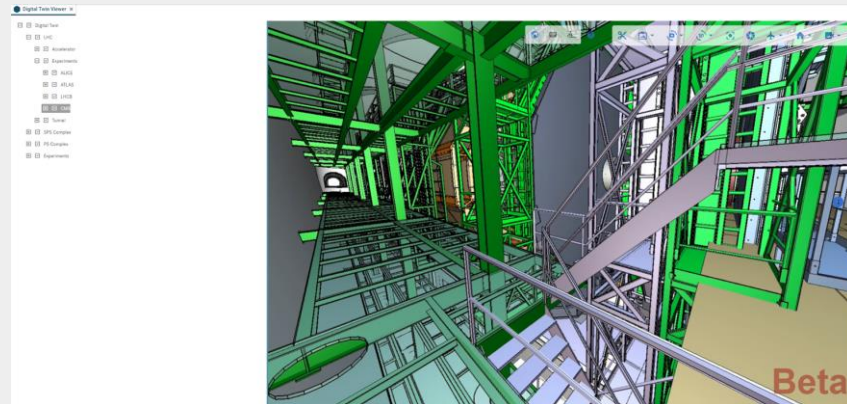
def xform "hello"
{
  custom double3 xformOp:translate = (4, 5, 6)
  uniform token[] xformOpOrder = ["xformOp:translate"]

  def sphere "world"
  {
    float3[] extent = [(-2, -2, -2), (2, 2, 2)]
    color3f[] primvars:displayColor = [(0, 0, 1)]
    double radius = 2
  }
}
```

3D Recreation

- ❑ CERN hosts a collection of CAD models representing every object used at CERN.
- ❑ We can convert these models to USD and then reconstruct the entire complex in 3D

The EN-IM - PLM team at CERN has made a live-hosted 3D digital twin in an older engine, and this is the view of the CMS experiment



After partial migration to Omniverse, we can display the room housing the CMS experiment

Intervention Simulation

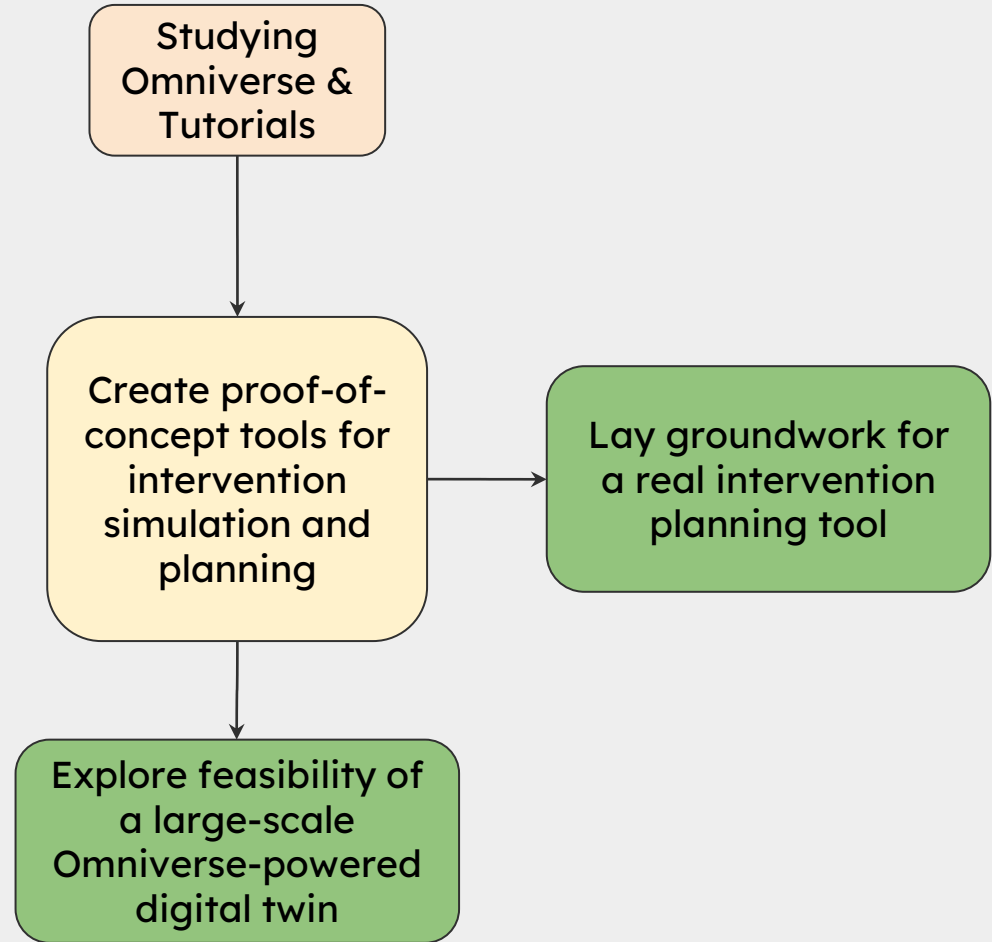
- ❑ Regular maintenance at CERN is done in the form of **interventions**.
- ❑ These need to be planned, with parts, locations, routing, and necessary machinery prepared.



Image source: CERN

The Project

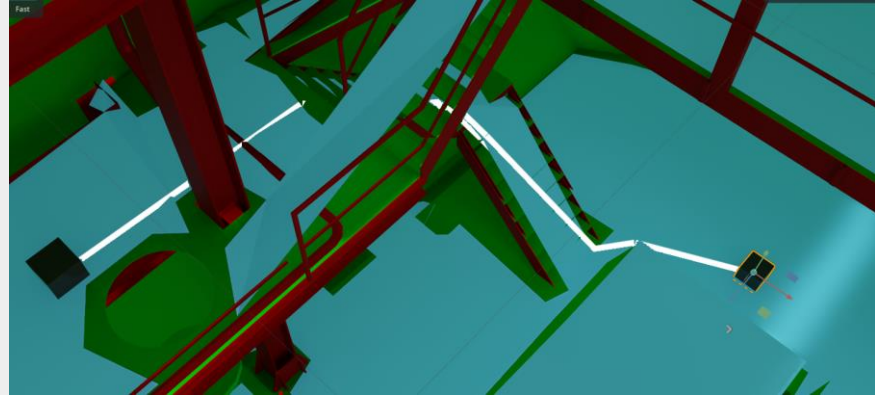
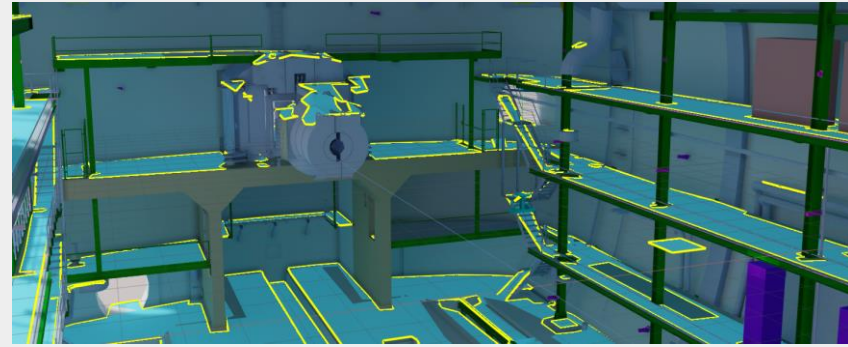
- ❑ To see if we can create a tool using Omniverse and the 3D digital twin to simplify and assist with intervention planning
- ❑ Explore the feasibility of using Omniverse for a live digital twin



Navigation

- ❑ Omniverse's Navmeshes can automatically generate navigable surfaces in a 3D scene
- ❑ This information is used to generate paths to any destination in the accelerator's digital twin

Within the CMS housing chamber, we can automatically generate a navmesh that looks like this



Even though it doesn't *look* perfect, we can get pretty good paths, that even go over things like stairs and around columns

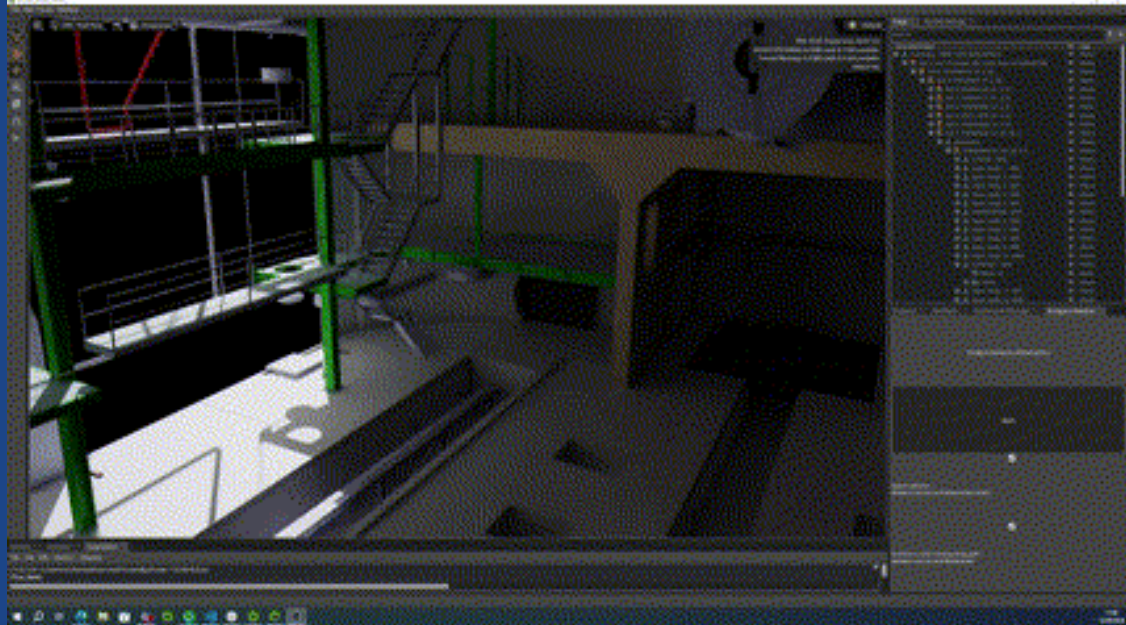
Navigation



Animation

(mostly done by Saumy)

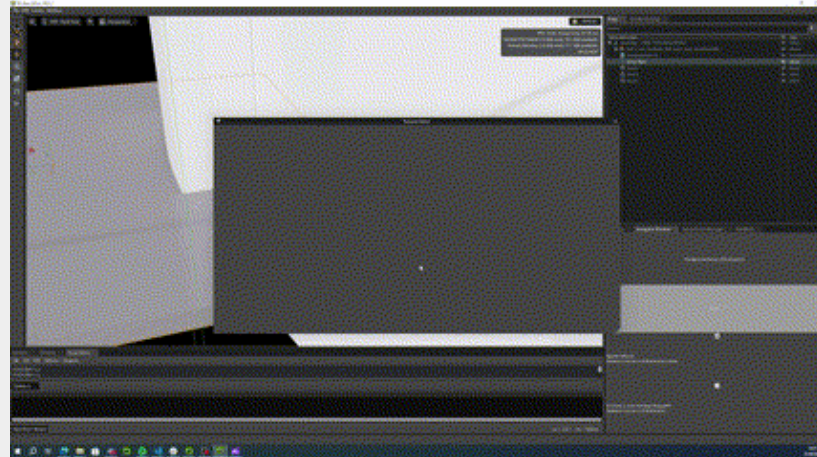
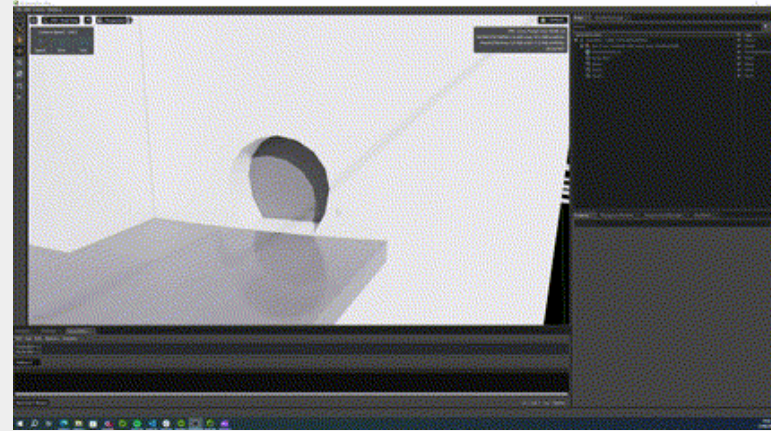
- ❑ From generated paths, we can animate objects moving along this path
- ❑ As objects move, we can check for physics collisions to make sure the intervention is possible



Access Control

- ❑ Some interventions require more access than others
- ❑ Using data from the CERN complex, we can block navigation through paths that the user can't access

This door was created in the CMS complex leading to some external platform; its default access requirement is "0", and the user's is "2"

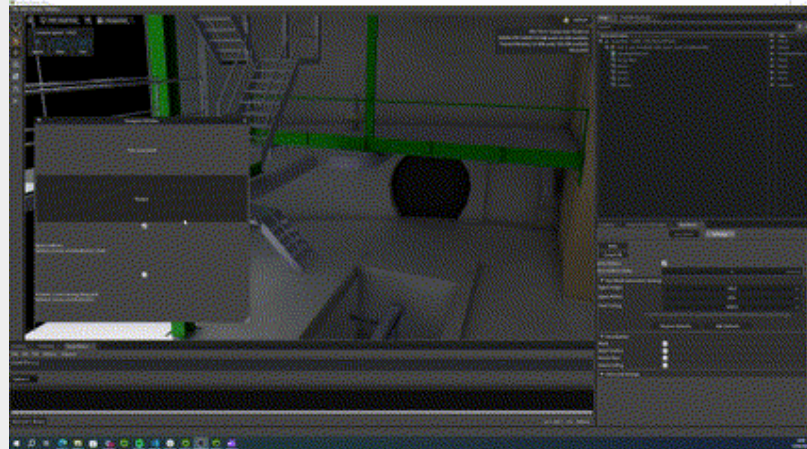
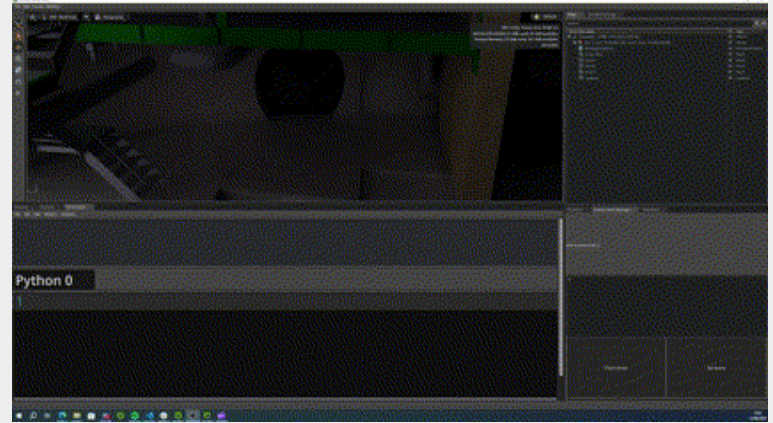


Requesting a path through the door works fine, going right through - as if the door was open

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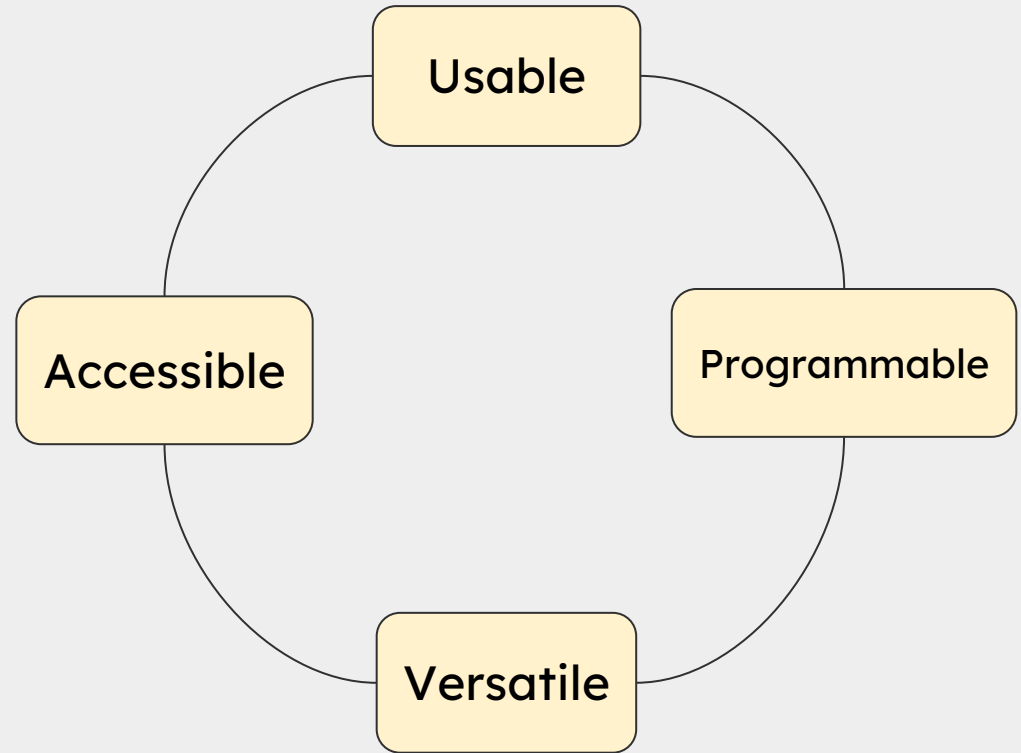
Access levels for objects can be set, and saved in the USD file, so that future access requests are correct; here, the access requirement is set to 3



Now, requesting a path through the door is blocked, and no path can be found - the door requires an access level that the user does not have

Conclusions & Project Future

- ❑ A 3D digital twin in Omniverse is very usable for tools like intervention simulation
- ❑ CERN's 3D digital twin should have a lot of functionality, be easy to use, and be programmable
- ❑ While Omniverse requires powerful hardware, any user on any device should be able to access it (via streaming)



Thank you!

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