How To Test Digital Twins

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Let me introduce myself

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3. Examples of industrial sectors where digital twins are used
4. Real life examples of digital twins
5. Demo pages of digital twins
6. Manual testing of digital twins
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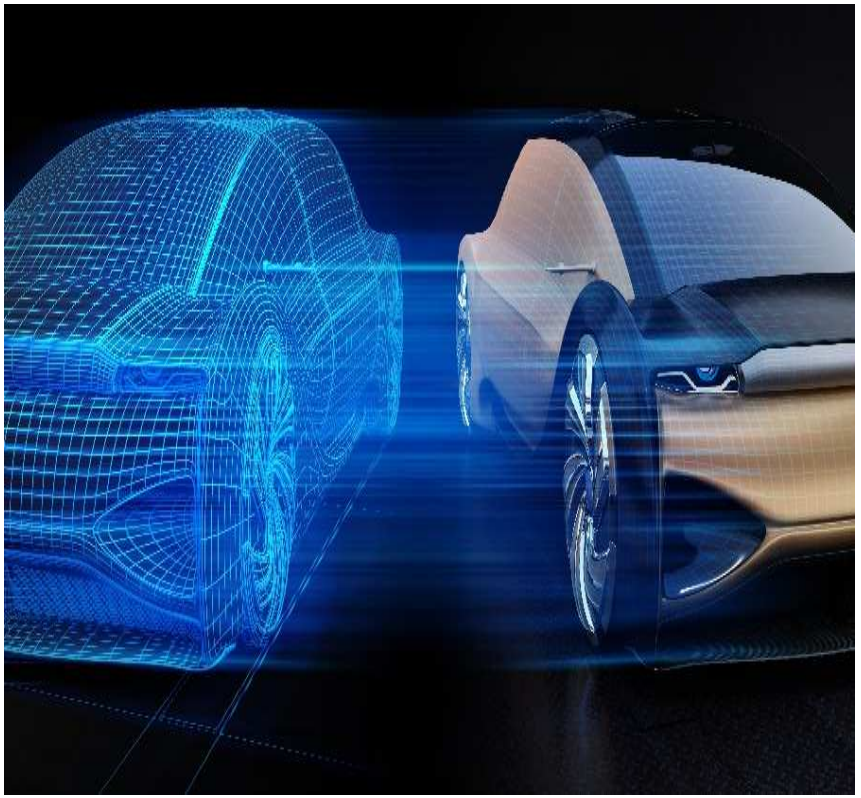
Definition of digital twins

A digital twin is a **virtual representation** of an entity or system that exists in the physical world,

it is composed of the following three elements:

- a **physical** entity in real space;
- the **digital** twin in software form;
- **data** that links the first two elements together

It is used to **optimize** operations, **improve** quality, **reduce** costs, and **enhance** innovation

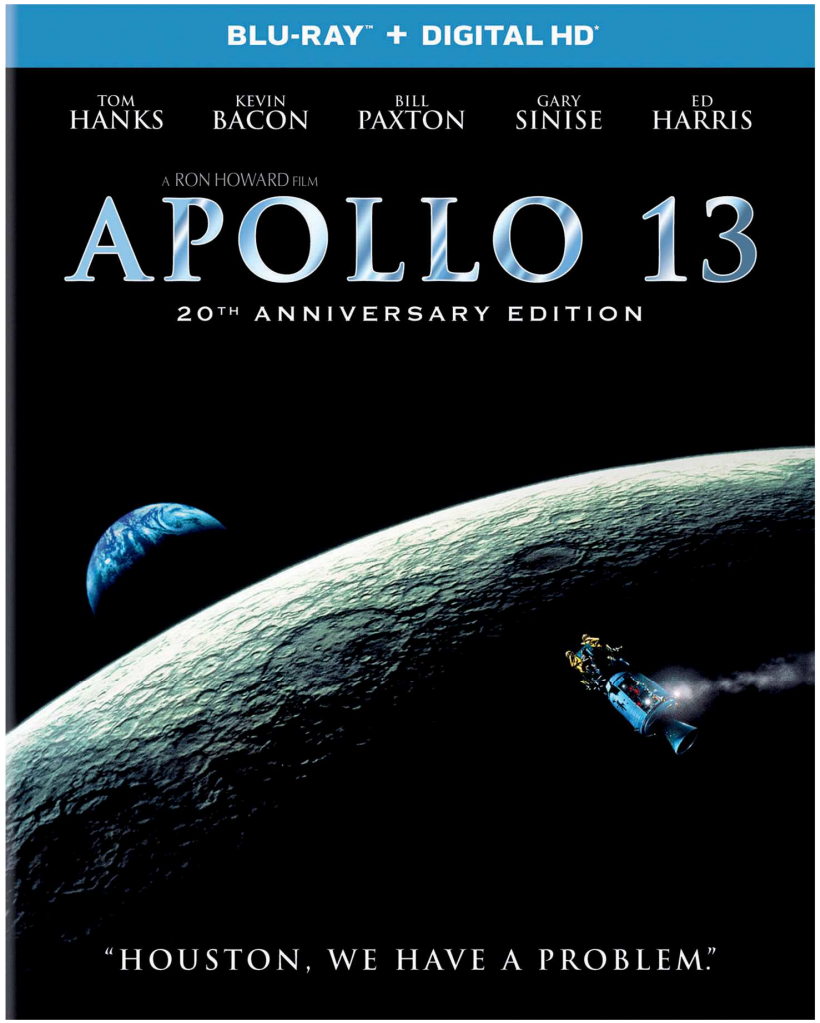


History of digital twins – Apollo 13

After the **launch** of Apollo 13 on **April 1970**, no one could have predicted it would become a fight for survival as the oxygen tanks exploded early into the mission.

It became a famous **rescue mission** as the world held its breath, with technical issues needing to be resolved from up to 200,000 miles away.

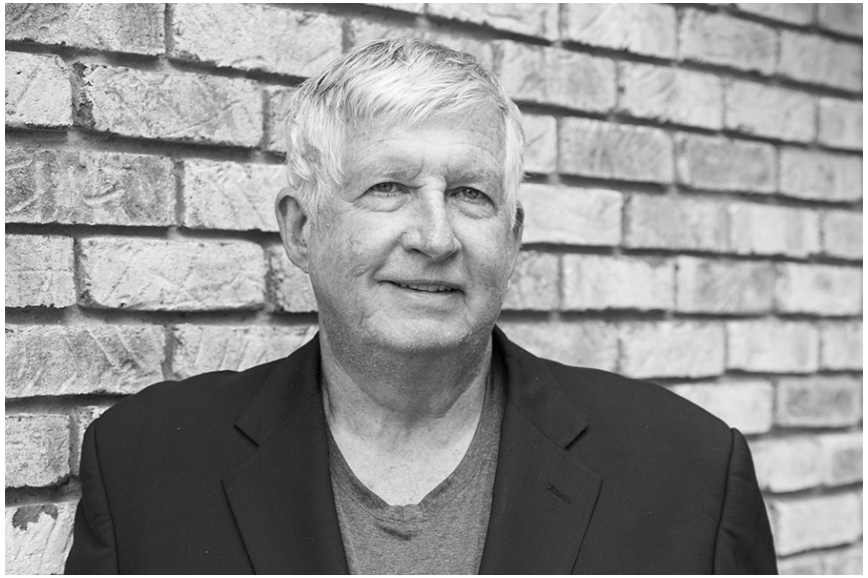
A **key** to the rescue mission, however, was that NASA had a **digital twin model** of Apollo 13 on earth which allowed engineers to test possible solutions from ground level.

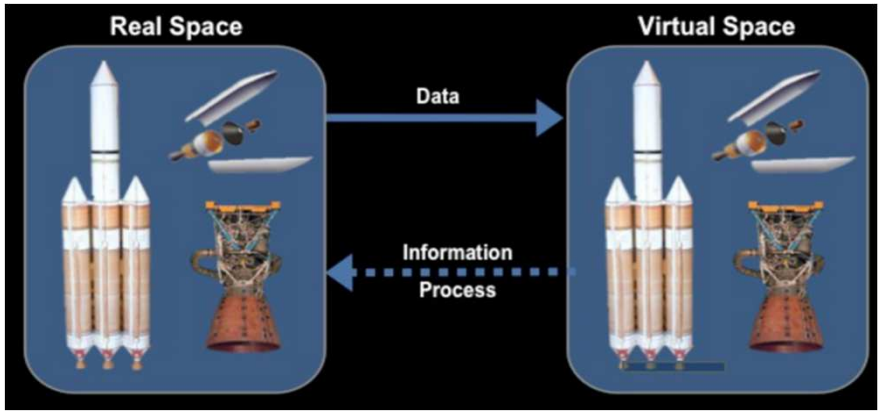


History of digital twins – Michael Grieves

The digital twin **concept** gained recognition in **2002** after Challenge Advisory has hosted a **presentation** for **Michael Grieves** in the University of Michigan on technology

The presentation involved the development of a **product lifecycle management** center. It contained all the elements familiar with the digital twin including; **real** space, **virtual** space and the spreading of **data** and information flow between real and virtual space.





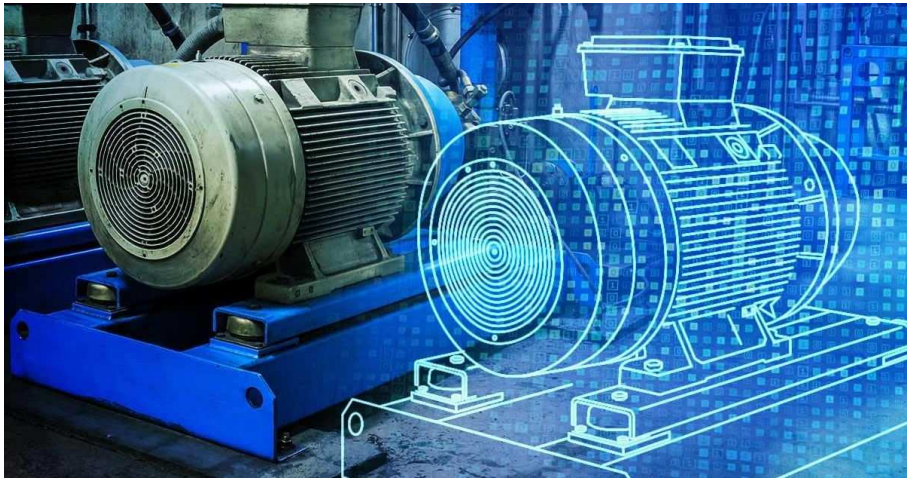
Examples of industrial sectors where digital twins are used

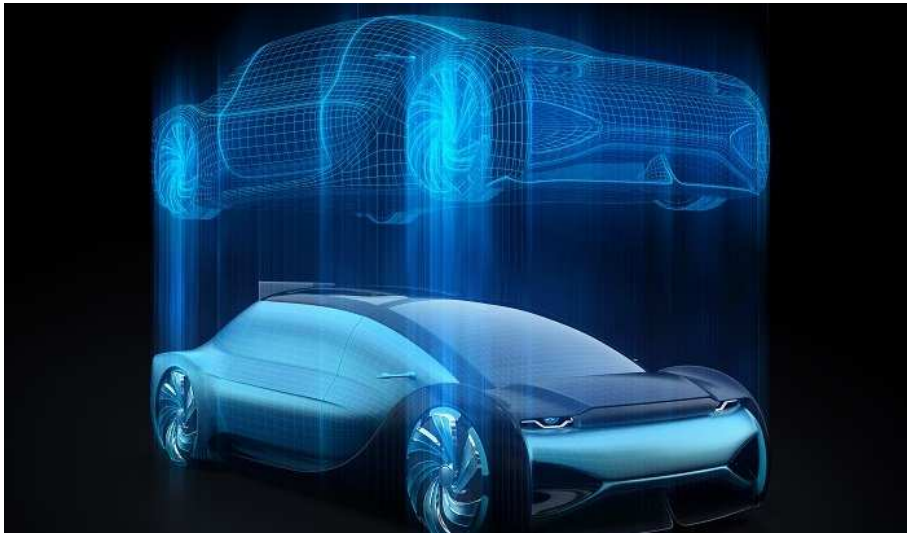
1. Manufacturing

- **Factory** design and **layout**
- **Robotics** simulation
- **Monitoring**, guided **maintenance** and **repair**

2. Automotive

- 3D car **design** and product **development**
- **Autonomous** driving simulation
- Human-machine **interfaces**

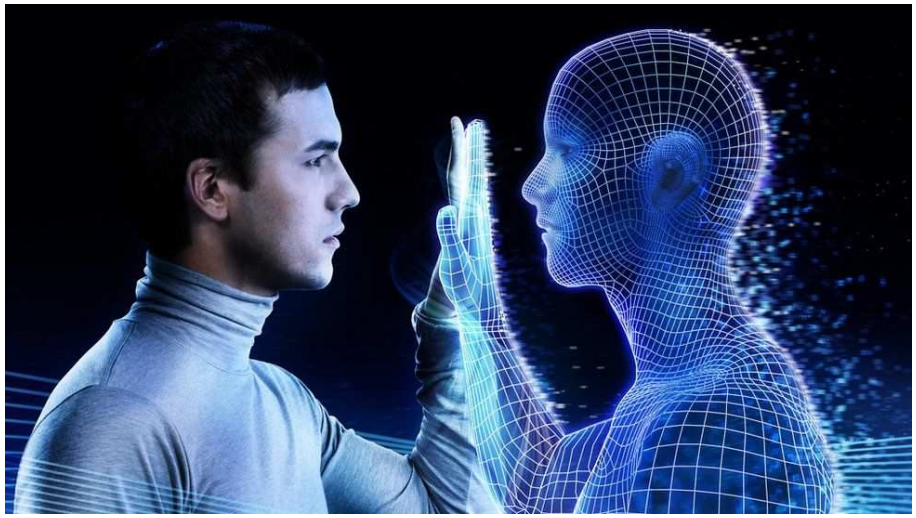




Industrial sectors where digital twins are used

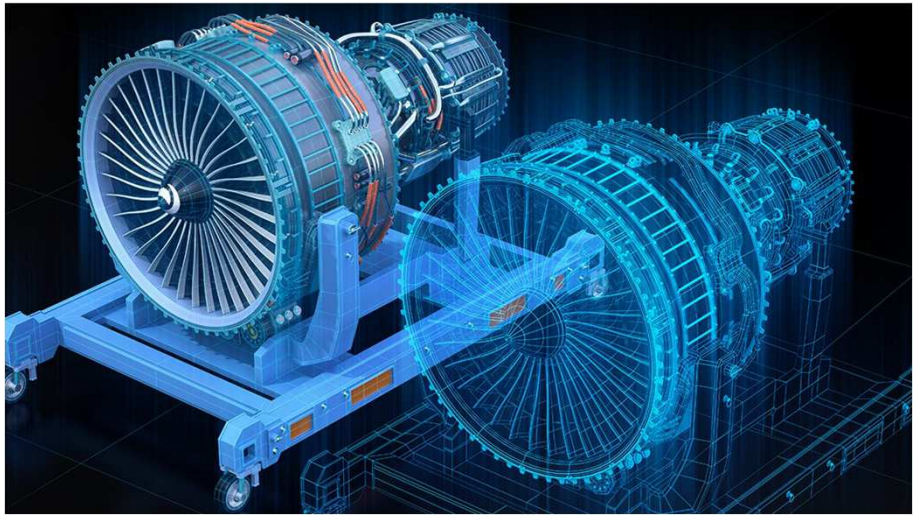
3. Health Care

- **optimize** facility **operations**
- improve **hospital designs**
- build a visual and digital **twin** of a **patient's heart** to be used for **further study**



4. Aerospace

- product development and **prototyping**
- **simulation** and **training**



Real life examples of digital twins – Virtual Singapore

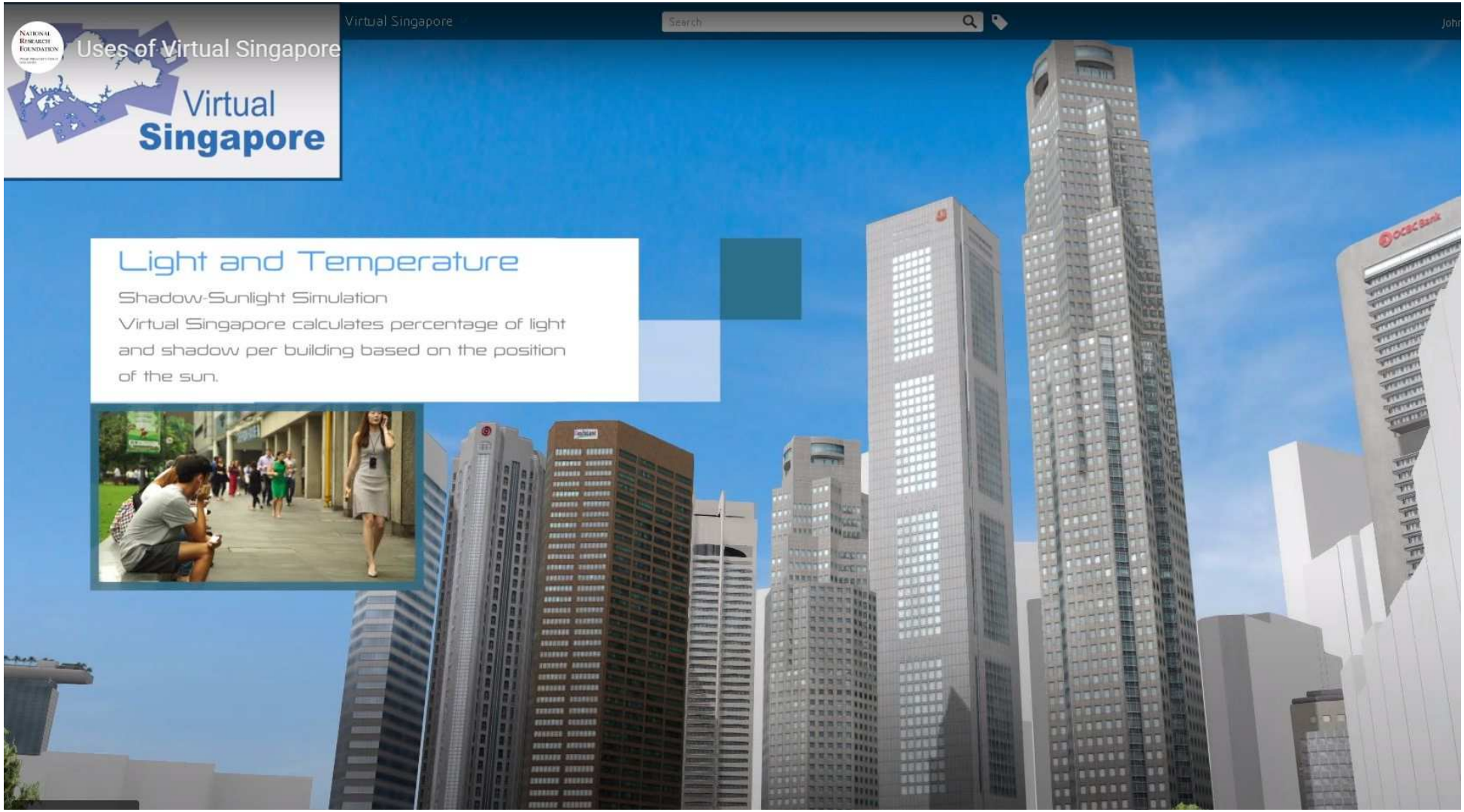
Virtual Singapore

The Virtual Singapore platform is a **digital twin** of the **city-state** of Singapore.

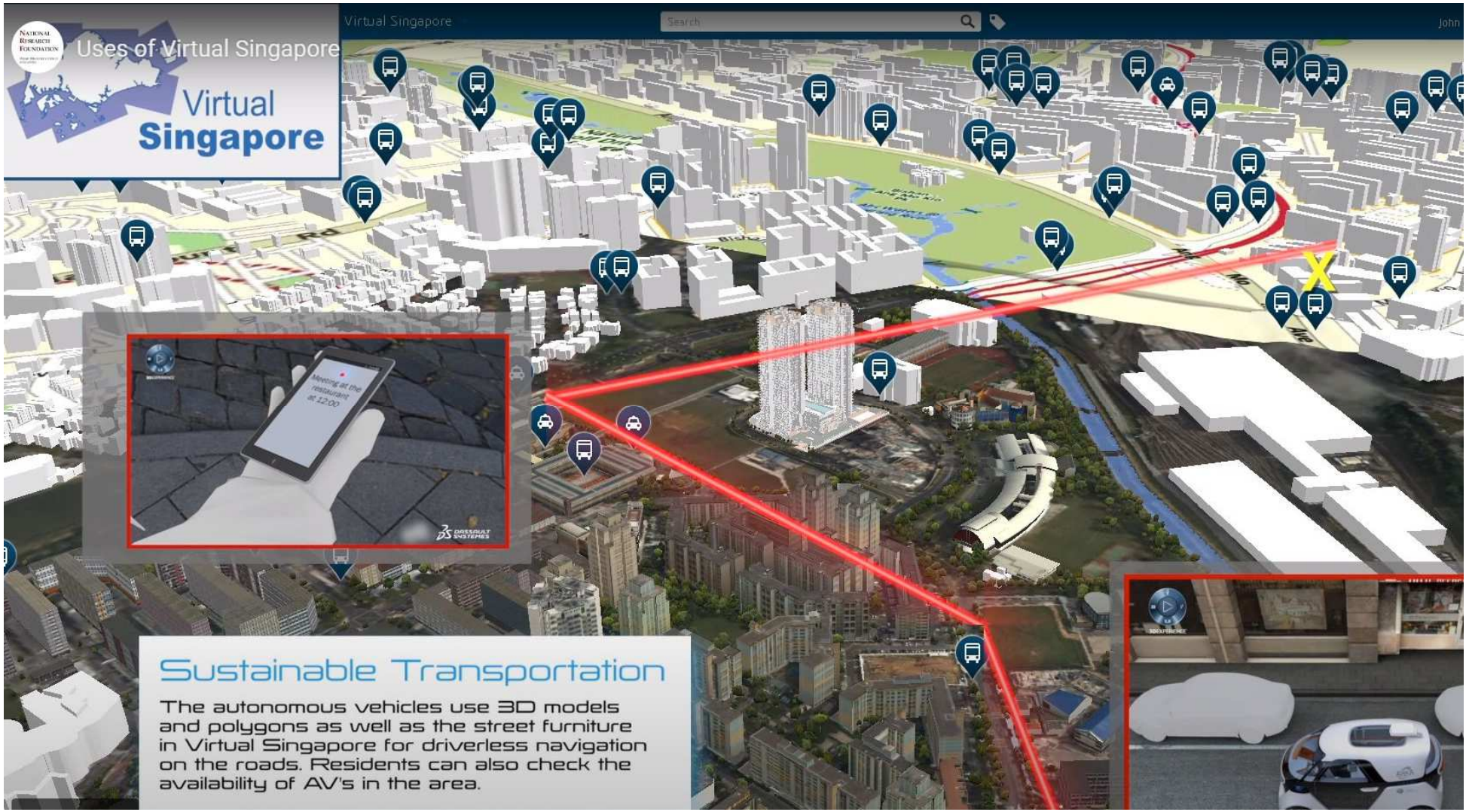
It **enables** users from different sectors to develop sophisticated tools and applications for **test-bedding concepts** and services.

It also helps in **planning and decision-making**, and research on technologies that could solve complex and emerging challenges in the country

Virtual Singapore

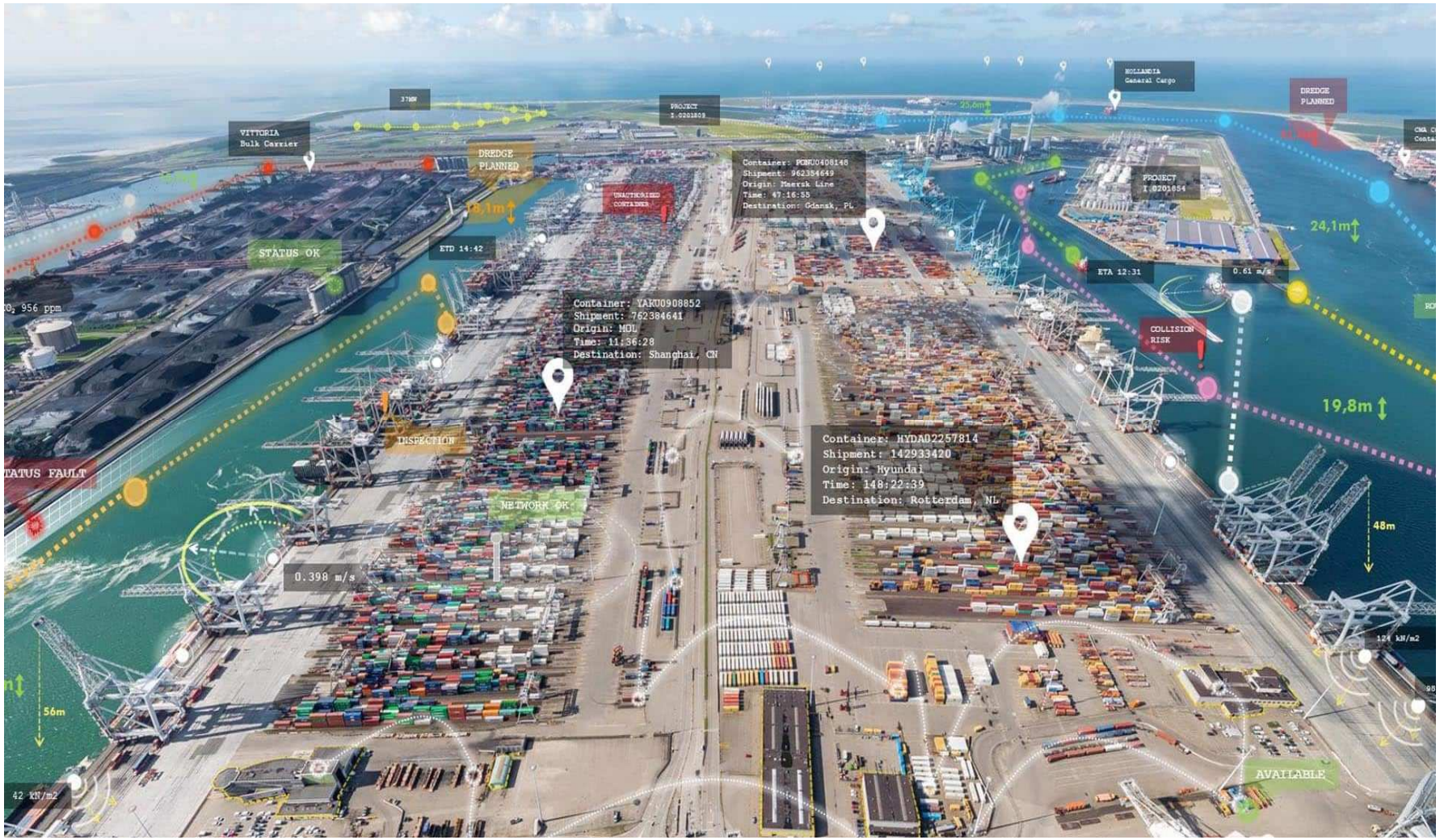


Virtual Singapore



Virtual Singapore

Real life examples of digital twins – the Digital Port of Rotterdam



Digital Port of Rotterdam

Important step in the process of enabling **autonomous shipping** within the port of Rotterdam by the year 2030 is the development of the port's **digital twin**.

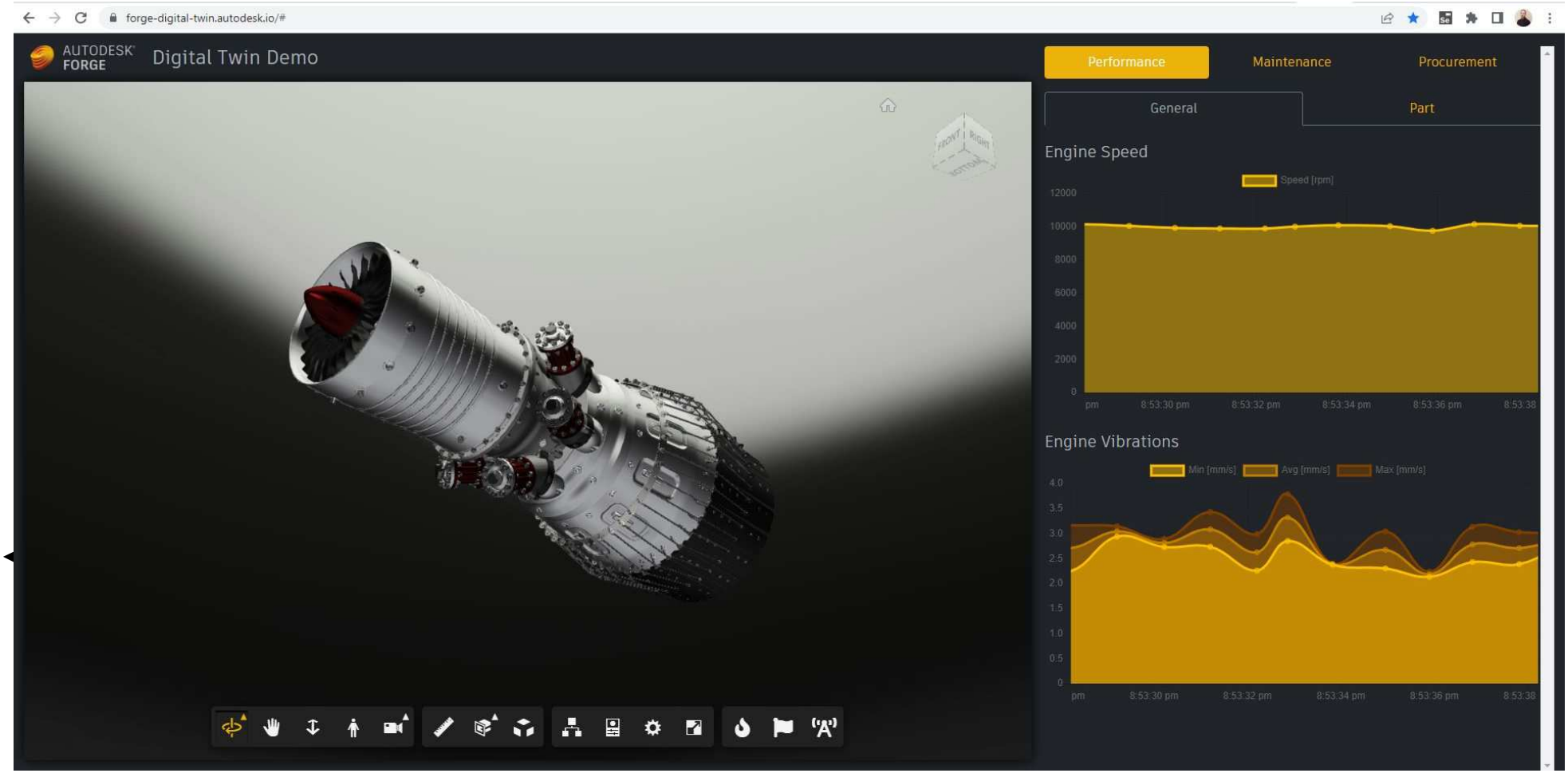
Digital Port of Rotterdam

This digital version incorporates **all manner of data** about the port area, including all **infrastructure objects**, **shipping movements**, **weather conditions** and **hydrological readings**.

The platform is intended to help the port **reduce waiting times** and **optimize** mooring, loading and departure windows.

Demo pages of digital twins - engine

https://forge-digital-twin.autodesk.io/#



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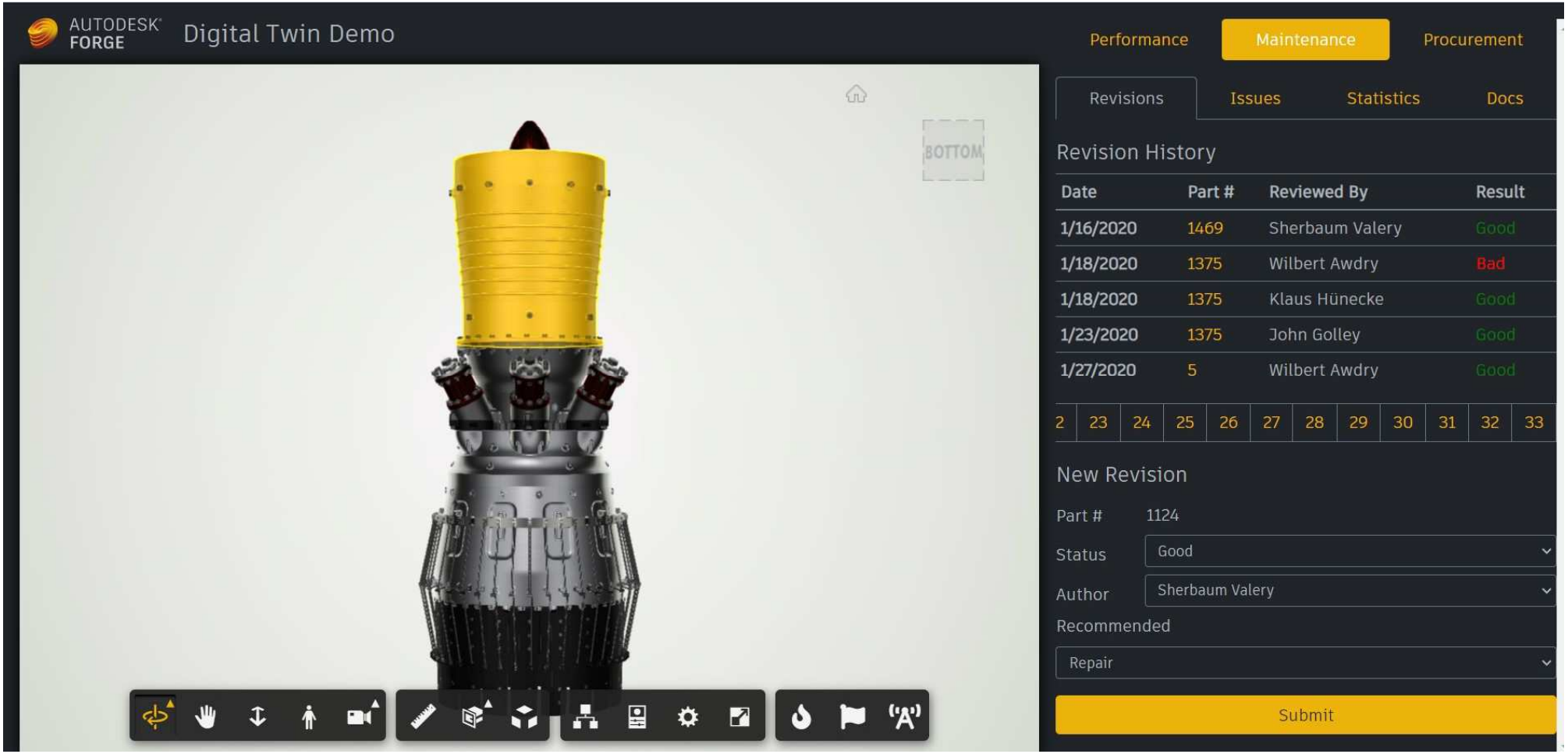
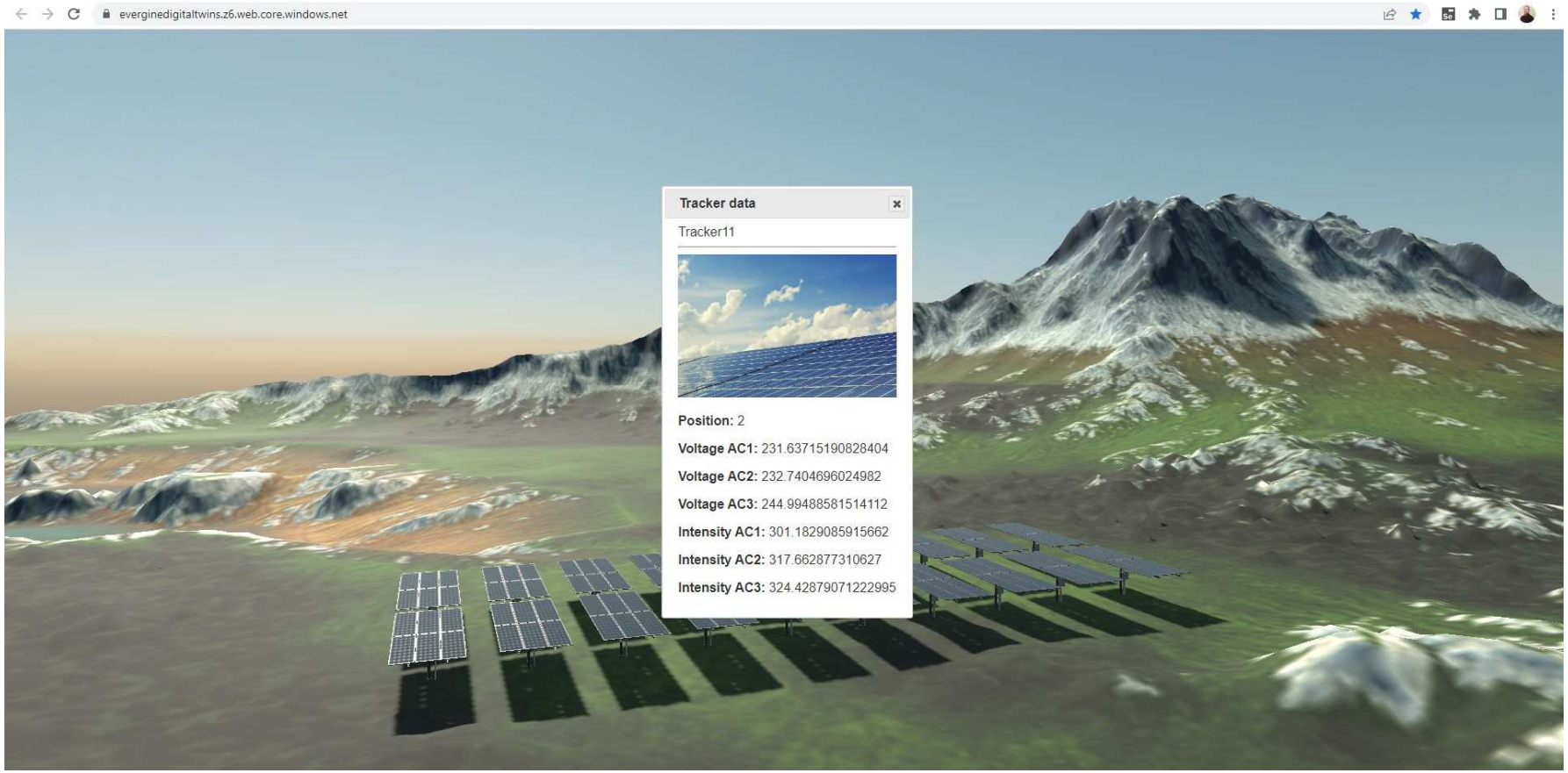


Demo pages of digital twins – solar energy field

https://everginedigitaltwins.z6.web.core.windows.net/



Manual testing of digital twins

1. Validation of data
if the data is **inaccurate** or **incomplete**, it can lead to errors or inaccuracies in the virtual model and in the testing results.

2. Verification of the model
process of checking that your digital twin model is **built** according to the **specifications** and **requirements** that you defined. It involves testing the logic, functionality, and structure of your models, and identifying and correcting any errors or bugs

3. Validation of the model
checking that your digital twin model is **consistent** with the **reality** that they represent. It involves comparing the outputs and behaviors of your models with the reality, and measuring and improving their accuracy and fidelity

Manual testing of digital twins

4. Sensitivity analysis

assessing how the **outputs** of your model **vary** with different values or ranges of the inputs or parameters. It helps you to identify the most influential factors that affect your results, and to optimize your models for different scenarios or objectives

5. Uncertainty analysis

estimating the level of **confidence** or **error** that you have in your outputs, given the **uncertainty** or **variability** in the **inputs**, **parameters**, or **assumptions**. It helps you to quantify and communicate the **reliability** and **robustness** of your models, and to account for any gaps or limitations in your data or knowledge

Manual testing of digital twins

6. Testing integration with existing systems
This can include testing related to **data transfer**, **communication**, and **compatibility**

7. Validation of Standards and regulations
ensure that the virtual model meets the standards and regulations **for the industry**. This can include issues related to **data privacy**, **security**, and **compliance**.

Automation testing of digital twins

Automation testing of digital twins

Demo

https://github.com/maroskutschy/Digital_Twin_Demo.git

Key takeaways

- Digital twins are very interesting topic
- Testing of digital twins is important
- Automation testing of digital twins can be done
- Study digital twins now and be prepared for the future

Q&A

Thanks for your attention