

# How To Test Digital Twins

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# Let me introduce myself

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# Agenda

1. Definition of digital twins
2. History of digital twins
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
7. Automation testing of digital twins + demo
8. Key takeaways
8. Q&A

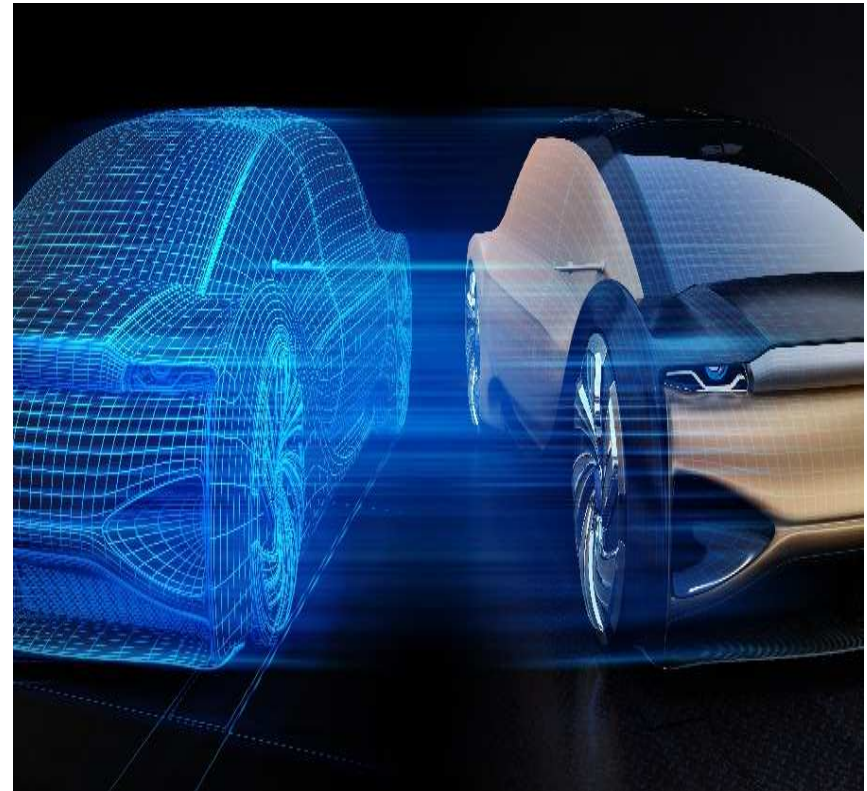
# Definition of digital twins

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

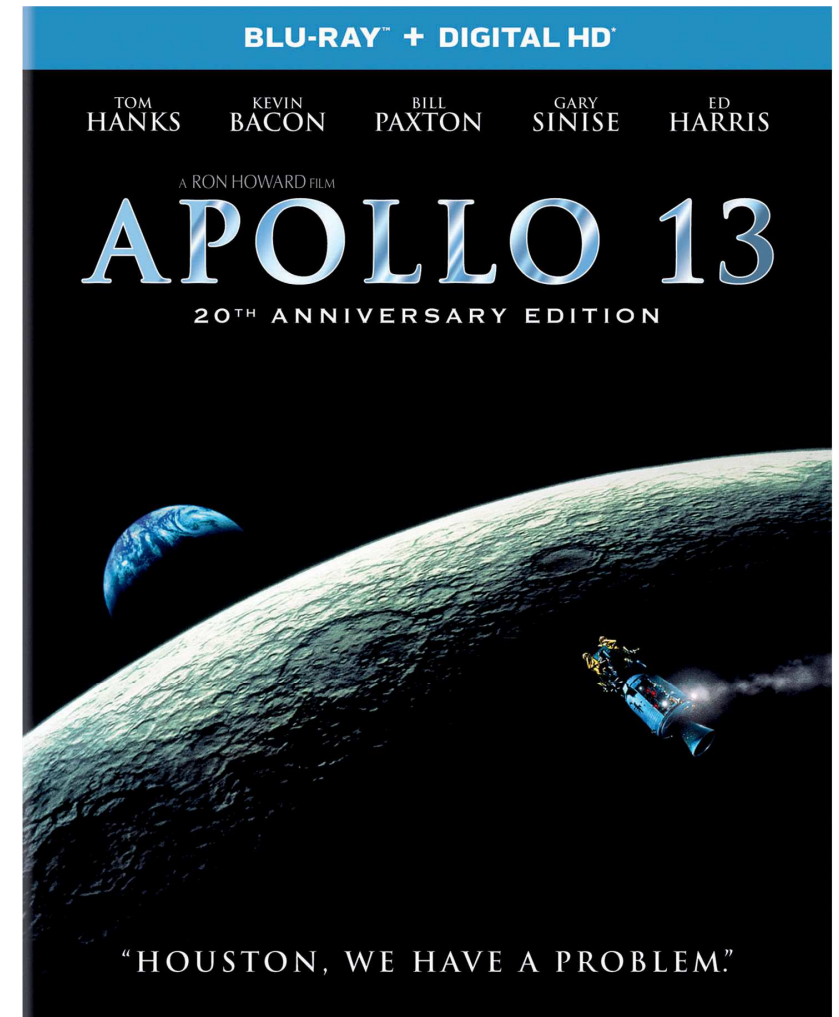


# History of digital twins – Apollo 13

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.

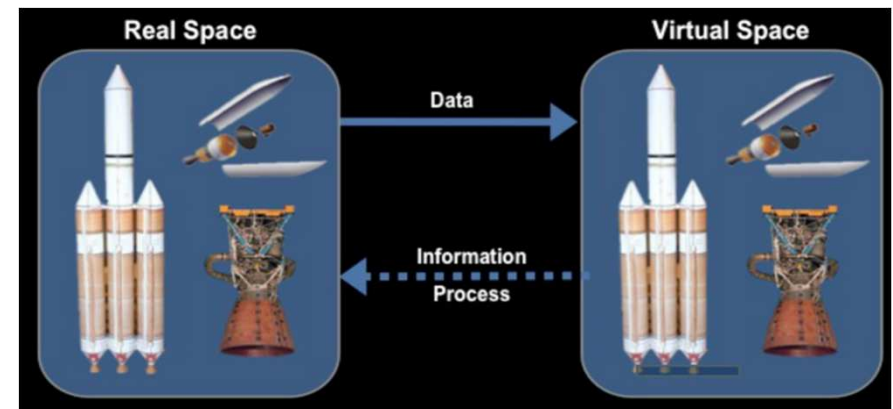
A **key** to the rescue mission, however, was that NASA had a **digital twin model** of Apollo 13 on earth which allowed engineers to test possible solutions from ground level.



# 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

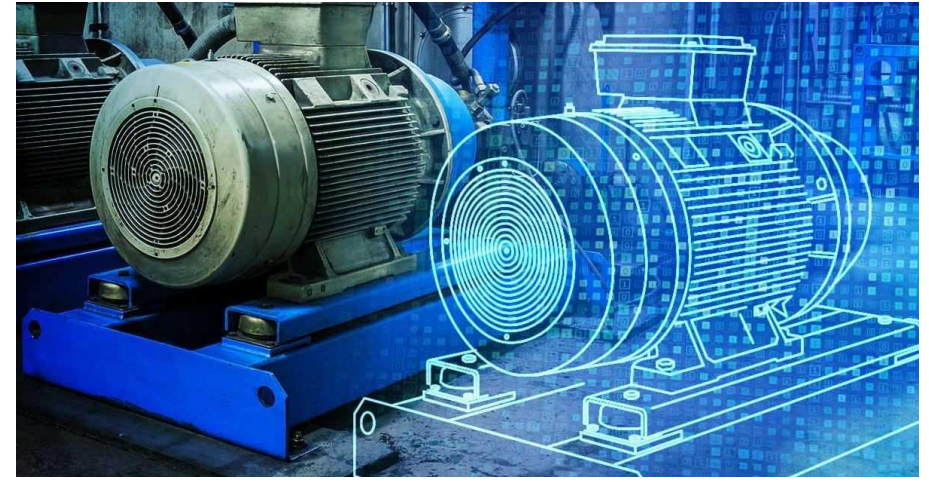
The presentation involved the development of a **product lifecycle management** center. It contained all the elements familiar with the digital twin including; **real** space, **virtual** space and the spreading of **data** and information flow between real and virtual space.



# Examples of industrial sectors where digital twins are used

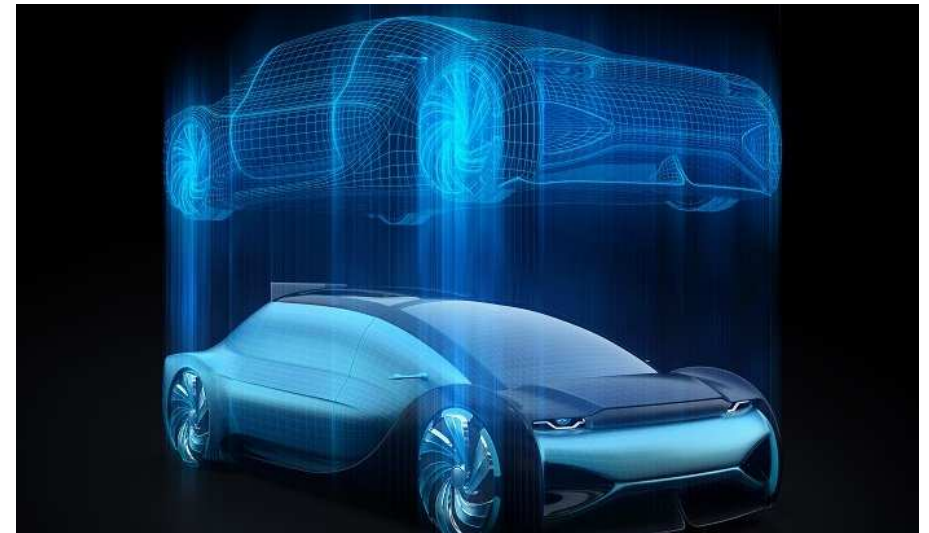
## 1. Manufacturing

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



## 2. Automotive

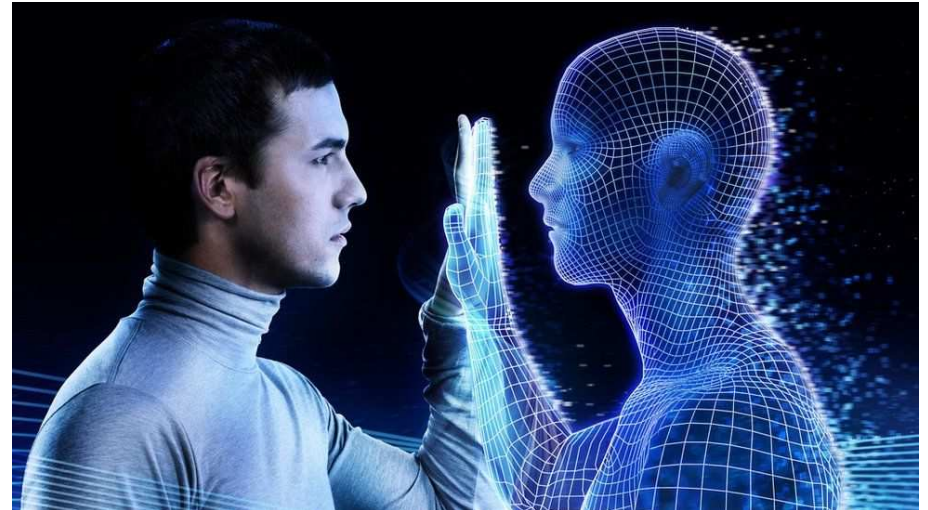
- 3D car **design** and product **development**
- **Autonomous** driving simulation
- Human-machine **interfaces**



# 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



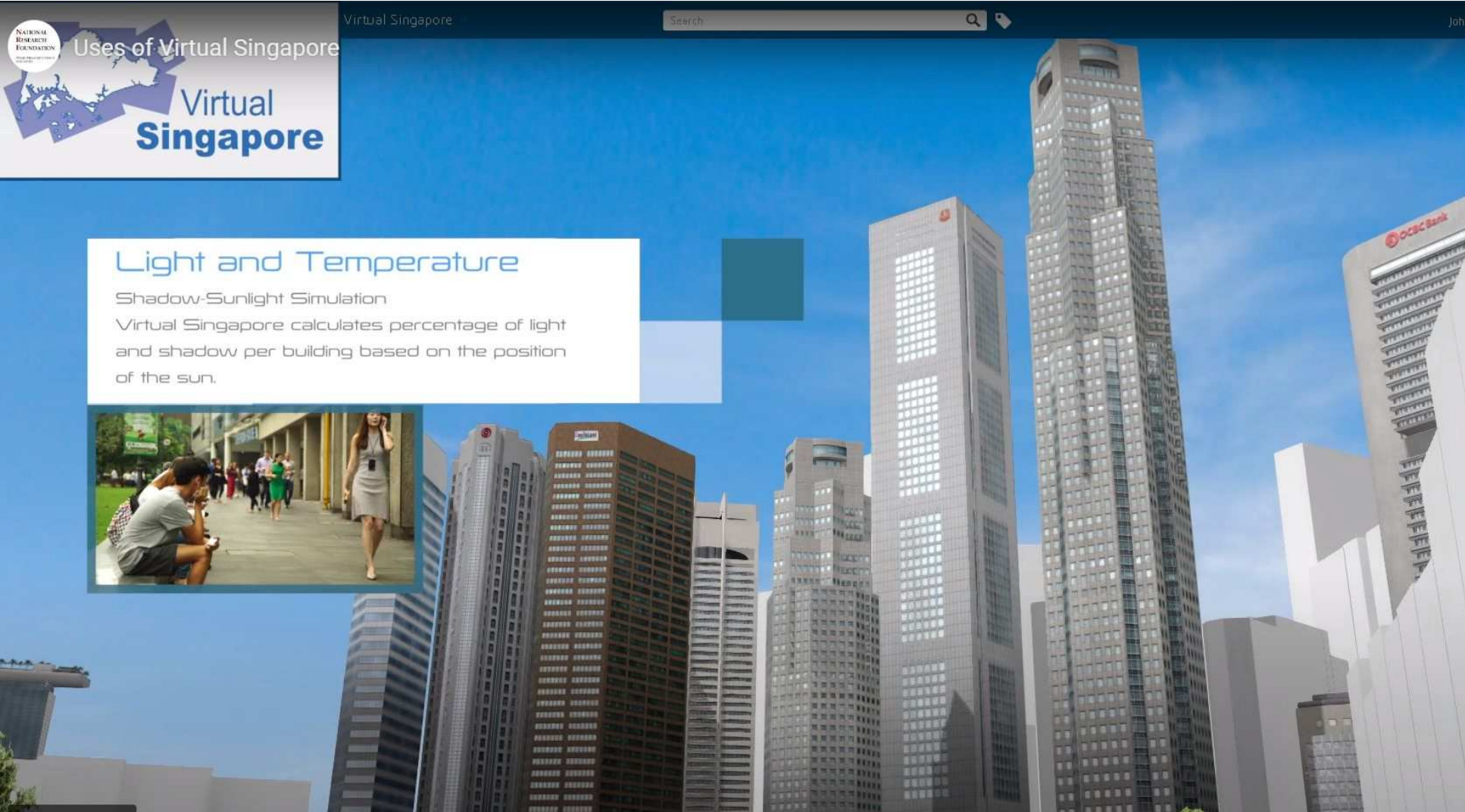
# Virtual Singapore

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



NATIONAL RESEARCH FOUNDATION  
Virtual Singapore

Search


Uses of Virtual Singapore

## Virtual Singapore

### Light and Temperature

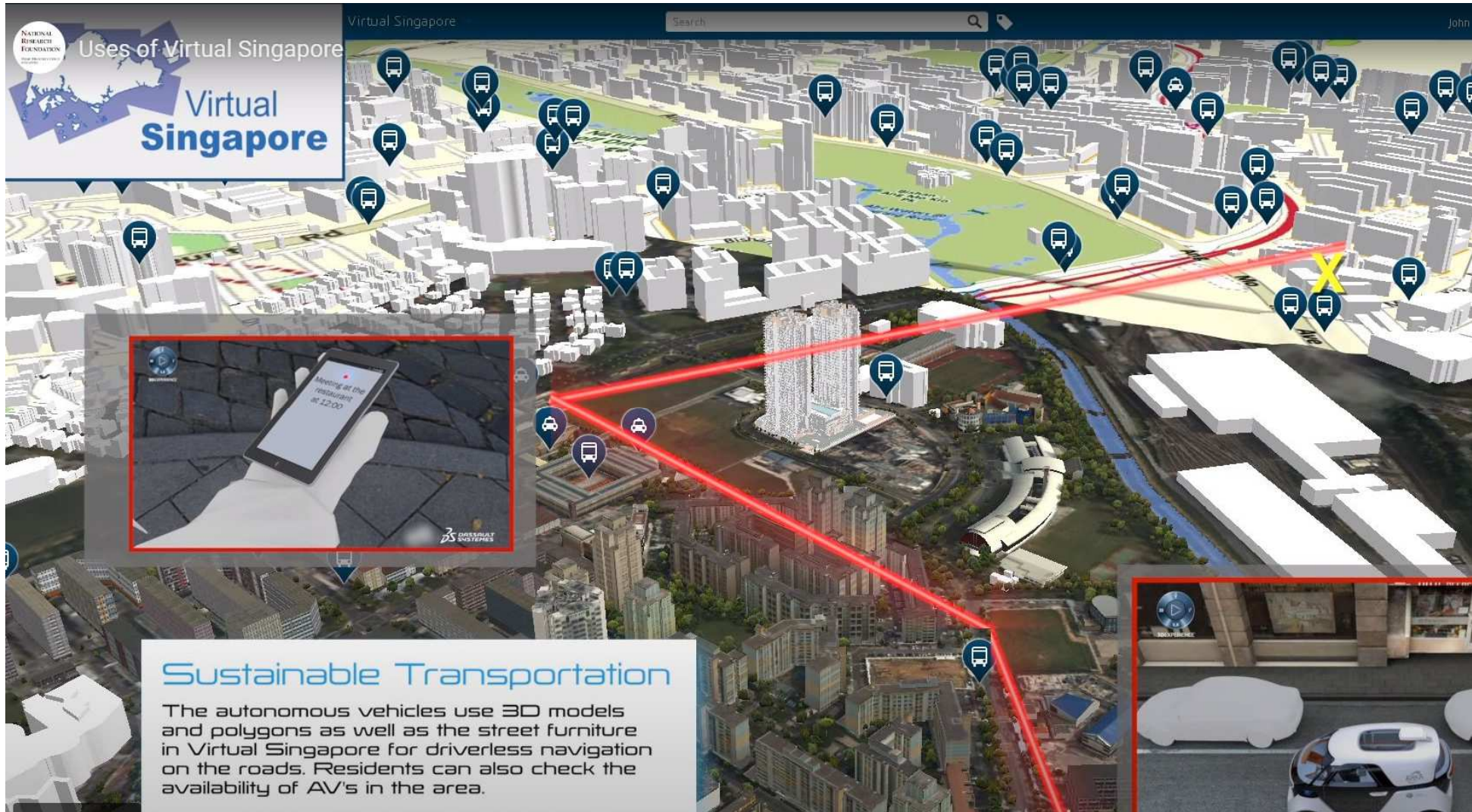
Shadow-Sunlight Simulation

Virtual Singapore calculates percentage of light and shadow per building based on the position of the sun.



The screenshot displays the Virtual Singapore website interface. At the top, there is a dark navigation bar with the National Research Foundation logo, the text 'Virtual Singapore', a search bar, and a user profile icon labeled 'John'. Below the navigation bar, the main content area features a large 3D rendering of a city skyline with several tall skyscrapers. A white text box is overlaid on the left side of the image, containing the title 'Light and Temperature' and a sub-heading 'Shadow-Sunlight Simulation'. The text explains that the system calculates the percentage of light and shadow for each building based on the sun's position. An inset image in the bottom left corner shows a virtual street scene with people walking and sitting on a bench, illustrating the application of the simulation.

# Virtual Singapore



The image shows a screenshot of the Virtual Singapore application. At the top left, there is a logo for the National Research Foundation and the text "Uses of Virtual Singapore". The main interface features a 3D city model with numerous blue bus icons scattered across it. A prominent red line traces a path through the city, starting from the bottom left, moving towards the center, and then curving towards the top right. A yellow 'X' is visible on the path in the upper right quadrant. The interface includes a search bar at the top center and the name "John" at the top right. Two inset images are present: one on the left showing a hand holding a smartphone with a notification that says "Meeting at the restaurant at 12:00", and another on the bottom right showing a white autonomous vehicle on a road.

**Virtual Singapore**

Search

John

NATIONAL RESEARCH FOUNDATION

Uses of Virtual Singapore

Virtual Singapore

Meeting at the restaurant at 12:00

CONSULT SYSTEMS

## Sustainable Transportation

The autonomous vehicles use 3D models and polygons as well as the street furniture in Virtual Singapore for driverless navigation on the roads. Residents can also check the availability of AV's in the area.

# Virtual Singapore

Virtual  
Singapore

## Emergency Services

Gas leaks can be simulated in Virtual Singapore to identify the affected areas to the first responders and prepare escape routes for the residents.



# 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**.

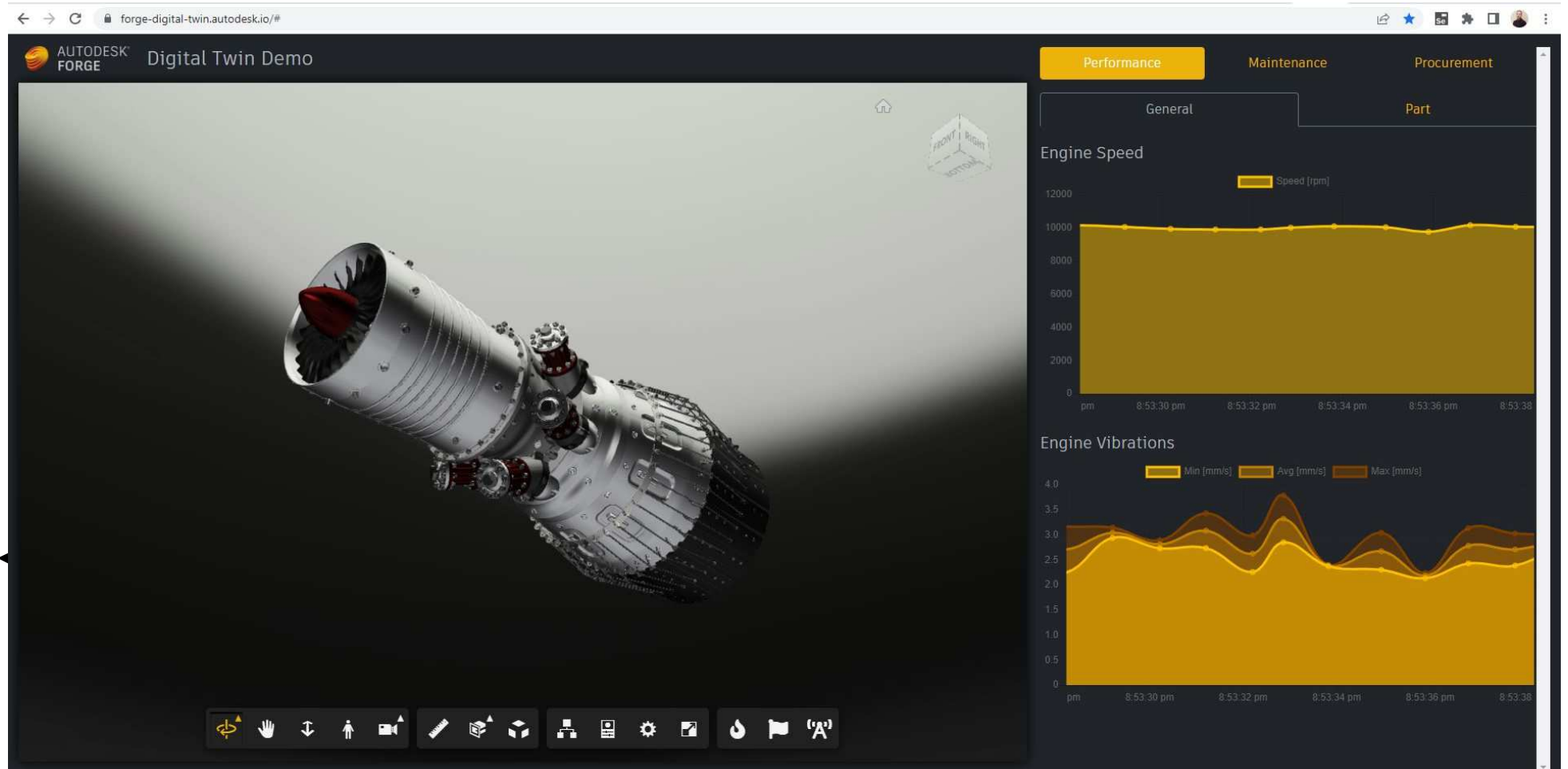
The platform is intended to help the port **reduce waiting times** and **optimize** mooring, loading and departure windows.





# Demo pages of digital twins - engine

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



# Demo pages of Digital Twins - engine

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

AUTODESK FORGE Digital Twin Demo

Performance Maintenance Procurement

Revisions Issues Statistics Docs

Revision History

Date	Part #	Reviewed By	Result
1/16/2020	1469	Sherbaum Valery	Good
1/18/2020	1375	Wilbert Awdry	Bad
1/18/2020	1375	Klaus Hünecke	Good
1/23/2020	1375	John Golley	Good
1/27/2020	5	Wilbert Awdry	Good

2 23 24 25 26 27 28 29 30 31 32 33

New Revision

Part # 1124

Status Good

Author Sherbaum Valery

Recommended Repair

Submit

# 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



Visual Studio Code



ROBOT  
FRAME  
WORK/



Selenium



Playwright



applitools

AI powered Visual Testing & Monitoring

# Automation testing of digital twins

# Demo

[https://github.com/maroskutschy/Digital\\_Twin\\_Demo.git](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