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## Patterns for Digital Twins

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**1.Introduction**

**2.Concerns for twining**

**3.Life cycles**

**4.Patterns and cases**

**5.Way forward**

**The digital/virtual approach is now in the process of being standardized. See ISO, IEC, OMG, etc.**

E.g. ISO 23247 series under development.

**With more or more precise terms and concepts:**

“Digital twin: a **digital representation** of a **particular physical entity or a process** with data connections that enable **convergence between the physical and digital states** at an appropriate rate of synchronization, and provides an integrated view **throughout the lifecycle of the physical entity** or the process that helps to **optimize the overall performance.**”

*[Source: ISO JTC1 — Information Technology.]*

**One of the first twining experimentation:**

For the NASA Apollo program, two equal space shuttles (one in space, one on Earth) were produced to mirror the conditions during the flight.

*(Glaessgen & Stargel, 2012; Boschert & Rosen, 2016; C. Mikinis, 2019)*

### Some problematic interpretations

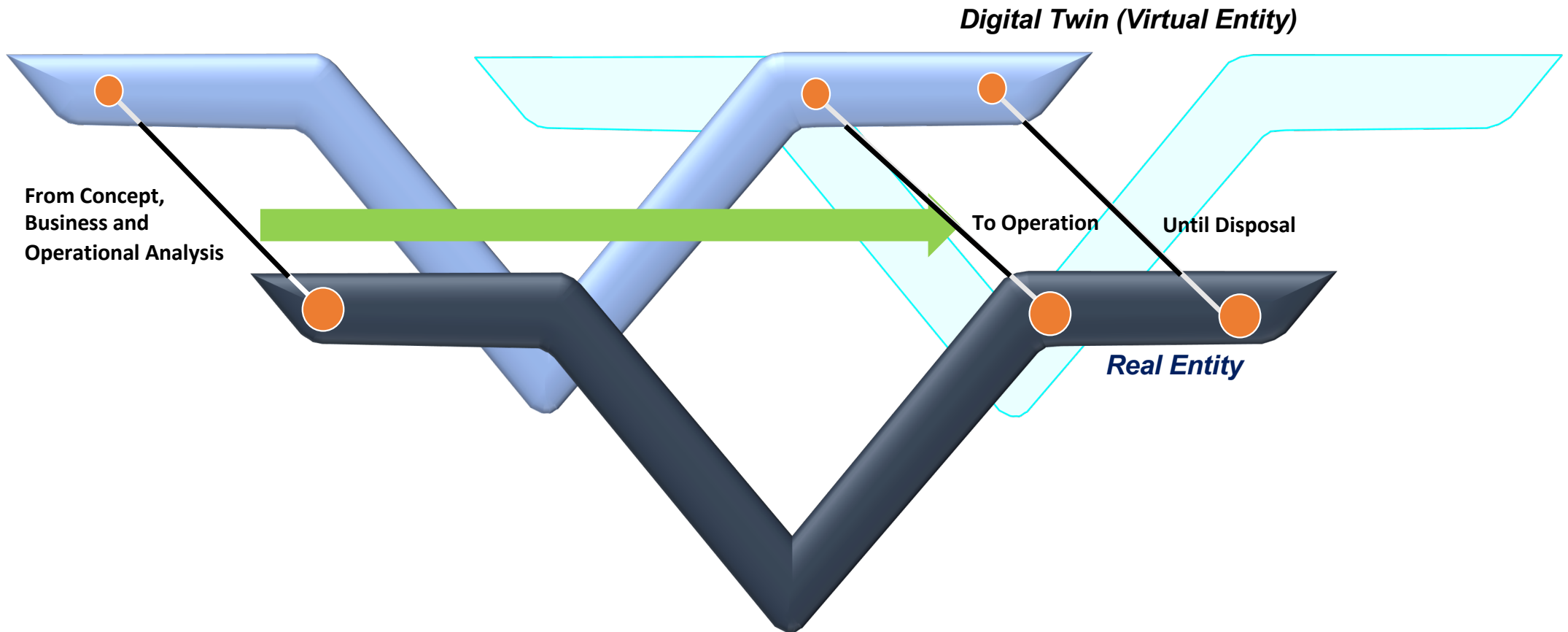
- This is not [only] about a Model-Based and/or simulation approach
- This is not [only] about software
- This is not [only] about digital transformation

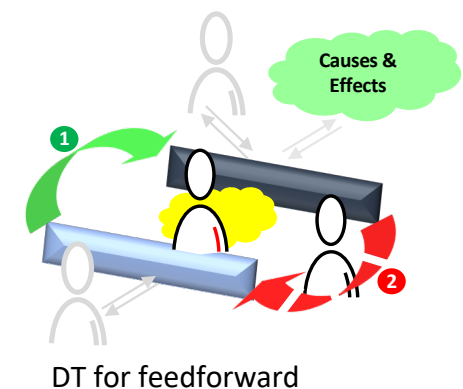
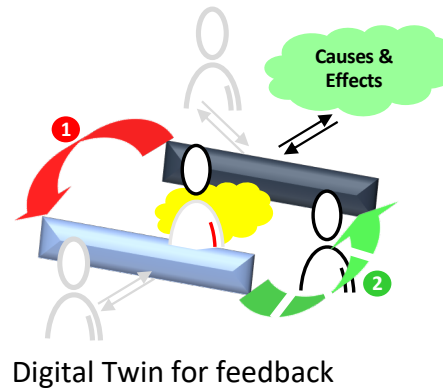
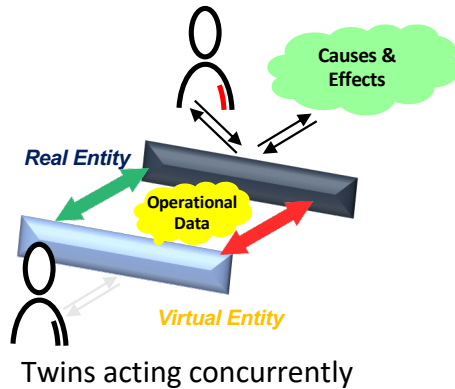


### Some correct interpretations

- A Digital Twin can be a copy of any physical entity
- A Digital Twin can be the representation of an intangible entity
- Twining can be extended to triplex or more copies if/as necessary.

The life cycle of each twin shall be considered: with *Stages and Phases*





## ❖ Business case #1.1: Avatars

- Examples in the space domain
- Training centers with augmented reality
  - Robotics for manufacturing

## ❖ Business case #1.2: complementary activities

- Examples in the space domain
- Human in the command & control loops. E.g. Drone remote control

## ❖ Business case #2.1: Closed loop

- Examples in the space domain
- On-the-move surveillance
  - Power regulation

## ❖ Business case #2.2: Open loop

- Examples in the space domain
- Health and usage monitoring systems (HUMS), with possibly maintenance activities.
  - Diagnostics

## ❖ Business case #3.1: Closed loop

- Examples in the space domain
- Automated command & control
  - Virtual operator(s)

## ❖ Business case #3.2: Open loop

- Examples in the space domain
- Human in planning activities, on the ground segment.
  - Prognosis

- ❖ **Improvement of the foundations**
  - Improvement of DT **Concepts** and **definitions**
  - Define the **non-functional principles** (safety, Security, Human factors) governing DT usage
  - Exploration of new **case studies** to assess **patterns** and possibly define others
- ❖ **Development of methodologies to sustain **Systems Engineering and Architecting** approaches**
- ❖ **Learn from **Products, Services and Systems**, involved in a twining approach**
- ❖ **Development of technical reports and **standards** to formalize the state of the art and specify the DT development and operation domains.**

Questions  
&  
Answers



6th and 7th October

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