Biomedical Digital Twin Components

NASEM Definition of a Digital Twin

"A digital twin is a set of virtual information constructs that mimics the structure, context, and behavior of a natural, engineered, or social system (or system-of-systems), is dynamically updated with data from its physical twin, has a predictive capability, and informs decisions that realize value. The bidirectional interaction between the virtual and the physical is central to the digital twin."

The NASEM report presents several key challenges for digital twins:

1) "Fit for purpose" problems to address,

2) Verification, Validation and Uncertainty Quantification (VVUQ) of dynamic, interacting virtual and physical assets,

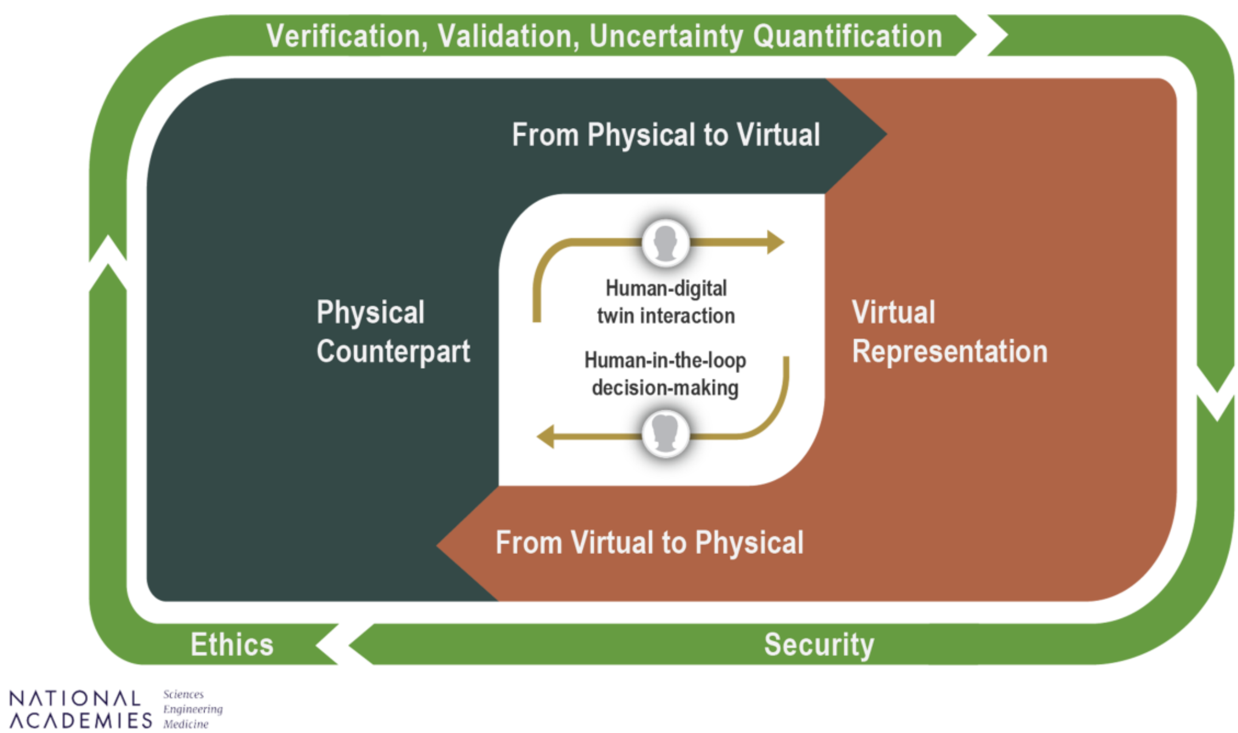
3) Bi-directional, real-time assimilation of measurable data,

4) Interoperability of physical and virtual assets that can be sustained long-term through rapidly changing technologies,

5) Democratizing access of digital twins that are ethical and appropriately used.

[Click here to find full report]

A Digital Twin is More Than Just Simulation and Modeling



Day 1

8:45-9:15am Main Meeting Room	**NASEM Digital Twin Definition and Application to Biomedical Research**	**Speaker:** Caroline Chung **Moderator:** Gary An
9:15-10:15am Main Meeting Room	**Panel Discussion: Unique Features of Biomedical Digital Twins: Examples of Pre-Meeting Exercise #1**	**Moderator:** Caroline Chung **Speakers:** William Lytton, Carlos Lopez, Gary An, Peter Hunter

Fit-for-Purpose Questions when Conceptualizing a Biomedical Digital Twin (BDT)

- What is the problem you are trying to solve?
- How will a BDT solve this problem?
- What makes your BDT realistic?
- What enables your BDT to change and mature over time?
- What is the physical asset?
- What is the virtual asset?
- What information will be passed between the physical and virtual assets in real time?
- What are the ethical issues that must be considered in developing and using this BDT?

Notes: Unique features for the biomedical Domain

10:45-11:45 Breakout Discussion: Apply Fit-for-Purpose to my BDT

What is the problem I'm trying to solve?

How will a BDT solve this problem?
What makes this BDT realistic?
What enables this BDT to change and mature over time?
What is the physical asset?
What is the virtual asset?
What information will be passed between the physical and virtual assets in real time?
What are the ethical issues that must be considered in developing and using this BDT?

Day 1

Part 1: 1:00-1:30pm Part 2: 1:30-2:00pm Main Meeting Room	**Addressing Gaps and Challenges for Successful BDT Implementation - Part 1** **NASEM DT Components - Beyond Fit-for-Purpose** Part 1: Technical Components Part 2: Social Components	**Moderator:** Gary An **Speakers:** Reinhard Laubenbacher, Julian Goldman, Michelle Bennett, Barbara Evans

Major BDT Components based on NASEM definition

- Fit-for-Purpose BDT

Technical BDT Components

- Verification, Validation, and Uncertainty Quantification (VVUQ)
- Mathematical and Statistical Foundations for BDT
- Physical Assets/Data Collection/Sensors
- Virtual to Physical Control Algorithms/Expert in the Loop

Social Components

- Ethical, Security Issues
- Team Science Approach, Governance

Notes: Unique features for the biomedical Domain

Day 2

10:45-11:45am Main Meeting Room	**Addressing Gaps and Challenges for Successful BDT Implementation - Part 2** Deeper Dive into BDT Components	**Moderator:** Julia Berzhanskaya **Speakers:** Natalia Trayanova, Ralph Smith, Maria Eduarda Montezzo Coelho, Barbara Evans

Major BDT Components based on NASEM definition

- Fit-for-Purpose BDT

Principles around BDT Components

- Fit-for-Purpose BDT problems
- Modularity/Interoperability/Systems of Systems mindset
- Sustainability, regulatory issues
- Data/Knowledge systems

Notes: Tools and resources to address above principles

How does this tool fit biomedical problems at the population level versus at the individual level. What math/stats/computational methods can be used to couple population to individual levels?

How does this tool incorporate mechanistic modeling versus data-driven modeling. What math/stats/computational methods will be used to reflect the biological mechanisms of the system?

What mathematical, statistical, and computational methods can be integrated to represent unique biomedical assumptions, factors and features. Are these assumptions realistic/feasible?