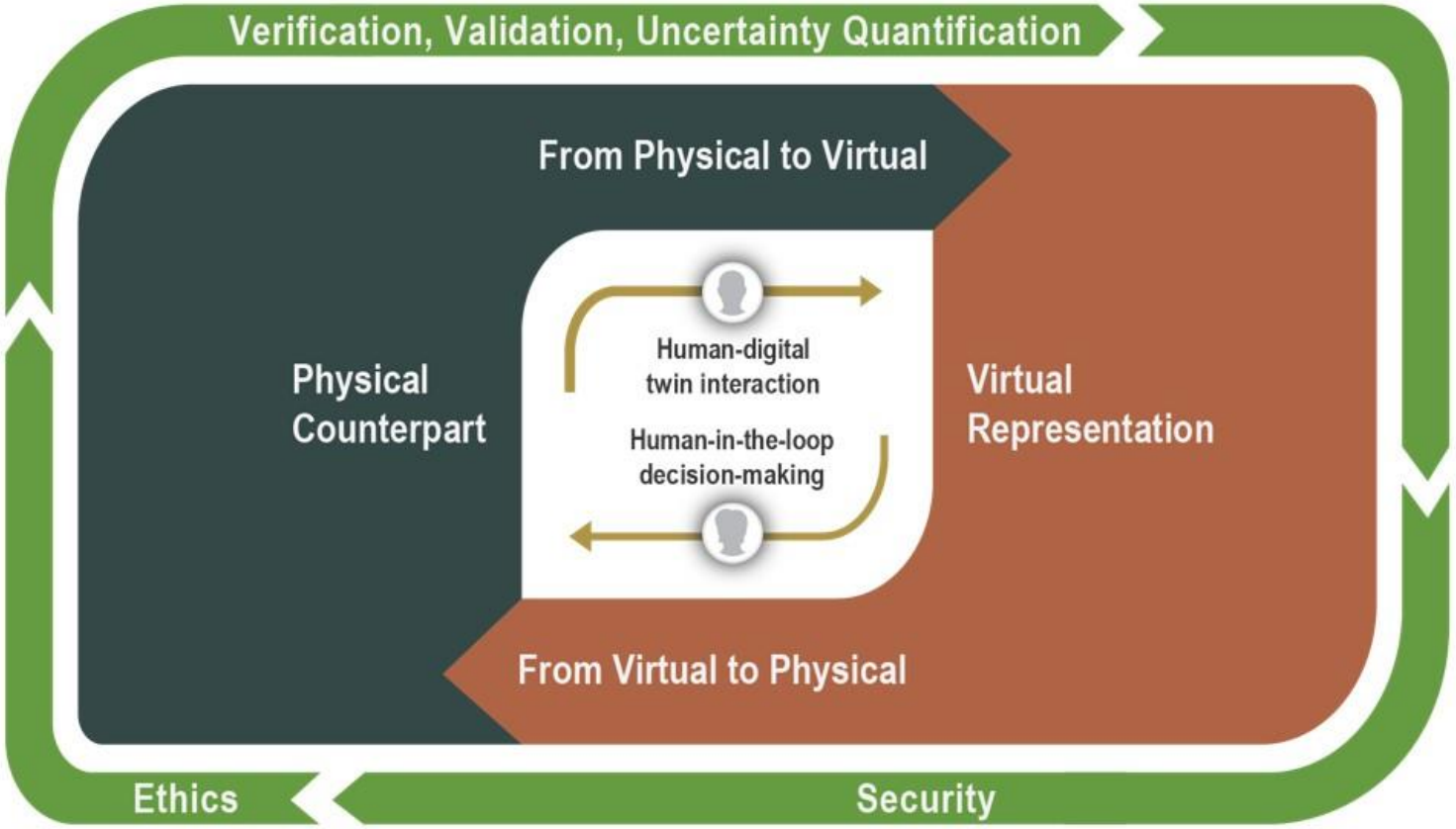
BDT Project: Surgeon Performance Digital Twin

The “Team”
September 30, 2024
IMAG/MSM Teaming4BDT Meeting

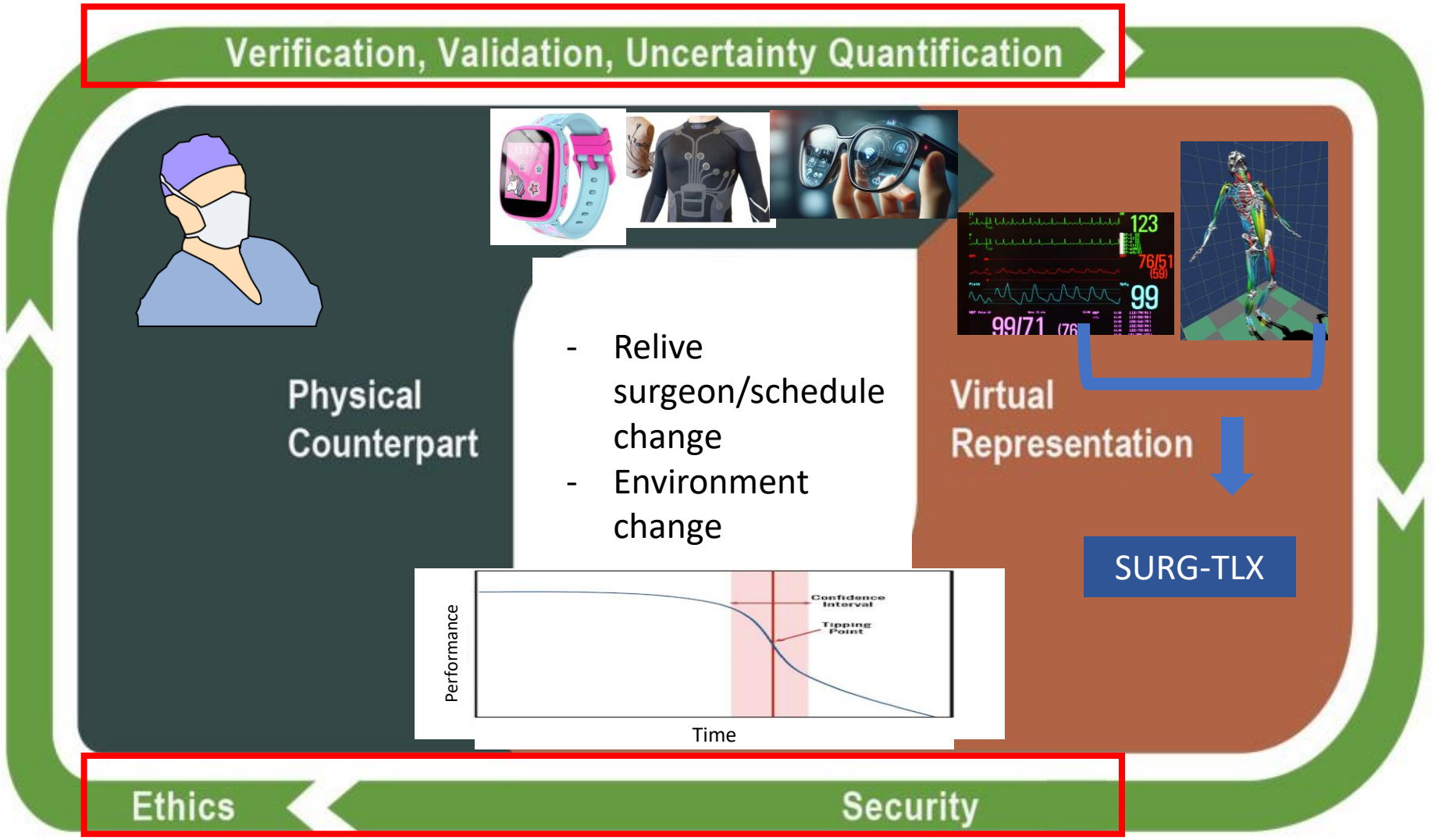
NASEM Definition of a Digital Twin

“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."



A Digital Twin is More Than Just Simulation and Modeling

NASEM Loop: BDT Project Title



Problem and BDT Solution

- What is the problem you are trying to solve: Degradation of surgical performance due to fatigue
- How will it solve the problem: Create a virtual representation of a surgeon that tracks metrics of fatigue
- What makes the BDT realistic: Off line pretraining of sensor outputs and mapping to existing performance scoring in physical simulation environment
- What makes it mature: Ongoing maturation/refinement (retraining of predictive algorithm) with use, able to add new sensors

Physical and Virtual Assets and Their Interaction

- What is the physical asset?: Surgeon
- What is the virtual asset? Data structure/Composition of sensor outputs + Dynamic Parametric Posture Model
- What information is passed between the physical and virtual assets in real time?:
  - Sensor outputs for metrics associated with fatigue level (physiologic monitor, smart glasses, smart textiles)
  - Mapping of output metrics to established scoring system of surgeon performance (SURG-TLX)
  - Forecasting model for time horizon of performance degradation (~30 min interval due to actionability)
- Actionability:
  - Seek surgeon to take over
  - Alter schedule of cases if able
  - Change environment (mitigate distractions)

Ethical Issues and Team Science Considerations

- What are the ethical issues that must be considered in developing and using this BDT? :
  - Personal surgeon tracking
  - Liability: Surgeon and Institution
  - Licensing
- Level of maturity of addressing ethical issues => Fair*
- What are the Team Science considerations?
  - Systems of systems/Multidisciplinary expertise (materials, domain experts, assessment expertise, score development, ethics/legal)
  - Implications for surgical/OR team in deployment

Needed Expertise?

- Expertise in smart textiles
- Neuroscience/cognitive scientists for testing development
- Surgical Education (experience with assessment)
- Ethics/Legal
- Mathematician for VUQ and Forecasting algorithm development (hybrid data-centric/mechanistic)
- Software engineering (UI, UX, Interoperability)

Questions

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