

Digital Twin - Data Science Engine

Gang Mu
Director, Data Science Product Management
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CERN Open Lab

Johnson & Johnson
Innovative Medicine



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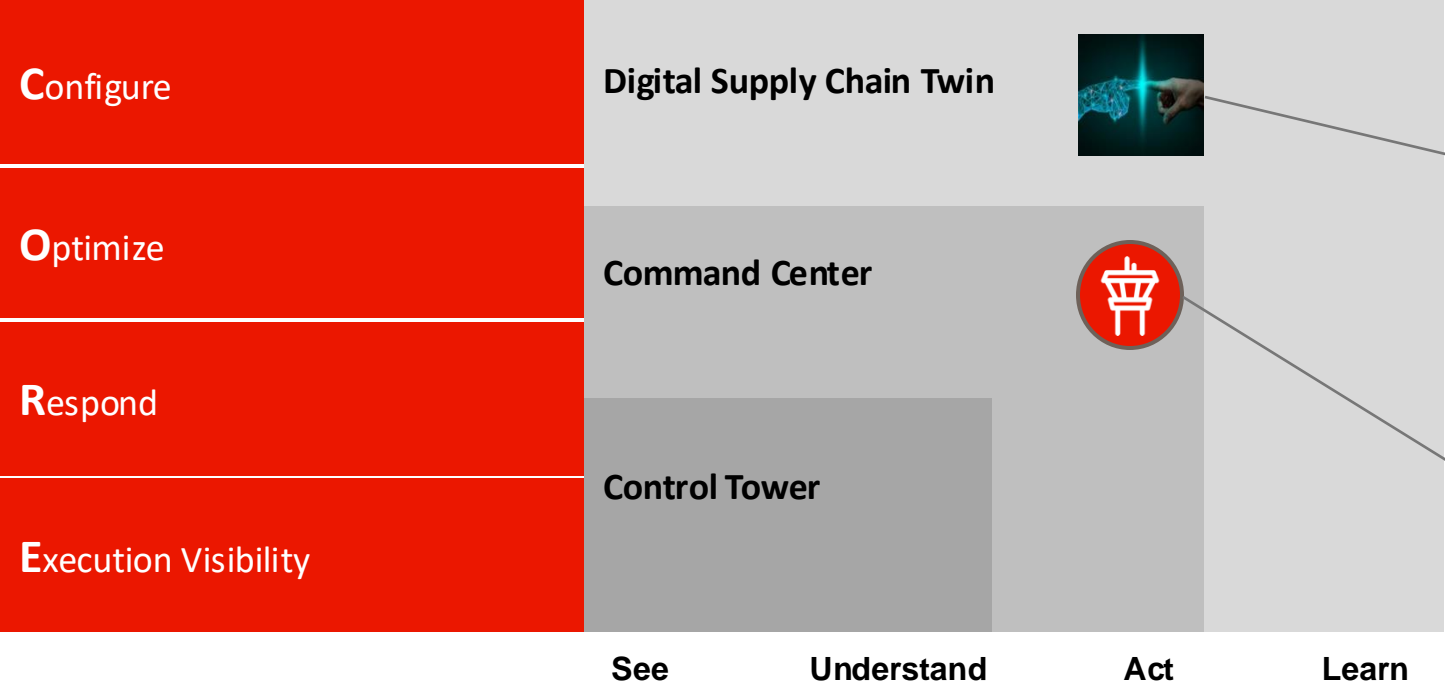
Motivation: Why are we proposing a Digital Twin – DS Engine?

We have a lot of challenges in the Healthcare Ecosystems around the world. As JnJ, we want to continuously leading the industry to use Data Science as an engine that propels us toward new frontiers of innovation while **generating insights to have outcomes** for our patients, from **R&D, Supply Chain, to Patients.**

Outside In perspectives for Digital Twin

And our interpretations

"The command center is an emerging aspiration for organizations aiming to become more connected, converged and orchestrated for increased cross functional process efficiency and decision quality within their ecosystem."

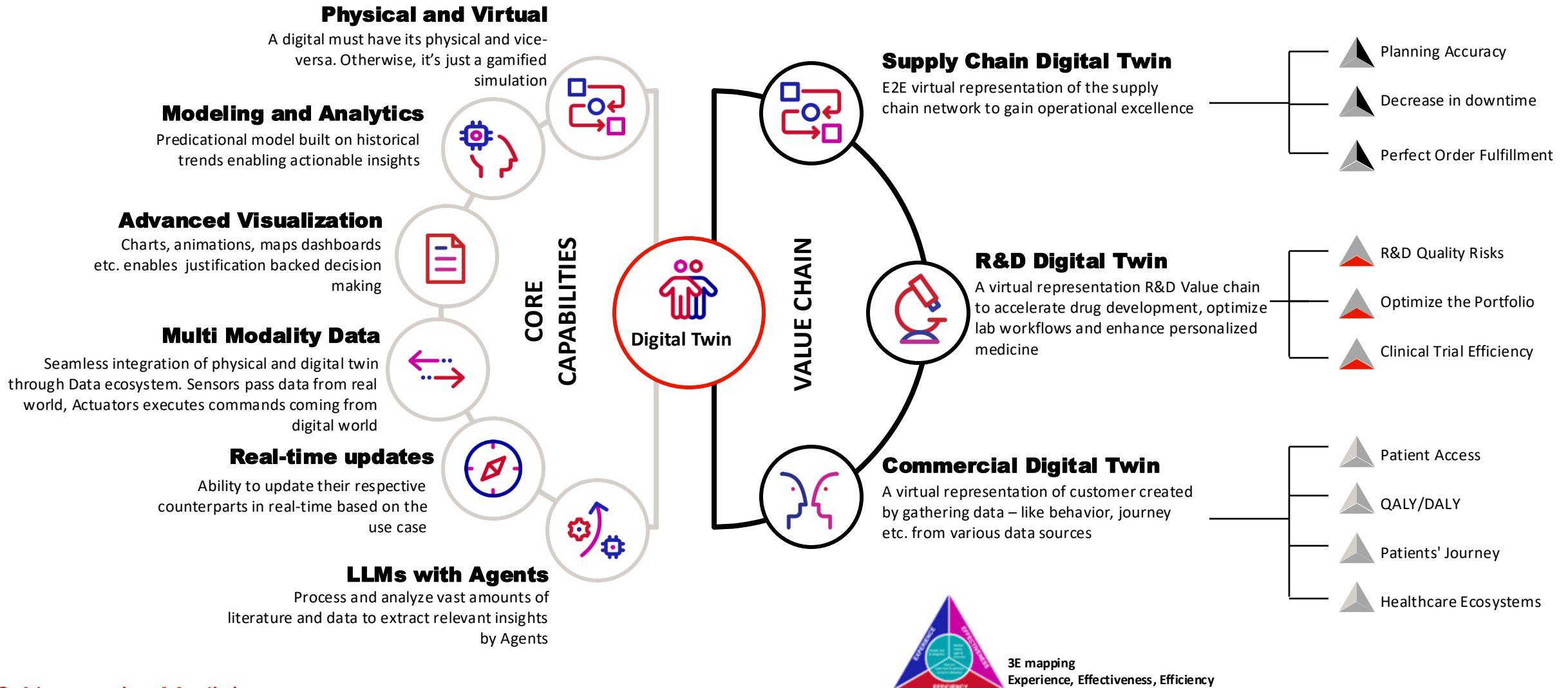


We are shifting the gear to AI use cases generating more insights for decision making support. It is also a chance to leverage the **Digital Supply Chain Twin** to become a **DS Engine** for all digital products across value chain we have.

We believe that the E2E SC Control Tower is a large step into the Gartner Command Center space.

Our Understanding of Digital Twin

Digital Twin has core capabilities spread across the IM Value Chain mapped with 3E's and KPIs



Digital Twin application in Healthcare

From Micro to Macro

R&D



ODEs - A model in Pharmacokinetics
Monte Carlo Simulation - Molecular dynamics, protein folding problem.
LASSO-- estimate the clinical trial outcomes

Digitalized Healthcare



Feature Engineering - Digital treatment on Alzheimer.
Solve PDE from fluid-structure interaction - design cardiac devices

Diagnosis



ML on video: diagnosis of Parkinson's disease
ML on static images -Optical CT images
Inverse problem of PDE - Ultrasound Scan for cancer diagnosis

Healthcare Economics



VaR – Risk Management Framework
Pricing model, American options - investment of new products.
Game Theory – Pricing with biosimilar impact

Partnership



Distributed ML, parameter server - promote cooperation with healthcare companies.
Algebraic geometry,, Yao's Millionaires' problem - protect privacy of patients

Electronic Health Record



ML on EHR collection and normalization.
NLP - information retrieval
Knowledge representation integrate structured and unstructured data.

Precision Medicine



Personalized oncology treatment
Storage and encryption of big data - Collecting and analyzing genomic data
ODEs/PDEs – personalized dosage

Healthcare Administration

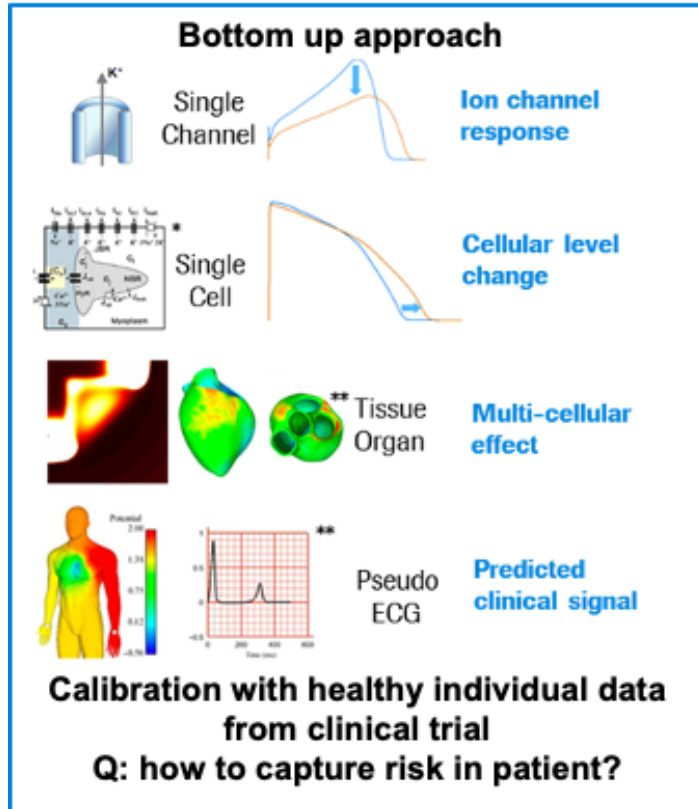


Multiscale calculation - build framework for macro decision making.
Knowledge management: build framework to manage healthcare knowledge

Digital Twin for Cardiac Safety

From single channel to burden of the adverse event

Identify the cardiac risk



Mathematical modeling

Let us begin with the parabolic-parabolic form of the bidomain equations (Keener and Sneyd, 1998)

$$\nabla \cdot (\sigma_i \nabla \phi_i) = \chi \left(C_m \frac{\partial V}{\partial t} + I_{\text{ion}}(\mathbf{u}, V) \right) - I_i^{(\text{vol})},$$

$$\nabla \cdot (\sigma_e \nabla \phi_e) = -\chi \left(C_m \frac{\partial V}{\partial t} + I_{\text{ion}}(\mathbf{u}, V) \right) - I_e^{(\text{vol})},$$

$$\frac{\partial \mathbf{u}}{\partial t} = \mathbf{f}(\mathbf{u}, V),$$

current in the intra- and extracellular spaces respectively.

Pathmanathan, Pras, Miguel O. Bernabeu, Rafel Bordas, Jonathan Cooper, Alan Garny, Joe M. Pitt-Francis, Jonathan P. Whiteley, and David J. Gavaghan. "A numerical guide to the solution of the bidomain equations of cardiac electrophysiology." *Progress in biophysics and molecular biology* 102, no. 2-3 (2010): 136-155.

Digital Twin Approach

Applying Feynman-Kac formula that turns the PDE into PBSDE.

$$\begin{cases} X_t = \xi + \int_0^t b(s, X_s, Y_s) ds + \int_0^t \sigma(s, X_s, Y_s) dW_s, \\ Y_t = g(X_T) + \int_t^T f(s, X_s, Y_s, Z_s) ds - \int_t^T (Z_s)^T dW_s, \end{cases}$$

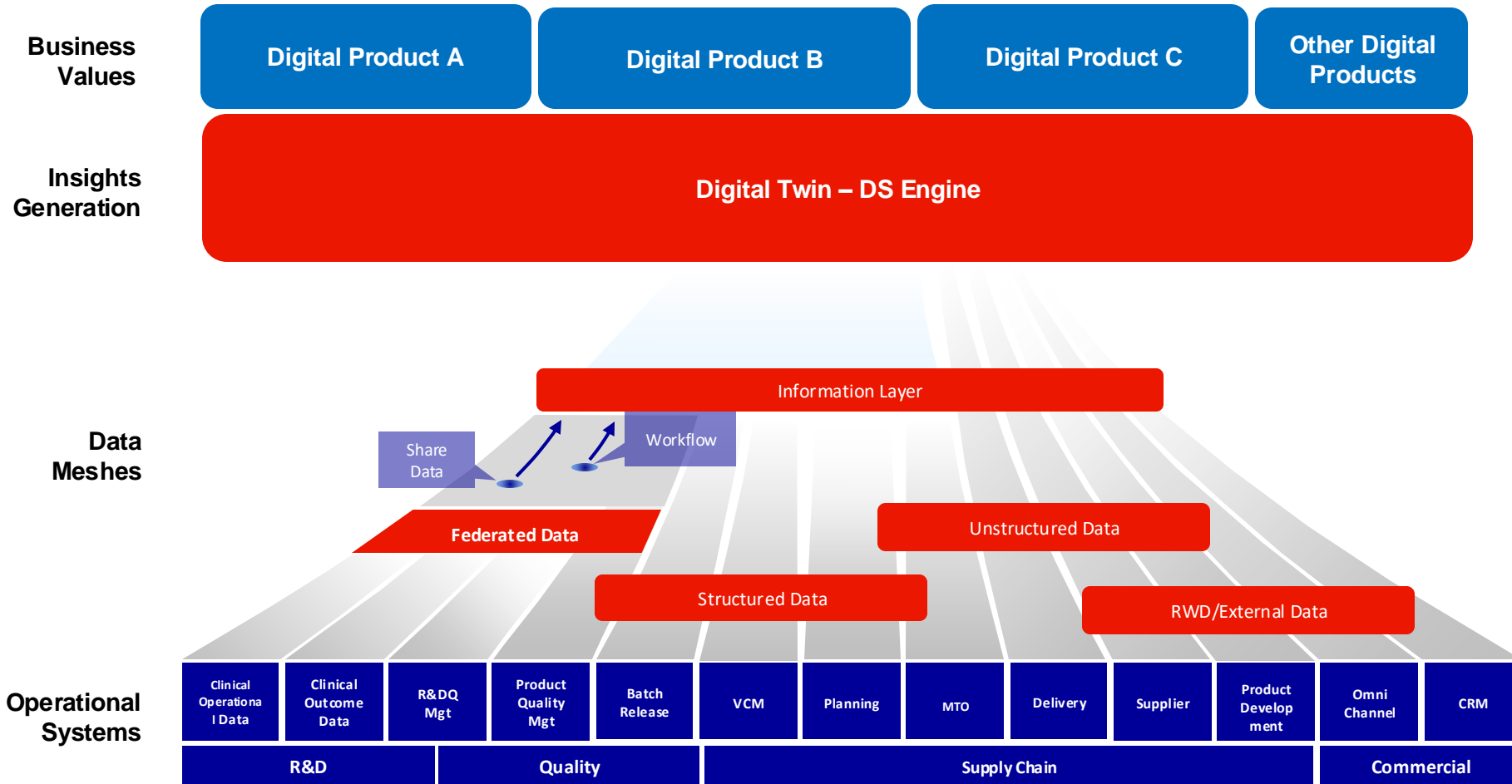
Accelerating the calculation by using the neural network provided by TensorFlow framework.

<https://github.com/frankhan91/DeepBSDE>

Han, Jiequn, and Jihao Long. 2020. "Convergence of the Deep BSDE Method for Coupled FBSDEs." *Probability, Uncertainty and Quantitative Risk* 5 (1): 1-33.

Digital Solution Overview

Joint invest with business customer to develop a use case driven Digital Twin – DS Engine Solution



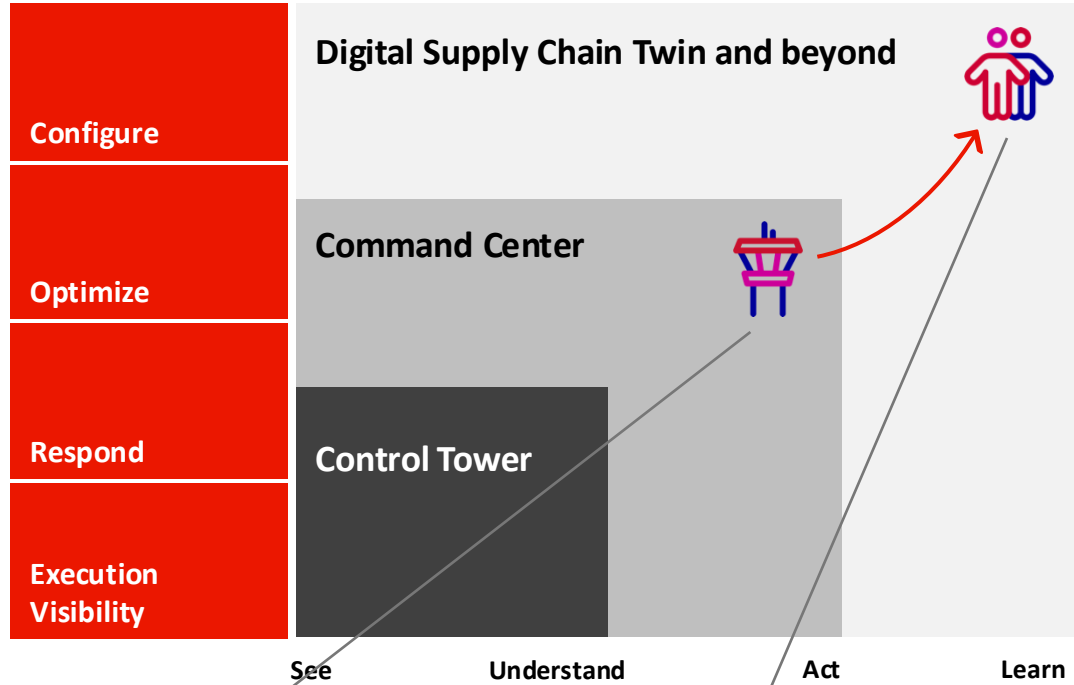
Digital Twin – DS Engine

- is an intelligent solution that utilizes multi-modality data and information spanning across diverse business domains to generate valuable insights for Digital Products within the Innovative Medicine value chain.
- it includes state-of-art DS capabilities empowered by cutting edge technologies, which are driven by real-world business demands and specific use cases.
- it is strategically positioned as an enterprise solution that integrates MLOps, allowing for the seamless reuse of algorithms from repositories.

Multi-year Roadmap

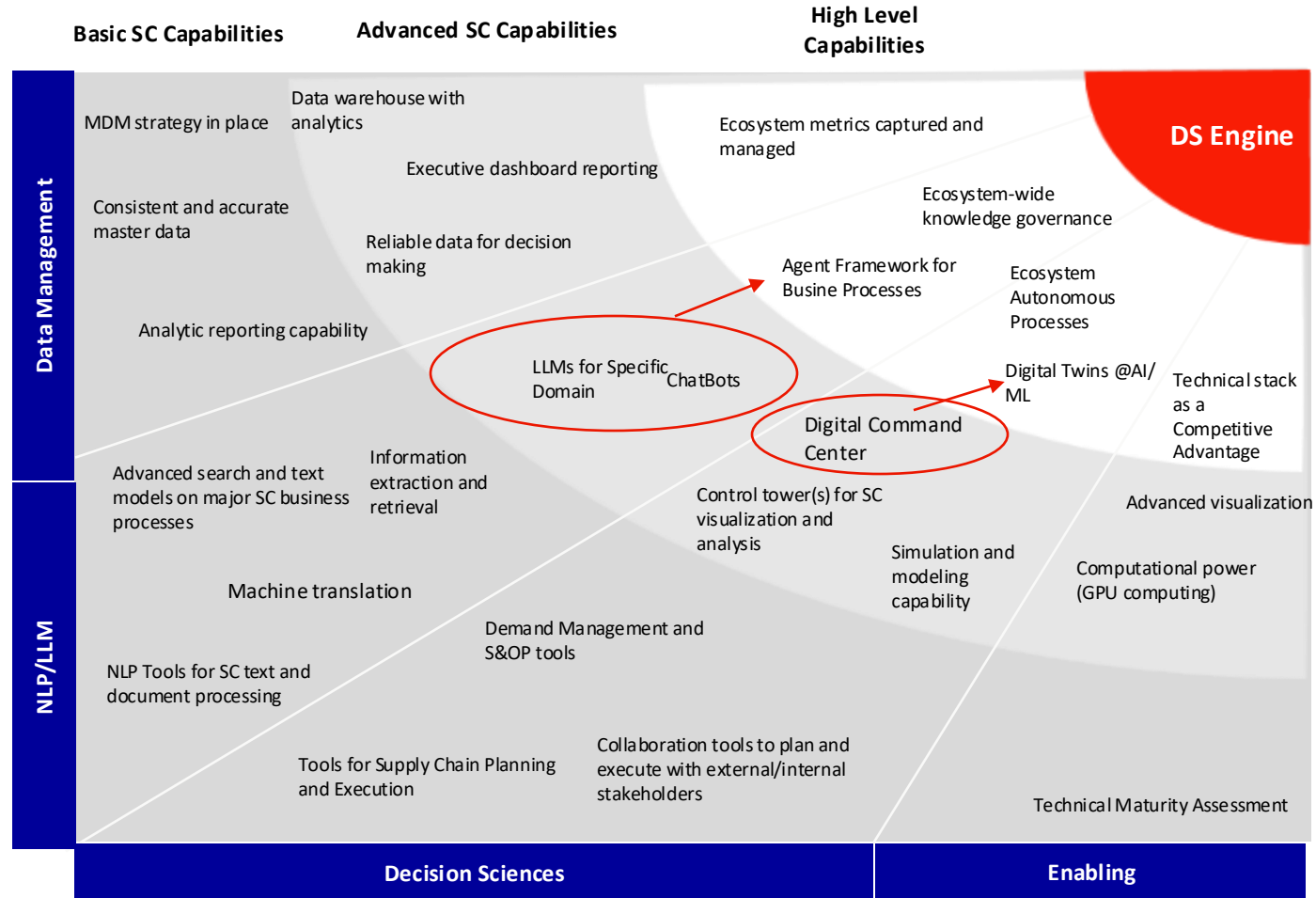
We are eager to leverage open science and open data for our innovation collaborations

Control Tower Evolvement



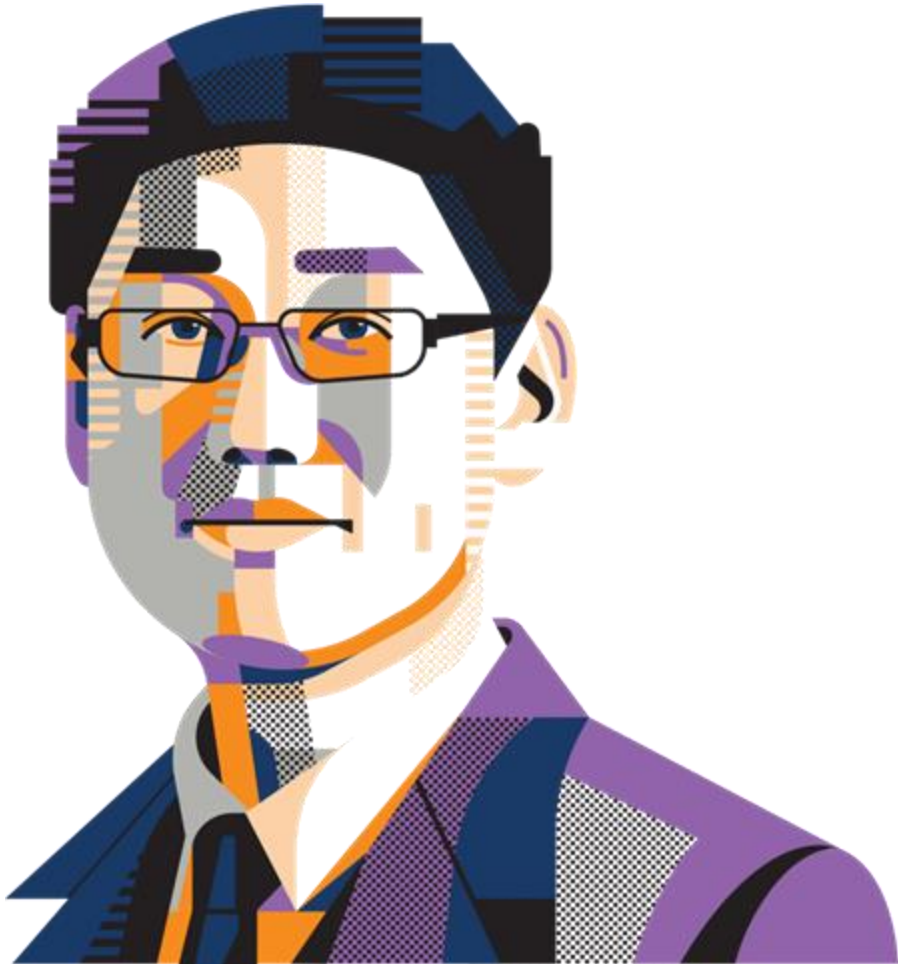
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The Challenge to build a framework to have Digital Twin in the value chain of healthcare?

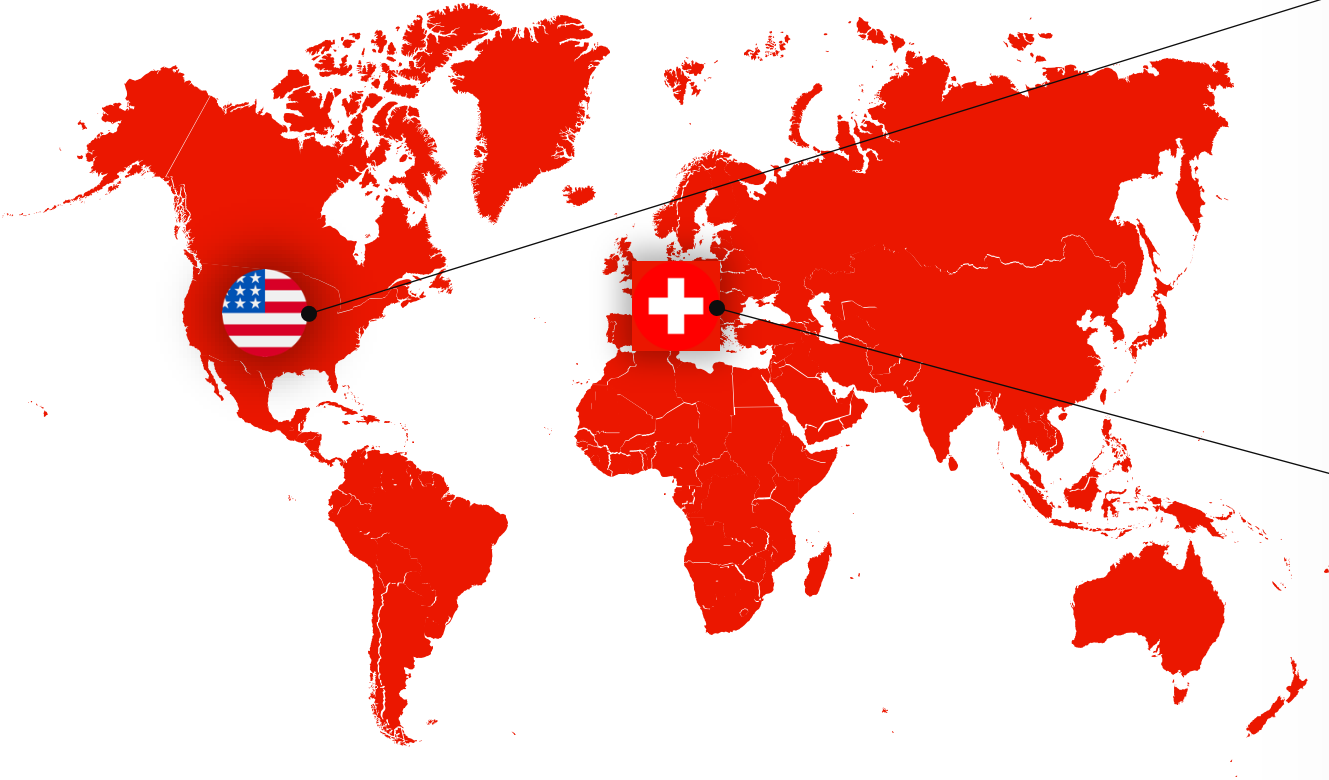
- Business use case development
- The design of the Framework of Open Science and Open Data
- Data Collection and manipulation
- Coupling multiscale problems
- The center of large-scale computing and its implementation



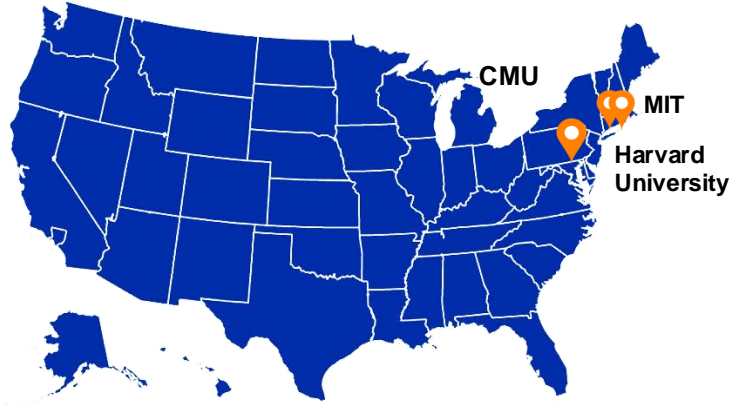
“Let’s have a global Open Science/Open Data Digital Twin community to generate insights for patient impacts”

Academic and Research Network

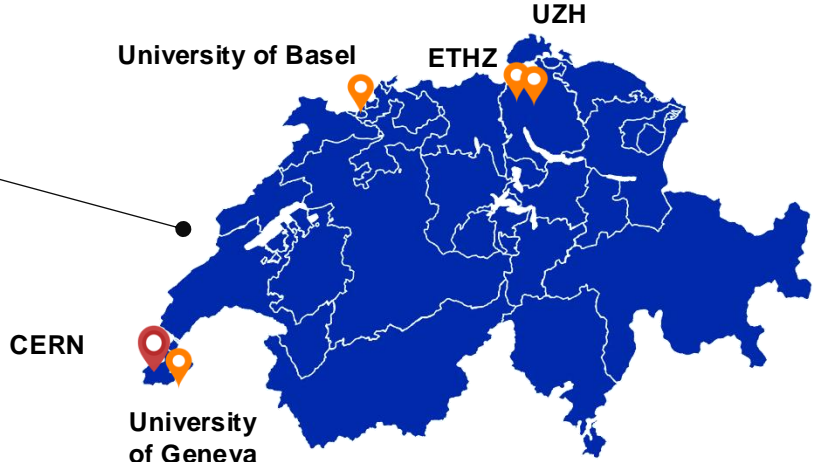
Dual-Hub of Innovation in the US and Switzerland



USA & Switzerland are right now significant players in the field of pharma innovations



USA



Switzerland

Thank you

If you have more questions, please contact:
Gang Mu
gmu6@jnj.com

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