AWS re:Invent

MFG203

Modernizing pharmaceutical manufacturing with IoT and AI/ML

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Moderna

AWS re:Invent

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Process manufacturers want to establish

Better data = better decisions

Innovation—but within existing workflows

Prediction—identifying the process variables that are related to an outcome

Better real-time process modeling, simulation, and visibility

Maximized operator performance



“Manufacturing can and should become a competitive advantage”

Paul Hudson

CEO, Sanofi

Boston Business Journal
Oct 15, 2019

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moderna™

Roland Smith

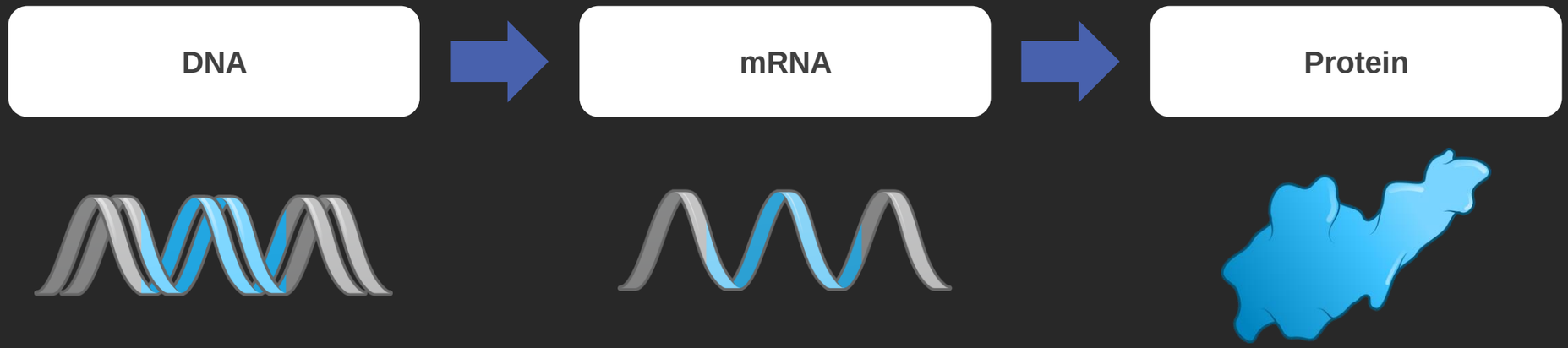
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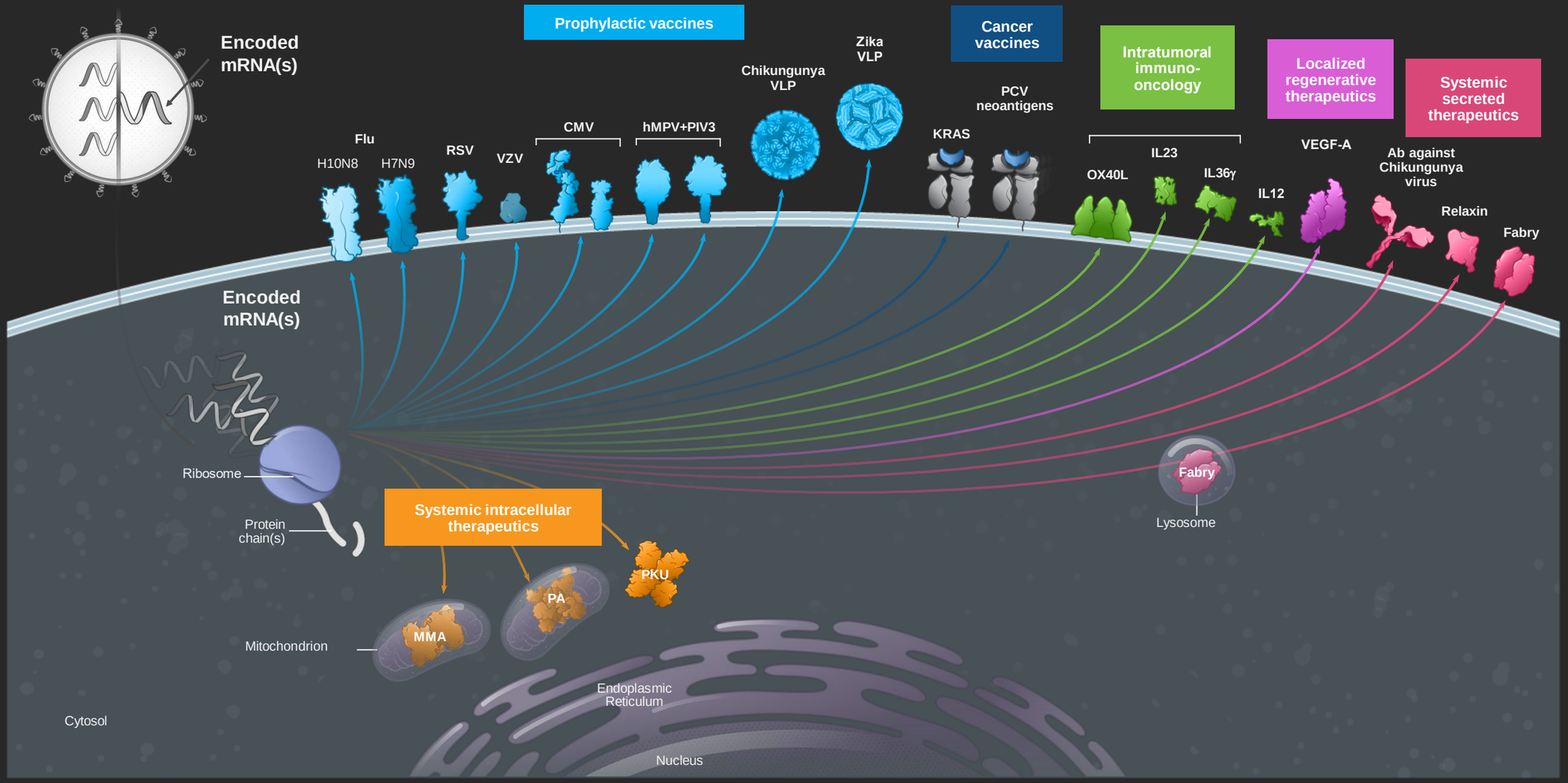
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mRNA—a potential new class of medicines



Our current development pipeline



Norwood “Facility of the Future”

Vertically integrated—Flexible—Native digital

FOYA 2019

Facility of the Year Awards

CATEGORY WINNER

Facility of the Future



How we enable digital

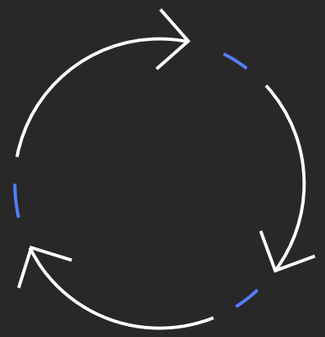


People

Digital Culture

User Experience

Operating Model



Processes

Value Stream Design

Compliance

Lean Principles



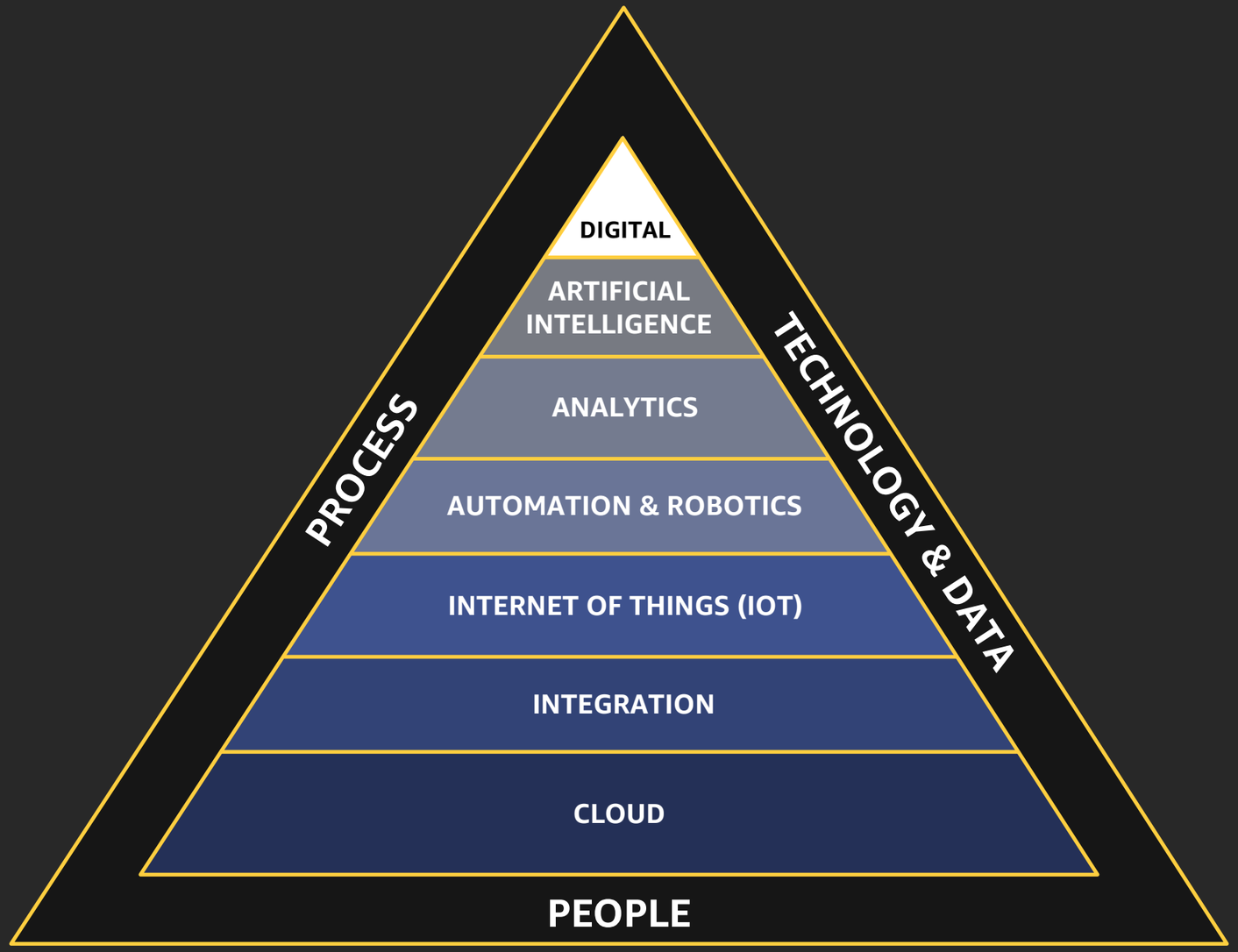
Technology

Data Driven

Future Proof

Innovative

Moderna digital strategy



Brining the power of AWS to the shop floor

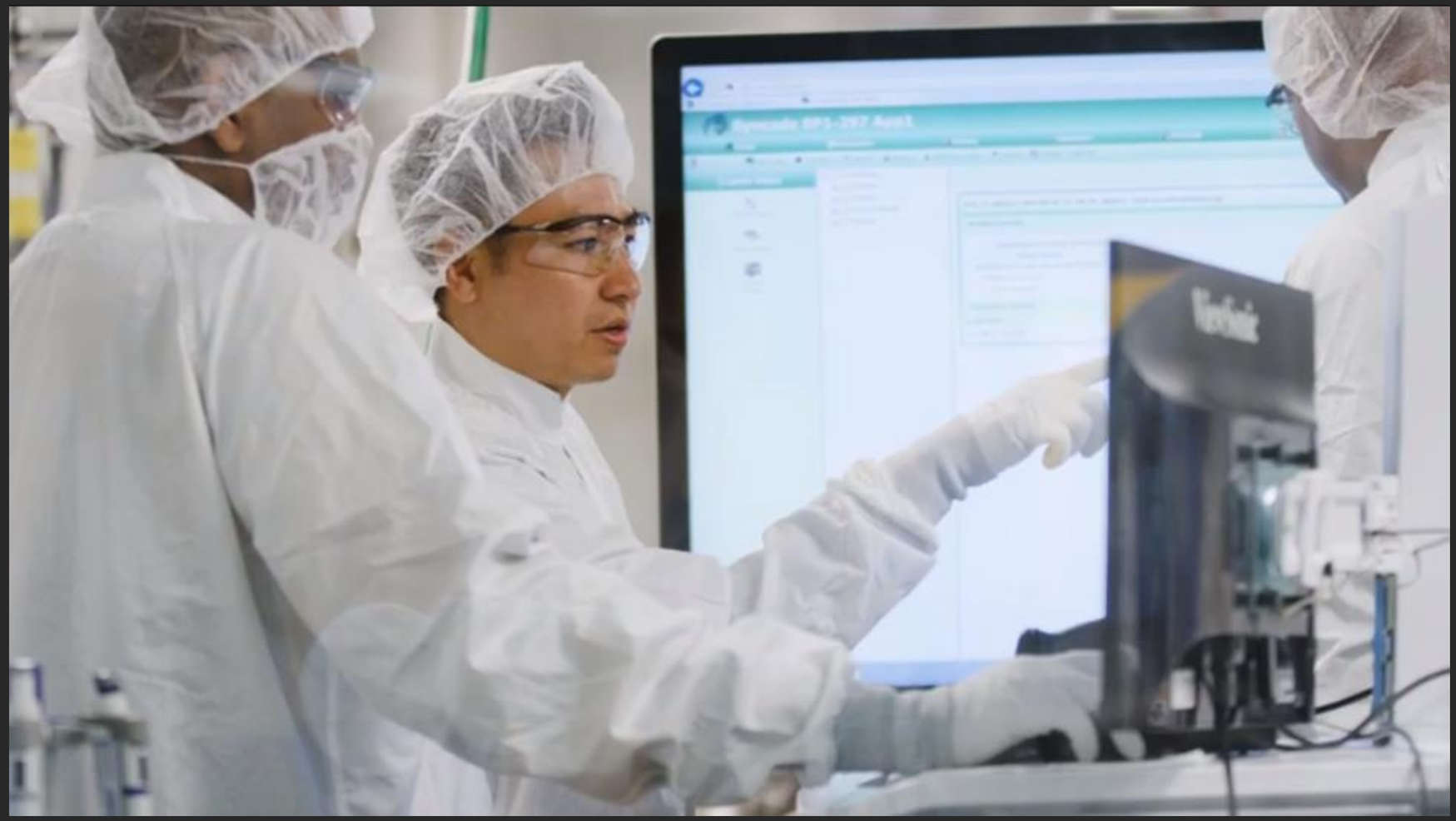
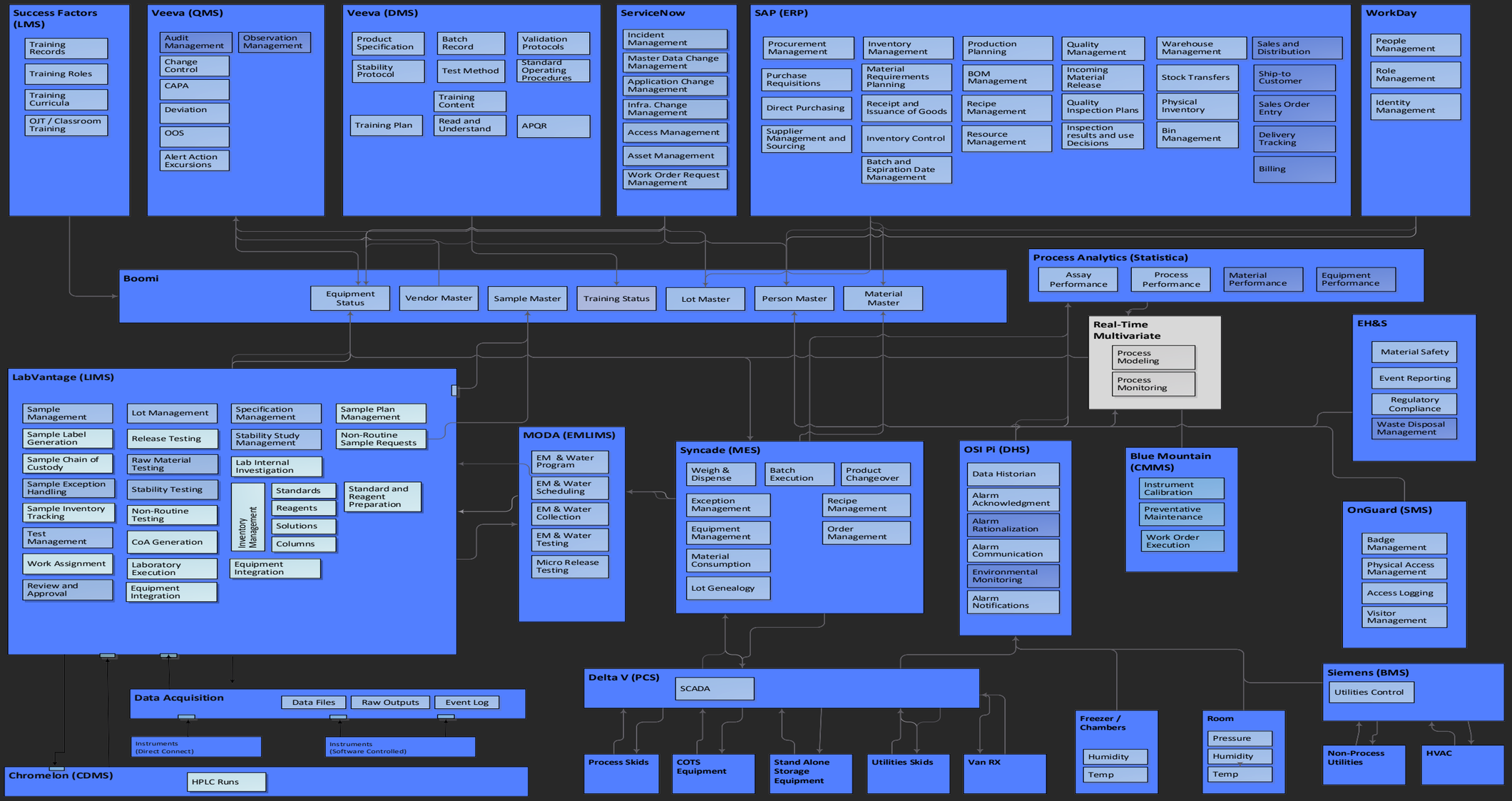
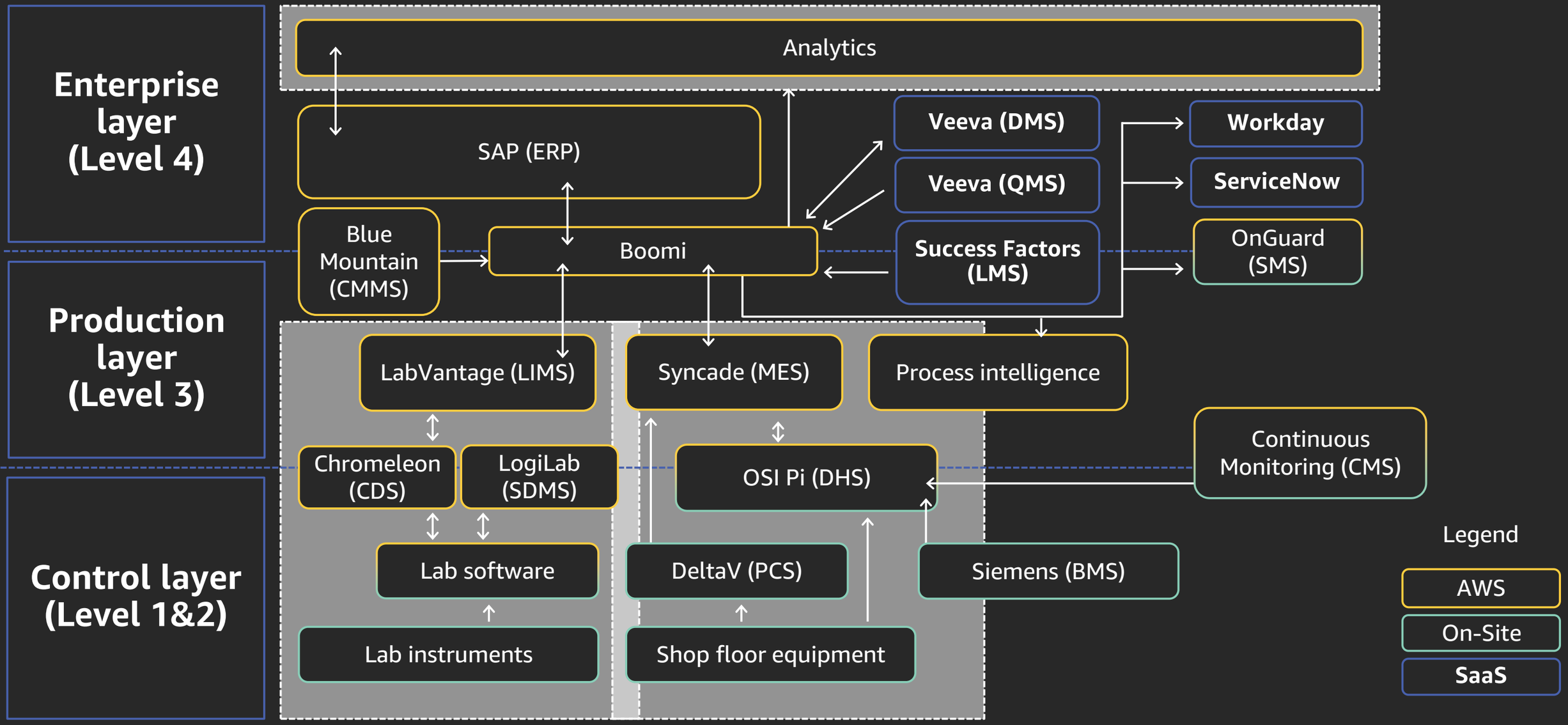


Photo courtesy of Moderna

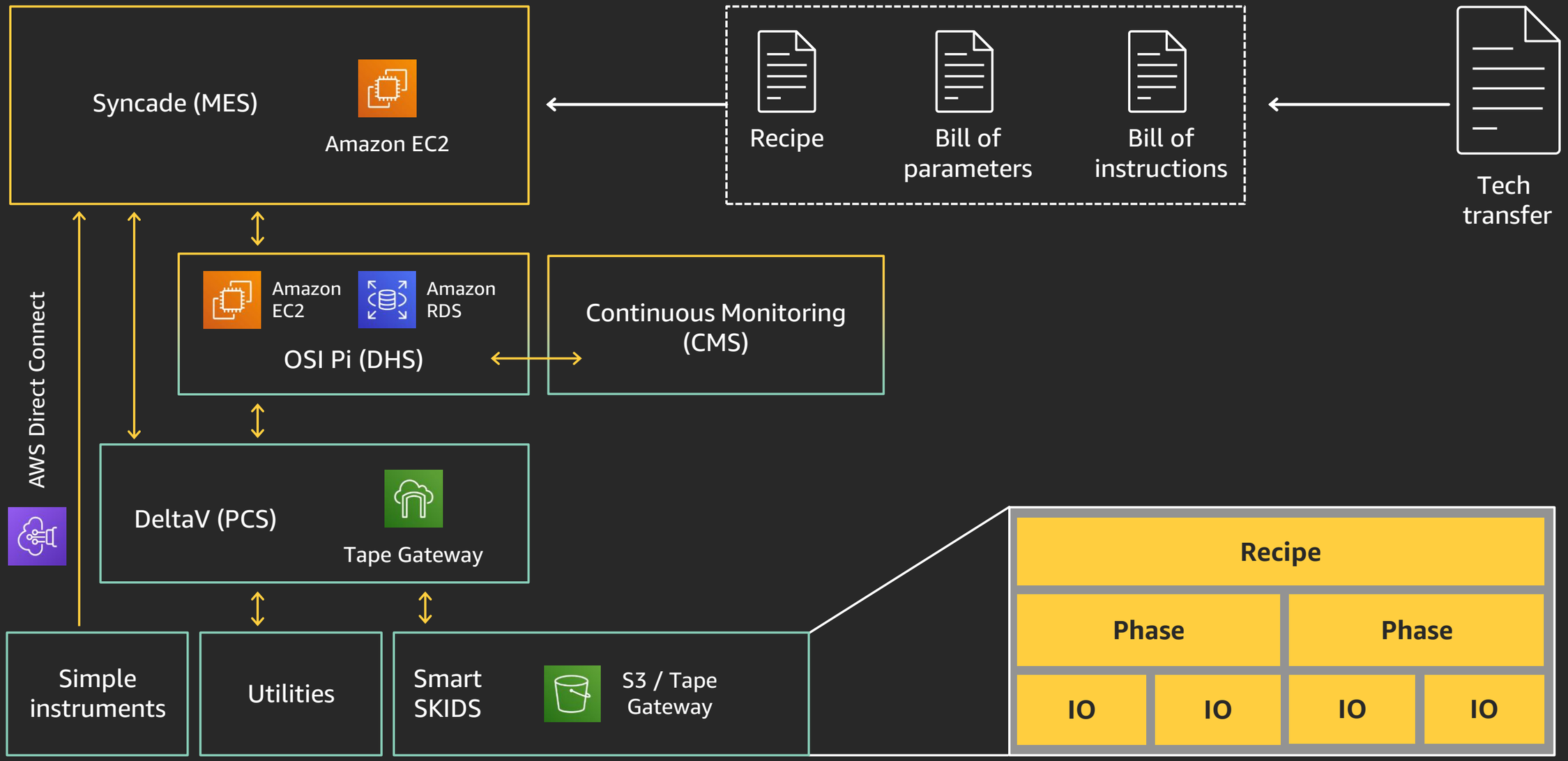
Systems landscape design



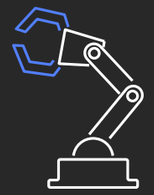
AWS based design



AWS enabled process control



Digital transformation on the shop floor



Equipment



Raw material



QC sample



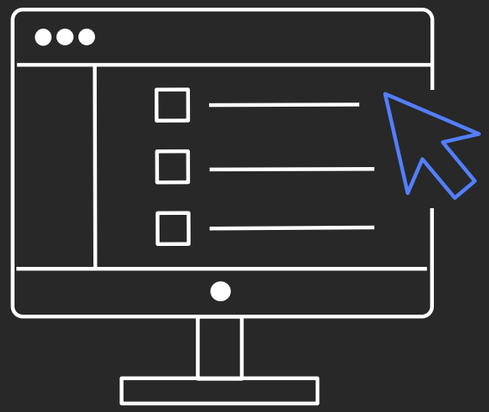
Automated exceptions



Real-time quality review

- **Reduced manual exceptions by 85%**
- **Reduced shift labor by 40%**
- **Reduced batch review from 3 days to 3 hours**





IoT enabling operator centric operations





Transforming the lab benchtop with AWS

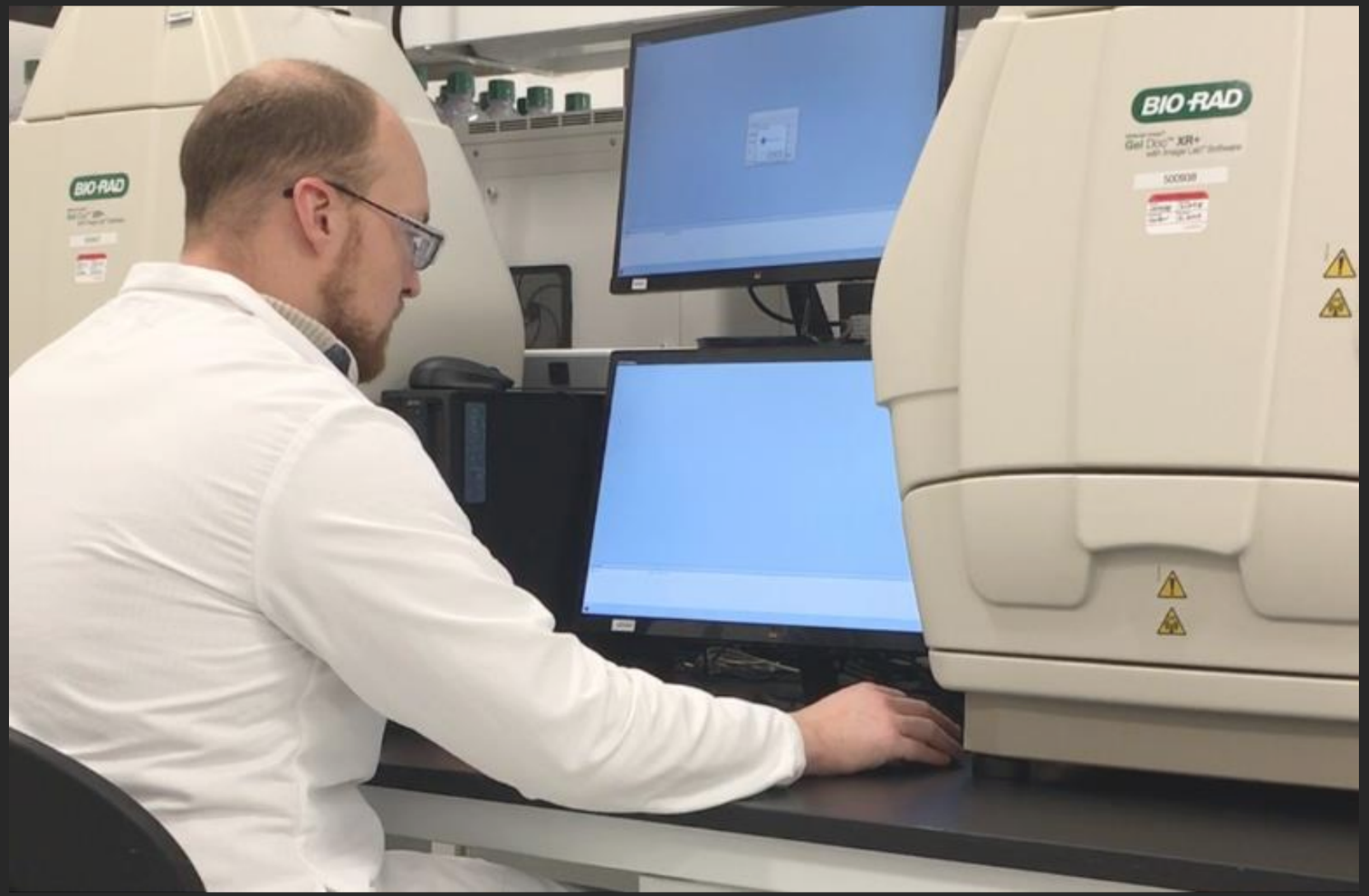
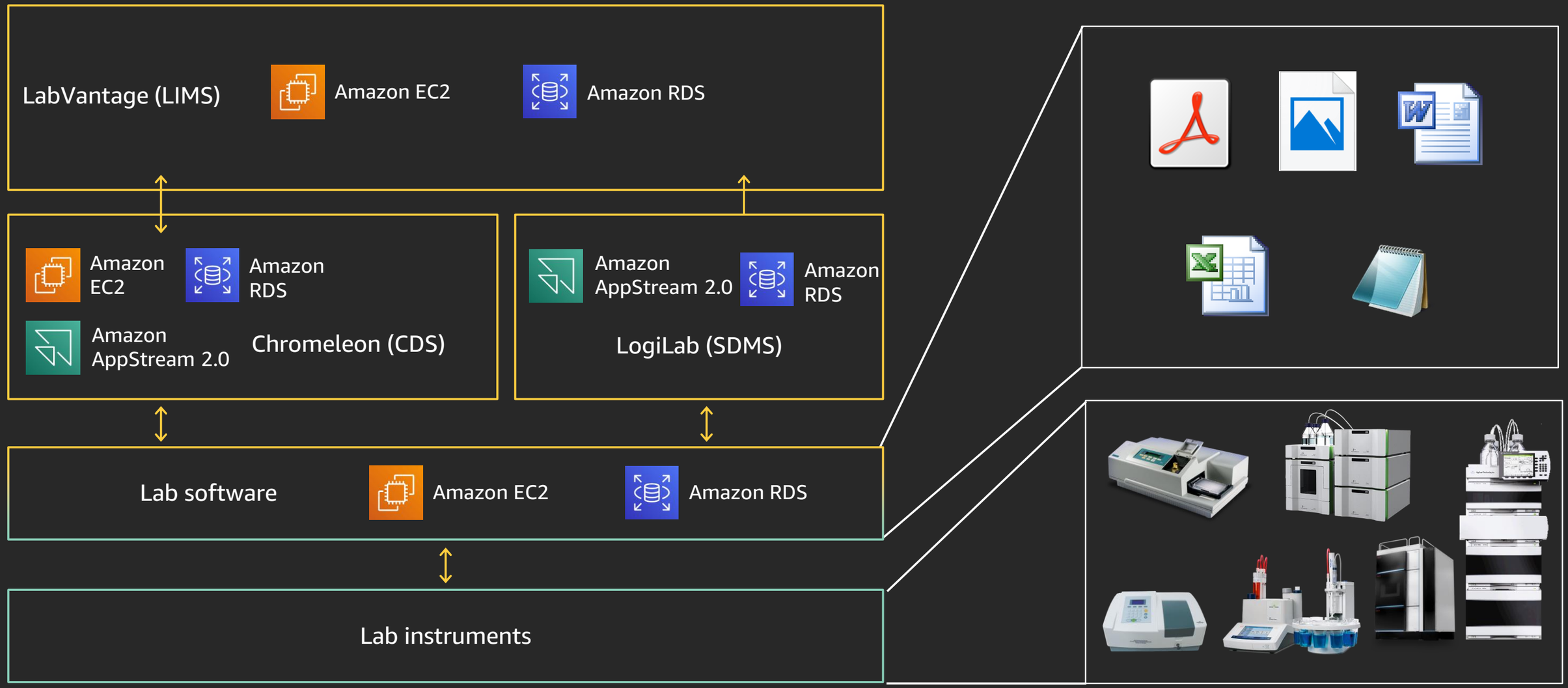
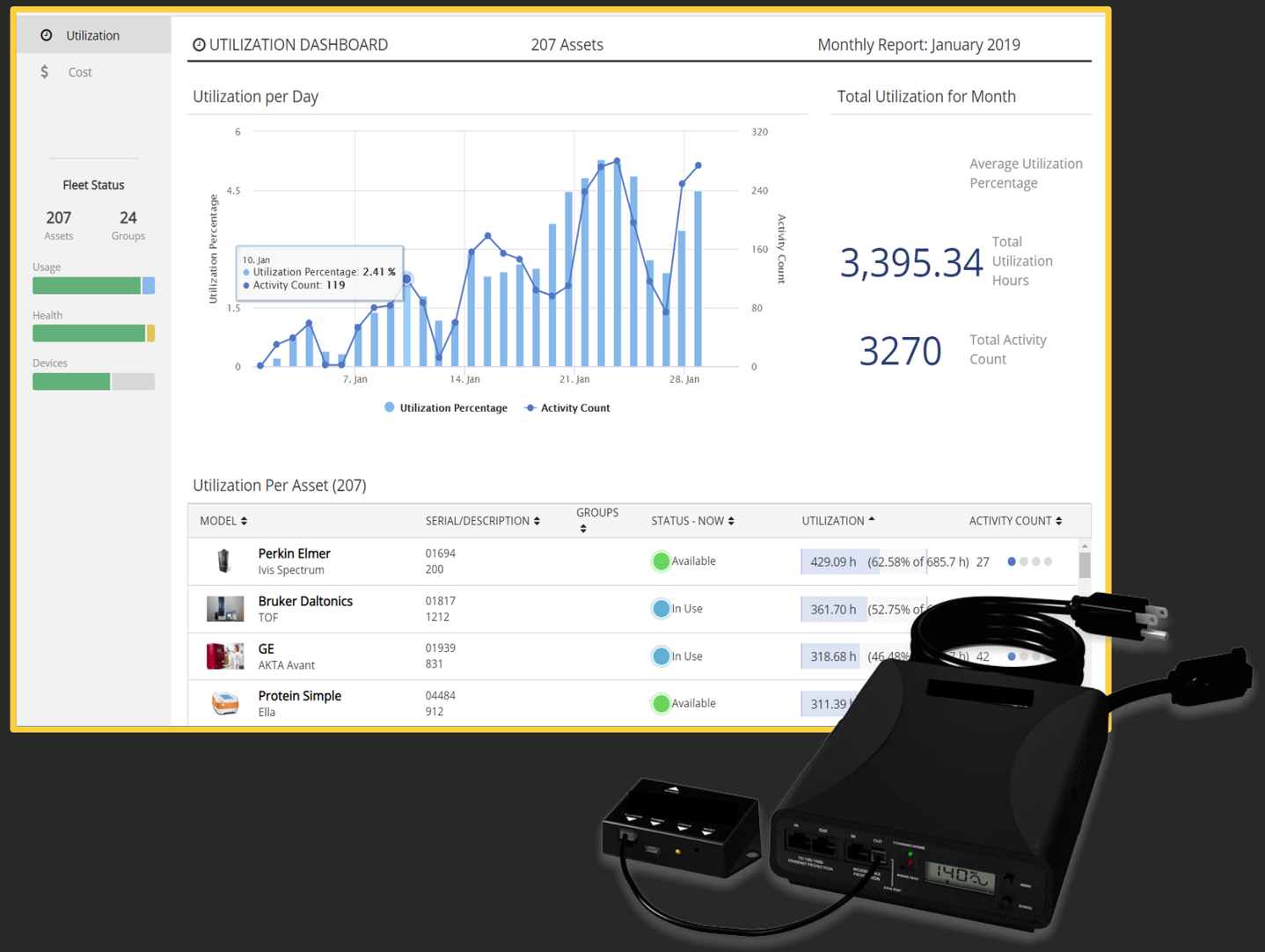


Photo courtesy of Moderna

Enabling laboratory testing on AWS



Playing the long game



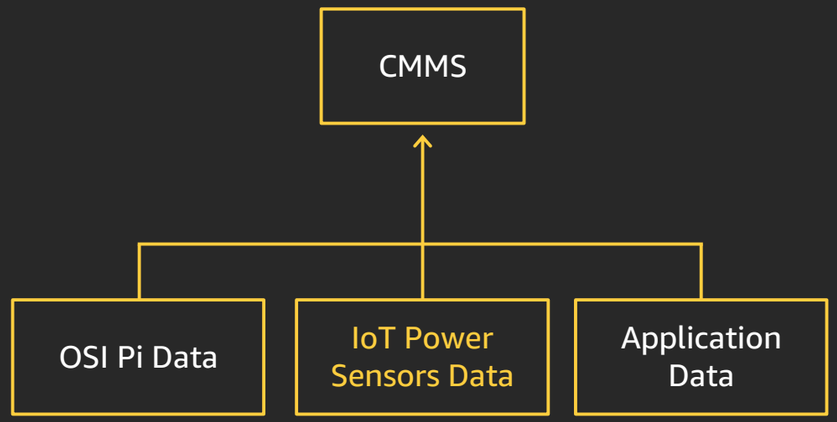
Establish Use Based Calibration

↑

Correlate Usage with Failure Modes

↑

Drive Capital Investments

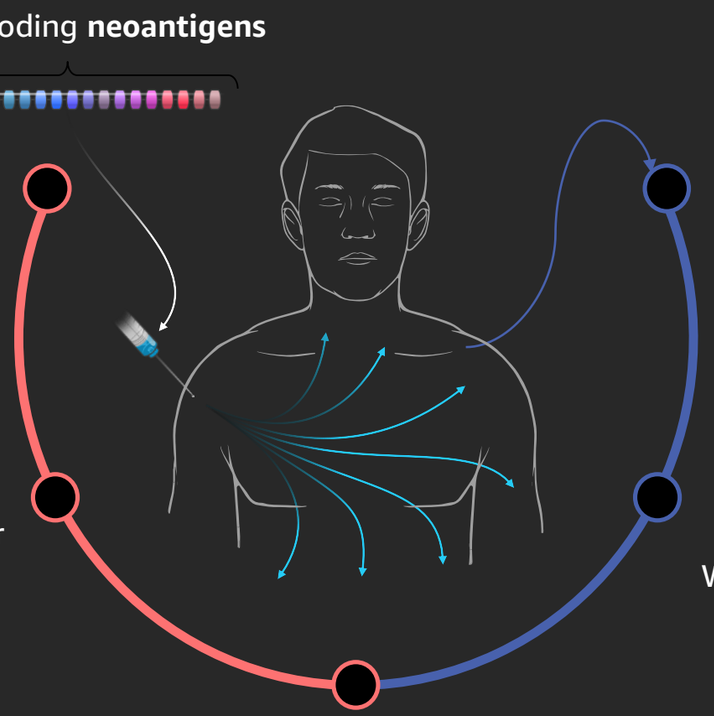


Extending our flexible landscape on AWS



Photo courtesy of Moderna

Personalized cancer vaccines: A “batch of one”



Administration
by health care professionals

Tissue Samples
Tumor (biopsy) and normal (blood)

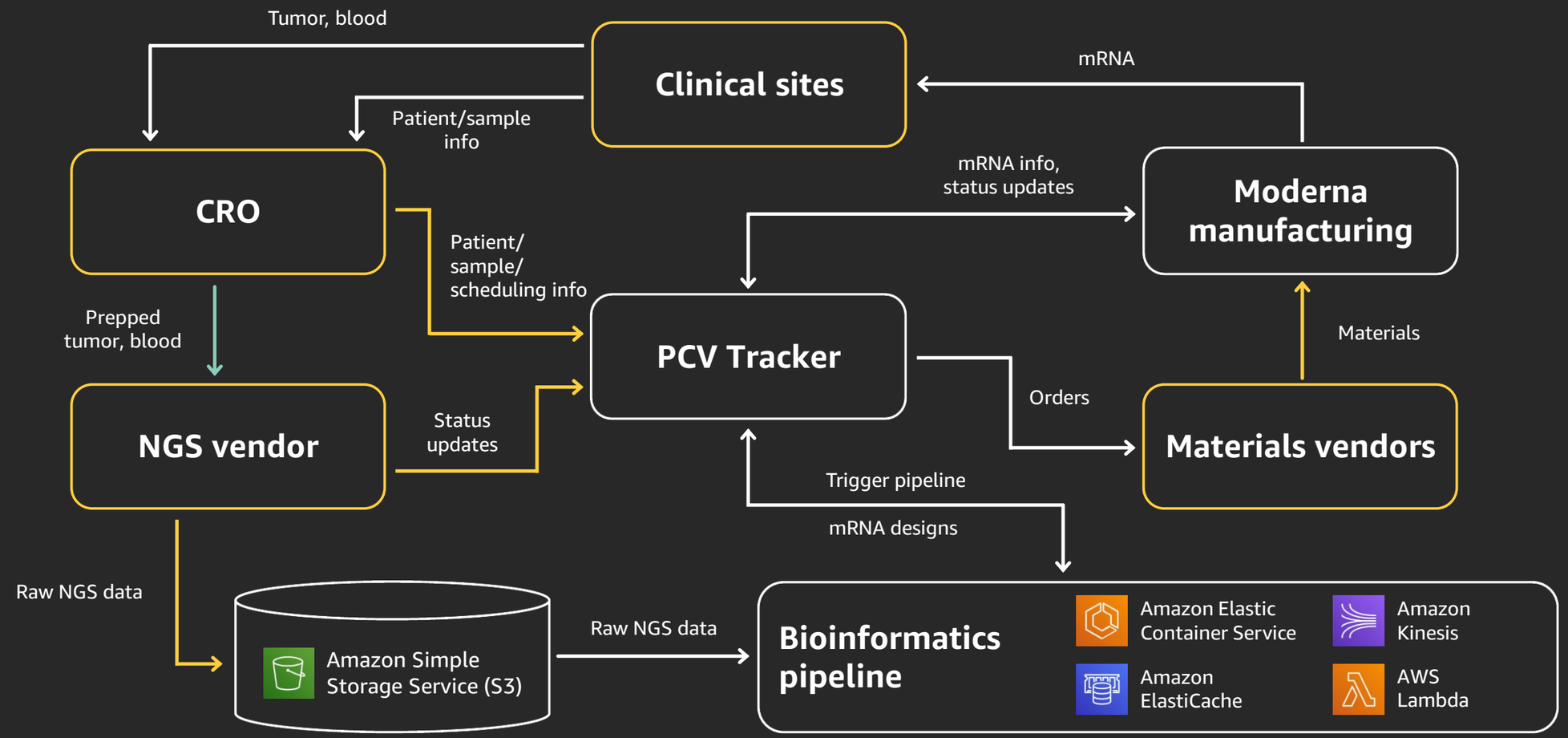
cGMP Manufacturing
One batch per patient rather than one batch for many patients

Next Generation Sequencing (NGS)
What are the mutations?

Vaccine Design
Which mutations are predicted to be the most immunogenic?
What is the best design for a drug to present these mutations to the immune system?

Needle to needle chain of custody and identity

Delivering personalized cancer vaccines

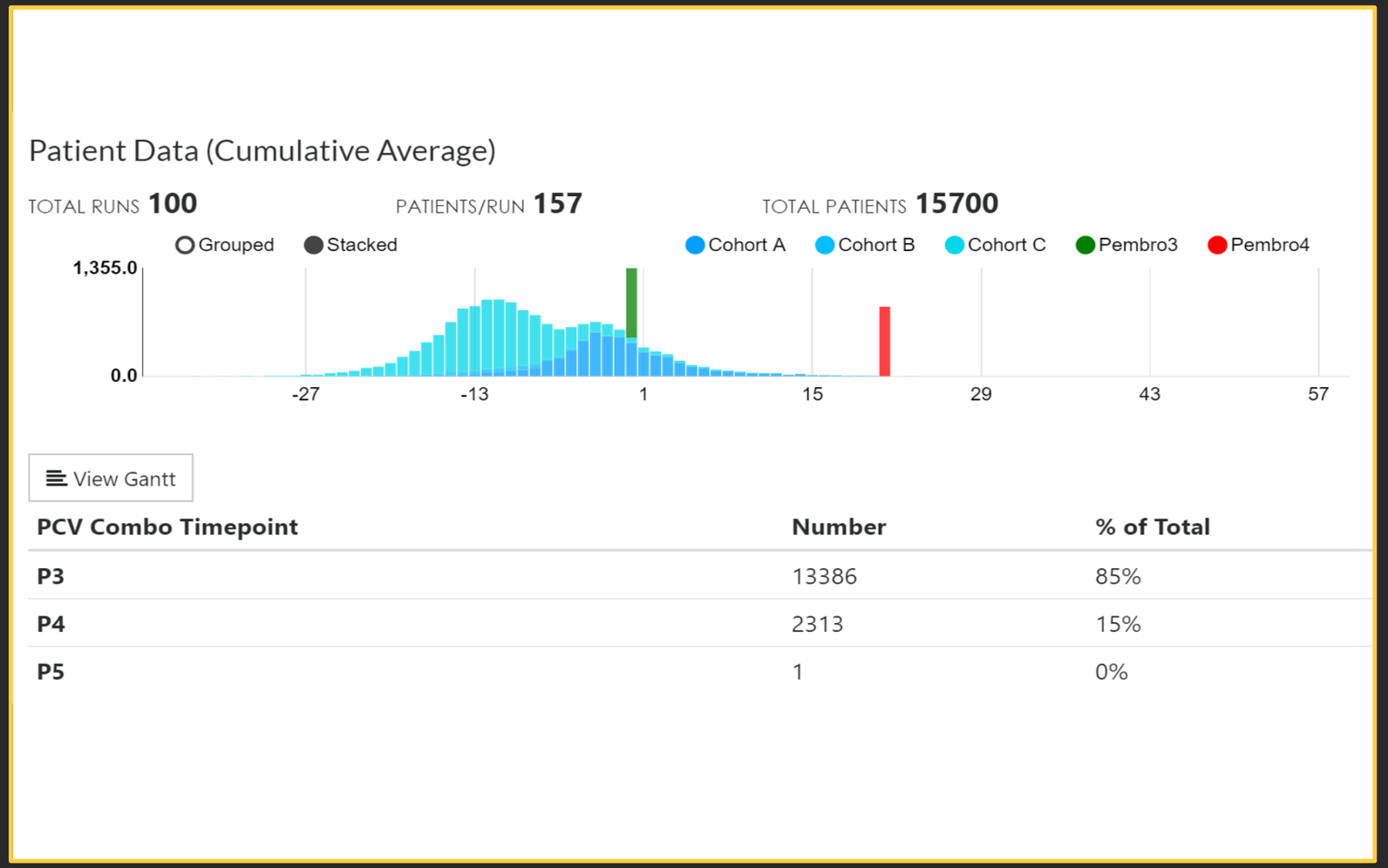


White = Moderna
Gold = Outsourced Contractors

Clinical trial simulations with machine learning

Simulate 100s of virtual trials to predict behavior

- Amazon EC2
- Amazon Simple Storage Service (S3)
- Amazon Redshift
- Amazon SageMaker

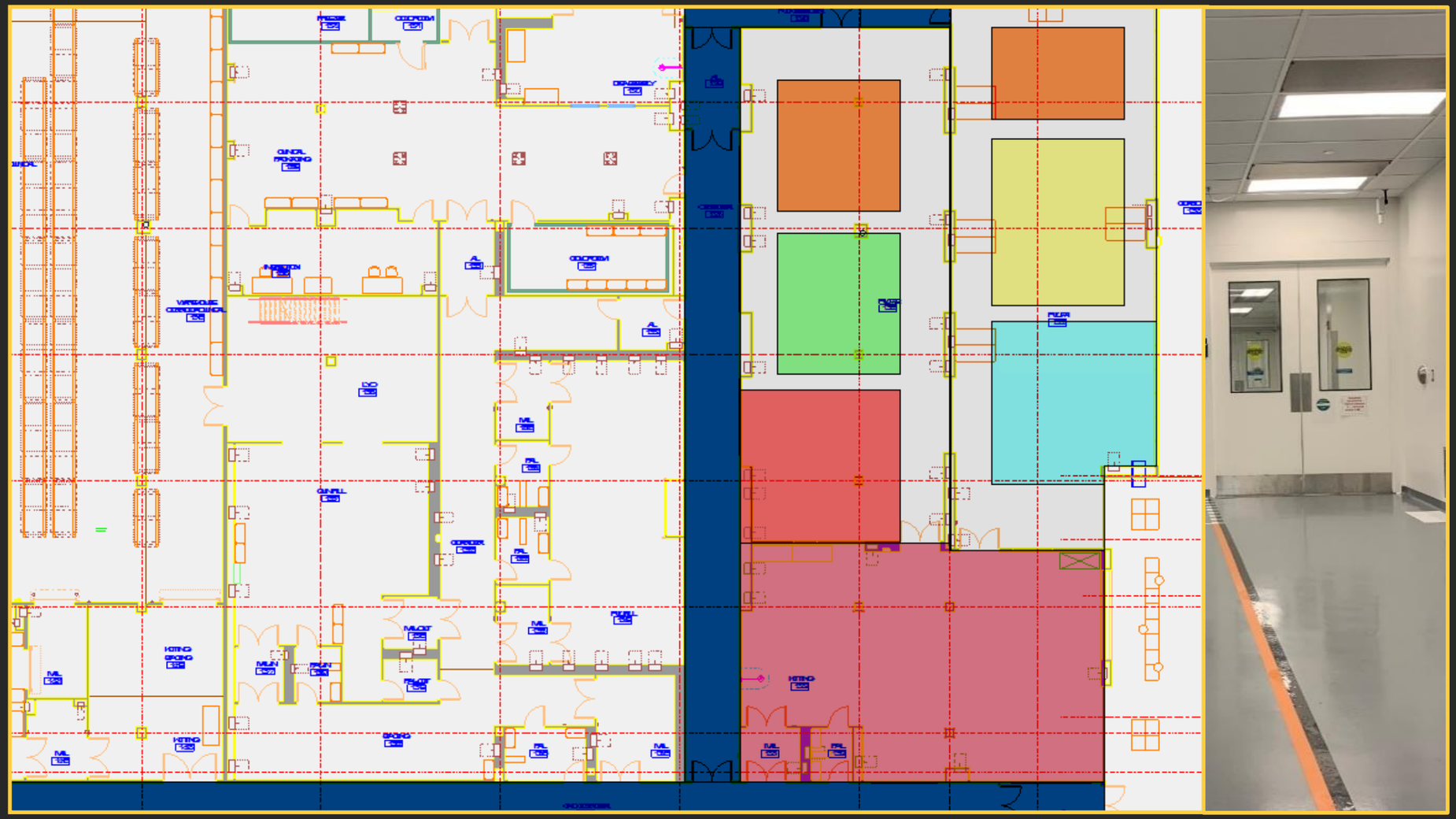


PCV Combo Timepoint	Number	% of Total
P3	13386	85%
P4	2313	15%
P5	1	0%

Real-time operator tracking

Utilizing location services to ensure train segregation





Enabling the power of data with AWS

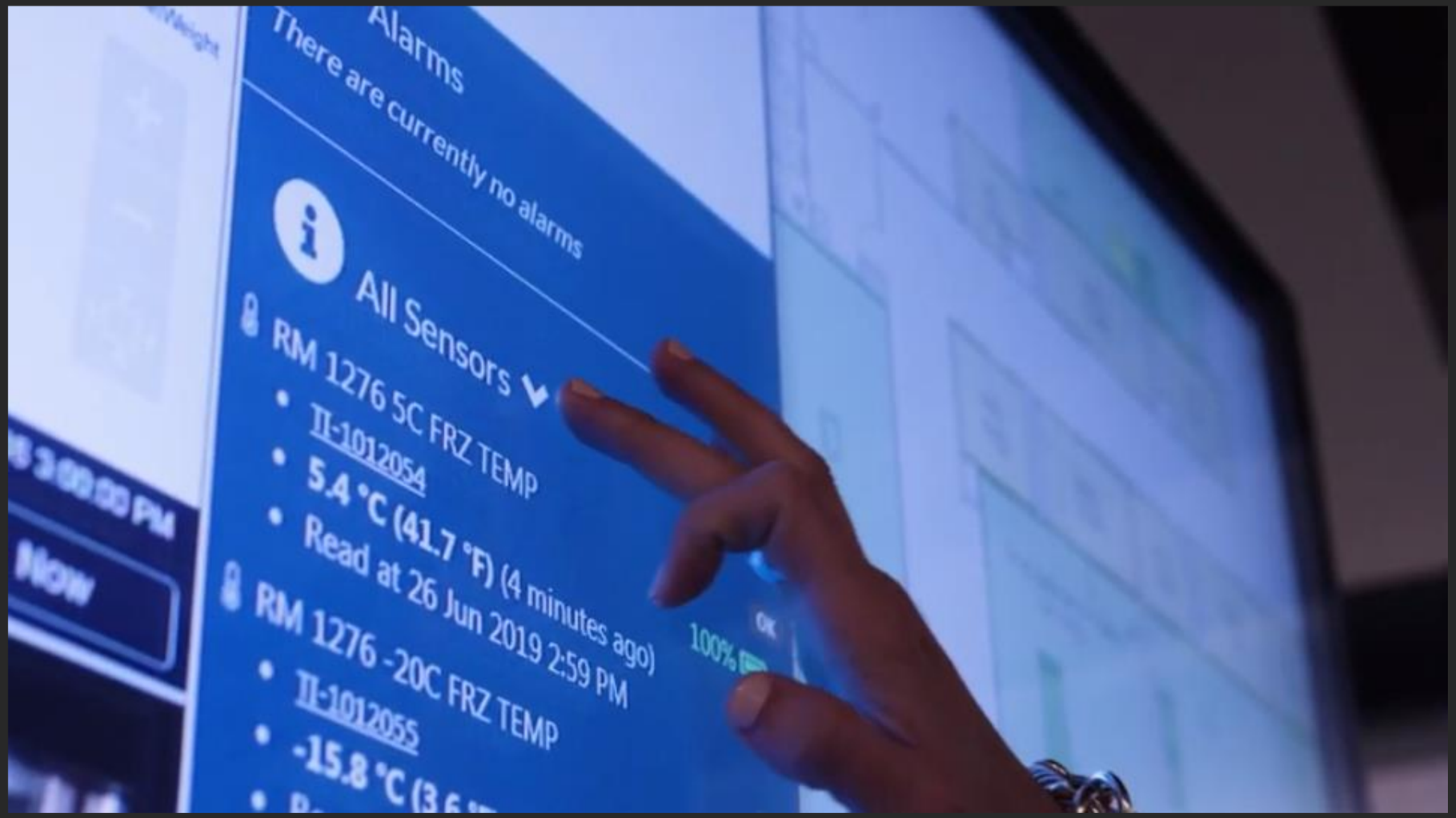
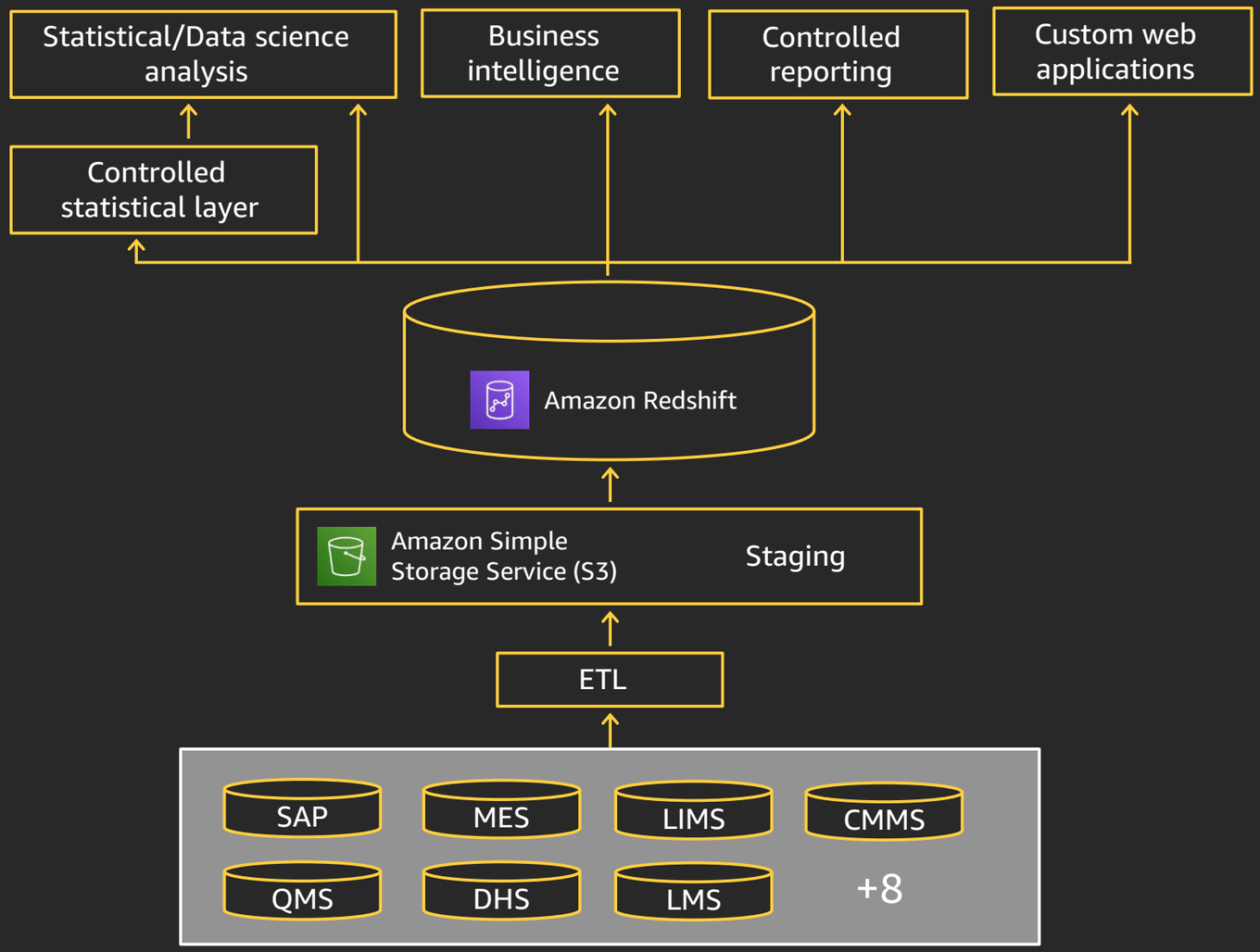


Photo courtesy of Moderna

Democratization of manufacturing data

Integrated analytics strategy



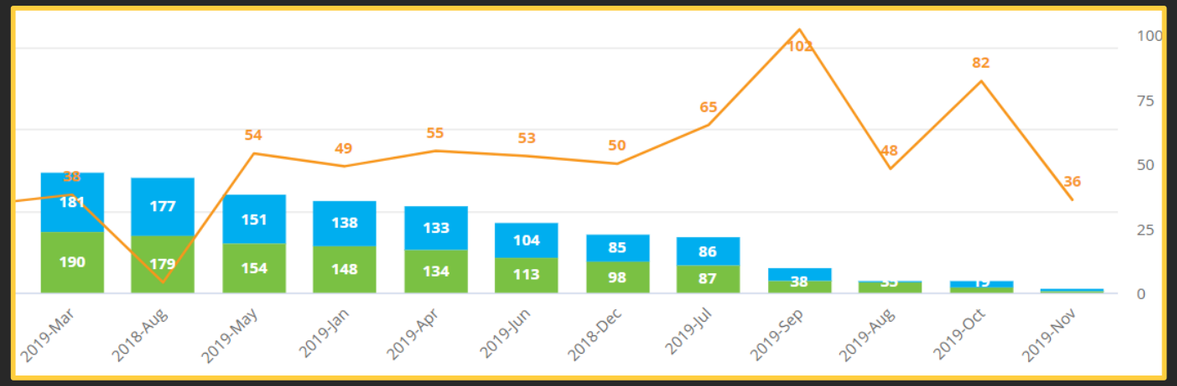


Analytics driven operations

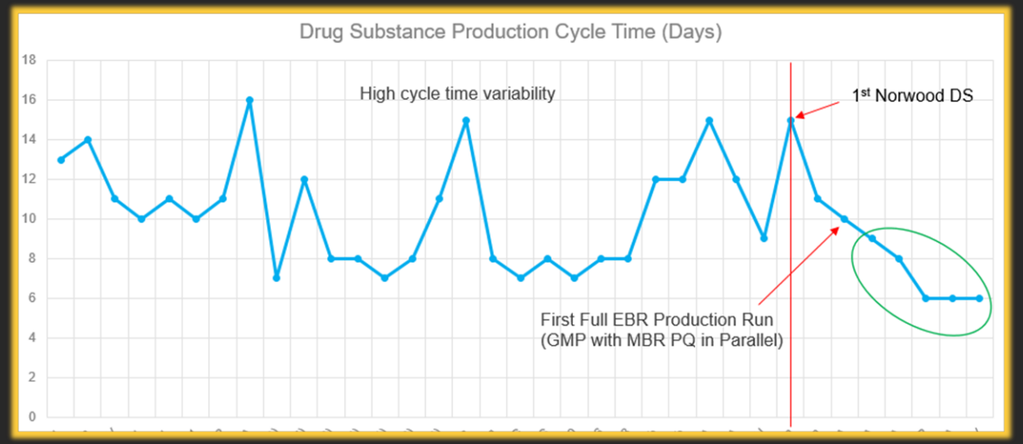
Operational Control Tower



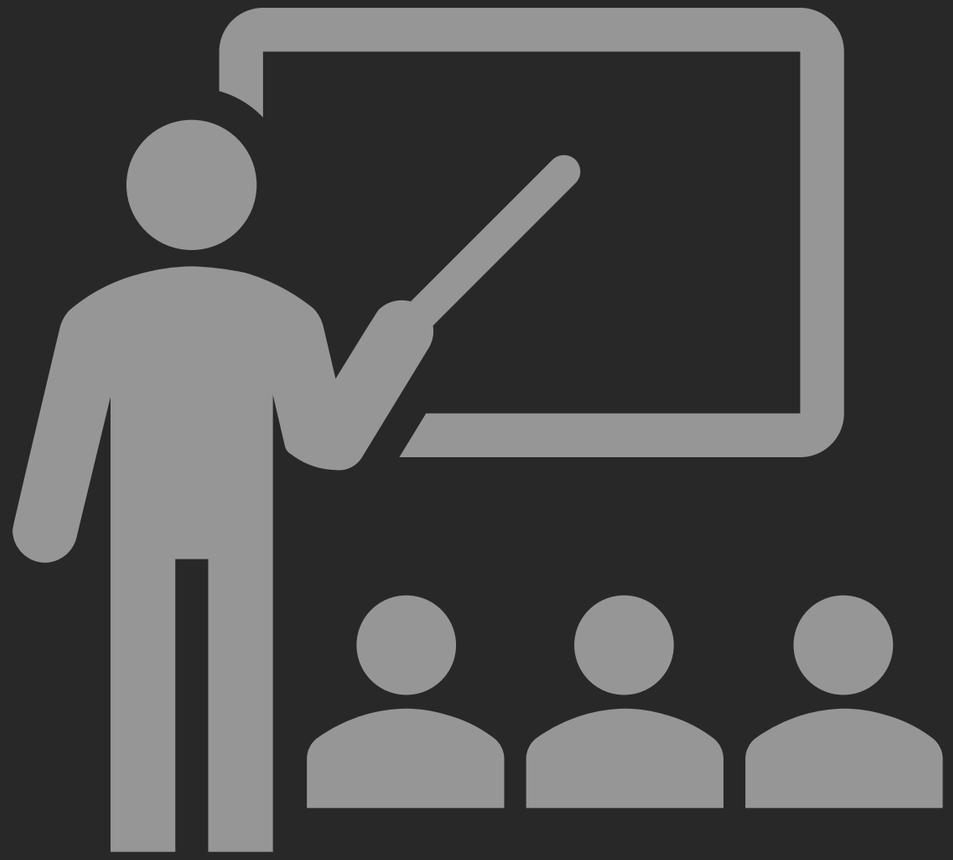
Analyze product performance



Driving Continuous Improvement



Lessons Learned



Lesson Learned 1: Start with a strategy





Lesson Learned 2: Partner with quality early





Lesson Learned 3: Integrate vendors into our culture

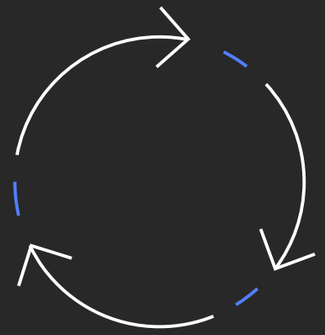




In Closing



Culture



Processes



Technology

Thank you!

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