



# COVID-19 Vaccination Supply Chains

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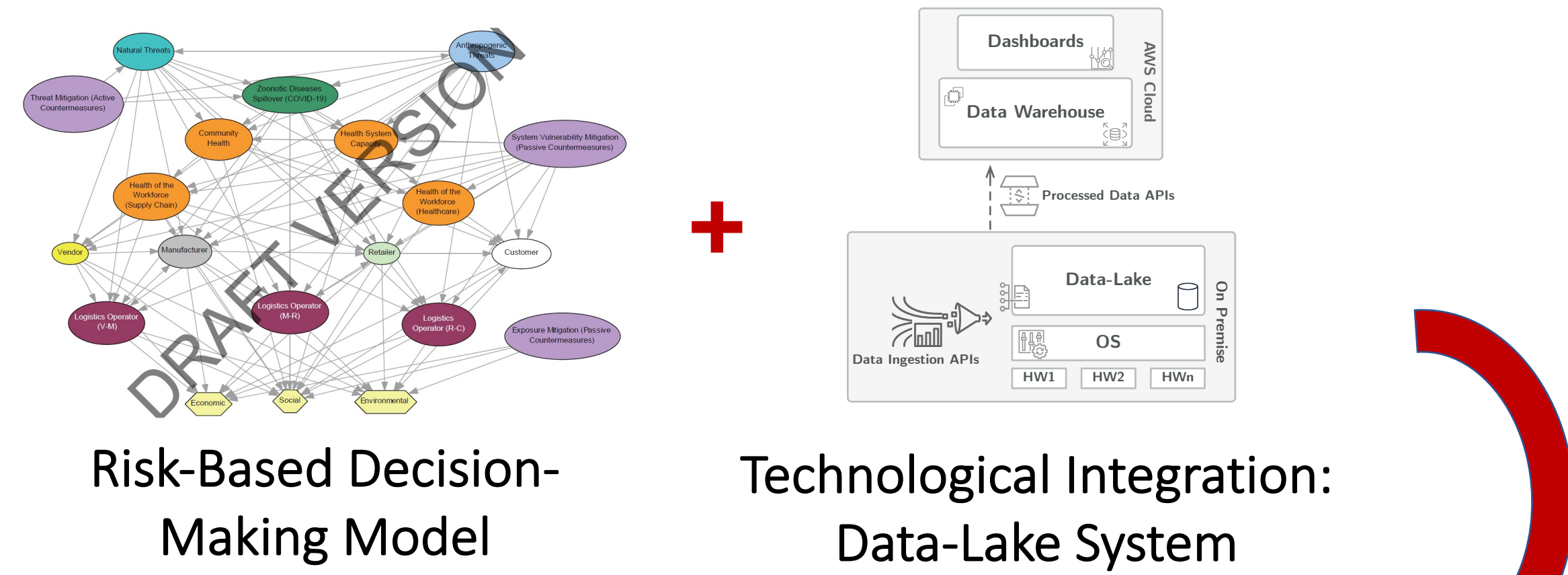
## Homeland Security Challenge



The ongoing COVID-19 pandemic has severely disrupted supply chains in the United States; the objective of this poster is to provide relevant information to key stakeholders in academia, government, and the general public by providing evidence-based predictive models and risk analytics on the causes and effects posed by COVID-19, on the U.S. trade supply chain infrastructure. The identification and characterization of evidence depicting the dynamics of infrastructure interactions of U.S. domestic and international trade supply chains, from procurement, manufacturing, warehousing, to transportation processes, are expected to derive inferences from public sources of information, and databases following a common risk framework developed by our research group at Texas A&M University.

## Approach / Methodology

R-7 / R-13 Risk Model Development & Data-Lake System Validation Projects



**Healthcare Infrastructure**  
Research Problem 1: COVID-19 Vaccination  
Research Problem 2: PPE Shortage

**State of Health of the Workforce**  
Research Problem 1: Healthcare Sector  
Research Problem 2: Auto Manufacturing Sector

Fig. 1 – R7 & R13 Methodology and Research Problems Overview

Five research problems to identify evidence sources and provide initial validation of the risk framework model and data lake have been identified. We focused on COVID-19 Vaccination in the United States and Mexico as the predominant mitigating action. In addition to reliable sources of information, we've identified preordered vaccine supply, its main supply chain elements, and the critical facilities involved in the manufacturing and distribution of millions of doses. In this poster, we present an initial assessment and findings for this mitigating action.

## Outcomes / Results

Table 1 – Approved U.S. COVID-19 Vaccines Comparison as of March 14, 2021

Vaccine	Type	Doses	Efficacy	Cold Supply Storage	\$ per Patient	Reported Manufacturing Bottleneck
Pfizer and BioNTech	mRNA	2x - 21 days apart	95%	-75°C	\$39.0	Lipids production which occurs during the first half of its manufacturing process
Moderna	mRNA	2x - 28 days apart	94%	-20°C	\$50.0	Lipids production to combine mRNA
Johnson & Johnson	Adenovirus-based	1x	72%	7°C	\$15.0	Cell culture growth on Bioreactors and slow manufacturing cycle (60-80 days)

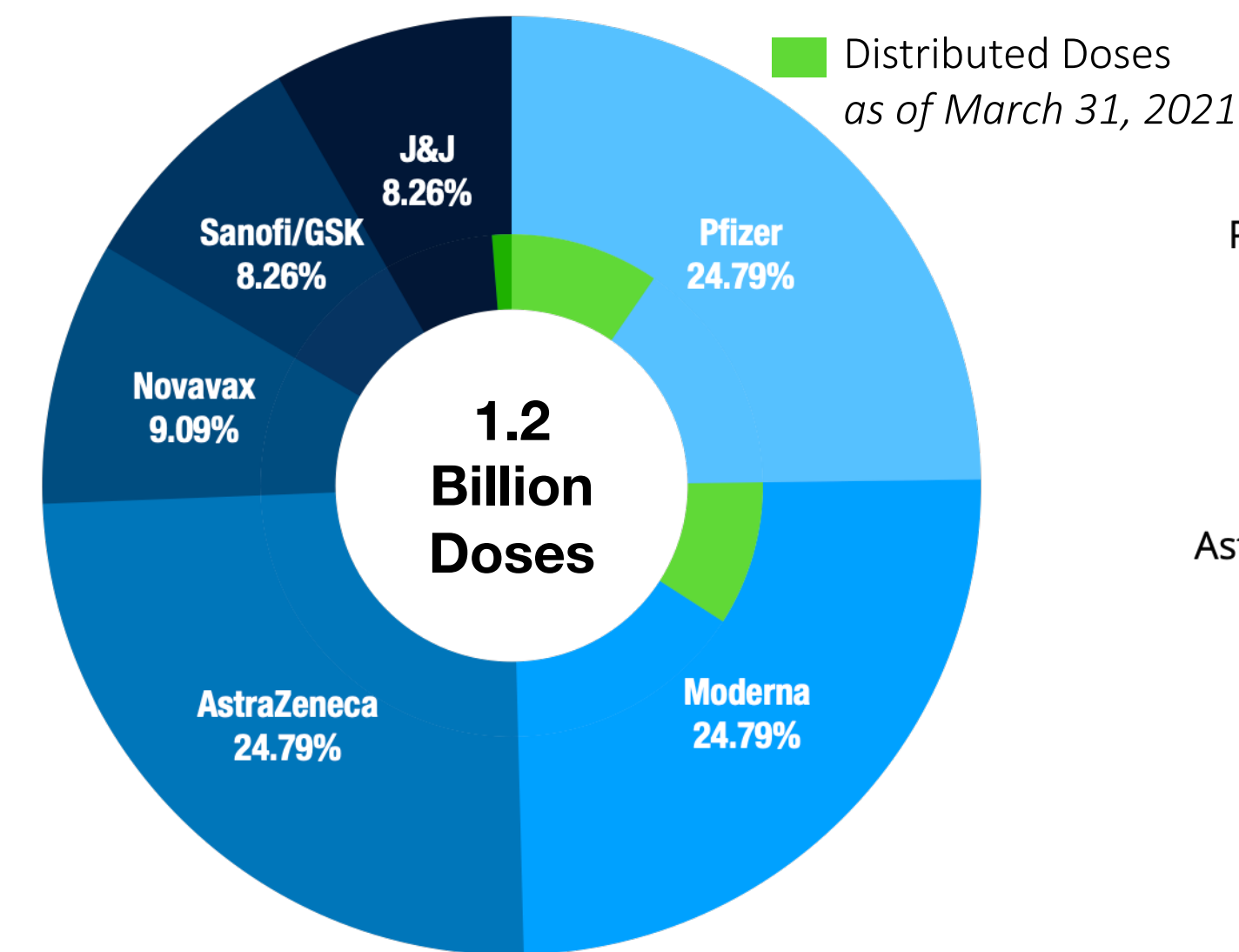


Fig. 2 – U.S. Preordered Vaccine Supply

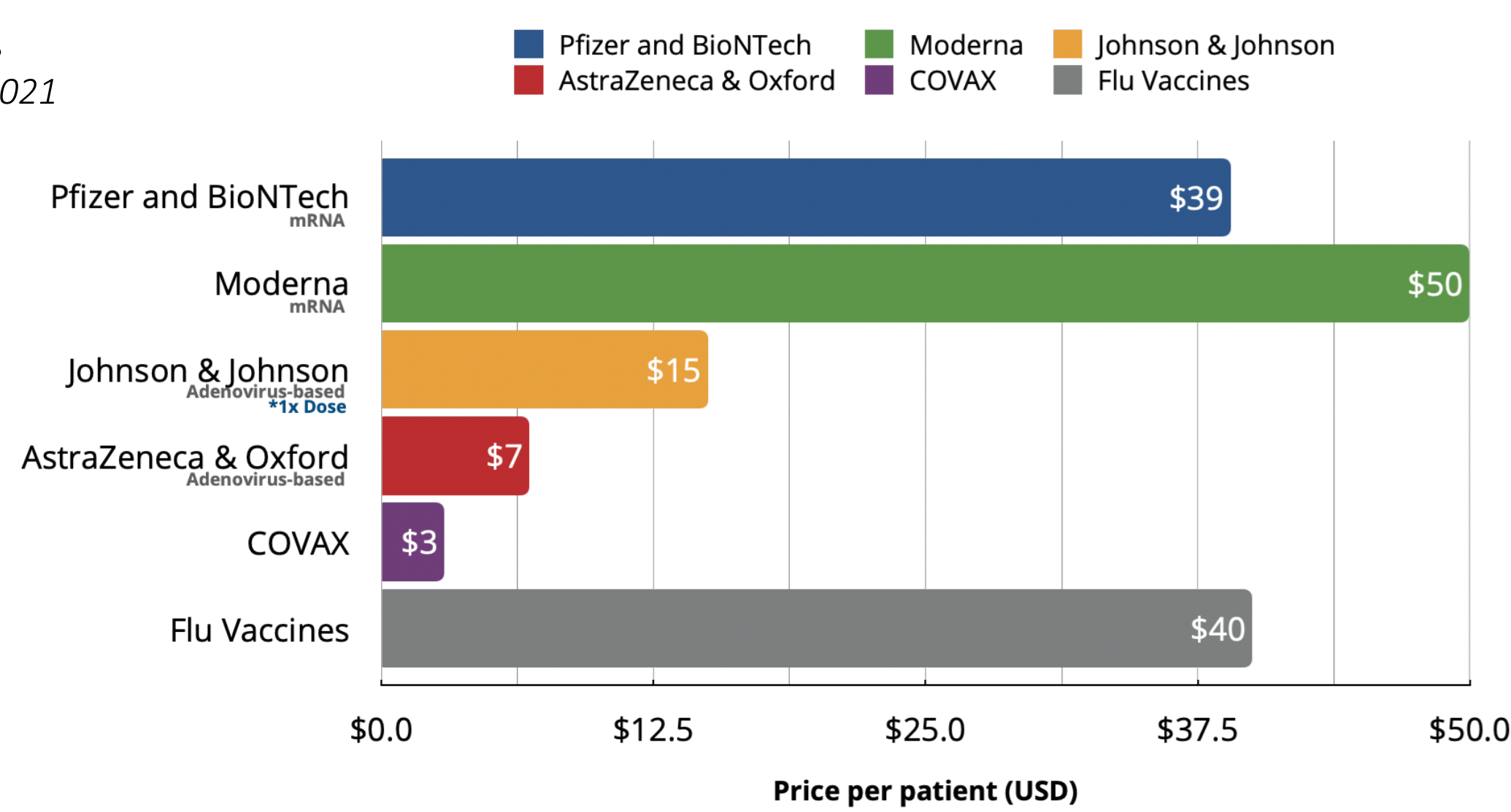
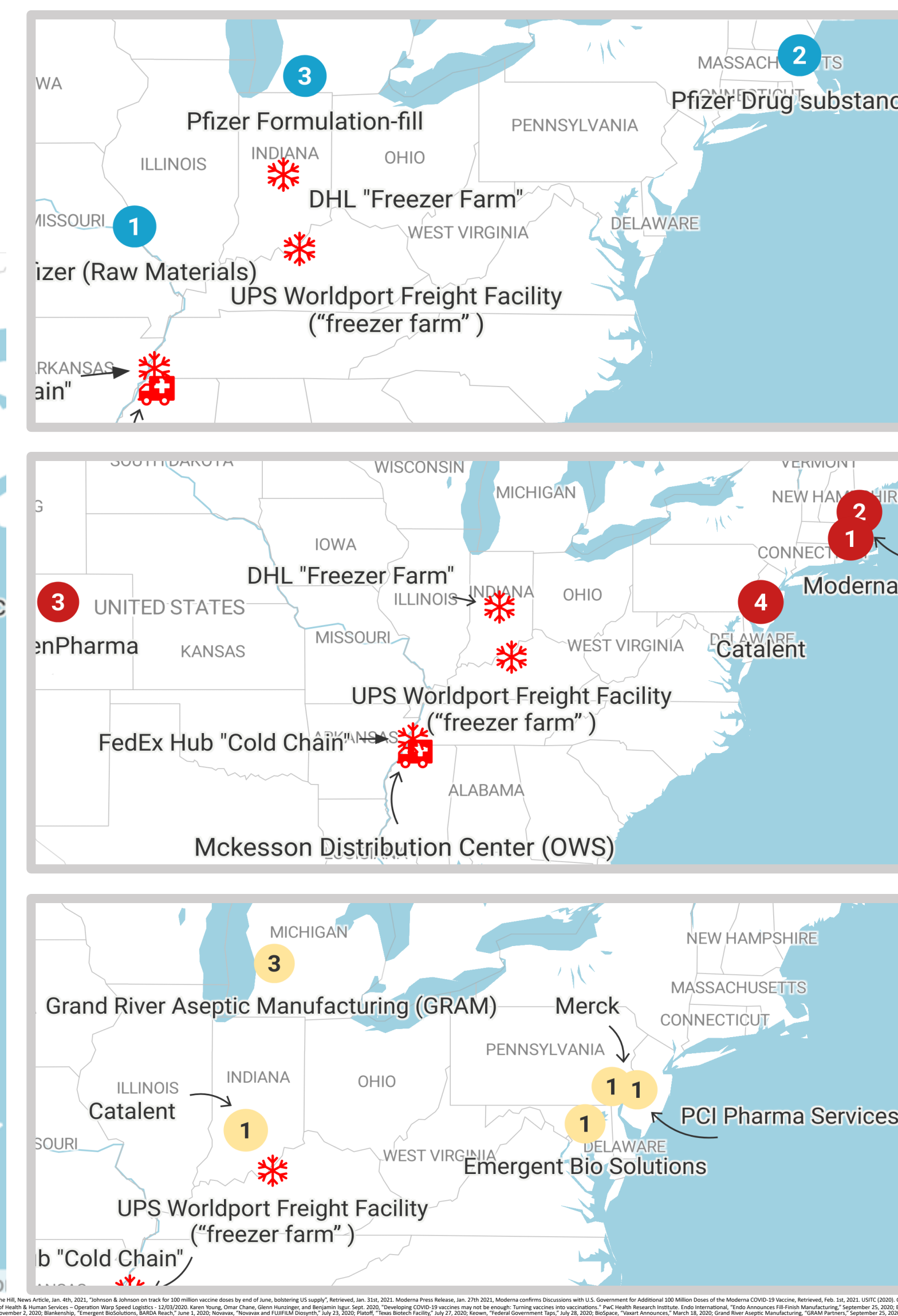
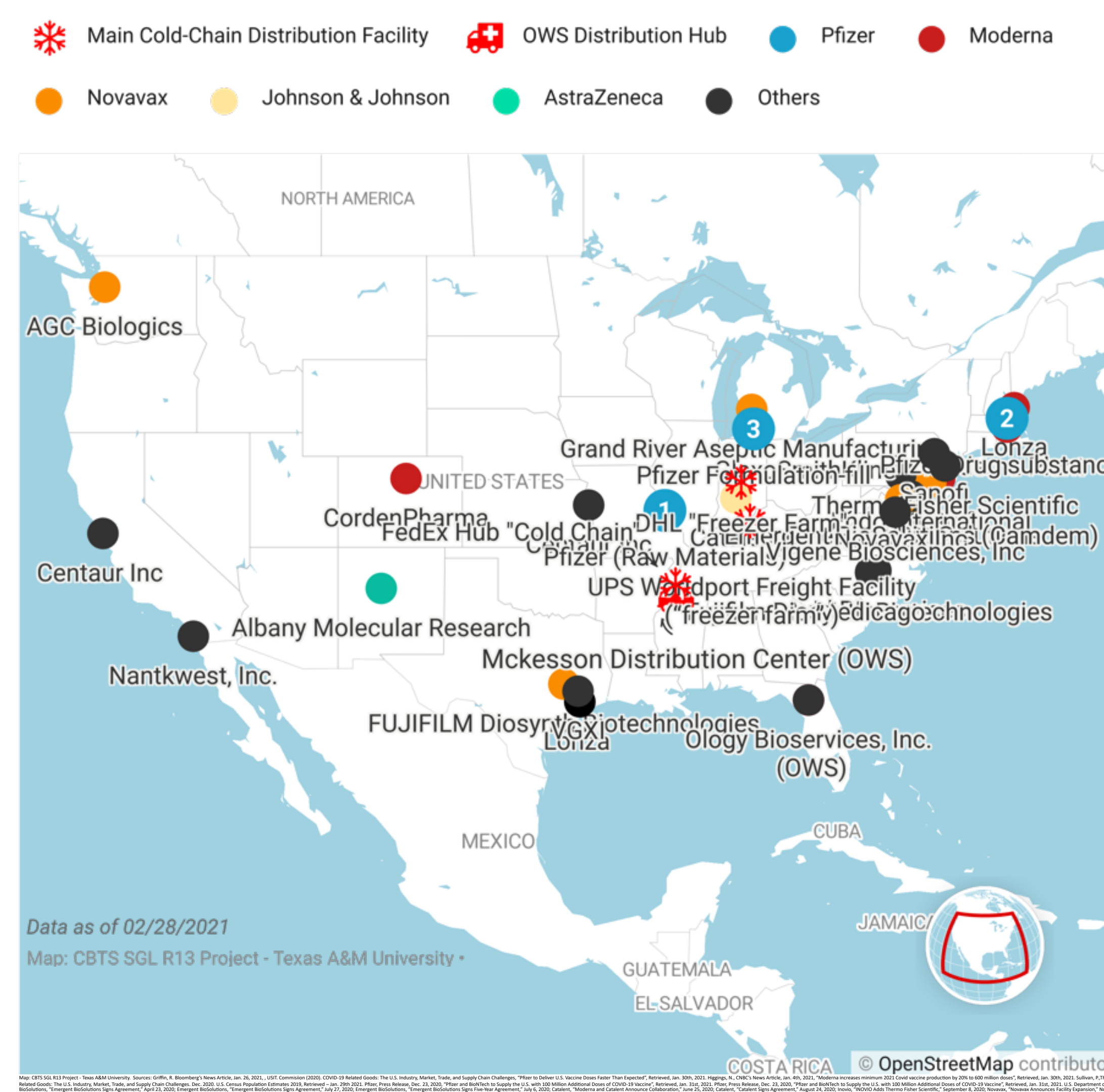


Fig. 3 – Approximate wholesale prices listed by vaccine manufacturer

## Main U.S. COVID-19 Vaccine Manufacturing Facilities



**Pfizer**  
Pfizer's U.S. vaccine production is mostly vertically integrated. The most critical manufacturing step of its supply chain is combining mRNA production with lipids which occurs during the first half of the manufacturing process.

- Pfizer is producing DNA for the U.S. Market with plants located in Kalamazoo, Michigan, St. Louis, Missouri and Andover, Massachusetts
- Critical infrastructures updates during February 2021 caused a ~40% drop in weekly supply for that month but has since recovered

**Moderna**  
Expected to deliver a total of 300 million doses to the U.S. Government: 100 million by the end of March 2021, 100 million by the end of May 2021, 100 million by end of July 2021

- The most critical manufacturing step of its supply chain is the combining mRNA production with lipids which occurs during the first half of its supply chain
- Moderna and Lonza are producing DNA for the U.S. Market with plants located in Norwood, Massachusetts and Portsmouth, New Hampshire

Subcontracting:  
Lonza  
Corden Pharma  
Catalent Pharma

**J&J Janssen**  
Expected to deliver a total of 200 million doses to the U.S. Government: 20m by the end of March 2021, 80m by the end of June 2021, 100m by the end of December 2021

- JJ's manufacturing cycle is the longest ranging from 60 to 80 days
- The most critical manufacturing step of its supply chain is the cell culture growth which occurs at the beginning of the manufacturing process
- Emergent Bio Solutions and Merck Pharmaceutical are producing DNA for the U.S. Market with plants located in Baltimore, MD and Philadelphia, PA

Subcontracting:  
Emergent Bio Solutions  
Merck Pharmaceutical  
Grand River Aseptic Manufacturing (GRAM)  
Catalent, Inc  
PCI Pharma Services

- Sources of information and evidence were identified to ingest into the Data-Lake
- The Risk Model was validated qualitatively based on this research problem
- Ongoing work focusing on applying more quantitative analyses, and methodologies based on public and premium data sources related to one specific binational supply chain to provide real-time reporting and forecasting

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