Overall Concept

Feedback loop

Objective function

Input data → Simulation → Optimization ← Limitations ← Constraints
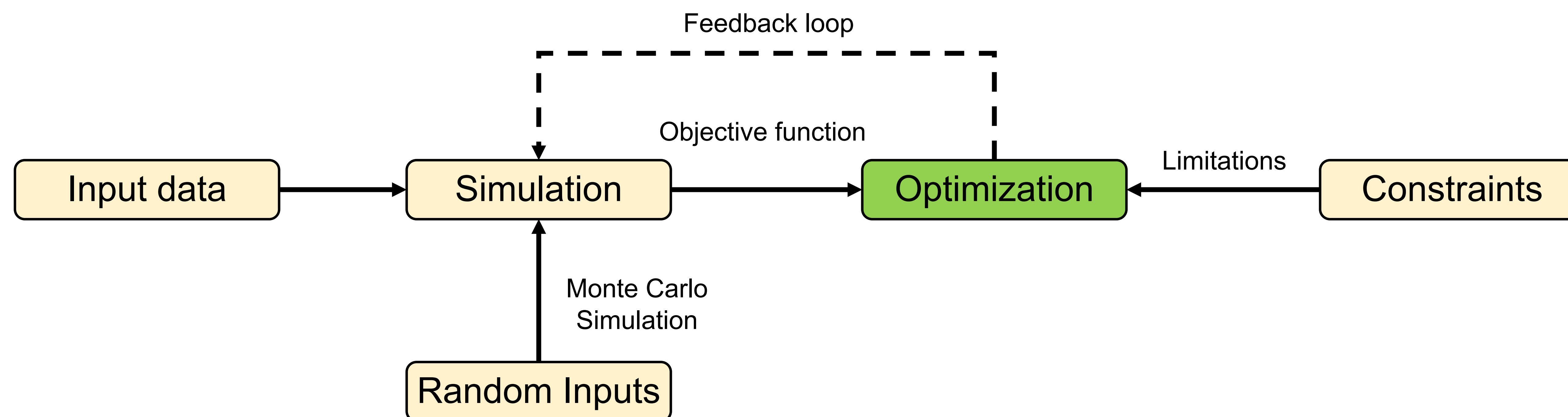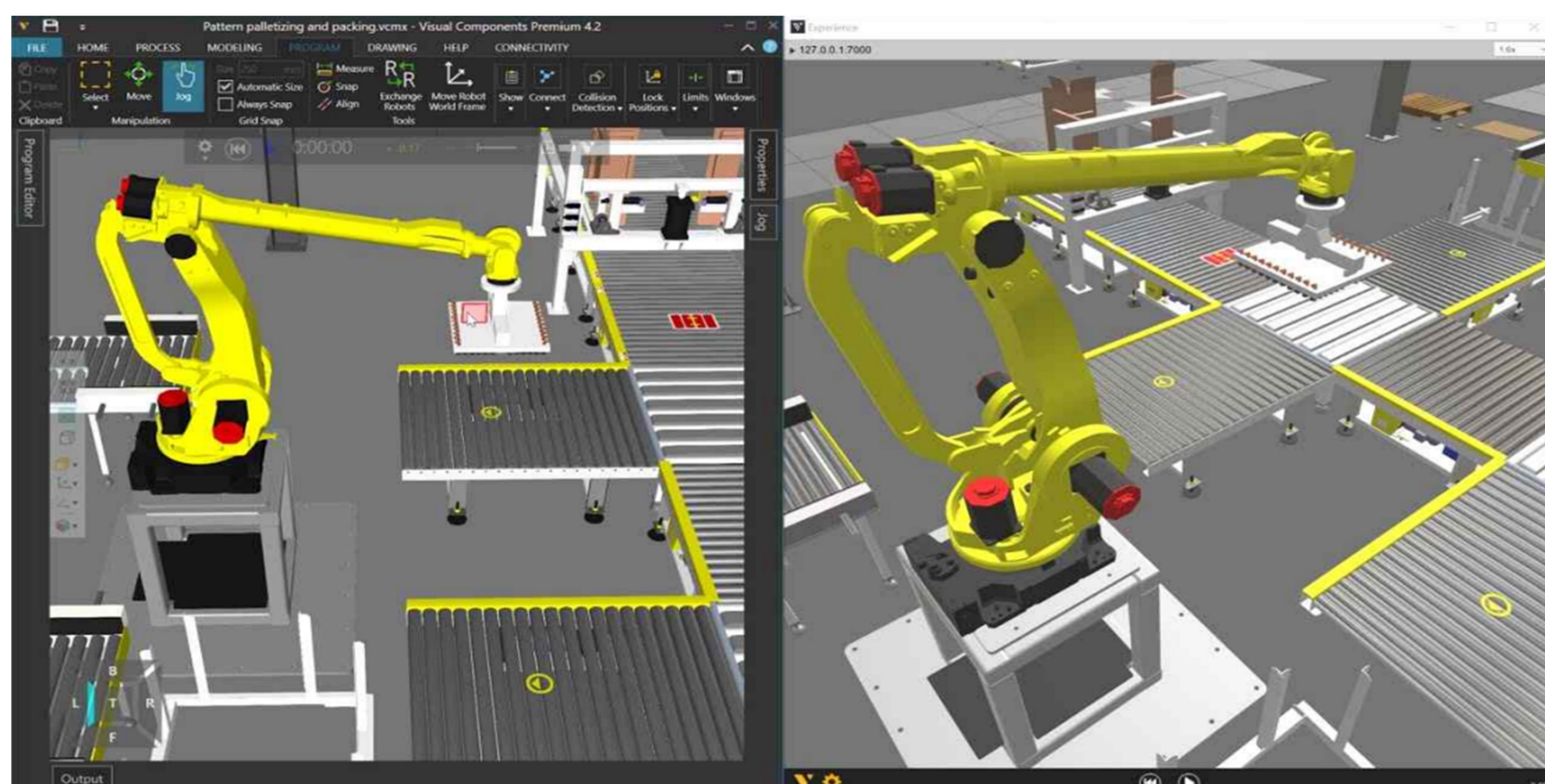
Monte Carlo Simulation

Random Inputs

Simulation optimization is a domain in IE that searches for optimal solutions to complex problems that involve uncertainty and randomness and can be studied with computer simulations. Simulation optimization can also improve algorithms in machine learning and data science.
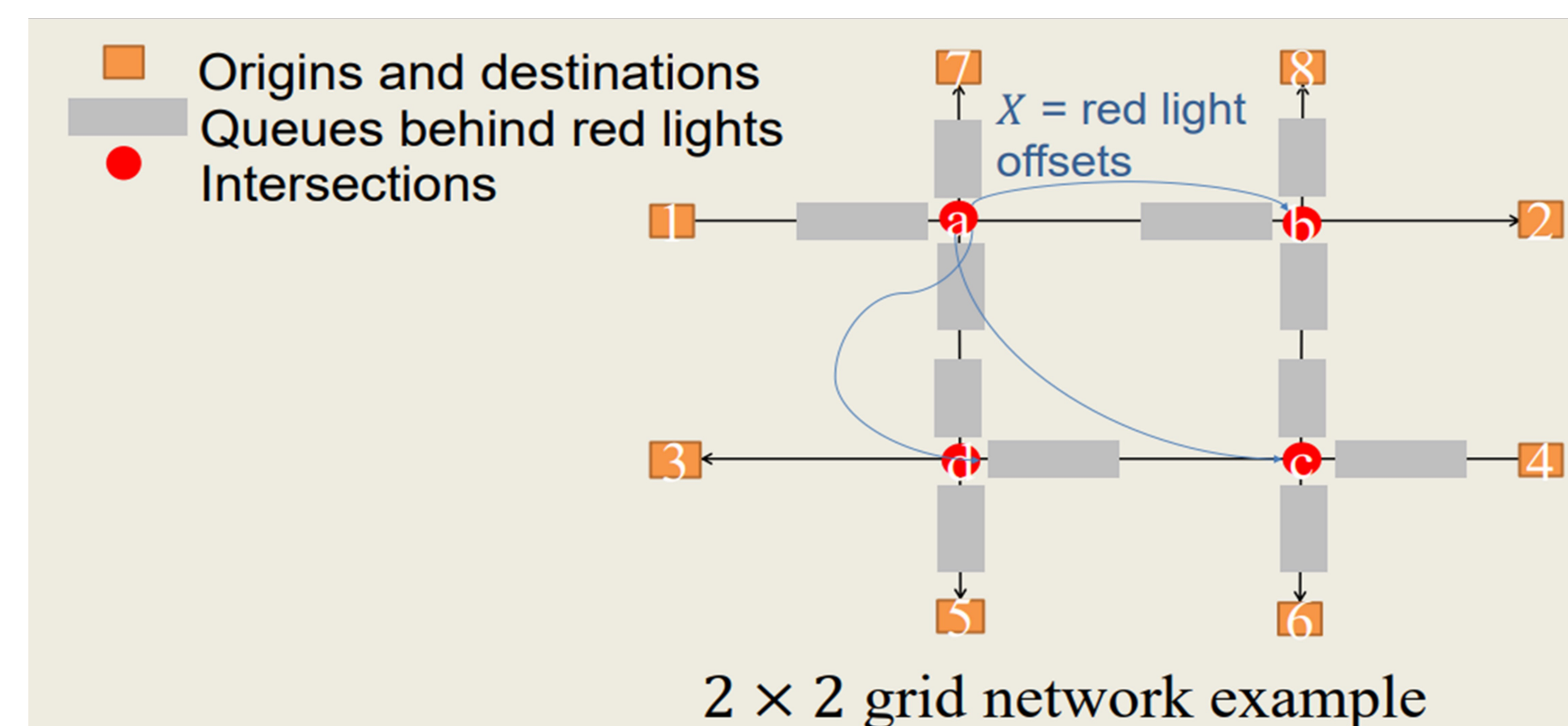
The key feature of simulation optimization is generating multiple scenarios to estimate the average performance of the system of interest under different decisions and identify the best choices that could maximize productivity, efficiency, and quality while minimizing costs and waste.

Wind Power Systems Optimization

❏ Simulation optimization improves wind farm efficiency by analyzing large amounts of data for turbine placement and blade angle control

❏ Engineers can manipulate various aspects of scenarios for improved performance via simulation optimization

❏ Predictive maintenance through simulation optimization identifies potential equipment failures, minimizing downtime
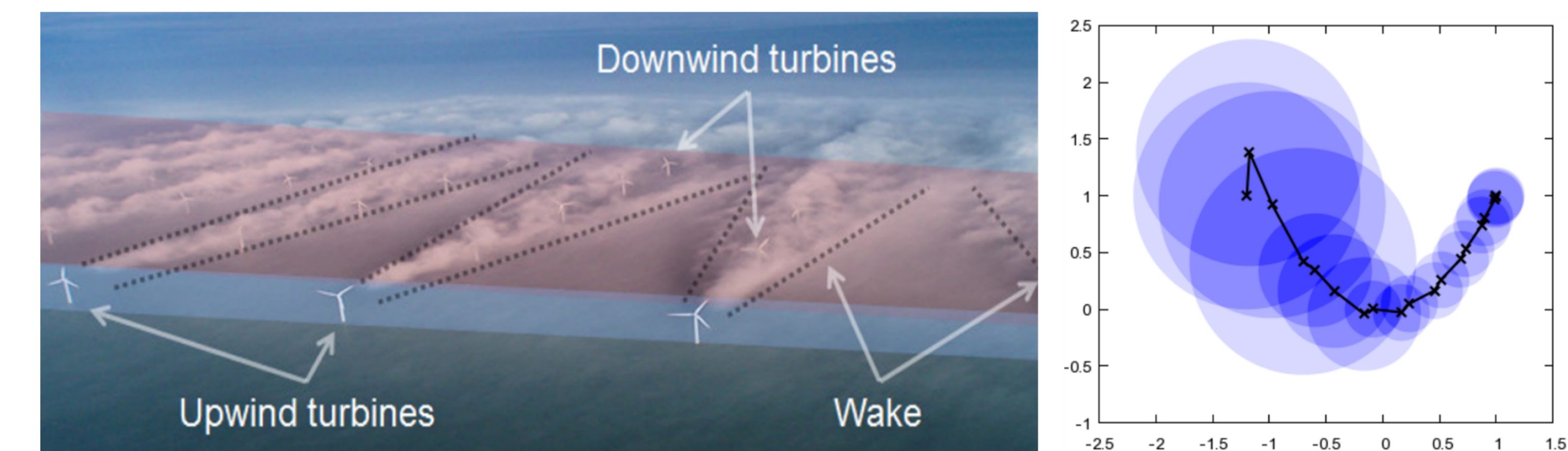
Manufacturing Process Optimization

❏ Battery factory workers struggled with managing production process due to uncertain processing time estimates

❏ A virtual factory simulation helped engineers to quantify uncertainty and make informed decisions

❏ Simulations led to reduced idle time and increased efficiency, showing the effectiveness in solving complex challenges

Traffic Signal Control Optimization

□ Origins and destinations
▬ Queues behind red lights
● Intersections

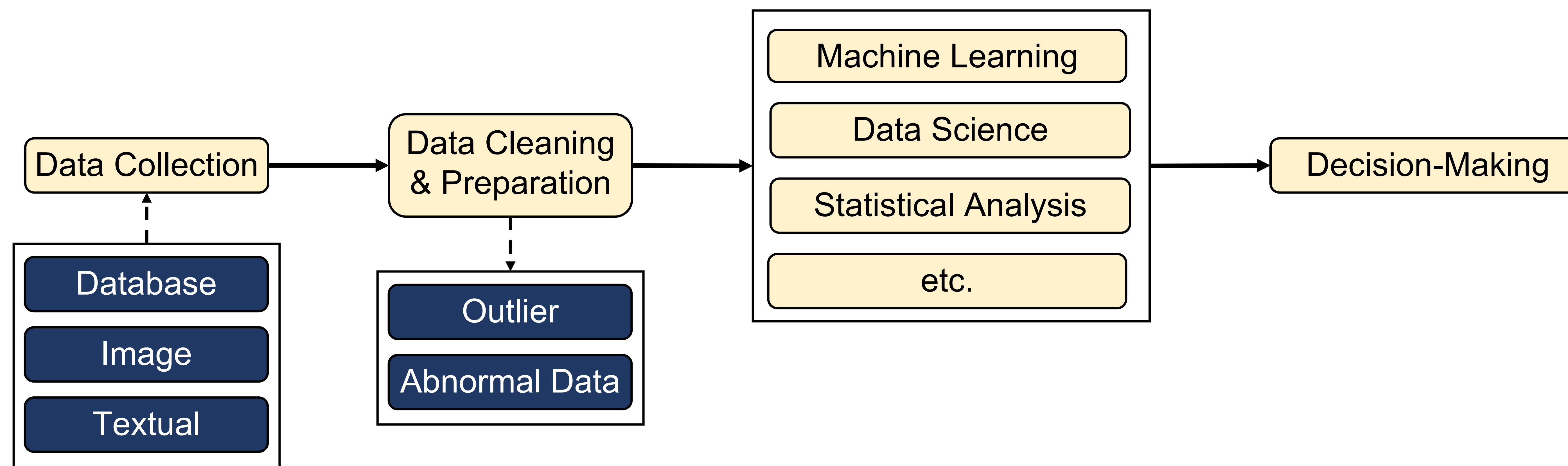X = red light offsets

2×2 grid network example

❏ Controlling traffic signal is important because it helps to improve traffic flow and reduce congestion on roads

❏ Using simulation optimization, engineers can test and refine different traffic scenarios to optimize the signal timings

❏ By minimizing the conflicts between pedestrians and vehicles at the intersection, we can reduce the risk of accident

Logistics Optimization
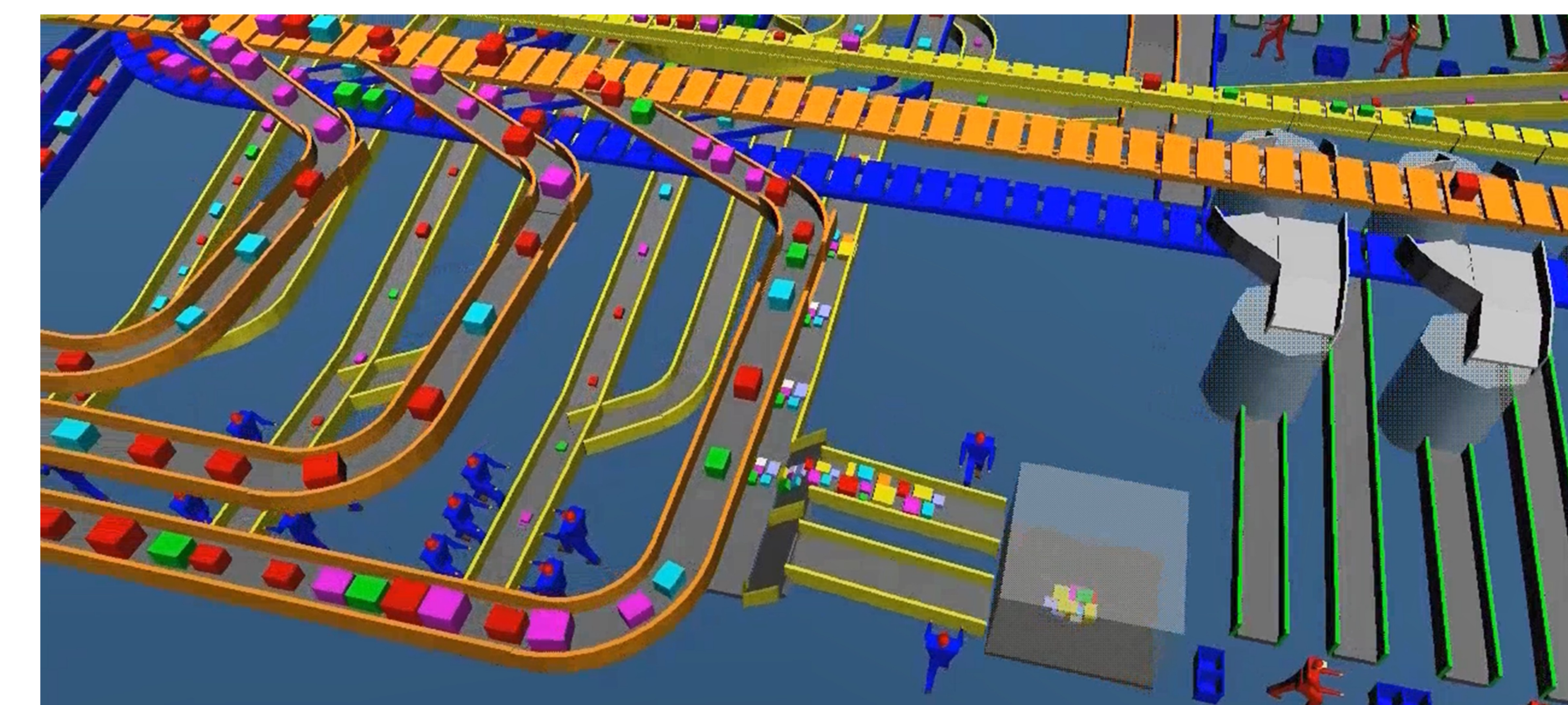
❏ Logistics plays an important role in the success of companies that are involved in e-commerce and retail (e.g., Amazon)

❏ Efficient logistics operation are essential to ensure the products to be delivered to customers in timely and cost-effective manner

❏ This optimized logistics control can be achieved using simulation by constructing virtual warehouses
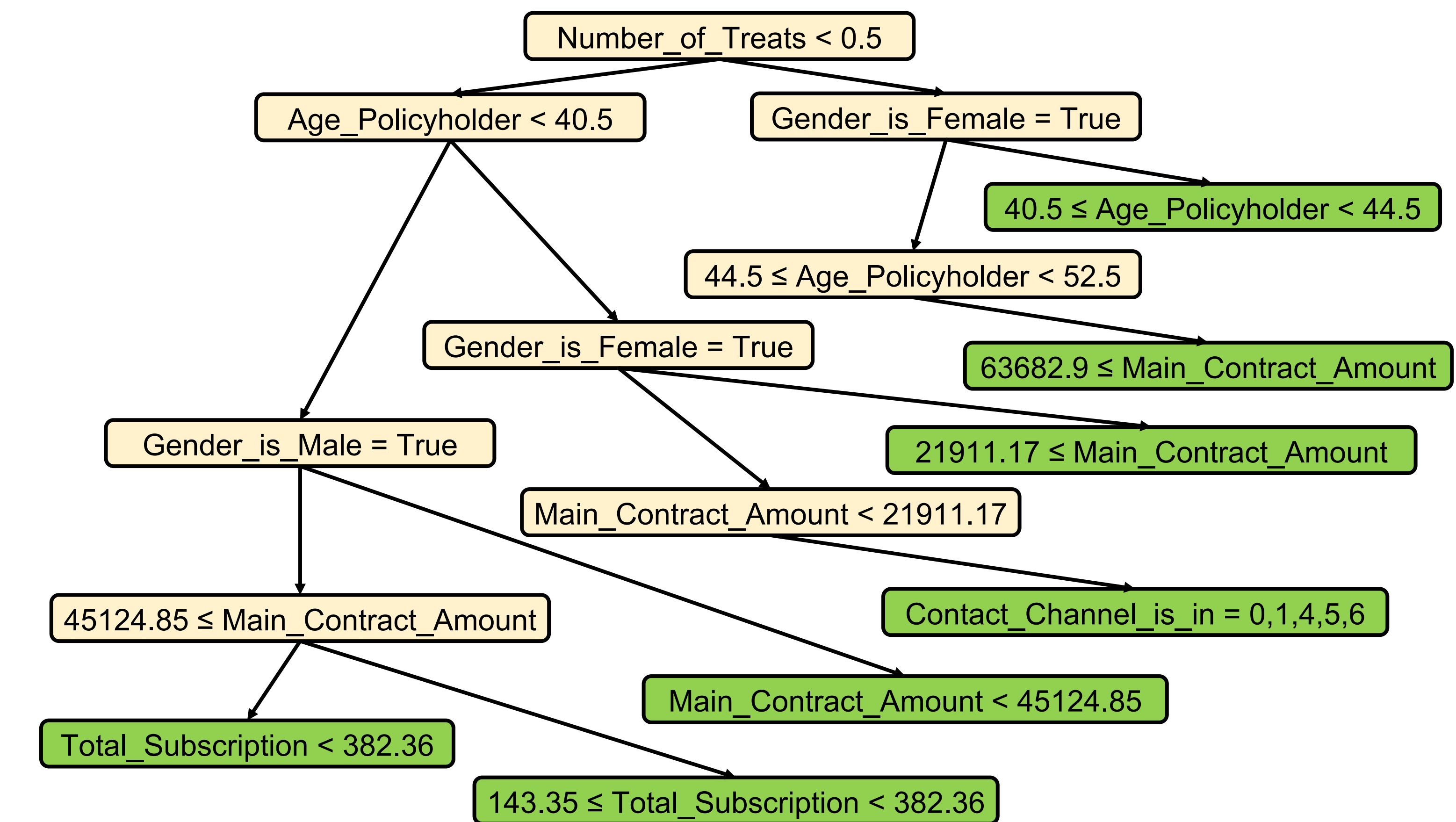
From Data to Decisions

Data Collection
- Database
- Image
- Textual

Data Cleaning & Preparation
- Outlier
- Abnormal Data

- Machine Learning
- Data Science
- Statistical Analysis
- etc.

Decision-Making

Data Analytics is the process of collecting, processing, and analyzing large volumes of data to derive insights and make informed decisions.
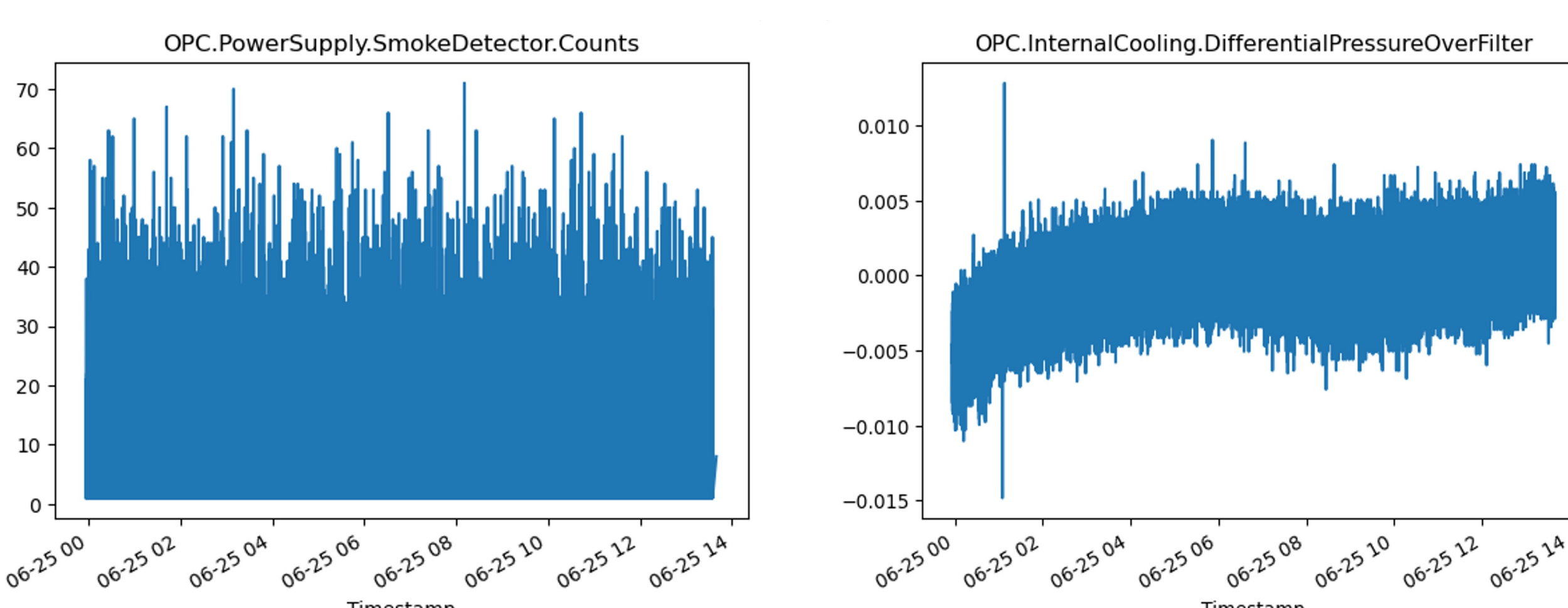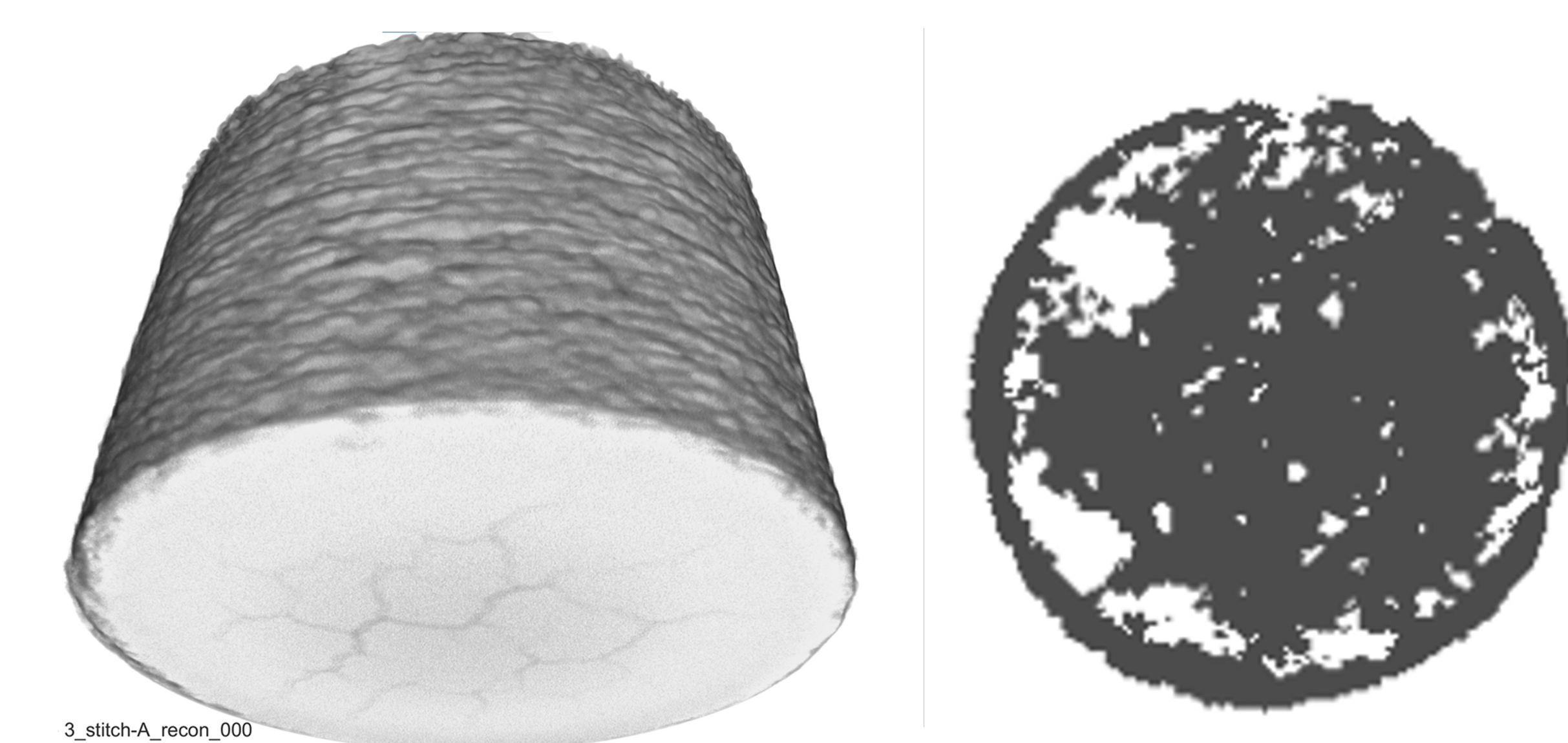
By analyzing data, organizations can better understand customer needs, predict future trends, optimize operations, and improve decision-making. Data analytics is a rapidly evolving field, actively discussed with new tools and technologies.

Uncovering Hidden Patterns in Life Insurance Data

Number_of_Treats < 0.5
Age_Policyholder < 40.5
Gender_is_Female = True
40.5 ≤ Age_Policyholder < 44.5
44.5 ≤ Age_Policyholder < 52.5
Gender_is_Female = True
63682.9 ≤ Main_Contract_Amount
Gender_is_Male = True
21911.17 ≤ Main_Contract_Amount
Main_Contract_Amount < 21911.17
45124.85 ≤ Main_Contract_Amount
Contact_Channel_is_in = 0,1,4,5,6
Main_Contract_Amount < 45124.85
Total_Subscription < 382.36
143.35 ≤ Total_Subscription < 382.36

❏ In the insurance industries, it is crucial to identify low-risk customers to minimize the potential financial losses from claims

❏ By analyzing the customer data (e.g., age, credit score), we can extract some "hidden patterns" of low-risk customers

Identifying Defects in Additive Manufacturing

3_stitch-A_recon_000

OPC.PowerSupply.SmokeDetector.Counts

OPC.InternalCooling.DifferentialPressureOverFilter

❏ Additive manufacturing, also known as 3D printing, is a rapidly growing field that has the potential to revolutionize manufacturing industries

❏ One of the challenges of additive manufacturing is identifying defects occurred inside of the printed parts

❏ To address this challenge, data analytics techniques are being used to identify defects by exploring millions of sensor records

Predicting Hurricane Induced Power Outages

Actual   S18: 2 stage

Customer Outages
- 0~200
- 200~1000
- 1000~5000
- 5000~10000
- >10000
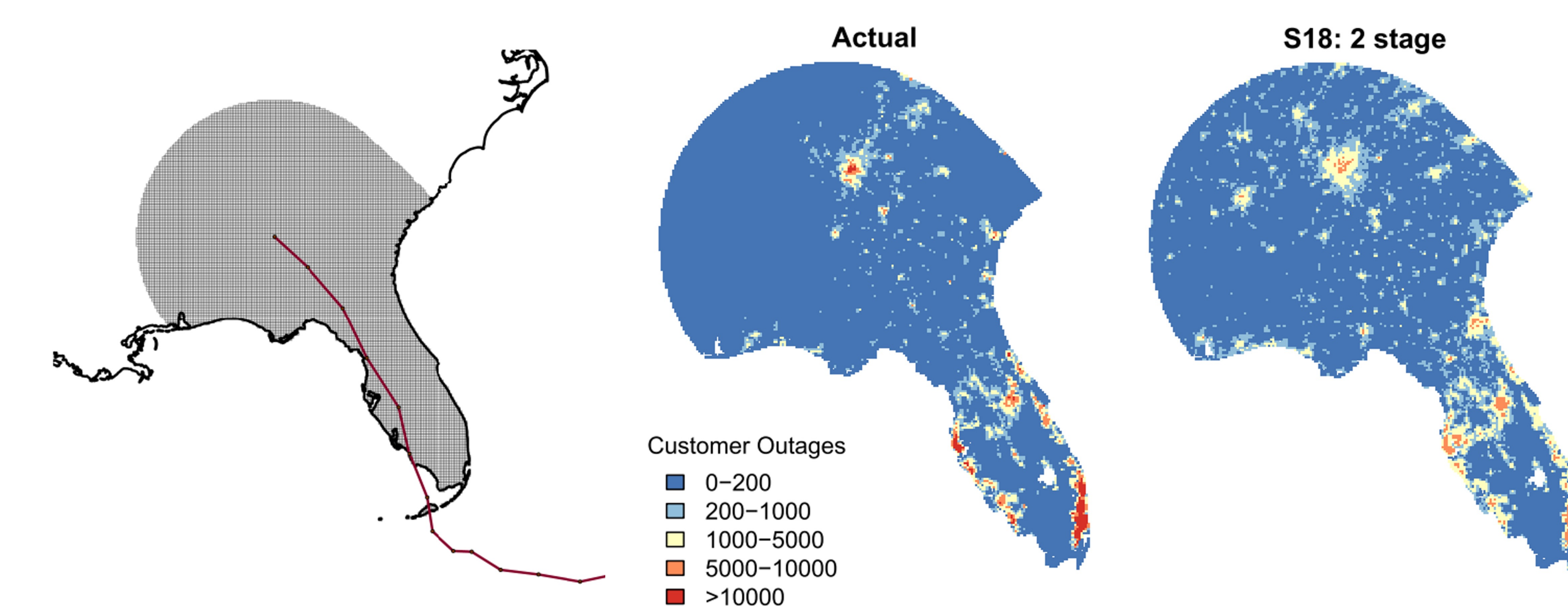
❏ Hurricanes are one of the hazardous natural phenomena that threat our lives and society.

❏ Predicting accurate impact of power outages incurred by hurricane is significant since it can damage water systems and transportations.

❏ Early estimates of precise outage occurrences can help to plan pre-storm requirements and resources needed for restoration planning.