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Decision Making for Different Types of Variation in a Manufacturing System

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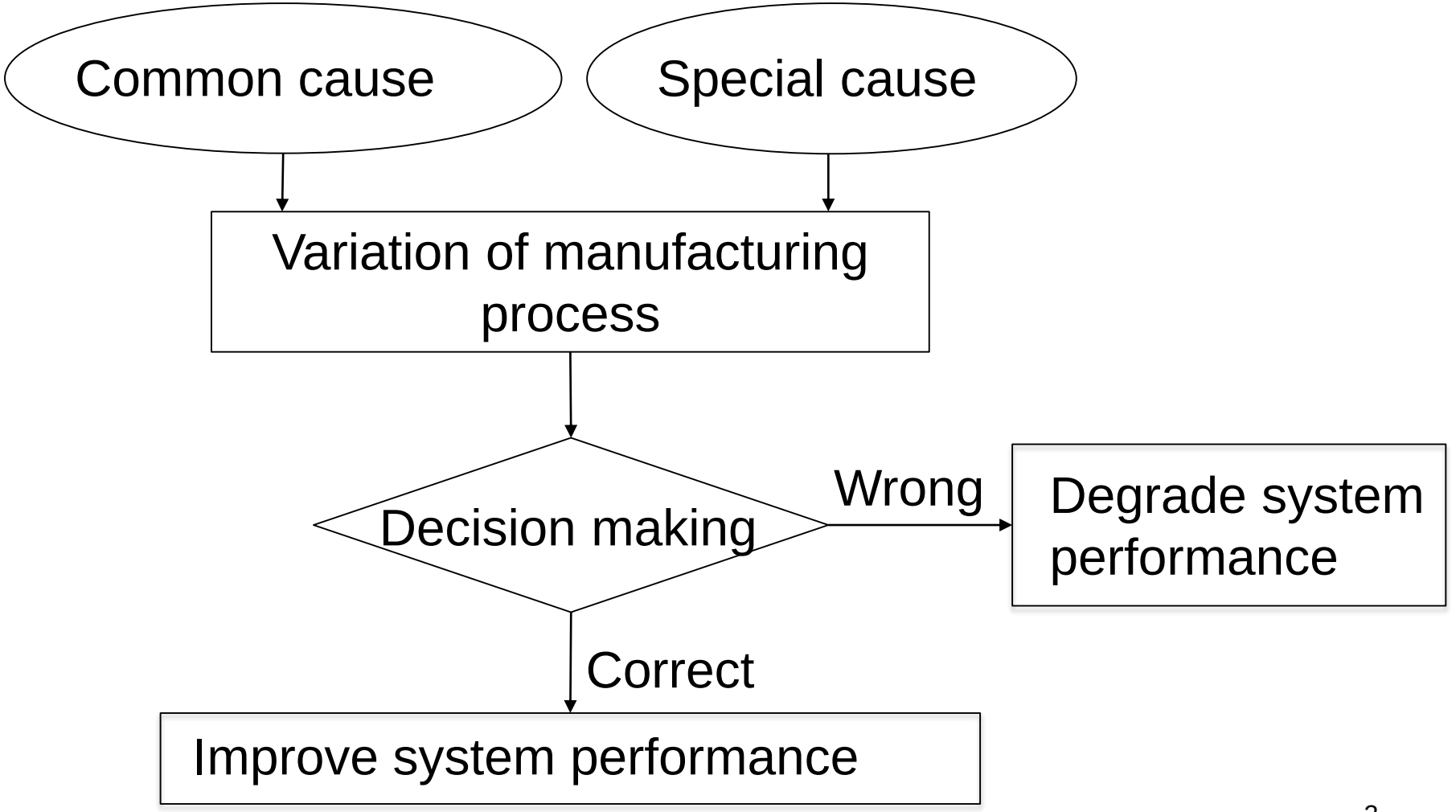
Common cause variation

- Natural part of the process
- Acting on process

Special cause variation

- From external sources
- Searching and mitigating causes

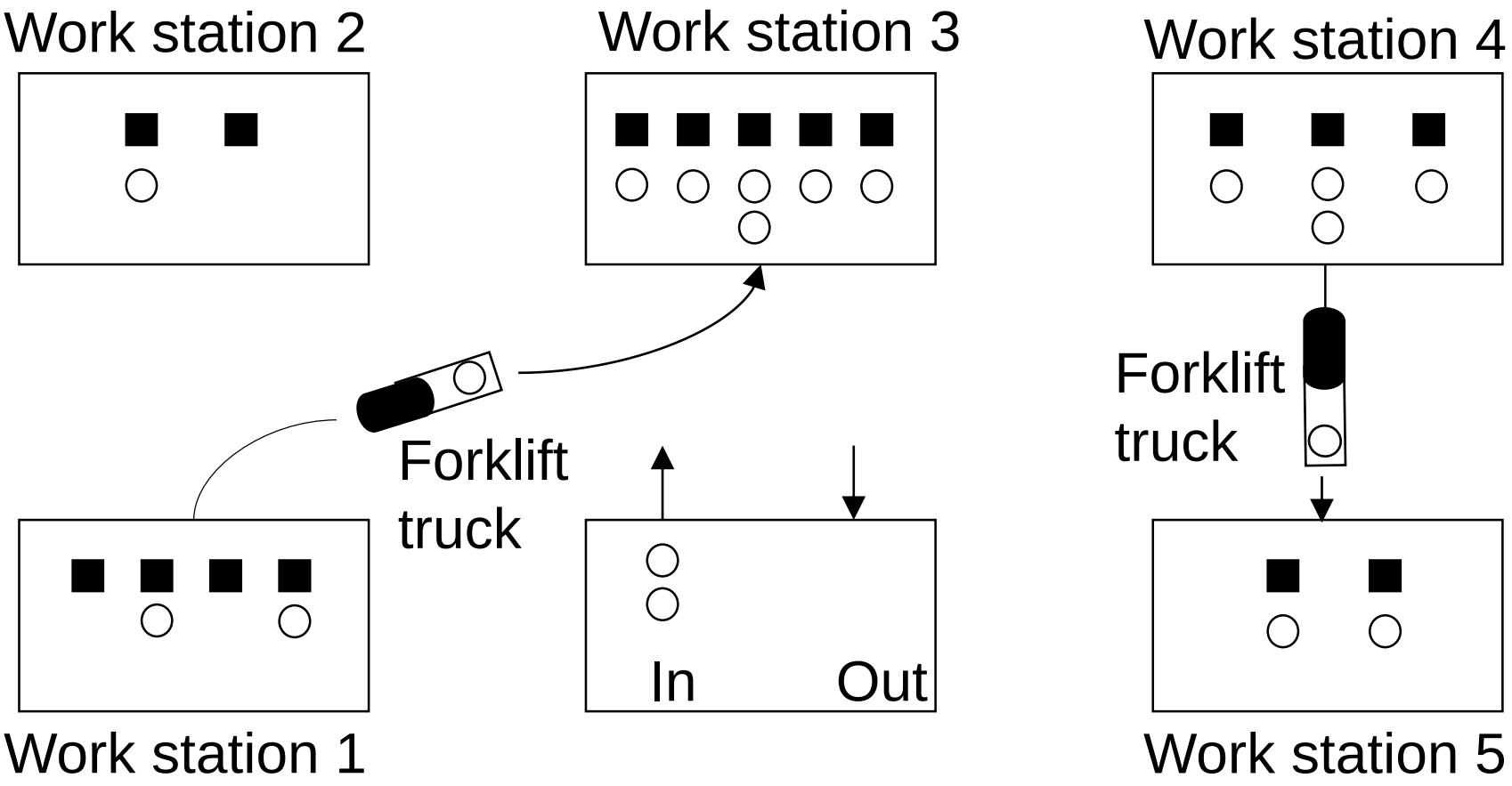
Motivation


Common cause
Special cause
Variation of manufacturing process
Decision making
Wrong
Degrade system performance
Correct
Improve system performance

Research goals

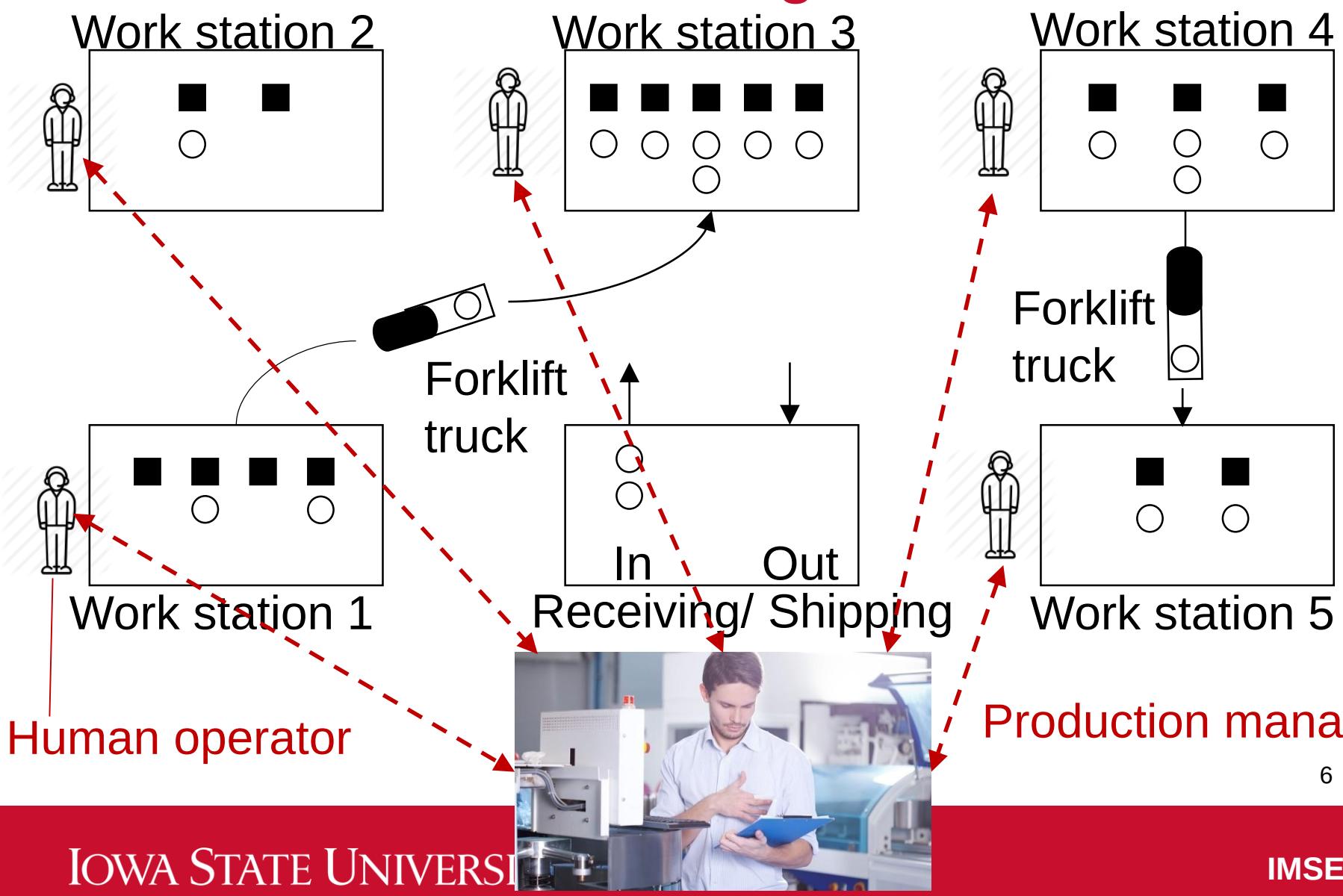
- Analyze and quantify how common cause variation and special cause variation impact system performance
- Simulate how human operators may
  - Interpret causes of variation
  - Make decisions to reduce causes of variation
- Quantify impact of decision making
  - If human operators correctly interpret variation
  - If human operations incorrectly interpret variation

Simulation of manufacturing system

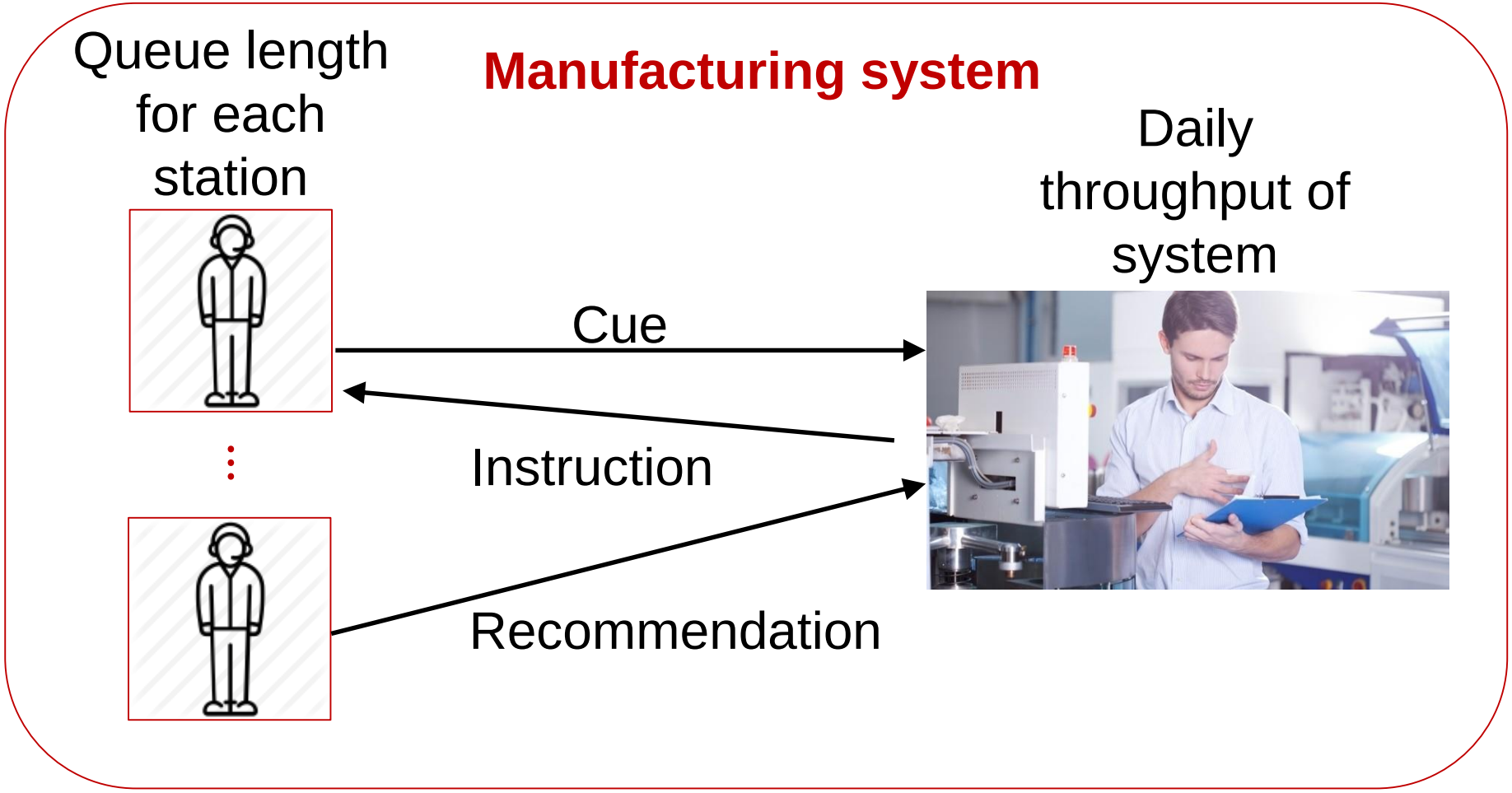


Law, A. M. *Simulation Modeling and Analysis*, 4th ed. New Delhi: Tata McGraw-Hill Publishing (2007).

Human decision making



Interaction within the decision team



Shared mental model

Simulate decision making

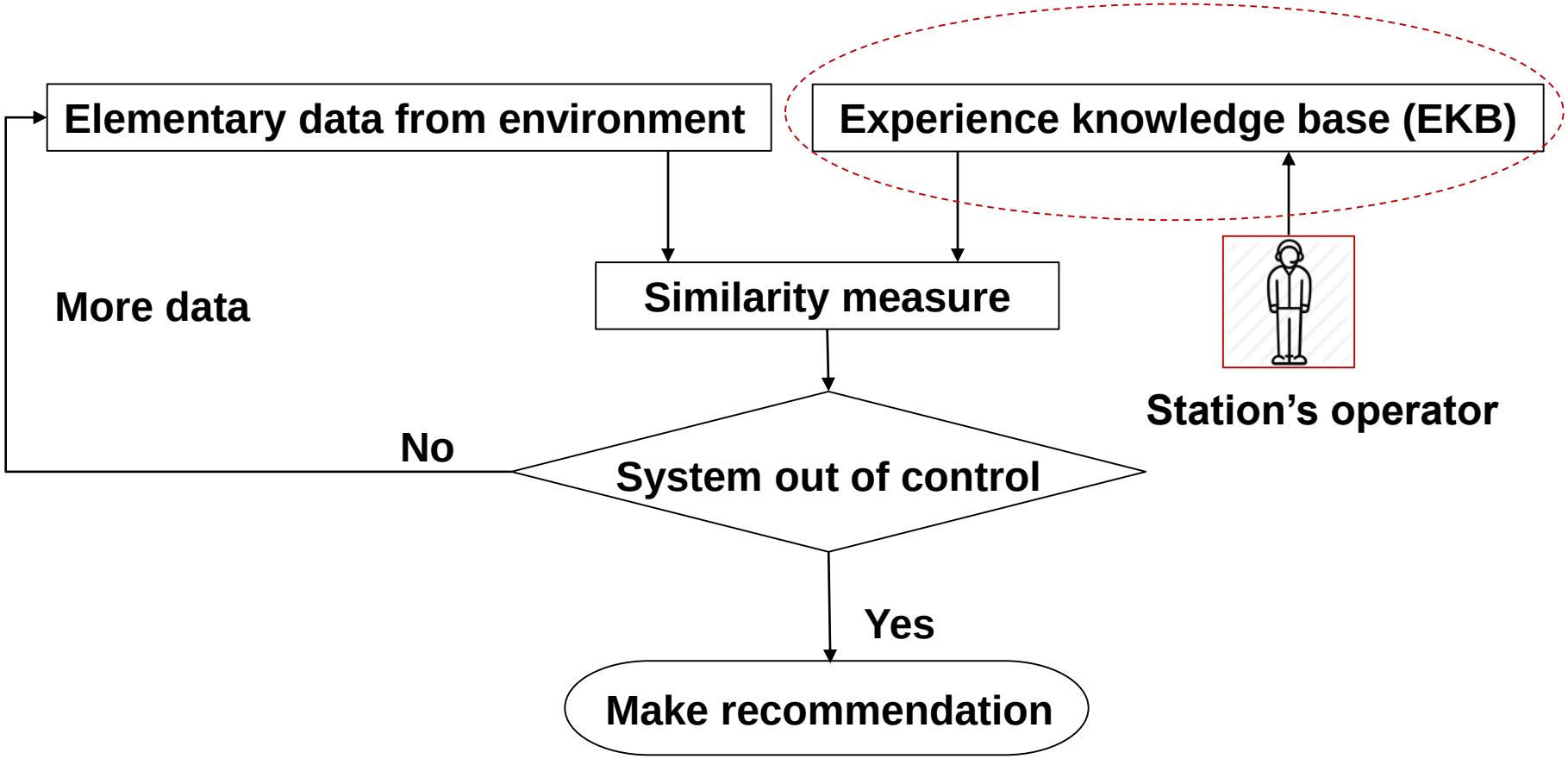
- How should each station operator give recommendations to the production manager?

- How should the production manager make decisions based on the recommendations and give the cues?

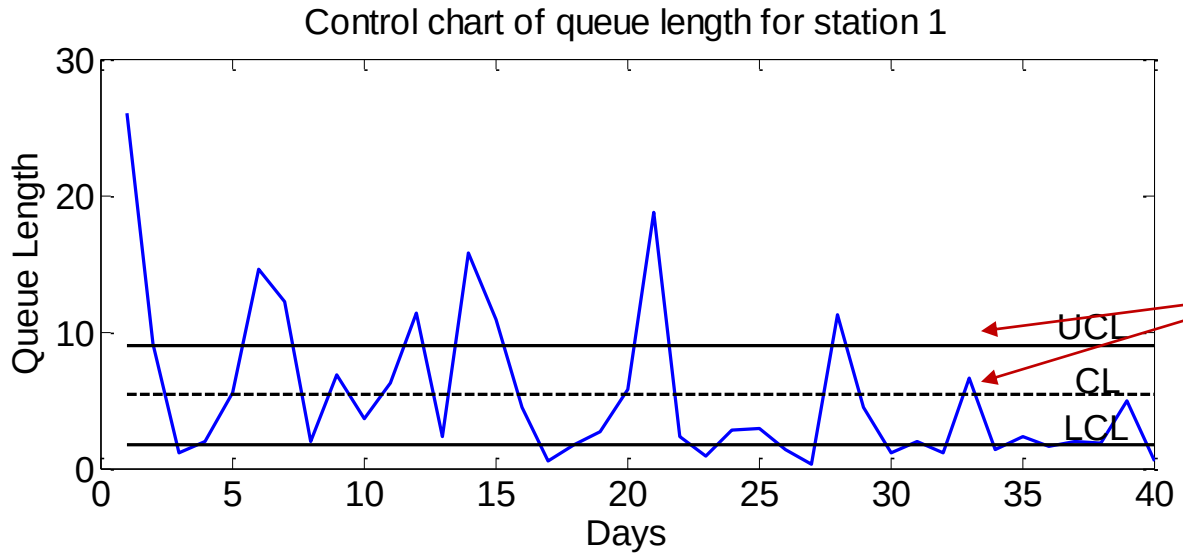
-Recognition-primed decision (RPD) model

Klein, Gary A. *A recognition-primed decision (RPD) model of rapid decision making*. New York: Ablex Publishing Corporation, 1993.

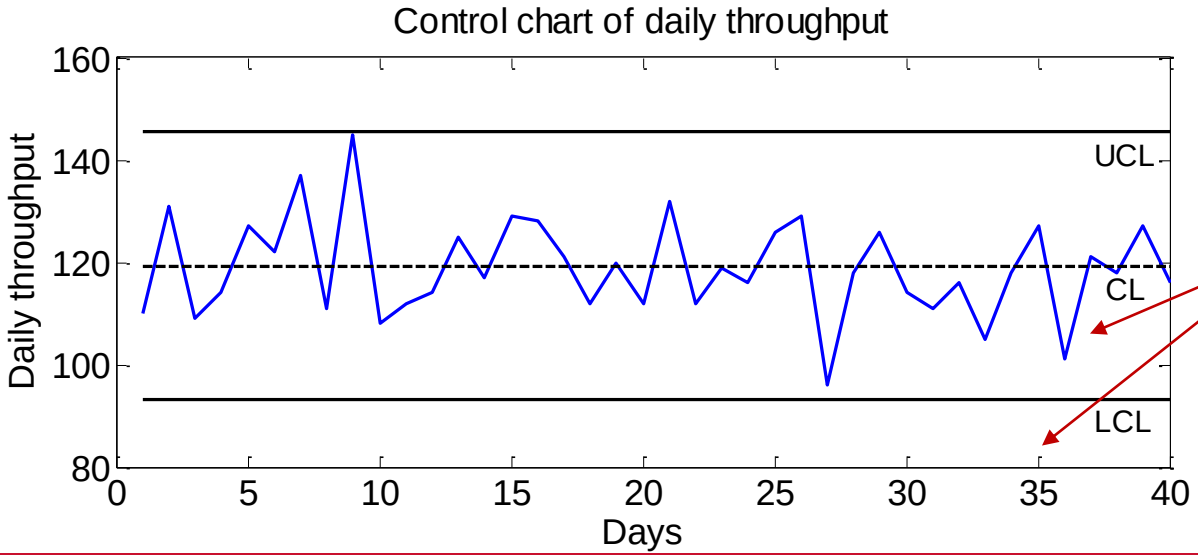
Modified RPD model for station's operator



Experience Knowledge Base (EKB)



Station's operator



Production Manager

Simulation

- Simulate manufacturing system (40 days) → control chart parameters
  - Daily throughput
  - Queue length for each station
- Use simulation to analyze how performance metrics change
  - If production team attempts to reduce common cause variation
  - If special cause variation is introduced
  - If production team misinterprets cause of variation (future work)

Common cause and special cause variation

- Actions to reduce common cause variation
  - Change mean process time of station's machines
  - Reduce variation of process time of station's machines
  - Change mix of arriving jobs
- Special cause variation problems
  - Forklifts move more slowly
  - Machine breaks down
- Actions for special cause variation: identify system problem and fix problem

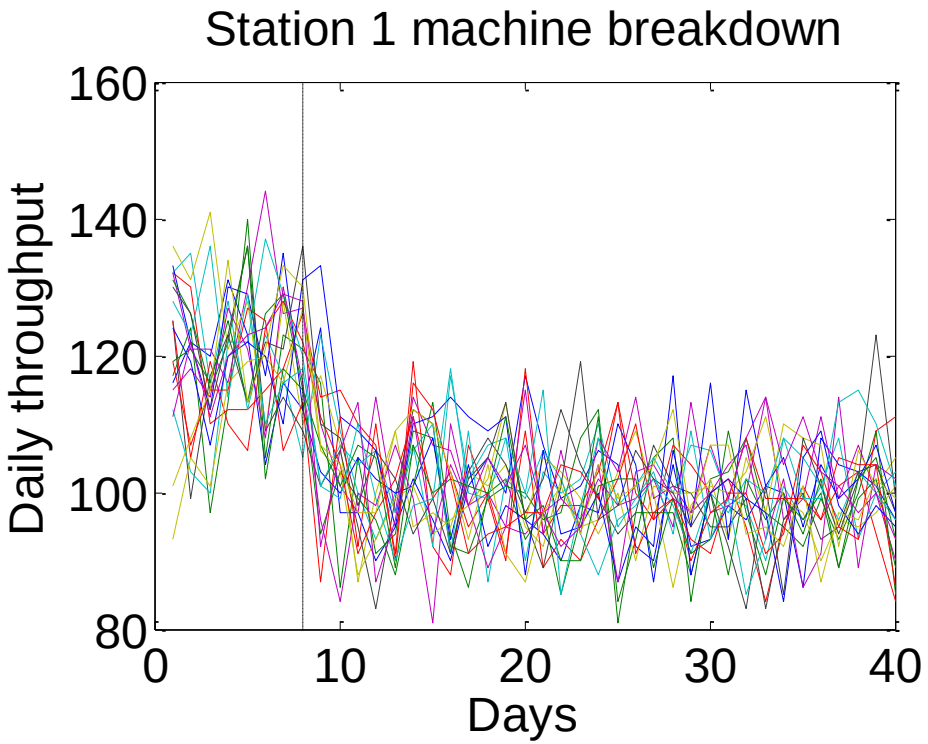
Change mix of 3 job types

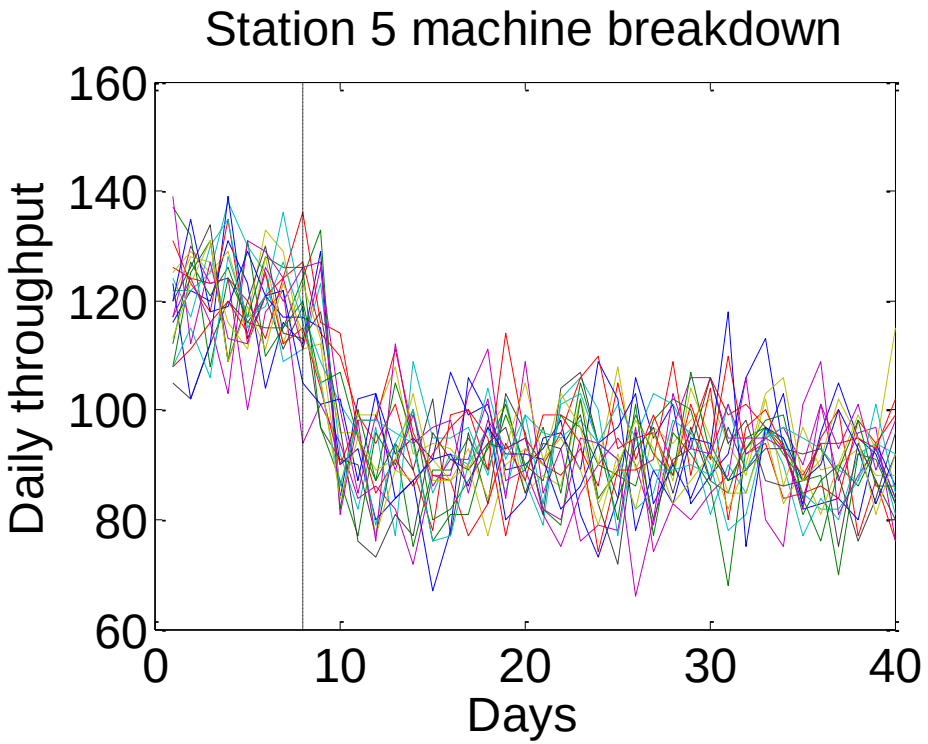
		1↑ 2↓ 3↓	1↓ 2↑ 3↓
Daily throughput	Mean	↓	≈
	STD	≈	≈
Queue length of station 1	Mean	↓↓	↓
	STD	↓↓	↓
Queue length of station 2	Mean	≈	↓
	STD	≈	↓
Queue length of station 3	Mean	≈	↑ (< 3)
	STD	≈	↑ (< 3)
Queue length of station 4	Mean	≈	≈
	STD	≈	≈
Queue length of station 5	Mean	↑↑	↓
	STD	↑↑	↓

Decrease one station's process time, increase another station's process time

		I	II	III
Daily throughput	Mean	≈	≈	≈
	STD	≈	≈	≈
Queue length of station 1	Mean	≈	≈	↓
	STD	≈	≈	↓
Queue length of station 2	Mean	↑ (< 1)	≈	≈
	STD	↑ (< 1)	≈	≈
Queue length of station 3	Mean	≈	↓	≈
	STD	≈	↓	≈
Queue length of station 4	Mean	≈	↓	≈
	STD	≈	↓	≈
Queue length of station 5	Mean	↓	≈	↓↓
	STD	↓	≈	↓↓

Special cause variation: Machine breakdowns





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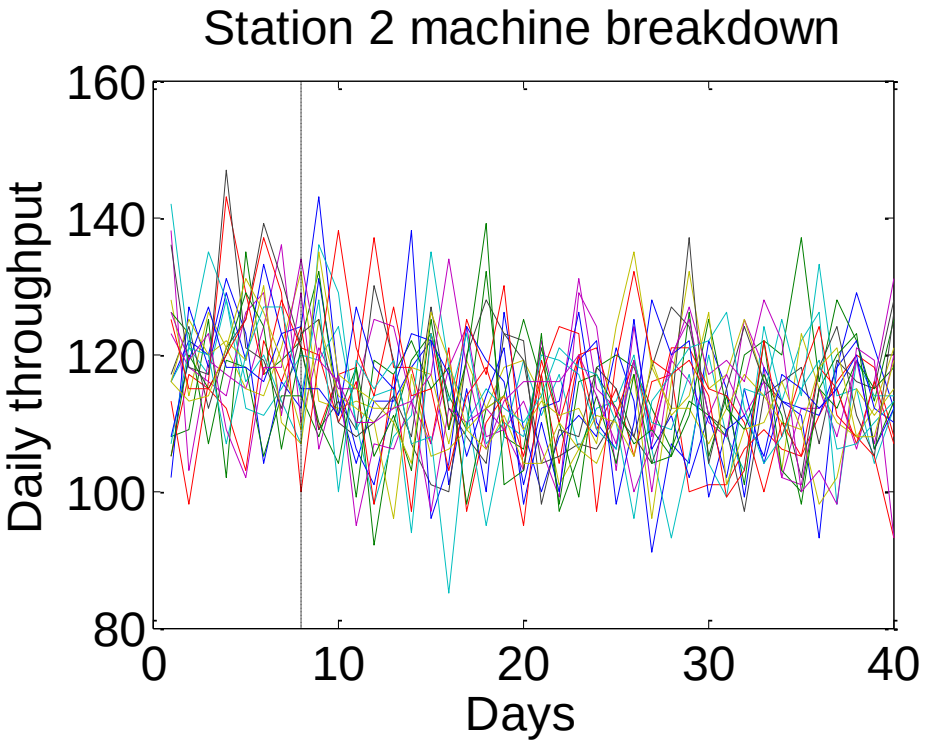
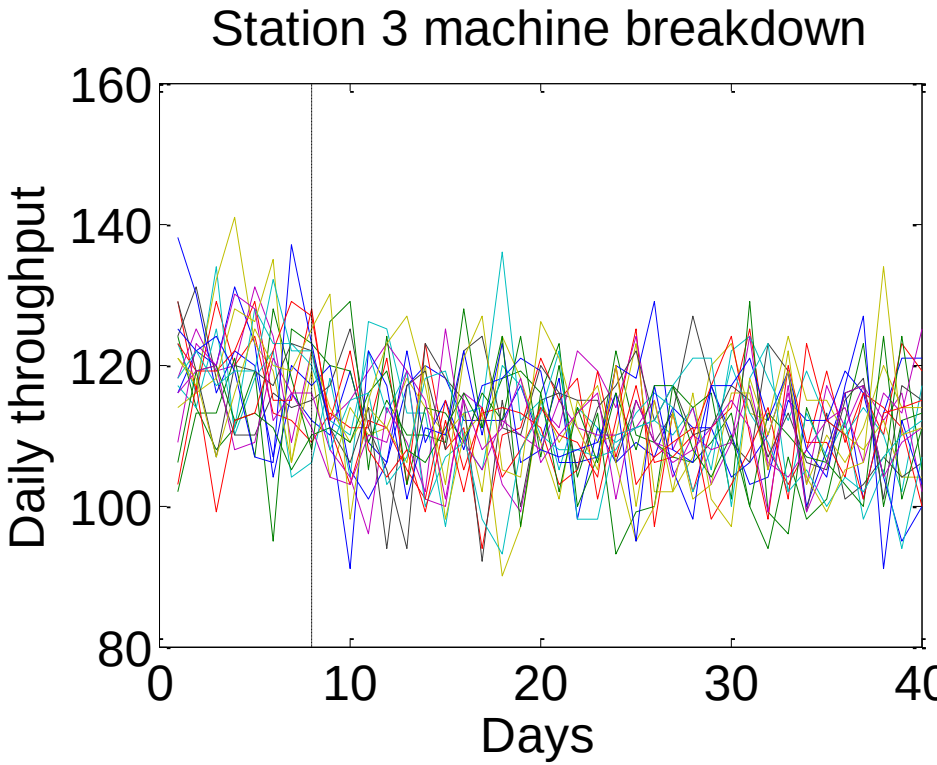
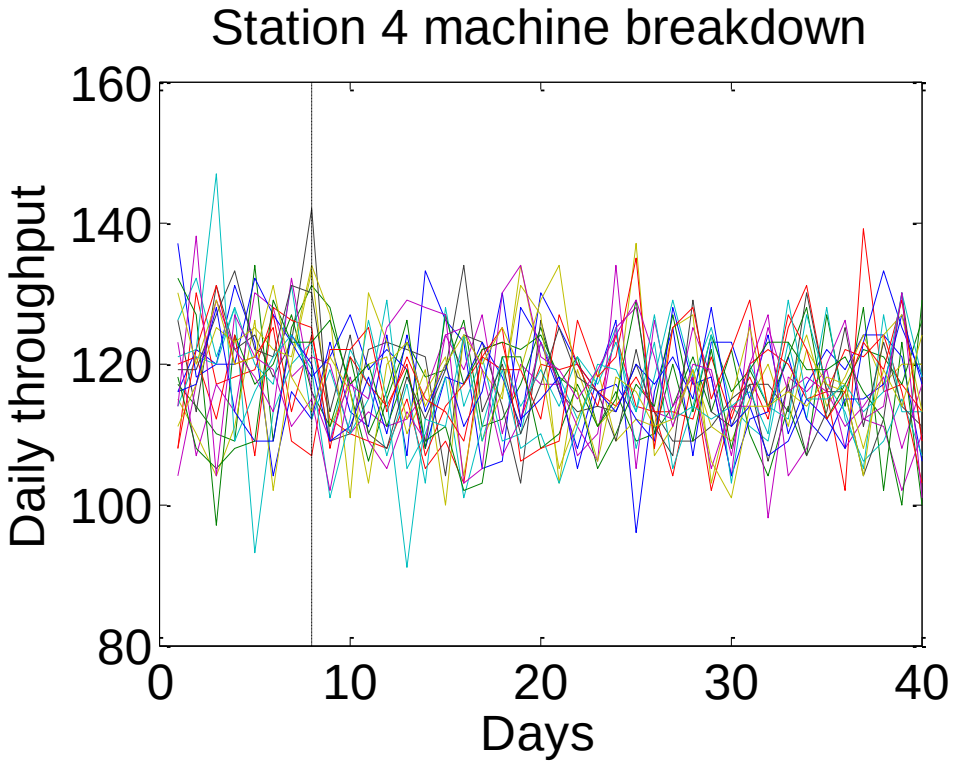
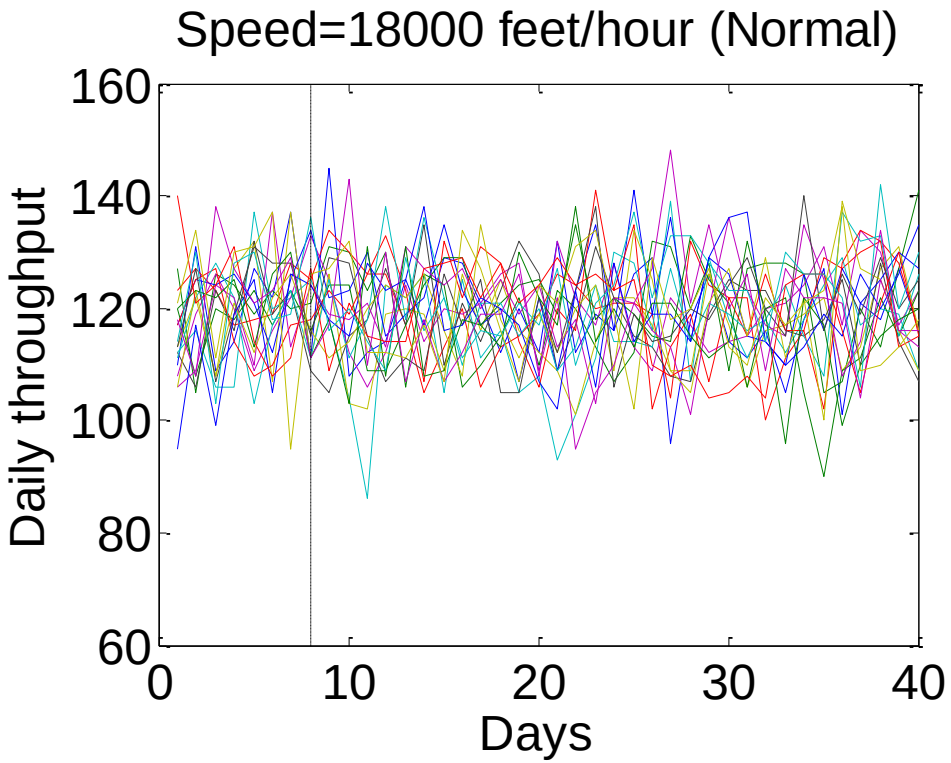


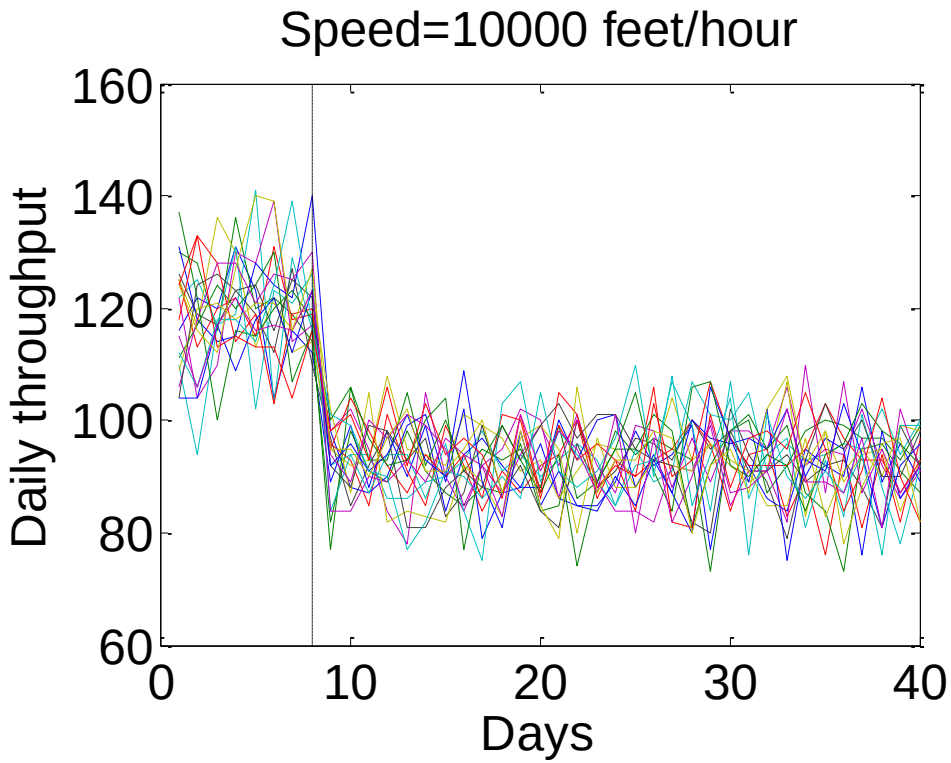


Special cause variation: Machine breakdowns



Special cause variation: Forklift trucks move more slowly





Preliminary contributions

- Recognition-primed decision making model applied to manufacturing system
  - Embed interplay among decision team within the shared mental model
  - Represent knowledge base of experts through control charts
- The importance of distinguishing common cause variation and special cause variation

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