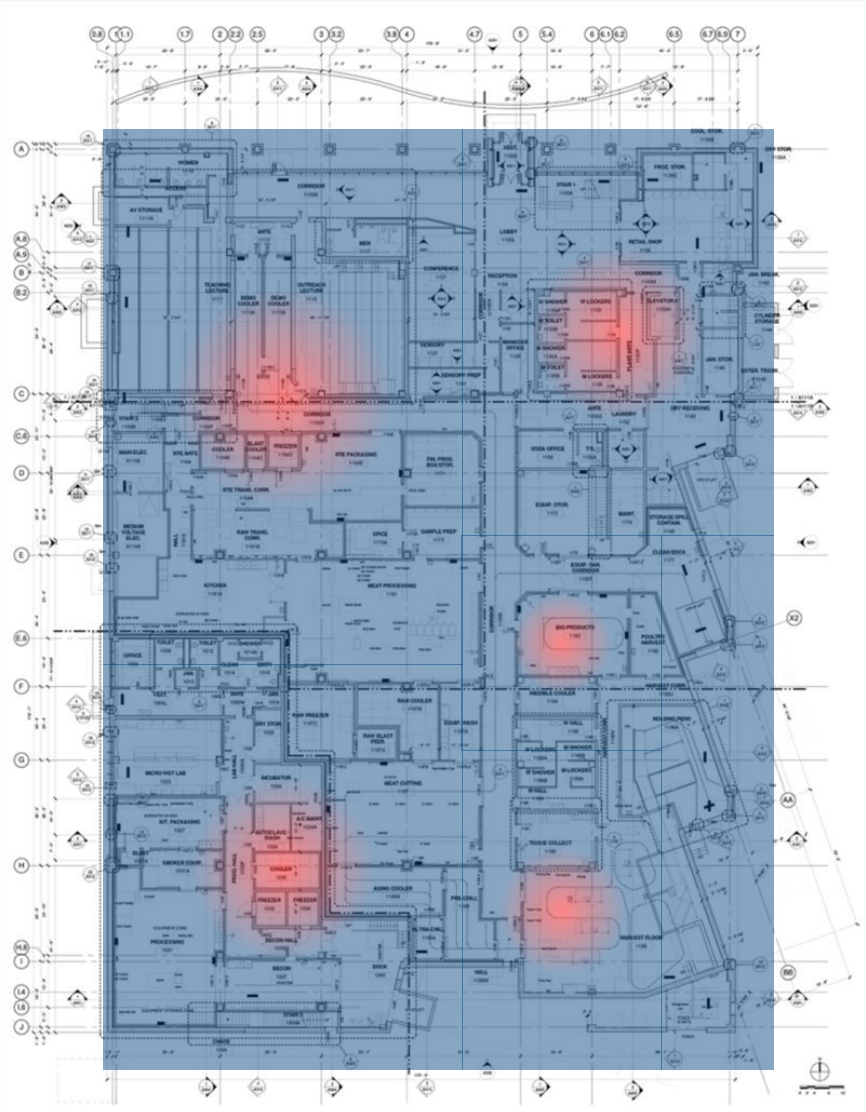
# ADAPTIVE SAMPLING:
# RISK-BASED ENVIRONMENTAL MONITORING

May 14, 2025 | Hannes Pouseele

# OVERVIEW

- **THE FACTORY: A LIVING SYSTEM …**
- **… WITH A MICROBIAL RISK**
  - What is risk?
  - How do we measure and model it?
  - How do we improve observing the factory microbial state?
  - How do we respond to issues?
- **ADAPTIVE SAMPLING:**
  **reduce risk** and **maximize resource efficiency**

# MICRO RISKS IN THE FACTORY ENVIRONMENT



**ENVIRONMENTAL MONITORING: A RISK MAP**
observing the microbial state of the factory where is it hot? where is it cold?

**ENVIRONMENTAL SAMPLING: A SNAPSHOT**
measuring the microbial state of specific locations at specific times

- Where do I look?
- How often do I look?
- How many samples can I afford?
- What action do I take?

**FROM A SNAPSHOT TO A RISK MAP?**
How does a limited set of samples inform me about the factory state as a whole?

# WHAT CONSTITUTES RISK?

REAL WORLD EXAMPLE

LISTERIA RISK IN FROZEN FOODS PLANT

## RISK: THE LIKELIHOOD OF SOMETHING HAPPENING

~~**Severity:** if something happens, how bad is it?~~

### Estimated risk

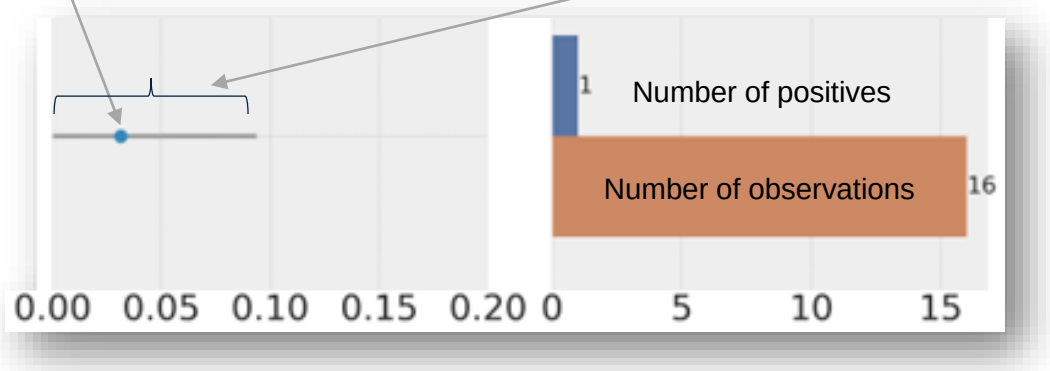
**How likely is an out-of-spec occurring?**

- Positivity rate …
- For a location that never tested positive, **is there zero risk?**

### Uncertainty of the estimate

**How certain are we about our estimate?**

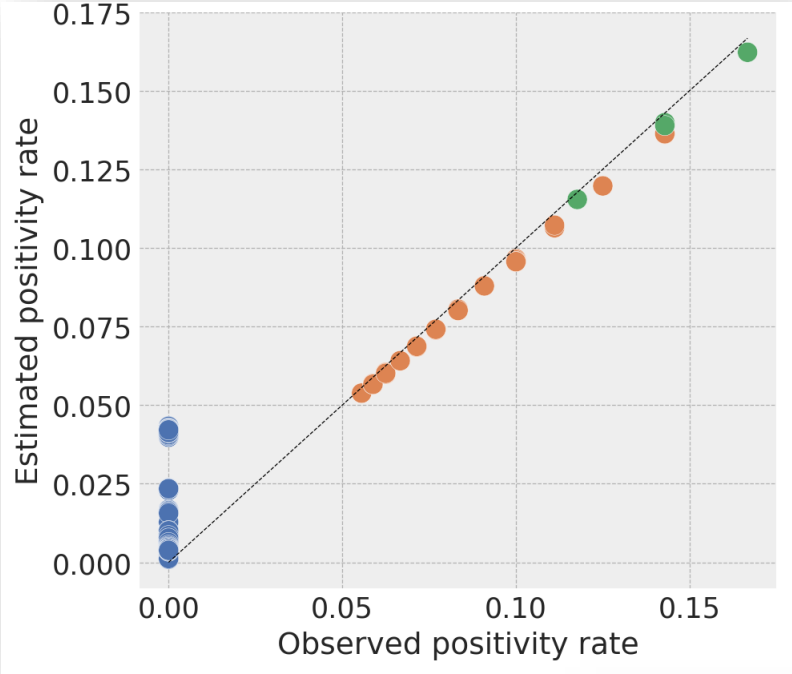
- If we measure location A once a month and location B once a week, **are we equally certain about the result?**

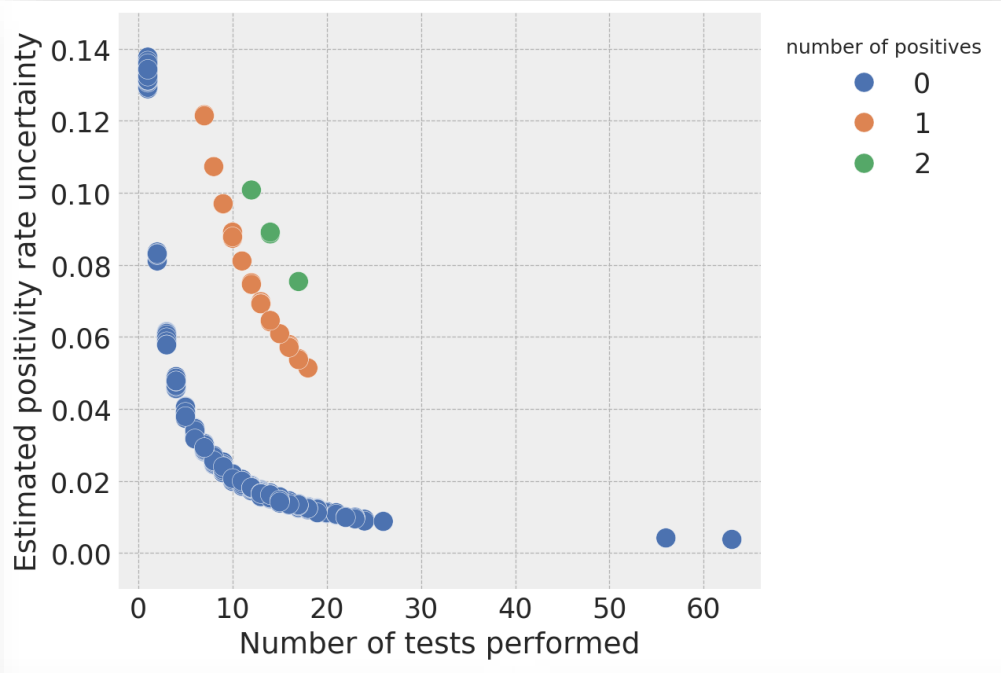


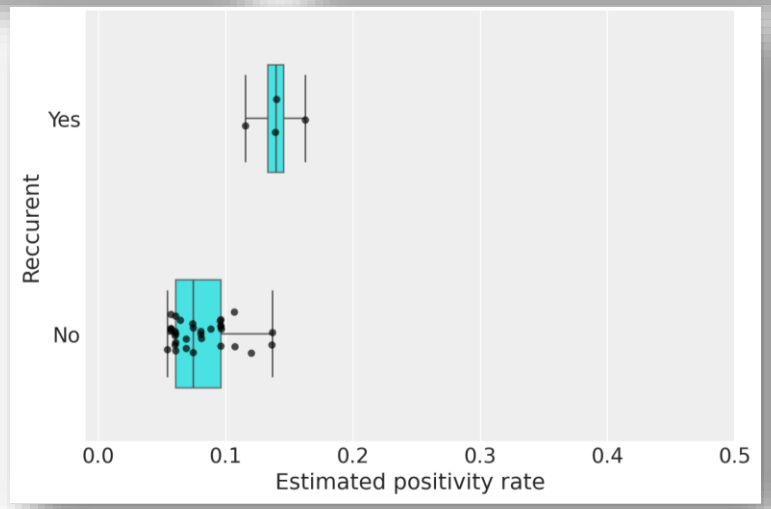
# MODEL vs. REALITY

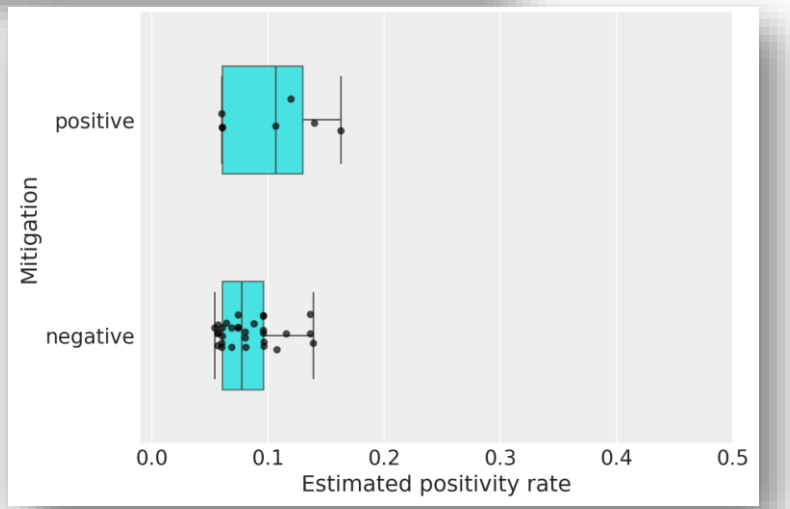
REAL WORLD EXAMPLE

LISTERIA RISK IN FROZEN FOODS PLANT



# VALUE AT RISK

REAL WORLD EXAMPLE

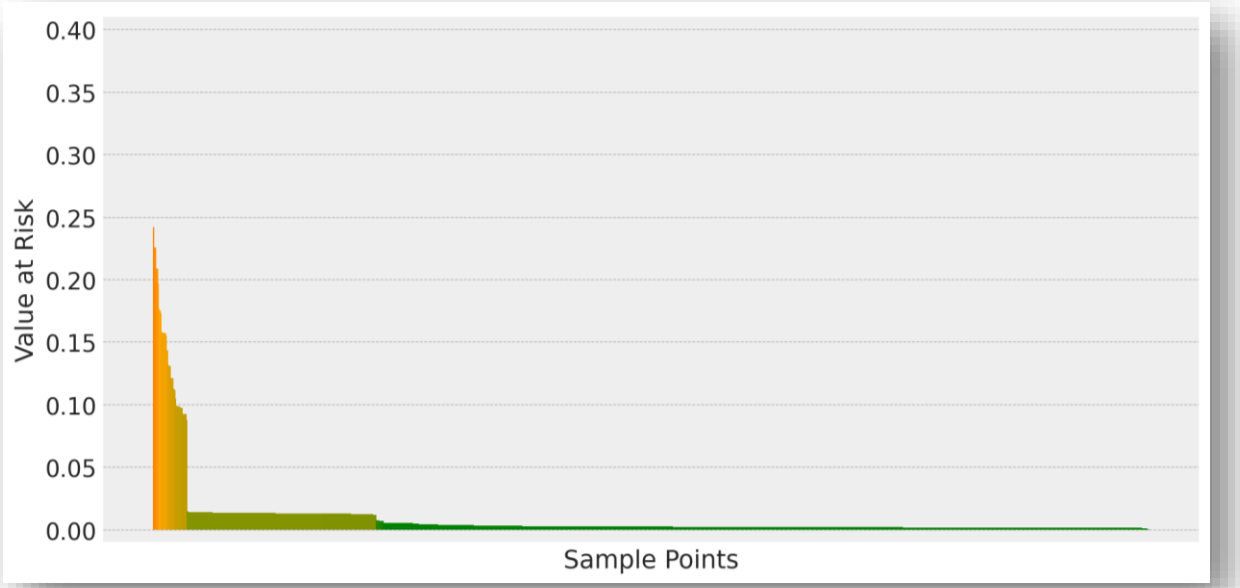
LISTERIA RISK IN FROZEN FOODS PLANT

## RISK: THE LIKELIHOOD OF SOMETHING HAPPENING

**ESTIMATED RISK** + **UNCERTAINTY OF THE ESTIMATE**

→ **VALUE AT RISK**

**How bad does it get on a "usual" day?**



# REMAINING RISK AND SAMPLING OPTIMIZATION

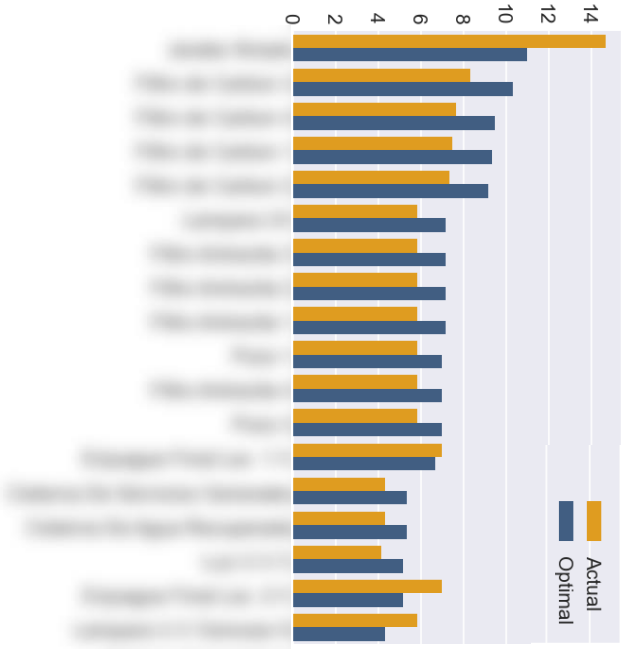
REAL WORLD EXAMPLE

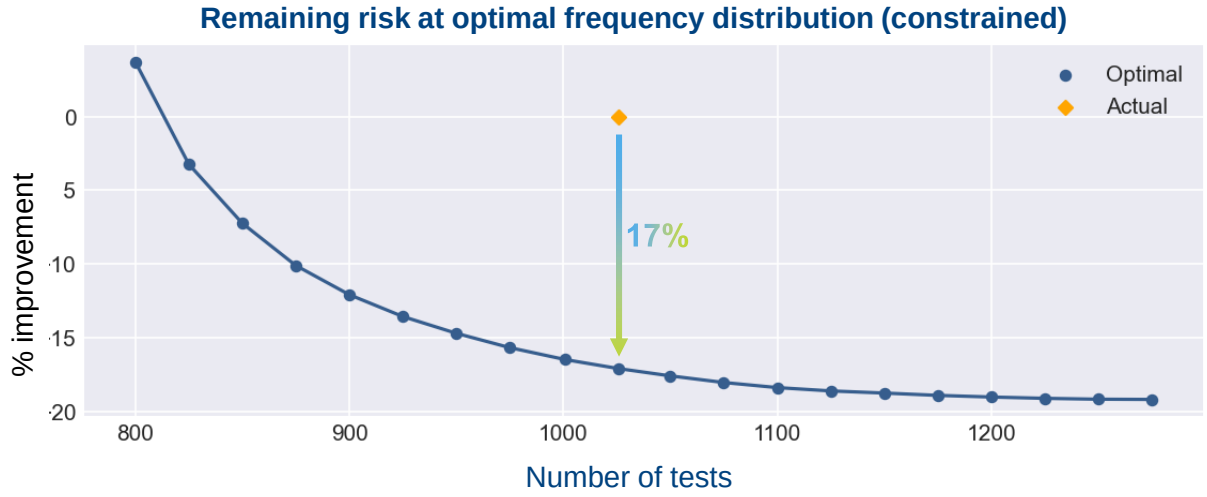
YEAST & MOLD RISK IN BEVERAGE PLANT

## REMAINING RISK: HOW MUCH OF THE VALUE AT RISK IS UNOBSERVED?

$$\sum_{sampling\ points} sampling\ frequency\ * value\ at\ risk$$

By modifying sampling frequency, we **minimize the risk** while controlling for the sampling volume.



# MIGRATION

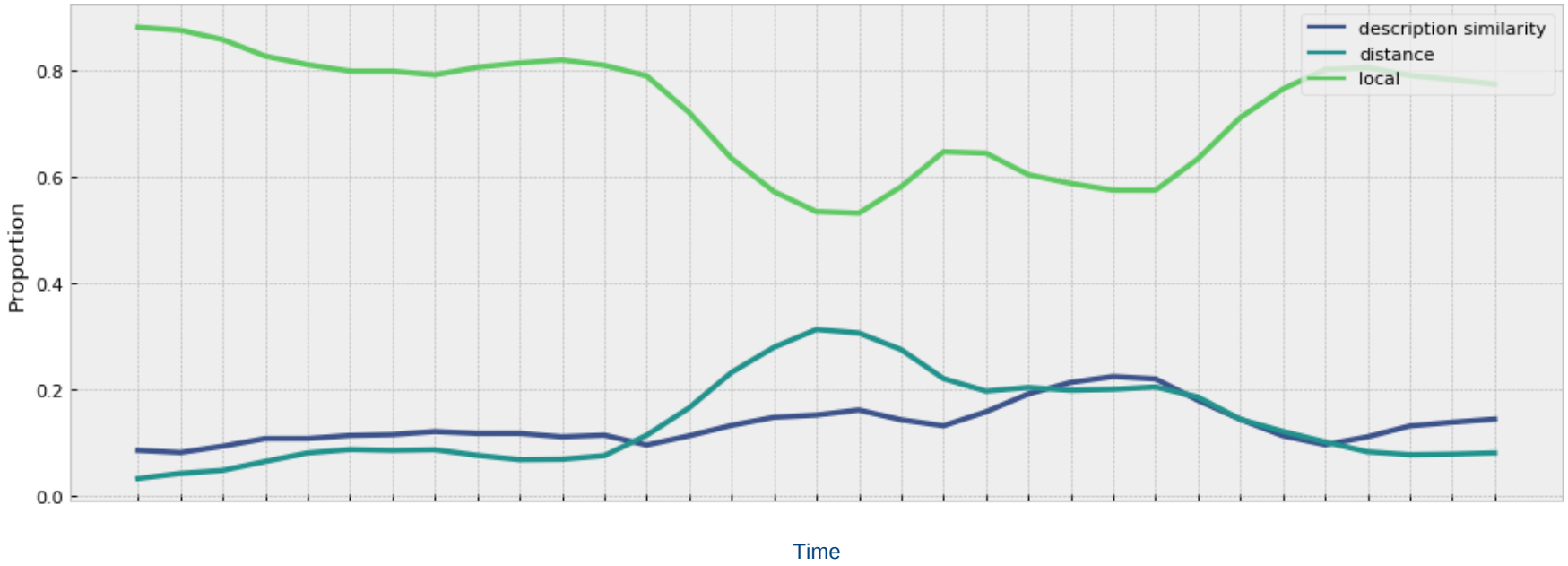
REAL WORLD EXAMPLE

LISTERIA RISK IN RTE PLANT

## HOW DO MICRO PROBLEMS MOVE THROUGH THE FACTORY?

- Distance
- Description similarity
- Product
- People
- Teleportation

**Relative importance of different transmission mechanisms**

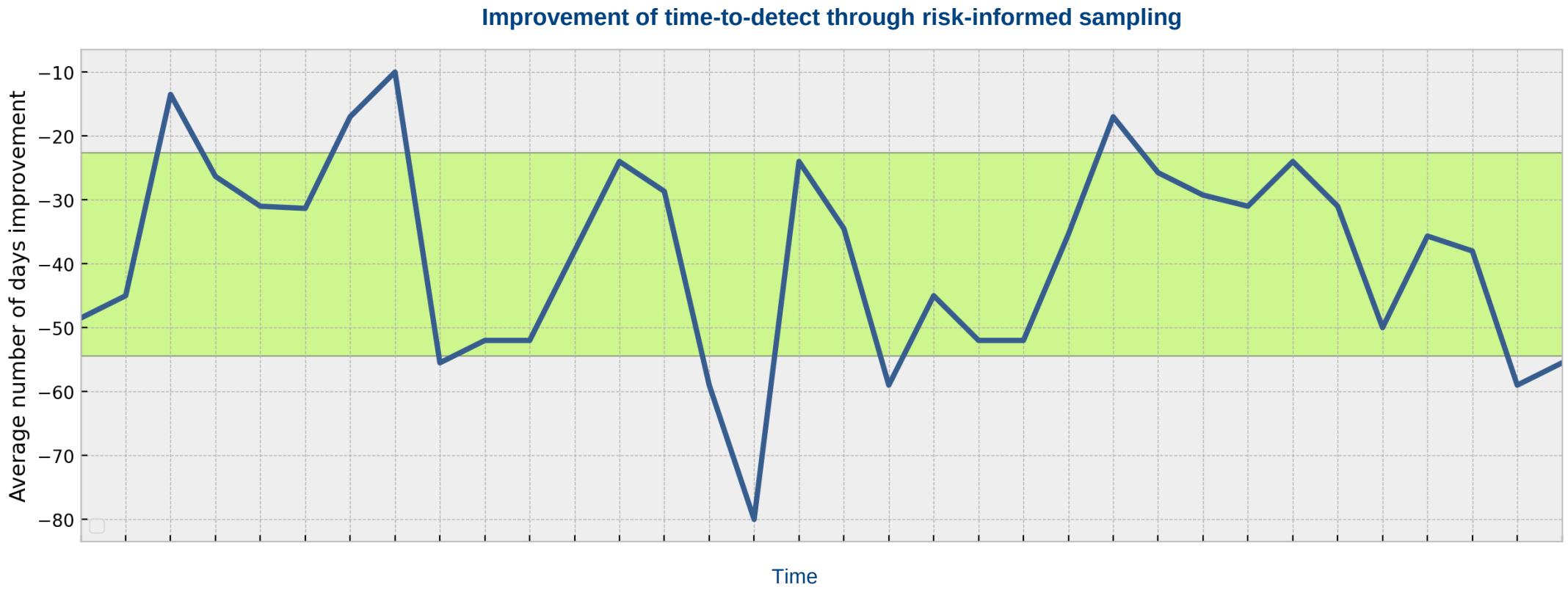


# EXPLORATORY SAMPLING

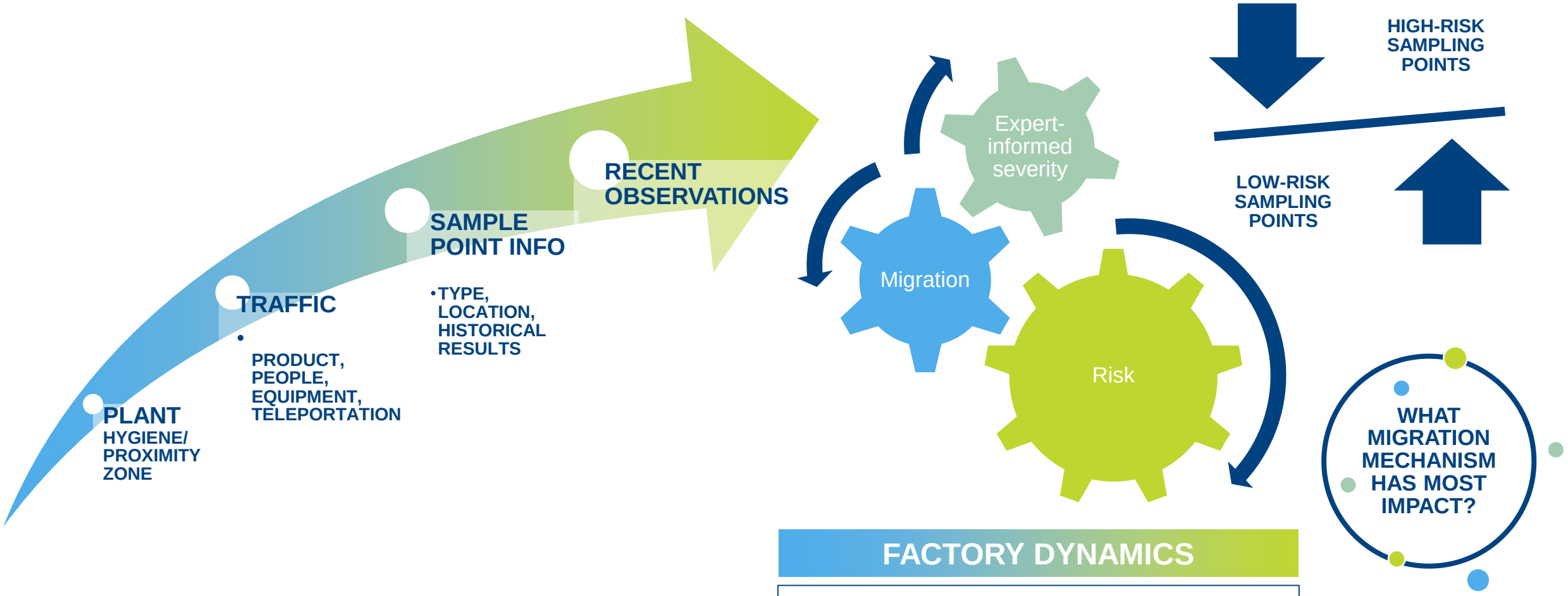
REAL WORLD EXAMPLE

LISTERIA RISK IN RTE PLANT

## RISK PROPAGATION THROUGH MIGRATION INFORMS EXPLORATORY SAMPLING



# ADAPTIVE SAMPLING



# ACTION!

BIOMÉRIEUX

- **ADAPTIVE RISK-BASED ENVIRONMENTAL MONITORING AVAILABLE NOW!**
- SOFTWARE/SERVICE OFFERING **TAILORED TO YOUR NEEDS**
- COME SEE US A **BOOTH 424**

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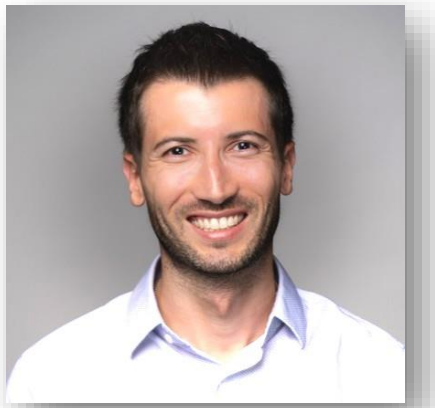
Connect with me

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