Work Smarter Not Harder

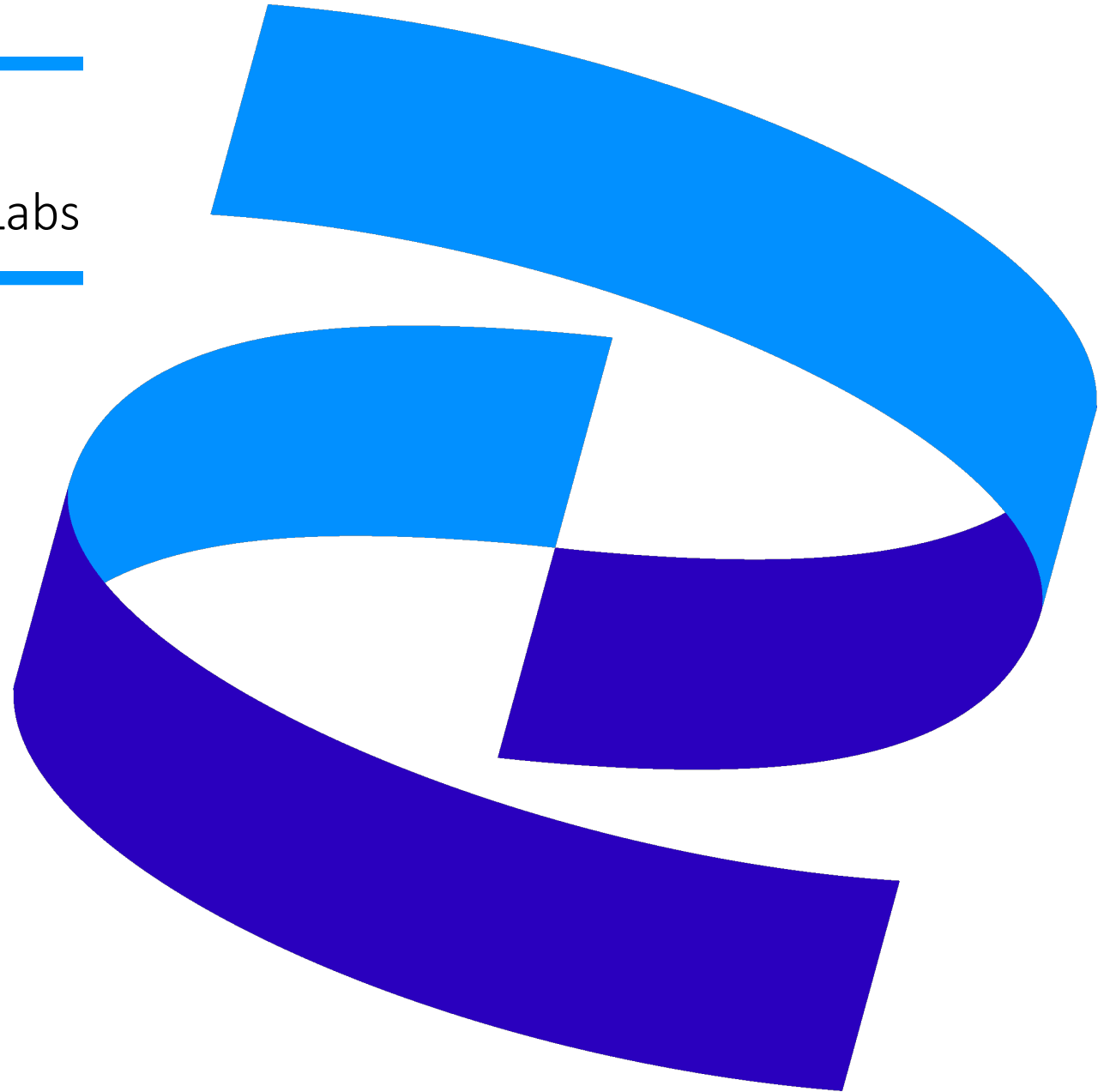## Optimal Scheduling for Quality Control Labs

Authors:
Michal Laskowski & Shannan Liu

Faculty Advisor:
Professor Nikos Trichakis
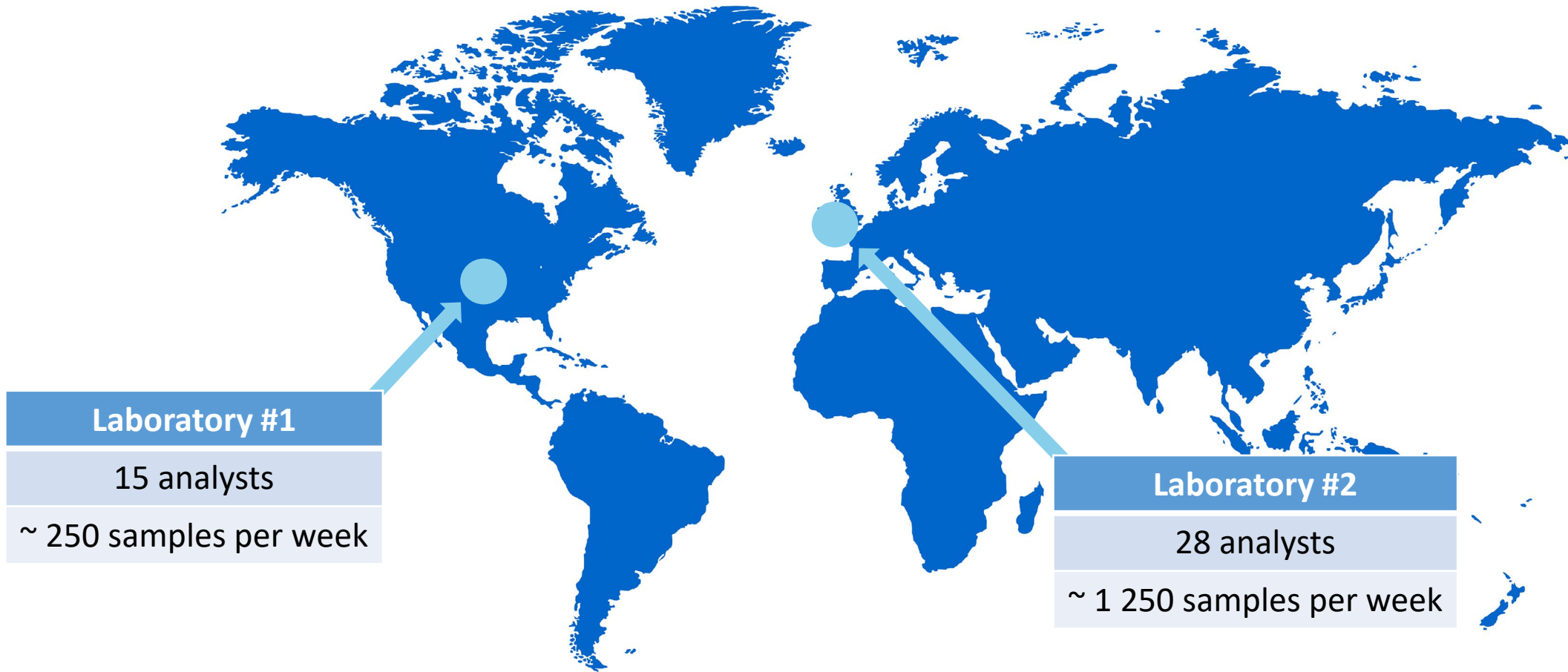
Pfizer Mentors:
Caroline Daugherty & Abigail Garrett

Quality control is imperative to Pfizer

Global project scope

Laboratory #1

15 analysts

~ 250 samples per week

Laboratory #2

28 analysts

~ 1 250 samples per week

Project goal

Create a **weekly schedule** for a Quality Control lab
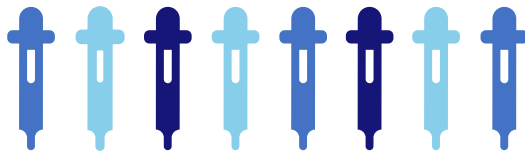that efficiently **groups samples** and **assign them to analysts**

Project goal

Create a **weekly schedule** for a Quality Control lab
that efficiently **groups samples** and **assign them to analysts**

Analysts

Samples

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Analysts

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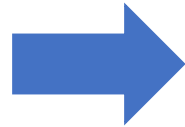# Project goal

Create a **weekly schedule** for a Quality Control lab
that efficiently **groups samples** and **assign them to analysts**

Analysts

Samples

>12 h

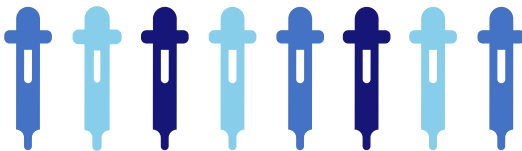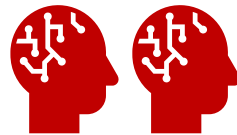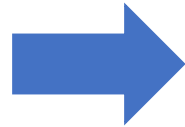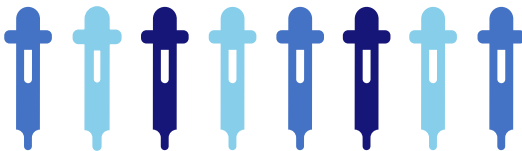# Project goal

Create a **weekly schedule** for a Quality Control lab
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Analysts

Samples

<2 h

12 h
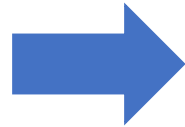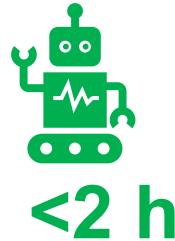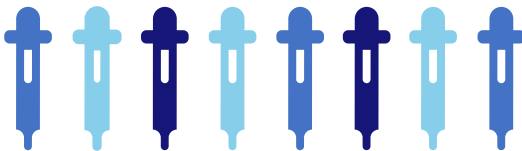
Grouping is critical for testing efficiency

Marginal sample runtime vs Equipment setup time
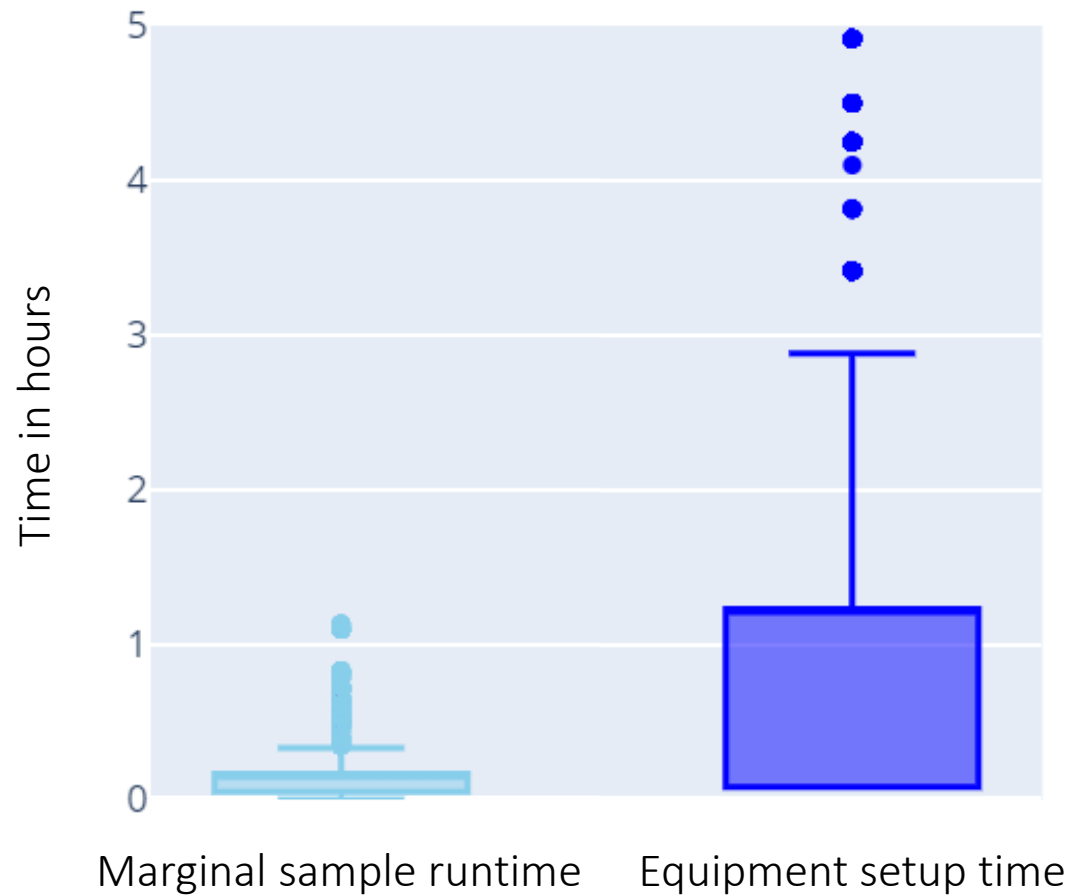
Average **equipment setup time is 14x longer** than average **testing time**

Robust Mixed-Integer Optimization

Decisions

When sample is:
- **Pulled out**
- **Tested**
- **Reviewed**

Which analyst:
- **Tests**
- **Reviews**

Robust Mixed-Integer Optimization

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Objective

Minimize
- **Total testing time**
  - **Cycle time**

Ensure
- **Work-life balance**
- **No late samples**

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Constraints

Subject to

- **Complex regulatory requirements**

- **Laboratory testing conditions**

Robust Mixed-Integer Optimization

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Robustness

Potential extended testing & reviewing time

Achieving balance

Trade-off between testing time and cycle time

Average testing hours

Average cycle time in days

α

Current performance

Testing time can be **reduced with little impact on cycle time**

Pfizer Global Supply Operations Insights
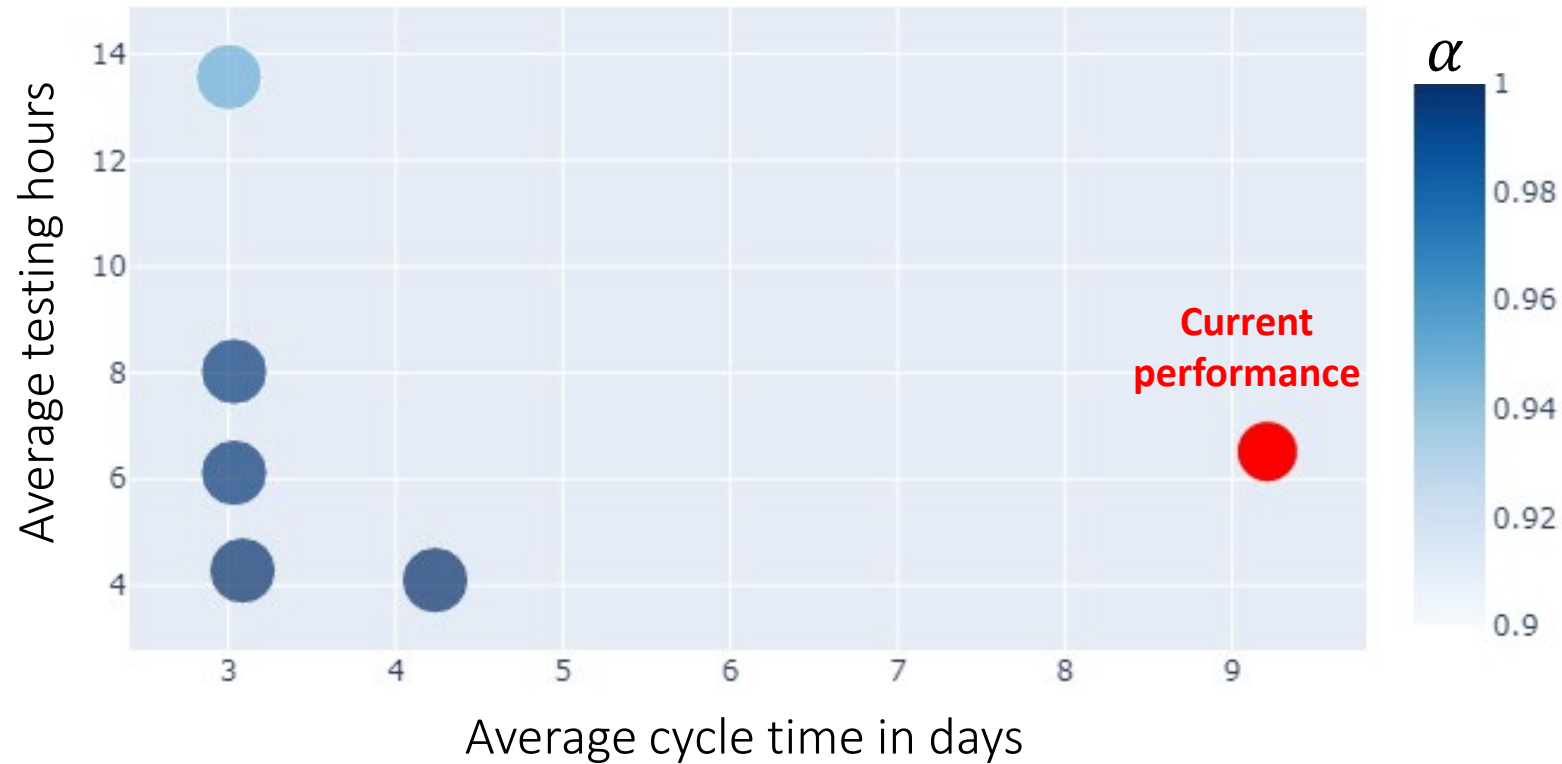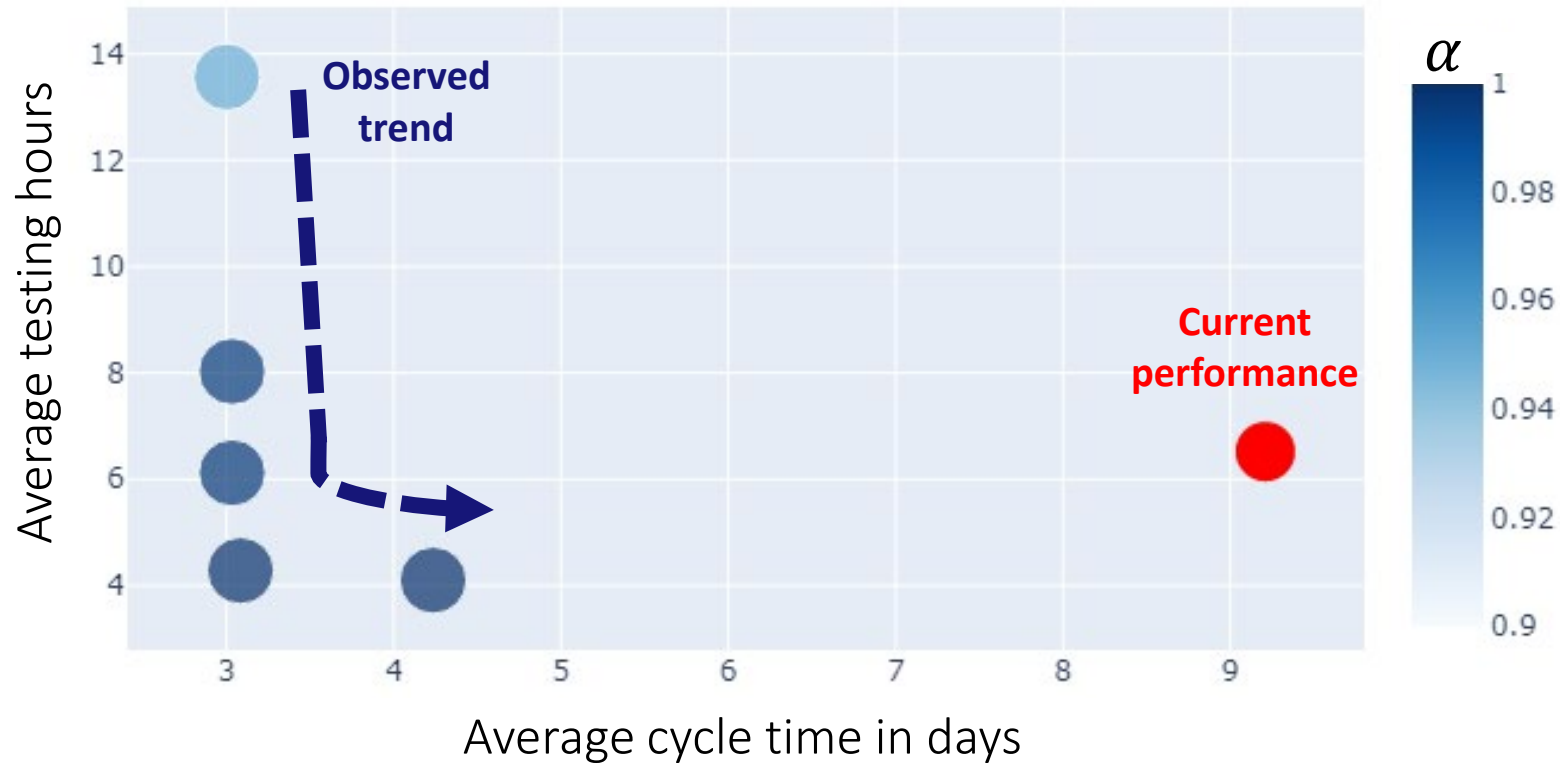
Achieving balance

Trade-off between testing time and cycle time

Testing time can be **reduced with little impact on cycle time**

Achieving balance

Trade-off between testing time and cycle time

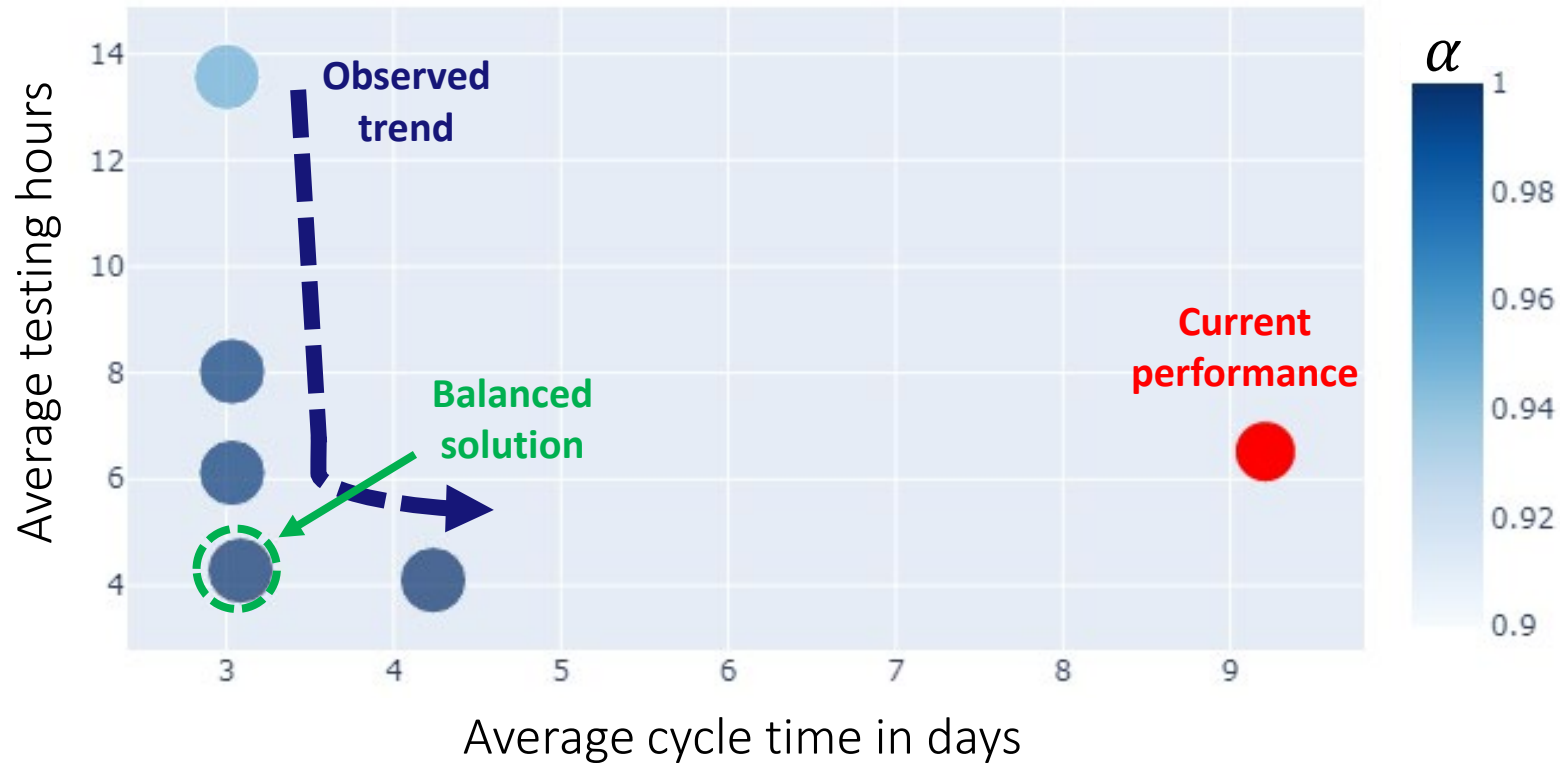**Testing time** can be **reduced with little impact on cycle time**

Stable schedule

Average daily working hours for an analyst
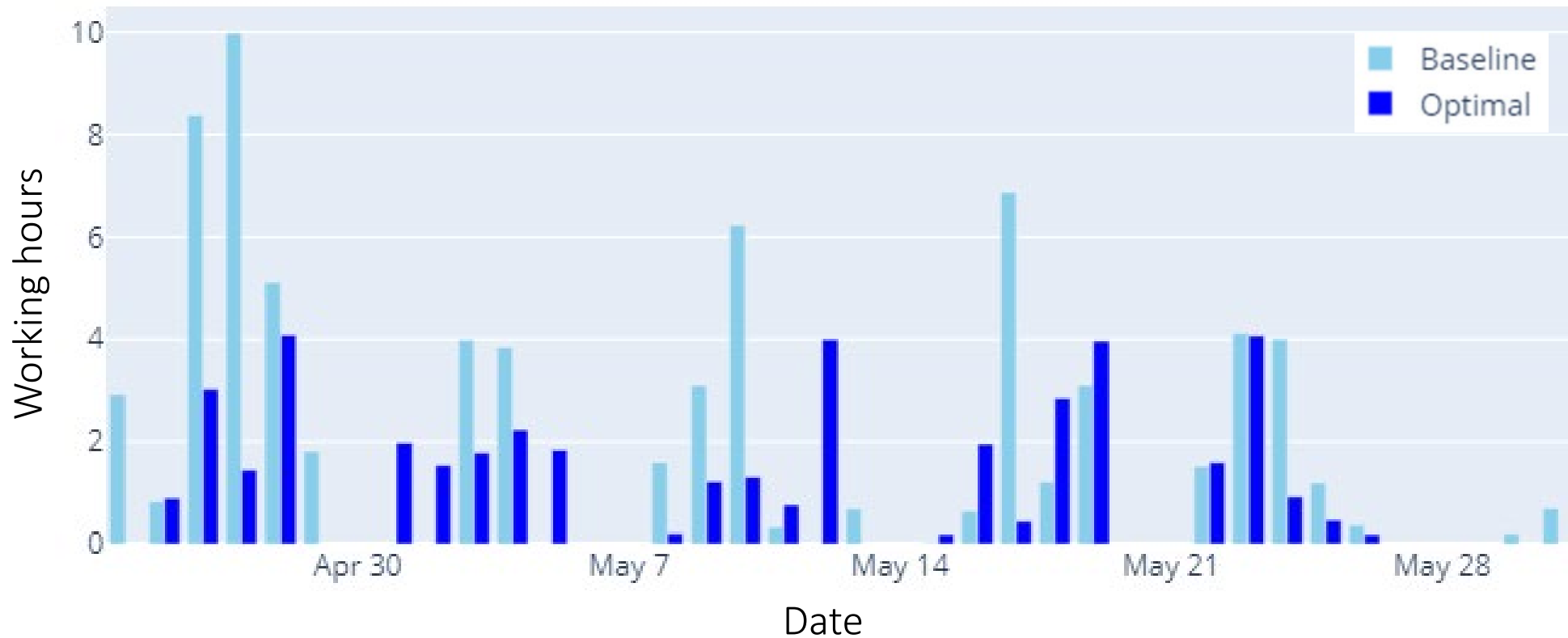
Every day is a **busy day**, but **no** day is an **overwhelming day**

Pfizer Global Supply Operations Insights

Stable schedule

Average daily working hours for an analyst

Every day is a **busy day**, but **no** day is an **overwhelming day**

Efficient sample grouping

Samples per test
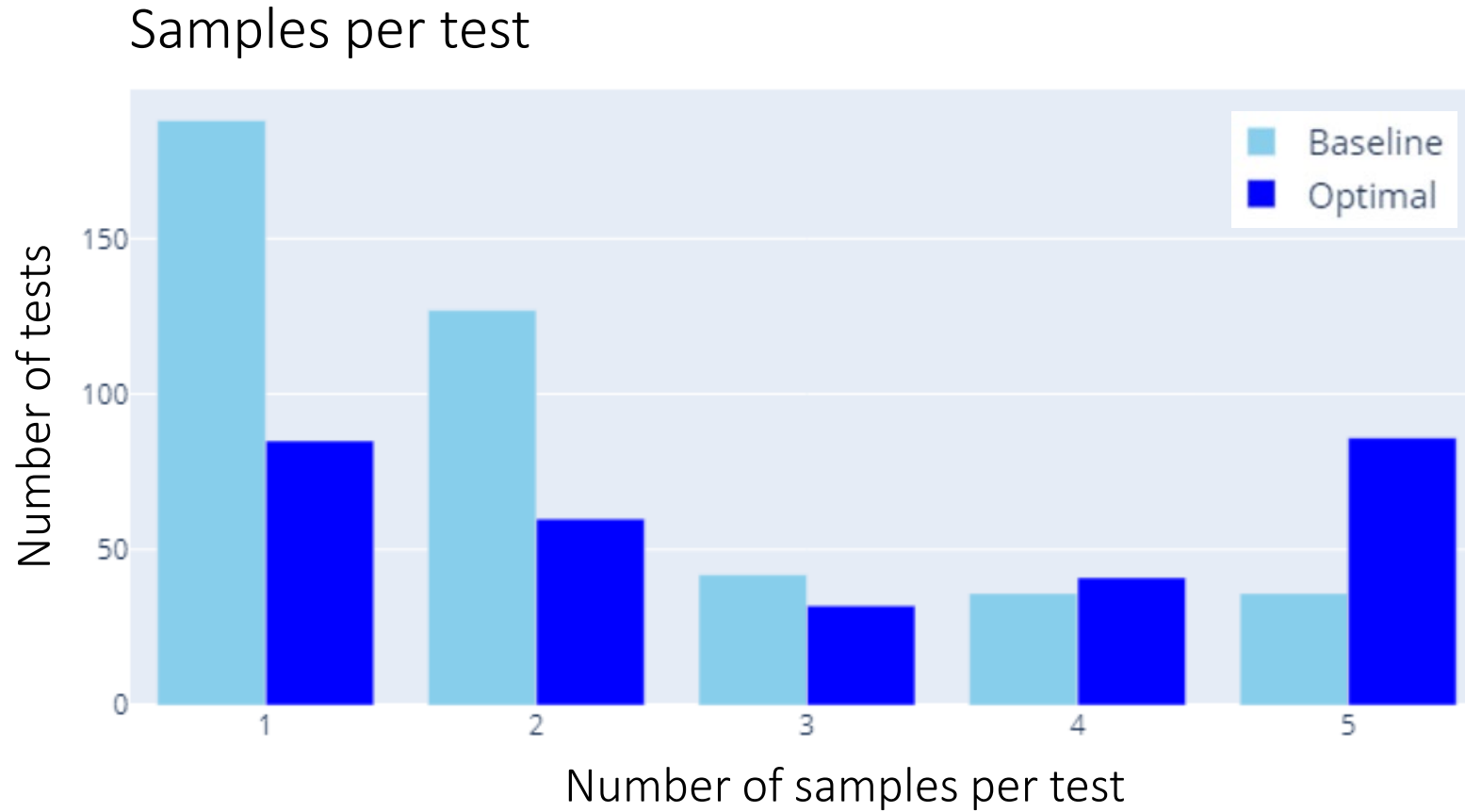
Optimization improves sample **grouping** for tests

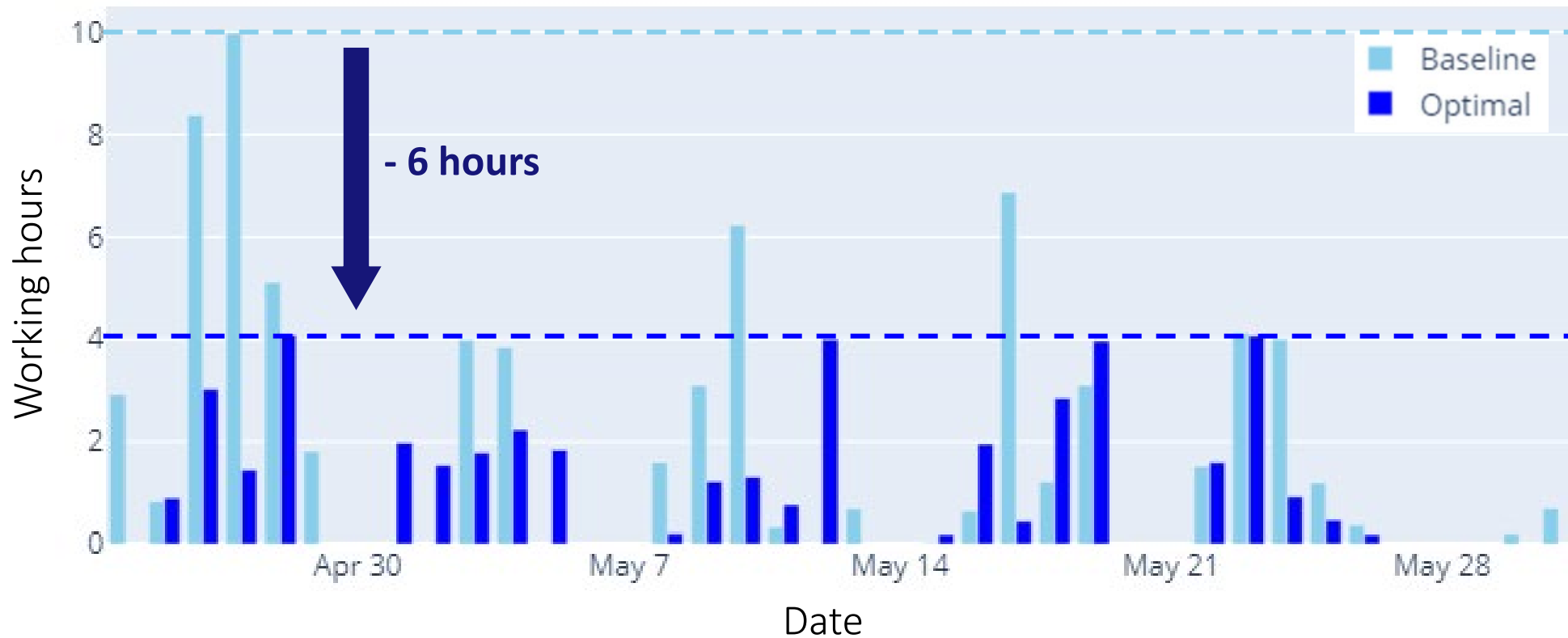# Efficient sample grouping

Samples per test
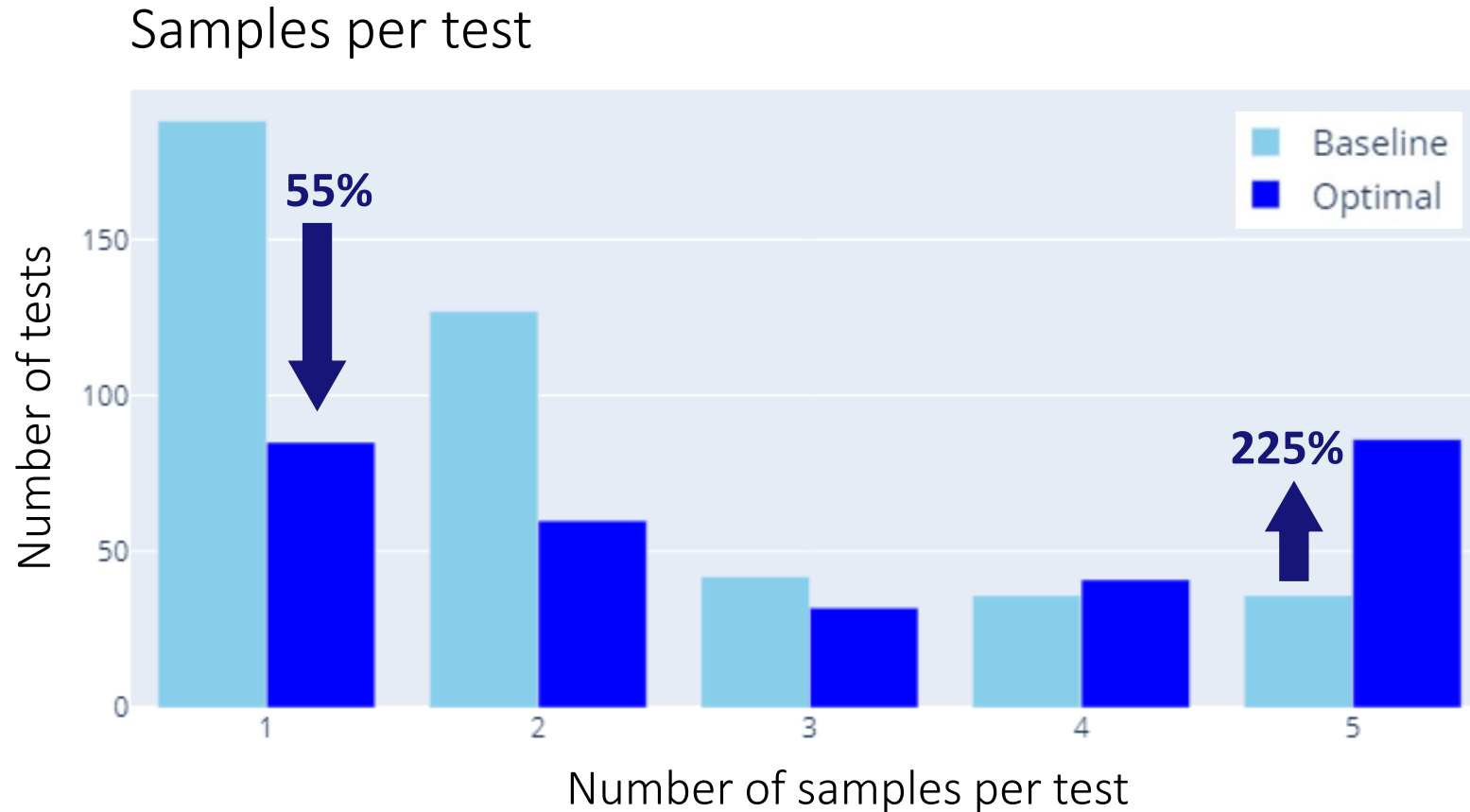
Optimization improves sample **grouping** for tests

Tangible impact

Reduced scheduling time from ~12 hours **to ~2 hours per week**
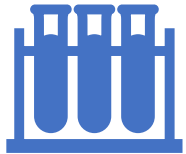
Decreased number of conducted **tests/reviews by 18%**

Saved $1.6M in analyst working hours **per year**

Scheduling tool

Thank you!

Michal Laskowski & Shannan Liu

"That's **amazing!**
Big value is clearly there, especially with the **end user confirmation!**"

- Beth Craig,
Digital Transformation Manager

— Optimization formulation

Decision variables

- $w^j_{a,s,r,g,t}$: binary, if process j is performed by analyst a on sample s of type r by time t
- $u^j_{a,s,r,g,t}$: binary, if process j is performed by analyst a on sample s of type r at time t
- $y^j_{a,g,t}$: integer, number of times a process j is performed by analyst a on a sample from group g at time t
- $o_{a,t}$: continuous, overtime of analyst a on day t
- $d_{s,r,t}$: binary, time t by which the final process for a specific sample s of type r is initiated

Objective function

$$
\min_{y,u,d,o,w} \alpha\left(\underbrace{\sum_{a\in A}\sum_{g\in G}\sum_{t\in T}\sum_{j\in J} c^0_{g,j} y^j_{a,g,t} + \sum_{a\in A}\sum_{s\in S}\sum_{r\in R}\sum_{g\in G}\sum_{t\in T}\sum_{j\in J} c^1_{g,j} u^j_{a,s,r,g,t}}_{\text{Total estimated testing time}}\right) +
$$

$$
+ 24(1-\alpha)\underbrace{\sum_{s\in S}\sum_{t\in T}(p_{s,1,t} - d_{s,1,t})}_{\text{Total cycle time}} + \underbrace{\sum_{t\in T}\sum_{a\in A}\lambda_1 o_{a,t}}_{\text{Penalty for overtime}} + \underbrace{\sum_{s\in S}\sum_{g\in G}\lambda_2 * \sum_{a\in A}(1 - w^{j_{end}}_{a,s,1,g,t_{end}})}_{\text{Penalty for late tests}}
$$

Parameters

- c^0_g: sample setup cost of group g
- c^1_g: sample run time of group g
- $p_{s,r,t}$: 1 on and after the scheduled arrival date for each sample s of type r, and 0 otherwise
- λ_1: penalty for 1h of overtime
- λ_2: penalty for one sample not fully tested
- j_{end}: final process
- t_{end}: final day of optimization horizon

Optimization formulation

Constraints

1. Total samples pulled/tested/reviewed cannot exceed the maximum possible number of samples in tests

2. Each sample can only be pulled/tested/reviewed once

3. Each sample can be pulled/tested/reviewed only on particular days

4. Each sample must be pulled within a certain time frame

5. Samples can only be tested on the day they are pulled or within 30 days after day

6. Samples can only be reviewed on the day they are tested or within 5 days after that

7. If an analyst has overtime on a specific day, no one else can test or review the samples they are in charge of

8. The total cost of running samples in all processes must be less than the analyst capacity on that day,
or it requires overtime work (greatly penalized)

9. An analyst cannot test and review the same sample

Intuitive graphical user interface for lab managers

Simple, clean schedule for labs to use

Lab 1 Schedule

Scheduled Tests: from April-25-2023 to May-26-2023

Analyst 0

Date	Material	Analysis Code	Sample	Arrival Date	Due Date
Apr-26-2023	Material 1	Code 6	19107	Apr-26-2023	May-26-2023
May-02-2023	Material 4	Code 8	88	Apr-25-2023	May-25-2023
May-02-2023	Material 0	Code 8	6775	Apr-27-2023	May-27-2023
May-02-2023	Material 1	Code 8	6778	Apr-26-2023	May-26-2023
May-02-2023	Material 2	Code 8	19132	Apr-30-2023	May-30-2023
May-05-2023	Material 3	Code 22	21185	Apr-27-2023	May-27-2023
May-11-2023	Material 4	Code 4	191	Apr-25-2023	May-25-2023
May-16-2023	Material 4	Code 0	55	Apr-25-2023	May-25-2023
May-16-2023	Material 0	Code 0	172	Apr-27-2023	May-27-2023
May-16-2023	Material 1	Code 0	19553	Apr-26-2023	May-26-2023
May-16-2023	Material 2	Code 0	19650	Apr-30-2023	May-30-2023
May-18-2023	Material 4	Code 8	83	Apr-25-2023	May-25-2023
May-18-2023	Material 0	Code 8	6770	Apr-27-2023	May-27-2023
May-18-2023	Material 1	Code 8	19127	Apr-26-2023	May-26-2023