Work Smarter Not Harder

Optimal Scheduling for Quality Control Labs

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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
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

>12 h
Project goal

Create a **weekly schedule** for a Quality Control lab that efficiently **groups samples** and **assign them to analysts**.
Grouping is critical for testing efficiency

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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• Tested
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Which analyst:
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Objective

Minimize
• Total testing time
• Cycle time

Ensure
• Work-life balance
• No late samples
Robust Mixed-Integer Optimization

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Constraints

Subject to
• Complex regulatory requirements
• Laboratory testing conditions
Robust Mixed-Integer Optimization

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When sample is:
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Objective
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• Work-life balance
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Constraints
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Robustness
Potential extended testing & reviewing time
Achieving balance

Testing time can be reduced with little impact on cycle time
Achieving balance

Testing time can be reduced with little impact on cycle time
Achieving balance

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
Every day is a **busy day**, but no day is an **overwhelming day**
Efficient sample grouping

Optimization improves sample grouping for tests
Efficient sample grouping

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 & Shennan Liu

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

- Beth Craig, Digital Transformation Manager
Optimization formulation

Decision variables

- \( w_{a,s,r,g,t}^j \): binary, if process \( j \) is performed by analyst \( a \) on sample \( s \) of type \( r \) by time \( t \)
- \( u_{a,s,r,g,t}^j \): binary, if process \( j \) is performed by analyst \( a \) on sample \( s \) of type \( r \) at time \( t \)
- \( y_{a,g,t}^j \): 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

\[
\min_{y,u,d,o,w} \alpha \left( \sum_{a \in A} \sum_{g \in G} \sum_{t \in T} \sum_{j \in J} c_{g,j}^0 y_{a,g,t}^j + \sum_{a \in A} \sum_{s \in S} \sum_{r \in R} \sum_{g \in G} \sum_{t \in T} \sum_{j \in J} c_{g,j}^1 u_{a,s,r,g,t}^j \right) + \left( \sum_{s \in S} \sum_{t \in T} (p_{s,1,t} - d_{s,1,t}) \right) + \sum_{t \in T} \sum_{a \in A} \lambda_1 o_{a,t} + \sum_{s \in S} \sum_{g \in G} \sum_{a \in A} \lambda_2 (1 - w_{a,s,1,g,t_{end}}^j)
\]

Parameters

- \( c_{g}^0 \): sample setup cost of group \( g \)
- \( c_{g}^1 \): 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
- \( \lambda_1 \): penalty for 1h of overtime
- \( \lambda_2 \): 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

Quality Control Lab Weekly Schedule

- **Start date**: 2023-05-31
- **Time horizon to optimize over [in days]**: 7
- **Analyst working days**: Monday, Tuesday, Wednesday, Thursday, Friday
- **Analysts to schedule**: Analyst 9, Analyst 10, Analyst 11, Analyst 12, Analyst 13, Analyst 14, Analyst 15
- **Analyst working hours (per day)**: 5
- **Buffer time for each test [in minutes]**: 10
- **Buffer time for each review [in minutes]**: 4

Optimize
Simple, clean schedule for labs to use

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<tr>
<th>Date</th>
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<th>Analysis Code</th>
<th>Sample</th>
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<th>Due Date</th>
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