Optimizing the

SHUI-YUAN TOWING ROUTE

OPERATIONS RESEARCH FINAL PROJECT

TEAM 5


國立臺灣大學

You don't feel good when your bike is gone.

YOU ARE SOMETIMES JUST TOO BUSY TO PARK THE RIGHT WAY.

This, however, is our OR project.

WE SHALL CONSIDER THE ISSUE IN THE OPPOSITE WAY.

Why?

WHAT ROUTE SHALL THE TOW TRUCK TAKE?

Let's move on to the details.

Assumptions and Constants

1. TC, the truck's capacity
2. M, the number of bike parking spots in NTU
3. N_i, the number of parking violations on the i^{th} spot
4. T_{ij}, the time spent for the truck to travel from spot i to j

Assumptions and Constants

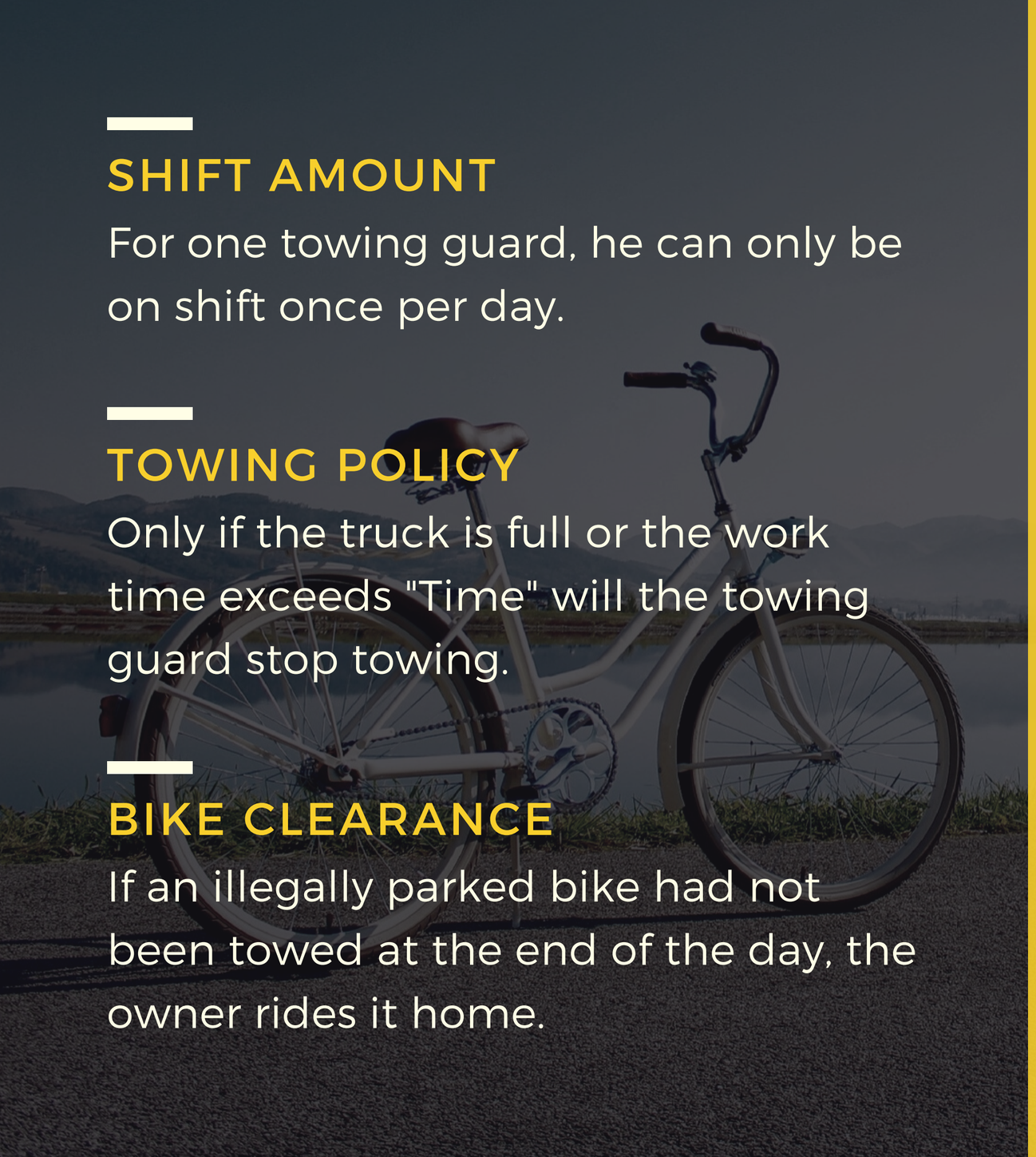
5. $Weight_i$, the weight of each spot
6. F_i, the least times spot i be visited per week
7. $Time$, the maximum time for one towing guard to be on shifts per week
8. TB, the time required to move a bike onto the truck

Team Disussions

Rates and decides which spots are easily crowded due to violations

Google Forms

We received 68 responses and were able to determine the weights.



SHIFT AMOUNT

For one towing guard, he can only be on shift once per day.

TOWING POLICY

Only if the truck is full or the work time exceeds "Time" will the towing guard stop towing.

BIKE CLEARANCE

If an illegally parked bike had not been towed at the end of the day, the owner rides it home.

More Settings

Formulation

PHASE ONE

Determine the spots the truck heads for.

PHASE TWO

Arrange the shortest path with a fixed destination.

SOLUTION

Obtain the optimal solution for the second phase.

The Integer Program: Phase One

$$\begin{cases} x_{dm} = 1 \\ z_{dm} = 1 \end{cases} \qquad \begin{cases} x_{dm} = 1 \\ z_{dm} = 0 \end{cases} \qquad \begin{cases} x_{dm} = 0 \\ z_{dm} = 0 \end{cases}$$

On day d, spot m, all bikes are towed.

On day d, spot m, not all bikes are towed.

On day d, spot m is not visited.

q_{dm}, the number of towed bikes at spot m on day d

The Integer Program: Phase One

$$\max \sum_{d} \sum_{m} q_{dm} \times W_m$$

The Integer Program: Phase One

$$
\begin{aligned}
\text{s.t.} \quad & q_{dm} \leq x_{dm} \cdot N_{dm} \\
& \sum_{m} z_{dm} \leq 1, \forall d \\
& z_{dm} \leq x_{dm}, \forall d, m \\
& q_{dm} \geq x_{dm} \\
& x_{dm} \cdot N_{dm} - q_{dm} \leq M_1(z_{dm})
\end{aligned}
$$

The Integer Program: Phase One

$$\text{s.t.} \quad \sum_{m} q_{dm} \leq TC, \forall d$$

$$\sum_{d} x_{dm} \geq F_m, \forall m$$

$$\sum_{d} \sum_{m} q_{dm} \cdot W_m \leq B$$

The Integer Program: Phase Two

$$\min \sum_{(i,j) \in E} T_{ij} \times y_{ij}$$

The Integer Program: Phase Two

$$\text{s.t.} \quad \sum_{i \in V, i \neq k} y_{ik} = 1, \forall k \in V$$

$$\sum_{j \in V, j \neq k} y_{kj} = 1, \forall k \in V$$

$$y_{ij} \in \{0, 1\}, \forall (i, j) \in E$$

The Integer Program: Phase Two

$$
\begin{aligned}
\text{s.t.} \quad & u_0 = 1, u_{last} = N \\
& 2 \leq u_i \leq (N-1), \forall i \in V/\{1, N\} \\
& u_i - u_j + 1 \leq (n-1)(1 - x_{ij}), \forall (i,j) \in E, i, j \neq 1, N
\end{aligned}
$$

Our Obstacles

FUEL OR TIME?

The fuel limit constraint was not as practical as the time limit constraint.

PHASE ONE SOLUTIONS

If there are multiple solutions for phase one, we apply these solutions in phase two.

Solution

FOR PHASE 1 AND PHASE 2

Interpretations

PHASE 1: 5028.631

The profit a towing guard can earn after one shift, applied to Phase two.

SOLUTION COUNT: 10

Exist 10 optimal solutions, with an error to omit.

Interpretations

TIME GAP:
[4, 15, 16, 18, 21, 15, 16, 13, 15, 16]

Time exceeded the time limit.

at 17 catch 46

At spot 17, the towing guard tows 46 bikes.

total_bike = 200

The total amount of bikes towed is 200.

Day 0

```
0
At 17 catch 46
At 2 catch 22
At 13 catch 96
At 21 catch 1
At 40 catch 3
At 25 catch 2
At 1 catch 30
0
total_bike = 200
```

Day 1

```
0
At 15 catch 11
At 13 catch 110
At 23 catch 1
At 43 catch 4
At 17 catch 74
0
total_bike = 200
```

Result

```
total_benefit =
        5021.455

total_time = 1617

Time gap [7, 9, 0]
```

The Corresponding Spots

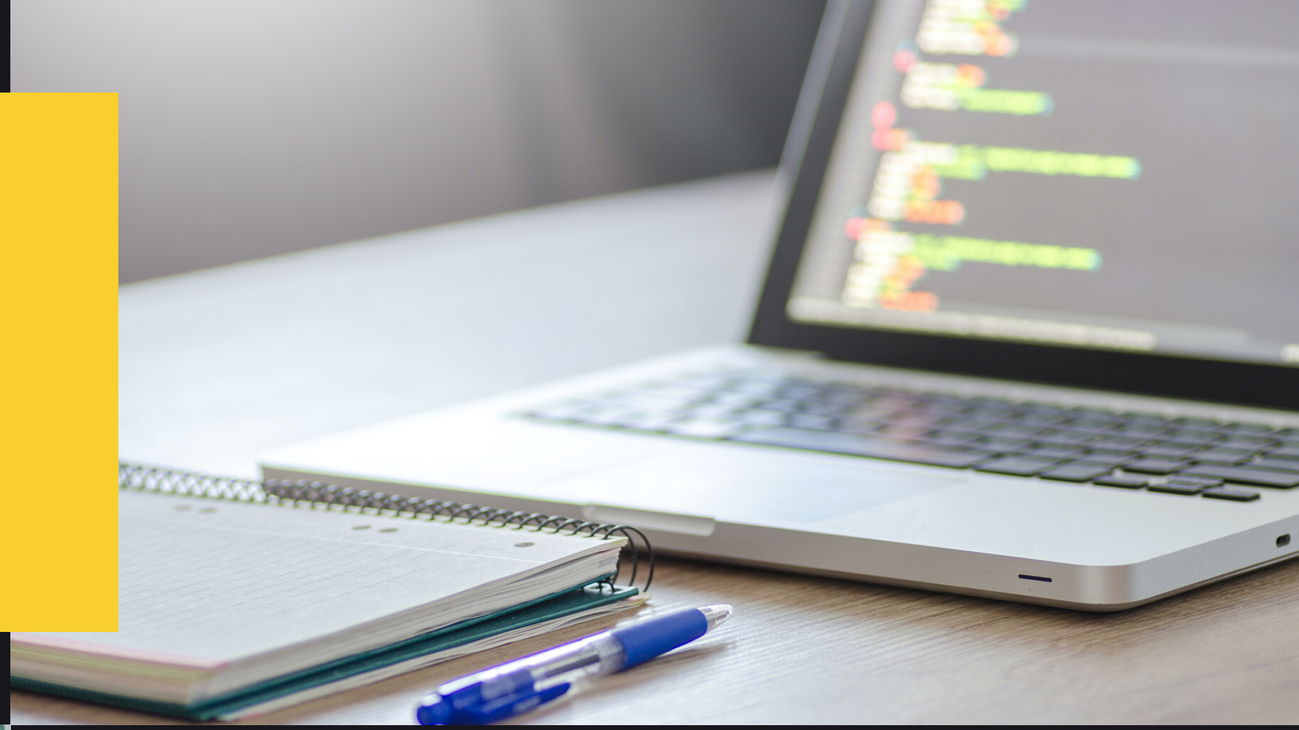
Index	*Spot Name*	*Tow amount*
15	科技大樓周邊	11
13	捷運公館站	110
23	資工所	1
43	女一、二、三、五舍	4
17	總圖書館	74

Suggestions

FOR THE REAL WORLD CASE

Data Collection

Collect the data of towing and can make better estimations.



New Spots

Add new spots to the model to ensure the uncertainty of routes.