Metro Math

This presentation at:

kwkelly.com/pres/metro-pres/

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A Typical Day

You're on your way to work, heading home, or going to meet some friends...

... and you walk into the station and see this:

Waiting for WMATA

Fact:

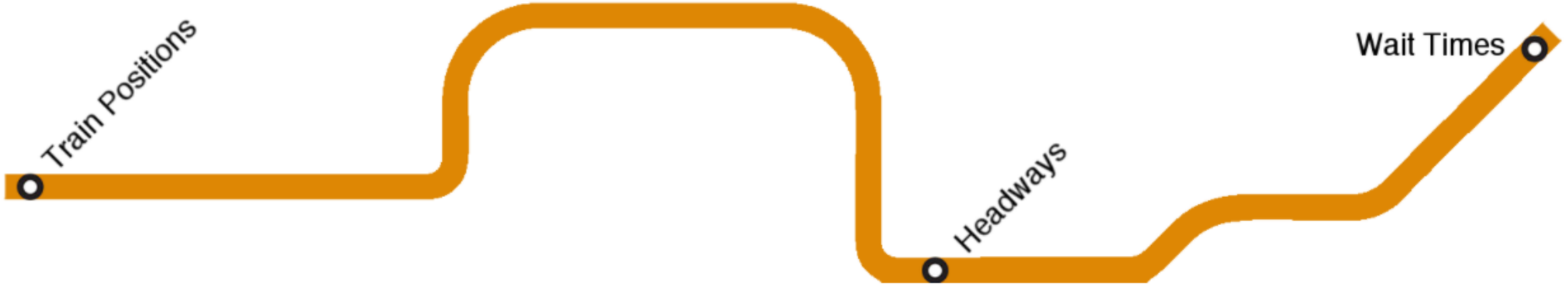
- Riders hate waiting for trains; waiting time is regarded as wasted time.

Question:

- How long do Metrorail riders typically wait for their trains?

Analysis Map

Train Positions → Train Headways → Passenger Waiting Times



Train Positions

- Old rail predictions API 👎
  - Tough to reliably determine if it's a new train at a station
- Newer train positions API 👍
  - CircuitId ← Standard Routes API to determine if circuit is at a station
  - DestinationStationCode
  - DirectionNum
  - LineCode
  - TrainId

Getting Headways

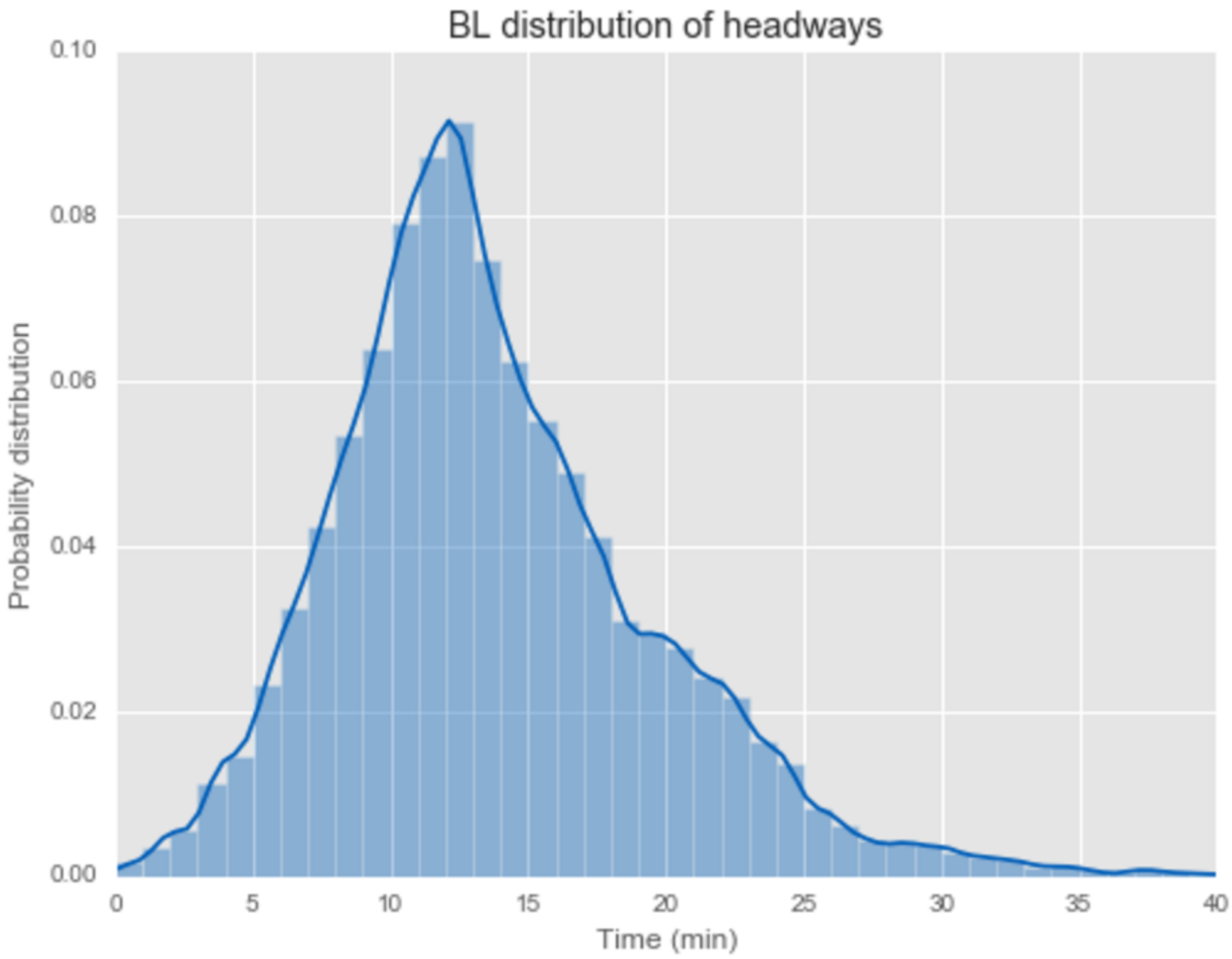
Position data + route data + query time → headways

- Keep data in chronological order
- Simply ignore all position data where a train is not at a station
- Then for a given station, line, and direction, compute the time difference between each row of data

```
# df = all data
df = df[df['StationCode'] == station]
df = df[df['LineCode'] == line_code]
df = df[df['DirectionNum'] == dir_num]
head = np.diff(df['DateTime'])
```

Getting Headways

BL GR RD OR YL SV



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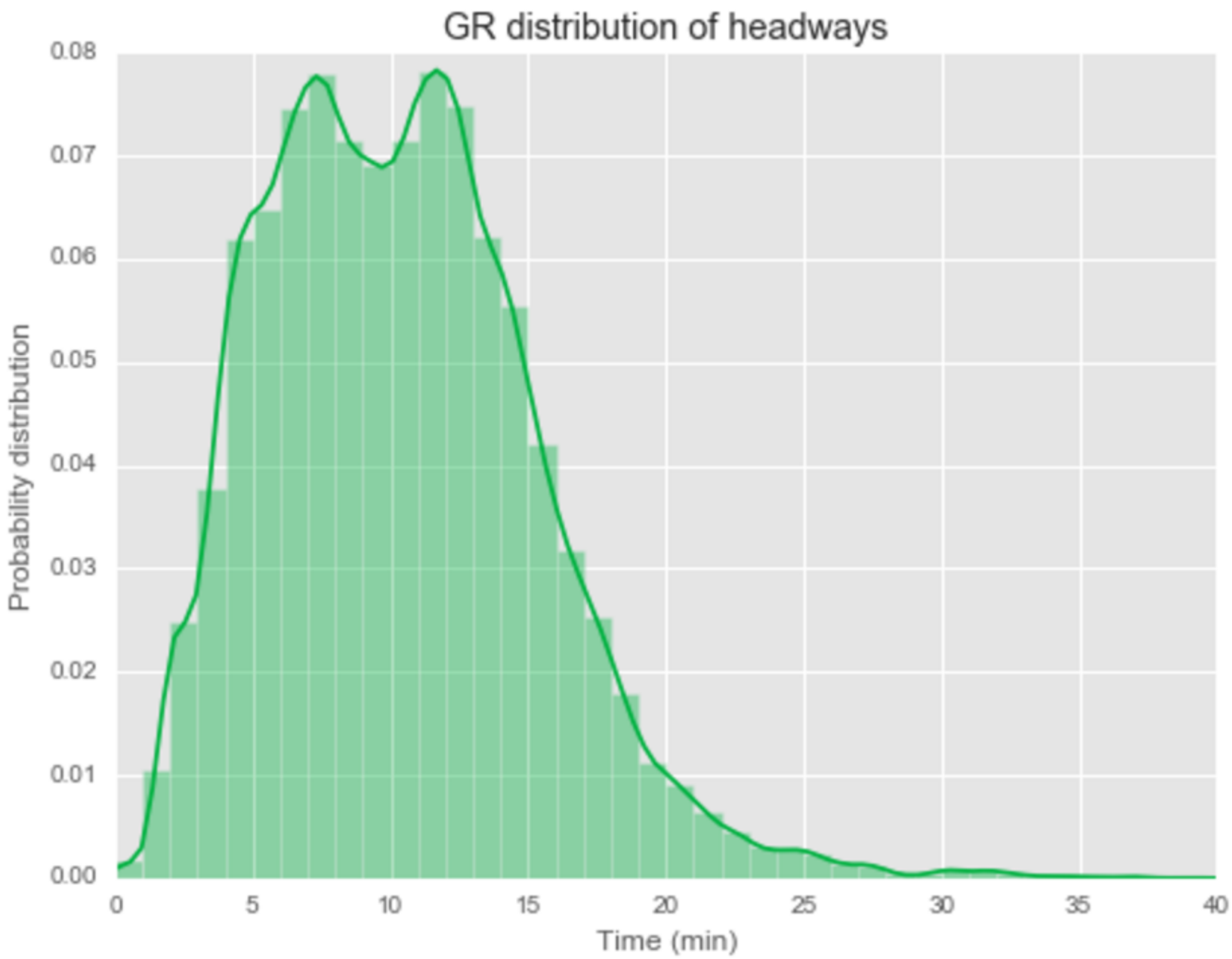

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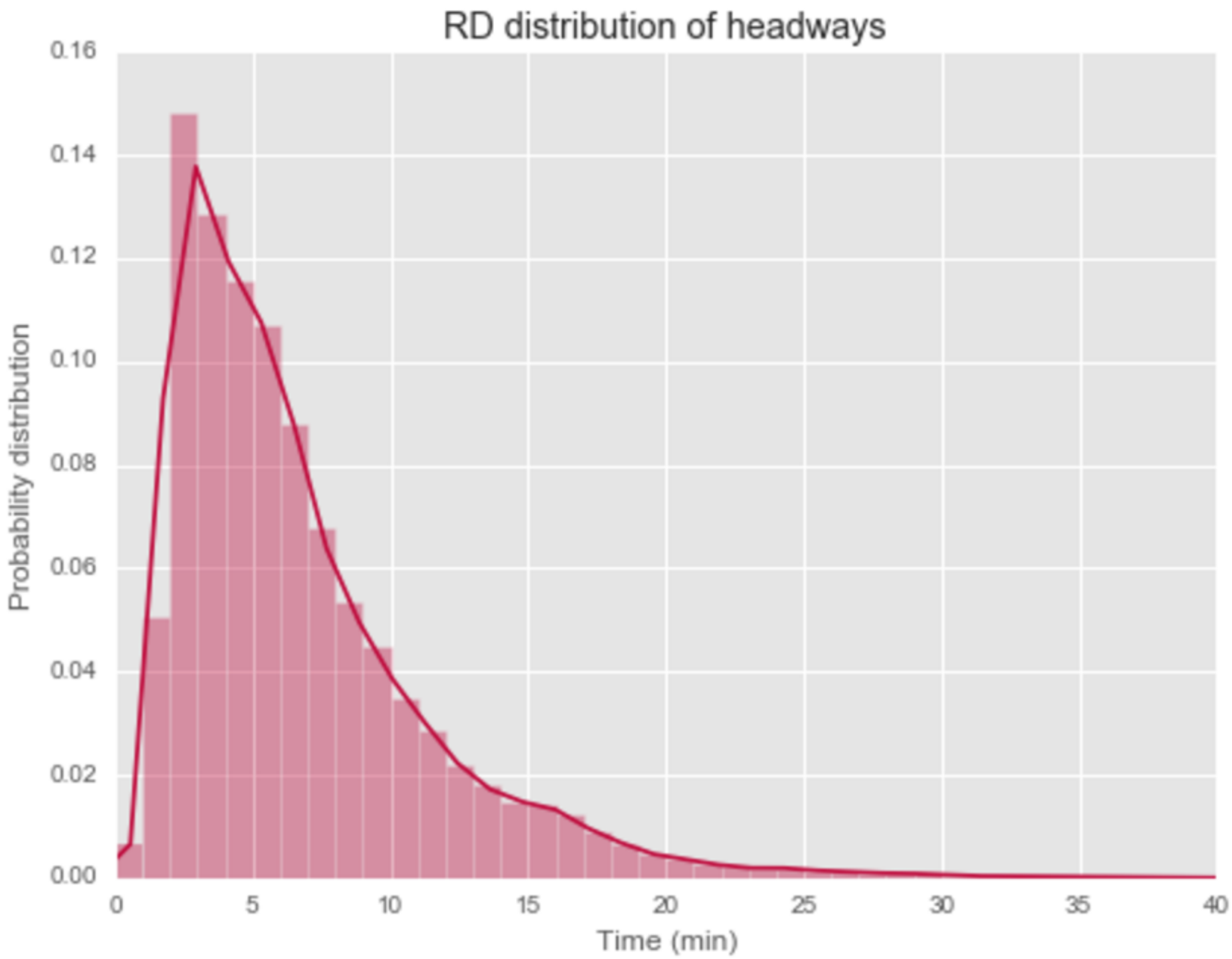

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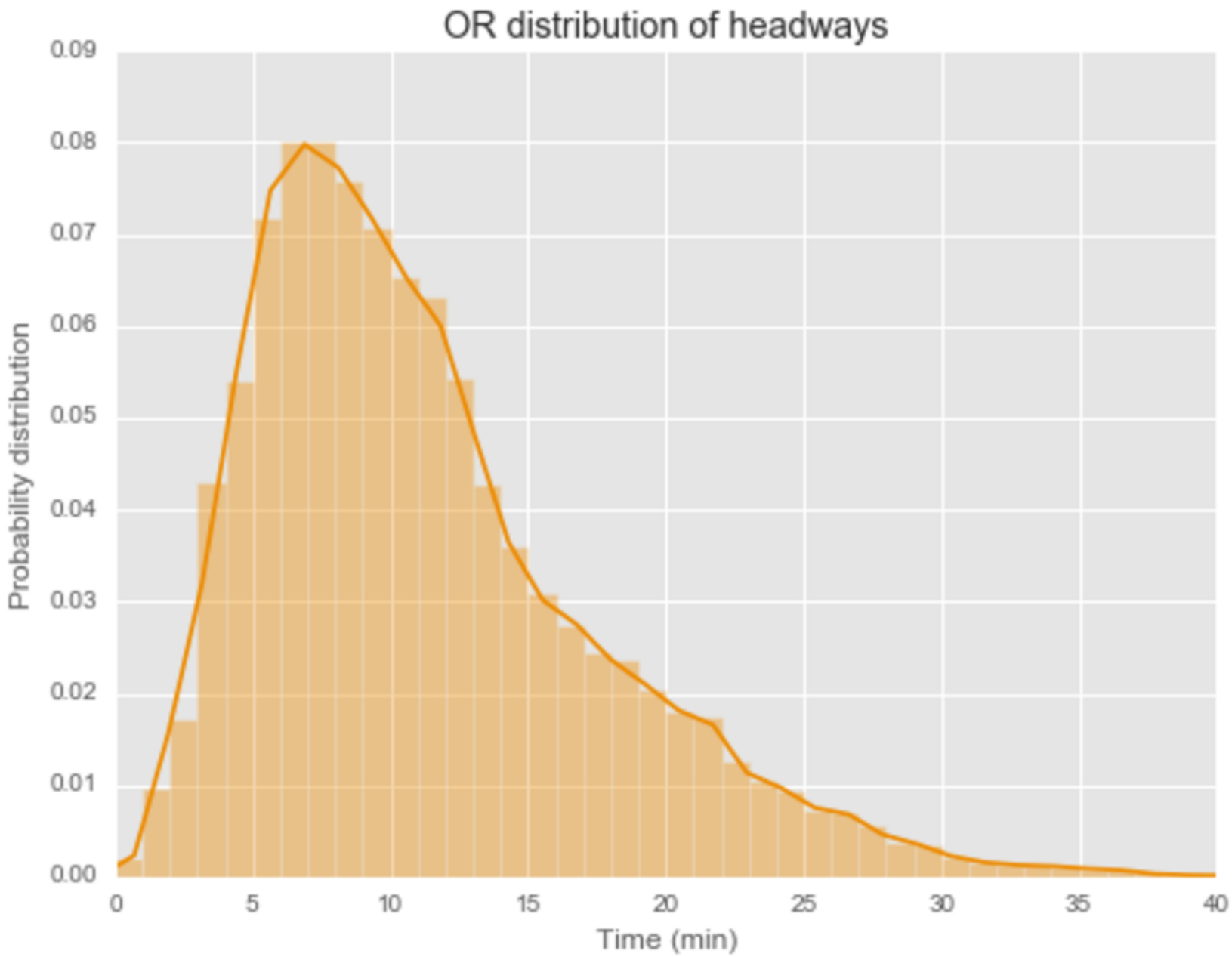

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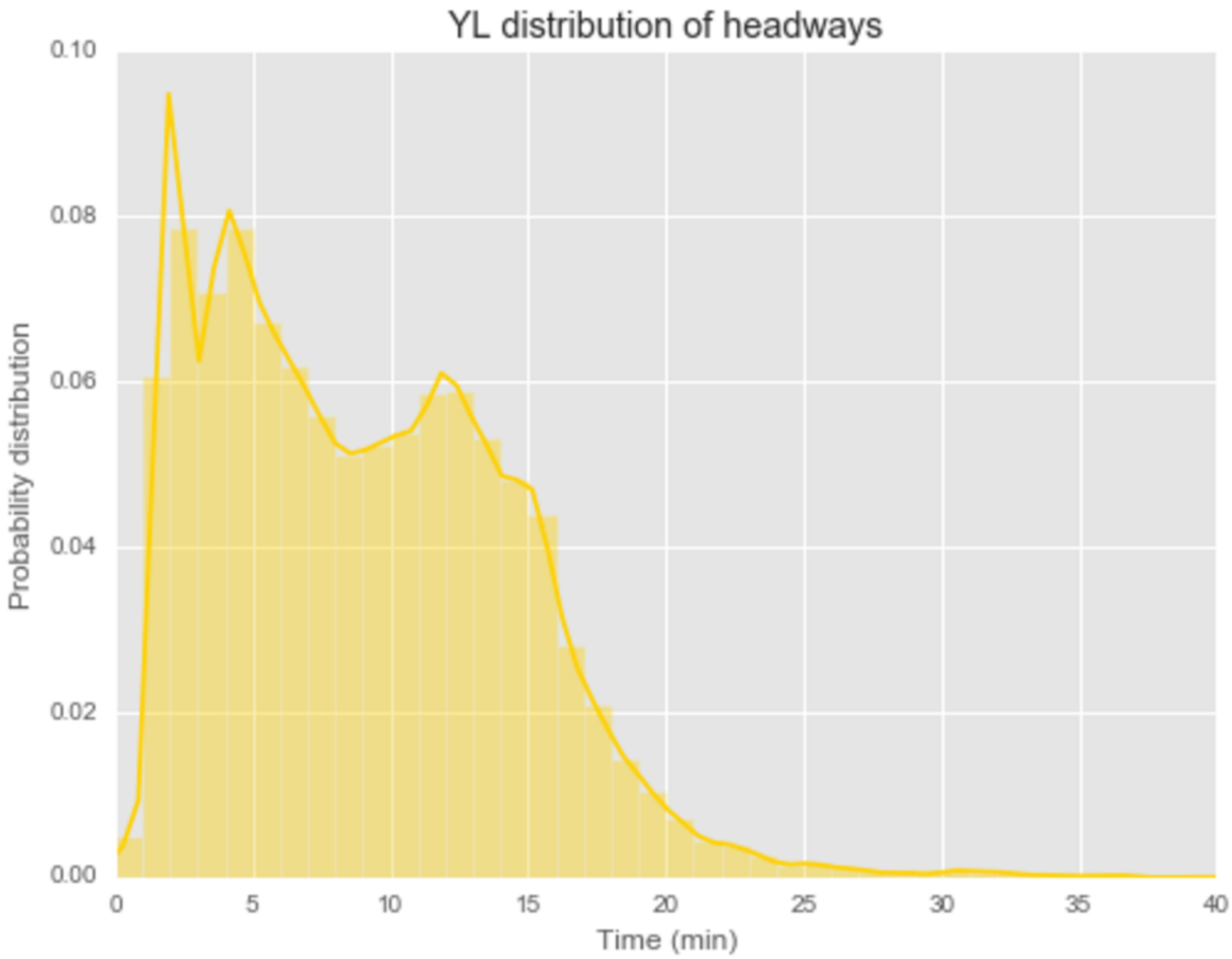

Getting Headways

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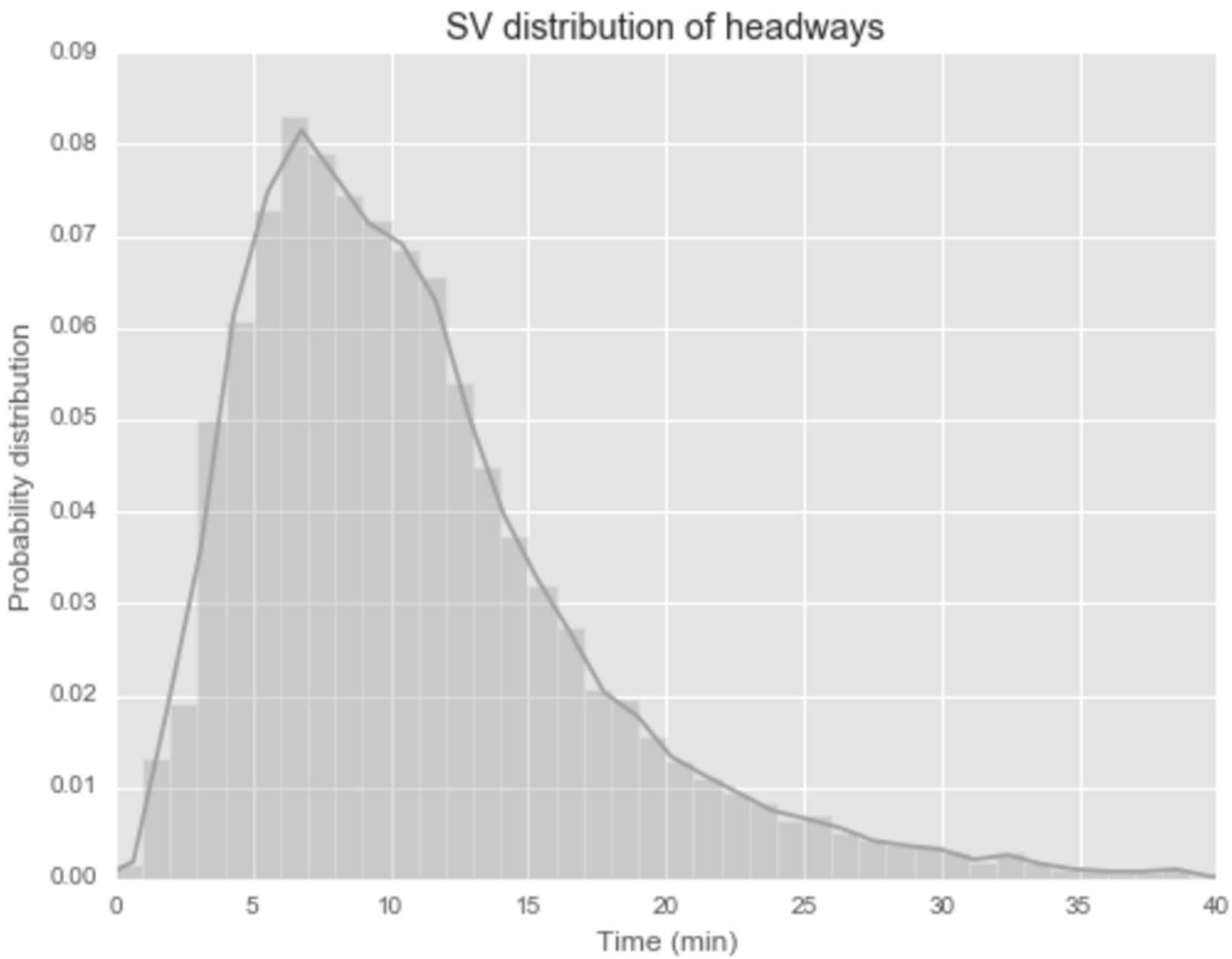


Estimating Wait Times

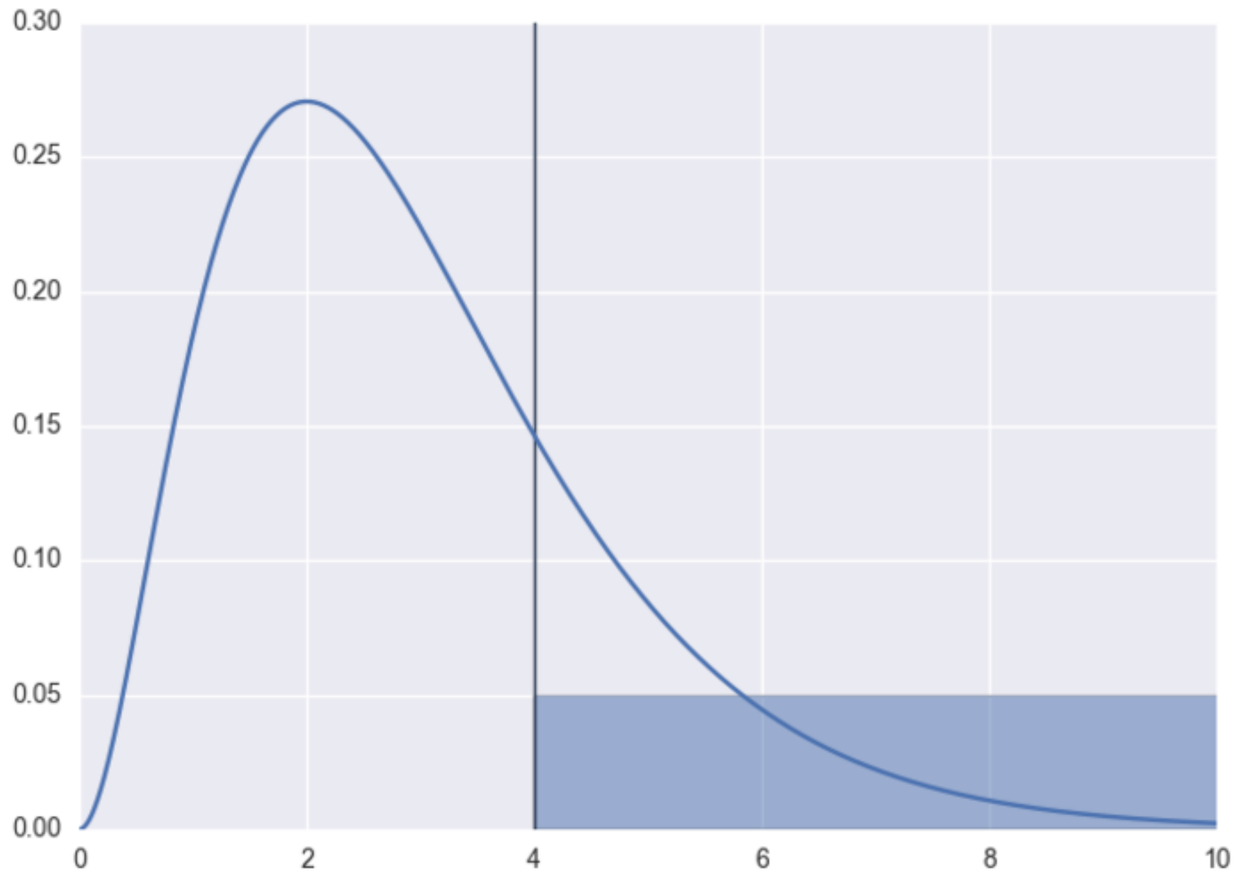
- Headways are about trains, waiting is about people
- We have data about trains, but not people

Assumptions

- No strategic behavior of passengers w.r.t. common lines
- No congestion phenomena
- Passenger arrivals are uniformly distributed

Estimating Wait Times

Since passenger arrivals are assumed to be uniformly distributed, the probability of waiting an amount of time t is proportional to the probability of a headway greater than t.



Estimating Wait Times

Let $h(t)$ be the distribution of headways. Then wait times $w(t)$ can be computed as

$$w(t) \propto \int_t^\infty h(s)\,ds = \bar{H}(t)$$

Finding the constant of proportionality is of course just normalizing the distribution, so that

$$w(t) = \frac{\int_t^\infty h(s)\,ds}{\int_0^\infty \bar{H}(s)\,ds} = \frac{\int_t^\infty h(s)\,ds}{\int_0^\infty s\,h(s)\,ds}$$

But we really don't care about the constant, just the proportion becuase we are using a computer and can normalize after the fact.

Estimating Wait Times

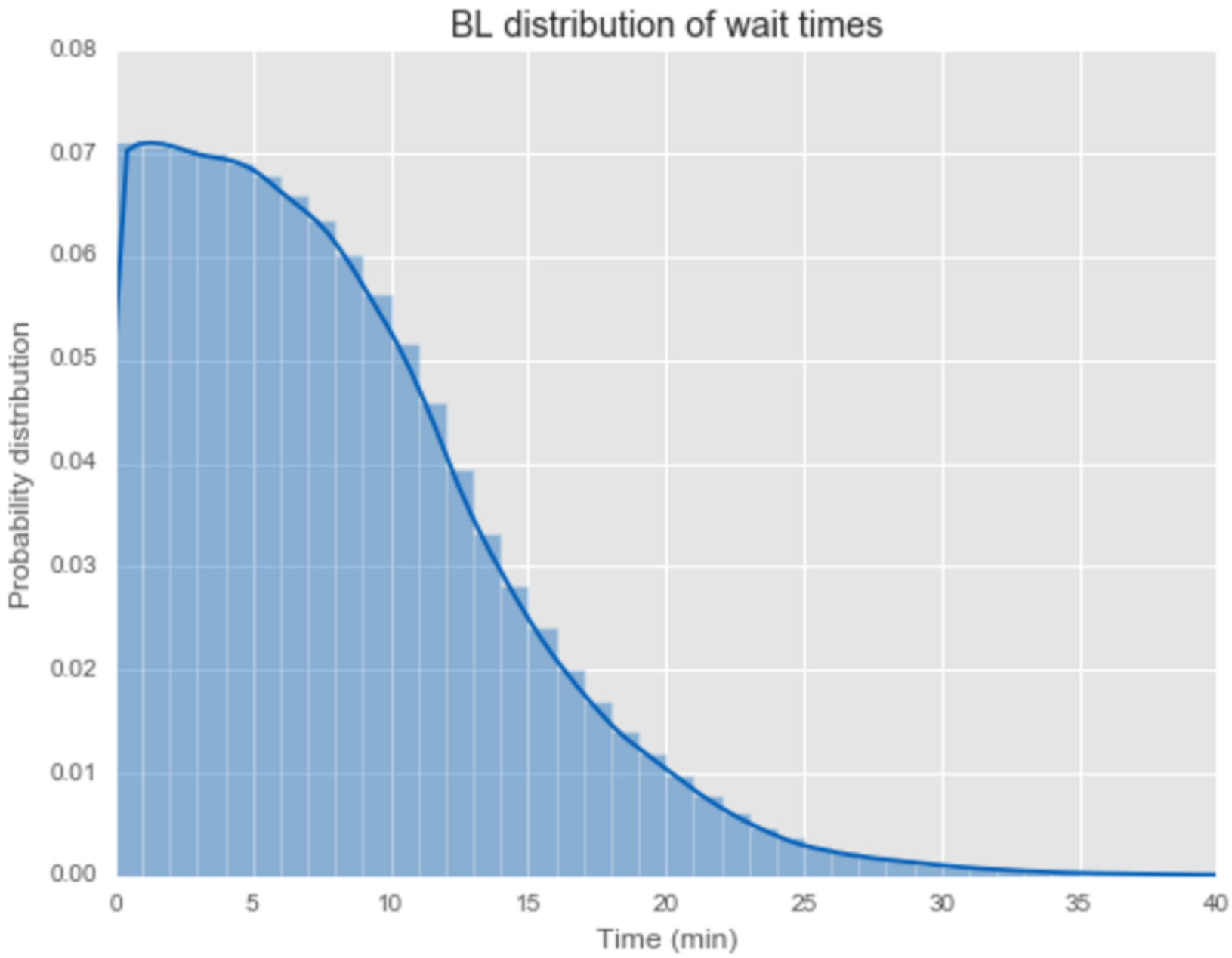
In practice though, we just sample from the headway distribution.

```
# diffs = all headways for a single line
waits = itertools.chain(*[np.arange(0, diff, 0.5).tolist() for diff in diffs])
```

Headway

Estimating Wait Times

BL | GR | RD | OR | YL | SV



Estimating Wait Times

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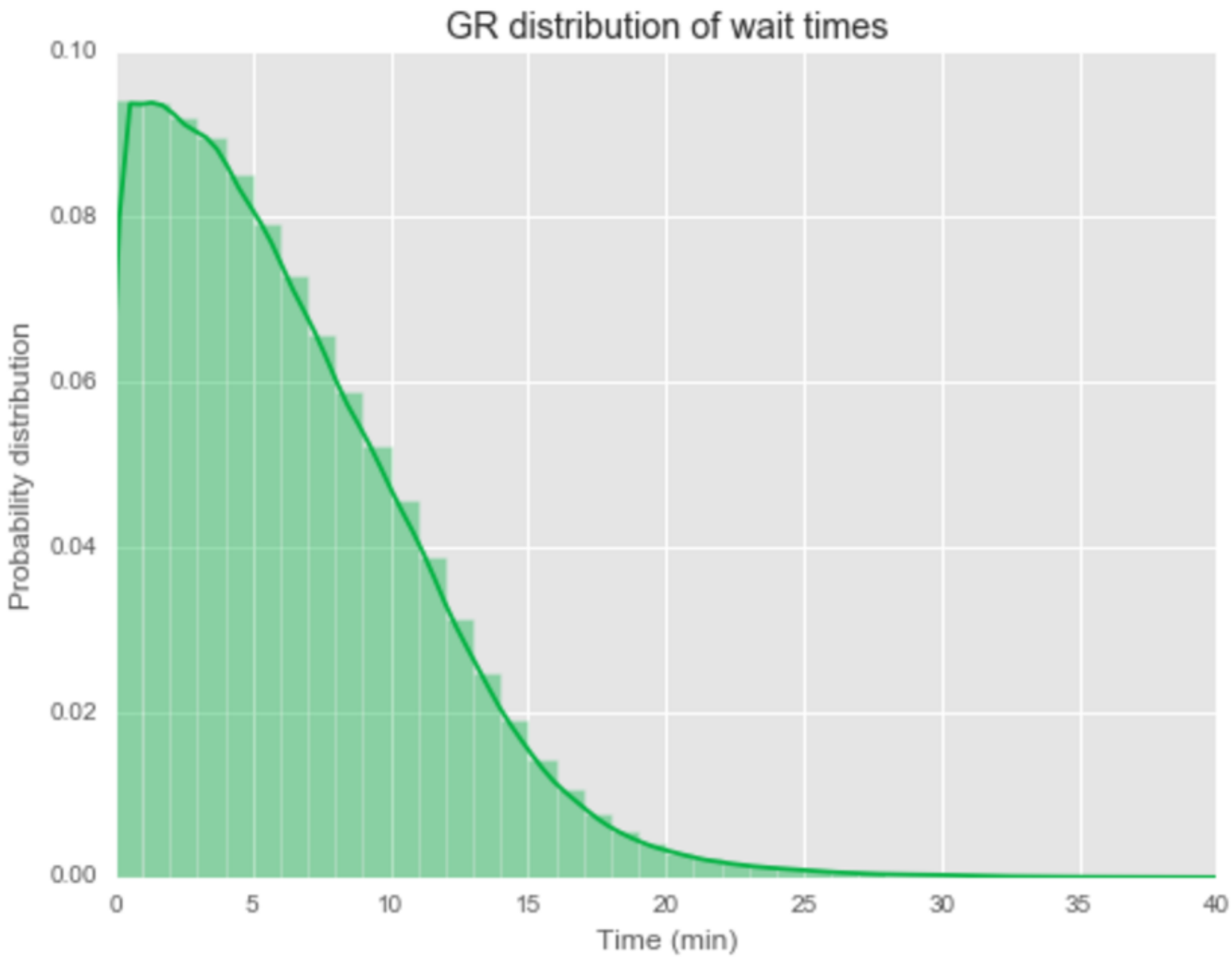

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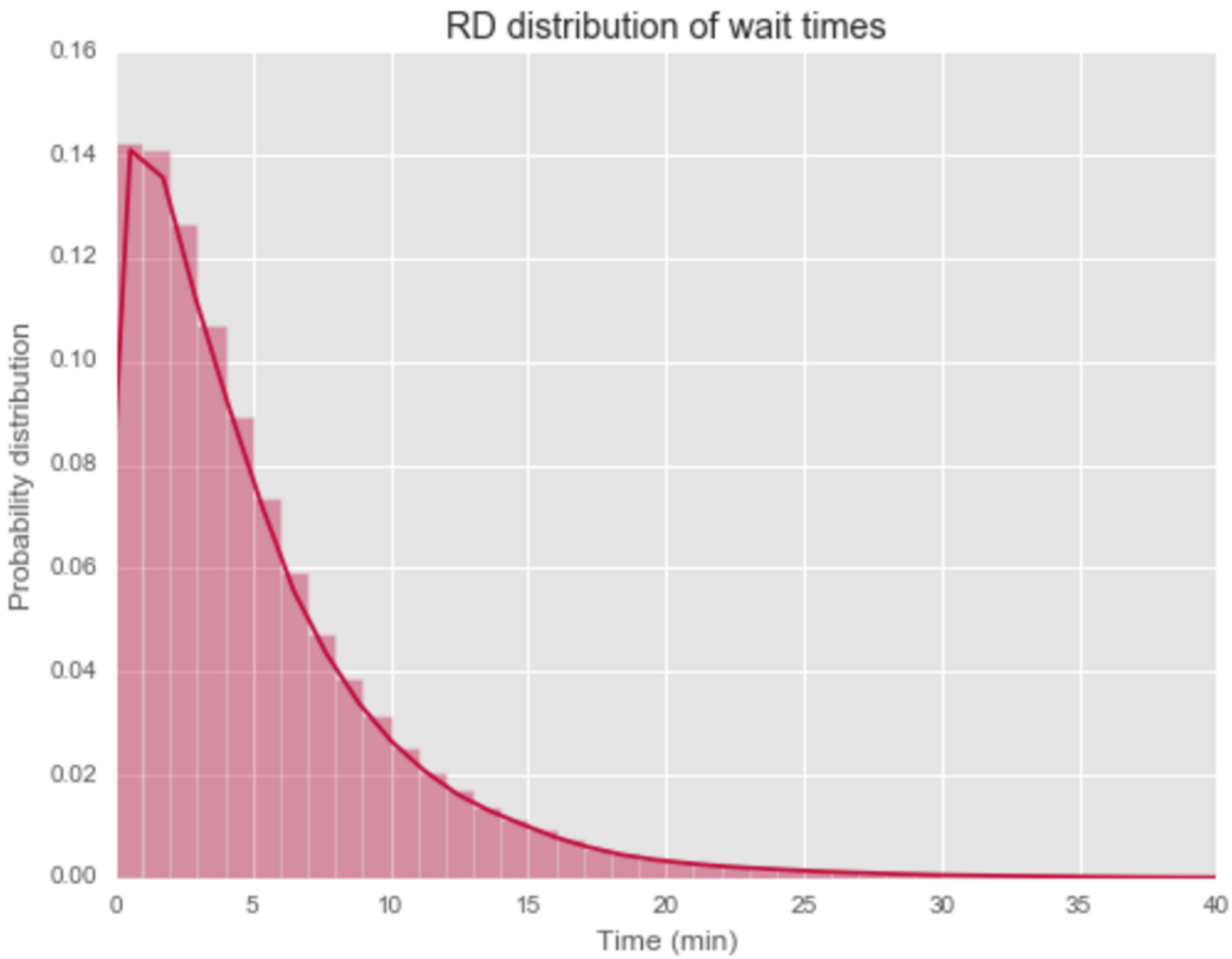

Estimating Wait Times

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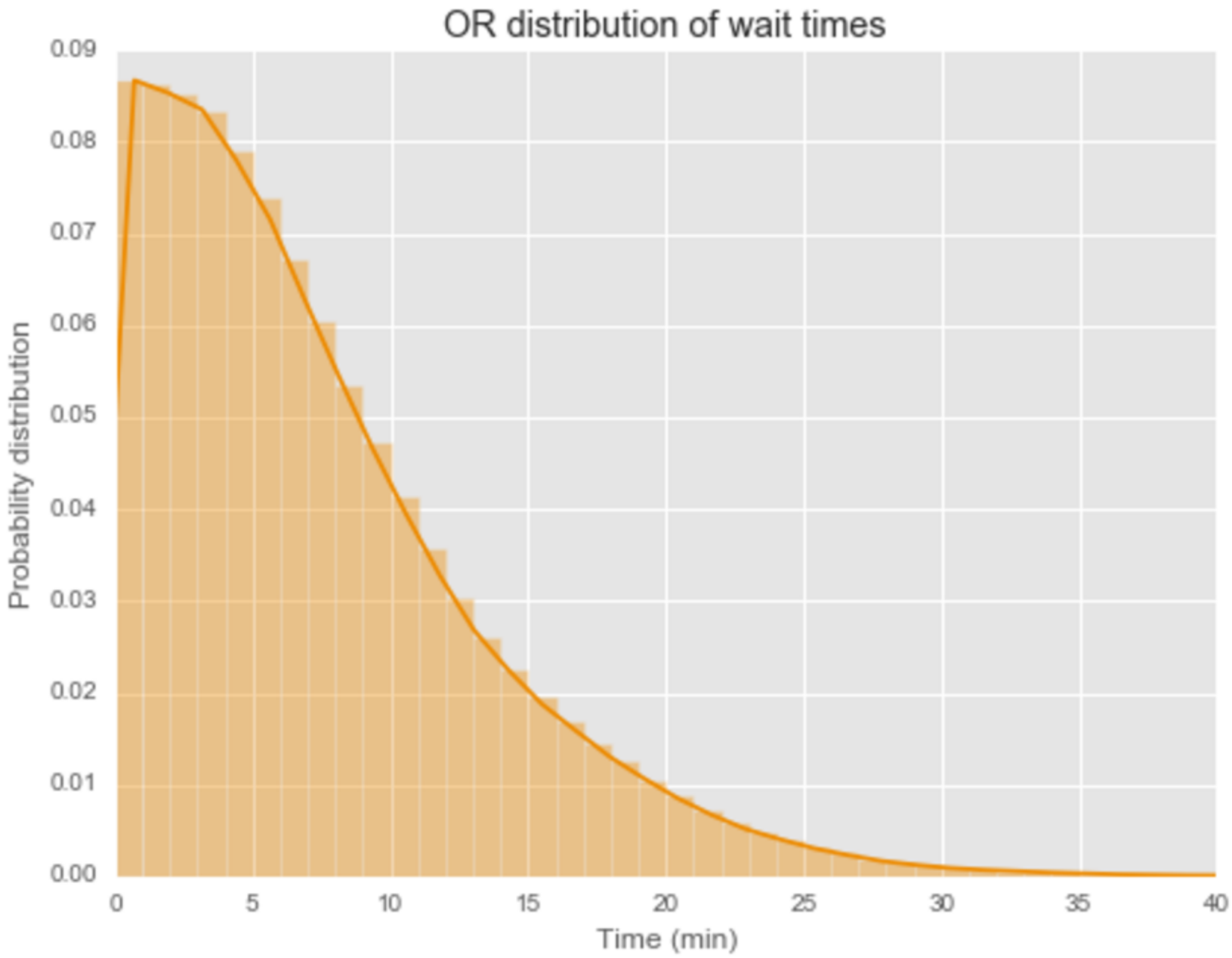

Estimating Wait Times

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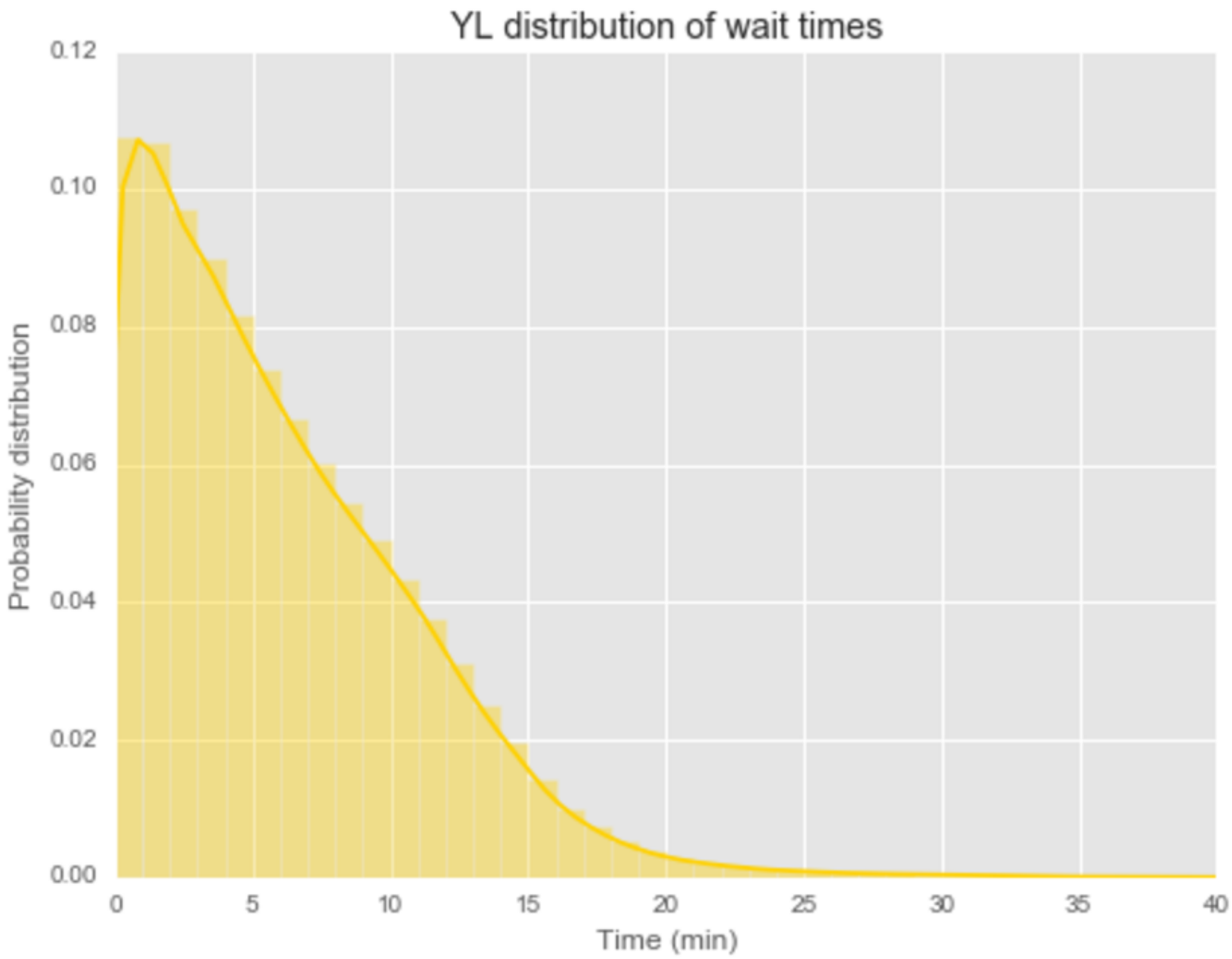

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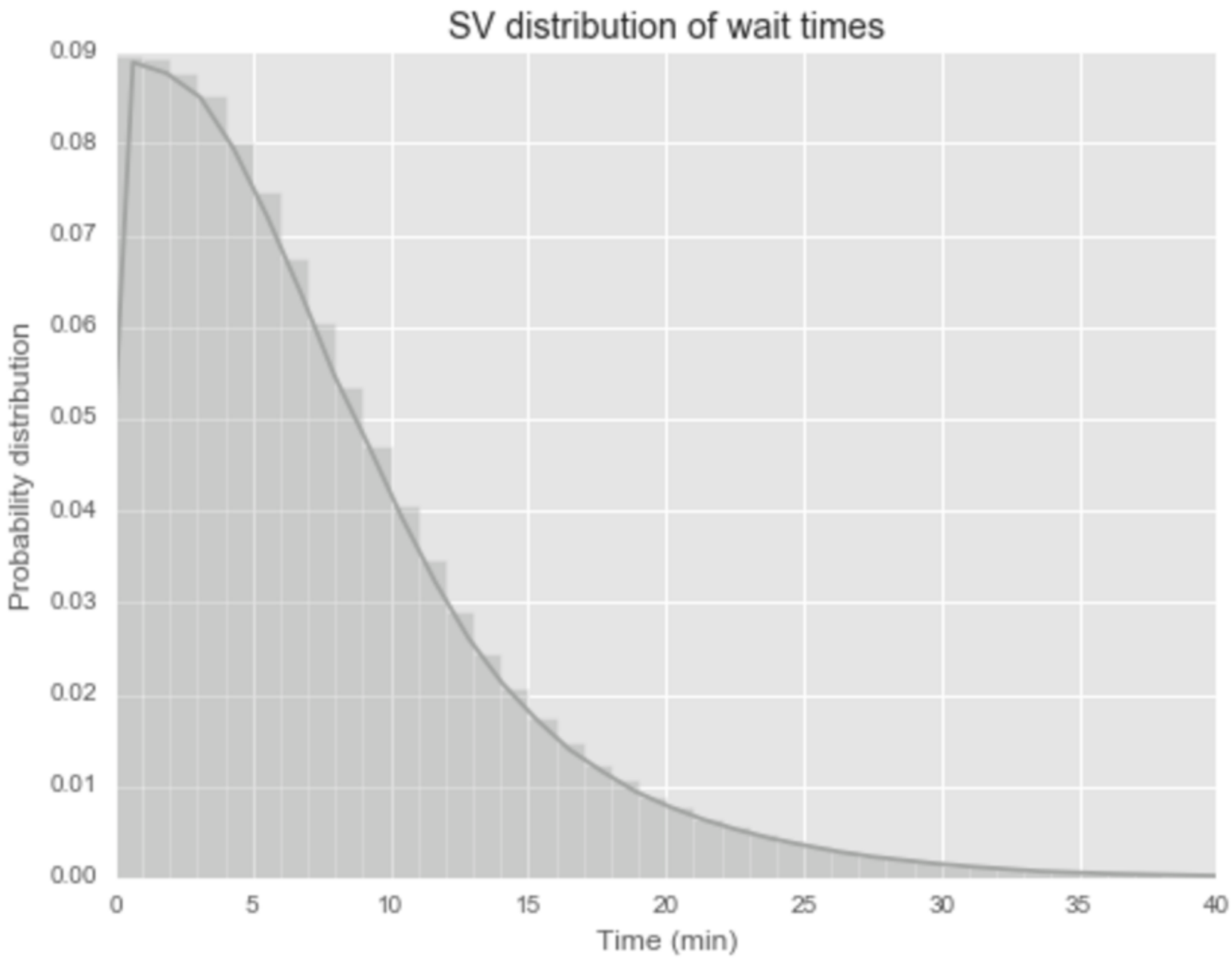
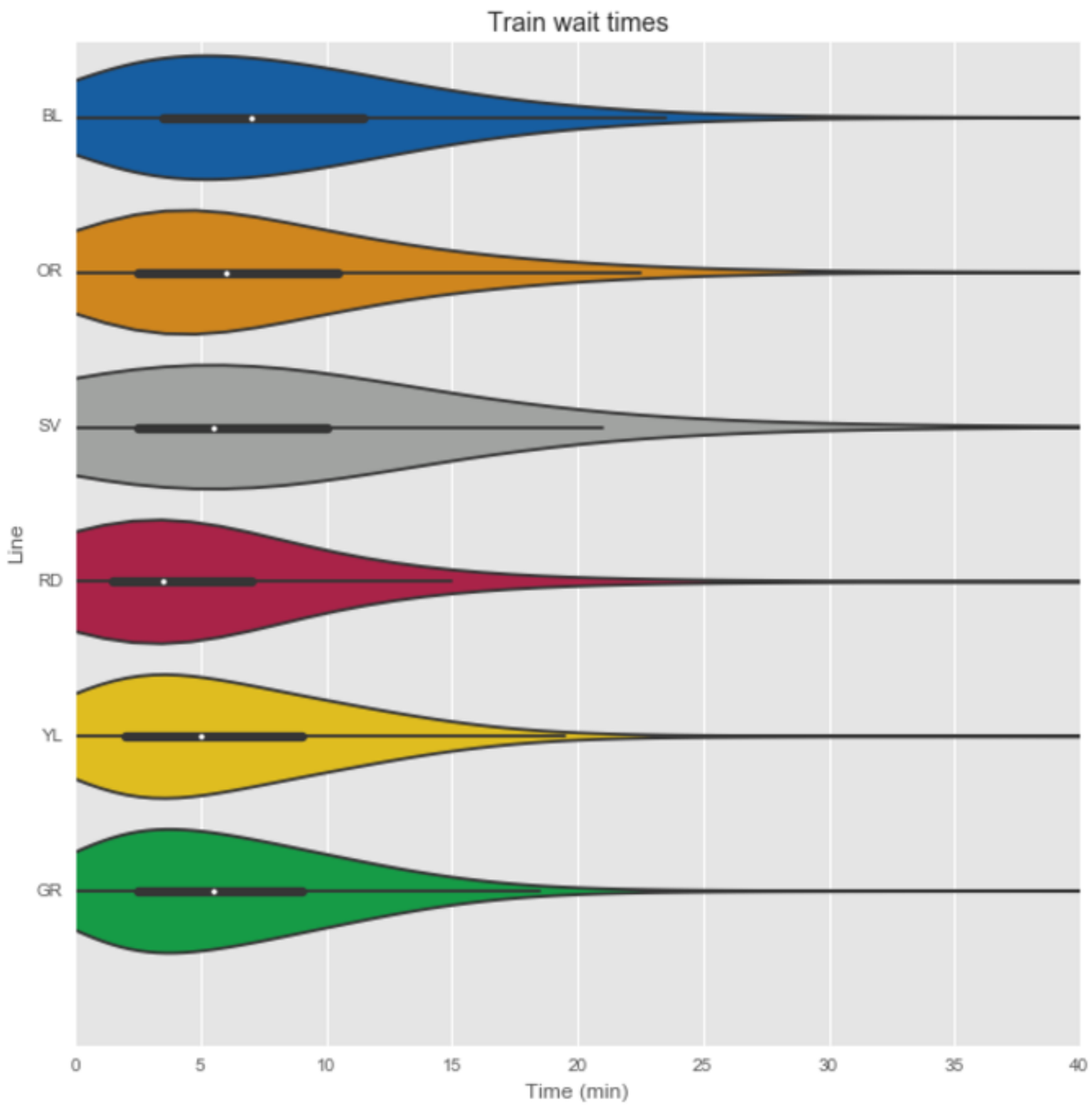
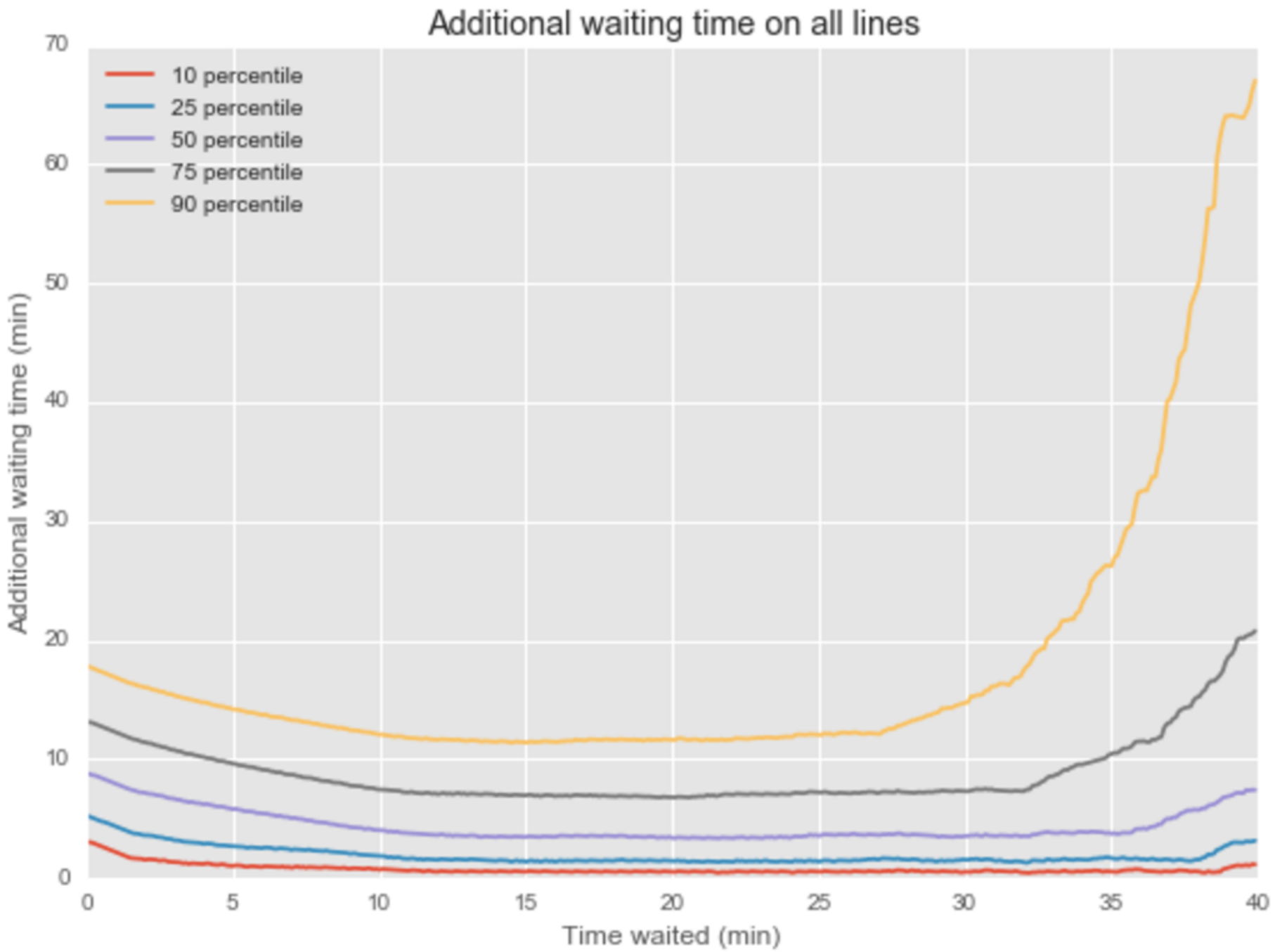


Estimating Wait Times



Additional Wait Times



Thanks!