# Applying Data Science Tools to Transit Planning

*Applications in Time-Series Ridership Analysis*

Joel Huting, Metro Transit

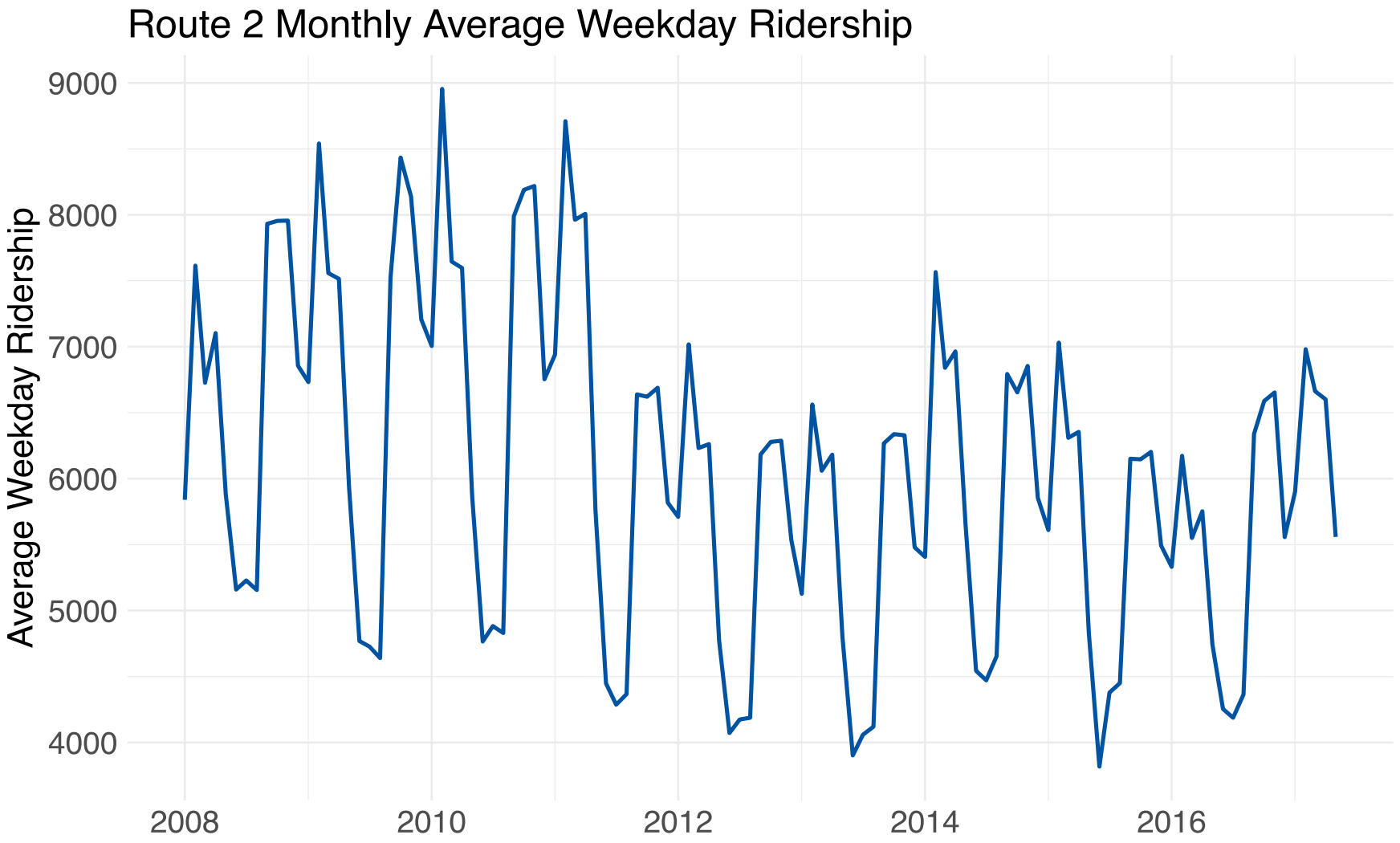
# Overview

- Seasonal-trend decomposition of ridership
- Time-series forecasting methods
- Metro Transit Web-based ridership analysis app
- Open-source app for any agency to use

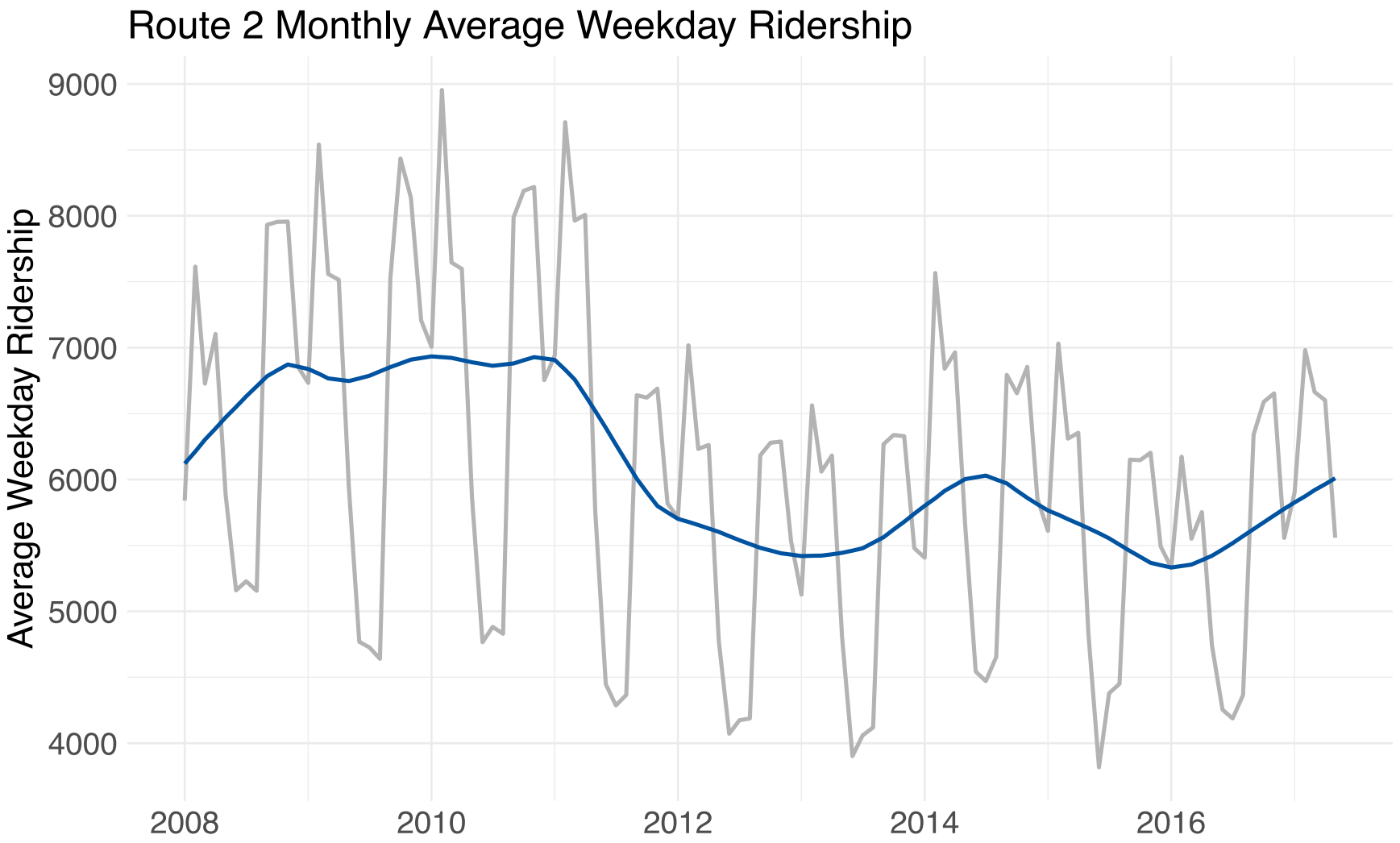
# Seasonal-Trend decomposition (STL)

- Transit ridership data are noisy
  - Seasonal variation
  - Random variation
  - Underlying trend
- STL allows us to quickly and easily decompose ridership
  - Identify underlying “big picture” changes
  - Identify seasonal fluctuations
  - Easy to operationalize through apps
- Decompose time-series of any frequency
  - Daily
  - Monthly

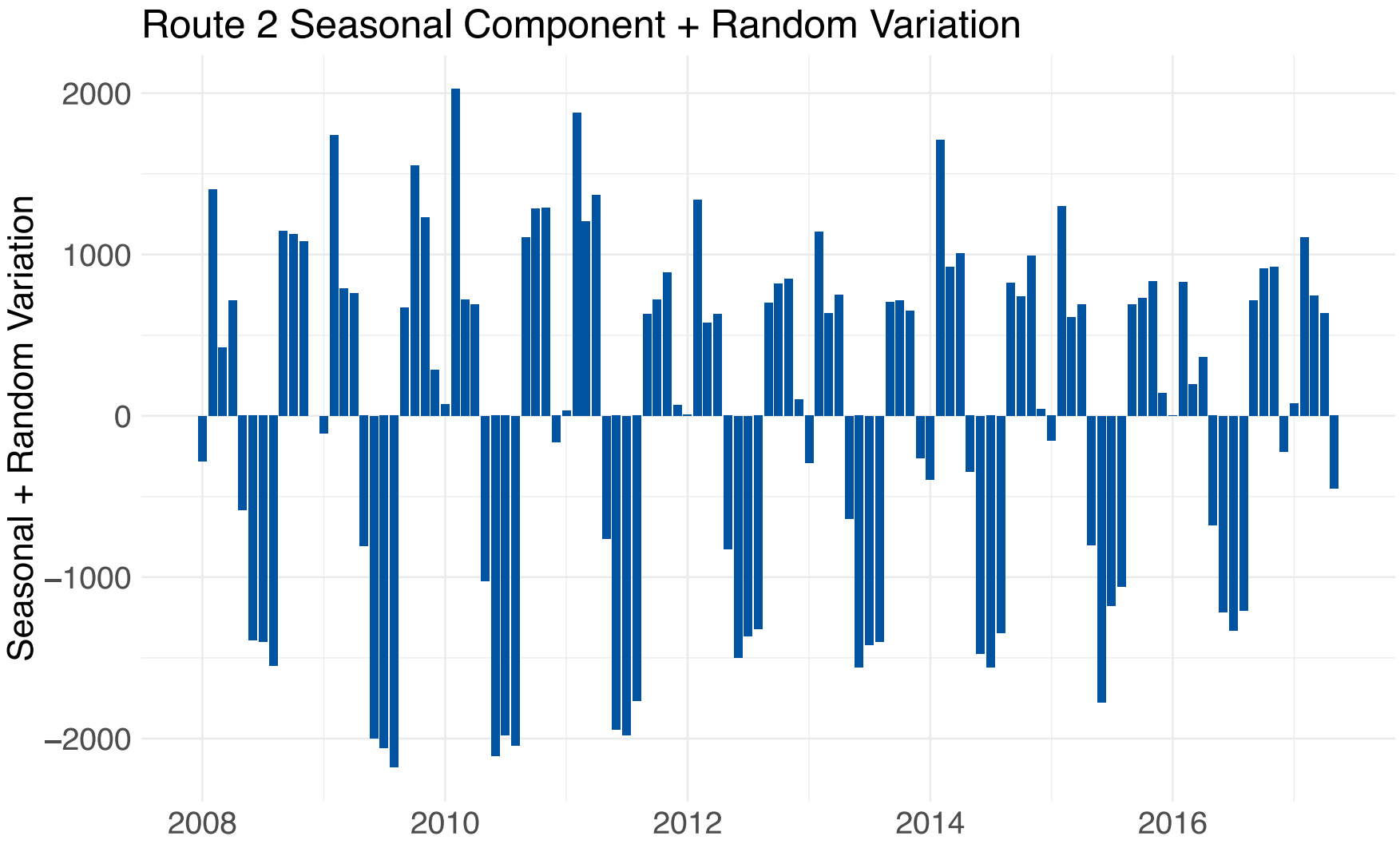
# Step 1. Plot ridership time-series



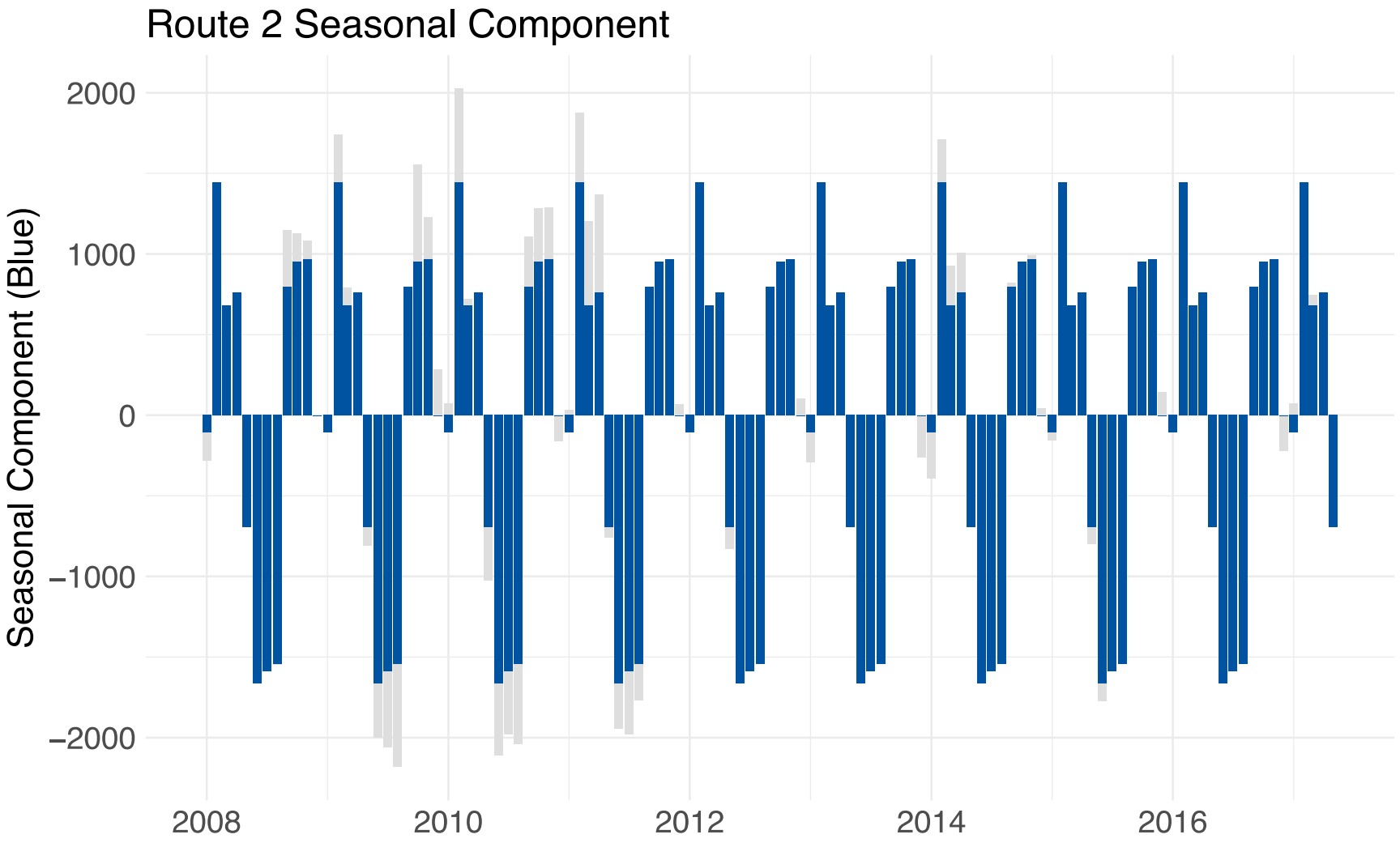
# Step 2. Extract trend



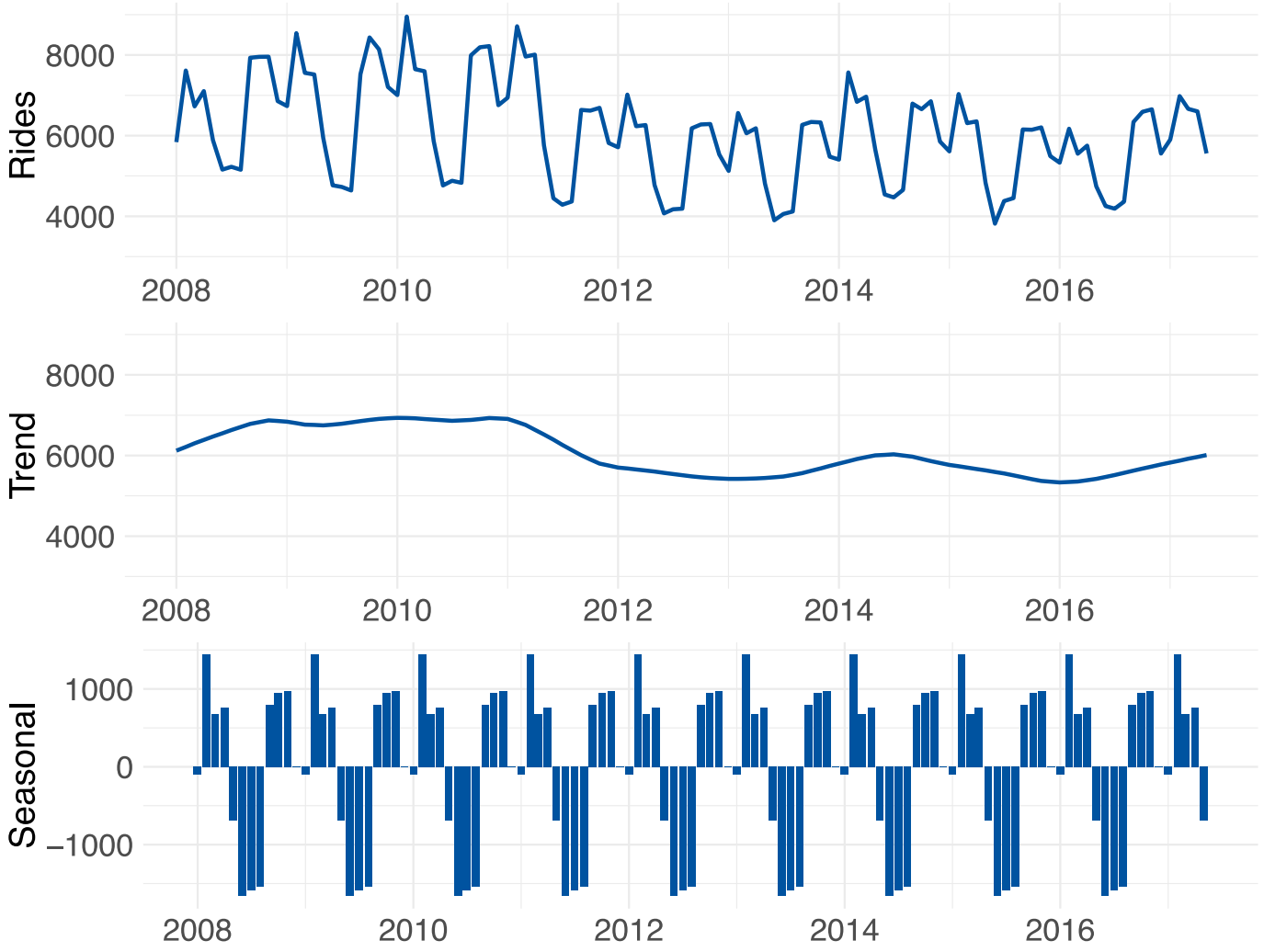
# Step 3. Remove trend



# Step 4. Extract seasonal component



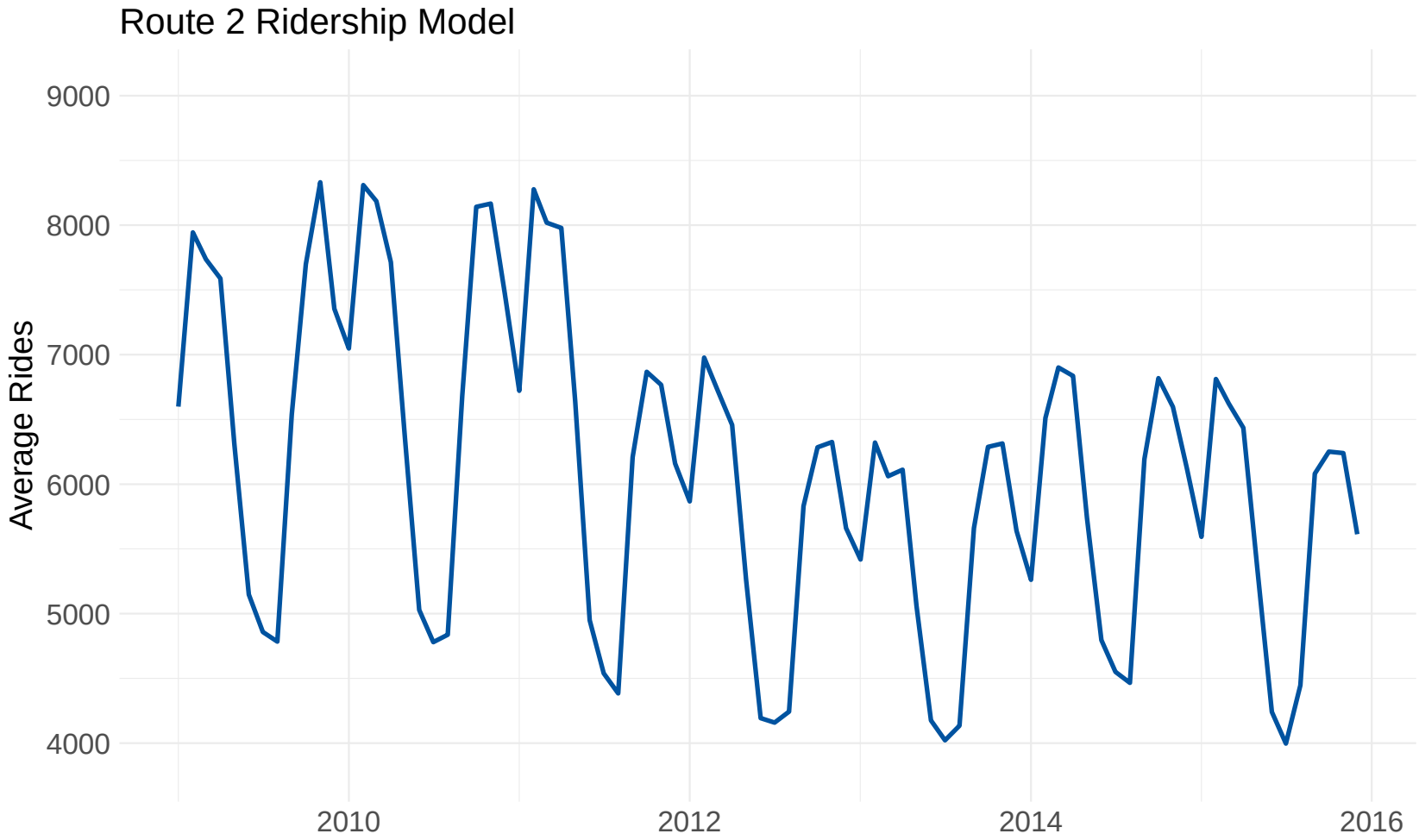
# Step 5. Summary of STL



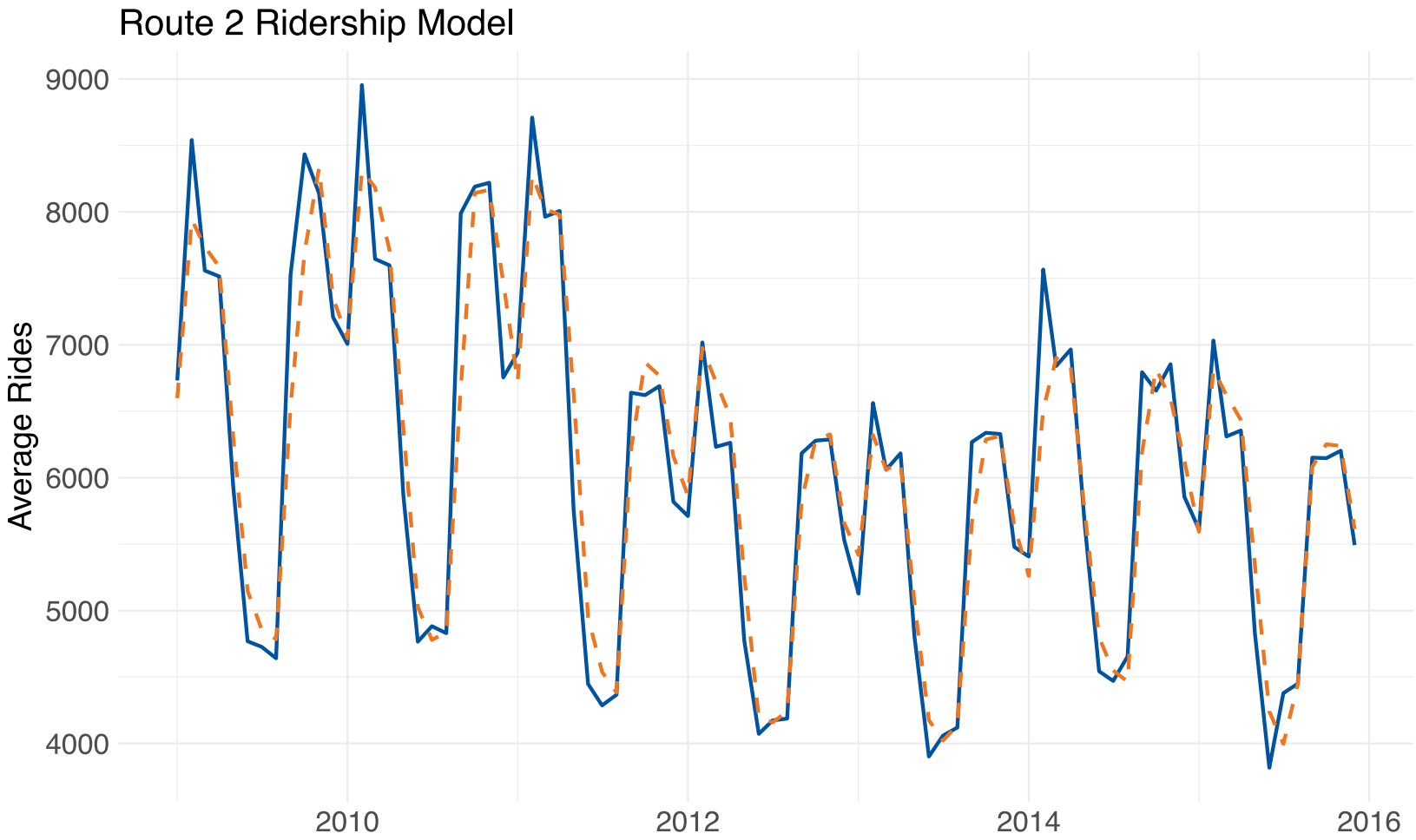
# Forecasting

- Use past values of ridership to forecast future values
- Seasonality, trend, etc.
- Baseline for developing goals, budgets, planning service levels, etc.
- Many different types of models – as a general rule use ensemble of models
- Can incorporate predictor variables

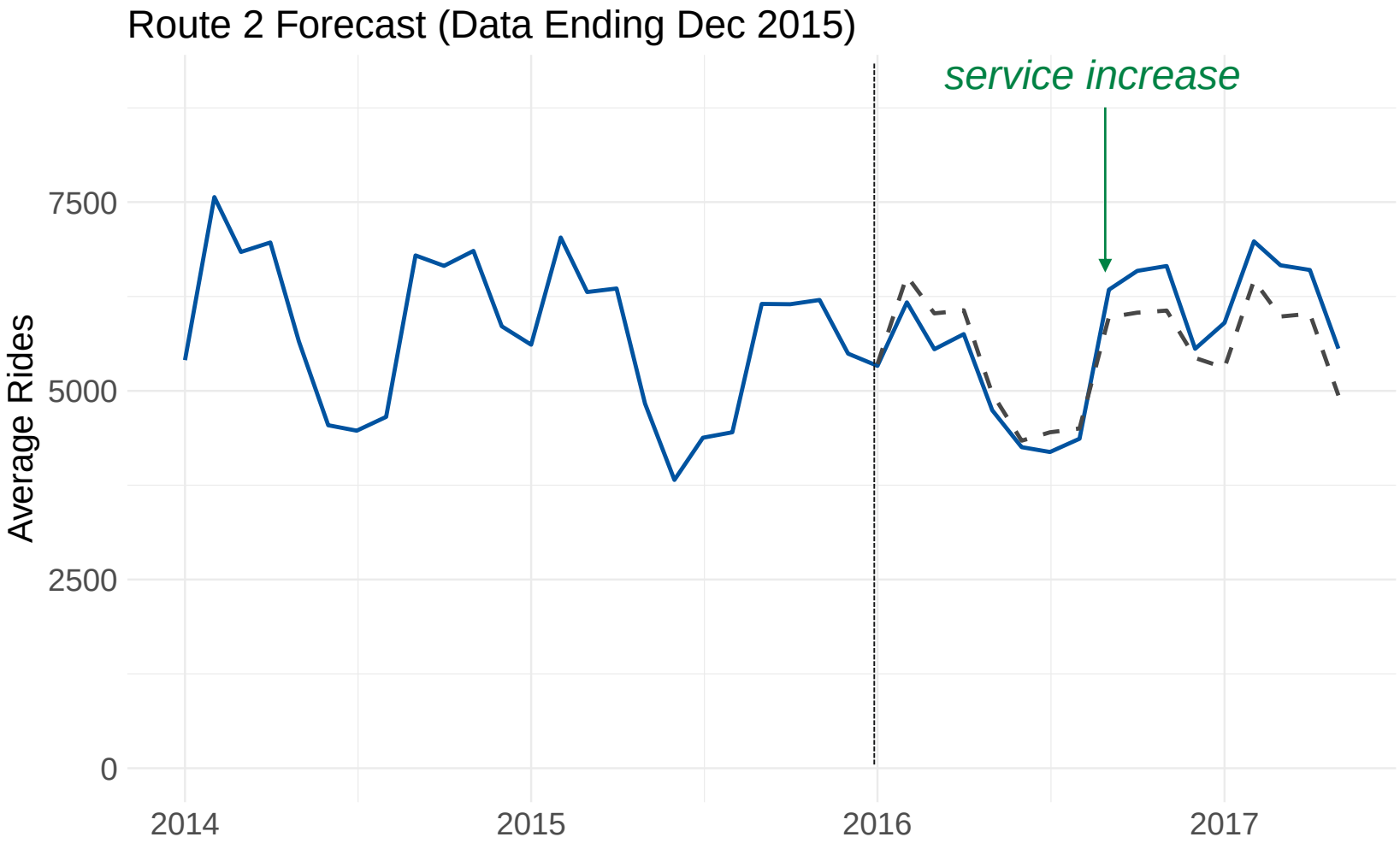
# 1. Build and examine ridership models



# 2. Compare model fit to data



# 3. Make Forecast (Data Ending Dec 2015)



# Accuracy

- Models have performed very well over last several years
- Below is the YTD difference between forecast and actual by mode:

| Mode/Route Type | 2017 YTD Mean Absolute Percent Error (MAPE) |
|---|---|
| All Bus | 1.62% |
| Express | 2.63% |
| Urban Local | 1.66% |
| Suburban Local | 2.38% |
| Green Line | 4.22% |
| Blue Line | 8.26% |
| Northstar | 8.93% |

# Operationalizing Models

**Metro Transit Route-Level Ridership Analysis App**:
https://metrotransitmn.shinyapps.io/RouteTrends/

**Any Transit Agency can load their own data:**
https://metrotransitmn.shinyapps.io/trends-and-forecasts-user-input-data/

You can request access to use the tool by sending an email to joel.huting@metrotransit.org

# Route Trends and Forecasts

About | Trends by Route | Trends by Route Group | Trends by Day of Week | Trends by Time of Day | Trends across Routes | Forecasts by Route | STL Decomposition by Route | Feedback

**Route**

2

**Schedule**

Weekday

**Service**

Rush and Non-Rush

- [x] Show Actual Data on Route Charts
- [ ] Show Productivity for Modal Chart
- [x] Start Y-Axes at Zero

Date Range: **Jan 2008 – May 2017**

Route **2 - Weekday** serves **Franklin Av - Riverside Av - U of M - 8th St SE**

First trip starts at **4:47:00 AM**

Last trp starts at **1:23:00 AM**

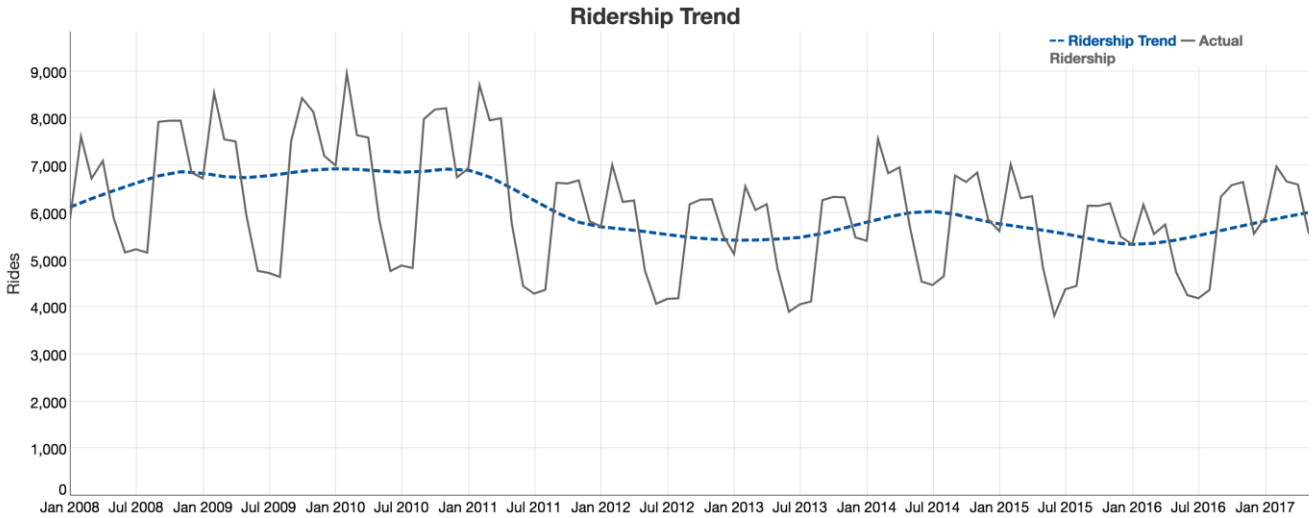
Service spans **20:36** hours

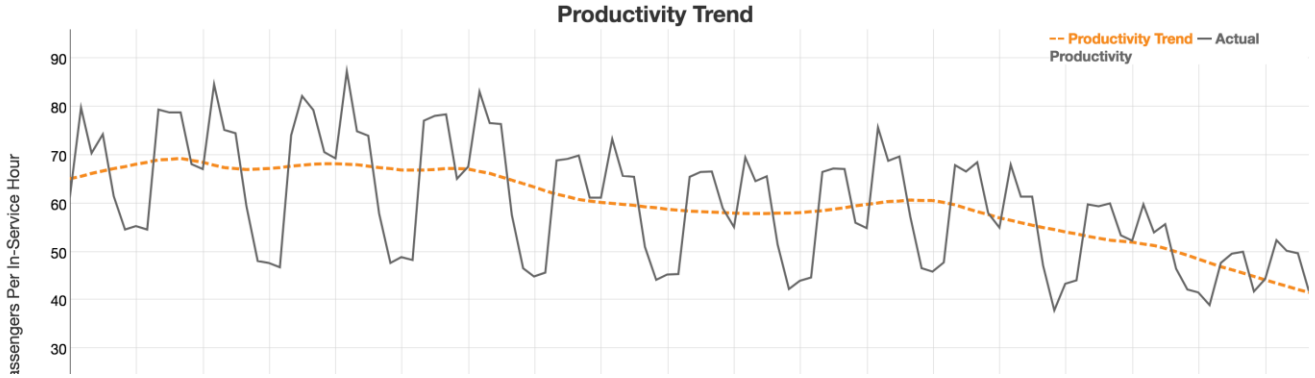
**Detail:** The first two plots display ridership trend and productivity trend for the combination of inputs selected (Route, Schedule, and Service). The third plot shows the ridership or productivity trend (based on whether Show Productivity for Modal Chart is checked) of the route class in which the selected route is. You can use the range selector at the buttom of the page to zoom in or out the plot within the date range. Plots default to plotting with zeroed y-axes. To zoom in the y-axes, uncheck Start Y-Axes at Zero checkbox.

*Data source: Service History database*

*Data were last updated on 2017-06-26 14:54:38*

## *Route 2 Trends: Weekday , Rush and Non-Rush*



# Route Trends and Forecasts

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**Select Route(s):**

10 11 17 18 25 59

**Schedule**

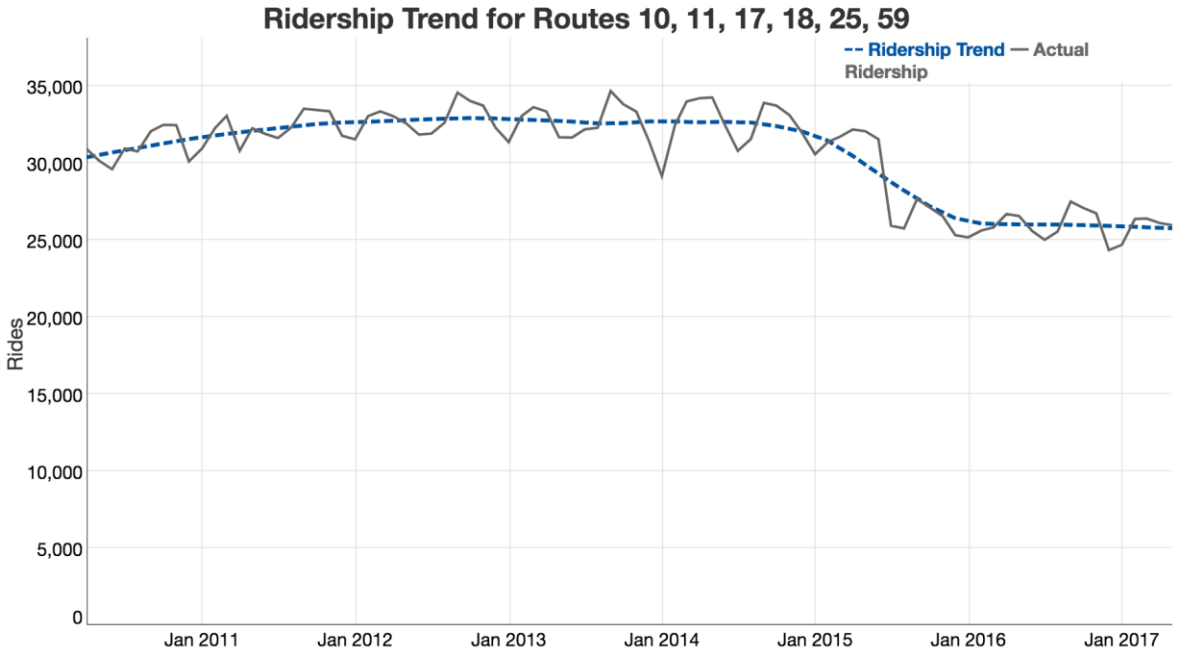
Weekday

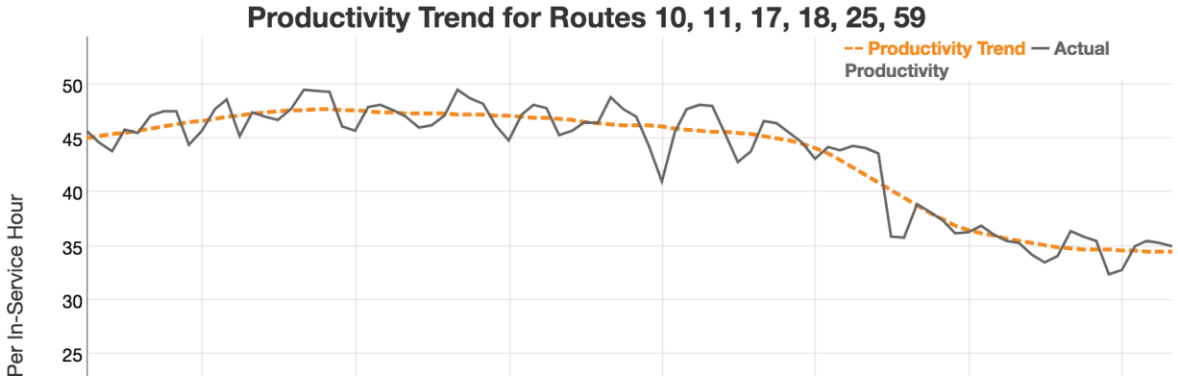
**Service**

Rush and Non-Rush

☑ Start Y-Axes at Zero

Plot



# Route Trends and Forecasts



**Route**

2

☑ Start Y-Axes at Zero

Date Range: **Jan 2008 – May 2017**

Route **2** serves **Franklin Av - Riverside Av - U of M - 8th St SE**

First trip starts at **4:47:00 AM**

Last trp starts at **1:23:00 AM**

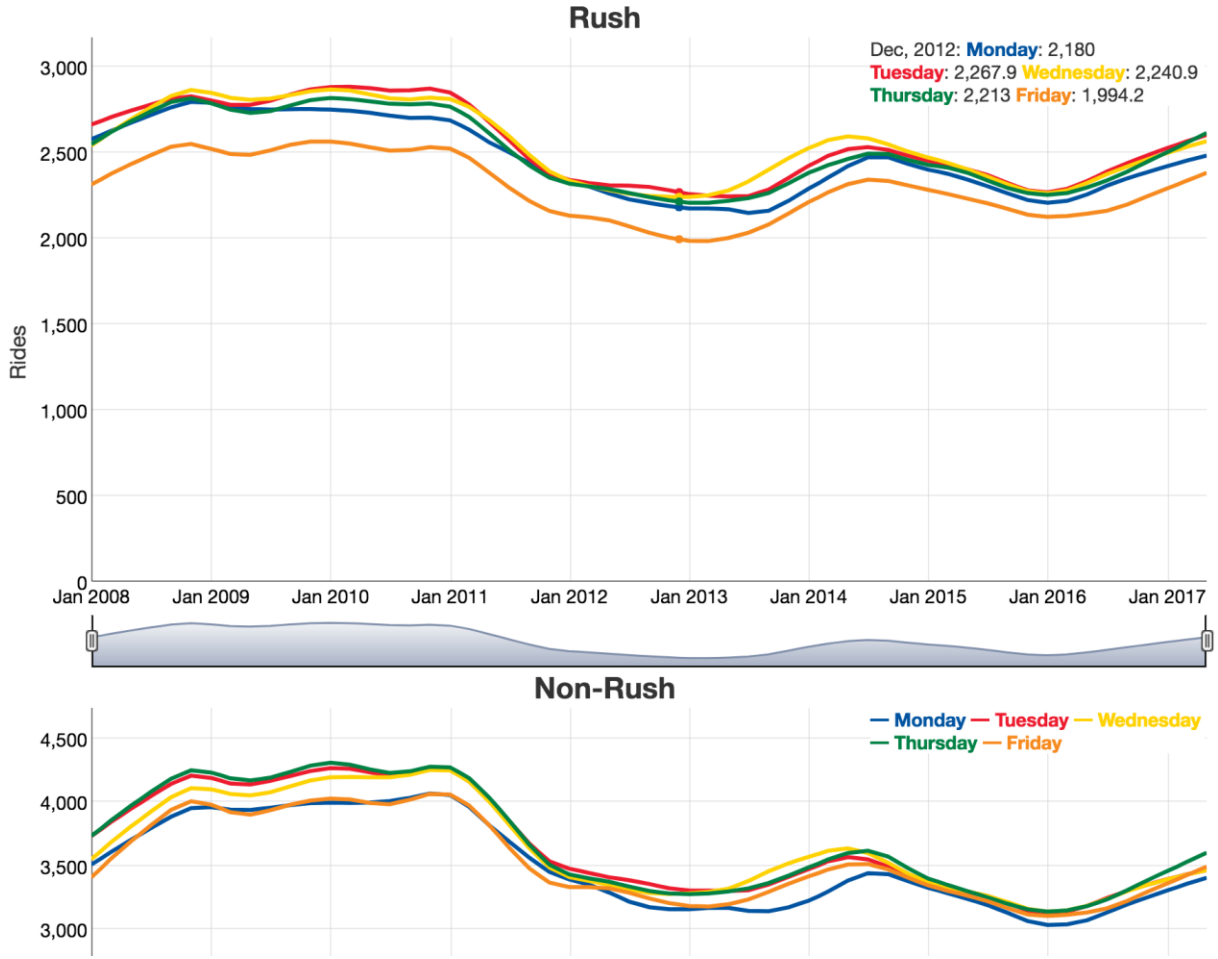
Service spans **20:36** hours

**Detail:** These plots display trends of the selected route for every weekday and for rush and/or non-rush hours. You can use the range selector at the buttom of the page to zoom in or out the plot within the date range. Plots default to plotting with zeroed y-axes. To zoom in the y-axes, uncheck Start Y-Axes at Zero checkbox.

*Data source: Service History database*

*Data were last updated on 2017-06-26 14:54:38*

## *Route 2 Trends: Day of Week and Time of Day*



# Route Trends and Forecasts

About | Trends by Route | Trends by Route Group | Trends by Day of Week | Trends by Time of Day | Trends across Routes | Forecasts by Route | STL Decomposition by Route | Feedback

**Select Routes:**

2
3
4
5

**Reference Date:**

January 2016

**Comparison Date:**

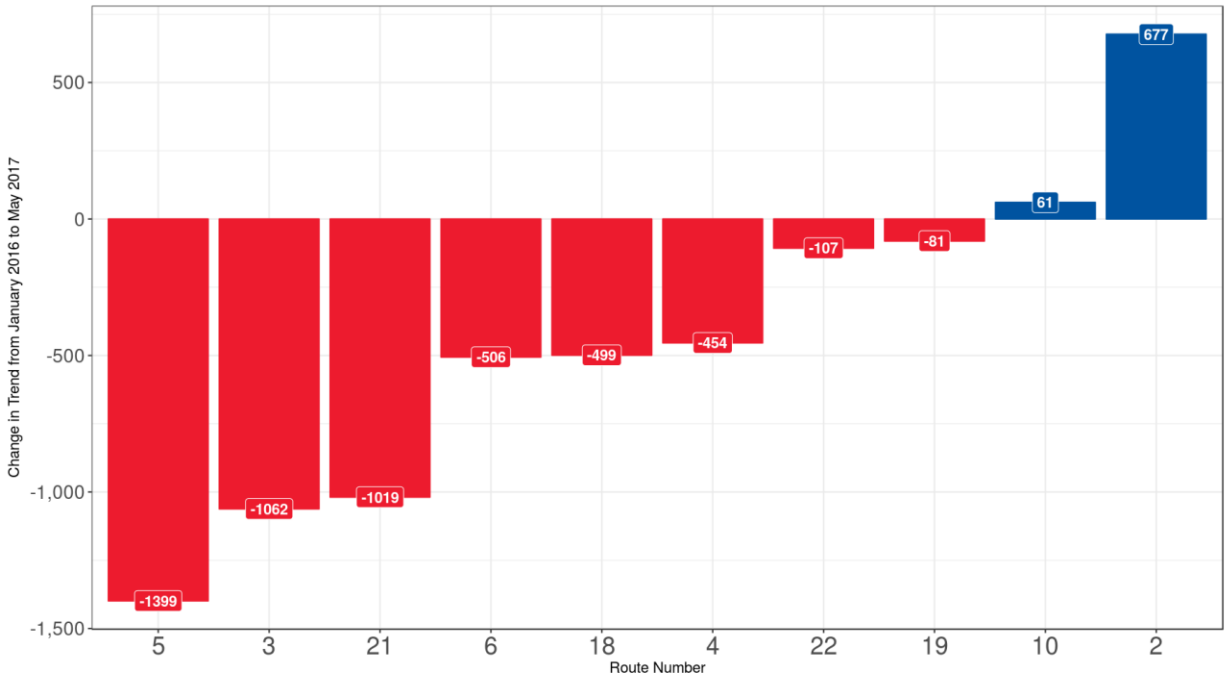
May 2017

☐ Sort by Percent Change

☐ Plot Actual Rides (Default to Trend)

**Detail:** Negative trend means the route has been having a downward sloping trend, in other word ridership has been decreasing when adjusted for seasonality. Positive trend indicates an increase in ridership. You can select as many routes as you want, but more than 20 at a time is not recommended. Check Sort by Percent Change in Trend to sort by percent change instead of absolute change. The table below the plots displays the underlying data.

## Change in Monthly Average Weekday Ridership Trends



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**Route**

2

**Schedule**

Weekday

**Service**

Rush and Non-Rush

☑ Start Y-Axes at Zero

Date Range: **Jan 2008 – May 2017**

Model used for forecasting: **A Hybrid of ETS, STLM, and TBATS Models**

Route **2 - Weekday** serves **Franklin Av - Riverside Av - U of M - 8th St SE**

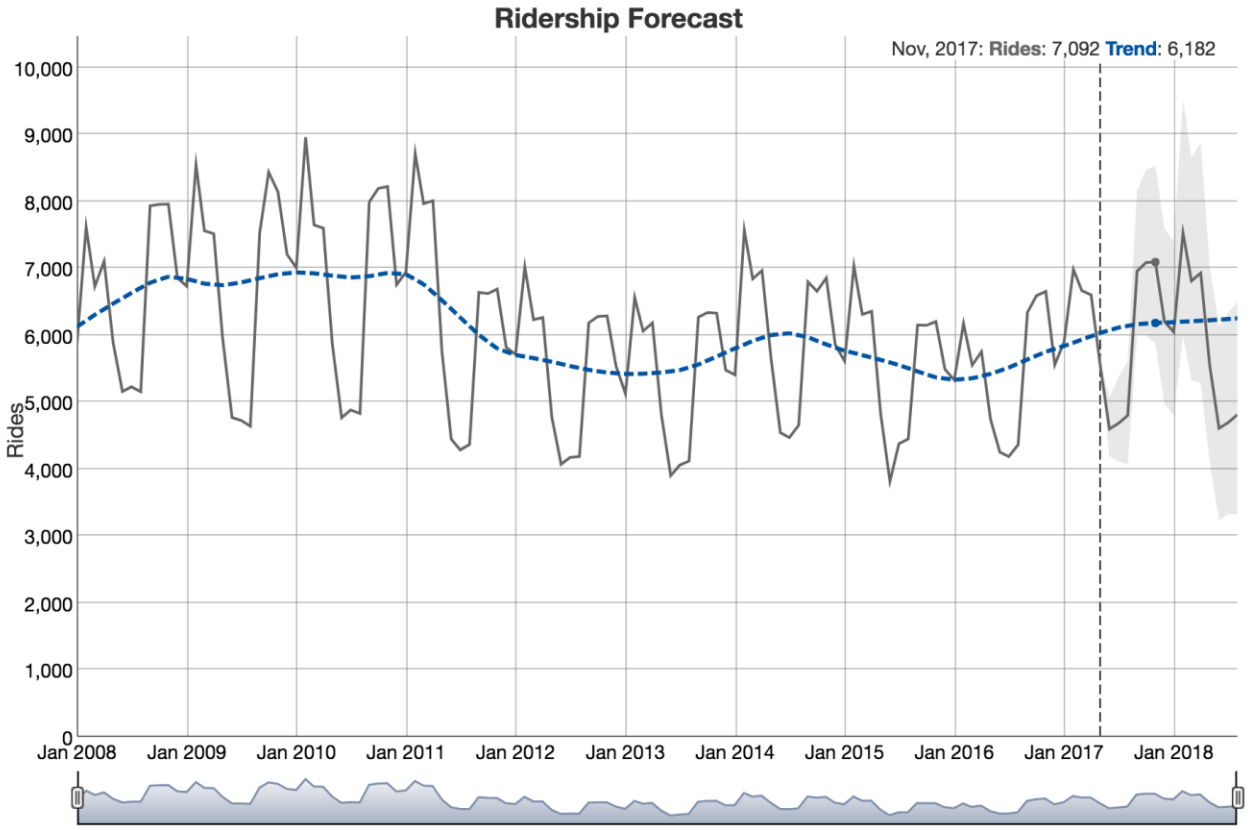
First trip starts at **4:47:00 AM**

Last trp starts at **1:23:00 AM**

Service spans **20:36** hours

**Detail:** This plot displays the trend of the selected route, schedule and service from actual ridership as well as the forecasted ridership for the next 15 months. The table below displays the underlying actual and forecasted ridership values. You can use the

## *Route 2 Forecast: Weekday , Rush and Non-Rush*



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**Route**

2

**Schedule**

Weekday

**Rush or Non-Rush**

Rush and Non-Rush

Date Range: **Jan 2008 – May 2017**

Route **2 - Weekday** serves **Franklin Av - Riverside Av - U of M - 8th St SE**

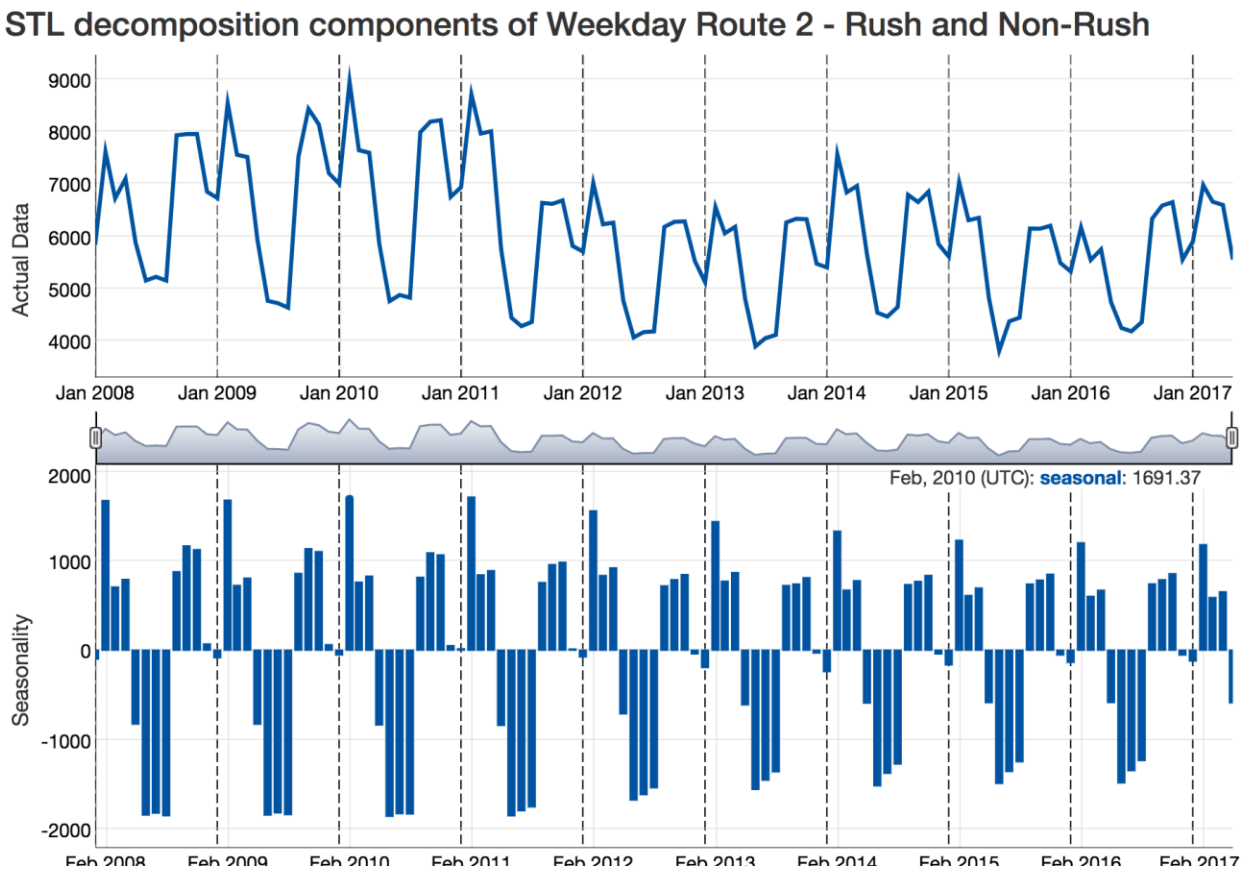
First trip starts at **4:47:00 AM**

Last trp starts at **1:23:00 AM**

Service spans **20:36** hours

**Detail:** These plots attempt to show how STL Decomposition works by displaying the actual ridership and seasonal, trend, and remainder components that add up to the actual ridership. You can use the range selector to zoom in or out the plot within the date range.

*Data source: Service History database*



# Stop Trends

Stop Trends
About
Map
Feedback
Central Mississippi Riverfront Park
Philip W Pillsbury Park
1st Avenue North
Marquette Avenue South
2nd Avenue South
Washington Avenue South
4th Street South
6th Street South
8th Street South
Mississippi River
Loring Park
Stop ID: 51533
Route(s): 2
Board Trend: 228.2 → 308.1
Pct Change in Trend: 35.0%
West Franklin Avenue
East Franklin Avenue
Portland Avenue South
Park Avenue South
Mississippi Gorge Park
% Change Board per month
-24.265 – -23.884
-23.884 – -17.828
Date Range:
September 2016
to
June 2017
Measure
Board
Route
All
2
3
4
Time
Total
Service
Weekday
Dir
Any
Show Percent Change
Download Data

# Questions

Joel.Huting@metrotransit.org

*Thanks to:*

- *Kim Eng Ky, Data Scientist*
- *Eric Lind, Senior Data Scientist*