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Introduction

The Transit Planning Analysis Workflows Playbook serves as a guide, offering blueprints for transit planners to replicate successful analysis workflows derived from real-life case studies. This resource aims to empower transit professionals with practical tools and methodologies to optimize their planning processes, enhance decision-making, and ultimately create more efficient and sustainable transit systems. By drawing insights from various successful projects, this playbook provides a roadmap to navigate the complex landscape of transit planning, enabling planners to adapt and implement proven strategies in their own contexts.

This document is a collaborative effort, championed by a team of experienced transit planners and data analysts. These practitioners have curated a collection of case studies, distilled best practices, and crafted a playbook that aims to encompass a wide range of analysis workflows. The playbook is primarily designed for transit planners and professionals involved in the process of designing, developing, and optimizing transit systems. It caters to individuals working in government agencies, transportation authorities, and metropolitan planning organizations.

The Transit Planning Analysis Workflows Playbook intends to assist transit planners as a go-to resource to:

- Learn from successful case studies
- Access proven analysis workflows
- Support decision-making processes
- Promote collaboration and knowledge sharing
How Does This Playbook Work?

Workflows

Each collected case study added to the Playbook features a similar workflow. First, a problem or need is identified. In order to address this problem or need, the case study would determine which questions need to be asked. One or more analyses are constructed to provide answers to the questions. Software and their relevant features are evaluated to pair with each needed analysis. Finally, the outputs, their interpretation, and how to organize them is determined. This process standardizes the Playbook format for all included case studies solicited through the Community of Practice.

Workflows consists of three primary sections—a flowchart, narrative, and an in-depth technical analysis. The flowchart depicts the pipeline shown above and the specific approaches used to answer each need. The narrative contextualizes the flowchart by providing rationale for each step and key information like case study title, date drafted, software used, and a hyperlink to the corresponding technical analysis. The Technical Analysis portion of each case study is a long-form, step-by-step instruction organized into an appendix.

Playbook Maintenance

Any technical documents produced for case studies are included as an appendix in the Playbook. Technical documents cataloged in this Playbook should include the date of the case study and the specific software versions used to perform the analysis. Deprecated analyses will require updates and replacements each time a new and relevant case study was conducted to answer a similar question or need as a previous case study.
Workflows

This Playbook aims to gather and document workflows that address various problems or needs. Each collected case study follows a standardized workflow to ensure consistency and effective analysis:

1. Problem/Need Identification
   a. The first step is to identify a problem or need that requires attention. Understanding the context and specific challenges is essential for developing appropriate solutions.

2. Determining Key Questions:
   a. Once the problem or need has been identified, the workflow proceeds by determining the key questions that need to be answered. These questions will guide the analysis process and help in extracting relevant insights.

3. Constructing Analyses:
   a. With the key questions in mind, the workflow proceeds to construct the analysis. This step involves designing an analytical framework or multiple frameworks to provide answers to the identified questions. The choice of analysis method depends on the nature of the problem and the available data.

4. Evaluating Software and Pairing Features:
   a. To execute the analysis effectively, the workflow evaluates different software options. The goal is to select software that aligns with the specific analysis needs. This step involves pairing the appropriate features from the software to the required analysis, ensuring that the selected tools can generate the desired insights.

5. Determining Outputs and Interpretation:
   a. Once the analyses are complete, the workflow focuses on determining the outputs and their interpretation. The findings need to be presented in a clear and understandable manner. Additionally, it is crucial to consider the limitations of the analysis and address any potential biases or uncertainties. This step ensures that the interpretation is accurate and comprehensive.

The following tables of Workflow by Need and Workflow by Question can be utilized for quick reference.
## Workflows by Need

<table>
<thead>
<tr>
<th>Need</th>
<th>Workflow</th>
</tr>
</thead>
<tbody>
<tr>
<td>I need to create a transit network ecosystem to better understand systemic changes.</td>
<td>• <a href="#">Travel Time Impacts of Systemic Changes</a></td>
</tr>
<tr>
<td>I need to determine what systemic travel times impacts occur if a specific route is changed.</td>
<td>• <a href="#">Travel Time Impacts of Systemic Changes</a></td>
</tr>
</tbody>
</table>
## Workflows by Question

<table>
<thead>
<tr>
<th>Question</th>
<th>Workflow</th>
</tr>
</thead>
<tbody>
<tr>
<td>How long does it take to travel to and from select O-D in the current system?</td>
<td>● <a href="#">Travel Time Impacts of Systemic Changes</a></td>
</tr>
<tr>
<td>What systemic travel time changes occur if a select route is truncated or removed?</td>
<td>● <a href="#">Travel Time Impacts of Systemic Changes</a></td>
</tr>
</tbody>
</table>
Travel Time Impacts of Systemic Changes
Westchester County Bee Line Case Study (2022-2023)

Link to Appendix

<table>
<thead>
<tr>
<th>Needs Met</th>
<th>Questions Answered</th>
<th>Analyses Performed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I need to create a transit network ecosystem to better understand systemic changes.</td>
<td>1. How long does it take to travel to and from select O-D in the current system?</td>
<td>1. Create a transit network ecosystem.</td>
</tr>
<tr>
<td>2. I need to determine what systemic travel times impacts occur if a specific route is changed.</td>
<td>2. What systemic travel time changes occur if a select route is truncated or removed?</td>
<td>2. Construct an existing conditions baseline of travel times from select O-Ds.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Adjust the GTFS network to reflect route variants: removal and truncation.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Compare the GTFS variants to the baseline O-D travel times.</td>
</tr>
</tbody>
</table>

Software Requirements

<table>
<thead>
<tr>
<th>Software</th>
<th>Features Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conveyal</td>
<td>● Multi-Model Network Creation from GTFS Files and OSM</td>
</tr>
<tr>
<td></td>
<td>● Point to Point Travel Time Calculations</td>
</tr>
<tr>
<td></td>
<td>● Transit Network Modifications</td>
</tr>
<tr>
<td>Excel</td>
<td>● Post-Processing with INDEX and MATCH Functions</td>
</tr>
</tbody>
</table>

Case Study Product

<table>
<thead>
<tr>
<th>Title: The Bee-Line – Westchester: Analysis of Proposed Route Elimination</th>
<th>Date: 01/19/2023</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>This workflow is the result of a pilot project that sought to determine what impact the removal or truncation of a specific route’s service would have on the transit network ecosystem and how existing service can meet the needs of current ridership.</td>
<td></td>
</tr>
</tbody>
</table>
Flowchart - Westchester Case Study

Need 1: I need to create a transit network ecosystem to better understand systemic changes.

Question: How long does it take to travel to and from select O-D in the current system?

Analysis 1: Create a transit network ecosystem.

Analysis 2: Construct an existing conditions baseline of travel times from select O-Ds.

Next Step: Determine appropriate balance of cost savings and population served based on analysis results and agency policy.

Need 2: I need to determine what systemic travel times impacts occur if a specific route is changed.

Question: What systemic travel time changes occur if a selected route is truncated or removed?

Analysis 3: Adjust the GTFS network to reflect route variants: removal and truncation.

Analysis 4: Compare the GTFS variants to the baseline O-D travel times.

Software Feature:
- Multi-modal network creation from GTFS tiles.
- Point to point travel time calculations with analyst selected parameters.
- Transit Network Modifications.
Workflow Narrative

Purpose
The purpose of this workflow is to determine what impact the removal or truncation of a specific route’s service would have on travel times from many origins to many destinations within a transit network ecosystem. The output will assist the analyst determine how existing service can meet the needs of current ridership.

Problem/Need Identification
This workflow has two clear needs;

- **Need 1**: a transit network ecosystem to test changes; and
- **Need 2**: a way to compare the impacts of these changes.

Based on the purpose of this workflow, the transit network ecosystem will need to comprehensively include as many potential travel modes—meaning the test environment must support multi-model GTFS files. The metric used to measure performance within this workflow is travel time.

Key Questions
Considering the needs and metrics, two questions can be formulated;

- **Question 1**: How long does it take to travel to and from select O-D in the current system?
- **Question 2**: What systemic travel time changes occur if a select route is truncated or removed?

Analysis Construction and Software Pairing

**Analysis 1: Construct a Transit Network Ecosystem**
To meet **Need 1** and **Question 1**, a multi-modal transit network ecosystem must be constructed. There are multiple software options available for this, but this workflow uses Conveyal. The analyst (likely in conjunction with a software engineer) will create a package of all transit options’ GTFS files as a bundle. The bundle is loaded into Conveyal’s interface creating the environment.

**Analysis 2: Construct an Existing Conditions Baseline of Travel Times from Select Origins and Destinations**
To meet **Need 1** and **Question 1**, the travel times of the current system need to be benchmarked so changes have a baseline to compare against. The analyst must construct a list of select coordinates that can be loaded into Conveyal. Once complete, the analyst runs Conveyal’s “Regional Analysis” to calculate travel times for those select O-Ds. Conveyal will output a CSV file that contains a list of each coordinate as an origin to each coordinate as a destination and the travel time between them. To make this output actionable, the analyst should post-process this output using Excel. Post-
processing involved making an O-D matrix that indexed travel times to each O-D combination.

**Analysis 3: Adjust the GTFS Network to Reflect Route Variants like Removal and Truncation**

This analysis utilizes Conveyal’s “Modifications” feature where an analyst can make changes to one or more routes that will be reflected in the Regional Analysis output’s travel times. **Analysis 3** can be split into three parts;

1. Run Regional Analysis with a modification that removes a specific route entirely.
2. Run Regional Analysis with a modification that removes specific stops from a route truncating it.
3. Construct Matrices for both outputs.

**Analysis 4: Compare the GTFS Variants to the Baseline O-D Travel Times**

Comparing the variants to the baseline travel times is relatively simple since all of the outputs are in the same matrix formatted. Using Excel, the analyst can put all matrices as separate sheets in a single document. By entering a subtraction equation that references the other sheets, baseline and modification, a difference matrix can be constructed.

**Outputs and Interpretation**

If by removing the route a large cohort of ridership is impacted negatively with dramatically longer travel times, the analyst should identify a point of truncation that has the least impact of travel time increase. The analyst should test truncation at all of the most impacted stops sequentially. When comparing truncation points, the point of diminishing returns is indicative of the desired stop.

**Next Steps**

This workflow focuses entirely on the metric of travel time as its sole performance measure. While this is a major component of transit planning, other metrics need to be factored for comprehensive decision making. The suggested next step would be to perform a financial impact of route changes, then determine the appropriate balance of cost savings and service based on analysis results and agency policy.
Scoring and Comparing Routes
Rochester: Increasing Employment Access through Increased Fixed-Route Frequency

<table>
<thead>
<tr>
<th>Needs Met</th>
<th>Questions Answered</th>
<th>Analyses Performed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I need to understand who is being served by the current routes of interest.</td>
<td>1. What demographics are each of the routes of interest currently serving?</td>
<td>1. Existing Conditions of Demographics Served</td>
</tr>
<tr>
<td>2. I need to determine the impact to ridership of each fixed route’s frequency increase.</td>
<td>2. What fixed-routes routes would an increase in service frequency be most beneficial to focused demographics?</td>
<td>2. Route Frequency Increase Cost Assessment</td>
</tr>
<tr>
<td>3. I need to compare results and validate outputs.</td>
<td>3. How do the two individual outputs compare with each other?</td>
<td>3. Evaluate and compare each route with a composite score that incorporates all relevant attributes.</td>
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Software Requirements

<table>
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<tr>
<th>Software</th>
<th>Features Used</th>
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<tbody>
<tr>
<td>TBEST</td>
<td>● Socio-Economic Market Analysis</td>
</tr>
<tr>
<td></td>
<td>● Land Use Market Analysis</td>
</tr>
<tr>
<td>Remix</td>
<td>● Socio-Economic Market Analysis</td>
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<tr>
<td></td>
<td>● Land Use Market Analysis</td>
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<td>● GTFS Editing</td>
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Case Study Product

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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
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</table>

This workflow is the result of a pilot project that sought to develop an impact score for ranking low-frequency, local routes based on ridership demographics, income, and employment to provide RTS with an evidence-based approach for adjusting the frequency of routes within their system.
Workflow Narrative

Purpose
The purpose of this workflow is to construct an impact score for ranking routes based on ridership demographics, income, employment, and other attributes to provide planners with an evidence-based approach for adjusting route service within their system.

Problem/Need Identification
This workflow satisfies three needs;

- **Need 1**: to understand who is being served by the current routes of interest.
- **Need 2**: to determine the impact to ridership of each fixed route’s frequency increase.
- **Need 3**: to compare results and validate outputs.

These needs require software that can support depicting transit routes and demographics.

Key Questions
Considering the needs, three primary questions can be formulated;

- **Question 1**: What demographics are each of the routes of interest currently serving?
- **Question 2**: What fixed-routes routes would an increase in service frequency be most beneficial to focused demographics?
- **Question 3**: How do the two individual outputs compare with each other?

Analysis Construction and Software Pairing

**Analysis 1: Existing Conditions of Demographics Served**
To understand the impact of changes, a baseline of the current existing conditions is necessary to compare against. Planners can identify who the current transit system routes using demographics data.

**Analysis 2: Route Frequency Increase Cost Assessment**
Changes to the system can be made via GTFS editing. This analysis adjusts the frequency of routes and calculates the increased cost of running specific routes more frequently.

**Analysis 3: Evaluate and compare each route with a composite score that incorporates all relevant attributes.**
With a baseline of served demographics constructed, analysts can determine what demographics they would like to prioritize service for—like zero-vehicle households or populations below the poverty threshold. All route attributes are normalized to be
converted into comparable values, each multiplied by a weight value, then added together to develop a composite score.

**Outputs and Interpretation**

The outputs of this workflow are intended to be a spreadsheet for each system modification scenario. Each spreadsheet contains demographics metrics by route and can be sorted by composite score for comparison against each other.

**Next Step**

This workflow focuses entirely on the process of accessing demographics data and constructing a composite score to measure route performance. The suggested next step would be to determine if any supplementary attributes should be incorporated into a composite score. Finally, a determination should be made to find the balance between increasing route frequency that would most benefit the ridership and cost efficiency.
Aligning Service With Demand
Oswego: Service Alignment Study
Replica and STOPS

Link to Appendix

<table>
<thead>
<tr>
<th>Needs Met</th>
<th>Questions Answered</th>
<th>Analyses Performed</th>
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Software Requirements

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<tr>
<td>Description</td>
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</tr>
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</table>
Flowchart - Oswego Case Study

Need 1
I need to understand the region’s potential ridership needs.

Question
What areas within the service area have the highest propensity to use the transit system?

Analysis 1
Develop Enhanced Transit Propensity Index

Software Feature
- Synthetic Travel Survey Data - Spatial Trip Patterns
  - Neptica

Optional Need
I need an MPO model to run STOPS.

Analysis 2
Demographics Sensitivity Analysis

Software Feature
- O-D Trip Pattern to Block Group Mapping
  - ESRI ArcMap

Need 2
I need to identify the routes that can be changed to increase ridership and access while balancing costs.

Question
What is the systemic impact on ridership of specific redesign changes?

Analysis 3
Construct a Geographic Zone-to-Zone System (in lieu of an MPO Travel Demand Model)

Software Feature
- Ridership Forecasting
  - STOPS

Analysis 4+
Forecast Ridership for Each Change

Software Feature
- GTFS Editing
  - GTFS Edit

Next Step
Validate system redesign insights with agency cost assessments and implement changes.
Workflow Narrative

Purpose

Problem/Need Identification
This workflow has X needs;
- Need 1:
- Need 2:

Key Questions
Considering the needs, X questions can be formulated;
- Question 1:
- Question 2:

Analysis Construction and Software Pairing
Analysis 1:

Analysis 2:

Analysis 3:

Analysis 4:

Outputs and Interpretation

Next Step
Modeling Network Ridership
Capital District Transportation Authority: Route Restructuring
TBEST, Remix, and ArcGIS

Link to Appendix

<table>
<thead>
<tr>
<th>Needs Met</th>
<th>Questions Answered</th>
<th>Analyses Performed</th>
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</table>

Software Requirements

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<td>TBEST</td>
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Case Study Product

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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Description
Flowchart - CDTA Case Study

Need 1
I need to reconfigure my routes in Troy NY in order to better serve my community.

Question
Where is there latent demand in Troy NY?

Analysis 1
Create a Transit Propensity Index by census tract.

Software Feature
Mapping of census tracts with high propensity.

ESRI ArcGIS

Need 2
I need to test the efficacy of my new system.

Question
Has ridership changed?

Analysis 3
Find or make a baseline model that accurately describes the system ridership.

Software Feature
Ridership Estimation Modeling

Analysis 4
Compare a model using the new GTFS to the baseline model?

Software Feature
Socio-Economic Market Analysis

Next Step
Realign Transit network to serve population and update GTFS.
Workflow Narrative

Purpose

Problem/Need Identification
This workflow has X needs;
  ● Need 1:
  ● Need 2:

Key Questions
Considering the needs, X questions can be formulated;
  ● Question 1:
  ● Question 2:

Analysis Construction and Software Pairing
Analysis 1:

  Analysis 2:

  Analysis 3:

  Analysis 4:

Outputs and Interpretation

Next Step
Appendix A: Technical Analyses

The following Technical Analyses are a step-by-step documentation of the methodologies used in each case study project. Transit planners can use these detailed analysis design documents to replicate the analyses, or to learn about applicable steps in the methodologies of each project.
A transit network ecosystem was established in the back end to set up an instance of Conveyal, which is addressed in detail in the “Software Assessment” section. Establishing a “transit network ecosystem” involves selecting and formatting all GTFS files that the software will attempt to transport a synthetic rider on. The following GTFS systems were packaged together to create the ecosystem:

- MTA New York City Transit
- Long Island Railroad
- Metro-North Railroad
- MTA Bus Company
- Suffolk County Transit
- Bee-Line Bus

Note: Nassau County GTFS was initially included in the package but was removed due to a processing conflict.

Next, the software required a list of locations formatted as a CSV file with three columns: stop_id (name of the location), stop_lat (location latitude), and stop_lon (location longitude). During the preliminary stages of the pilot project, the list of locations consisted solely of stops along the BxM4C, but as the project progressed, it was revised several times. A full list of the origins and destinations can be found in the appendix.

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>stop_id</td>
<td>stop_lat</td>
</tr>
<tr>
<td>2</td>
<td>1941</td>
<td>40.78059</td>
</tr>
<tr>
<td>3</td>
<td>1942</td>
<td>40.76435</td>
</tr>
<tr>
<td>4</td>
<td>1943</td>
<td>40.75927</td>
</tr>
<tr>
<td>5</td>
<td>1944</td>
<td>40.75398</td>
</tr>
<tr>
<td>6</td>
<td>1945</td>
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<tr>
<td>7</td>
<td>1946</td>
<td>40.74334</td>
</tr>
<tr>
<td>8</td>
<td>1947</td>
<td>40.74128</td>
</tr>
</tbody>
</table>

After the transit network ecosystem is established and the final list of relevant locations is selected, parameters need to be defined to determine the behavior and priorities.
The Conveyal software provides a user interface for defining parameters. This image depicts the final selection of parameters that were modeled.

Synthetic riders were determined to access and egress all types of available transit by walking. Two-hundred simulated schedules were generated to take place between 5:00am and 10:00am. Synthetic riders were defined as having a walk speed of 5 km/h and only willing to walk for 30 minutes and make 3 transfers at most.

The final set of parameters are defined when the analysis is converted into a regional analysis. At this phase, the analyst defined both the origin and destination points as the same set of points. The intent was to create a matrix assessing travel time from each origin point to each destination point. Cutoff Minutes, or the total duration that a synthetic trip could take before being determined invalid, was set to 120 minutes.

Finally, the percentiles Conveyal was to output were determined. If all the travel times from every trip possible within all other parameters were mapped on a bar graph, the graph would have a normal distribution. The 5th percentile indicates the travel times under the top 5% performing circumstances (i.e., as though a synthetic rider arrived at the bus stop just as the bus was arriving at the stop). The 50th percentile shows the average circumstances. Finally, the 95th percentile shows the worst-case scenario—the synthetic rider sees the bus they intended to catch drive away as they arrive at the stop and now must wait for the next bus.

Using the outlined parameters, outputs were generated for both existing conditions and a scenario in which the BxM4C was completely removed from service. Additionally, Conveyal
supports the use of scenario modifications that allow the user to adjust a transit system and perform analyses on the adjusted scenario. The screenshot below depicts the “Remove Stops” modification in which all the red-highlighted stops were removed from the line.

The Research Team performed multiple variations of this modification, each truncating the BxM4C at different stops. After each modification, the network analysis was run, the travel time CSV output was downloaded, and the data was converted into one or more matrices following the indexing process outlined further in this section. The following stops were selected for truncation analyses:

- 3069 - 5TH AVE @ 98TH ST
- 1941 - 5TH AVE @ 85TH ST
- 2968 - 5TH AVE @ 69TH ST
- 1942 - 5TH AVE @ 59TH ST
- 1943 - 5TH AVE @ 51ST ST

Conveyal provides five potential outputs from an analysis: GeoTIFF, Scenario and Modification JSON, Paths CSV, Times CSV, Access CSV. The majority of our analyses utilized Times CSV outputs like the example below:

<table>
<thead>
<tr>
<th>origin</th>
<th>destination</th>
<th>percentile</th>
<th>time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1941</td>
<td>1942</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>1941</td>
<td>1943</td>
<td>5</td>
<td>13</td>
</tr>
<tr>
<td>1941</td>
<td>1944</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>1941</td>
<td>1945</td>
<td>5</td>
<td>17</td>
</tr>
<tr>
<td>1941</td>
<td>1946</td>
<td>5</td>
<td>19</td>
</tr>
</tbody>
</table>
These spreadsheets depict the travel time from an origin to a destination for the selected percentile. The first row indicates that if a rider is within the 5th percentile of trip travel time, then going from stop 1941 to 1942 will be 11 minutes. The multiple scenarios and modifications outlined in the Analysis Design section were exported, combined, and compared to each other:

<table>
<thead>
<tr>
<th>origin</th>
<th>destination</th>
<th>percentile</th>
<th>BxM4C time</th>
<th>no BxM4C</th>
<th>difference</th>
<th>diff values</th>
</tr>
</thead>
<tbody>
<tr>
<td>1941</td>
<td>1942</td>
<td>5</td>
<td>8</td>
<td>11</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>1941</td>
<td>1943</td>
<td>5</td>
<td>10</td>
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The first row in this comparison indicates that, in the fifth percentile, it takes 8 minutes to travel from stop 1941 to 1942 with the BxM4C and 11 minutes if the route were removed from service. This results in an increase of 3 minutes of travel time as shown in the “difference” column. **Note:** Since the contents of the “diff” column were calculated using an Excel equation (=[@[no bxm4c]]-[@[bxm time]]), they could not be indexed correctly into the matrices—so they were duplicated as “values only” into a new column—“diff values”.

The final outputs of the team’s analyses were a series of matrices. These matrices were initially constructed manually, but as it became an iterative process, a formula was developed so the analyst could make use of a matrix template with the equations. The equation uses the ‘INDEX’ function to copy information from the Conveyal output and the ‘MATCH’ function to identify which information to index. The colors in the full equation shown below are coordinated with their respective cells in the table screenshot below.
Each time travel cell in the matrix contains the equation above that matches the associated origin (light orange), destination (blue), and percentile (purple) with the corresponding columns on the Conveyal output CSV. The green highlighted cell can be dragged across the spreadsheet to duplicate the equation for each destination, then the entire row is highlighted and dragged down to perform the index/match with all origin/destination pairs on the sheet. This method was faster and easier than manually creating the matrices but still requires a substantial amount of uninterrupted processing time—approximately 7 to 13 minutes.

Once the INDEX function has completed processing for all cells, the matrix fills in the values from the output data corresponding with each origin/destination/percentile combination.

To facilitate analysis interpretation, the data was highlighted and “Conditional Formatting” of “Red – Yellow – Green Scale” was selected. This made all 0 travel time valued cells green, the highest travel time value cell red, and then range between scaling yellow to orange from smallest to largest. The result is a color-coded origin-destination matrix showing travel times from each origin to each destination under the analyses’ conditions.

For the first scenario, 9 total matrices were constructed—the 5th, 50th, and 95th percentile each had a matrix with three versions: All Stops, Northbound Stops Only, and Southbound Stops Only. During analysis interpretation, the Research Team agreed to concentrate their efforts to focus on Southbound Stops Only at the 5th percentile.
Travel Time – Southbound, 5th Percentile, BxM4C (Existing Conditions)

This matrix shows the travel time from and to all southbound stops and destinations for the 5th percentile with the BxM4C as it is. Conveyal calculates the fastest way to get from an origin to a destination within the entire transit network ecosystem. The “Stop ID” column and row are both listed in route beginning-to-end sequential order. The darkest green values are “0” travel time (i.e., same origin as destination). A diagonal line of these non-travel values can be seen through the spreadsheet. Since this portion of the route is one-directional and linear, a rider cannot arrive at a destination before their origin. Subsequently, all values below the “0” line can be disregarded. All values are colored on a gradient scale of green to red indicating lowest to highest travel times.
Travel Time – Southbound, 5th Percentile, No BxM4C

This matrix shows the travel time from and to all southbound stops and destinations for the 5th percentile if the BxM4C were completely removed from service. At a glance, these two matrices are very similar, so a new type of matrix was constructed to highlight the differences in the scenarios (next page).
Generating the difference matrix used an excel formula where the travel time value of the “BxM4C” scenario matrix cell was subtracted from the same cell location on the “No BxM4C” scenario matrix (`="SB, 5% 5-10AM, TT NoBxM4C"!D4-"SB, 5% 5-10AM, TT BxM4C"!D4`). Like the previous matrices, green is “0” and the highest value is red. Since Conveyal calculates the fastest way to get from an origin to a destination within the entire transit network ecosystem, if the BxM4C is removed and there is no impact or another route could get the rider from their origin to the same destination with no time difference, then the time travel value will be a “0” in this matrix. Within this difference matrix, a very clear problem area emerges: Origin stops 457-792 traveling to destination stops 3069, 1941, and 2968.
O-D Pair Difference Table

Using two outputs from Conveyal, the TIMES and PATHS .CSV files, the Research Team constructed a table (using the same INDEX/MATCH methodology as in the matrices) to sort and compare BxM4C to No-BxM4C outputs. The “Counts” related columns detail how many different pathways a rider could take to make it from that origin to that destination. Count values were generated with the equation “=COUNTIFS("Paths Output BxM4C (Values)!$A:$A,A2,"Paths Output BxM4C (Values)!$B:$B,B2)”, with A2 being the origin and B2 being the destination. The equation scans through the PATHS .CSV output file and returns the number of times that the specified O-D pair is found together. The “Transfer” related columns calculate how many transfers occur in total across all counts. Calculating number of transfers requires a new column in the PATHS output with the equation “=LEN([@routes])-LEN(SUBSTITUTE([[@routes]],"|",""))”. Since Conveyal distinguishes when a transfer occurs using the “|” symbol, this equation counts the occurrences of that symbol within the “routes” column and returns a numerical value of the times that the symbol appeared. Then, in the O-D Difference Table, the Transfers column uses “=SUMIFS(Table7[Number of Transfers], Table7[origin],[@origin],Table7[destination],[@destination])” to search the PATHS file for the O-D combination and then sum together all values returned by the former equation (aggregating the transfers for all counts).
### Truncation Matrices

This matrix shows the difference of travel times in minutes between two scenarios; one where BxM4C is the full route and one where the route is truncated at stop 3069. The next page contains four other matrices comparing different truncation scenarios to the full route (truncation at 1941 [top-left], 2968 [top-right], 1942 [bottom-left], and 1943 [bottom-right]). These five matrices combined constitute a sensitivity analysis that allowed the Research Team to identify at which stop truncating the BxM4C will result in diminishing returns of travel time savings.

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Scoring and Comparing Routes

Link to Appendix
Aligning Service With Demand

Link to Appendix
Modeling Ridership

[Link to Appendix]
Appendix B: New Workflow Template

Workflow Title
Case Study Title

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Software Requirements

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Case Study Product

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Description
Flowchart
Workflow Narrative

Purpose

Problem/Need Identification
This workflow has X needs;
● Need 1:
● Need 2:

Key Questions
Considering the needs, X questions can be formulated;
● Question 1:
● Question 2:

Analysis Construction and Software Pairing
Analysis 1:

Analysis 2:

Analysis 3:

Analysis 4:

Outputs and Interpretation

Next Step