Market Analyses and Software Recommendations

NYSAMPO Shared Transit Service Planning and Analytics Initiative

December 2021

AVAIL transpogroup Sam Schwartz mca Marlene Connor Associates LLC

Table of Contents

List of Figures and Tables

Figures

Tables

Forward

This white paper was an early deliverable in the Shared-Use Transit Software project launched by the New York State Association of Metropolitan Planning Organizations (NYSAMPO). The intent of this document was to inform the Research Team on the transit software market landscape prior to the implementation of four pilot projects. Each of the four pilot projects provided lessons critical insights about both software functionality and lessons learned that supersede the information presented in this paper.

Introduction

Transit service is a key element of our transportation networks. In recent years, major technological disruptions and new data-driven solutions have expanded what public transportation is, how it can be accessed, and how far it can reach. These include the development of innovative on-demand services, shared mobility, and microtransit alternatives. Together with the continuing shifts in vehicle autonomation and electrification, they are dramatically changing urban transit and transportation networks. In parallel to these significant developments, the data and technology tools used to plan and analyze transit networks and travel activity have also seen significant innovation. More robust transit data and planning software now offers the potential to understand transit ridership and impacts in more detail, with more nuance, and in near-real-time – but first, public agencies must understand which tools are most relevant to their needs and priorities.

As part of the Shared Transit Service Planning and Analytics Initiative, sponsored by the New York State Association of Metropolitan Planning Organizations (NYSAMPO), a market assessment was conducted in Fall 2021 to better understand transit planning software usage at the metropolitan planning level, as well as the challenges agencies confront in procuring and/or using transit planning software packages. The assessment took two forms; a survey of practitioners and a review of available transit planning software.

The survey assessment targeted New York State's (NYS) Metropolitan Planning Organizations (MPOs) and Transit Authorities (TAs), with the following objectives in mind:

- Assessing the goals and objectives of each organization as it relates to their utilization of transit planning tools.
- Identifying and ranking the features of these tools that are most useful to the organizations.
- Understanding the technological challenges in transit planning technology, both in current projects and in future endeavors.

The Research Team developed and implemented a short survey focusing on the objectives described above. The survey was designed based on the team's understanding of the challenges that MPOs and TAs currently face and the types of data available to them. Further, a fundamental objective of the survey was to understand each MPO's immediate and long-term plans in software and data utilization, any upcoming projects where the tools may be applicable, or ongoing challenges that these tools could

help alleviate. Recognizing there isn't one tool that addresses all agencies' needs, all individual survey responses were analyzed to determine what software functionalities and features are most important.

For the software assessment, the Research Team reviewed both proprietary vendor software that meet feature needs and budgetary considerations, and a variety of available open-source modules that packaged together meet the following planning and ridership communication functions:

- Accessibility of transit services to jobs, population, medical/education institutions, and other services, including those deemed essential during the current pandemic by New York State
- Ridership demand forecasting and revenue projections
- Operational scenario planning:
    - Route, frequency, and transfer analysis
    - Stop consolidation
    - Detour impact analysis
- On-time performance analysis
- Park and ride and transit center/ mobility hub market analysis
- Last mile connection analysis
- Title VI analysis

In addition to these functionalities, the software packages were assessed by a number of other measures that may impact MPOs or TAs and organized into two primary categories: agency resource needs and software considerations. The Market Research Survey Questionnaire responses indicated that staff expertise and time constraints played a critical role in measuring the efficacy of implementing a new software within their organization. These agency needs were considered when referring to the technological environment necessary to operate a software and the difficulty of designing an analysis within it. Software was assessed by its data needs, user interface, complexity of analysis process, customizability, and support that was offered. Together these measures provided a metric for assessing the software landscape.

TBEST, STOPS, Conveyal, and the ESRI Network Analyst Tools were analyzed in-depth using these metrics. TBEST was shown to be an extraordinarily versatile planning tool with valuable outputs but required extensive data configuration prior to use. STOPS' functionality was shown to be limited, specializing in forecast modeling, though it excelled at it. Conveyal was excellent for isochronal mapping and had a web-based user interface, but its functionality and features were limited. The ESRI Network Analyst Tools appear valuable for planning and operations functionality, but the steep learning curve may be a deterrent to many users.

After analyzing the agency resource needs and software considerations, five potential outcomes of this research became evident. The following five potential outcomes are not mutually exclusive. They are useful considerations in reviewing transit planning software, and in making recommendations for a pilot program:

- A Community of Practice and Training Partnership – where NYSAMPO organizes a group that meets regularly for sharing analysis and practice.

- A Statewide Shared Open-Source Planning Software – where NYSDOT and/or NYSAMPO provides a shared planning software or combination of software.
- Transit and MPO Partnership(s) – where TAs and MPOs form individual or statewide partnerships to utilize shared proprietary software that meet both operations and planning needs.
- Share Configured Data Resources – where NYSDOT and NYSAMPO Provides Statewide Shared Data Input Resources in Appropriate Formats for Specific Tools
- Processed Software Outputs as Data Resources – where NYSDOT and/or NYSAMPO provides batch processed software outputs as statewide data resources

These outcomes are discussed in further detail in the *Outcome Analysis* section.

Finally, the Research Team synthesized the findings of the agency survey, the software analysis, and the potential outcomes to create a set of pilot implementation models:

- Model 1 – Shared Open-Source Software
  - Model 1a – Support for agencies with staff capacity
  - Model 1b – Design and interpret pilot study for agencies without capacity
- Model 2 - Proprietary Software
- Model 3 - Community of Practice Statewide Analysis

This set of pilot implementation models allows the Research Team to cater the design of the pilots to the specific needs of each participating agency or collection of agencies. The implementation models provide maximum flexibility wherein the design, implementation, and results of the pilot studies become input data for synthesizing a set of recommendations for the future statewide shared use program outlined in the RFP.

Market Assessment Summary

Survey Deployment

The survey was comprised of 25 questions, including multiple choice, ranked choice, and open-ended questions, focusing on the agencies' experience with transit planning tools and data, the challenges in utilizing them, the analyses and tasks currently undertaken by the agencies using the tools, and the objective that agencies are looking to address in the future. Also included were basic questions about the responsibilities of the individual employee responding the survey, and agency's roles related to transit services (supporting, planning, operations, etc.). A copy of the survey is included in Appendix A.

Hosted online and open for responses between September 27, 2021 and October 20, 2021, the survey was distributed through email messages to specific planning staff members of each MPO and selected TAs in New York State. Responses were received from 21 agencies including 12 MPOs, 8 TAs, and the NYS Department of Transportation (NYSDOT) Modal Grant Bureau. As part of this analysis, the MPOs were further grouped into 3 categories based on their population size. Figure 1 and Table 1 provide an overview of the participating MPOs and TAs by category[1]. NYSDOT Modal Grant Bureau was excluded from subsequent survey results due to its distinct functions and software needs.

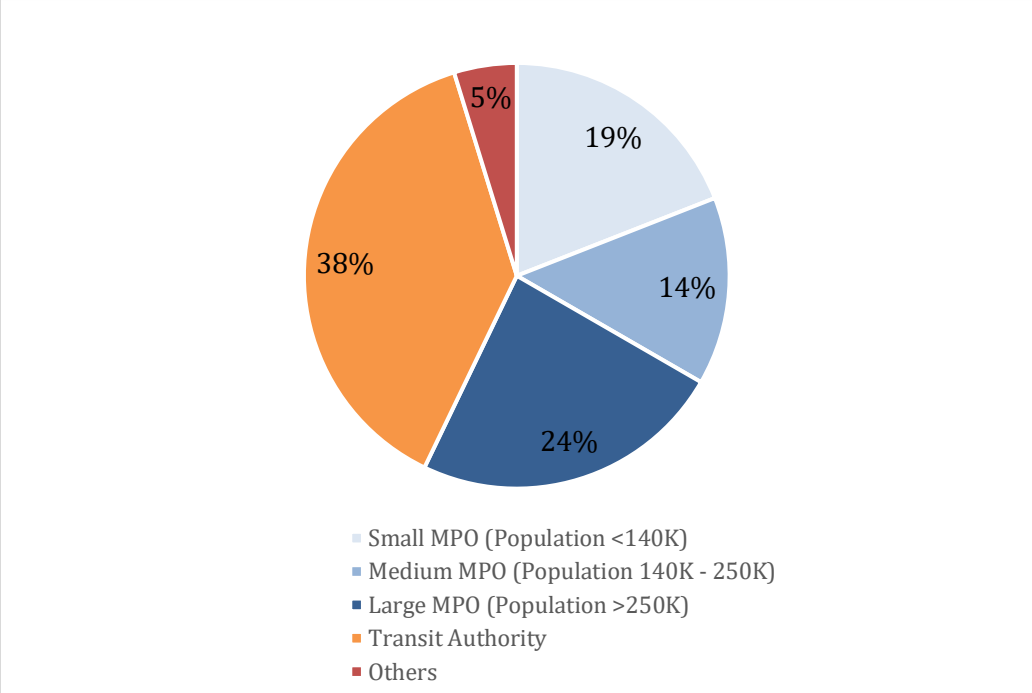


Figure 1. Survey Participants, by Agency Type and MPO Population Category

1 Note that the MPO encompassing the New York City region – New York Metropolitan Transportation Council (NYMTC) - was categorized as a Large MPO. Despite the unique characteristics of the region it serves, its responses were indistinct compared to the other MPOs in New York State.

Table 1. List of MPO and Agency Survey Respondents

Small MPO (population <140K)
Watertown-Jefferson County Area Transportation Council (WJCTC)
Ithaca Tompkins County Transportation Council (ITCTC)
Herkimer-Oneida Counties Transportation Council (HOCTC)
Elmira-Chemung Transportation Council (ECTC)
Medium MPO (population 140K - 250K)
Binghamton Metropolitan Transportation Study (BMTS)
Adirondack / Glens Falls Transportation Council (A/GFTC)
Ulster County Transportation Council (UCTC)
Large MPO (population >250K)
Greater Buffalo Niagara Regional Transportation Council (GBNRTC)
Capital District Transportation Committee (CDTC)
Syracuse Metropolitan Transportation Council (SMTC)
Duchess County Transportation Council (DCTC)
New York Metropolitan Transportation Council (NYMTC)
Transit Authorities
Central New York Regional Transit Authority (CENTRO)
Rochester Genesee Regional Transportation Authority (RTS)
Capital District Transportation Authority (CDTA)
Nassau Inter-County Express (NICE)
Greater Glens Falls Transit (GGFT)
Broome County Transit
County of Orange/Transit Orange
Westchester County Dept. of Planning
Other (excluded from subsequent survey results)
NYSDOT/Modal Grants Bureau

Survey Results

The following section provides an overview of the main survey results and findings. The findings are presented separately for MPOs and TAs due to their distinct relationship with transit planning software. While TAs use software to plan, operate and monitor transit services, most MPOs are focused on software for long range transportation planning and transit planning support.

Current Software Uses

Several survey questions focused on the objectives and tasks that agencies currently undertake or have interest in undertaking. In one of the questions, participants were provided with a list of 25 transit related activities and asked to rank the importance of each activity for the agency.

MPOs

TransCAD is the most utilized transit planning software among MPOs as 8 of 11 MPOs indicated they have used it, either in-house or through a third party/consultant. It is important to note that most MPOs use TransCAD for travel demand forecasting and general transportation planning, not only for transit planning purposes. GTFS Editor and STOPS are the second most utilized software among respondents with 3 and 2 MPO users, respectively.

The highest priority transit-related software tasks ranked by 9 MPOs as either critically or very important are transit accessibility analysis, travel time analysis, equity analysis, and current ridership analysis. Figure 2 shows the top ranked tasks and the share of MPOs that ranked these as highly important, by MPO size.

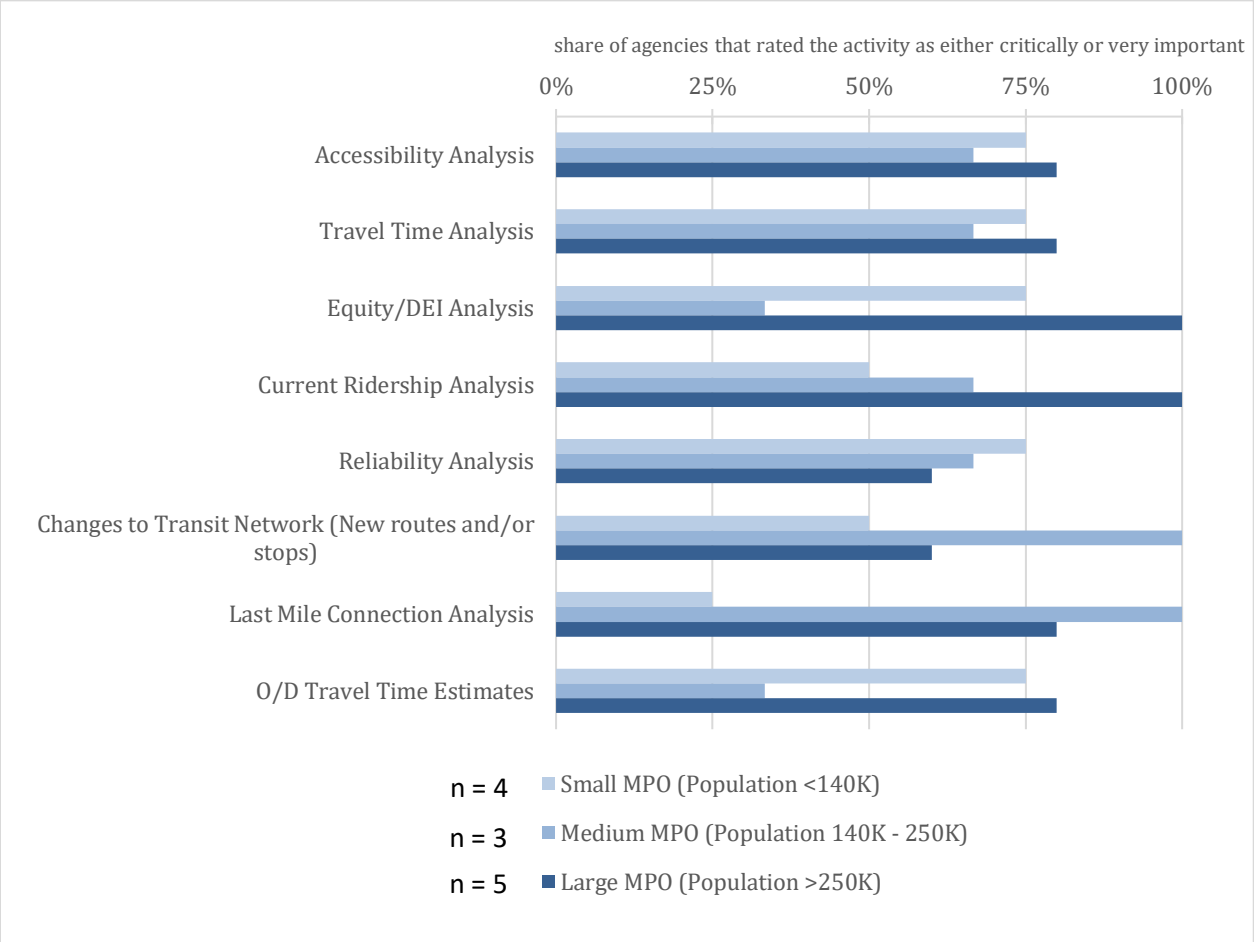


Figure 2. High Importance Tasks Currently Undertaken by MPOs, by MPO Population Category

Transit Authorities

Trapeze, GTFS Editor, and TransCAD are the most popular planning software among TAs as 6 out of 8 participants indicated their agency has used these tools.

The top tasks, which were ranked as either critically or very important by more than 6 TAs, are changes to transit schedules, ridership analysis, transit demand analysis, customer satisfaction analysis, on-time performance, last-mile connection analysis, real-time fleet management, and runcutting (driver and vehicle assignments). The overview of TAs ranked these tasks as either critically or highly important are shown in Figure 3.

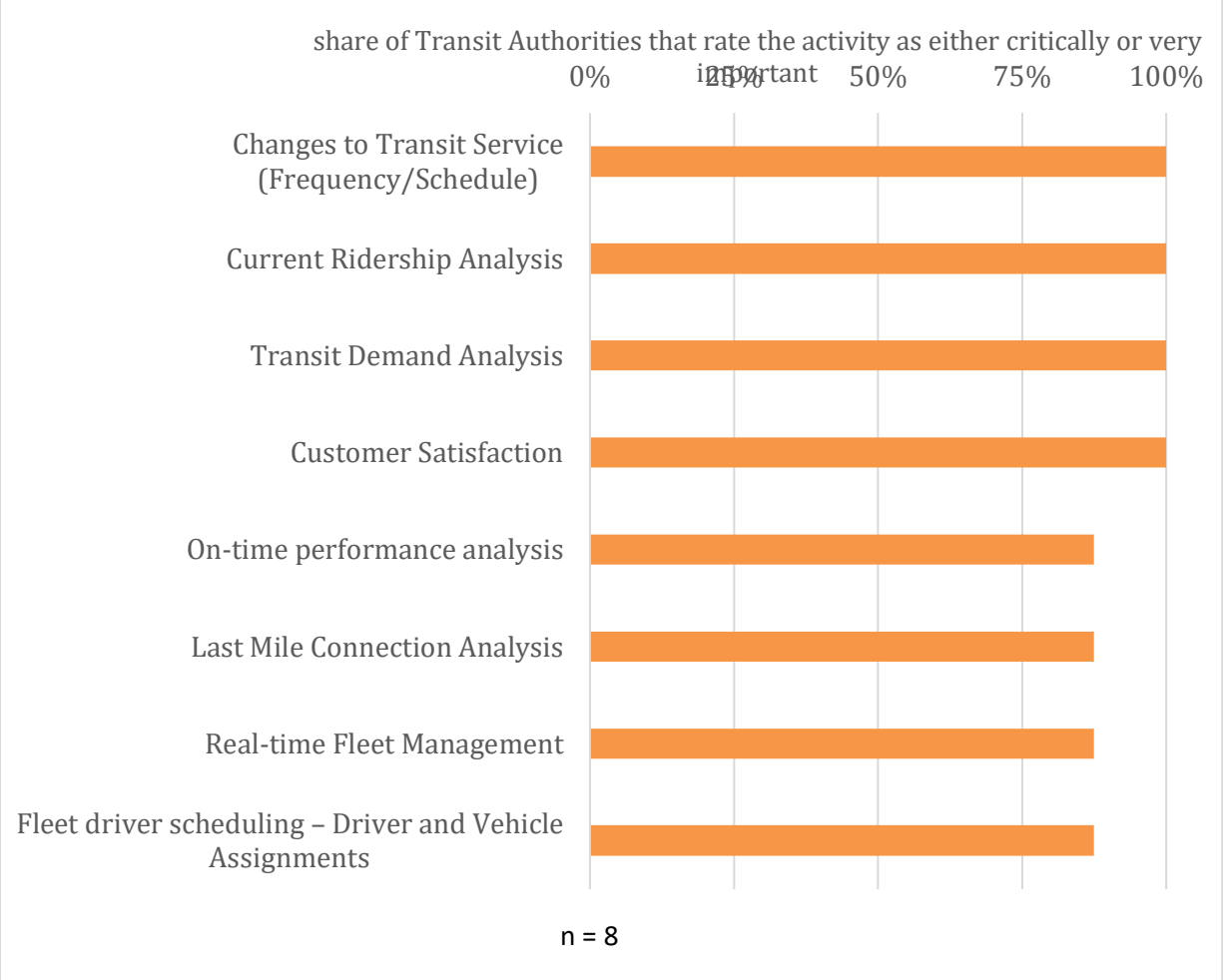


Figure 3. High Importance Tasks Currently Undertaken by Transit Authorities

Future Objectives

Many of the survey questions looked at transit related objectives that agencies are expecting, or have interest to study in coming years. Participants were provided with a series of 18 potential objectives and asked to rank the importance for their agency.

MPOs

The top-ranked objectives for which MPOs would use transit planning tools and software packages in the next 5 years are increasing transit readership, better serving disadvantaged communities and 'choice riders', and improving access to employment. All 12 MPOs ranked these as either critically or very important. Additional highly ranked objectives included reducing journey times for transit riders, improving access to social services, and improving sustainability (11 MPOs in total). The top activities selected by MPOs are shown in Figure 4.

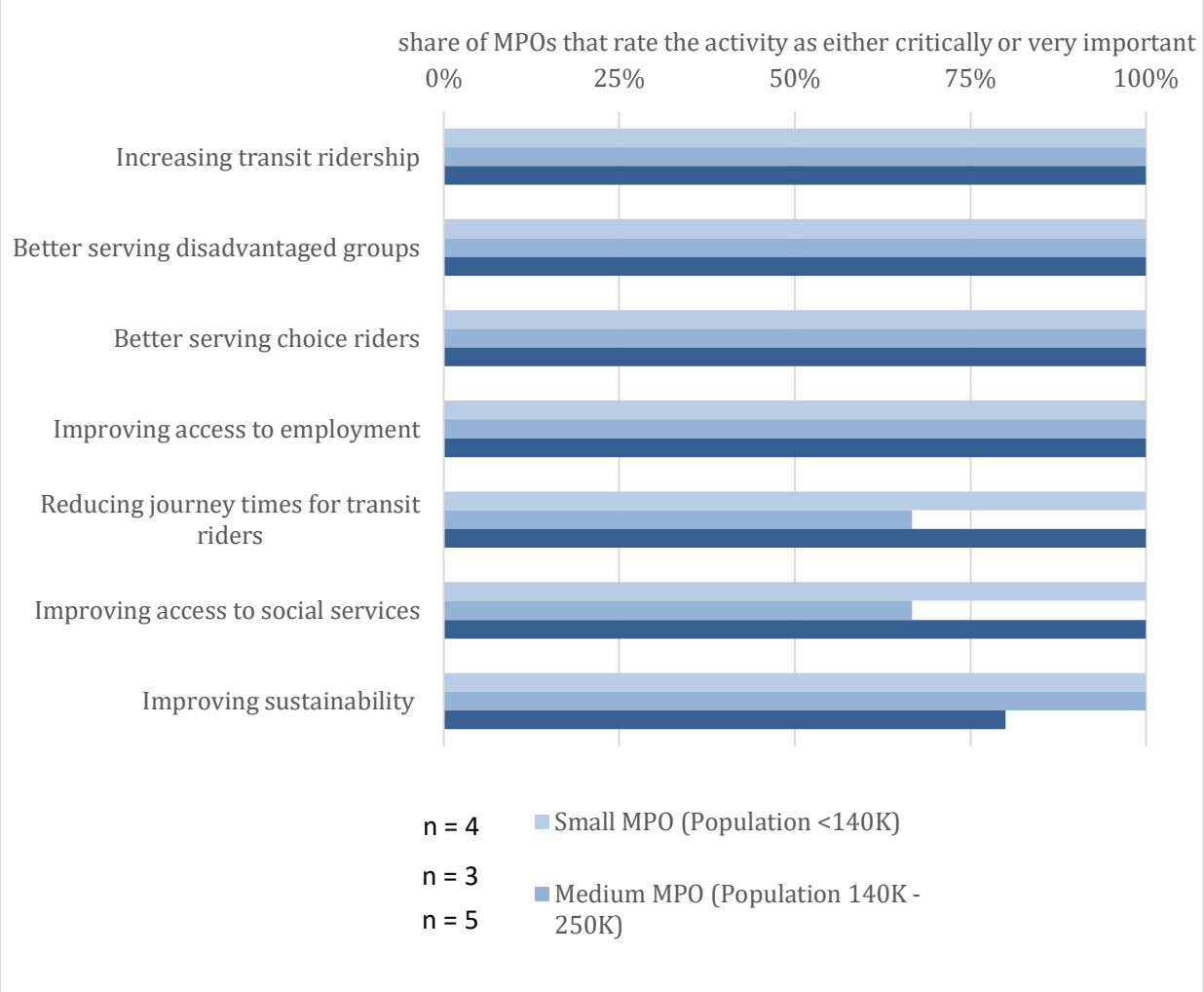


Figure 4. Transit Related Objectives Ranked as Highly Important by MPOs to Undertake in the 5 Next Years

Transit Authorities

For TAs, the most important objective to undertake in the next 5 years is improving service for disadvantage communities - it was selected by all 8 TAs as either critically or very important. Several other tasks were ranked highly by the majority of TAs, as shown in Figure 5.

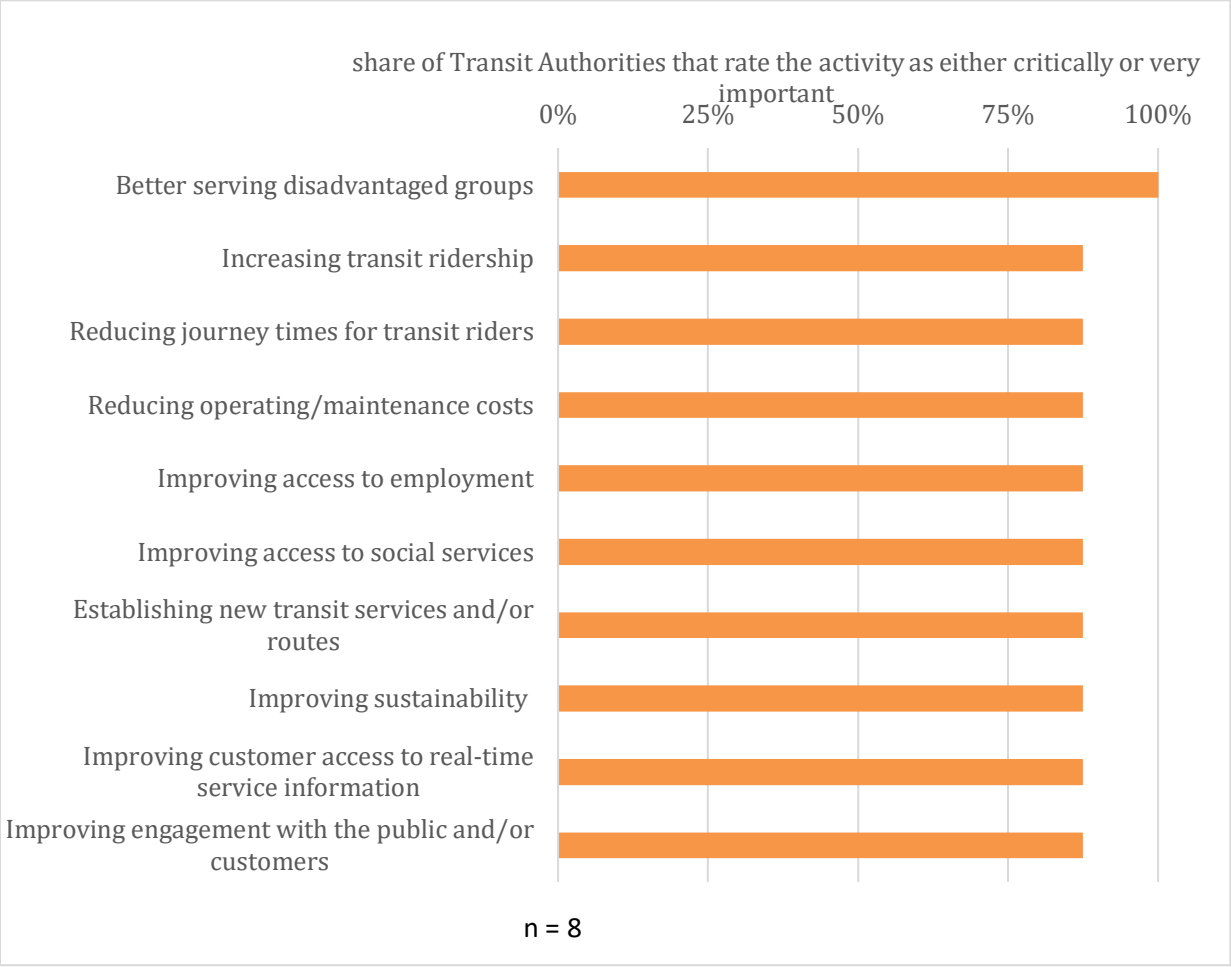


Figure 5. Transit Related Objectives Ranked as Highly Important by Transit Authorities to Undertake in the Next 5 Years

Software Challenges

To understand the challenges various agencies face while using transit planning tools, the survey included several questions focusing on the limitations and constraints keeping agencies from undertaking tasks or achieving their objectives. Table 2 lists the challenges indicated by agencies related to the tools used in current tasks and tools that might be utilized in future ones. In this section, the responses of MPO and TAs were not distinct thus the table below show the constraints of both groups combined.

The most noticeable difficulties related to software are personnel and resource constraints. That is, many of the agencies do not have the bandwidth to operate more advanced planning tools and/or the

financial resources to precure the software or service. Additionally, several agencies indicated they face difficulties in making the data generated more useful and meaningful.

Table 2. Constraints and Limitations MPOs and TAs Encounter Using Transit Planning Software

Note: some agencies indicated more than one constraint

	Number of Agencies	
Challenge	**Current Tasks/Objectives**	**Future Tasks/Objectives**
Lack of qualified staff to operate the software	5	8
Funding resource constraints	3	3
Challenge making the data suitable for the agency's purposes	6	3
Inability to collaborate with other agencies	1	1
Lack of agency demand to use software		1

Desired Software Functionality

To better understand the potential uses of transit planning software by the agencies, participants were asked to rank several features by their importance to their agency, and to list any functionalities that the agency seeks in transit planning software packages.

MPOs

Almost all MPO survey participants (11 out of 12) view software integration with the agency's existing GIS software and data as critically or very important. Software's technical support and user-friendliness were also highly ranked among MPOs participants. Figure 6 shows all software attributes presented by the survey, and the number of MPO participants who ranked them as either critically or very important.

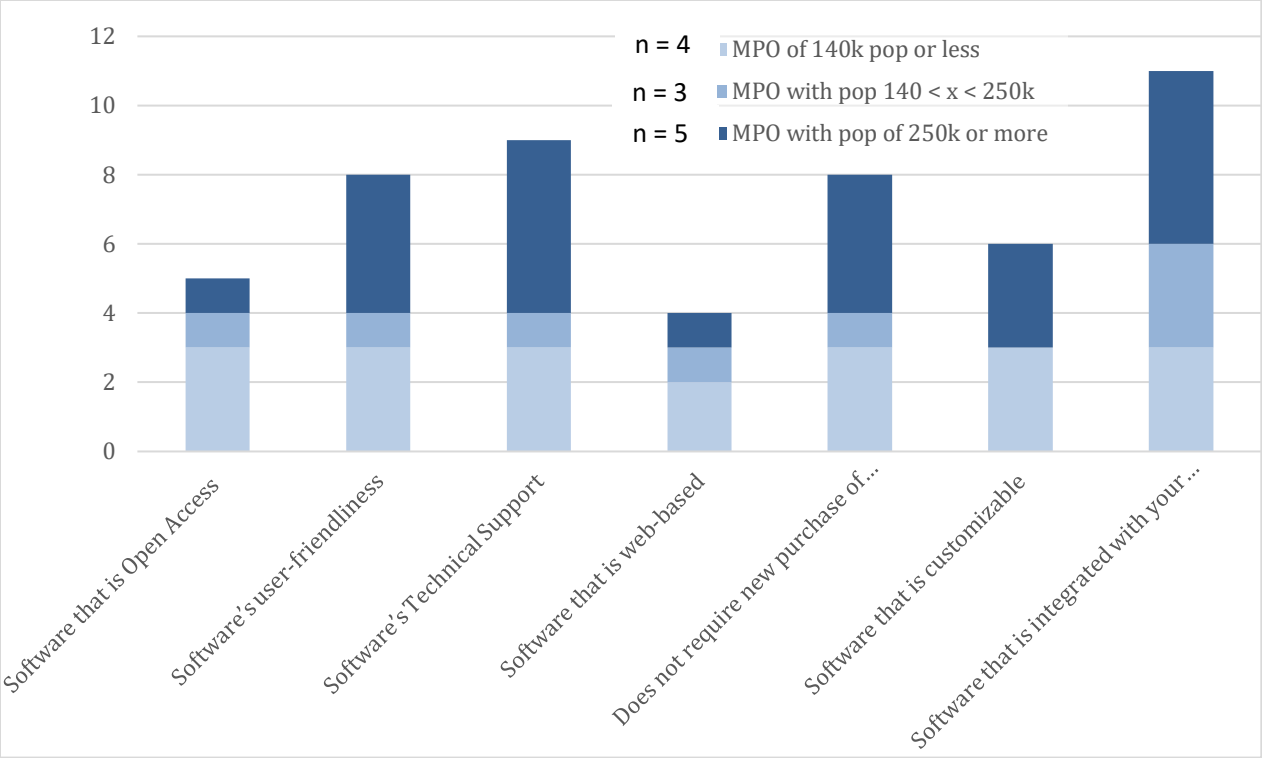


Figure 6. Software Attributes and the Number of MPOs that Ranked them as Either Critically or Very Important

Transit Authorities

All 8 TAs on the survey ranked software's user-friendliness and technical support as either critically or very important. Software customization was ranked as highly important by 7 of the agencies. Figure 7 depicts all software attributes presented by the survey, and the number of transit agency participants who ranked them as either critically or very important. Additionally, some of the TAs described specific software functionalities of their planning software (in an open-ended question[2]). These are:

- User friendly and simplicity
- Ability to migrate data between different systems with zero or minimal need for an external (contracted) support.
- Reduction of duplicative work
- Provision of a single software with broad functionality rather than piecing together numerous packages
- Public-facing visualization capabilities

2 MPO participants did not provided responses to this question.

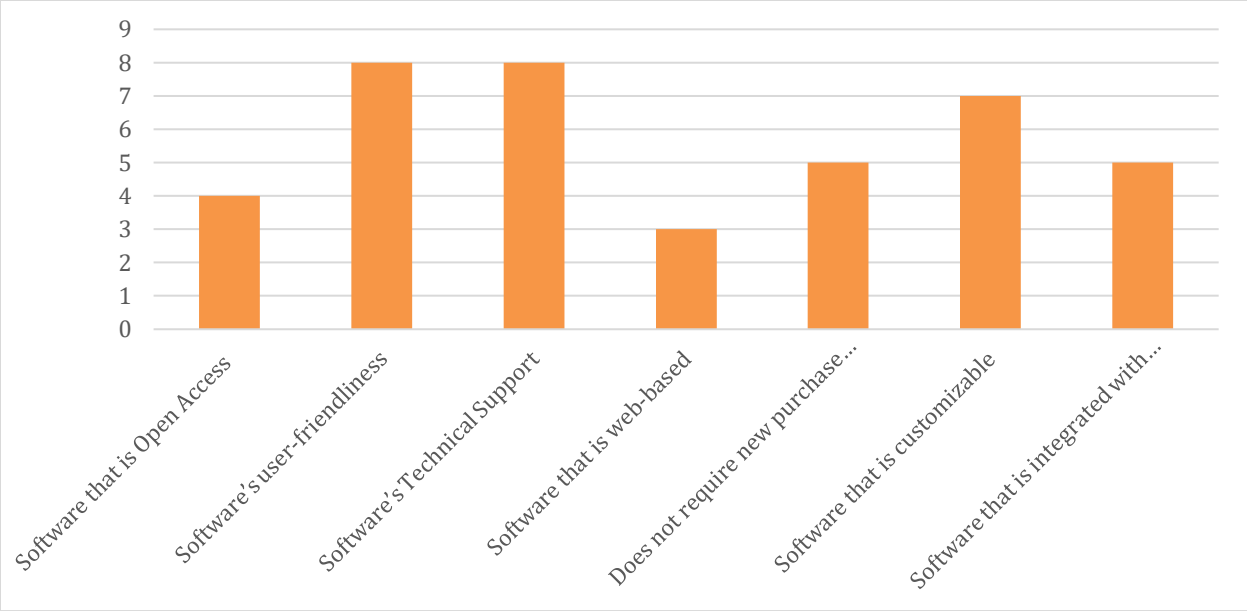


Figure 7. Software Attributes and the Number of Transit Authorities that Ranked them as Either Critically or Very Important

Desired Project Use

To align with agencies future objectives, participants described a project they would like to undertake, for which a transit software package is necessary, but the resources to operate or precure it are unavailable. Due to their distinct roles related to transit services, MPOs and TAs have different objectives. Listed below are the projects indicated by the survey participants.

MPOs

- O/D studies
- Passenger miles traveled analysis
- Ridership forecasting
- Analyzing transit projects using VISUM
- Access to employment analysis (transit vs. car)
- Equity analyses of transit service changes

Transit Authorities

- Bus routes review and optimization
- Headway management
- Travel demand analysis
- Real-time info of bus location for customers
- Customer service Chatbot

Key Takeaway

Based on the findings described in Section 2, listed below are the survey findings that may support the study. First, as noted above, the transit-related roles of MPOs and TAs are quite distinct. While MPO's typically support transit planning in funding administration and regional data analysis, TAs are focused on planning, operating, and monitoring their provided services. Therefore, the needs and challenges of MPO's and TAs are different in most cases.

MPOs Takeaways

Overall, MPOs have a large number of planning functions they are trying to accomplish using software. However, constrained resources will make software procurement and training more difficult.

It would be best to have a single software package that could do lots of different things and house all the data in one place. Additionally, software as a service (SaaS) is essential, as it will result in critical updates that allow the MPO to react to new service delivery models.
While many MPOs have experience with TransCAD, which does offer a suite of analysis tools, it is unclear whether this will meet the MPOs' future needs due to software evolution.
The most essential transit related tasks for which MPOs use or would like to use planning software are transit accessibility analysis, travel time analysis, equity analysis, and current ridership analysis. When asked about their transit related objectives in the next 5 years, all MPO participants highly ranked increasing transit readership, better serving disadvantage communities and 'choice riders', and improving access to employment.
Further, if new software packages would become available, MPOs would be looking to embark on the following tasks:

- O/D studies
- Passenger miles traveled analysis
- Ridership forecasting
- Analyzing transit projects using VISUM
- Access to employment analysis (transit vs. car)

The top challenges related to transit planning software, which both MPOs and TAs face are constrained funding resources, lack qualified staff to operate the software, and the inability to make the data suitable for their agency's purposes.
Almost all MPO survey participants (11 out of 12) view software integration with the agency's existing GIS software and data as critically or very important. Software's technical support and user-friendliness were also highly ranked among MPOs participants.

TAs Takeaways

TAs are collecting a lot of service data (e.g., boarding/alighting data, vehicle crowding, travel times), but it is difficult to manage these datasets and merge them with planning software in a way that can support critical decision-making on service changes.

Like MPOs, TA software needs to incorporate forward-thinking service delivery ideas. For example, while most transit professionals can analyze the performance of a bus line using low-tech software, fewer have the tools to project on-demand transit ridership or usage of contactless payment media, which require more complex analysis. Software as a service with regular updates is critical to meet this need.

The most essential tasks for which TAs use or would like to use transit planning tools are changes to transit schedules, ridership analysis, transit demand analysis, customer satisfaction analysis, on-time performance, last-mile connection analysis, real-time fleet management, and runcutting (driver and vehicle assignments).

As to future objectives, surveyed TAs indicated that improving service for disadvantaged communities is either critically or very important to undertake in the next 5 years. If new software packages would become available for them, TAs indicated several operational and customer service tasks as potential uses, including bus routes review and optimization, headway management, travel demand analysis, real-time info of bus location for customers, and customer service Chatbot.

Software Market Analysis

Introduction

The following section outlines the process undertaken by the Research Team in reviewing and assessing software for transit planning. The Research Team first compiled an exhaustive list of software and appended that list with descriptive attributes such as open-source or proprietary, whether the software had a planning focus or an operations focus, and which transit related tasks the software can assist practitioners in completing. The Research Team then assessed the objective qualities of each software, such as technology prerequisites and data resource needs. Finally, the Research Team assessed the more subjective qualities of the software, such as software design, resource, staff, and time requirements, and flexibility and useability of the software. To do this, the Research Team utilized the software, when available, in replicating known case studies, or reviewed the software product literature and available case study reports, for those software which were unavailable. This qualitative assessment of software was conducted according to a rubric of considerations organized into two primary categories: *agency resource needs* and *software considerations*.

Varieties of Transit Software

The transit software reviewed for this paper can be organized into two primary buckets: open-source and proprietary. Open-source is released under a license which allows users the rights to use, change, and distribute the software and its source code to anyone and for any purpose. This approach offers great flexibility, growth potential, and cost savings. The disadvantages of open source, however, should be carefully considered as well. The software can often frustrate users due to the lack of resources available for specific user-interface improvements.

Proprietary vendor software has some competing advantages. It can often be more ready for immediate implementation when compared with open-source. Such software products usually have a wide and engaged user-base which means that the software has been tested in a variety of use-cases against a variety of user workflows. The large customer demand for consistent up-time means bugs are usually repaired quickly. Such products are often difficult to customize, however, especially for small and mid-size customers.

Transit Software can also be organized into two domain categories based on functionality and intended user; operations and planning.

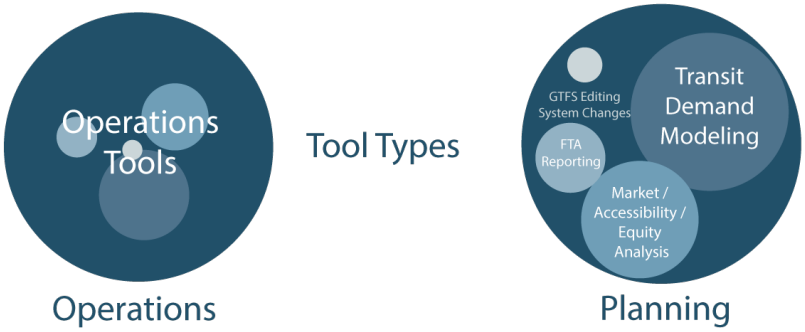


Figure 8. Tool Types

Operations-oriented software focuses on organizing and expediting the day-to-day functions of a transportation operation. Some example functions of operations-oriented software includes real-time rider communication, real-time fleet management, fleet driver scheduling, incident management, on-time performance analysis, and cost assessments. TAs are likely to find more utility in the operation-oriented software as their functionality aligns with organizational responsibilities.

Planning-oriented software are designed for long-range projections and planning of transportation systems. These tend to be software originally designed as operations-oriented and have added planning in recent development.

Some common functions of planning-oriented software include transit demand modeling and GTFS editing. Metropolitan Planning Organizations (MPOs) responsible for long term regional transportation planning and analyses will find more utility with planning-oriented software.

Though operations-oriented and planning-oriented software are designed for TAs and MPOs respectively, it is critical to note that this is a generalization. Some software, typically proprietary ones, combine elements of operations and planning functions that work synergistically to provide more detailed and actionable information.

Figure 9. Software Offering Both Operations and Planning

Software Outputs

The Research Team compiled a list of software outputs based on literature review and product testing to determine which software offered which features. This list of software outputs was also presented to the participating agencies in the survey where respondents assessed importance of the various outputs:

- Changes to Transit Network (New routes and/or stops)
- Changes to Transit Network (Consolidate stops and/or services)
- Changes to Transit Service (Frequency/Schedule)
- Changes to Transit Service (Cost/Payment Structure)
- Title VI Reporting
- Accessibility Analysis
- Equity/DEI Analysis
- Land use Market Analysis
- O/D Travel Time Estimates
- Reliability Analysis
- Travel Time Analysis
- Transfer Analysis
- On-time performance analysis
- Detour Analysis
- Last Mile Connection Analysis
- Natural Disaster/Emergency Evacuation Analysis
- Current Ridership Analysis
- Modeled Ridership Analysis
- Transit Demand Analysis
- Park and ride and transit center/ mobility hub market analysis
- Customer Satisfaction
- Real-time Rider Communication
- Real-time Fleet Management
- Fleet driver scheduling – Driver and Vehicle Assignments
- Incident Management

Different software require different dependencies and provide a range of outputs from the data. The Research Team found four categorizations of software based on input/output metrics:

Table 3. Resource Requirements and Outputs

Few Resource Requirements to Few Outputs	Does not require many resources from users and require less, if any, data configuration. They provide few outputs, but the outputs generated are typically specialized and data rich.
Many Resource Requirements to Few Outputs  Many Resource Requirements to Few Outputs	Requires significant quantities of data sources and subsequently may require substantial data configuration. They provide few outputs, but the outputs generated are typically specialized and data rich.

Many Resource Requirements to Many Outputs  Many Resource Requirements to Many Outputs	Require significant quantities of data sources and subsequently may require substantial data configuration. They are capable of providing many complex outputs of different varieties.
Few Resource Requirements to Many Outputs  Few Resource Requirements to Many Outputs	Does not require many resources from users and require less, if any, data configuration. Often these software require a subscription to a third party that manages the resource inputs. They are capable of providing many complex outputs of different varieties.

For a complete matrix of transit planning outputs by software see Appendix C.

Data Resources Management

Transit software are vastly different in how they use data resources, but they often require the same underlying data components to function. All transit software utilize some combination of transportation, demographics, workforce, and/or land use data sources. In some respects, transit software can be considered a graphical user interface "skin" that utilizes a defined set of data resources.

Figure 11. Required Resource Types

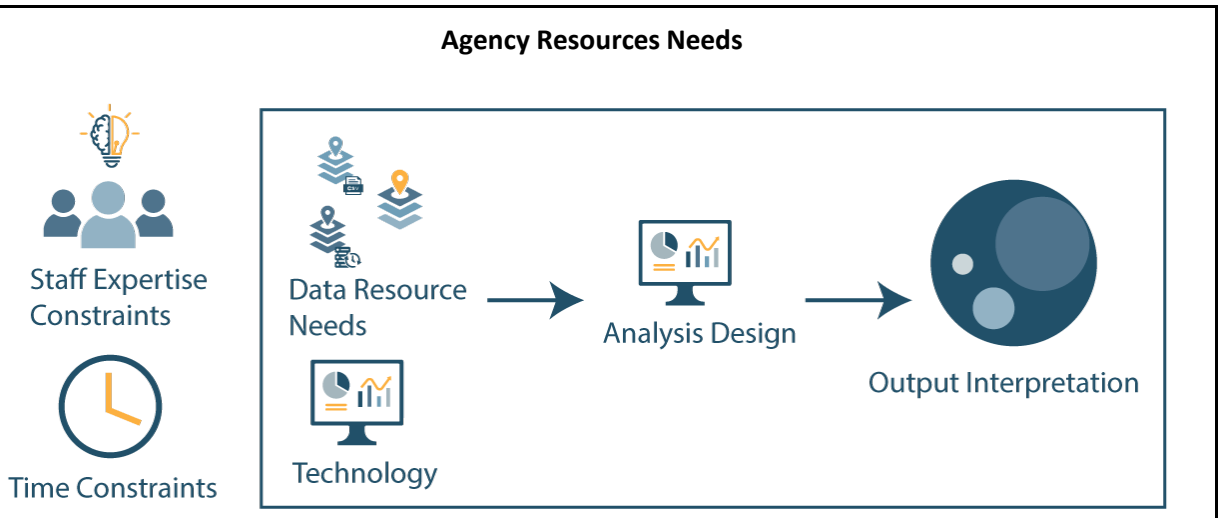
The specific data resources required vary based on the particular needs of a software, particularly between operations- and planning-oriented software. The level of data configuration required by the software varies greatly and many times, just having the data is insufficient. Most of the software have been designed to use Census data without configuration as that data is universally formatted and available. Some data sources may require a substantial overhaul to rearrange the fields into a format that programs can recognize. The process of formatting data is technical, requires a functional understanding of data manipulation techniques, and should not be underestimated.

Data configuration requires staff knowledgeable in large quantity data manipulation or database management. Software installation can be completed within minutes but configuring data as a software-specific input may take weeks depending on a user's skillset. There is a moderate to high risk of erring during the data configuration process in a way that could subtly impact output results. There is an undeniable benefit to employing a third-party expert (consultant, proprietary software provider, etc.) to configure data to ensure accuracy and to rely on for data management.

Qualitative Assessment

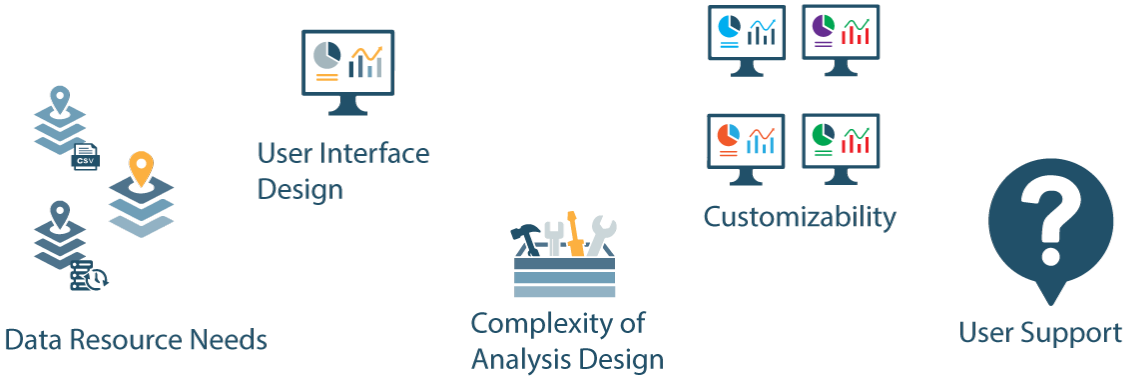
The list of transit software identified at the beginning of the assessment was extensive (see Table 4 on page 26), requiring the Research Team to eliminate many to provide more detailed analyses of the remainder. Using the responses from the Market Research Survey Questionnaire indicating which software had been used, as well as the availability of the software to be procured and trialed, seven (7) were selected for a deeper analysis. This further analysis utilized the two primary components for assessment: agency resource needs and software considerations.

For the purposes of this document, Agency Resource Needs will refer to the resource, staff, and time requirements of the agency in operating a software. Software Considerations will refer to the qualities of the software itself. The chart below outlines each of the considerations within these categories and a brief description:



Time Constraints	Quantities of time required to set up/configure software and to run processes/analyses.
Staff Expertise Constraints	The limitations that an agency has regarding their staff availability and capability to learn, set up, and/or operate software.
Data Resource Needs	The expertise and time requirements of an agency in gathering and configuring the data resource inputs.
Technology Environment	The technological hardware and software that an agency is required to utilize in order to run a given software, as well as time and expertise required to set up the software.
Analysis Design	The process of developing and configuring an analysis to generate a desired type of output.
Results Interpretation	The effort behind interpreting the software outputs to determine accuracy, viability, and an understanding of the results.

Software Considerations



Data Resources Needs	The quantity, complexity, and variety of data resource inputs the software requires to generate outputs. This may also include optional data components a software would use to enable additional features.
User Interface Navigation	The software's graphical user interface (UI), its complexity, and how intuitive that UI is to navigate effectively.
Complexity of Analysis Process	The level of effort required to perform a designed analysis within the tools (i.e., how many settings must be adjusted/buttons pressed to run an analysis).
Customizability	The degree of which users (or power users) could tweak/edit/configure a software to run additional analysis or processes that the software was not originally designed for.
Support	The amount of third-party support available specific to the software. This may include one-on-one meetings, tutorials/training offered, and software documentation.

Software Utilization by Agencies

TAs and MPOs do not have a uniform practice across NYS. Some agencies do not utilize transportation software beyond limited outputs while others have invested more time and energy into using software to their full potential. Table 2 outlines the results from the survey sent to MPOs and TAs that outline which software respondents were familiar with and/or had previous experience with:

Key:

x - Never Heard of It

0 - Have Heard of or Looked into But Never Used

1 - Consultants Have Used (highlighted light blue for ease of reference)

2 - Have Used (highlighted darker blue for ease of reference)

Table 4. Organizational Software Experience

Agency	STOPS	TBEST	Remix	Trapeze	HASTUS	OptiBus	GTFS Editor	BetterBusBuffers (ESRI TOOL)	Transit Network Analysis Tools (ESRI	TNExT	TransCAD
Central New York Regional Transit Authority - CENTRO	x	2	0	2	0	x	x	0	0	0	x
Regional Transit Service / Rochester Genesee Regional Transportation Authority	0	0	2	2	0	x	0	0	0	0	0
Westchester County Dept.of Planning	x	x	0	1	0	x	0	0	0	x	0
Nassau Inter-County Express NICE	0	0	2	1	1	2	1	0	2	x	x
Greater Glens Falls Transit	x	x	x	0	x	0	2	0	0	0	0
Capital District Transportation Authority	x	x	2	2	2	0	1	x	x	x	x

Agency	STOPS	TBEST	Remix	Trapeze	HASTUS	OptiBus	GTFS Editor	BetterBusBuffers (ESRI TOOL)	Transit Network Analysis Tools (ESRI	TNExT	TransCAD
Binghamton Metropolitan Transportation Study	x	x	x	x	x	x	0	x	0	x	0
Chemung County/ECTC	x	x	0	0	x	0	0	x	x	x	x
Broome County Transit	x	x	0	2	0	0	2	0	0	x	0
NYSDOT/Modal Grants Bureau	0	0	0	0	x	x	0	0	0	x	0
Greater Buffalo Niagara Regional Transportation Council	1	0	0	0	x	x	2	0	0	x	2
WJCTC	x	x	x	x	x	x	x	x	x	x	x
Ithaca Tompkins County Transportation Council (ITCTC)	x	x	0	0	x	x	x	x	0	x	2
Capital District Transportation Committee (CDTC)	x	0	0	x	0	x	x	x	0	x	2
Syracuse Metropolitan Transportation Council	1	0	0	0	x	x	0	2	0	x	2
Herkimer-Oneida Counties Transportation Council	0	0	0	0	0	0	0	0	0	0	0
County of Orange/Transit Orange	x	x	x	0	x	x	0	x	x	x	0
Dutchess County Transportation Council (DCTC)	x	x	0	0	x	x	0	x	x	x	2
Adirondack / Glens Falls Transportation Council	x	x	x	0	x	x	0	x	0	x	2
UCTC	x	x	0	2	x	x	2	x	0	x	2
Total	**2**	**2**	**6**	**12**	**3**	**2**	**10**	**2**	**2**	**0**	**14**

Potential Research Outcomes

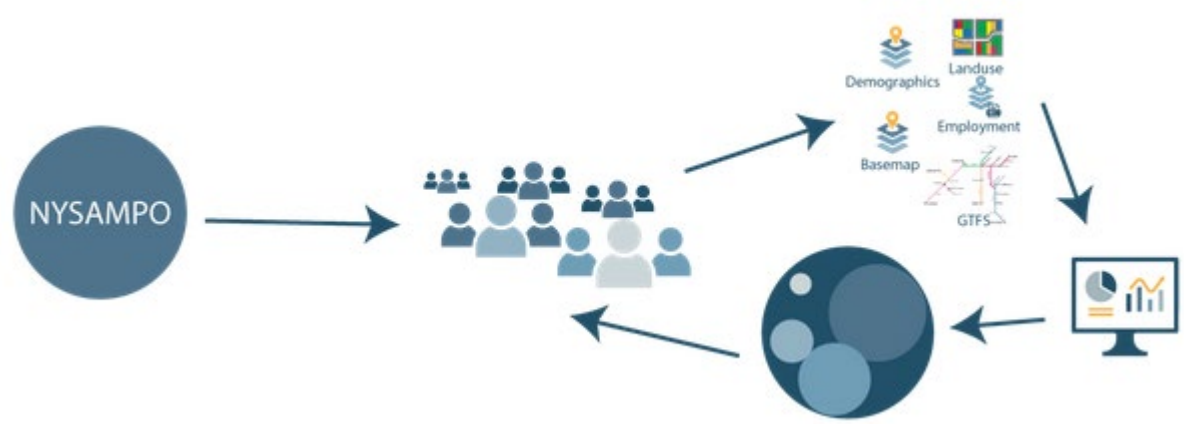
The Research Team identified five (5) potential project outcomes based on the dimensions outlined in the *Software and Agency Considerations* section of this report. These potential outcomes are useful considerations in recommending transit planning software for a pilot program. The forthcoming pilot program will provide a testbed for the recommended software through which the Research Team will assess their compatibility with a proposed future statewide shared use program. The proposed future shared use program is one in which a statewide partnership of MPOs organizes around a common program of transit planning analysis. The program could take a variety of shapes, the basic building blocks of which are described in the five potential outcomes. It is important to note that these outcomes are not mutually exclusive. There is a strong potential for this project to produce multiple and hybrid outcomes.

At this stage of the analysis, monetary costs have not been directly assessed due to the level of detail required, including the financial investment in software licenses (if proprietary), software support, data configuration by a third party (e.g., research partner/consultant). Each outcome would benefit from dedicating a full-time staff member to assist in organizing the effort, analysis interpretation, data processing, and troubleshooting. A thorough explanation of the five potential outcomes can be found on the follows.

Outcome 1

Community of Practice and Training Partnership

Where NYSAMPO Organizes a Group that Meets Regularly for Sharing Analysis and Practice.



This outcome is a natural evolution of the collaborative process and is a valuable outcome likely to occur regardless of other outcomes. Interested parties will establish a community that shares resources to strengthen each other's knowledge and expertise. That community may also select a single software by making a shared purchase of a proprietary software or by contracting a shared consultant to either run a single software, gather and configure the necessary data resources needed for various software, or provide the partners with a collection of data outputs from a variety of software.

Outcome 1: Agency Resources Needs

- **Time Constraints:** Establishing a community of practice would require a time commitment by the organizing agency for agenda creation, outreach, and moderation of meetings. Each participating organization would need to spend time gathering lessons learned to articulate to the community during meetings. The NYSAMPO Transit Working Group is an existing potential venue for this COP. It is currently being organized by a consultant who can create agendas and follow up with presenters. The NYSAMPO Modeling Working Group provides a model for how to organize a COP around shared analysis needs and available software.
- **Staff Expertise Constraints:** In an optimal community of practice and training partnership, there is a dedicated staff member experienced in group facilitation and staff at all partnering agencies prepared to discuss their specific case studies.
- **Technology Environment:** The required technological environment for a community of practice is minimal, needing only a functioning computer with an internet connection or a phone to call into regular meetings.
- **Analysis Design:** A COP provides a venue for reviewing analysis design, providing feedback and insight on them, and assisting each other in designing analyses with increasing efficacy and cross agency impact.

- **Results Interpretation:** A COP provides a venue for reviewing software outputs and providing feedback and insight. By sharing results and collective interpretation, the COP develops a shared language and methodology across agencies.

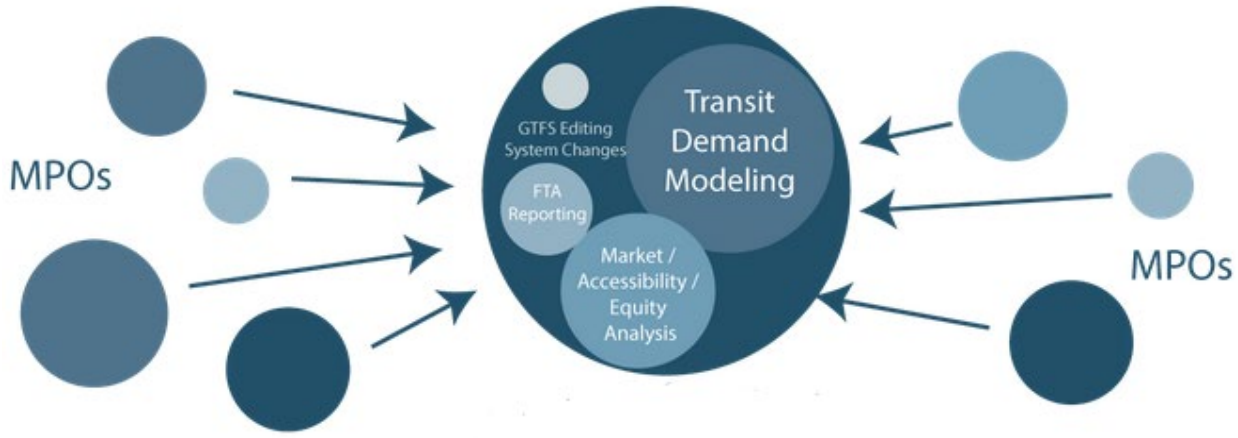
Outcome 1: Software Considerations

- **Data Resources Needs:** The stakeholders would be responsible for gathering and configuring all data resources required to run their desired software(s), including organizationally specific data sources to strengthen results (i.e., observed ridership counts, GTFS, etc.). There would be an opportunity to provide each other with configured data to limit redundant work across organizations and to assist each other in in understanding best and worst practices.
- **User Interface Navigation:** The ease of user interface navigation would be entirely dependent upon the software platform that each organization uses. The community of practice would create a venue for stakeholders to share their user experiences with others to reduce the friction of learning new software.
- **Complexity of Analysis Process:** The COP provides an opportunity for stakeholders to share their analysis process about software(s) that they use.
- **Customizability:** The COP provides an opportunity for stakeholders to share modules, scripts, or other custom software tweaks with each other.
- **Support:** The COP provides a venue for users to clarify and share their support questions and responses, amplifying the value of whatever support they are receiving.

Outcome 2

Statewide Open-Source Planning Software

Where NYSDOT and/or NYSAMPO Provides a Shared Planning Software or Combination of Software



In this project outcome, a single or collection of open-source software is made available through NYSDOT, or NYSAMPO, that all MPOs can utilize. All the MPOs utilizing the same software for analyses would create more uniformity between analyses and potentially reduce costs through shared purchase of consultant support. This is also a gravitational mechanism for creating and maintaining a Community of Practice (COP).

Outcome 2: Agency Resources Needs

- **Time Constraints:** Time requirements for data configuration and software setup vary by software. Developing a community of practice (Outcome 1) could dramatically reduce time constraints as users could share their successes and challenges with others. A consultant may be necessary to set up and/or support the software.
- **Staff Expertise Constraints:** Configuration staff would need an understanding of GIS software (ArcMap), Microsoft Access, and other software tools required for data manipulation. Staff that utilize the software would require training on it and potentially on interpreting the results. A consultant may be necessary to support users.
- **Technology Environment:** The technology environment is greater than many other outcomes as the stakeholders would be required to run the software and analyses locally. This would require disk space, computer processing power, and server space for sharing outputs. Many of the software reviewed for this paper require a subscription to Esri ArcGIS as a foundational component, and some require the Network Analyst plugin.
- **Analysis Design:** Analysis design is dependent upon the software selected but may require additional thoughtfulness as stakeholders would be limited with support from software providers. It may be necessary to hire a consultant to assist in analysis design.

- **Results Interpretation:** Interpretation of the outputs will require staff expertise of underlying data sources and could require an understanding of software calculations. It may be necessary to hire a consultant to assist in result interpretation.

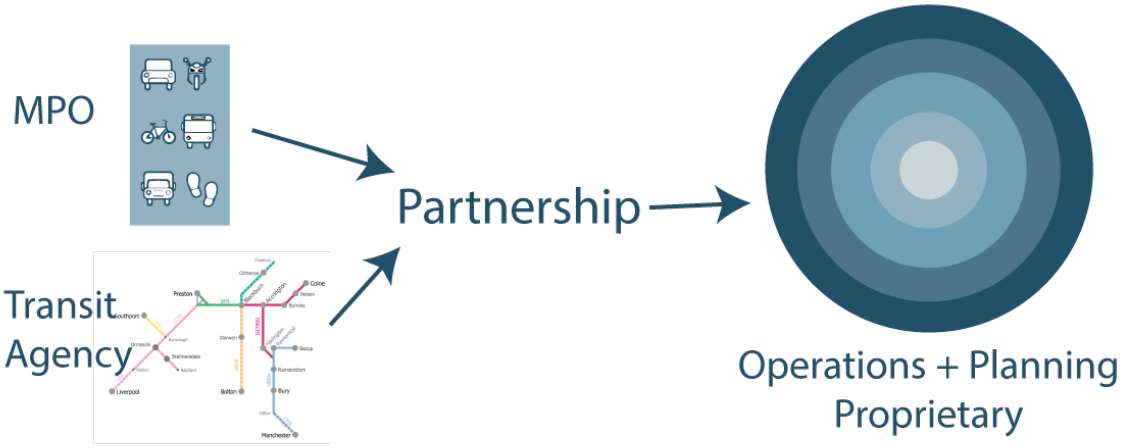
Outcome 2: Software Considerations

- **Data Resources Needs:** The stakeholders would be responsible for gathering and configuring all data resources required to run the software analyses, including organizationally specific data sources to strengthen results (i.e., observed ridership counts, GTFS, etc.).
- **User Interface Navigation:** The ease of user interface navigation would be entirely dependent upon the selected software platform. Typically, open-source user interfaces are less "polished" than proprietary platforms.
- **Complexity of Analysis Process:** The analysis process would be moderately complex as stakeholders would need to determine or design analyses without having a comprehensive understanding of all user-determined parameters.
- **Customizability:** This outcome would provide the maximum amount of customizability of all the outcomes, dependent upon the selected software's customizability options.
- **Support:** The level of support would be entirely dependent upon the software selected. Most open-source software provide detailed documentation on installation, configuration, and user guidance. One-on-one level of support is unlikely to be available.

Outcome 3

Transit and MPO Partnership(s)

Where TAs and MPOs Form Individual or Statewide Partnerships to Utilize Shared Proprietary Software that Meet Both Operations and Planning needs



If there are TAs already using proprietary software that have quality planning analysis features useful for long term planning for MPOs, it is possible that the MPOs could join a contract with the TA and their software provider. If the TAs entering all their own data, the MPOs would get the benefit of data availability. This outcome has the potential to reduce financial, time, and expertise costs by sharing a platform.

One important potential pitfall to note is that a software like Remix is now owned by Via, a mobility-on-demand provider. There is a potential conflict of interest in using Remix for planning as it may be in the interest of Via to highlight the need for their services.

Outcome 3: Agency Resources Needs

- **Time Constraints:** Time requirements for data configuration and software setup are negligible as a third-party would be completing this phase.
- **Staff Expertise Constraints:** Staff would need to learn how to use the proprietary software but support is available.
- **Technology Environment:** Typically, the technology environment requirements for running a proprietary package are minimal, needing only a functioning computer with an internet connection. Many proprietary software are web-based and compute analyses using their own servers, requiring very little computing power from users.
- **Analysis Design:** The analysis design process ranges widely depending on which proprietary software is selected. Some software allow substantial user-defined parameters to create analyses unique to their organizations. Other software limit the number of user-defined parameters to “streamline” the analysis design process and reduce complexity.

- **Results Interpretation:** The effort to interpret results is often reduced with proprietary software. These software typically provide additional tools or insights that aid with interpretation.

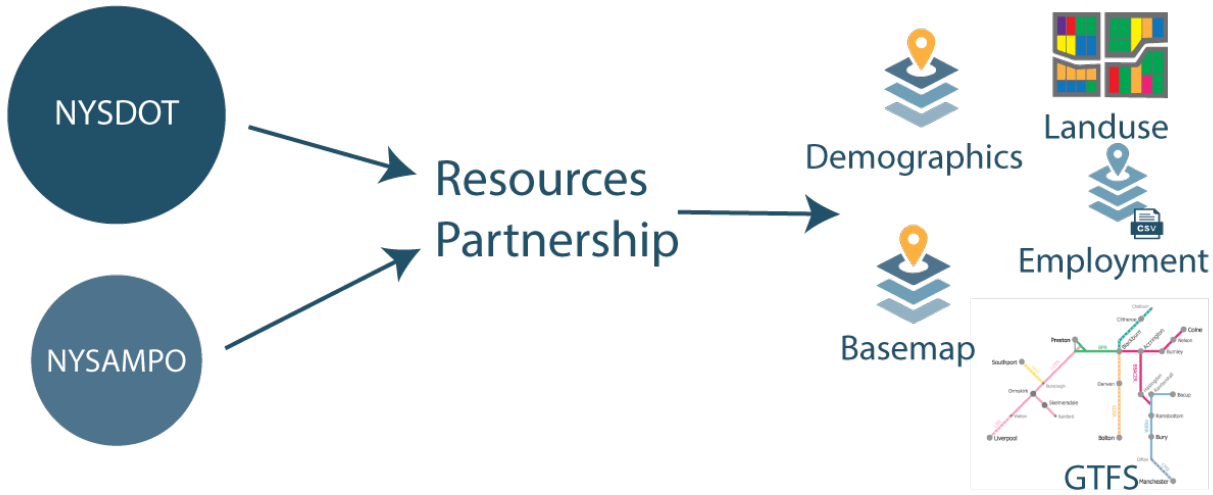
Outcome 3: Software Considerations

- **Data Resources Needs:** While the bulk of data usable in the software would be configured and provided by the software provider, organization-specific data that may enrich outputs would likely need to be gathered and given to the provider for them to configure.
- **User Interface Navigation:** The ease of user interface navigation would be entirely dependent upon the selected software platform. Typically, proprietary platforms provide more "polished" user interfaces that may simplify the user experience.
- **Complexity of Analysis Process:** The complexity of the analysis process would be entirely dependent upon the selected software. Some software offer a "wizard" solution to analyses, where a pop-up window guides users through the parameters they need to define.
- **Customizability:** The level of customizability would vary based on software selected but is anticipated to be lower than other outcomes. As the software and analyses are likely being run server-side, users have limited opportunity to create their own modules unless the software explicitly allows for that (which is highly unlikely).
- **Support:** The level of support varies by provider but would be the greatest of all the other outcomes. Many providers include customer support within their pricing structure to assist with the eventualities that arise from using a new software.

Outcome 4

Shared Data Resource Repository

Where NYSDOT and/or NYSAMPO Provides Statewide Shared Data Input Resources in Appropriate Formats for Specific Tools



In this outcome, it is not necessary that a specific software is selected for all the stakeholders to use. Instead, a centralized repository is created to provide access to all required data resources. This digital space to share would include source data files pre-configured for use in multiple software.

Providing stakeholders with the data resource components would reduce the initial friction associated with establishing the use of a new software.

Outcome 4: Agency Resources Needs

- **Time Constraints:** NYSDOT and NYSAMPO staff would need to format data sources into a number of different configurations depending on how many software are chosen to be supported by this outcome.
- **Staff Expertise Constraints:** Configuration staff would need an understanding of GIS software (ArcMap), Microsoft Access, and other software tools required for data manipulation.
- **Technology Environment:** This would require space on a server to act as a centralized repository accessible to multiple organizations.
- **Analysis Design:** N/A - The effort required to design analyses would be entirely dependent upon the software that the configured data is used in.
- **Results Interpretation:** N/A - The effort required to interpret results would be entirely dependent upon the software using the configured data.

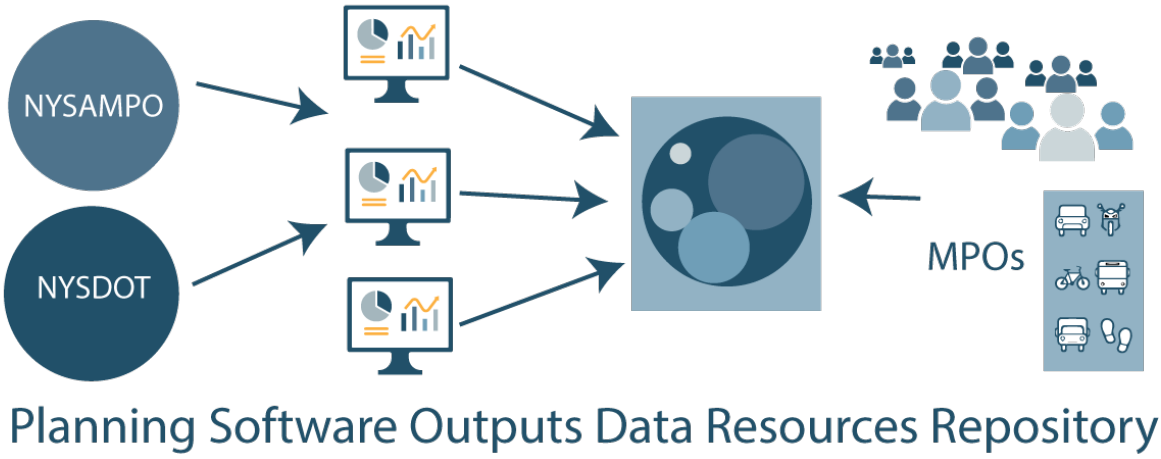
Outcome 4: Software Considerations

- **Data Resources Needs:** While the bulk of data usable in the software(s) would be configured and provided by NYSDOT and NYSAMPO, organization-specific data that may enrich outputs would likely require additional configuration.
- **User Interface Navigation:** N/A - The ease of use would be entirely dependent upon the software using the configured data.
- **Complexity of Analysis Process:** N/A - The complexity of analyzing would be entirely dependent upon the software using the configured data
- **Customizability:** N/A - The level of customizability would be entirely dependent upon the software using the configured data.
- **Support:** N/A - The level of support would be entirely dependent upon the software using the configured data

Outcome 5

Processed Software Outputs as Data Resources

Where NYSDOT and/or NYSAMPO Provides Batch Processed Software Outputs as Statewide Data Resources



This outcome would require hiring an external party to run one or more software to create a set of analyses. These analyses would then be made available at a state level via a shared platform or data repository hosted by NYSDOT or NYSAMPO. The process of selecting a software to use would change dramatically as the stakeholders would be receiving the outputs and not dealing directly with the software themselves.

Outcome 5: Agency Resources Needs

- **Time Constraints:** Most time efficient outcome as the processes of setting up software and designing analyses can be outsourced. The necessary agency time constraints would include determining quantity / types of analyses and interpreting the outputs.
- **Staff Expertise Constraints:** Staff would be required to understand the software outputs to determine the scope of requested analyses. Staff expertise would be required to interpret output data and apply it internally.
- **Technology Environment:** The least intensive technology environment would be required as software and analyses would be run externally. Additional software, like GIS, would be useful for further utilizing output data.
- **Analysis Design:** A determination would need to be made on the types and quantities of the outputs that are desired. This would require determining what outputs would be valuable to the organizations now and in the future.
- **Results Interpretation:** Interpretation of the outputs will require staff expertise of underlying data sources and could require an understanding of software calculations.

Outcome 5: Software Considerations

- **Data Resources Needs:** A limited number of data resources would be required as an external party would be required to configure the bulk of data to run the software analyses. Stakeholders would be providing organizationally specific data sources to strengthen results (i.e., observed ridership counts, GTFS, etc.).
- **User Interface Navigation:** N/A
- **Complexity of Analysis Process:** The analysis process would be moderately complex due to the nature of the outcome. Stakeholders would need to determine or design analyses without a comprehensive understanding of all user-determined parameters.
- **Customizability:** N/A
- **Support:** Stakeholders would have the external party as a direct contact for support for the contract period. After the contract period ended, support would be limited to available documentation about the software that was used.

Recommended Software and Potential Pilot Studies

The Research Team presents the following software recommendations as a set of Potential Pilot Studies. To build the set of Potential Pilot Studies, the Research Team utilized the market assessment survey to identify agency needs, including their self-reported potential upcoming planning and analysis projects. The Research Team then matched those various needs to the software outputs inventoried during the software market assessment (see Appendix C). The Research Team reduced the list of all transit software to a shorter recommended set of software by selecting for software that was readily available to be deployed and/or tested. The Research Team also selected a collection of software for testing that together met the identified transit planning needs, that were indicated by Market Research Survey Questionnaire respondents as being familiar and/or currently in use at their respective agency, and were available to the Research Team for testing. That process reduced the list to seven (7) software, or software categories, selected for full analysis and recommendation.

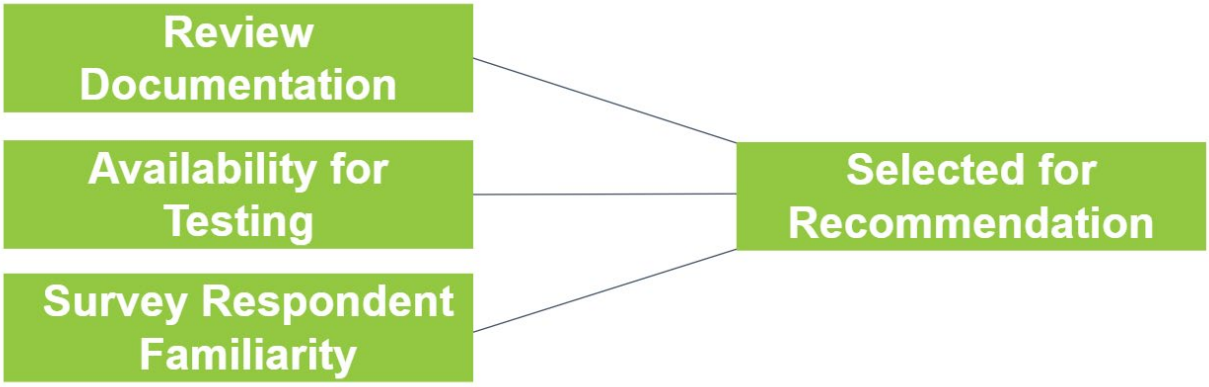


Figure 12. Rubric for Selection of Software

The Research Team then considered the strengths and weaknesses of each software, based on the agency and software considerations rubric and the five potential outcomes, to match software with their most likely hybrid outcomes. Finally, the Research Team outlines a set of pilot implementation models based on the recommended software that provides maximum flexibility wherein the design, implementation, and results of the pilot studies become input data for synthesizing a set of recommendations for the future statewide shared use program outlined in the RFP for this project.

Recommended Software

The following are a list of software with their potential pilot studies and how each software would likely fit into a proposed future statewide shared use program. For more on these software please see Appendix B.

TBEST

TBEST provides a wide variety of software features which can be utilized to perform many of the planning functions outlined in this assessment. TBEST is an executable software that requires ESRI ArcGIS to operate. ArcGIS is an industry standard software so it is certainly possible to run TBEST as a statewide software but it would require each user to initiate their specific instance and setup is quite complicated, due to data management issues. As a potential statewide shared use program TBEST would be best utilized in relationship with a hired consultant tasked with maintaining a warehouse of statewide configured data, with assisting partners with setting up and using the software, and with interpreting results. TBEST is an outstanding candidate for organizing a statewide transit COP.

PROS	**CONS**
Free to use	Setup is complicated
Wide variety of features	Executable format makes statewide deployment difficult
Provides analysis for a variety of objectives	Unpleasant user interface
Intuitive user interface	

Potential Pilots

Corridor Studies, Accessibility Analysis, Title VI Reporting, Stop Consolidation, Route Changes, Market Analysis, and many more.

Best Fit for Shared Use

Community of Practice, Shared Data Resource Repository

ESRI Transit Tools

ESRI Transit Tools provide a wide variety of software features which can be utilized to perform many of the planning functions outlined in this assessment. The ESRI Transit Tools are free to use but require the Network Analyst plugin for ESRI ArcGIS to operate. The Network Analyst is an additional expense that some agencies may not already account for. ArcGIS is an industry standard software so it is certainly possible to run the ESRI Transit Tools as a statewide software implementation but it would require each user to initiate their specific instance and setup is quite complicated, due to the extensive number of data and software configuration steps. As a potential statewide shared use program ESRI Transit Tools would be best utilized in relationship with a hired consultant tasked with maintaining a warehouse of statewide configured data, with assisting partners with setting up and using the software, and with

interpreting results. ESRI Transit Tools is an outstanding candidate for organizing a statewide transit COP.

PROS
Free to use (w/ ESRI Network Analyst)
Wide variety of features
Provides analysis for a variety of objectives
Utilizes ArcGIS which is a common interface

CONS
Setup is complicated
Executable format makes statewide deployment difficult
Requires ESRI Network Analyst Plugi

Potential Pilots
Corridor Studies, Accessibility Analysis, Title VI Reporting, Stop Consolidation, Route Changes, Market Analysis, many more.

Best Fit for Shared Use
Community of Practice, Shared Data Resource Repository

Conveyal

Conveyal offers a set of features for assessing accessibility and travel time within a transportation network. Conveyal is available as an open-source software and can also be purchased with additional features and support from the vendor. The software is web-based so it requires little configuration but the analysis design and results interpretation are both complicated by the user interface which manages to be both pleasing to the eyes and confusing to navigate. As a web-based vendor software, no data configuration is required to run Conveyal. The Research Team has also deployed an instance of the open-source version of Conveyal for this project, with configured data, to test the possibility of utilizing the software in an open-source statewide shared use program. The Isochrone outputs that Conveyal specializes in could also be very useful as a statewide dataset, in which NYSDOT and/or NYSAMPO hired a consultant, or the vendor, to run, host and maintains a series of accessibility isochrones for transit planners across the state. Both the open-source and proprietary versions of Conveyal could be helpful in organizing a statewide transit COP.

PROS
Attractive data visualizations
Web-based
Open source or proprietary options

CONS
Limited functionality
Confusing user interface
Complicated configuration and analysis desig

Potential Pilots
Corridor Studies, Accessibility Analysis

Best Fit for Shared Use
Community of Practice, Data Outputs Repository

STOPS

STOPS is provided by FTA for transit demand modeling. STOPS is an executable software that requires either TransCAD or ESRI ArcGIS to operate. STOPS takes a substantial amount of time to configure the foundational data to begin running the software. The user interface is antiquated but straight-forward to navigate. The outputs are provided in a set of files which are difficult to manage, requiring extensive workarounds. The functionality is limited in terms of variability of analysis but the software is highly flexible for running transit demand models. STOPS is a powerful tool that could serve as the center piece of a Community of Practice discussion. If the COP chooses to focus its utilization effort on STOPS, it would be helpful for the NYSDOT and/or NYSAMPO to configure and maintain data input resources for the state.

PROS
Freely Available
Powerful and flexible
User interface is simple

CONS
Setup is complicated
Outputs are challenging to make actionable
Executable format makes statewide deployment difficult
Limited analysis features beyond forecasting

Potential Pilots
Transit Demand Modeling

Best Fit for Shared Use
Community of Practice, Shared Data Resource Repository, Data Outputs Repository

---

GTFS Editors

There are a variety of GTFS Editors available as free executables, as developer friendly open-source code, and commercially. GTFS editing software is used for editing, maintaining, and exporting GTFS schedule and route data. One of the many GTFS editor software can be provided as a web-based statewide shared use software. As a potential statewide shared use program a GTFS Editor would be best utilized in relationship with a hired consultant with in-house developers tasked with hosting the software and assisting partners in using the software.

PROS
May be freely available
Simple to operate
Can be web-based

User interfaces can be rudimentary
Limited functionality

CONS
Limited datasets required for setup

Pilots
Stop Consolidation, Route Changes

Best Fit for Shared Use
Community of Practice, Shared Data Resource Repository, Data Outputs Repository

---

REMIX

Remix provides a wide variety of features which can be utilized to perform many of the planning functions outlined in this assessment. Remix is a proprietary web-based software which makes it an ideal candidate for a statewide shared license or for regional shared license partnerships between TAs and MPOs. As a web-based vendor software, no data configuration is required to run Remix other than providing GTFS files. Remix offers extensive support. In a demo call they said that they provide more than the standard user support services, including assistance in analysis design and results interpretation.

PROS
Wide variety of features
Provides analysis for a variety of objectives
Intuitive and pleasing user interface
Little data configuration required

CONS
Proprietary
Cost
Limited customizability

Potential Pilots
Accessibility Analysis, Title VI Reporting, Stop Consolidation, Route Changes, Network Costs, Market Analysis, many more.

Best Fit for Shared Use
Transit Agency MPO Partnership(s)

HASTUS, Optibus, and TRAPEZE

HASTUS, Optibus, and TRAPEZE provide some of the best operations features in the industry and are increasingly offering high quality planning features. Some of these proprietary software are web-based which makes them an ideal candidate for a statewide shared license or for regional shared license partnerships between TAs and MPOs. It should be noted that TRAPEZE is currently the most utilized transit software in the state. If given the opportunity throughout the course of this project, the Research

Team will expound on all of these software separately, giving each a more thorough evaluation of its strengths and weaknesses.

PROS

Offers operations and planning features
One of the most utilized operations software in the state of New York

Limited access and publicly available documentation
Proprietary
Cost
Limited customizability

CONS

Potential Pilots

MPO and TA partnership to utilize the planning features of one of these software, Accessibility Analysis, Title VI Reporting, Stop Consolidation, Route Changes, Network Costs, Market Analysis, and many other planning and operations projects.

Best Fit for Shared Use

Transit Agency MPO Partnership(s)

Potential Pilot Implementation Models

The Research Team proposes three (3) potential pilot implementation models based on the market and software analyses.

Model 1a and 1b - Open-Source Software

The first implementation model is to design pilots to meet the specific needs of an agency. In this model, the agency will be an enthusiastic pilot partner with a specific goal. The pilot will be designed to match a specific software to the specific goal. The implementation design of the pilot will be based upon the agency's staff capacity. In a situation where staff capacity is available to conduct the pilot study, the Research Team will provide support to the agency in setting up the software, configuring the data, designing analysis and interpreting the results. This implementation model is the most desired result. In situations where staff capacity is limited, the Research Team will conduct the analysis off-site. The second, more supportive form of this implementation model, will provide additional information about how to design a future shared use program.

Model 2 - Proprietary Software

Across New York State there are several Transit Authorities using Trapeze, Hastus, Optibus or Remix, both proprietary operations software with planning features. In this implementation model, the Research Team will provide support to the agency or agencies in setting up the partnership, configuring any additional required data, designing an analysis, and interpreting the results. An enthusiastic TA partner would likely be necessary for this implementation model. The TA partner would either have a specific planning goal or would be willing to work with an MPO partner to assist that MPO partner with a specific planning goal. This implementation model will provide information about how to design a shared use program based around a proprietary platform.

Model 3 - Community of Practice Statewide Analysis

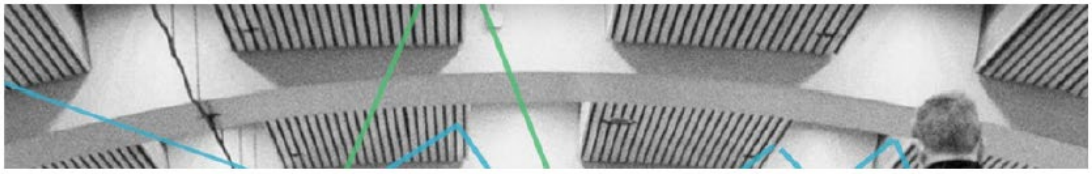
One potential outcome of this project is to utilize open-source software to batch process software outputs, creating a statewide output data repository. A candidate for this type of implementation model is the Conveyal software, particularly its accessibility isochrone output data. If there is enough statewide interest, the Research Team could run a series of regional accessibility analyses to create a statewide accessibility dataset. The project would provide regular monthly meeting content around a shared goal, either for this project steering committee, or for the NYSAMPO Transit Working Group. A shared statewide analysis would provide a model for a future statewide Transit Planning COP.

Appendices

A. Market Research Survey Questionnaire

transpogroup

PLANNING ENGINEERING DEVELOPMENT PEOPLE JOBS BLOG CONTACT Search...



NYSAMPO Survey

Thank you for your willingness to participate in this project to evaluate the effectiveness of Transit Software. This survey is designed to learn about your agency's current practices and goals for this project.

Please answer the questions in this survey to the best of your ability, and if necessary speak with colleagues at your agency to ensure accuracy of the responses. Please contact the AVAIL Project Team with any questions/feedback on this survey, or any requests for clarification. 518.860.0438 ekrans@albany.edu

NYSAMPO Survey

1. What is the name of your agency?*

2. What is your name?*

3. What is your job title?*

4. What is your contact email address?*

5. Which of these are responsibilities of your agency?*
Select all that apply.

- [ ] Planning transit services in your region
- [ ] Operating transit services in your region

6. Within your agency, which of these are your professional responsibilities?*

Select all that apply. If *Other*, please briefly describe responsibilities.

- ☐ Transit scheduling
- ☐ Ridership forecasting
- ☐ Data archiving/management
- ☐ Transit operations analysis
- ☐ Fleet management
- ☐ Transit equity analysis
- ☐ Feasibility planning
- ☐ other:

7. Please rate the importance of the following objectives for your agency in the next 5 years on a scale of 1 to 4:

	1. Not important at all	2. Somewhat important (lowest priority)	3. Very important (medium priority)	4. Critically important (highest priority)
Increasing transit ridership	○	○	○	○
Better serving disadvantaged groups	○	○	○	○
Better serving choice riders	○	○	○	○
Increasing farebox revenue	○	○	○	○
Reducing journey times for transit riders	○	○	○	○
Improving journey time reliability for transit riders due to recurring congestion	○	○	○	○
Improving journey time reliability for transit riders due to incidents/road-work zones	○	○	○	○
Reducing operating/maintenance costs	○	○	○	○
Improving access to employment	○	○	○	○
Improving access to social services	○	○	○	○
Integrating microtransit and fixed-route services	○	○	○	○
Improving multi-modal access to transit centers	○	○	○	○
Establishing new transit services and/or routes	○	○	○	○

etc.)

Improving safety (i.e. reducing collisions)	○	○	○	○
Improving customer access to real-time service information	○	○	○	○
Improving engagement with the public and/or customers	○	○	○	○

8. Please rate the importance of the following tasks/analyses that your agency currently undertakes or has interest in undertaking:

	Not important at all	Somewhat important (lowest priority)	Very important (medium priority)	Critically important (highest priority)
Changes to Transit Network (New routes and/or stops)	○	○	○	○
Changes to Transit Network (Consolidate stops and/or services)	○	○	○	○
Changes to Transit Service (Frequency/Schedule)	○	○	○	○
Changes to Transit Service (Cost/Payment Structure)	○	○	○	○
Title VI Reporting	○	○	○	○
Accessibility Analysis	○	○	○	○
Equity/DEI Analysis	○	○	○	○
Land use Market Analysis	○	○	○	○
O/D Travel Time Estimates	○	○	○	○
Reliability Analysis	○	○	○	○
Travel Time Analysis	○	○	○	○
Transfer Analysis	○	○	○	○
On-time performance analysis	○	○	○	○
Detour Analysis	○	○	○	○

Current Ridership Analysis	○	○	○	○
Modeled Ridership Analysis	○	○	○	○
Transit Demand Analysis	○	○	○	○
Park and ride and transit center/ mobility hub market analysis	○	○	○	○
Customer Satisfaction	○	○	○	○
Real-time Rider Communication	○	○	○	○
Real-time Fleet Management	○	○	○	○
Fleet driver scheduling – Driver and Vehicle Assignments	○	○	○	○
Incident Management	○	○	○	○

9. For tasks/analyses that your agency is currently undertaking, what are the limitations that you encounter, if any (i.e. personnel constraints, software constraints, data availability, etc)?

10. For tasks/analyses that your agency wants to undertake, what limitations are keeping your agency from currently undertaking them?
(i.e. personnel constraints, software constraints, data availability, etc)

11. How do you use data, and what data do you use to justify future objectives?
(i.e. data evidence for funding or forecasting)

12. How do you use data, and what data do you use to report on efficacy?
(i.e. performance measures that are reported to federal, state, regional, and/or local agencies and stakeholders)

13. How do you use data, and what data do you use to manage operations?
(i.e. scheduling, route optimization, fleet size)

transpogroup

PLANNING ENGINEERING DEVELOPMENT PEOPLE JOBS BLOG CONTACT Search...

	Never heard of it	Have heard of it, but have not looked into it	Have looked into it, but not used it	Agency staff have used it	Consultant(s) have used it under contract to my agency
STOPS	○	○	○	○	○
TBEST	○	○	○	○	○
Remix	○	○	○	○	○
Trapeze	○	○	○	○	○
HASTUS	○	○	○	○	○
OptiBus	○	○	○	○	○
Peartree	○	○	○	○	○
Transitr	○	○	○	○	○
GTFS Editor	○	○	○	○	○
BetterBusBuffers (ESRI Tool)	○	○	○	○	○
Transit Network Analysis Tools (ESRI Tool)	○	○	○	○	○
Conveyal	○	○	○	○	○
Transitland	○	○	○	○	○
Ridepilot	○	○	○	○	○
TNExT	○	○	○	○	○
TransCAD	○	○	○	○	○
TripSpark	○	○	○	○	○
Spare Realize	○	○	○	○	○
Route Trends	○	○	○	○	○

Click here for additional information regarding the software packages listed above.

15. Beyond the software packages listed in Question 14, please list any other software packages and your agency's experience with each software package:

transpogroup

PLANNING ENGINEERING DEVELOPMENT PEOPLE JOBS BLOG CONTACT Search...

16. For each software package that you have used (as identified in Question 14 and 15), what does your agency view as the *Strengths of each software package*?

17. For each software package used (as identified in Question 14 and 15), what does your agency view as t... *Limitations/Weaknesses of each software package?*

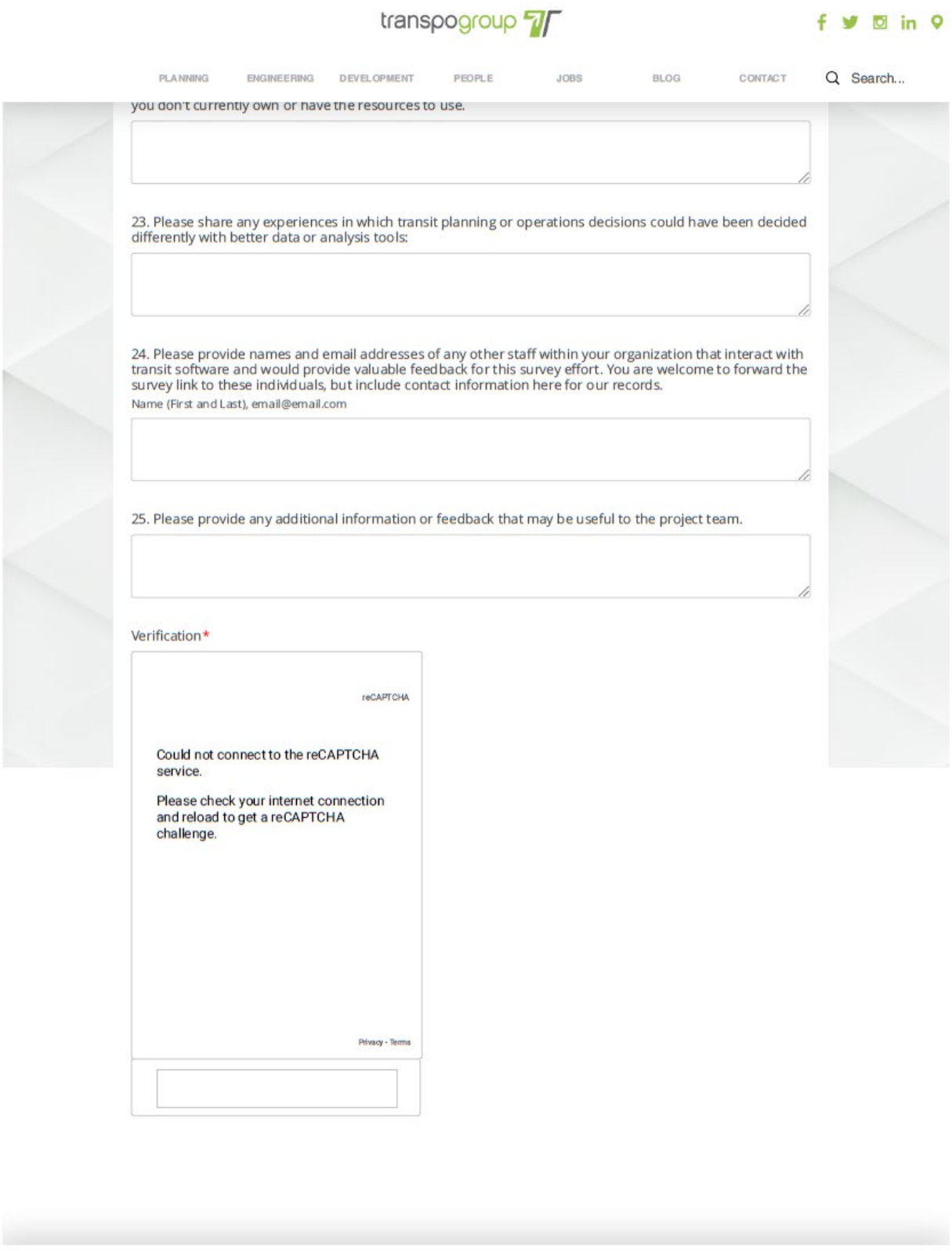
18. For each software package used (as identified in Question 14 and 15), please describe the application/use case in which your agency's staff and/or consultants applied each software package:

19. Please rank the importance of the following transit software attributes for your agency's needs:

	Not at all important	Somewhat important	Very important	Critically important
Software that is Open Access (zero-cost)	○	○	○	○
Software's user-friendliness (minimal training required)	○	○	○	○
Software's Technical Support	○	○	○	○
Software that is web-based	○	○	○	○
Software that does not require new purchase of computing hardware	○	○	○	○
Software that is customizable	○	○	○	○
Software that is integrated with your agency's GIS software and databases (rider surveys, AVL, etc.)	○	○	○	○

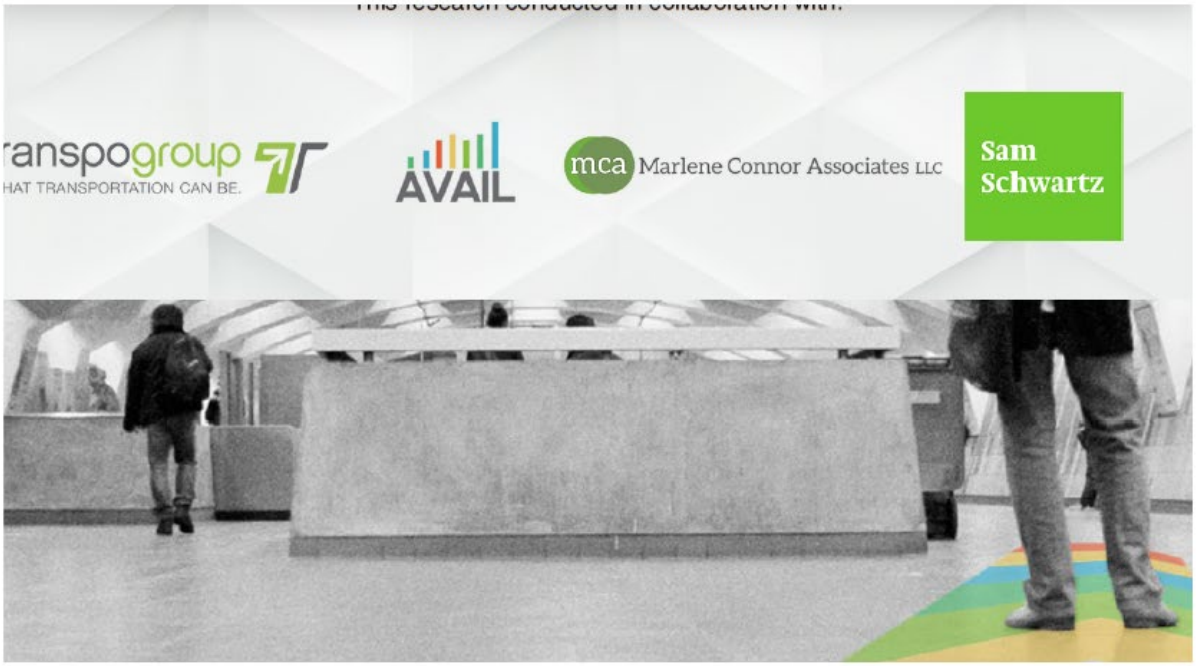
20. Are there other desired attributes/functionality that your agency seeks in transit software?
Please briefly describe.

21. When was the last major review of transit route services (fixed route) in your region:
(select one)


transpogroup
PLANNING
ENGINEERING
DEVELOPMENT
PEOPLE
JOBS
BLOG
CONTACT
Search...
you don't currently own or have the resources to use.
23. Please share any experiences in which transit planning or operations decisions could have been decided differently with better data or analysis tools:
24. Please provide names and email addresses of any other staff within your organization that interact with transit software and would provide valuable feedback for this survey effort. You are welcome to forward the survey link to these individuals, but include contact information here for our records.
Name (First and Last), email@email.com
25. Please provide any additional information or feedback that may be useful to the project team.
Verification*
reCAPTCHA
Could not connect to the reCAPTCHA service.
Please check your internet connection and reload to get a reCAPTCHA challenge.
Privacy - Terms

transpogroup

PLANNING ENGINEERING DEVELOPMENT PEOPLE JOBS BLOG CONTACT Search...



transpogroup

12131 113th Ave NE #203
Kirkland, WA 98034, USA

contact@transpogroup.com

425.821.3665

B. Software Assessments

Transit Boardings Estimation and Simulation Tool (TBEST) 4.7

Software Type (Planning / Operations): Predominantly a planning software but includes minor operational elements like fare and route cost calculations.
Output Type: Many Resource Requirements to Many Outputs
Inputs:

- Population
  - SF1 Census Attribute Table
  - American Community Survey (ACS) 5-Year Estimates
  - Census Block-level polygon shapefile
- Employment
  - Address-level (point) data
  - LEHD Block-Level Workplace Area Characteristics (WAC)
  - Zonal Employment Shapefile
- Land Use
  - Parcel Centroid (Point) Data
- Base Map
  - ArcGIS Hosted (OpenStreetMap or others)
  - Local Map File (.mxd / .lyr)
  - TIGER-Line Shapefile (Primary and Secondary roads)
- Transportation
  - General Transit Feed Specification (GTFS)

Outputs:

- Strategic Planning and Service Planning support including a robust, GIS-based network coding environment for introducing route geometry modifications and service-level adjustments into proposed future-year scenarios.
- Model Validation tools that provide model transferability between distinct geographic contexts including various transit system sizes.
- General Transit Feed Specification (GTFS) Interoperability Tools that provide network import and export capability so that the TBEST model network accurately reflects operational network characteristics and can be produced in minutes vs. detailed network coding which can take days.
- Extensive Scenario Planning environment to create an array of scenario alternatives including simple scenarios which introduce a single input change or more complex scenarios which combine fare modifications, socio-economic growth factors, network re-configurations, service span adjustments, and many more.
- Scenario Comparison Reports to easily identify route-level ridership, socio-economic, performance or cost differences between scenarios.
- Performance Reports that provide enhanced route performance statistics.

- BRT Modeling support that introduces detailed BRT characteristic scoring methodology into the model equation.
- Comprehensive Operational Analysis (COA) Support
- Evaluating Access to Transit and Access via Transit
- Socio-Economic and Land Use Market Analysis
- Network Accessibility Summarization
- FTA Title VI Service Equity Analysis

Agency Resources Needs

- **Time Constraints**: TBEST takes a substantial time to configure the foundational socio-economic data package. Generating the package with census data from all 62 counties in NYS took approximately 160 continuous hours of unassisted processing. Once that data package was completed, the time it took to run many analyses was nearly instantaneous.
- **Staff Expertise Constraints**: Staff that will be setting up and configuring the software should be at least knowledgeable about database editing using Microsoft Access and attribute editing in ESRI ArcGIS. Additionally, TBEST is a complex software that would require staff trained in its operation.
- **Technology Environment**:
    - **Required Software**
        i. Microsoft Windows 7, 8, 8.1 or 10
        ii. ArcGIS 10.2.2, 10.3.1, 10.4.1, 10.5.1, 10.6.1, 10.7.1, and 10.8.1 (Basic License Level)
        iii. Microsoft SQL Server Express 2019 LocalDB (installed with TBEST)
        iv. Microsoft Data Connectivity 2007 (installed with TBEST)
        v. Microsoft SQL Server ODBC Driver 13 (installed with TBEST)
        vi. Microsoft Access
    - **Recommended Hardware Specifications**
        i. Quad Core 2.4 GHz Intel processor (or better)
        ii. 16 GB RAM or greater
        iii. Solid State Drive (SSD) with Windows installed on SSD
        iv. “40 GB free disk space after installation of TBEST”
- **Analysis Design:** TBEST offers several analyses that require little user-defined parameters and generate reports from those parameters. There is very limited knowledge required to design supported reports. Report types that are not explicitly supported may take considerable time to generate and could require the assistance from a software coder.
- **Results Interpretation:** Results from supported report types are outlined simply and require little effort to interpret. Having not generated any unsupported report types, this paper cannot address the interpretation of those types of reports.

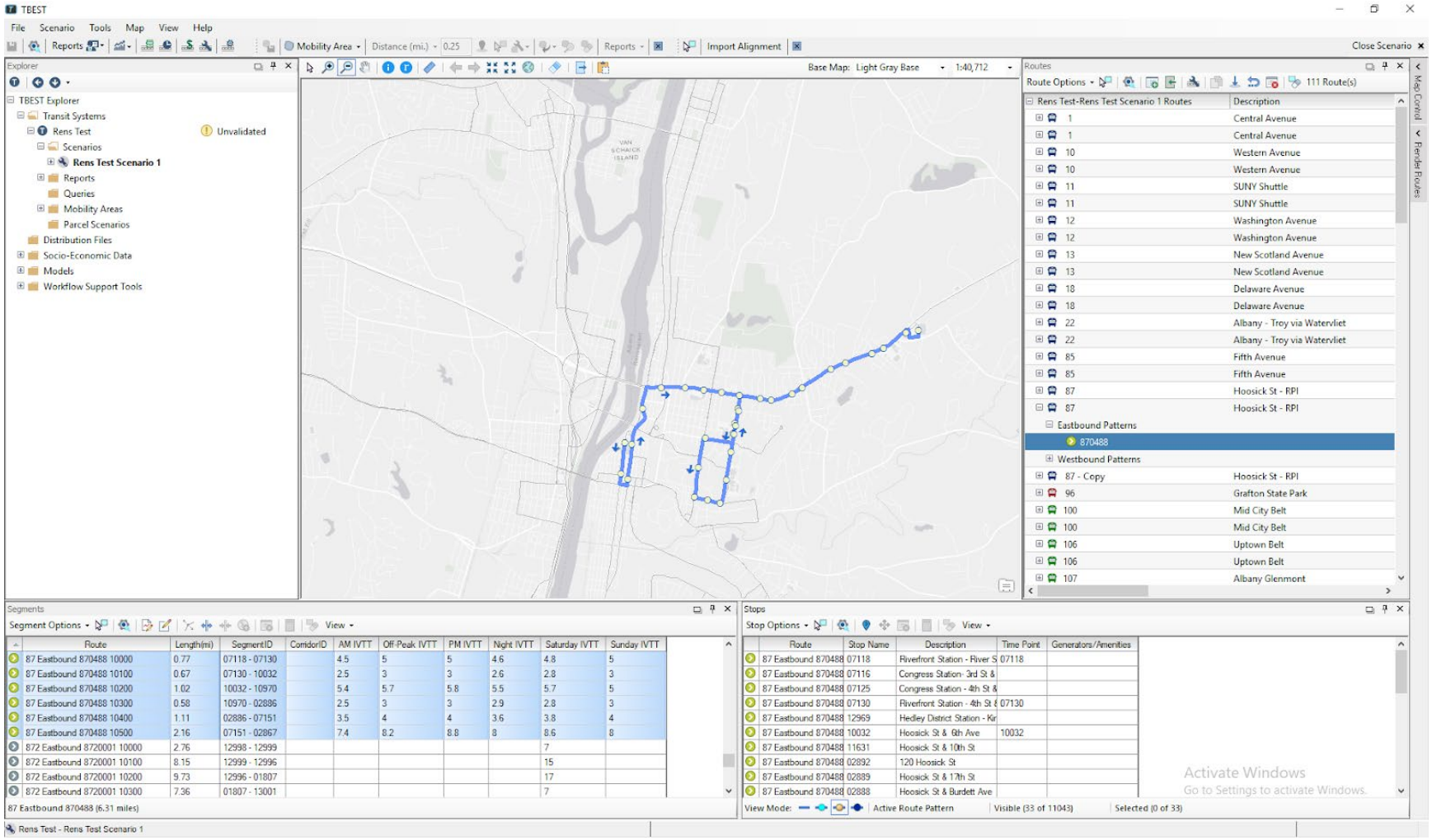
Software Considerations

- **Data Resources Needs:** Preprocessing and configuring the data is intensive and requires a basic understanding of ArcMap and Microsoft Access. A general overview of the configuration steps is listed below:
    - Generate a County FIPS Codes Text Files

  - Generate an Excel Configuration File
  - Add and Calculate New Fields to TIGER/Line Shapefile in ArcMap
  - Use Microsoft Access to Modify SF1 Database (and Link Multiple Databases if Necessary)
  - Download and Place ACS Data
  - Configure LEHD Employment Data and Import into Access Database
  - Processes Census Data with Utility (~120 Hours for NYS)
  - Configure Parcel Land Use Data
  - Configure Background Roads Data
  - Generate TBEST Socio-Economic Data Package
  - Verify Package
- **User Interface Navigation:** The user interface navigation for TBEST has a steeper learning curve in comparison to many other software. Once users have learned the layout of the software and its functions, the interface is intuitive.
- **Complexity of Analysis Process:** The complexity of analyses and processes to develop them vary greatly. By default, the software provides an ample number of developed analyses that require few user-defined parameters and can be run quickly and easily. Contrastingly, users have the capability to draft and develop their own analyses using a partially integrated Microsoft Visual Studio component (requires separate download and installation). Analyses drafted within this software feature require an understanding of coding and would likely require a multi-disciplinary team to complete.
- **Customizability:** Customizability is very robust. TBEST's default analyses provide a number of user-definable parameters that vary by analysis. Users can develop an unlimited quantity of different scenarios that can be configured in nearly every aspect.

  Noted in the section above, TBEST has partially integrated Microsoft Visual Studio to establish a platform for drafting user-envisioned tools and analyses. The customizability provided by this feature is nearly limitless but would be resource intensive to develop.
- **Support:** TBEST provides regular software updates, comprehensive documentation (user guide and socio-economic data configuration guide) and offers regular training sessions that are extraordinarily informative. There is a digital forum on their website, but it appears to be relatively inactive with the latest post from two years prior.

TBEST – User Interface



TBEST – Route Service Summary Output

Rens Test - Rens Test Scenario 1 Route Service Summary

Route: 87 - Hoosick St - RPI Radial Bus

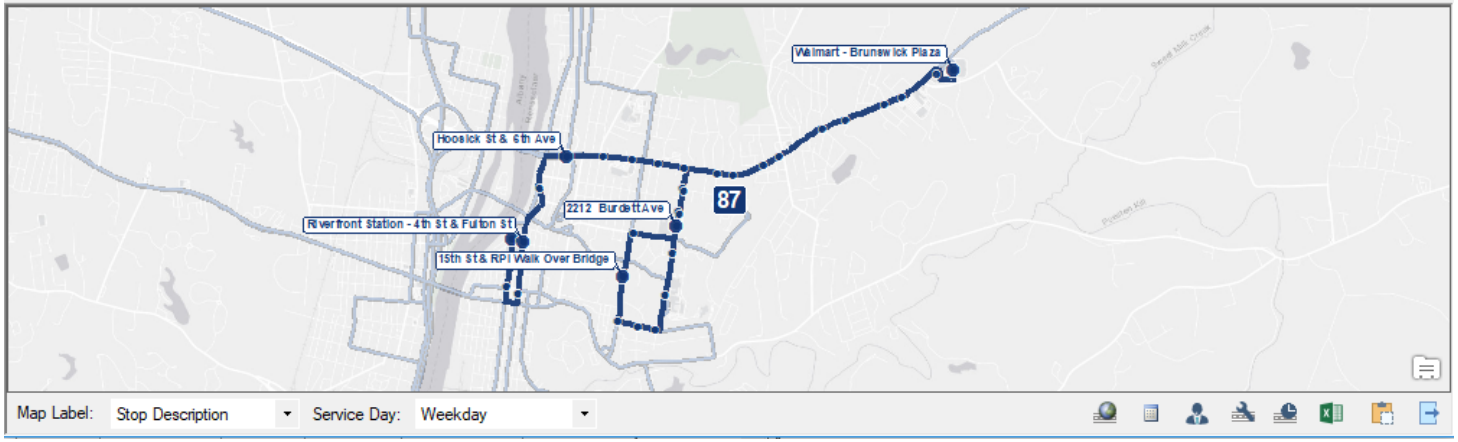
Route Service Summary			
Weekday Route Properties		**Service Hours**	
Round Trip Length (mi.)	6.3	Weekday	05:55 AM to 11:15 PM
Stops Served	33	Saturday	05:55 AM to 11:15 PM
Avg. Stop Spacing (ft.)	1,009	Sunday	08:05 AM to 07:25 PM

Route Operations Settings	
Service Hour Cost	$1.0
Service Mile Cost	$1.0
Minimum Layover (%)	0.0%
Vehicle Capacity (Seats)	60

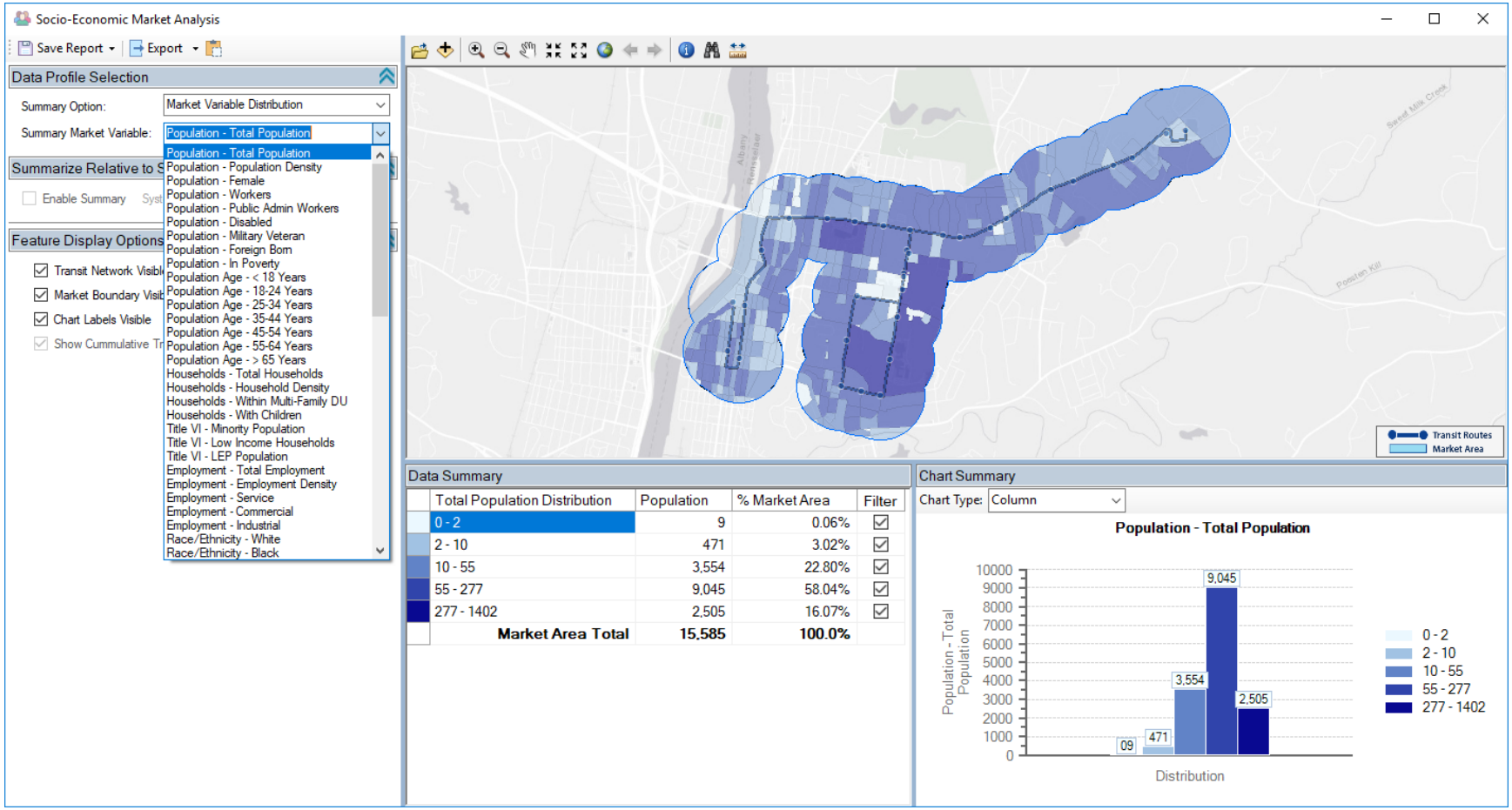
2019 Weekday Demographics (0.25 mi.)	
People | per sq. mi.	15,585 | 6,337.1
Jobs | per sq. mi.	15,633 | 6,356.6
Minority	34.8%
Low Income	36.9%
Seniors and Minors	22.4%
One-Vehicle or Less	66.8%

Route Service Detail by Time Period (No interlined Routes) ☐ Annualize

Time Period	Service Span (Hours)	Revenue Service Trips (One Way)	Headway (Minutes)	Round Trip Travel Time (Minutes)	Speed (MPH)	Vehicles	Average Layover	Revenue Service Hours	Revenue Service Miles	Route Cost
AM Peak	3.0	49	6	25.7	14.7	5	13.3%	13.2	170.3	$183.5
Off-Peak	6.0	133	5	28.9	13.1	5	3.3%	33.4	422.7	$456.0
PM Peak	3.0	69	5	29.6	12.8	5	0.0%	16.8	214.5	$231.2
Night	5.3	58	10	27.0	14.0	3	10.0%	13.6	170.3	$183.9
Total Weekday	17.3	309	7	27.8	13.4	5	6.4%	77.0	977.8	$1,054.7
Saturday	17.3	77	26	28.5	13.3	2	44.2%	33.3	246.0	$279.3
Sunday	11.3	52	26	28.0	13.5	2	46.2%	22.5	164.0	$186.5



TBEST – Socio-Economic Market Analysis Output



Simplified Trips-On-Project Software (STOPS) 2.50

Software Type (Planning / Operations): Planning Only

Inputs:

- Census Transportation Planning Products (CTPP)
    - The Year 2000 Census Long Form
    - The 2006-2010 American Community Survey
- Journey-to-Work (JTW)
- MPO's Traffic Analysis Zones (TAZs) in Shapefile Format
- Transit Timetables in General Transit Feed Specification (GTFS) Format

Outputs:

- Primary: ASCII (text) data file (.prn) with 200,000+ lines containing a variety of data tables
- Secondary: Trips Generated Map File (.mxd)

Agency Resources Needs

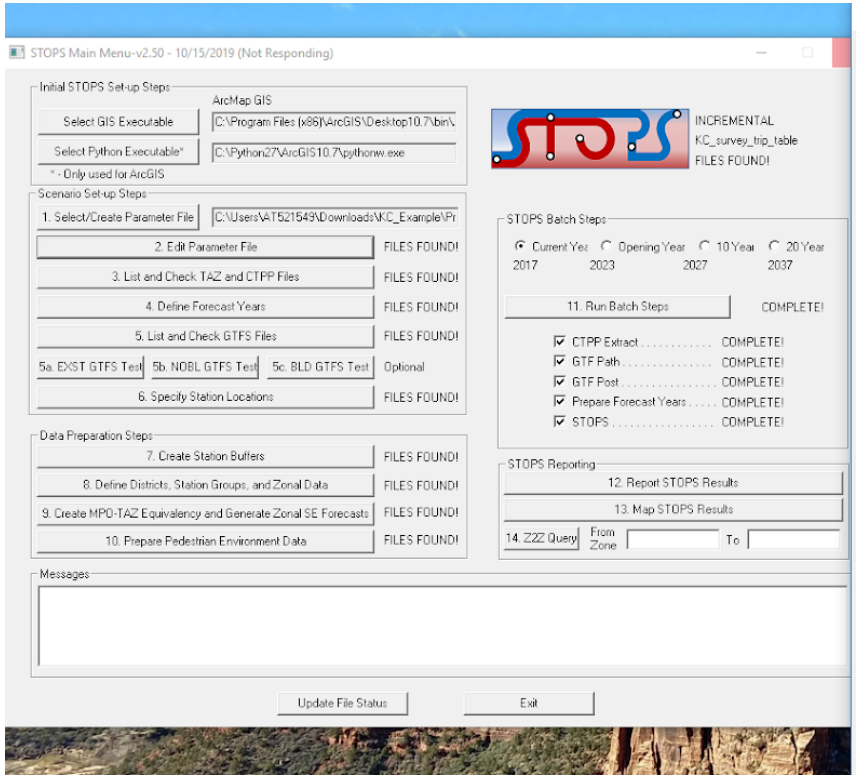
- **Time Constraints:** STOPS takes a substantial amount of time to configure the foundational data to begin running the software.
- **Staff Expertise Constraints:** Staff will
- **Technology Environment:**
    - **Required Software**
        i. Microsoft Windows 7 or above, 32/64-bit
        ii. Any GIS editing software, though STOPS automates the linkage to two of the most common GIS packages used in transportation analysis and modeling:
            - TransCAD Version 5.0/6.0
            - ArcMap Version 10.1 or later
    - **Recommended Hardware Specifications**
        i. Quad Core Processor or greater
        ii. 8 GB Required, 16 GB RAM or greater recommended
        iii. Screen resolution of 1024x768 or greater
        iv. 20 GB to 100 GB per scenario; a USB external hard drive is recommended
- **Analysis Design:** STOPS offers a "wizard" style of analysis design that require many user-defined parameters to generate a report from. Extensive knowledge about entry fields is required to design supported reports.
- **Results Interpretation:** The interpretation of STOPS results is a demanding process. The software provides two outputs; a .mxd (map) file and a dense .prn (text) file filled with a variety of tables (without a standardized format).

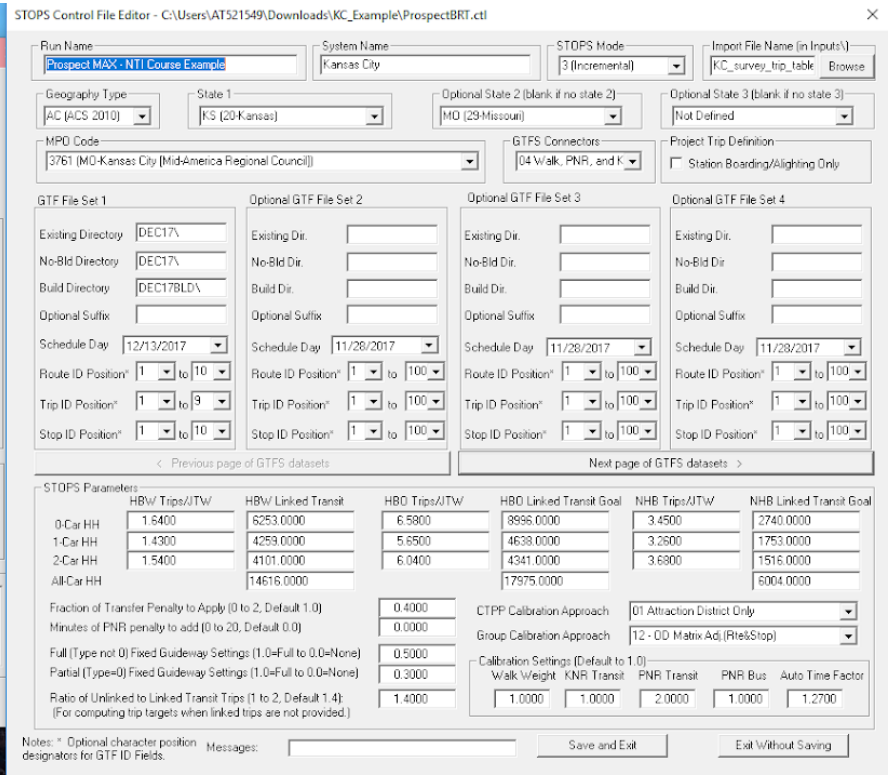
Software Considerations

- **Data Resources Needs:**
    - Census Transportation Planning Products (CTPP)
        i. The Year 2000 Census Long Form
        ii. The 2006-2010 American Community Survey

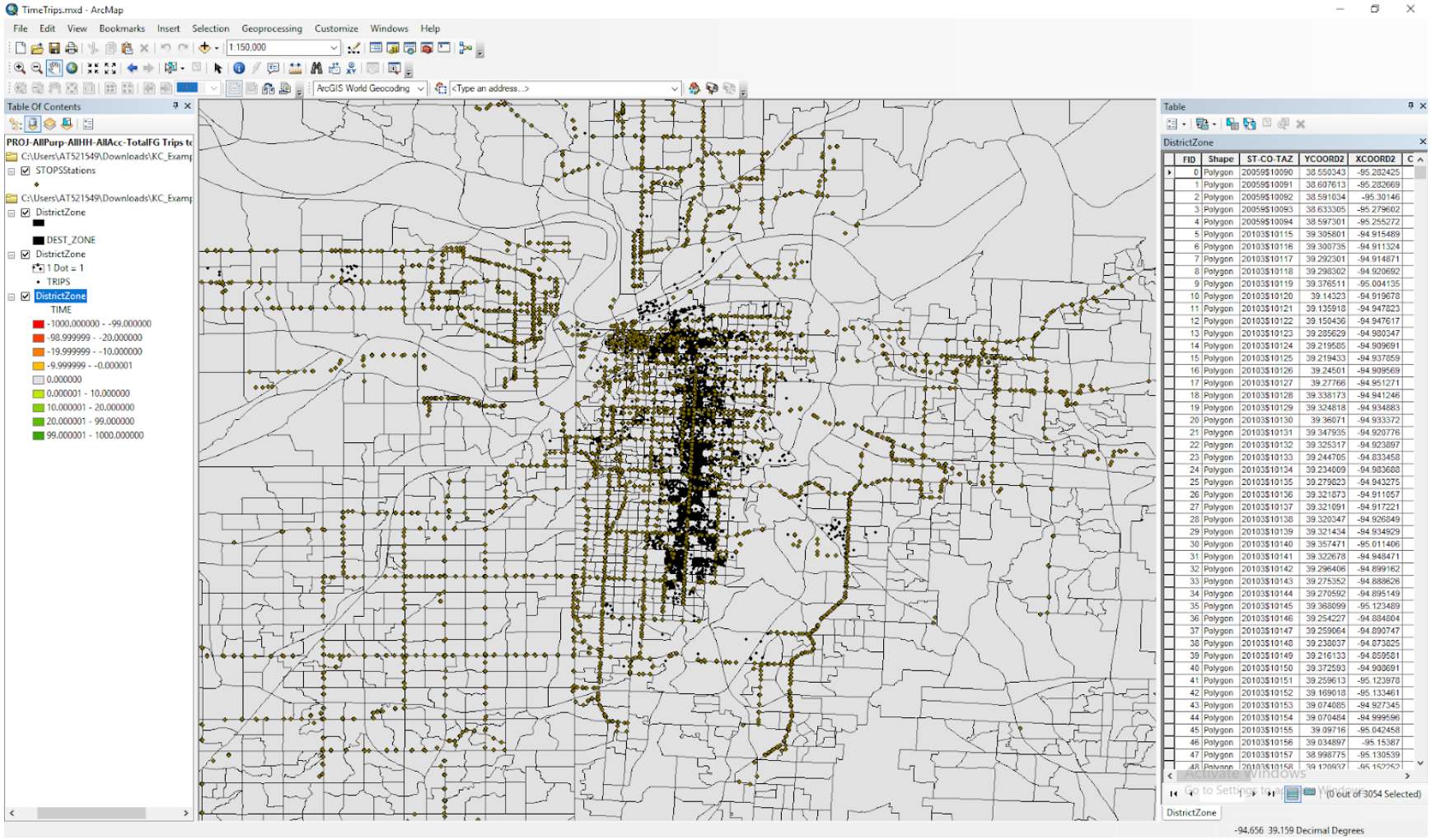
  - Journey-to-Work (JTW)
  - MPO's Traffic Analysis Zones (TAZs) in Shapefile Format
  - Transit Timetables in General Transit Feed Specification (GTFS) Format
- **User Interface Navigation:** The user interface of STOPS is somewhat straight-forward. It consists of a main page with many buttons for running processes that are listed in chronological order by when they need to be run. Towards the beginning of the process buttons is one that opens a menu for users to set parameters and data weighting.
- **Complexity of Analysis Process:** The analysis process is complex, requiring users to determine weights of data to be used in the calculation, requiring model validation for the region, and then configuring the program differently for each analysis run.
- **Customizability:** STOPS is customizable as it allows moderate parameter configuration and modification of variable weights in its equations.
- **Support:** The software has a fairly comprehensive documentation that clearly outlines many components of the software. Online support from the Federal Transit Administration appears to be limited.

STOPS – User Interface





STOPS – Trip Map Output



STOPS – Data File Output

```
Program STOPS - FTA Simplified Trips-on-Project Software                                                    Page    25
Version: STOPS-v2.50 - 10/10/2019                                                                           10/20/2021
Run:    Prospect MAX - NTI Course Example                                                                     12:34:33
System: Kansas City
Table     4.01

*** WEEKDAY LINKED TRANSIT TRIPS (All Transit/All car HH) ***
District to District MODEL Summary for Scenario  3: Y2017 BUILD
All Purposes All Transit All Access All car HH
```

Idist	CBD	NCBD	CrwnC	Midto	Plaza	UMKC	CClub	ECBD	Emidt	SPrsp	EInd	EastS	Swope	BlRid	SE	South	FarSo	FarEa	NKC	NE	FarNE	GladS	NW	KCI	Far
CBD	567	459	817	366	288	17	99	145	102	94	332	58	18	28	27	55	0	0	16	10	0	13	0	23	
NCBD	838	35	368	37	40	0	14	23	6	0	76	0	0	30	31	0	0	0	1	9	0	12	0	17	
CrwnC	982	402	153	316	159	30	80	73	47	59	40	37	56	31	6	13	0	0	7	17	0	2	0	12	
Midto	622	46	399	774	260	91	223	144	288	125	77	146	90	57	27	28	0	0	19	20	0	26	0	18	
Plaza	198	27	124	526	59	2	82	59	52	41	4	3	15	0	15	15	0	0	7	6	0	4	0	15	
UMKC	41	5	37	180	2	6	24	30	43	31	1	16	13	0	2	3	0	0	1	6	0	0	0	16	
CClub	462	18	234	246	149	36	216	117	17	57	10	70	54	10	23	47	0	0	9	0	0	24	1	5	
ECBD	544	149	115	191	24	45	75	179	218	97	487	96	98	0	3	31	0	0	31	19	0	39	0	15	
Emidt	558	30	221	863	136	28	78	225	312	257	127	194	155	8	28	38	0	0	38	27	0	5	0	17	
SPrsp	603	9	311	607	250	64	198	402	439	475	23	111	84	18	71	49	0	79	25	6	0	15	0	67	
EInd	525	88	174	178	18	29	15	404	108	37	260	49	17	39	18	20	0	0	64	1	0	78	0	44	
EastS	228	1	128	346	35	22	32	124	320	142	53	93	57	8	20	26	0	0	21	2	0	21	4	15	
Swope	58	0	20	56	6	5	17	36	23	2	5	8	0	0	9	0	0	0	2	1	0	0	0	0	
BlRid	122	31	17	30	39	2	10	8	21	14	1	0	22	28	64	0	0	0	13	11	0	16	0	0	
SE	313	5	78	95	23	15	46	40	32	5	26	42	29	59	38	19	0	0	9	0	0	3	0	0	
South	126	1	35	77	11	3	30	16	24	47	3	0	42	0	35	20	0	0	1	3	0	5	0	0	
FarSo	57	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
FarEa	111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
NKC	100	2	30	2	10	0	8	7	15	5	10	6	0	19	0	0	0	0	38	47	0	116	2	8	
NE	109	0	11	2	0	0	0	0	0	0	11	0	0	0	0	0	0	0	56	0	0	4	0	0	
FarNE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
GladS	284	27	76	45	2	1	1	3	14	4	0	2	9	0	2	0	0	0	90	0	0	275	46	20	
NW	152	0	13	3	1	0	2	0	5	0	0	0	0	0	1	0	0	0	0	0	0	3	8	0	
KCI	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Far N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Ind	207	0	37	13	12	0	0	24	7	2	35	10	3	11	10	3	0	24	10	1	0	5	0	1	
KCK	623	26	67	115	37	45	33	105	27	37	50	51	15	6	6	15	0	0	22	8	0	15	2	36	
WestC	240	14	54	61	56	7	14	14	24	9	31	3	12	11	0	9	0	0	2	17	0	0	4	1	
FarNW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Kansa	339	6	89	15	15	0	25	2	0	9	10	0	0	0	0	0	0	1	5	0	0	1	0	7	
North	39	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Total	9049	1381	3622	5146	1636	450	1323	2178	2141	1548	1674	995	787	365	434	391	0	104	488	211	0	684	68	339	

ESRI Public Transit Tools

Software Type (Planning / Operations): Predominantly a planning software but includes minor operational elements like time it takes to reach a certain area of town via public transit. The main purpose of Network Analysis Tools is to use public transit data to model public transit services.
Output Type: Many Resource Requirements to Many Outputs
Inputs:

- Feature Set and Feature Layer
- Raster Dataset and Raster Layer
    - TIFF, JPEG, Esri Grid, MrSid
- Double
    - Numeric value *with* fractional values within a specific range
- Long Integer
    - Numeric values *without* fractional values within specific range
- String (text)
- Date
- Base Map
    - OpenStreetMap
    - Local Map File
- Transportation
    - General Transit Feed Specification (GTFS)
- Land Use

Outputs:

- Maps contain scale, projection, purpose, symbolization, focus, simplification, and abstraction
    - Map types include -
        - Planimetric - portrays the horizontal positions of features (e.g, municipal base map)
        - Topographic - portrays features of earth's surface (e.g., elevation, hydrography, and cultural features)
        - Cadastral - represents boundaries of land parcels, ownership, land use, and value (e.g., municipal parcel map)
        - Image
        - Thematic - visualize spatial relationships and patterns (e.g., choropleth, proximal, isopleth, and point dot maps)
- Cartograms maps that distort geographic features based on the output values rather than size.
- Charts Pie charts, histograms, line charts, and additional pictures
- Directions showing how to get from point A to point B. This becomes available when running a network analysis based on moving a structure.

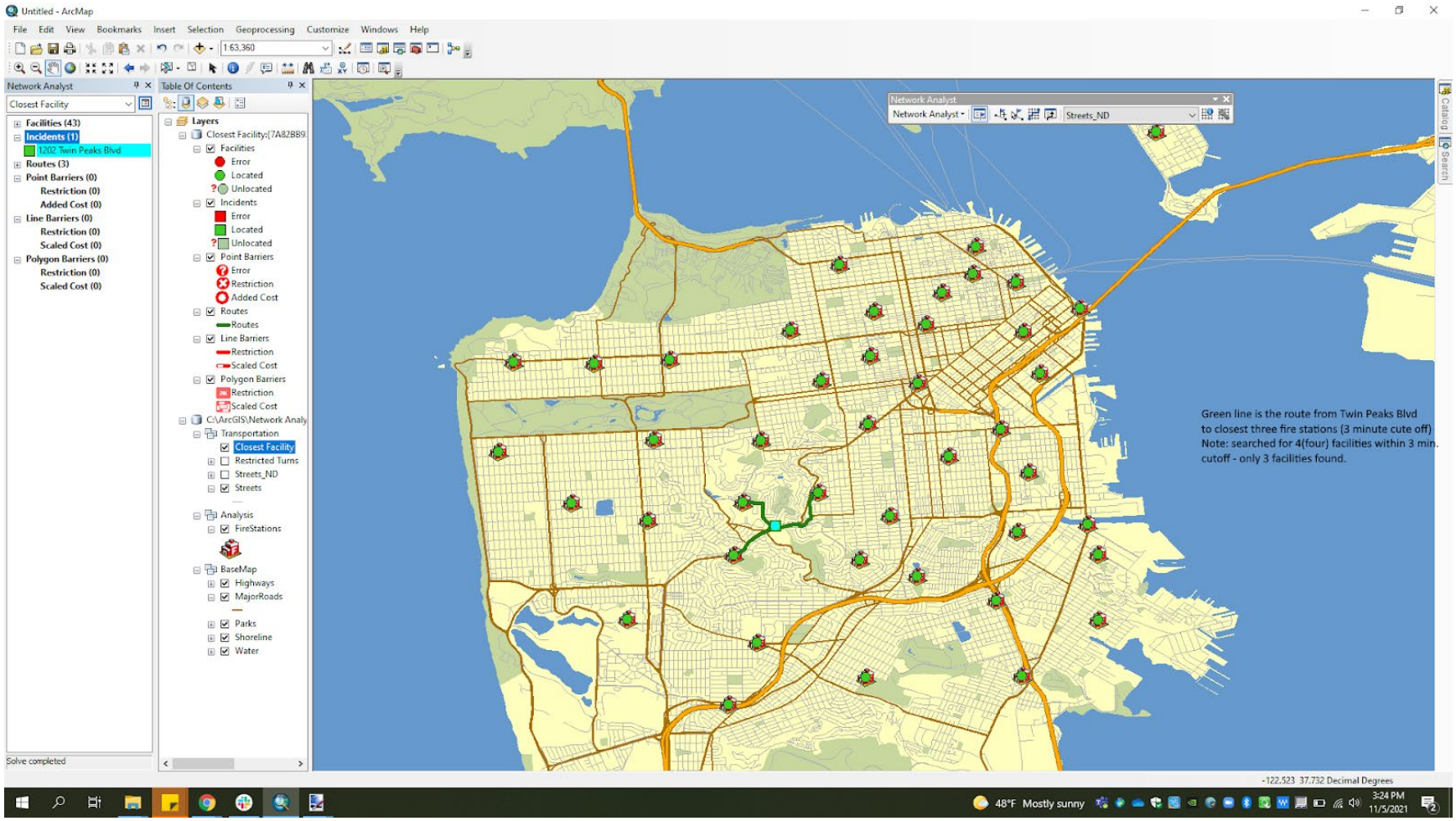
Agency Resources Needs

- **Time Constraints:** ESRI Network Analysis is a function within ArcGIS. In order to run a network analysis, users have to provide the proper data and functions. Installation of ESRI requires an up-to-date ArcGIS license. Obtaining a license can take anywhere from 1-7 days.
- **Staff Expertise Constraints:** Staff that will be setting up and inputting data functions should have a base level knowledge of data input and functionality of ESRI ArcGIS. If staff need to create their own data inputs, they should have a working knowledge of ESRI ArcGIS and how to import/export data measures, base maps, feature sets and layers.
- **Technology Environment:**
    - **Software Requirements**
        i. ArcGIS 10.1 - 10.8.1 (Basic License Level)
- **Analysis Design:** ESRI Network Analysis offers several analyses that require user-defined parameters to generate any type of report or map. Analysis 'reports' are generated as a map accompanied with a table of contents that provide an overview of the data inputs.
- **Results Interpretation:** Results from analysis are displayed on the map as different features (e.g., polygons, points, and lines). These features are representative of the input data used to generate the final analysis. Features are accompanied by the table of contents that provides a written overview of information on the map.

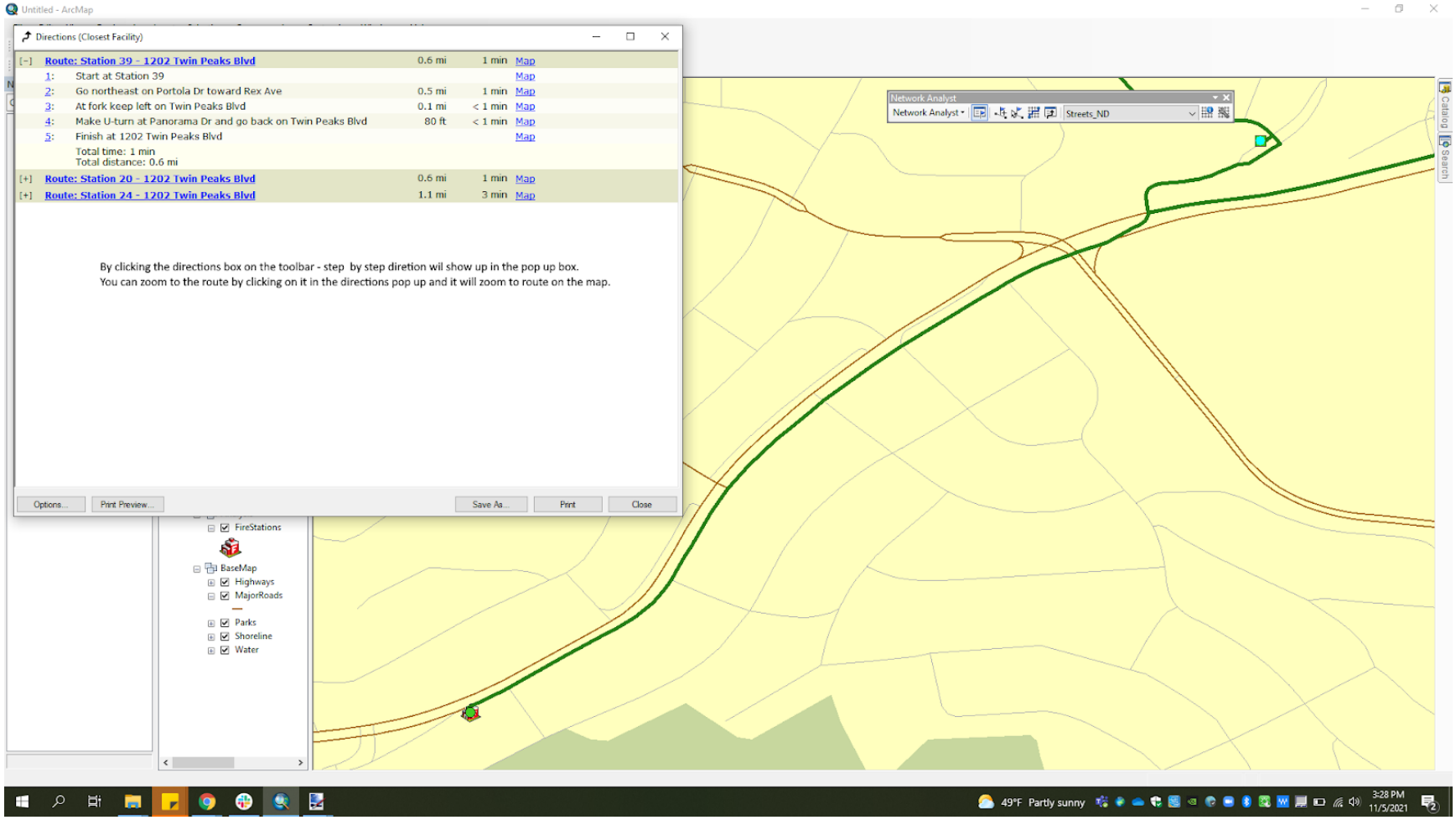
Software Considerations

- **Data Resources Needs:** Data requirements include ArcMap and a basic understanding of its tool bars and table of contents.
- **User Interface Navigation:** The user interface navigation for ArcGIS is beginner friendly in comparison to other software. Users can learn as they go with ArcGIS interface, the more use the easier it becomes to navigate.
- **Complexity of Analysis Process:**
- **Customizability:** Customizability varies within ArcGIS. Users set the parameters in order to identify specific data features (e.g., locating new facilities, finding populations underserved by transit or particular types of facilities, transportation routes between two businesses etc.) The software has the potential to be significantly robust with the type of analyses performed.
- **Support:** ESRI and ArcGIS have regular updates to the software, comprehensive manuals for ArcGIS online and ArcGIS Desktop programs. Based on the agency a license is required to access any of the Arc/ESRI interface.

ESRI Public Transit Tools – Output Sample 1



ESRI Public Transit Tools – Output Sample 2



Conveyal

Software Type (Planning / Operations): Primarily an operations-oriented software, designed to facilitate discussions, engagement, and consultation between planners, riders, and community stakeholders.

Inputs: Data inputs are based on the project staff has selected. The data inputs are dependent upon the bounds and region staff selects. When creating a new project, staff must first create new regions and bounds.

- OpenStreetMap (OSM)
- Transportation
    - General Transit Feed Specification (GTFS)
- Polygonal Zones
- Lists of Points

Outputs: Configuring two layers to compare different situations/scenarios can be displayed in the following ways;

- Raster Data Layer
    - Composed of pixels and specified by end points.
    - Utilizes polygons and and boundaries through mathematical outputs
    - .BMP, .TIF, .GIF, .JPG
- Vector Data Layer
    - Composed of paths, continuous smooth and straight lines
    - Utilizes points
    - .SVG, .EPS, .PDF, .AI, .DXF
- Dot Density Layer

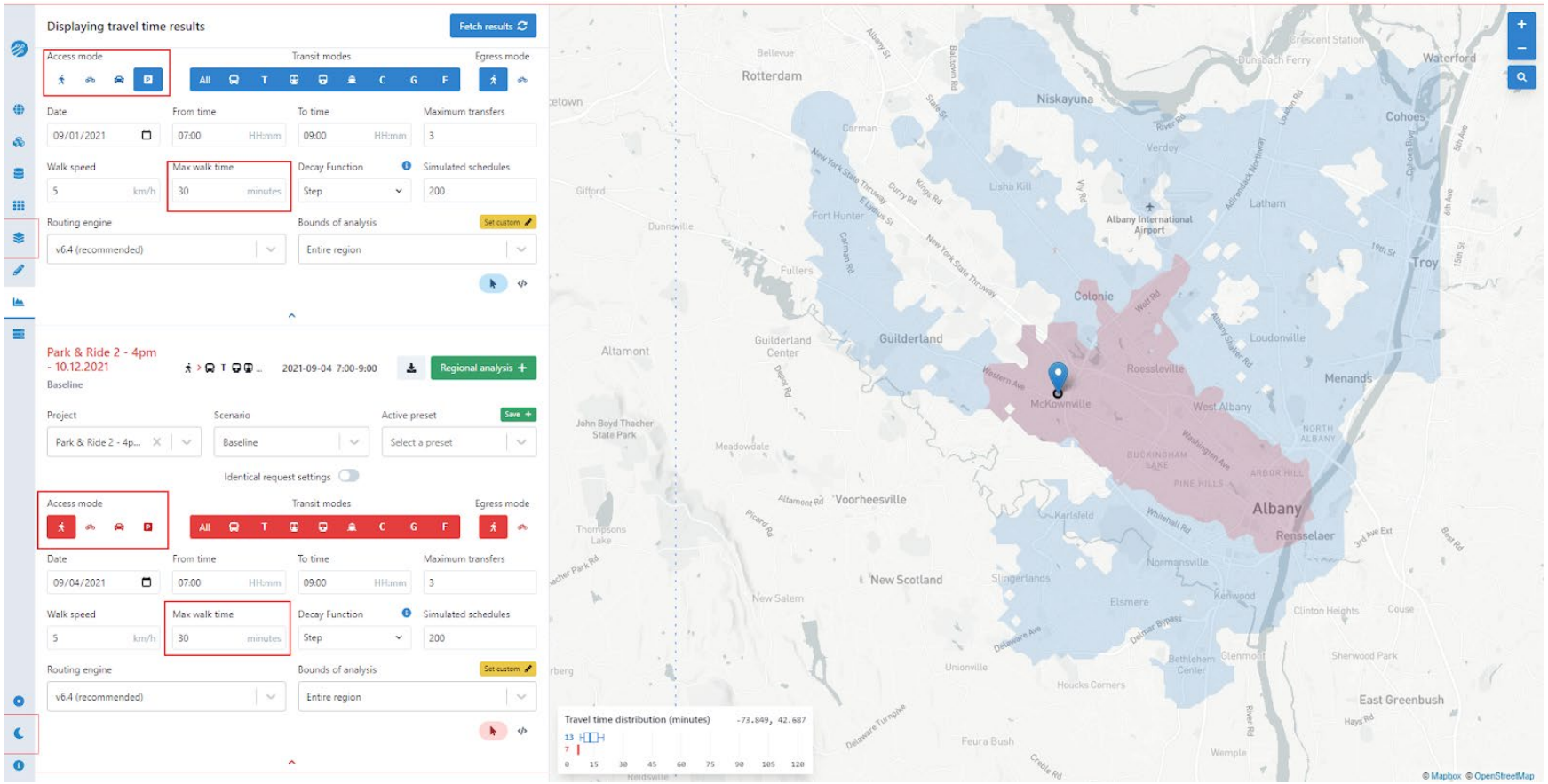
Agency Resources Needs

- **Time Constraints:** Conveyal is an open-source software network accessible online. Due to the nature of the software, setting up should take no more than one (1) business day.
- **Staff Expertise Constraints:** Staff will oversee uploading GTFS data into the Conveyal network and running analyses based on these inputs. Staff should have a basic knowledge of analysis runs and interpretation.
- **Technology Environment:** Online software does not require installation of additional programs. To enhance staff experience, having and using ArcGIS can provide additional data analysis.
- **Analysis Design:** Conveyal analysis provides a down to the second accuracy when exact details and data are provided.
- **Results Interpretation:**

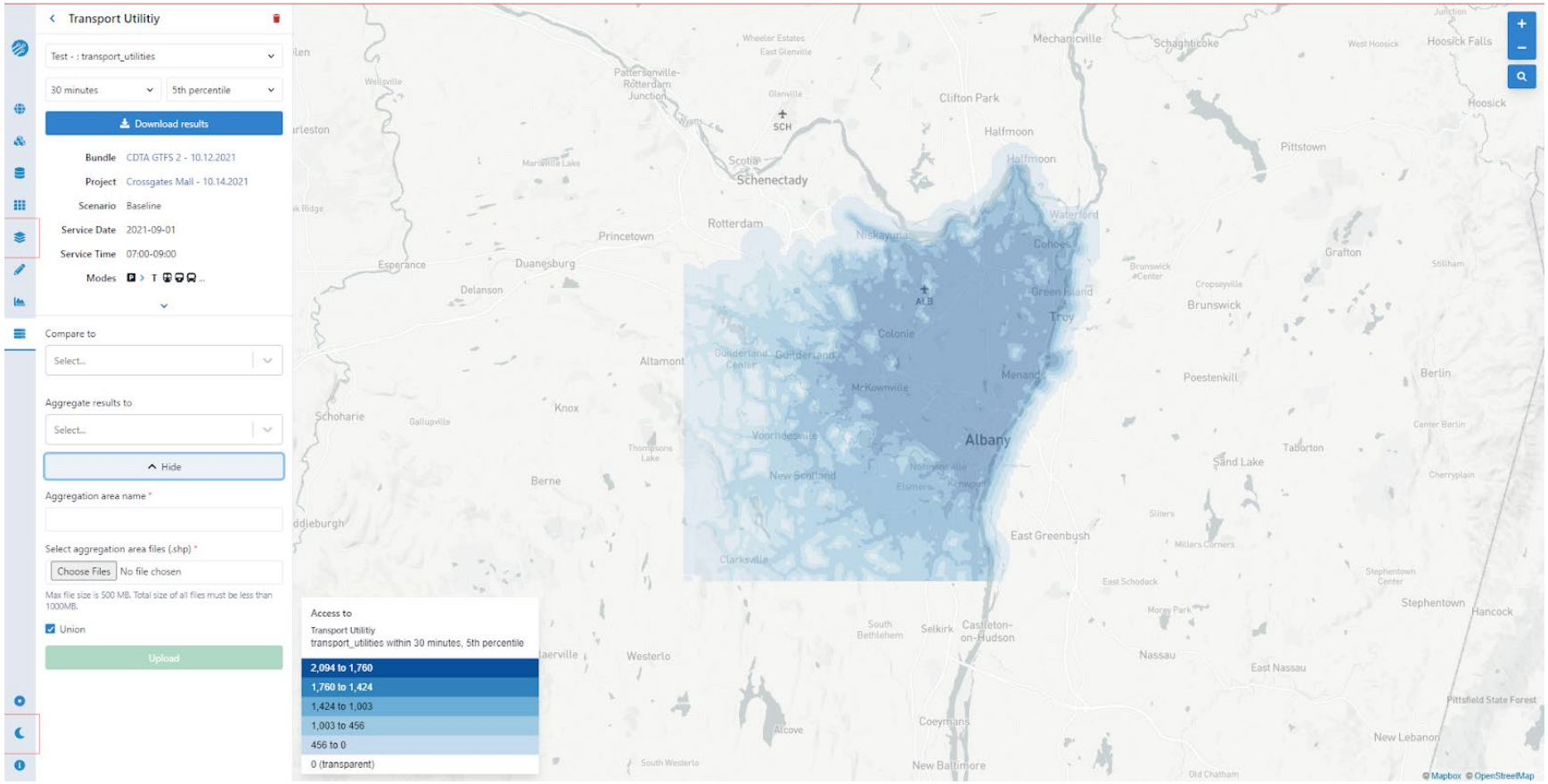
Software Considerations

- **Data Resources Needs:**
- **User Interface Navigation:**
- **Complexity of Analysis Process:**
- **Customizability:**
- **Support:**

Conveyal – Single Output Analysis



Conveyal – Regional Analysis



TransCAD

Software Type (Planning / Operations): Planning

Inputs:

- ACS/Census
- HERE
- CTPP
- LEHD
- TP+
- EMME
- TRIPS
- QRSII
- TMODEL
- TRANPLAN Cube Formats
- GTFS
- GIS shapefiles

Outputs:

- GIS shapefiles
- Maps
- Trip Generation Estimates

Agency Resources Needs

- **Time Constraints:**
- **Staff Expertise Constraints:**
- **Technology Environment:**
    - **Required Software**
        i. Microsoft Windows 7, 8, or 10 (Windows 10, 64-bit is recommended)
    - **Recommended Hardware Specifications**
        i. 6, 8, or 12+ core CPUs are recommended (Intel i5 line were noted as "satisfactory")
        ii. 16-32GB RAM or greater
        iii. 500GB of storage space, with SSD highly recommended
        iv. Graphics Card with 128MB video memory required, but 1+GB is recommended. (Integrated Intel HD Graphics are noted as functional but with lower 3D performance)
        v. Virtual Computing Environments are highly discouraged
        vi. Power Supply Units of 1500VA rating are recommended
- **Analysis Design:**
- **Results Interpretation:**

Software Considerations

- **Data Resources Needs:** Data resource appear to require limited configuration before importation into TransCAD. In software data configuration can involve “join” (relate) functions between data sets and attribute editing.
- **User Interface Navigation:** The user interface is moderately intuitive to users with ArcGIS experience. Map view takes up most of the screen space with tools lining the top of the UI. The UI is easily navigable and less intimidating than many other software.
- **Complexity of Analysis Process:**
- **Customizability:**
- **Support:**

Trapeze, Optibus, Hastus

The Research Team is waiting for a demonstration of the software, further information about the software is forthcoming.

Software Type (Planning / Operations): Predominantly an operation software but includes minor planning elements like community mobility planning and fixed route scheduling.

Inputs:

Outputs:

Agency Resources Needs

- **Time Constraints:**
- **Staff Expertise Constraints:**
- **Technology Environment:**
- **Analysis Design:**
- **Results Interpretation:**

Software Considerations

- **Data Resources Needs:**
- **User Interface Navigation:**
- **Complexity of Analysis Process:**
- **Customizability:**
- **Support:** Trapeze offers hands-on training on-site, through webinars and workshops. Technical support is available 24/7 when you are a registered user.

Remix

The research is awaiting a demo of the software, further information about the software is forthcoming.

Software Type (Planning / Operations): Predominantly a planning software but includes minor operational elements like bus and driver scheduling.

Inputs:

- GIS Data Platform
- General Transit Feed Specification (GTFS)
- GTFS-Ride
- Shared Street
- MDS
- GBF
- OpenStreetMap (OSM)

Outputs:

- GIS Map
- Ridership
- Origin Destination Data
- Collisions

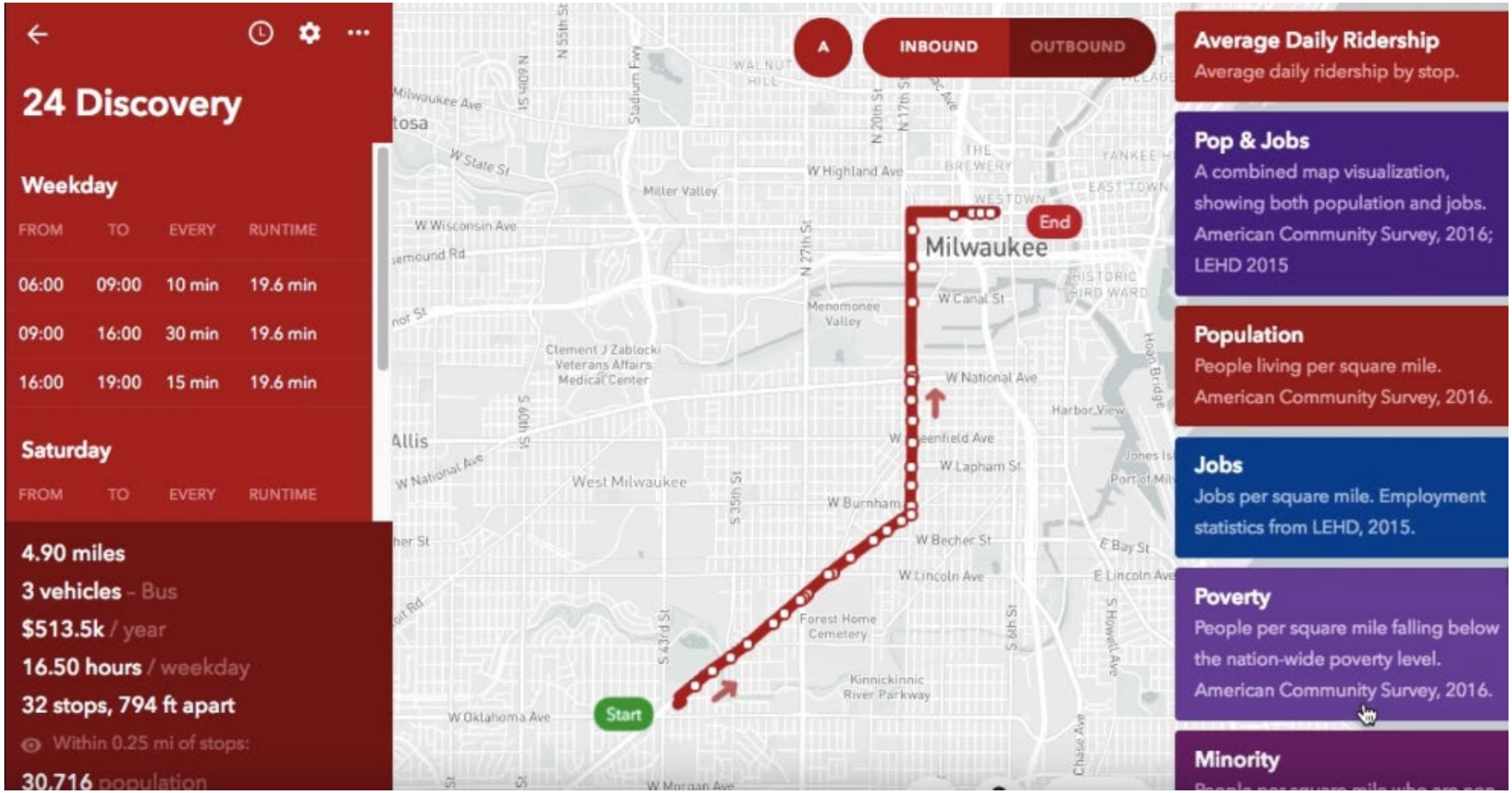
Agency Resources Needs

- **Time Constraints:**
- **Staff Expertise Constraints:** Companies and Staff need to acquire a license in order to utilize the Remix software.
- **Technology Environment:**
- **Analysis Design:**
- **Results Interpretation:**

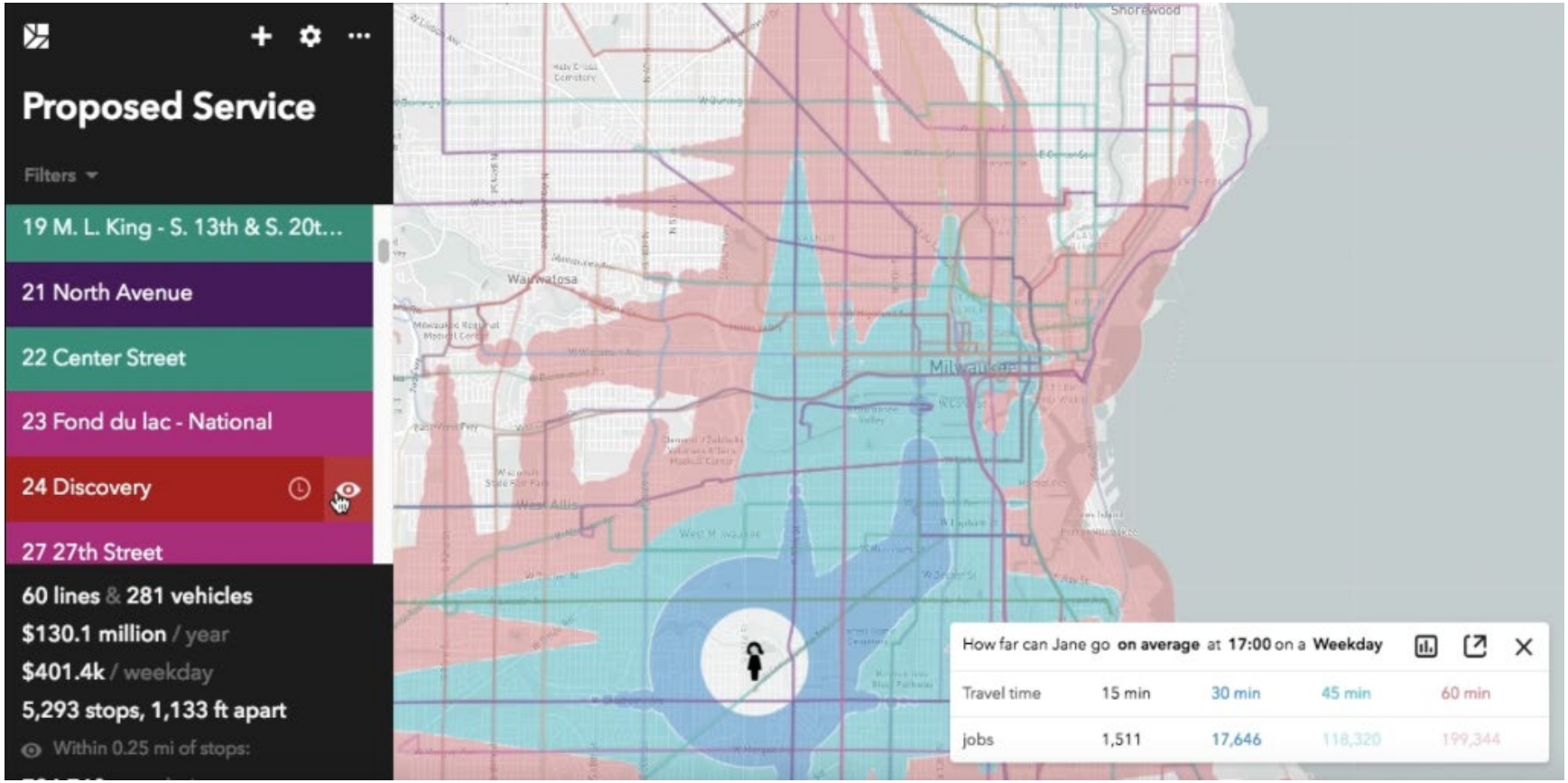
Software Considerations

- **Data Resources Needs:** Remix is a cloud-based software. It provides constant improvements and upgrades.
- **User Interface Navigation:**
- **Complexity of Analysis Process:**
- **Customizability:** Staff can create custom GIS layers through data inputs.
- **Support:** Remix offers support through their website. The 'Resource' tab on the homepage offers a resource library accustomed with white papers, webinars, e-books, and blogs. The website offers a 'Get In Touch' section that provides a link to a help center with additional help resources.

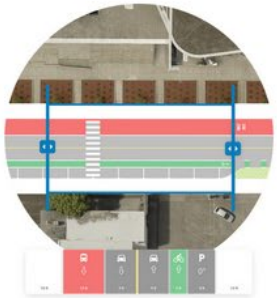
Remix – User Interface



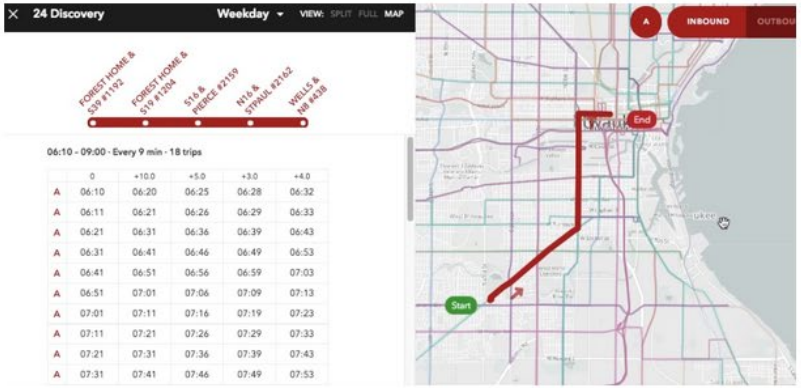
Remix – User Interface



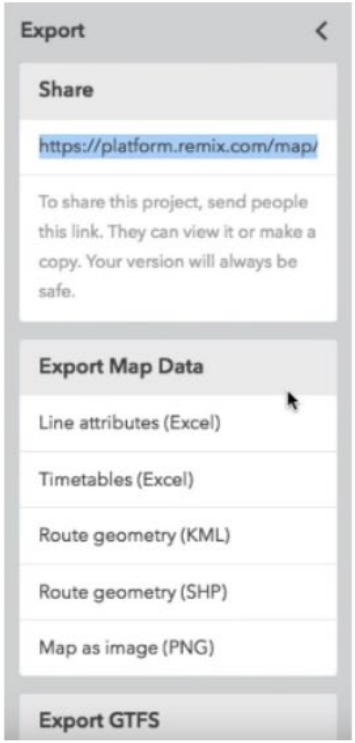
Remix – Sample Outputs



Street Designs



Route Details



Map Data Exports

C. Software Goals Matrix