Oswego: Service Alignment Study

NYSAMPO Shared Transit Project
3/21/2023

Table of Contents

Table of Figures

Executive Summary

Oswego is served by Centro bus service which provides local service within the city, dedicated service on and around the SUNY Oswego campus, and regional connections to Mexico, Fulton, and Syracuse.

The objective of this pilot project was to develop and then test a prospective redesign of Oswego's City Bus service by using two innovative travel demand analysis tools: Replica's synthetic travel-demand datasets and the Federal Transit Administration's Simplified Trips-on-Project Software (STOPS) open-access travel-demand modeling software package.

Replica data were employed to identify and prioritize among travel markets in Oswego. The prospective system redesign involved a primary east-west route along Rt. 104 (Bridge Street) and a secondary, less-frequent route to provide coverage to specific transit generators to the south of Bridge Street.

After developing prospective alignment and schedules, the operations of those changes to the Oswego city bus routes were coded using the industry-standard GTFS data format forming the primary input for running STOPS software.

It was found that the prospective redesign trades route-coverage for more service on the Rt 104 corridor, which would have negligible effects on ridership – in fact a decrease of 2.5% from 442 to 432 passenger-journeys per weekday. However, sensitivity analyses (which considered various combinations of routes, headways) show that 90% of the system's daily ridership could be served by operating only two bus vehicles along Rt 104, with the 3rd bus serving the off-corridor destinations providing much less productive service (in terms of ridership).

The Replica data were found to be very easy to access and process into a usable Transit Propensity Index that was Origin-Destination based (which extends from standard practice using Census and other spatial datasets). STOPS was found to provide credible forecasts in the context of this small-scale transit system, which is in contrast to the major capital investments in larger metro areas that STOPS was initially designed to model. A consistent theme was that specialized knowledge of travel demand modeling was key to this pilot study's success, meaning that ensuring knowledge-pooling/-sharing across NYS's planning agencies would be key to ensuring that the learning curve is as smooth as possible for staff and/or consultants.

Problem Statement

The Central New York Regional Transit Authority, commonly known as “Centro”, operates transit service primarily in and around the City of Syracuse (population ~150K) in Onondaga County. In addition, it provides bus service in the vicinity of the smaller City of Oswego (pop. ~17K) through Centro’s Oswego Division.

The Oswego Division’s City Routes (Routes 1A, 1B, 1C, 1D, 2A, 2C, and 2D as depicted in the Route Map below) provide local service within the City of Oswego. These routes complement the Oswego Division’s longer-distance routes (Routes 3 and 246) which connect to Mexico, Fulton, Phoenix, and Syracuse, as well as the on-campus routes that serve SUNY Oswego.

The focus of this Pilot is the City Routes, which were last critically evaluated decades ago. Centro operates three bus vehicles on the City Routes.

Per discussions with Centro planning staff, this Pilot aimed to use an evidence-based approach to propose a redesigned set of City Routes, and to then establish what the ridership impacts of redesigning the system would be. The starting point for the network redesign was an ambition to straighten and rationalize the City Routes, which currently follow indirect routings to serve various locations in the City of Oswego (see Figure 1).

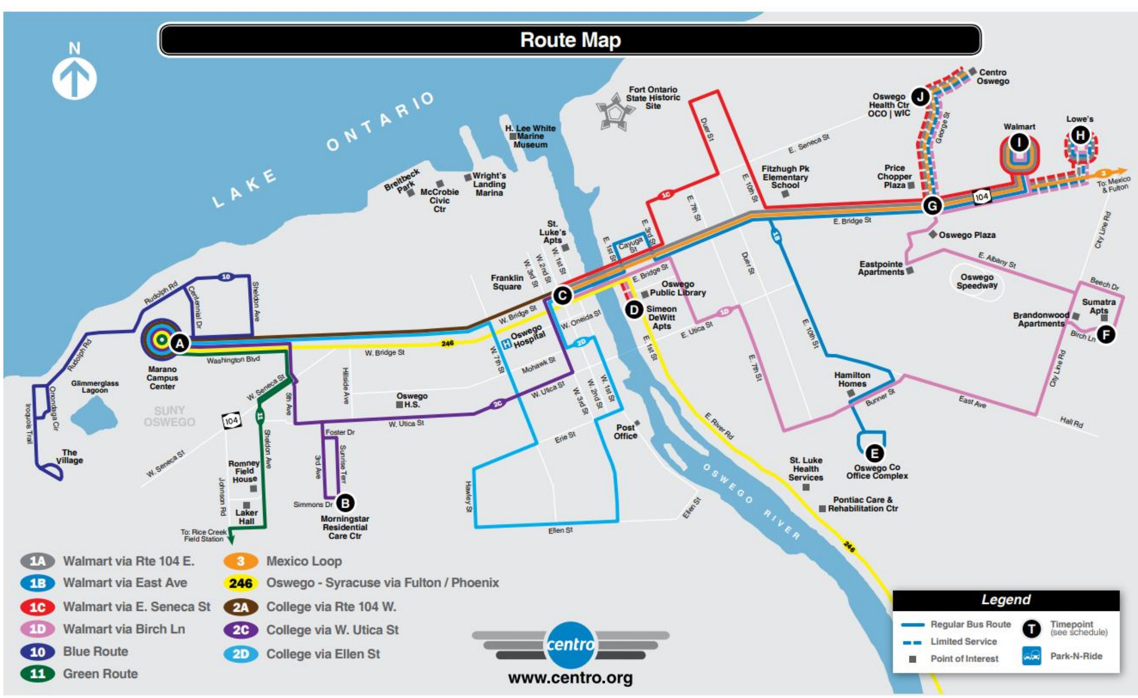

Figure 1: Existing Bus Services Provided by Centro Oswego Division in Vicinity of City of Oswego

Solution

Overall Approach

The workflow involved two workstreams that were undertaken sequentially.

The first task involved preparing the proposed redesign of Oswego's City Routes. This was a route-planning effort in which a workable solution needed to be informed by best-available data on travel demand patterns in Oswego and was also feasible operationally. The main work product of this task was a proposed service plan.

Once the service plan was complete, the second task was to prepare ridership forecasts for the proposed system redesign. The objective was to quantify the impact of the service plan on ridership, as a key piece of decision-support information for Centro to consider.

Overview of Transit Propensity Indices

A traditional approach for evaluating candidate locations for increased (or decreased) transit service is to evaluate a Transit Propensity Index (TPI)[1] for a small-area Census geography (Census blocks, block groups, or tracts). Typical inputs into a TPI formula include indicators of propensity to use transit, such as overall population, low-income population, population identifying as racial/ethnic minority status, overall employment, employment in sectors such as retail, etc. Data is generally drawn from the decennial Census[2] and/or related datasets such as the Census Bureau's American Community Survey[3] which is a smaller-sample survey that includes information that is not collected in the decennial Census (e.g., household income).

Calculating a Transit Propensity Index for each small-area unit of geography results in a two-dimensional surface, with some of the areal units identified as scoring high in transit propensity and others scoring low. This provides the evidence base that a bus service planning team would then use to re-design bus routes. A sample mapping of a TPI surface is shown in Figure 2.

[1] See e.g. https://www.cutr.usf.edu/wp-content/uploads/2012/08/propensity.pdf
[2] https://www.census.gov/programs-surveys/decennial-census.html
[3] https://www.census.gov/programs-surveys/acs

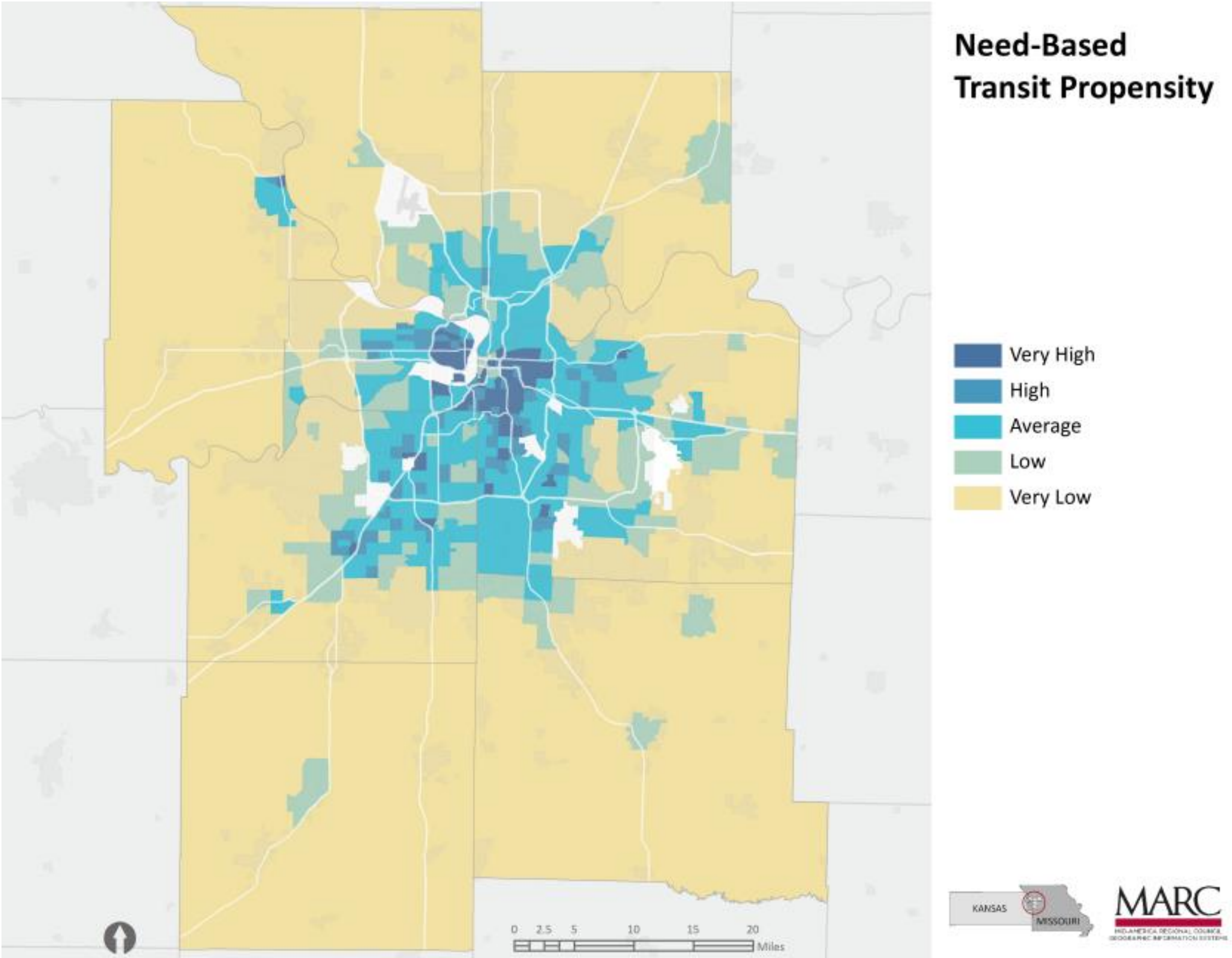

Figure 2: Example of a traditional two-dimensional mapping of a Transit Propensity Index for transit-service planning purposes. Source: http://www.kcsmartmoves.org/pdf/PlanDocuments_2017/Appendix_F.pdf

Need and Value for New Data Sources to Support Enhanced Transit Propensity Indices

The traditional approach to developing a Transit Propensity Index has several shortcomings:

1) Not sensitive to day-of-week or time-of-day, thus does not provide evidence which could be used to determine span-of-service
2) Not sensitive to the origin-destination patterns of prospective transit riders, and rather focusing on unlinked trip ends (origins separately from destinations)

Software Tool for Transit Propensity: *Replica*

This Pilot drew on *Replica*[4] data to perform an extended analysis of transit propensity. Replica data is a commercial data product to which all MPOs in New York State now have access through the vendor's online portal. Replica is a synthetic travel-survey database with advanced relational characteristics; it is described by its vendor as a *"High-fidelity travel model with simulated population and trip-taking activity"*.

Replica data are synthetic and fused from a variety of sources, such as the decennial Census and American Community Survey datasets noted above, as well as Census Transportation Planning Package (CTPP) data, Longitudinal Employer-Household Data (LEHD), in-vehicle GPS traces, and published count data such as Average Annual Daily Traffic (AADT). Replica data are generated for a representative day (separately for weekday or Saturday) of a season (e.g. the latest available data represent either a Thursday or Saturday, at the selection of the data-user, in Fall 2021). Replica data are available both in summary form through the online portal, or in disaggregate form (in format very similar to traditional travel-survey microdata). A major advantage of

Replica synthesizes the type of data that would normally come out of a custom regional travel survey, which does not exist in many parts of the country – including Oswego. In addition to providing quasi-travel-survey data where none exists, another strength of Replica data is that it, in principle, represents *all* travel rather than the small-sample slice of a region's travel (typically in the low single-digit percentages or lower) that can realistically be sampled in a regional household travel survey.

Additionally, Replica makes use of advanced relational-database functionality to allow the user to query the data in useful ways. For instance, a user could query all trips within a region, only trips that begin and/or end within user-defined locations, or only trips that make use of user-specified segments of a road network. Trip characteristics that are reported by Replica include journey purpose and time-of-day.

Figure 3 shows the spatial pattern of trips to retail centers in eastern Oswego. The unit of geography is census blocks: while Replica's standard smallest unit of geography is the census block-group, there is a function to allow the user to request that Replica make data available in a particular location at finer-scale geography, which was done on this Pilot. On the right-hand side are various characteristics showing the time-of-day profile of trips that begin in this shopping area, the pattern of mode usage (dominated by auto-driver and auto-passenger), and the distribution of journey purpose (dominated by shopping, as would be expected given the retail land use). While the data-presentation of Replica's online portal shown in Figure 3 is somewhat basic, the user can download (in the open CSV data-format) the microdata that underpins this visualization, and use any other desired visualization tool or approach.

[4] https://www.replicahq.com/

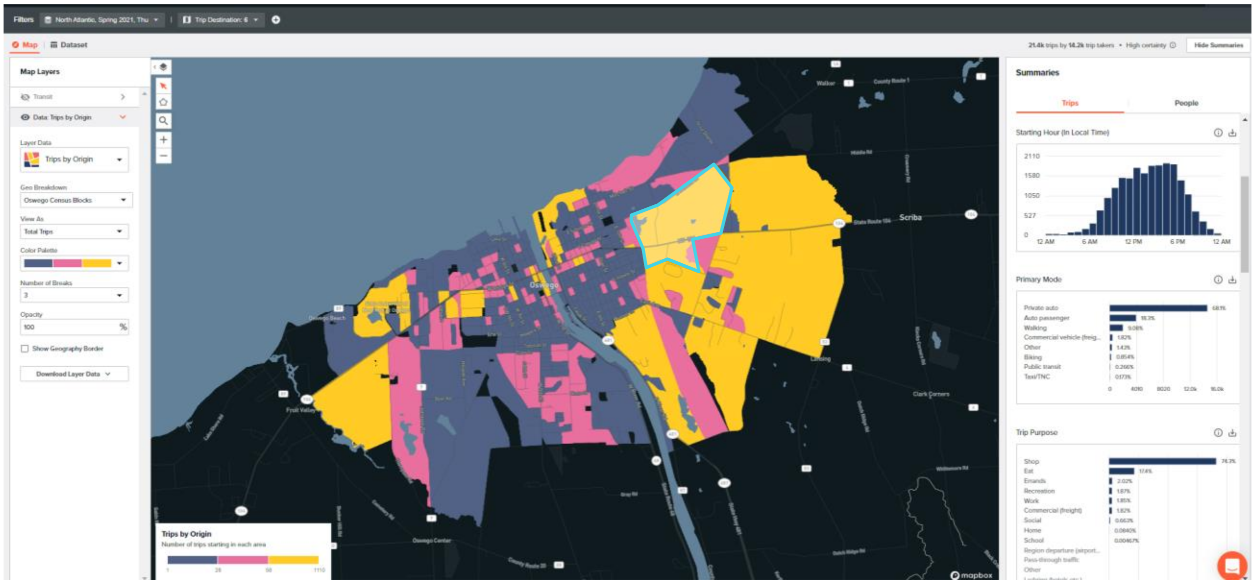

Figure 3: Replica online portal depicting the destination pattern of all trips which begin in the highlighted shopping district in eastern Oswego.

Preparation of Enhanced Transit Propensity Index

For this Pilot, we generated an enhanced Transit Propensity Index using the origin-destination attribute of Replica data, which provides functionality that extends beyond what can be done with a typical two-dimensional TPI surface (see Figure 2).

To do this, we first generated an origin-destination matrix of trips in Replica's synthetic database that met both of the following characteristics:

- Household income under $30,000/year
- Household car ownership of zero or one

Replica's system facilitated on-the-fly testing of various permutations of transit-propensity criteria (e.g.. HH income under $50K, only zero-car HHs, etc.), allowing the Research Team to conduct a sensitivity analysis to determine which criteria listed above which were found to work best for this Pilot's application.

The microdata for trips in Oswego that meet the specified transit-propensity criteria were exported from the Replica online portal and seamlessly imported into ArcMap, using the longitude/latitude coordinates of each block group. The mapping of the origin-destination pattern of trips meeting this Pilot's Transit Propensity Index attributes is shown in Figure 4. The O-D pairs highlighted in light-blue are in the top-10 O-D pairs in Oswego County. For reference, Figure 5 shows this same data but in a traditional Transit Propensity Index's two-dimensional surface, by mapping only origins rather than connecting origins and destinations as in Figure 4.,

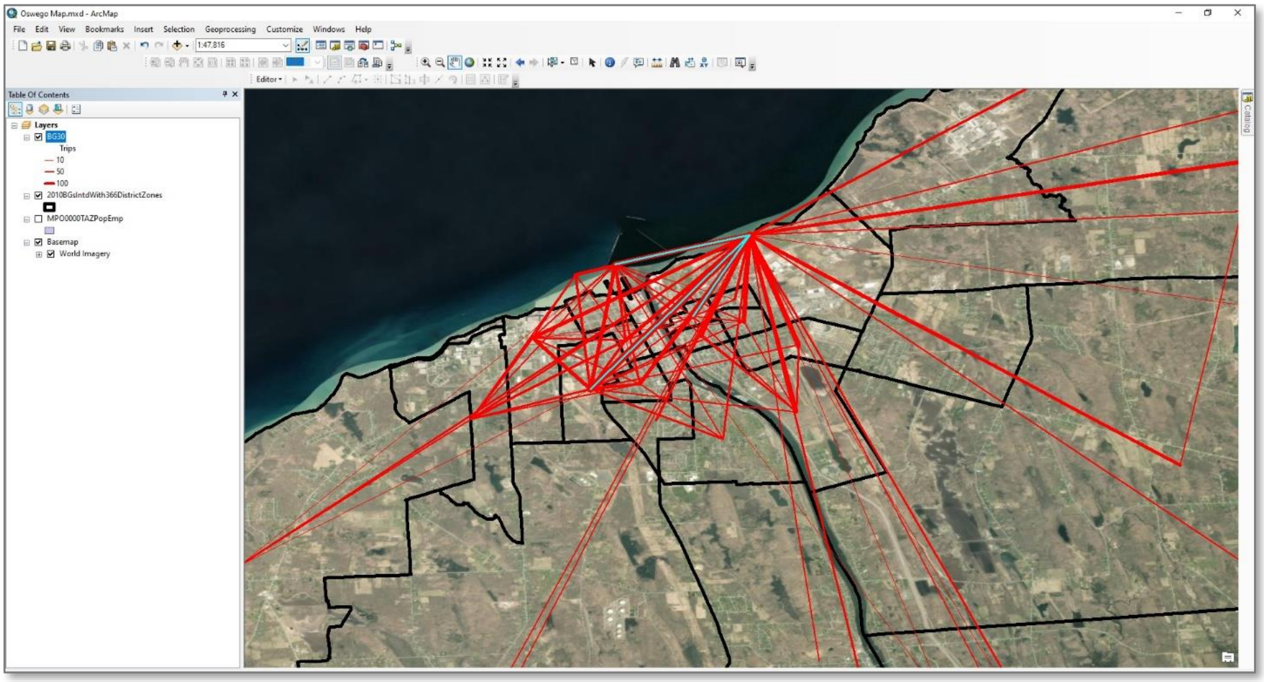

Figure 4: Mapping of origin-destination pattern of trips meeting this Pilot's Transit Propensity Index criteria

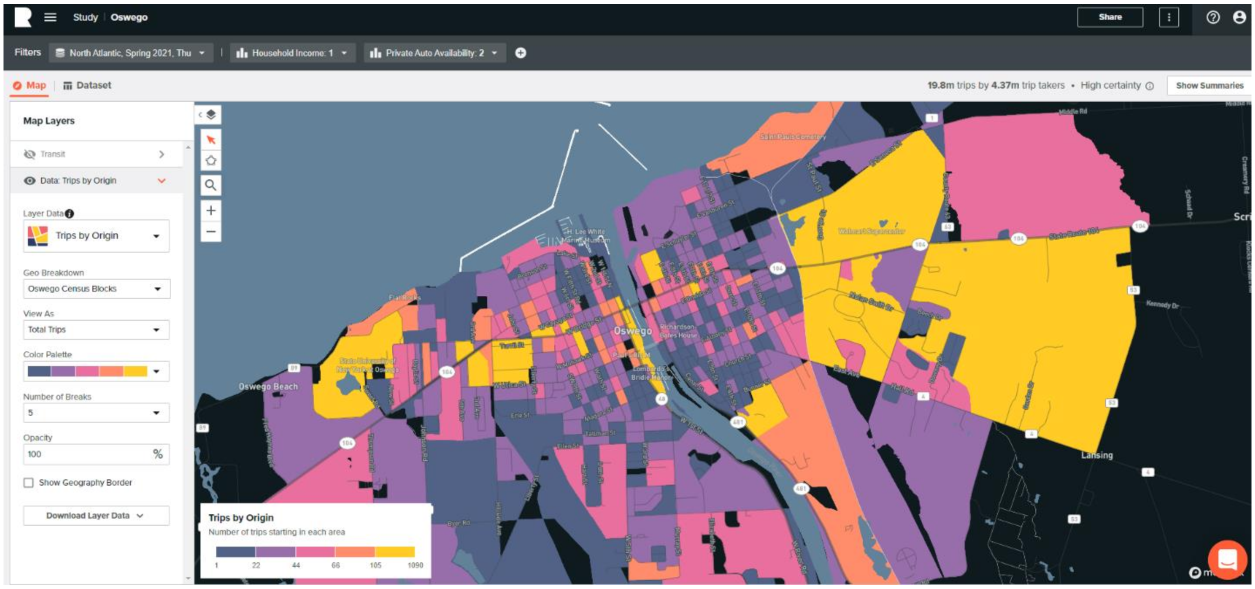

Figure 5: Two-dimensional mapping of this Pilot's Transit Propensity Index

Inputs Into Bus-Service Redesign

In order to develop the proposed redesign of the Oswego City Routes, the Pilot Research Team took into account the following information:

- The enhanced OD-based Transit Propensity Index generated from Replica data (see previous section)
- Ridership data (boardings) for Oswego's City Routes' bus-stops from Centro's Automatic Passenger Counter (APC) system (see Figure 6). APC data identified the SUNY Oswego campus, the Wal-Mart, and the City Center as the three largest generators of transit boardings.
- Guidance from Centro staff to consider straightening and simplifying the bus services
- Existing service patterns and destinations served (see Figure 1 which shows existing service map with major destinations highlighted), including Centro's run sheets for the existing City Routes
- The City of Oswego's geographical context: a smaller-scale urban core with relatively limited surrounding development, which is oriented east-west but with limited bridge crossings of the north-south Oswego River
- Feedback from Centro staff regarding physically difficult bus movements (e.g., locations where right-turns cannot be easily navigated by a bus) to be avoided

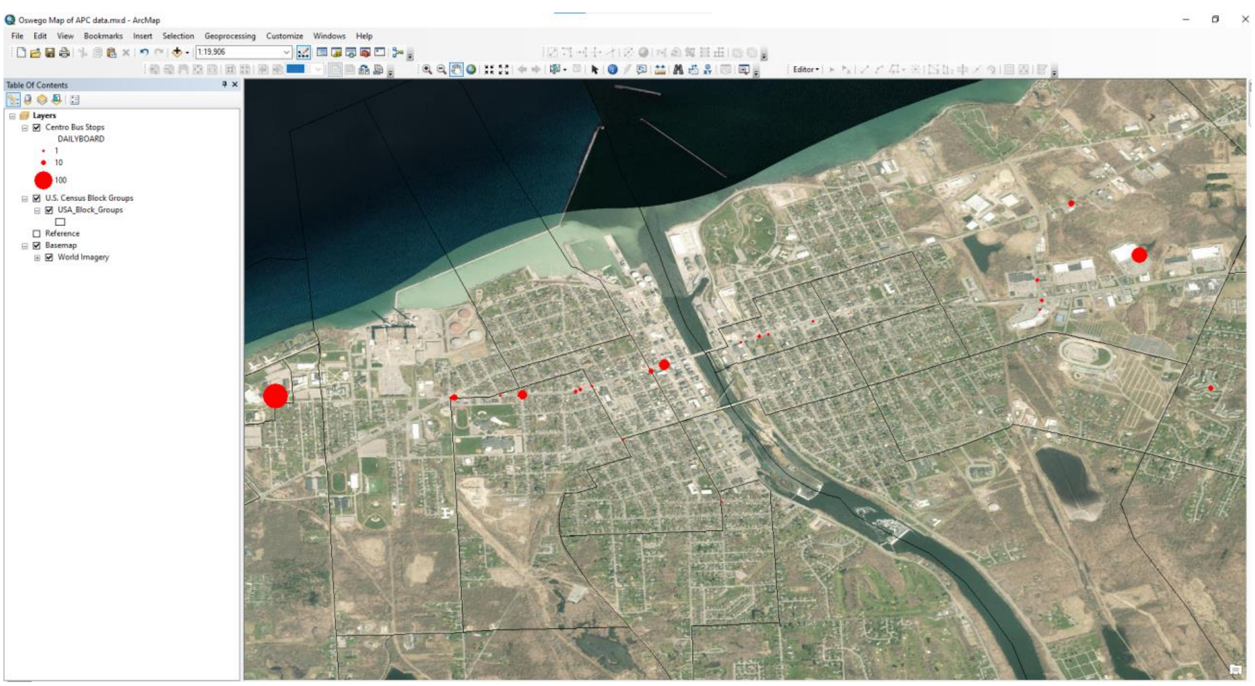

Figure 6: Number of boardings at bus stop locations from Centro's Automatic Passenger Counter data. SUNY campus is at west; Wal-Mart is at east; City Center is in the center of map immediately to west of Oswego River

Prospective Bus-Service Redesign

An iterative process was undertaken by this Pilot's Research Team and Centro staff to develop the proposed bus-service redesign, which accounted for the inputs enumerated in the previous section.

The prospective service maintains the east-west orientation of the existing City Routes, as well as the number of buses operating (three). Service is consolidated onto one higher-frequency route which operates east-west along Rt. 104 (Bridge Street) and connects between the SUNY campus in the west, the City Center in downtown Oswego, and the Wal-Mart and other nearby shopping opportunities in the east. This "High-frequency route" would be served by two buses operating in opposite directions. Additionally, a lower-frequency route ("South route") is proposed, with an allocation of one bus, which serves a number of important destinations that are roughly ¾-mile to 1-mile to the south of Rt. 104. Figure 7 depicts the two proposed routes; the High-frequency route would generally operate 30-minute headways, and the South route would generally operate 120-minute headways.

Figure 7: Prospective redesign of Centro's City Routes in Oswego

Preparation of Inputs for Ridership Forecasting

The next task involved preparing the set of inputs that would be used to develop the ridership forecasts for the prospective system redesign. Three key pieces of information were required:

1) A complete description of the operations of the existing City Routes as well as the prospective system redesign in General Transit Feed Specification (GTFS)[5] data standard. Note that the STOPS ridership-forecasting software only considers bus operations during the weekday morning peak period (7:00 to 9:00) and weekday midday (12:00 to 2:00) periods, thus GTFS data is only required during these periods.
2) Data on existing bus ridership patterns in Oswego, for use calibrating the ridership model prior to application of it for generating the ridership forecast
3) A geographic zone structure to be used by the STOPS ridership-forecasting software

Ridership-Forecasting Input #1: GTFS Data

The General Transit Feed Specification is an industry standard data specification that is used by thousands of transit providers to describe their operations.

The GTFS specification consists of multiple simple text files that each describe a different aspect of a transit service[6]. The software selected for preparing the ridership forecasts (STOPS; see below) requires two sets of GTFS files as input: one that describes the existing transit service (which Centro provided to the Research Team) and one that describes the prospective modified service (which was prepared by the Research Team).

In this Pilot, four of the GTFS files required editing:

- **Routes.txt:** This datafile has one line per each route in a transit system. One new line of code was required for each new route, thus in the Route.txt file only two new lines of code were required (one each for the High-frequency route and the South route)
- **Trips.txt:** This datafile has one line of code per each time that a bus completes a run of a route. For instance, one bus traveling on the High-frequency route from SUNY to Wal-Mart is one 'trip' as defined by GTFS for use in this file, and the same bus traveling in the reverse direction back to SUNY is another trip.
- **Stop times.txt:** This datafile has one line per each time that a bus stops at a bus stop. A bus trip's trajectory is defined by the timepoint at which it arrives (and same for when it departs) a given bus stop location. This file grows large in the number of rows because there is one row per each bus-vehicle stopping at each bus stop. Figure 8 shows an example of part of a Stop times.txt file created for this Pilot, with a bus operating on the South Route starting at 6:00 AM at the SUNY campus and traveling stop-by-stop to end at the Wal-Mart at 6:50 AM. GTFS does not specify the turn-by-turn trajectory of a bus in revenue service, rather only the stop locations and the timepoints. The average speed of the bus trip is implicit in the timepoints; in this Pilot an assumed average operating speed of 10 mph was assumed for purposes of specifying the timepoints.

[5] https://gtfs.org/
[6] The full set of GTFS text files and the datafields expected in each of them can be found at: https://gtfs.org/schedule/reference/

- **Frequencies.txt:** This datafile has one line of code per each trip defined in the Trips.txt file. It allows the analyst to make reference to a defined bus 'trip' and specify that the trip is repeated on a recurring basis with a defined frequency (in units of minutes).

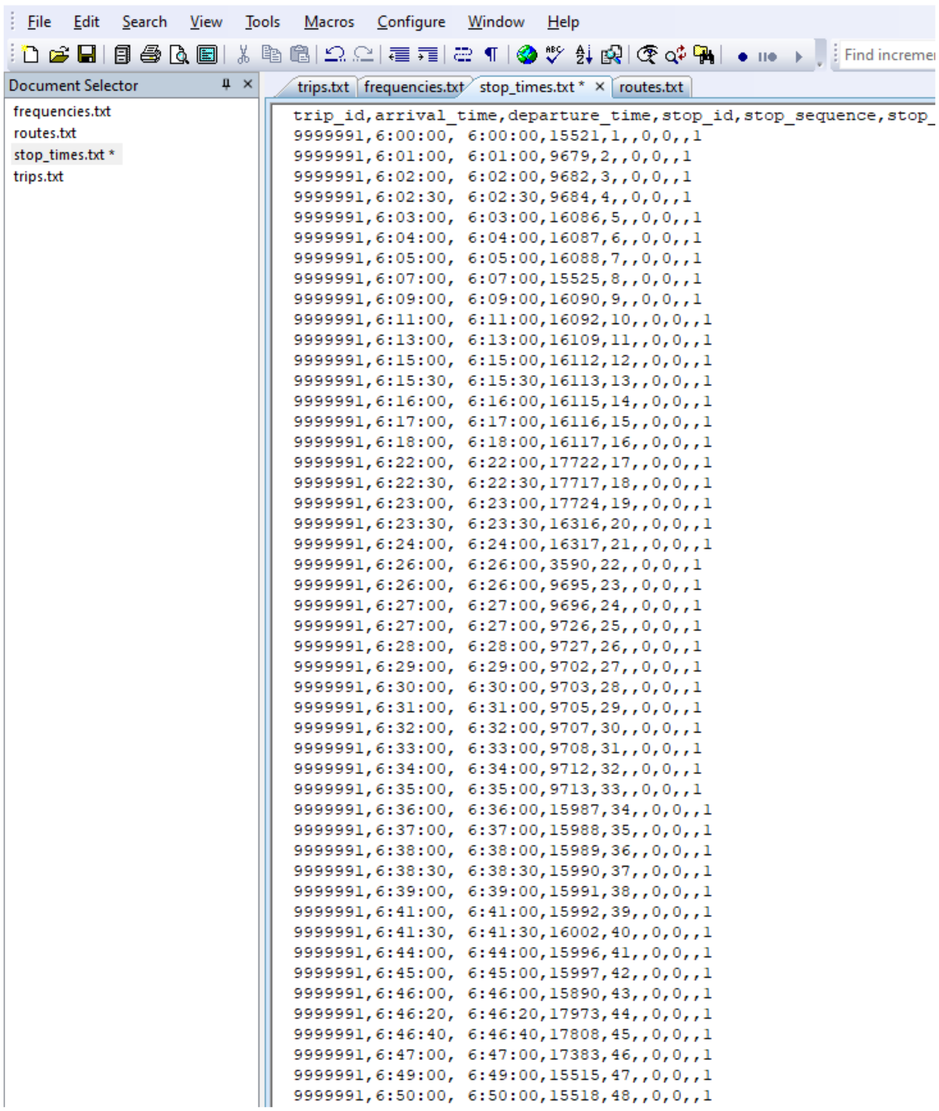

Figure 8: Example "Stop times.txt" GTFS file developed by the Research Team for the prospective system redesign

The most tedious and error-prone part of coding the GTFS of the prospective system redesign is the Stop times.txt file. For instance, an incorrect digit in a line of code could mean the entire set of GTFS files cannot be interpreted by STOPS, or that STOPS interprets an unreasonably fast or slow bus operating speed that is not what is intended.

Therefore, in order to error-check the GTFS coding, the Research Team made us of the "GTFSed" GTFS editor application[7] which can visually present the operations specified by a set of GTFS files (see Figure 9). Coding errors were much more easily identifiable in the visualization than by reviewing the GTFS text files themselves.

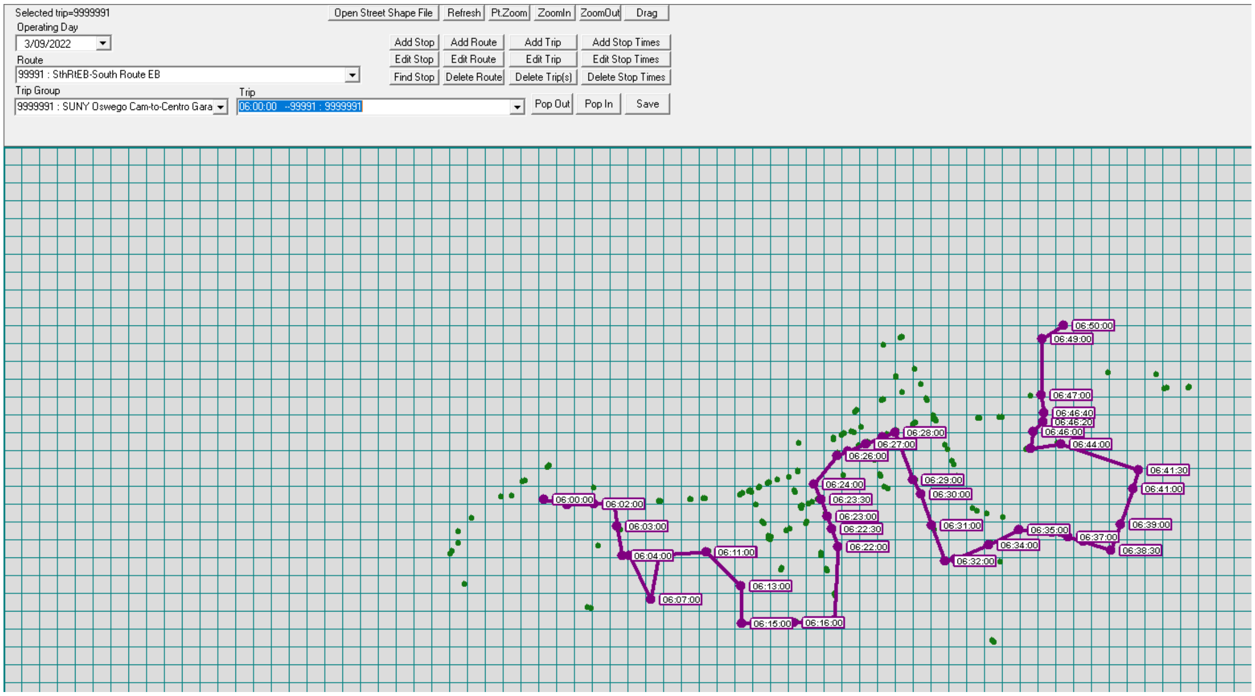

Figure 9: Example view of "GTFSed" editor, used to visualize a set of GTFS files. The prospective South route is shown in this image. All bus stops in the GTFS files are shown as green dots, and the stop-to-stop trajectory of the eastbound South route is shown in purple.

Ridership-Forecasting Input #2: Data on Number of Riders in Existing Conditions

The STOPS ridership-forecasting software is flexible to allow the user to input various types of data describing existing ridership of the current bus system. This flexibility allows STOPS to be used in situations where only very limited ridership data is available (i.e., total daily [weekday] system ridership), all the way to situations where daily ridership data at the unit of each individual bus stop is available or a bus-rider survey is available that captures origin-destination patterns of bus riders. STOPS then uses this information in a calibration process where the coefficients in the equations of the ridership-forecasting model are adjusted to attempt to approximately match the input of observed ridership data.

In the case of this Pilot in Oswego, Centro's APC data provided a rich data source that was exploited for this purpose. The Research Team first considered instructing STOPS to calibrate to observed boardings at

[7] The GTFS editor application is available on request from the Federal Transit Administration; interested readers are directed to contact information at: https://www.transit.dot.gov/funding/grant-programs/capital-investments/stops

each stop location. However, this option was abandoned because STOPS is based on a geographic zone system which may simulate all of the bus riders from a given zone boarding at one stop and none at another bus stop very nearby.

Therefore, the APC data were summarized into five geographic districts, and the calibration targets were the number of boardings within each district. The APC data were also averaged over weekdays in April so that ridership is modeled when SUNY Oswego is in regular session (during the spring semester).

Replica data of transit journeys can be used as targets to be used in model calibration, but in the case of Oswego the number of transit journeys within the synthetic Replica data was too low to be useful. Therefore Replica data were not used for this purpose, despite the Research Team having successfully used Replica data for model-calibration purposes in other assignments elsewhere.

Ridership-Forecasting Input #3: Geographic Zone System

The STOPS ridership-forecasting software has an automated process to generate the population and employment that it uses to forecast ridership, drawing on Census Transportation Planning Package (CTPP) and Journey-to-Work (JTW) datasets.

STOPS generally uses Block Groups as the geographic zones for representing trip origin and destination locations. In larger metropolitan regions this unit of geography works well and keeps computing requirements manageable. However, in a small region such as Oswego, the Research Team found that the Block Group level of geography was too coarse to generate reliable forecasts for the prospective bus system redesign.

Therefore, in consultation with the Federal Transit Administration (FTA; STOPS' sponsor), the Research Team specified Census Blocks (which are smaller than Block Groups) as the unit of analysis, and instructed STOPS to use them. This custom unit of geography was then found to yield more reliable current-day ridership estimates, and thus to increase confidence in the ability of STOPS to generate forecasts.

Additionally, STOPS is designed to use the zone system from an MPO's travel demand model (as well as the zone-to-zone travel times by automobile). This presented a unique challenge in this Pilot, because while Centro's main operations in Syracuse are within an MPO's boundaries (the Syracuse Metropolitan Transportation Council), Oswego is under the urban-population threshold to trigger a requirement for an MPO and is therefore not within an MPO's jurisdiction. To address this issue, the Research Team used Census Blocks in the City of Oswego (and Census Block Groups in the rest of Oswego County) as the geographic zone system, and generated zone-to-zone automobile travel times using an assumption of a representative 30 mph driving speed. This involved data processing within GIS (ArcMap) as well as spreadsheet software (Excel).

Software Tool for Ridership Forecasting: *STOPS*

The FTA has invested in development of the Simplified Trips-on-Project Software (STOPS) application, which is an open-access application that is *"…designed to quickly produce plausible forecasts of transit project ridership using readily available census data, transit ridership and schedule information."*

STOPS is open-access (the application; not the source code), free-of-charge and accessible from FTA's website[8], however users are advised that the website is not always maintained up-to-date, thus it is advisable to check with FTA prior to beginning a STOPS assignment to confirm that the latest version of STOPS, documentation files, and associated CTPP datafiles will be used. STOPS training courses are regularly offered through the National Transit Institute[9].

STOPS was designed to generate ridership forecasts for major capital investments in transit systems, which typically are found in the nation's large metropolitan regions. FTA confirmed to the Research Team that the application of STOPS in Oswego is towards the smaller scale of known STOPS applications nationally, and thus provides valuable insight into how STOPS works in small-scale cities with small transit systems.

An issue with STOPS is that the current version (v.2.5) uses CTPP/JTW data that is derived from the 2006-2010 American Community Survey datasets. The fact that this data is dated is not a major issue in regions where the spatial distribution of population and employment have not changed much in recent years, because STOPS self-calibrates to the newer ridership data that the user specifies. However, in fast-growing regions, the use of dated CTPP/JTW data is potentially a larger issue.

STOPS employs a state-of-the-art mode-choice model as its engine, which as noted above has its coefficients automatically calibrated to approximately match the user's input of observed ridership data.

STOPS produces, as its key output, forecasted daily ridership for a representative weekday, however the process through with STOPS generates this forecast is important. STOPS generates Home-Based-Work travel by simulating competition between automobile and transit usage in the 7:00 – 9:00 AM period, and all other travel by simulating the noon – 2:00 PM period. It then factors up the ridership generated during these two time periods to represent daily ridership, but STOPS does not consider the quality of transit service outside of these two time windows. Therefore STOPS will not produce estimates of the ridership impacts of a modification that expands a transit agency's hours-of-service later into the evening hours, and impacts in this circumstance would need to be generated by another approach.

The main STOPS user interface is shown in Figure 10. The STOPS application is powerful in its technical capabilities, however does not have intuitive and graphical attributes that are similar to the Replica online portal.

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[8] https://www.transit.dot.gov/funding/grant-programs/capital-investments/stops

[9] https://www.ntionline.com/rideship-forecasting-with-stops-for-transit-project-planning/

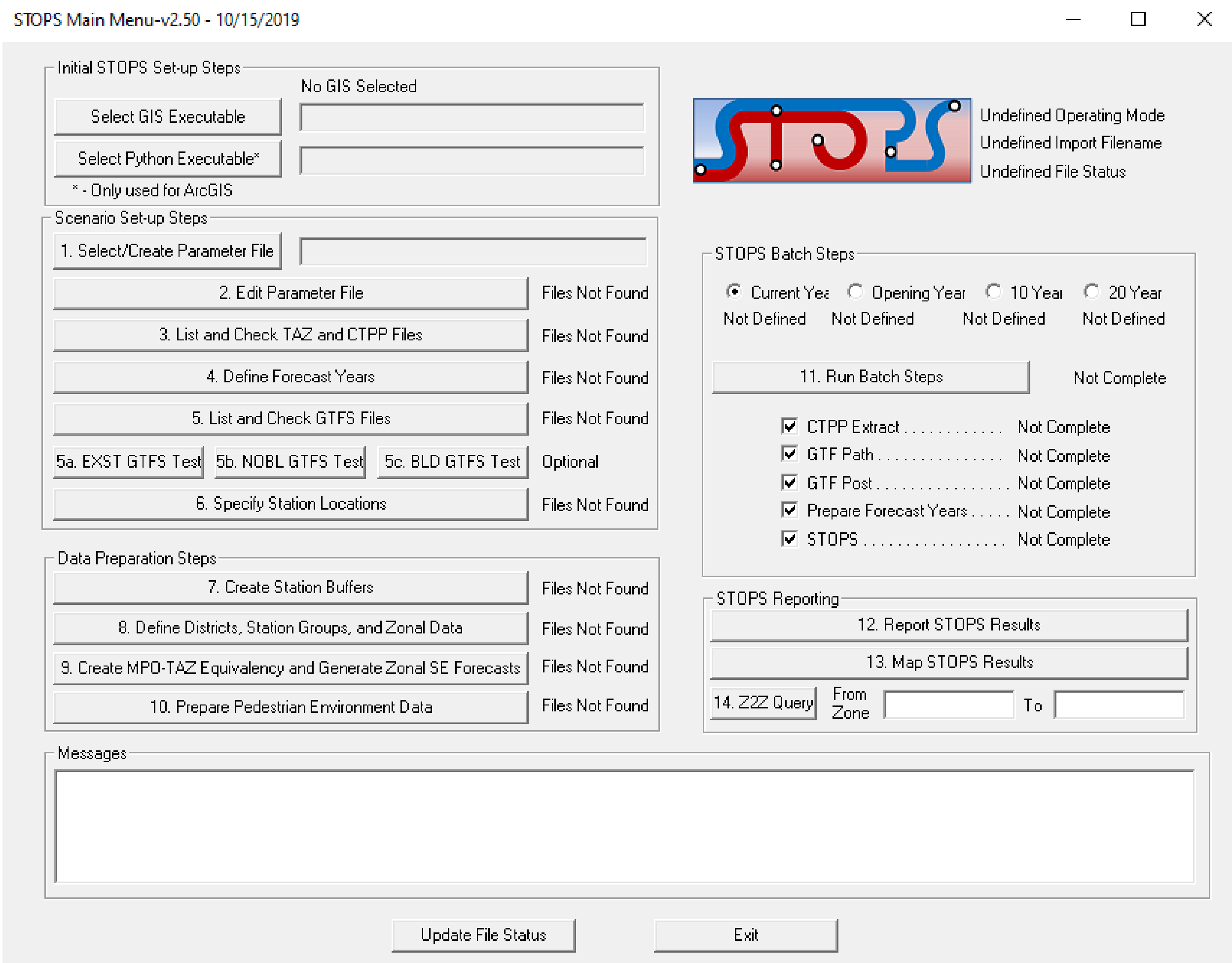

Figure 10: STOPS' main user interface

Calibration of STOPS in Oswego

'Calibration' refers to ensuring that the model reasonably simulates existing conditions before it is applied to simulate future conditions).

As noted above, district-level boardings were summarized from Centro's APC datasets and used to characterize existing bus ridership for model calibration purposes.

Additionally, it was found that including the City Routes (i.e., the routes of direct interest), the SUNY-campus routes targeted at university students on the campus (and its immediate vicinity), and Centro's two longer-distance routes that connect to Mexico/Fulton/Phoenix/Syracuse led to model-calibration problems. The issue encountered was that including these other routes led to STOPS placing less emphasis on matching existing ridership on the City Routes, and thus poorer fit between observed and simulated ridership on the City Routes.

The solution to this issue was to edit the GTFS files so that only the City Routes were simulated using STOPS.

Figure 11 shows the location of the districts that the Research Team defined for model-calibration purposes, and Table 1 shows the results of the model calibration process. Table 1 shows the raw text-file output from STOPS, which makes clear that the outputs are not in the most user-friendly and intuitive of formats, particularly for non-technical staff.

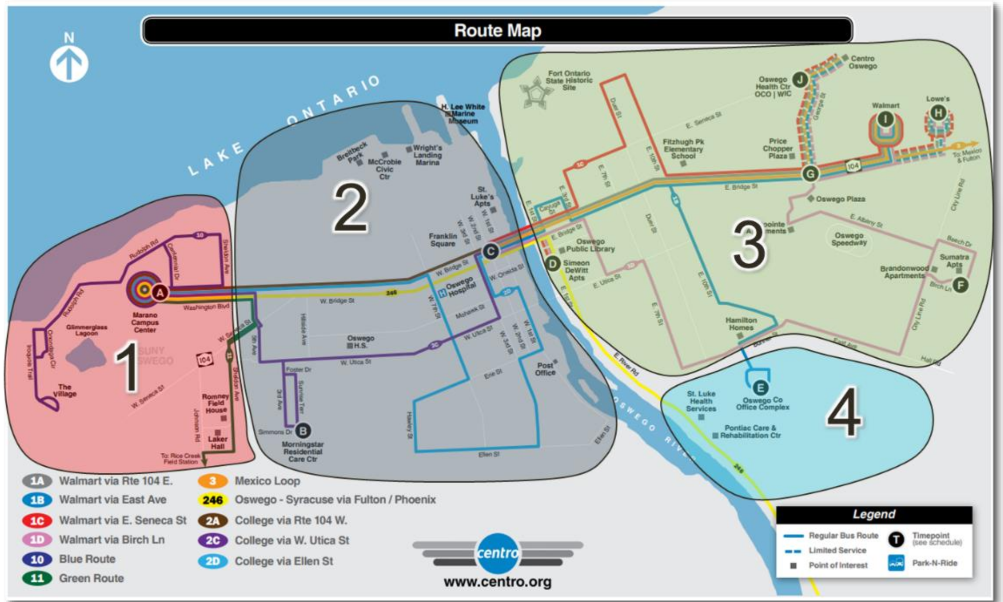

Figure 11: Map of districts used in STOPS for model-calibration purposes. District #5 (not shown) encompasses all geography not within one of Districts #1-4.

Scenario 1: Y2022 EXISTING
Raw linked transit trips: 15.00
Raw unlinked transit trips: 15.08
Target unlinked transit trips: 442.00
Regional calibration: 29.30

	Destination Group							
Origin Group	1	2	3	4	5	TOTAL	GOAL	COUNT
1- :	0	122	41	0	0	163	205	205
2- :	122	16	26	0	0	164	122	122
3- :	41	26	48	0	0	115	116	116
4- :	0	0	0	0	0	0	0	-
5- :	0	0	0	0	0	0	0	-
TOTAL :	163	164	115	0	0	442	-	-
GOAL :	205	122	116	0	0	-	443	-
COUNT :	205	122	116	-	-	-	-	443

Table 1: Calibration results as output by STOPS

Generation of Ridership Forecast

When the Research Team was satisfied with the calibration of the STOPS model to the district-level pattern of existing-conditions ridership, STOPS was then run using the GTFS files of the prospective system redesign to generate ridership forecasts.

The main outputs of STOPS are recorded in a large text file that is broken down into many tables (see Figure 12). The number of rows in the output text file can easily exceed 10,000, thus the user must be comfortable working with large text files to successfully navigate and interpret the STOPS outputs.

```
Program STOPS - FTA Simplified Trips-on-Project Software                                                        Page      1
Version: STOPS-v2.50 - 07/17/2019                                                                               10/11/2022
Run:     Calibration 1                                                                                            16:17:09
System: Oswego
TABLE OF CONTENTS
===============================================================================================================================


 SECTION 1: SUMMARY OF KEY INPUTS
   Run Parmameters:                                 1.01
   Station Listing:                                 1.02
   Input Route Count and Group Information:         1.03
   Assignment of GTFS Route_IDs to Route Groups:    1.04
------------------------------------------------------------------------------------------------
 SECTION 2: SUMMARY OF EXISTING SCENARIO RESULTS BEFORE STATION GROUP CALIBRATION
   Initial Calibration Statistics:                   2.01
   Iter. 1 Station Groups by Production District:    2.02
   Iter. 1 Station Groups by Attraction District:    2.03
   Station Group Boardings Prior to Adjustment:                          2.04
   Station Group Boarding Factor for Application to Later Iterations:    2.05
   Listing of Stop_ids not found in station file:                        2.06
   Type 10/12 Group-Level Calibration Summary-Stations/Stops-SKIPPED-    2.07
   Type 11/12 Group-Level Calibration Summary-Station/Route Summary:     2.08
------------------------------------------------------------------------------------------------
 SECTION 3: SUMMARY OF STATION GROUP CALIBRATION RESULTS
Station Group-Station Group Accumulators
   Station Group to Station Group Ridership-Existing:                          3.01
   Station Group to Station Group Ridership-No-Build:                          3.02
   Station Group to Station Group Ridership-Build:                             3.03

Station-Station Accumulators
   Station Group to Station Group Build Trips:                                 3.04
   Station Group to Station Group Build Trips (Added by Station Factors):      3.05
   Station Group to Station Group Project Trips:                               3.06
   Station Group to Station Group Project Trips (Added by Station Factors):    3.07
------------------------------------------------------------------------------------------------
 SECTION 4: SUMMARY OF PROJECT RESULTS
   Weekday Linked District-to-District Transit Trips, Build, All Trips:        4.01
   Weekday Incremental Linked Dist-to-Dist Transit Trips, Build, All Trips:    4.02
   Weekday Linked District-to-District Project Trips, Build, All Trips:        4.03
   Weekday Unlinked Station-to-Station Project Trips, Build, All Trips:        4.04
------------------------------------------------------------------------------------------------
 SECTION 5: SUMMARY OF PROJECT RESULTS FOR TRIPS ON FIXED GUIDEWAY (FG) MODES
   Weekday Linked District-to-District Transit Trips, Build, FG Trips:         5.01
   Weekday Incremental Linked Dist-to-Dist Transit Trips, Build, FG Trips:     5.02
   Weekday Linked District-to-District Project Trips, Build, FG Trips:         5.03
   Weekday Unlinked Station-to-Station Project Trips, Build, FG Trips:         5.04
------------------------------------------------------------------------------------------------
 SECTION 6: SUMMARY OF PROJECT RESULTS FOR TRIPS MADE BY 0-CAR HOUSEHOLDS
   Weekday Linked District-to-District Transit Trips, Build, All Trips by 0 Car HH:        6.01
   Weekday Incremental Linked Dist-to-Dist Transit Trips, Build, All Trips by 0 Car HH:    6.02
   Weekday Linked District-to-District Project Trips, Build, All Trips by 0 Car HH:        6.03
   Weekday Unlinked Station-to-Station Project Trips, Build, All Trips by 0 Car HH:        6.04
------------------------------------------------------------------------------------------------
 SECTION 7: SUMMARY OF PROJECT RESULTS FOR TRIPS ON FIXED GUIDEWAY (FG) MODES BY 0-CAR HH
   Weekday Linked District-to-District Transit Trips, Build, FG Trips by 0 Car HH:         7.01
```

Figure 12: Table of Contents at top of STOPS' main output text file

STOPS reports a rich variety of data in the large text file, which is available for the user to interpret to understand the ridership impacts of a prospective service change. Table 2 is one of the main output tables, which presents ridership for each route (both existing and proposed) in the system. The headline result is highlighted in the bottom row: ridership is forecasted to decrease from 442 trips/day to 432 trips/day from the service redesign, a decrease of ~2.5%. However, another caveat is that STOPS generates only weekday ridership forecasts, so does not output information about how weekend ridership is impacted by a service modification.

STOPS outputs can also be exchanged from the STOPS output text file into other software for visualization purposes. To generate Figure 13 below, we matched the bus-stop locations in the STOPS output file with their longitude/latitude coordinates from the GTFS file, to allow the locations of the forecasted boardings to be visualized. STOPS is forecasting that the SUNY campus and downtown Oswego areas will generate much of the ridership under the prospective system redesign.

***** AVG WEEKDAY ROUTE UTILIZATION ZONE BY (PRODUCTION-END) ACCESS TYPE ************
Comparison of Route Boardings by Scenario and Zone (Production-End) Mode-of-Access
Total Transit Trips

			Y2022 EXISTING				Y2022 NO-BUILD				Y2022 BUILD			
Route_ID	--Route Name	Count	WLK	KNR	PNR	ALL	WLK	KNR	PNR	ALL	WLK	KNR	PNR	ALL
18354	--Ful 4-Fulton - East	0	0	0	0	0	0	0	0	0	0	0	0	0
18355	--Ful 5-Fulton - West	0	0	0	0	0	0	0	0	0	0	0	0	0
18356	--Mex 3-Mexico - Fulton	0	0	0	0	0	0	0	0	0	0	0	0	0
18358	--Osw10-SUNY Oswego Blue Route	0	0	0	0	0	0	0	0	0	0	0	0	0
18359	--Osw11-SUNY Oswego Green Rout	0	0	0	0	0	0	0	0	0	0	0	0	0
18360	--Osw1A-Walmart via 104	50	8	1	0	9	8	1	0	9	0	0	0	0
18361	--Osw1B-Walmart - Hamilton Hom	31	63	6	0	69	63	6	0	69	0	0	0	0
18362	--Osw1C-Walmart via Seneca Str	15	59	1	0	59	59	1	0	59	0	0	0	0
18363	--Osw1D-Walmart via Brandonwoo	63	25	1	0	25	25	1	0	25	0	0	0	0
18364	--Osw2A-College via 104	164	61	2	0	63	61	2	0	63	0	0	0	0
18365	--Osw2C-College via West Utica	21	134	15	0	149	134	15	0	149	0	0	0	0
18366	--Osw2D-College via Ellen St	98	57	10	0	67	57	10	0	67	0	0	0	0
18367	--Osw46-Oswego - Syracuse	0	0	0	0	0	0	0	0	0	0	0	0	0
99991	--SthRtEB-South Route EB	0	0	0	0	0	0	0	0	0	26	1	0	27
99992	--SthRtWB-South Route WB	0	0	0	0	0	0	0	0	0	19	6	0	25
Test1	--Test1-SUNY to Walmart	0	0	0	0	0	0	0	0	0	26	1	0	26
Test2	--Test2-Walmart to SUNY	0	0	0	0	0	0	0	0	0	330	23	0	353
Total		442	407	35	0	442	407	35	0	442	401	31	0	432

Table 2: STOPS output showing route-level weekday daily ridership forecasts

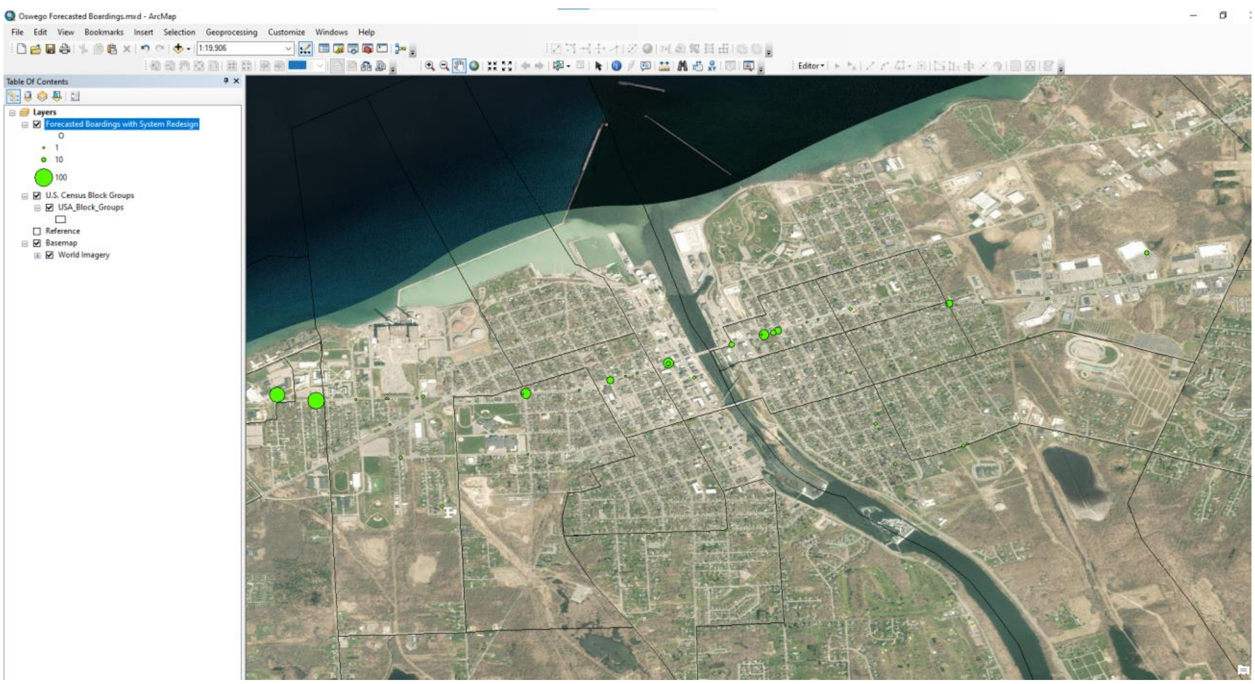

Figure 13: Visualization of STOPS ridership forecast, by stop location

Finally, in its output STOPS also reports a summary of how it interpreted the transit services specified in the GTFS files (see Table 3). This is valuable for error-checking purposes; if the amount of bus trips, revenue-miles, or revenue-hours of service under existing conditions or the proposed service modification as presented in this table are illogical, this is a red flag for the user to go back and review the GTFS files to be sure they are correctly specifying the desired transit service patterns.

Version: STOPS-v2.50 - 10/10/2019 10/11/2022
Run: Oswego Baseline 8:29:34
System: Centro
Table 10.03

***** PEAK TRIPS, MILES AND HOURS BY ROUTE ************
Comparison of Weekday Operating Statistics by Scenario
PEAK=any trip serving one or more stops between 5:00 am and 9:15 am

		Y2022 EXISTING			Y2022 NO-BUILD			Y2022 BUILD		
Route_ID	--Route Name	#Trips	Miles	Hours	#Trips	Miles	Hours	#Trips	Miles	Hours
18360	--Osw1A-Walmart via 104	3	5.54	0.47	3	5.54	0.47	0	0.00	0.00
18361	--Osw1B-Walmart - Hamilton Hom	3	12.32	1.00	3	12.32	1.00	0	0.00	0.00
18362	--Osw1C-Walmart via Seneca Str	1	2.97	0.30	1	2.97	0.30	0	0.00	0.00
18363	--Osw1D-Walmart via Brandonwoo	4	18.95	1.82	4	18.95	1.82	0	0.00	0.00
18364	--Osw2A-College via 104	7	10.08	1.17	7	10.08	1.17	0	0.00	0.00
18365	--Osw2C-College via West Utica	3	7.30	1.00	3	7.30	1.00	0	0.00	0.00
18366	--Osw2D-College via Ellen St	4	14.64	1.33	4	14.64	1.33	0	0.00	0.00
18367	--Osw46-Oswego - Syracuse	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
99991	--SthRtEB-South Route EB	0	0.00	0.00	0	0.00	0.00	2	14.90	1.67
99992	--SthRtWB-South Route WB	0	0.00	0.00	0	0.00	0.00	2	14.57	1.67
Test1	--Test1-SUNY to Walmart	0	0.00	0.00	0	0.00	0.00	6	19.73	2.00
Test2	--Test2-Walmart to SUNY	0	[illegible]	[illegible]	0	0.00	0.00	6	[illegible]	[illegible]
	Total	25	71.80	7.08	25	71.80	7.08	16	68.92	7.53

Program STOPS - FTA Simplified Trips-on-Project Software Page 50
Version: STOPS-v2.50 - 10/10/2019 10/11/2022
Run: Oswego Baseline 8:29:34
System: Centro
Table 10.04

***** OFF-PEAK TRIPS, MILES AND HOURS BY ROUTE ************
Comparison of Weekday Operating Statistics by Scenario
OFF-PEAK=any trip serving one or more stops between 10:00 am and 2:15 pm

		Y2022 EXISTING			Y2022 NO-BUILD			Y2022 BUILD		
Route_ID	--Route Name	#Trips	Miles	Hours	#Trips	Miles	Hours	#Trips	Miles	Hours
18360	--Osw1A-Walmart via 104	10	21.38	1.73	10	21.38	1.73	0	0.00	0.00
18361	--Osw1B-Walmart - Hamilton Hom	3	12.73	1.08	3	12.73	1.08	0	0.00	0.00
18362	--Osw1C-Walmart via Seneca Str	2	6.88	0.62	2	6.88	0.62	0	0.00	0.00
18363	--Osw1D-Walmart via Brandonwoo	4	19.82	1.88	4	19.82	1.88	0	0.00	0.00
18364	--Osw2A-College via 104	10	14.40	1.67	10	14.40	1.67	0	0.00	0.00
18365	--Osw2C-College via West Utica	5	12.15	1.67	5	12.15	1.67	0	0.00	0.00
18366	--Osw2D-College via Ellen St	6	21.85	2.00	6	21.85	2.00	0	0.00	0.00
18367	--Osw46-Oswego - Syracuse	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
99991	--SthRtEB-South Route EB	0	0.00	0.00	0	0.00	0.00	3	22.36	2.50
99992	--SthRtWB-South Route WB	0	0.00	0.00	0	0.00	0.00	3	21.85	2.50
Test1	--Test1-SUNY to Walmart	0	0.00	0.00	0	0.00	0.00	9	29.60	3.00
Test2	--Test2-Walmart to SUNY	0	[illegible]	[illegible]	0	0.00	0.00	9	[illegible]	[illegible]
	Total	40	109.22	10.65	40	109.22	10.65	24	103.37	11.30

Table 3: STOPS output summarizing bus service under existing conditions and prospective system redesign

Sensitivity Tests

In addition to generating a ridership forecast for the proposed system redesign in Oswego, it is good practice to perform a series of sensitivity tests to ensure that the STOPS outputs behave logically when the inputs are varied.

Table 4 shows the results of the series of sensitivity tests which were performed by the Research Team. Headline findings include:

- In all cases, the outputs are reasonable and logical responses to the variation in inputs – lending credibility to the ridership forecasts generated by STOPS.
- If Centro were to reduce service from three to two buses in concurrent operation, and only provide service on the High-frequency route (i.e., no South route), this would still allow Centro to serve 90% of the ridership that is projects with the three buses in operation (396 v. 432 riders/day).

- Doubling the number of buses on the High-frequency route from two to four buses, which would allow 15-minute headways on this route, would only result in a ~3% increase in ridership.

It is noteworthy that modifying the service frequencies for sensitivity-testing purposes was straightforward, accomplished simply by changing a single line of code in the GTFS *Frequencies.txt* input file. In contrast, a scenario in which bus speeds needed to be modified, such as testing a transit signal priority strategy that would increase average bus speeds, would require changing large numbers of lines of code, and hence would be much more tedious and time-consuming.

Sensitivity test	**Forecast weekday daily ridership (boardings)**
Only the High-frequency route	396
15-minute (rather than 30-minute) frequency on the High-frequency route	446
2-hour frequency on the High-frequency route	241
Only the South route	155
1-hour (rather than 2-hour) frequency on the South route	325

Table 4: Results of sensitivity tests

Lessons Learned

This Pilot study consisted of a common transit-planning question: *What will be the ridership impacts if transit service is modified?* The context of the Pilot was the small-scale bus services in the City of Oswego.

To answer this question, Replica data was used for decision-support purposes to decide where to place the redesigned transit service and how much service to put on each route. The redesigned service was then coded into the GTFS data specification, and STOPS software was used to generate ridership forecasts (and perform sensitivity tests).

Having completed this Pilot, the Research Team presents a series of observations to serve as 'lessons learned' for readers considering using Replica and/or STOPS.

1) Replica data was found to be both powerful and user-friendly, whereas STOPS was found to be technically strong but less user-friendly. STOPS was found to both require a specialized skillset in travel demand modeling, and to require occasional interaction with the Federal Transit Administration to ensure successful application of the software.
2) The generation of Replica data is a black-box, so the user must trust (and if possible verify) that the data are appropriate in a given application. This is most significant in cases where there are small-sample issues (such as bus service with dozens or a small number of hundreds of passenger journeys in the Replica datasets) or unusual land uses (e.g. a university campus like SUNY Oswego)
3) STOPS was found to require customization of the standard zonal geography to successfully operate in the small City of Oswego – requiring effort and substantial GIS skills.
4) STOPS has an innovative self-calibration approach and it can flexibly use any of a variety of inputs, but overseeing this process, interpreting results, and modifying calibration inputs turned out to be an iterative process in this Pilot. A significant troubleshooting skillset was required.
5) Ultimately, to reach successful outcomes using STOPS for this prospective system redesign, the application of STOPS in this Pilot became customized rather than 'off-the-shelf'.
6) Both Replica and STOPS allow output data to be readily exported into other software, (e.g., GIS and spreadsheet software) for visualization and analytical purposes, which proved to be very valuable in this Pilot.
7) Though STOPS was initially designed for use in large metropolitan areas, it was successfully applied to the small-scale Oswego bus services. However, as noted above, this required customization at various steps of the process to reach a successful outcome.
8) STOPS reports a weekday-average daily ridership, but it is important for the user to understand that this is based on simulating only a subset of hours of the day. Therefore, STOPS would probably not be the tool of choice if a transit provider was considering a change such as increasing the span of service (# of hours per day in which transit service operates).

Replicability: This project is replicable due to the statewide Replica license and the availability of STOPS, but STOPS has a steep learning curve and third party support might be essential to replication.

Recommendations

1. STOPS is a great software that provides comprehensive outputs with efficacious results. It is an excellent candidate for shared use in NYS.
2. Utilizing the STOPS tool is likely to require consulting or software support to build or configure inputs required for the software model and to assist with interpretation of the extensive output.
3. The STOPS software requires a regional model or additional customization to accurately output results for smaller geographies. In smaller or non-MPO regions that don't have model coverage, the Research Team recommends using a third-party data source like (Replica) to supplement.
4. When using Replica to support the STOPS model in non-MPO areas, the best practice is to verify the data to ensure accurate representation of the population. Additionally, the Research Team recommends coordinating with Replica to use data at the block-level—the lowest possible Census geography.
5. NYSDOT and MPOs should directly engage FTA to advocate for updating the STOPS software—specifically to make the output formatting more navigable.