

REPORT 3: EXISTING CONDITIONS REPORT

RED LANES EXISTING CONDITIONS

INTRODUCTION AND SUMMARY OF CONTENTS

PURPOSE OF REPORT

The Capital Area Metropolitan Planning Organization (CAMPO) RED Lanes Study is taking a comprehensive look at transit priority lanes as a potential part of the region's approach to enhancing its transportation system to meet growing demand, improve transit operations, and diversify modal options for local and regional travel. RED lanes are sometimes referred to as business access and transit (BAT) lanes or transit priority lanes. Transit priority lanes are an increasingly common component of regional transportation planning and transit investment across the U.S. and around the world. They can be a cost-effective solution for improving transit operations and service reliability.

Two previous reports – *RED Lanes Fundamentals* and *Key Plans in the CAMPO Region* – defined key concepts and components of RED Lanes and highlighted prior regional planning efforts related to RED Lanes implementation, respectively. This *Existing Conditions Report* (ECR) examines existing conditions and trends across a variety of indicators to provide insight into where RED Lanes are likely to be most appropriate. The ECR builds on the findings of the previous reports, relating key indicators to best planning practices for RED lanes and grounding indicator development in relevant past or ongoing planning efforts. The data and maps developed for this report will inform later phases of the CAMPO RED Lanes Study, including the development of a RED lanes evaluation/prioritization methodology for ranking corridors in the CAMPO region according to their suitability/readiness for RED lane implementation. Therefore, the ECR functions both as a snapshot of regional trends and conditions affecting transit system performance and regional mobility as well as a foundational component of the RED Lanes evaluation methodology.

REPORT STRUCTURE

The ECR is organized into four major sections. The first section ("Key Findings") summarizes key findings from the development and analysis of key indicators and metrics describing the performance of the regional transportation system, planned transit operations, facility contexts, and policy considerations. These findings offer general guidance for developing the RED Lanes evaluation methodology in the next phase of the RED Lanes Study.



Figure 1. The ECR is the last step before developing the evaluation methodology and scoring tool for candidate RED lanes.

The second section of the ECR (“Indicators and Metrics”) provides detailed analyses of specific indicators and metrics, offering maps and detailed insight beyond the high-level conclusions reported in the “Key Findings” section. Many of the metrics reported in this section will comprise the data to be incorporated into the RED Lanes evaluation methodology. Therefore, this section also outlines the key data sources required to reproduce metrics. For some indicators, potential alternative metrics, data sources, and/or analysis approaches are described for consideration in potential future applications of or updates to the RED Lanes evaluation methodology.

The “Indicators and Metrics” section is organized into major topic areas based on the RED Lanes Information Gathering Concept Matrix.¹ The ECR focuses primarily on the “Demand,” “Operations,” and “Contexts” topic areas as these are the most directly applicable to the evaluation and ranking of corridors for potential RED Lanes implementation. For example, corridors may be substantially differentiated based on transit ridership (demand), transit service frequency (operations), and service to disadvantaged population groups (contexts).

Indicators and metrics under the “Design” and “Other Considerations” headings are addressed in this report on an “as available and applicable” basis. These topics are primarily expected to inform how a RED Lane project should be designed and implemented and have limited applicability to corridor evaluation and prioritization. For example, while design considerations are important to the successful deployment of RED lanes, existing roadway design does not necessarily impact a corridor’s suitability for future RED lane implementation since the design may be changed as part of the implementation. However, RED Lanes may be difficult to implement on roadways where right-of-way constraints pose challenges to a redesign. For this reason, this report includes a planning-level analysis of available right-of-way to offer a coarse assessment of RED Lane feasibility within a given corridor.

Likewise, indicators within the “Other Considerations” topic area address key considerations for RED Lanes implementation and are not expected to directly inform the prioritization methodology for potential RED lane corridors. For example, RED Lanes are not intended primarily as safety improvements, and it would be inappropriate to prioritize RED Lanes based on existing safety data. Rather, safety is a key consideration in implementation, affecting design and amenities decisions for a given RED Lane project. For appropriate incorporation of the “Design” and “Other Considerations” topic areas in a particular RED Lane project, a review of the *RED Lanes Fundamentals* report is recommended, as design concepts, service characteristics, and best planning practices are described in that document.

The Information Gathering Concept Matrix is re-printed in Figure 2 below as a reminder of the major topic areas associated with RED Lanes planning and implementation.

The third section of the ECR (“Inventory of Data and Tools”) provides an inventory of data sources and analysis tools used to create the indicators and metrics presented in the previous section. The

¹ The *RED Lanes Fundamentals* report introduced the RED Lanes Information Gathering Concept Matrix as a simple and consistent framework for organizing and summarizing best practices, case studies, and literature review findings related to RED Lanes. It was also used in the *Key Plans in the CAMPO Region* report to summarize and interpret prior planning documents related to RED Lanes and transit priority treatments.

documentation of data sources is important to ensure the RED Lanes evaluation methodology can be reliably replicated by compiling and processing the same body of data used in this initial study.

Finally, the ECR closes by identifying potential corridors to add to the Candidate Corridors list and map developed in the *Key Plans in the CAMPO Region* report, based on ECR findings.

RED LANES INFORMATION GATHERING CONCEPT MATRIX		
Topic Area	Indicator	Findings
Demand (Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)	Transit Ridership	<i>Demand indicators are generally greatest in downtown Raleigh and other locations within the Beltline.</i>
	Transit Mode Share	
	Traffic Volume	
	Non-Motorized Users	
	Person Throughput	
Operations (Existing v. Forecast v. Targets, Peak v. Off-Peak v. Daily)	Transit On-Time Performance	<i>Operations indicators describe a variety of opportunities to enhance transit services that are spread throughout the more densely developed portions of the region. These indicators also highlight corridors with mobility constraints.</i>
	Transit Reliability (Route Travel Time)	
	Transit Service Frequency	
	Transit Signal Priority	
	Person/Vehicle Delay	
	Average Travel Speeds	
Contexts (Nearby uses, disadvantaged population, connectivity, freight routes, emergency routes)	Adjacent Land Uses	<i>Context indicators demonstrate a wide variation across the region, contrasting the characteristics of transit-supportive development patterns generally oriented toward regional activity centers, transit-dependent populations dispersed throughout the region (with a southeasterly focus typical of eastern seaboard fall line cities) and a latticework of potential network connections.</i>
	Context Classification/Complete Streets	
	Parking/Curb space	
	Accessibility	
	Facility Functional/Access Class	
Design (Available ROW, shared modes/movements)	Number of Lanes	<i>Certain design indicators including multiple travel lanes and wide building setbacks help identify regional opportunities. Most indicators are dependent on design strategies addressed at a project level.</i>
	Lane Width	
	Intersection Design	
	Separation of Traffic	
Other	Safety	<i>Safety, enforcement, maintenance, cost, and project length to be addressed at a project level, following best practices findings from RED Lanes Fundamentals report.</i>
	Enforcement	
	Maintenance	
	Cost	
	Project length	

Figure 2. The Information Gathering Concept Matrix organizes the findings of the ECR.

KEY FINDINGS

This section summarizes the key findings of the Existing Conditions Report, with a focus on highlighting broad trends revealed by the analyses presented in the “Indicators and Metrics” section and relating them to the RED Lanes evaluation methodology. Broadly, the analysis of indicators generated intuitive findings with respect to the general areas within the CAMPO region where transit demand, operations, context, and design factors are most supportive of RED Lanes and related improvements. However, it also highlighted how data availability, metric definitions, and analysis outputs affect the prospective use and interpretation of each indicator in the RED Lanes evaluation methodology, including the emphasis placed on each indicator in corridor prioritization.

Across all indicators and metrics, there is a **general confluence of RED Lanes suitability factors inside the I-540/NC-540 loop**. This includes the southeastern portions of the region around Garner, but is mostly concentrated on Cary, North Raleigh, and the Inside the Beltline communities within I-440. Isolated suitability for RED Lanes may be found in other parts of the region, but these are expected to be few and highly localized exceptions.

The ECR analysis revealed that some indicators are best suited to application in the RED Lanes **prioritization** process for determining which corridors in the region offer the best conditions for successful RED Lanes, while other indicators provide information that can help **guide appropriate development** of a RED Lane project within a particular corridor. Indicators with strong supporting data, clear metric definitions, and direct relationships to the policy goals that RED Lanes address are ideally suited for use in the prioritization process. Indicators for which data are sparse, metric definitions are imprecise, and/or analysis results relate more clearly to implementation approaches are better suited for guiding RED Lane project development. For example, forecasts of transit ridership can be used to prioritize high ridership corridors; analysis of ridership by time of day can be used to determine whether a RED Lane project should consider part-time or full-time lane restrictions. Based on the analysis provided here, part time restrictions are likely to be more appropriate on major commuting corridors, such as US 1, US 401 and NC 55. Full-time RED Lanes would be more appropriate on in-town corridors such as Oberlin Road, Raleigh Boulevard, and State Street. Policy considerations – such as complete streets and parking/curb space management – are difficult to operationalize for prioritization purposes and are better suited to guide implementation.

For many indicators and metrics, **accounting for directionality will be important**. RED Lanes are generally expected to be bi-directional symmetric improvements, providing priority bus treatments in both directions along a segment. For corridors with imbalanced peak hour/peak directional flows, bi-directional RED Lanes may be a sub-optimal use of the right-of-way, at least on a full-time basis. Top priority corridors will, ideally, have balanced directional flows throughout the day. Throughout the ECR, peak period metrics are reported for the PM period since more trips occur during the afternoon peak than any other travel period on a regional basis. When considering the impact of directionality on RED Lane design approaches, both the AM and PM period should be considered for the specific corridor.

Many of the region’s **Communities of Concern (CofC’s) are difficult to serve with transit**. CofC’s are areas that contain concentrations of one or more population groups identified in CAMPO’s Title VI, Minority, Limited English Proficiency (LEP), and Low Income Public Outreach Plan. CofC’s that are inside the I-540/NC-540 loop generally are served by transit that provides moderate-to-high access to jobs. However, the majority

of CofC's are in outlying communities that are only partially served by express services. RED Lanes benefits to these communities will likely be best achieved through the implementation of part-time RED Lanes at key delay points on commuting routes. However, since RED Lanes focus on enhancing travel speed and reliability on segments with frequent transit service, they are unlikely to significantly improve transit access for currently underserved communities.

Finally, the development of the ECR has revealed that the creation of a robust RED Lanes evaluation methodology will require reliable methods of relating spatial datasets from different sources to a **single authoritative dataset** that represents streets for consideration as RED Lanes corridors. Many of the datasets used to generate the measures produced for this ECR are developed independently such that, although features may be near one another, it is often difficult to relate them accurately to one another. This means combining and comparing metrics from one dataset with those in another dataset requires line conflation analyses. As an example, transit route lines may be generated by a transit agency, while highway features are obtained from the Triangle Regional Model. To analyze transit ridership and traffic volumes by segment, each route feature must be related to the highway segments on which the route operates. In establishing relationships among features it is important to ensure that unrelated features are not erroneously included. Common algorithms for determining spatial relationships, such as buffers, intersects, and spatial joins, are helpful but limited. Effective line conflation is likely to require automation of various spatial analysis routines as well as manual quality assurance checks.

INDICATORS AND METRICS

This section presents key indicators and metrics expected to be useful in evaluating candidate corridors for potential RED Lane implementation. For many indicators, forecastable trends are addressed instead of existing conditions to allow the RED Lanes evaluation methodology to account for future conditions. Indicators and metrics reported in this section are organized according to the major topic areas in the Information Gathering Concept Matrix as described in the introduction to this report.

In this report, a topic area refers to a collection of considerations that inform RED Lanes prioritization and planning. An indicator is a conceptual dimension of a topic area. For example, transit service frequency and transit on time performance are both dimensions of the operations topic area. To adequately and holistically account for operations issues in the RED Lanes Study, these and similar indicators must be examined. To this end, metrics are the specific measurements used to quantify and compare segments across various indicators. Continuing the previous example, transit service frequency is an easy to understand concept, but it needs to be measured and reported with clearly defined units, such as number of transit trips per hour, to be applicable in the RED Lanes evaluation methodology.

The RED Lanes Study Core Technical Team (CTT) provided guidance during Workshop #1 (March 5, 2019) regarding the relative importance of each indicator for inclusion in the Existing Conditions Report. The CTT also offered suggestions for aspects of a given indicator to emphasize for analysis. For example, the CTT suggested the transit service frequency topic area should focus on planned service frequency rather than existing frequency. In the subsections devoted to each indicator below, the CTT's input is summarized in a small call-out box, conveying what specific aspects of an indicator would ideally be examined and what the indicator's relative priority (High, medium, or low) in the RED Lanes evaluation methodology should be. It is important to note that the final determination of each indicator's priority in the RED Lanes evaluation methodology will ultimately be settled in subsequent phases of the RED Lanes Study. For a small number of indicators, analytical limitations such as a lack of regionally available data or methodological complexity sometimes prevented specific preferred aspects from being examined. For example, the CTT indicated an interest in peak-hour on-time performance for transit routes. However, the regional transit providers routinely track on-time performance on a daily basis. When these analytical limitations apply, they are noted in the text in each indicator's sub-section, often in the "other notes" unit.

Each indicator is introduced by defining what aspect(s) of transportation system analysis it describes (What is it?) and explaining the its relationship to RED Lanes planning and analysis (Why does it matter?). The details of metrics used to operationalize the indicators (How is it measured?) are then presented, followed by a discussion of the data sources and tools used to generate the measures (What data and tools are needed?). In most cases, maps of measures and a brief discussion of findings is then offered. Each indicator's sub-section closes with notes, if any, on additional research needs or potential future enhancements to guide the maturation of the RED Lanes evaluation approach over time as data sources and analytical capabilities evolve.

Table 1 provides an overview of the indicators included in the ECR report by topic area with notes on their suggested priority in the RED Lanes evaluation methodology based on CTT input as well as from the literature review conducted for the RED Lane Fundamentals report. The table also indicates whether a metric represents existing or future conditions.

Table 1 RED Lanes Indicators and Metrics at a Glance

TOPIC AREA			
Indicator	Metric	CTT Priority	Literature Priority
DEMAND			
Transit Ridership (p. 9)	Forecasted daily route-level transit passengers by segment in 2045	High	High
	Forecasted peak-hour route-level ridership as a share of daily route-level ridership by segment in 2045	High	High
Transit Mode Share (p. 13)	Transit commute (journey to work) mode share in 2015	Low	Low
Traffic Volume (p. 15)	Forecasted daily bi-directional traffic volume by segment in 2045	Low	High
	Forecasted PM peak hour volume-to-capacity ratio by direction in 2045	Low	Medium
Non-motorized Users (p. 19)	Walk access to jobs (proxy for non-motorized trip demand) in 2014	Low	Low
Person throughput (p. 21)	<i>To be addressed at a project level</i>	<i>High</i>	<i>High</i>
OPERATIONS			
Transit on time performance/reliability (p. 22)	On time performance rates by route in 2018/19	High	High
Transit service frequency (p. 26)	Transit vehicles per hour (bi-directional) by segment in 2019	Low	High
	Future RED Lanes-supportive frequency by segment by planning horizon year.	Low	High
Transit Signal Priority (p. 30)	<i>To be addressed at a project level</i>	<i>Medium</i>	<i>NA</i>
Person/vehicle delay (p. 31)	Forecasted AM peak hour congested-to-free-flow-speed ratio by direction in 2045	Low	Medium
Average travel speed (p. 34)	Forecasted peak hour bus travel speed by direction in 2045	Low	Medium
CONTEXTS			
Adjacent land uses (p. 36)	Activity unit density by TAZ in 2013	Medium	Low
	Intersection density by block group in 2011	Medium	Low
Context classification/ complete streets (p. 40)	<i>To be addressed at a project level</i>	<i>Medium</i>	<i>NA</i>
Parking/curb space (p. 42)	<i>To be addressed at a project level</i>	Low	Low
Accessibility (p. 44)	Transit-to-auto access to jobs ratio in 2013	Medium	NA
	Communities of concern by block group in 2012	Medium	Low
Functional/access class (p. 48)	Functional class by segment in 2045	Low	Low
DESIGN/OTHER			
Number of lanes (p. 51)	Segment lane count by direction in 2013	Medium	Medium
	Buildings intersected (within potential ROW buffer) per mile by segment in 2018	Medium	Medium
<i>Intersection design, separation of traffic, safety, enforcement, maintenance, cost, and project length to be addressed at a project level, following best practices findings from RED Lanes Fundamentals report.</i>			

DEMAND

- Transit Ridership
- Transit Mode Share
- Traffic Volume
- Non-Motorized Users

TOPIC | DEMAND

Travel demand considerations are important determinants of suitability for RED Lanes. Ideally, RED Lanes will be implemented to benefit the greatest number of travelers, and demand indicators support the identification of the region's busiest corridors. This section highlights existing conditions and forecasted trends for travel demand by mode; it also points out key findings for each indicator for consideration in developing the RED Lanes evaluation methodology.

INDICATOR | TRANSIT RIDERSHIP

What is it? Transit ridership reports the number of passengers using current transit services or the forecasted utilization of future services. Ridership can be reported on a systemwide, route, or street-segment level (route level or finer is most appropriate for RED Lanes and other corridor-level analyses). Ridership is often highest in peak commuting periods, especially for express services and other commuter-oriented routes.

*Core Technical Team input
Focus on forecasts and peak
hour ridership.*

*Priority in evaluation
methodology: High*

Why does it matter? RED Lanes can provide travel times savings and reliability benefits, and these are most impactful on high-ridership routes as greater numbers of passengers are benefited. There is a broad consensus in the literature that RED Lanes are most appropriate in high-ridership corridors.

How is it measured? Ridership is typically measured in units such as total passengers (on a daily or peak hour/peak period basis) or normalized by service characteristics such as passengers per revenue hour or revenue mile of service to focus on productivity. In this report, total daily passengers forecasted for the year 2045 is presented as the key ridership measure. This provides insight into which corridors are expected to carry the highest volumes of transit passengers in the intermediate- to long-term future. The share of daily passengers using transit during peak commuting periods is also reported, since this can provide useful guidance to RED Lane implementation and design considerations (full-time vs. part-time RED Lane, e.g.).

What data and tools are needed? For this report, ridership forecasts were obtained from the Triangle Regional Model (TRM) for the year 2045. The TRM provides ridership forecasts at the route level. Since multiple routes may operate within a single corridor, these route-level forecasts were aggregated at a segment level on the TRM 2045 highway network. This allows differentiation among segments where multiple routes operate. However, it is not the same as a segment level ridership forecast, which requires more detailed travel modeling. Rather, it reports the total number of riders for all routes operating on a segment. BRT and rail transit ridership data were excluded from the ridership estimates utilized in this analysis.

The consolidation of route-level ridership forecasts at the segment level was accomplished using custom geoprocessing scripts in ArcGIS. These scripts will be shared as part of the RED Lanes toolkit to be developed during a later phase of the study.

DEMAND

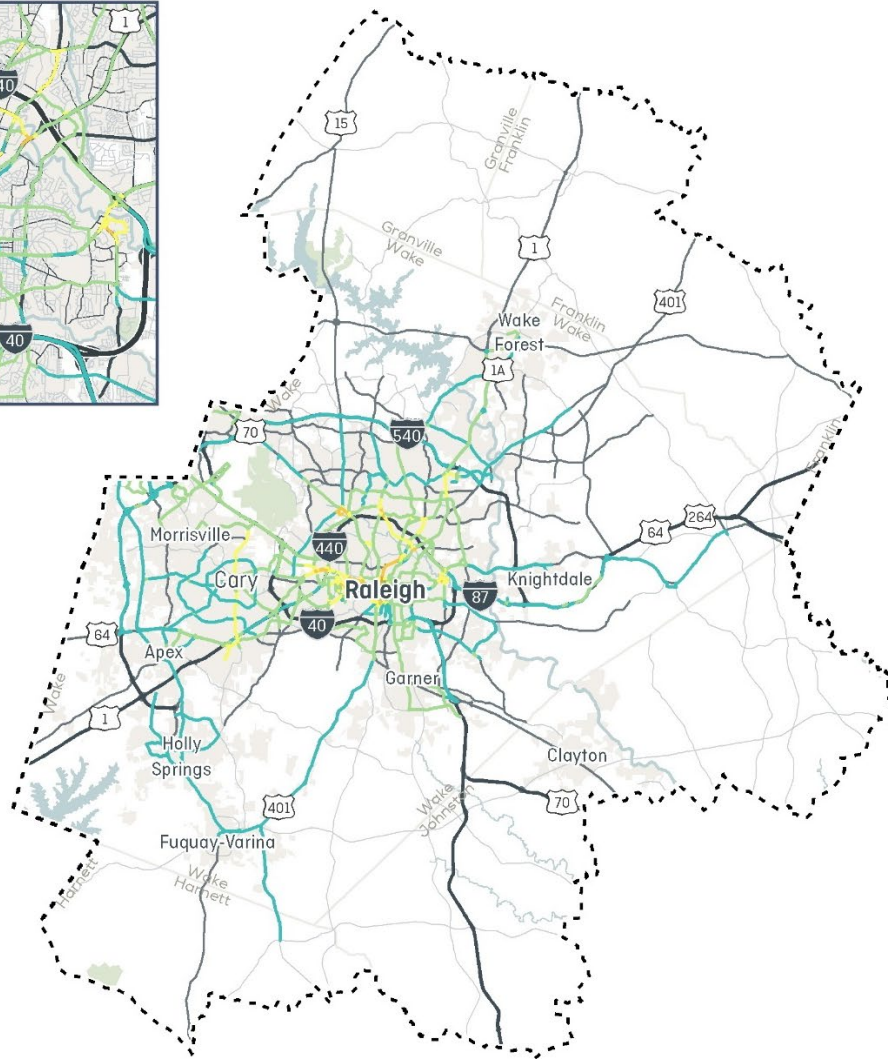
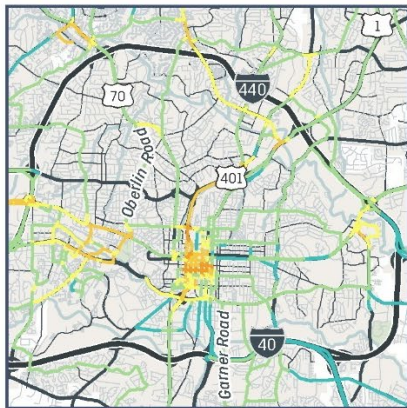
Transit Ridership

OPERATIONS

CONTEXTS

DESIGN

RED LANES | EXISTING CONDITIONS - TRANSIT RIDERSHIP



TRM Daily Ridership
on Routes Using Segment

- 0 - 1,000
- 1,001 - 5,000
- 5,001 - 10,000
- 10,001 - 20,000
- 20,001 - 53,251

DEMAND

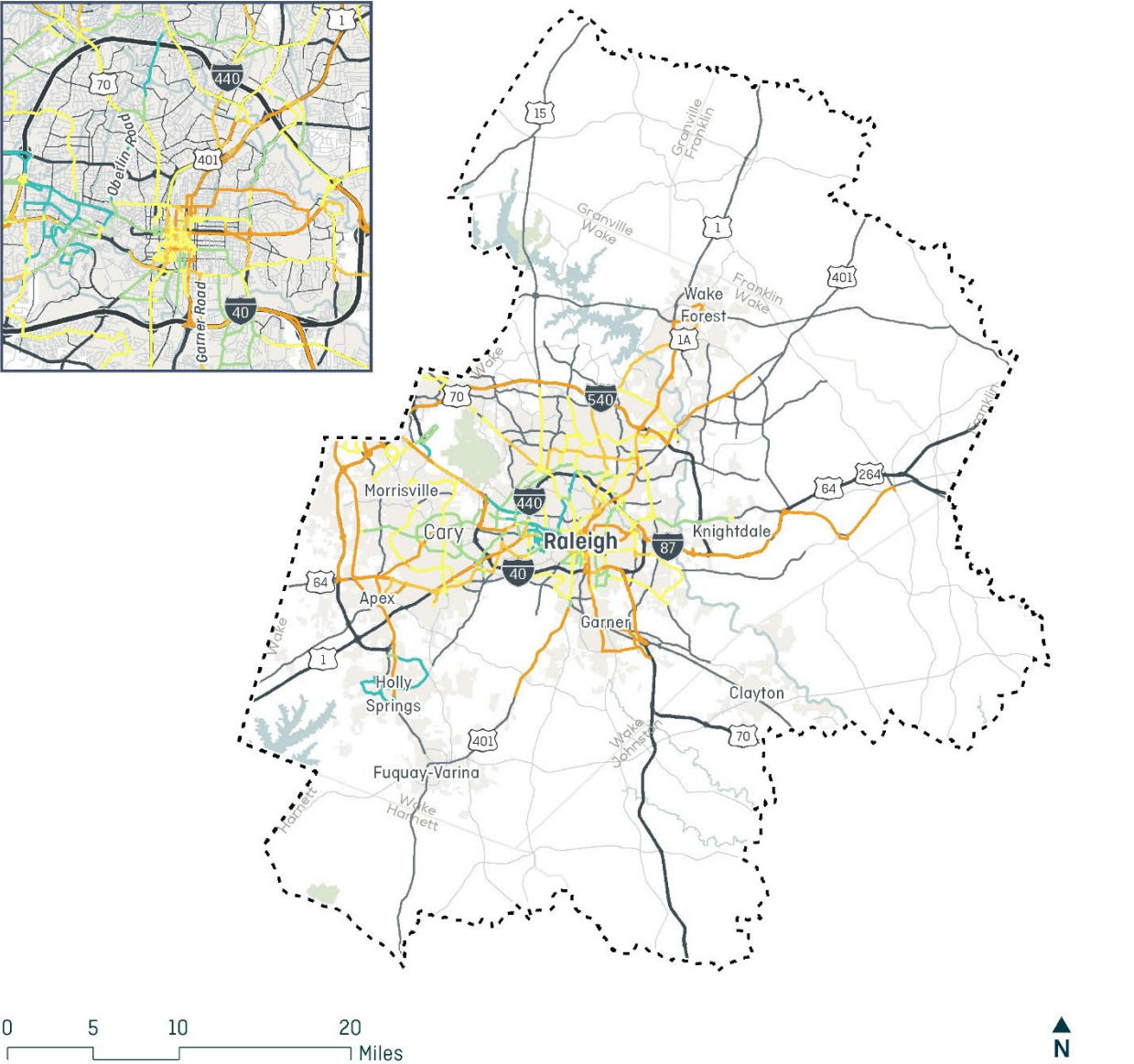
Transit Ridership

OPERATIONS

CONTEXTS

DESIGN

RED LANES | EXISTING CONDITIONS - TRANSIT RIDERSHIP



TRM Share of Route Ridership
in Peak Periods

- Up to 50%
- 50.1% - 60%
- 60.1% - 70%
- 70.1% - 80%
- More than 80%

DEMAND

Transit Ridership

OPERATIONS

CONTEXTS

DESIGN

Findings: Based on the TRM analysis, the CAMPO region’s highest transit ridership areas are in Downtown Raleigh, NCSU, Crabtree/North Hills, WakeMed, Capital Boulevard, and the north-south axis through Cary (Kildaire Farm Road and Harrison Avenue). Many segments with the highest cumulative route level ridership are short, spanning only a few blocks. Corridors with extensive high ridership include Kildaire Farm/Harrison, Six Forks Road, Hillsborough Street, Western Boulevard/MLK Boulevard, and Capital Boulevard/Atlantic Avenue.

The lowest shares of peak period ridership are around the NCSU campus, west Raleigh (Oberlin Road, Blue Ridge Road, Edwards Mill Road, e.g.), and on circulator routes in Cary, Holly Springs, Knightdale, etc. For corridors with high shares of daily ridership during peak periods, part time RED Lanes may be more appropriate than full time RED Lanes.

Other notes: Detailed evaluation of transit ridership can require sophisticated and data-intensive travel modeling approaches and tools. The findings of this analysis are based on outputs already being generated by the TRM. If the TRM can readily produce segment-level ridership forecasts, these may provide better insight into the details of transit travel demand. In future applications of or updates to the RED Lanes evaluation methodology, the availability of segment-level ridership forecasts should be investigated.

Alternatively, route level ridership estimates could be disaggregated to the segment-level based on stop-level boarding and alighting data, if available from partner transit agencies, such as GoRaleigh and GoCary. Automated Passenger Counters (APCs) are often used by transit agencies to track boarding and alighting activity. These could be used for route-level ridership disaggregation. The development of a reliable regionwide disaggregation methodology may serve a variety of planning purposes beyond application in RED Lanes evaluation but would require a level of effort beyond the scope of the current study.

INDICATOR | TRANSIT MODE SHARE

What is it? Transit mode share describes the percentage of total trips made using a transit mode. Mode share is typically analyzed at a zonal level, evaluating all travel to or from a given area and what proportion of total trip-making is made by each mode. For example, a downtown business district may conduct a study to learn what percentage of all trips to the district are made by non-auto modes. Mode share for an area reflects the cumulative mode choices of individual travelers making trips to/from that area; these individual choices may be affected by the availability of modal options (transit service, household vehicle availability, etc.), socio-economic and demographic characteristics (family size, income, etc.), and built environment characteristics (land use diversity, network connectivity, etc.).

*Core Technical Team input
Focus on forecasts.*

*Priority in evaluation
methodology: Low*

Why does it matter? High transit mode shares are often products of effective service design that makes transit travel times competitive with driving. In other cases, they may reflect a community's dependency on transit for trips beyond walking distance due to limited vehicle availability. RED Lanes are likely to be most effective in corridors serving areas that already utilize transit. They offer the potential to enhance transit travel times and reliability for these existing riders and boost ridership in other areas.

How is it measured? Transit mode share is typically reported as a percentage. For example, if an area has a mode share of five percent, it indicates that one in 20 trips generated from the area are made by transit. Mode share is typically reported for coarse zones (census block groups, census tracts, or traffic analysis zones, e.g.) that encompass many blocks. Estimating mode shares at a highly local level requires intensive travel models and/or robust local travel data to support model calibration.

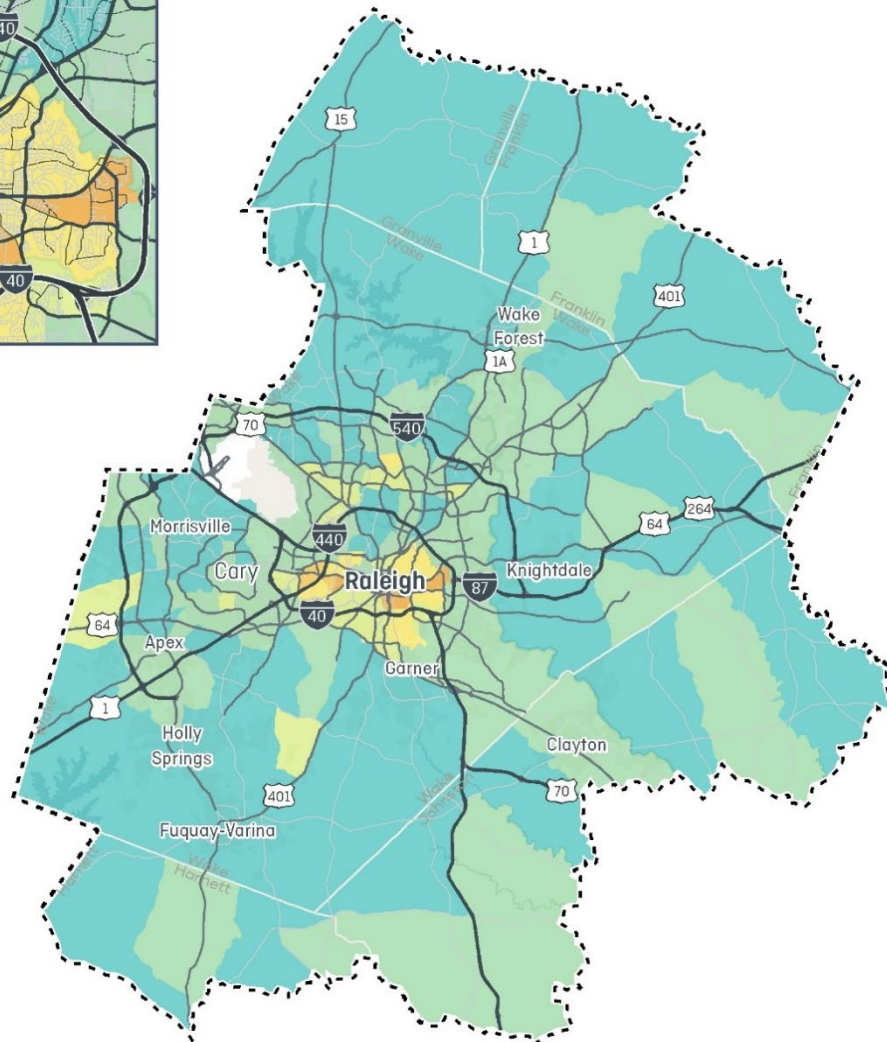
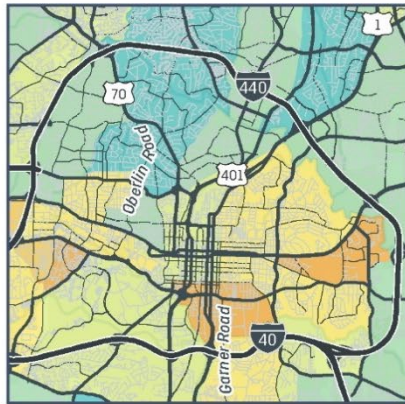
What data and tools are needed? Reliable mode share estimates and forecasts are difficult to obtain. Regional travel models (like the TRM) sometimes provide insightful outputs, but the application of these models often requires calibration to local conditions (i.e. for a specific sub-area within a region) to accurately forecast mode choices, making them unsuitable for regionwide analysis. This report utilizes mode share estimates from the American Community Survey's (ACS) Journey-to-Work (JTW) 2013-2017 tables. These provide estimates of commute mode share for census geographies down to the tract level. The JTW includes working from home as a mode, but this was excluded for the analysis presented here to focus specifically on transit commutes as a share of all commute trips.

Findings: Transit commute mode shares are generally low throughout the CAMPO region, with many of the region's most populous areas making less than one percent of commutes by transit. Transit shares are highest inside the I-440 beltway and at a smattering of other locations elsewhere in the region. Locations near the region's periphery with moderate to high mode shares likely reflect park-n-rider commuters.

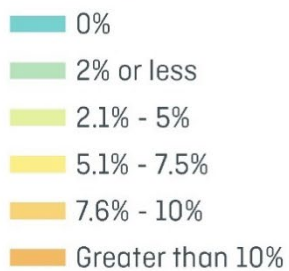
Other notes: Numerous current research efforts are focused on developing reliable, re-usable methods for providing fine-grained mode share estimates with reduced or no reliance on regional travel models. In some cases, these approaches lean on simple behavioral relationships – such as mode choice based on relative accessibility scores – while others utilize emerging travel data from big data vendors. Future updates to the RED Lanes evaluation methodology should explore innovative approaches to forecasting mode shares.

DEMAND	Transit Mode Share		
	OPERATIONS	CONTEXTS	DESIGN
Existing Conditions Report Indicators and Metrics			R-13 June 2020

RED LANES | EXISTING CONDITIONS - TRANSIT COMMUTE MODE SHARE



Percent of Commutes on Transit (Work-at-Home Excluded)



DEMAND

Transit Mode Share

OPERATIONS

CONTEXTS

DESIGN

INDICATOR | TRAFFIC VOLUME

What is it? Traffic volume is a fundamental measure of overall travel demand, quantifying the number of vehicles on a roadway for a given time period. It is generally reported on a segment basis for an average day as well as for peak commuting periods. In many cases, volume by direction is provided. Traffic volume also provides the basis for calculating volume-to-capacity (v/c) ratios for segments. A segment's v/c ratio compares vehicle demand relative to estimated capacity, providing some insight into how congested the facility is.

*Core Technical Team input
Focus on forecasts and peak
hour ridership.*

*Priority in evaluation
methodology: Medium*

Why does it matter? RED Lanes can pose an opportunity cost in terms of reduced general use capacity for other vehicles in cases where an existing travel lane is designed as a RED lane. Traffic volumes and related measures, such as Level of Service (LOS) and volume to capacity ratios (v/c), can be used to estimate potential impacts on existing road users and to gauge the appropriateness of RED Lanes facilities. Traffic volumes can also be useful in identifying potential applications of Transit Signal Priority (TSP) or other companion strategies. The greatest RED Lanes benefits generally occur at intersections where the operational v/c is between 0.8 and 1.0. From a planning perspective, a segment v/c ratio of 1.2 is a generally equivalent and appropriate upper threshold due to the systemwide nature of long-range travel demand forecasting models such as the TRM in which operational issues like vehicle spillback are addressed implicitly rather than explicitly.

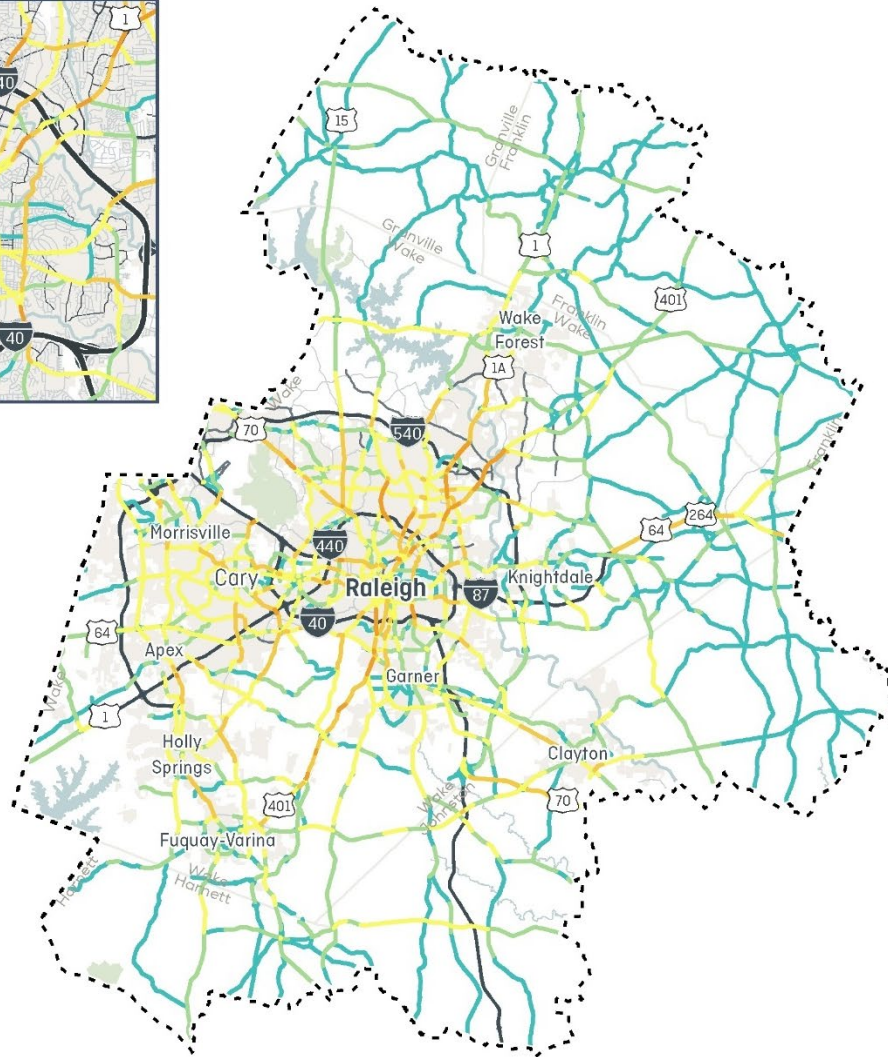
How is it measured? Absolute values of vehicles using each segment are typically reported. In this report, daily bi-directional volume forecasted for 2045 is presented first. This provides a clear sense of where the region's heaviest total travel demand is, which could heighten a corridor's suitability for RED Lanes if other considerations, such as transit service frequency and ridership are also favorable. However, a second measure – PM peak hour v/c ratio by direction for 2045 – provides additional insight into how much volumes are likely to affect roadway operations. Excessive v/c ratios (greater than 1.2) are often unsuitable for RED Lane implementation.

What data and tools are needed? TRM is the best source for developing regionwide traffic volume and v/c ratio estimates, especially for future year forecasts. Traffic volume metrics are obtained as outputs on the TRM's highway network in a readily-usable format. In this study, maps of daily traffic volumes excluded Interstate highways and other expressways or tollways, since these facilities often carry much higher volumes of traffic than surface streets and are not candidates for RED Lane implementation. PM Peak hour v/c ratios are mapped since these typically represent the time of day when traffic volumes are highest.

Findings: Volumes are highest in commuting corridors between Raleigh and suburban and exurban locations in all directions. Prominent high-volume corridors are listed in Table 2. Emerging secondary markets may be visible in southwestern Wake County (Fuquay-Varina – Holly Springs – Apex – Cary), the Research Triangle Park (RTP)/airport area, and between Clayton and Garner. In many of these major commuting corridors, the v/c map reveals a high degree of directionality. Though the ratios are generally within levels compatible with RED Lane implementation, transit priority treatments may be better suited to shorter high-volume corridors with less directional peaking, such as Kildaire Farm Road or Raleigh Boulevard.

DEMAND	Traffic Volume		
	OPERATIONS	CONTEXTS	DESIGN

RED LANES | EXISTING CONDITIONS - TRAFFIC VOLUME



0 5 10 20
Miles



2045 Total daily volume (TRM)

- 0 - 10,000
- 10,001 - 20,000
- 20,001 - 40,000
- 40,001 - 60,000
- 60,001 - 123,845

*Interstates and other expressways
and tollways excluded.*

DEMAND

Traffic Volume

OPERATIONS

CONTEXTS

DESIGN

RED LANES | EXISTING CONDITIONS - TRAFFIC VOLUME



2045 Volume-to-Capacity (v/c) ratio by direction (PM Peak Period)

- 0.00 - 0.75
- 0.76 - 0.85
- 0.86 - 1.05
- 1.06 - 1.25
- 1.26 - 2.25

DEMAND	Traffic Volume		
	OPERATIONS	CONTEXTS	DESIGN

Table 2 Corridors with 2045 Daily Volumes in Excess of 50,000

Road Name	Length (mi)	Daily Volume	v/c in NB or EB dir	v/c in SB or WB dir
S. Saunders St.	1.32	81,096	1.25	1.01
Rock Quarry Rd.	0.77	69,238	1.41	1.10
Six Forks Rd.	2.34	67,646	0.92	1.08
US 401 (NORTH)	4.30	67,591	0.53	0.59
Capital Blvd.	3.94	65,803	0.70	0.99
Western Blvd.	0.17	61,413	1.61	1.43
N. Harrison Ave.	0.42	60,462	0.69	0.67
Lake Wheeler Rd.	0.24	59,744	1.63	1.16
Falls of Neuse Rd.	0.79	59,528	0.81	1.00
Wake Forest Rd.	2.03	59,225	0.98	1.19
US 401	6.99	58,107	0.90	0.62
Walnut St	1.46	56,950	0.84	0.94
Glenwood Ave.	0.32	56,802	1.08	0.49
US 70	2.32	56,606	0.56	0.81
Kildaire Farm Rd.	0.34	56,448	1.27	1.18
S.E. Maynard Road	0.09	56,261	0.99	0.86
NC 55	1.45	56,112	1.18	0.92
Creedmoor Rd.	1.13	55,672	0.73	1.02
Aviation Pkwy	0.28	55,336	0.84	0.74
Gorman St.	0.12	54,940	1.26	1.03
Wade Ave.	2.19	54,394	1.16	1.13
Sunset Lake Rd	0.40	53,389	1.43	1.06
Wilmington St.	1.41	53,180	0.62	0.51
Walnut St.	0.25	52,933	0.79	0.86
NC 54	0.20	52,011	1.19	1.00
New Hope Rd.	0.29	51,994	1.12	1.20
New Bern Ave.	0.46	51,714	0.50	0.98
Holly Springs Rd	1.47	51,505	1.19	0.91
Davis Drive	0.45	51,378	1.22	1.00
Poole Rd.	0.21	50,824	1.06	1.37
Hammond Rd.	0.39	50,302	1.01	0.66
Spring Forest Rd.	0.19	50,288	0.97	1.25
Raleigh Blvd.	0.15	50,273	1.36	1.05

Table 2 shows the corridors with daily bi-directional traffic volumes exceeding 50,000 vehicles. PM Peak period v/c ratios are also shown. In many cases, v/c ratios are in acceptable ranges for RED Lanes implementation (highlighted cells). Since the table focuses on the highest-volume facilities, it suggests that many of the most congested facilities shown in the v/c map are only carrying moderate traffic.

Other notes: (None)

DEMAND	Traffic Volume		
	OPERATIONS	CONTEXTS	DESIGN

INDICATOR | NON-MOTORIZED USERS

What is it? Non-motorized travel modes are essential components of multimodal urban transportation. The two major non-motorized modes are walking and bicycling. Demand for these modes arises for utilitarian purposes (work and shopping trips, e.g.), multimodal connectivity (access to/egress from transit, e.g.), and recreational or social activities.

Why is it important? RED Lanes may present opportunities to add bike lanes to a corridor and are compatible with complete streets design approaches, which cater to all travel modes. Moreover, effective transit service and walkable districts are mutually supportive, providing reliable non-auto travel options. The presence of non-motorized users does not necessarily elevate a corridor for RED Lanes consideration but may influence appropriate design choices for high-ranking corridors.

How is it measured? Ideal measures of non-motorized demand would mimic transit ridership and traffic volume measures, estimating the number of non-motorized users on a given segment or within a given corridor. However, comprehensive non-motorized trip data are difficult (and often costly) to obtain. For this reason, proxy measures reflecting factors related to non-motorized trip-making propensity are often utilized to better understand where demand for these trips is likely to be strongest. For this report, walk access to jobs is used to highlight areas with sufficient concentrations of and connectivity to trip attractors (jobs) to suggest a strong potential for non-motorized activity.

What data and tools are needed? Walk accessibility is best measured using fine-grained land use and travel network data. The Accessibility Observatory (AO) at the University of Minnesota² tracks accessibility trends over time at the census block level for the largest metropolitan areas in the country. The AO data are generated using LEHD³ jobs data and OpenStreetMap⁴ networks. Since the AO analysis focuses on metropolitan areas, portions of the CAMPO region outside the core metro area counties (Wake, Johnston, and Franklin) are missing walk access data. Since these data are expected to be used to help guide RED Lanes design decisions rather than for prioritization purposes, this gap is acceptable for the current report.

Findings: Non-motorized travel demand (walk accessibility) is highest in central Raleigh, including many in-town neighborhoods adjacent to Downtown Raleigh. Several prominent suburban centers are also visible, including the Blue Ridge Road from the Arena District to Crabtree Mall, northeast Raleigh from Triangle Town Center to I-440, and the WakeMed Hospital area along New Bern Avenue. Exurban town centers in Apex, Wake Forest, Fuquay-Varina, etc. are also notable on the map. In these areas (and in environs with similar walk access scores) RED Lanes implementation should include non-motorized facilities and/or amenities.

*Core Technical Team input
Focus on forecasts and peak
hour ridership.*

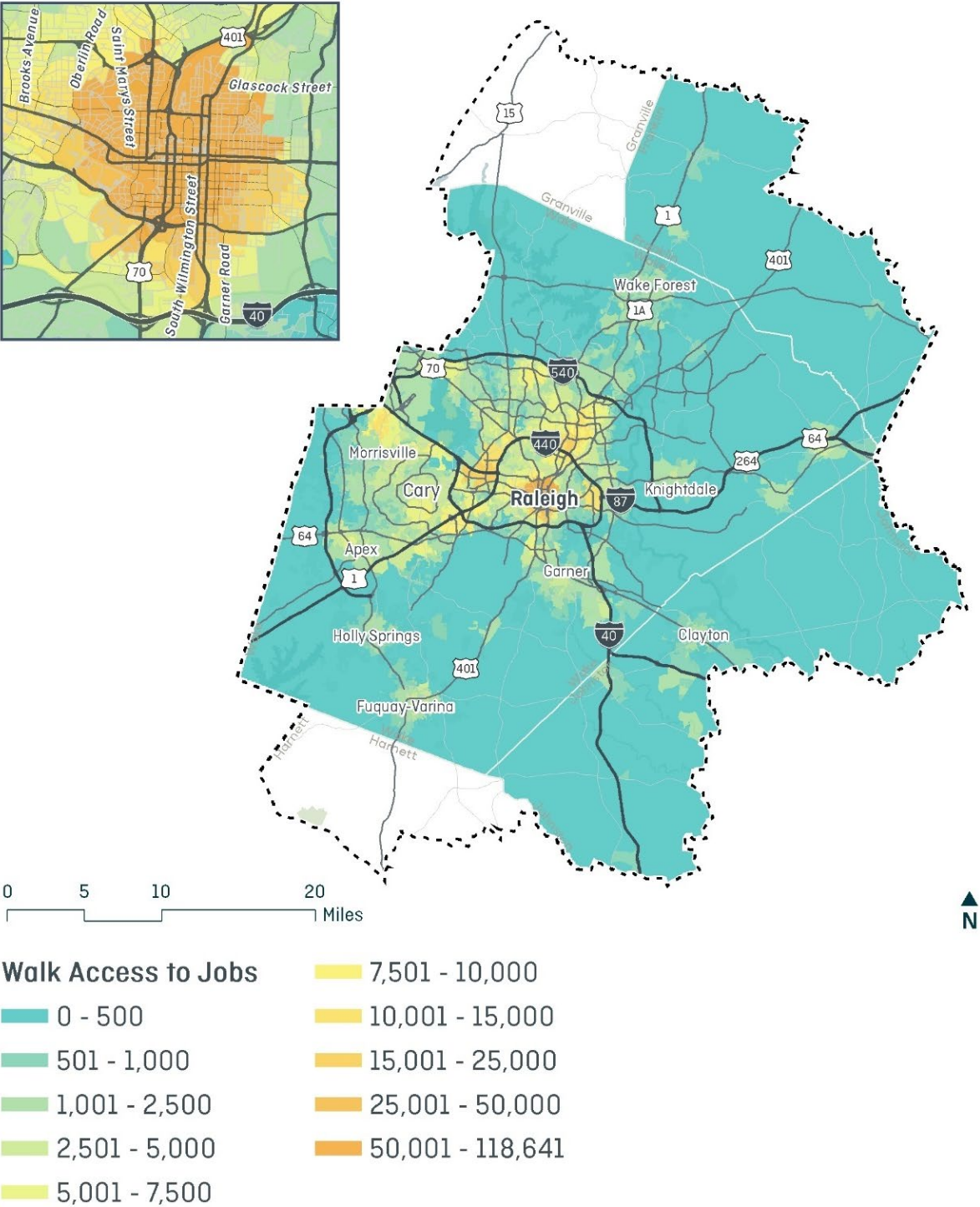
*Priority in evaluation
methodology: Low*

² <http://ao.umn.edu/>

³ <https://lehd.ces.census.gov/data/>

⁴ <https://www.openstreetmap.org/>

RED LANES | EXISTING CONDITIONS - WALK ACCESSIBILITY



DEMAND

Non-Motorized Users

OPERATIONS

CONTEXTS

DESIGN

Other notes: Walk accessibility has been shown to be a meaningful predictor of non-motorized demand.⁵ Accessibility-based modeling could be used to estimate non-motorized demand and assign non-motorized trips to local networks. Future updates to the RED Lanes evaluation methodology could offer more robust non-motorized demand estimates at a segment level to better inform facility design decisions.

INDICATOR | PERSON THROUGHPUT

What is it? Person throughput describes the total number of people moving through a corridor, regardless of mode. For example, a carpool of three co-workers commuting to work would contribute three person trips to the person throughput value for the segments they traverse, while 25 people on a bus would contribute 25 person trips to the segments along the bus route between stops.

Why is important? Recognizing the tradeoffs associated with RED Lanes (see “Traffic Volume” above), RED lane efficiency can be measured by comparing expected person throughput on the RED lane (bus passengers plus other users including cyclists and turning vehicles as appropriate) to the person throughput on adjacent travel lanes. Person throughput can also be used in combination with segment delay metrics to identify per person delay metrics. Several studies cited in the literature review in the *RED Lanes Fundamentals* report utilized person throughput measures for evaluating transit priority lanes (TCRP 183, AASTHO, MDOT, e.g.).

How is it measured? Person throughput can be expressed as total person trips on a segment, collection of segments, or system in a given period of time. For RED Lanes analysis, segment level estimates are most appropriate. Person trips completed per interval of time can be used as a productivity measure but requires complete trip information.

What data and tools are needed? Person throughput analysis requires reliable segment-level data reflecting complete trips by all modes. The traffic volume estimates provided above would need to be embellished to account for vehicle occupancy; transit ridership would need to be disaggregated from route to segment level; and non-motorized trips would need to be estimated and assigned to travel networks. Thus, a person throughput measure requires substantial data development and analytical effort to reliably produce. The combination of more readily developed modal demand metrics (traffic volume, e.g.) provide ample insight into segment utilization to support the initial RED Lanes evaluation methodology. Person throughput analysis should be considered in potential future updates to the methodology as data resources and analytical approaches for multimodal travel evolve.

⁵ <http://www.trb.org/Main/Blurbs/171138.aspx>

OPERATIONS

- Transit On-Time Performance
- Transit Service Frequency
- Transit Signal Priority
- Person/Vehicle Delay
- Average Travel Speed

TOPIC | OPERATIONS

RED Lanes are primarily focused on enhancing transit operations through the provision of transit priority lanes and supportive treatments, such as signal priority. Therefore, operational indicators are important considerations in identifying the suitability of RED lanes in a given corridor. Ideally, RED Lanes will be implemented in corridors where transit operations are critical for corridor mobility and/or where operations can be enhanced by the RED Lane. This section highlights existing and forecasted operational indicators, focusing on transit vehicle operations and

service design, highlighting key findings to consider in developing the RED Lanes evaluation methodology.

INDICATOR | TRANSIT ON-TIME PERFORMANCE/TRAVEL TIME RELIABILITY

What is it? Transit routes typically operate on a schedule, serving stops at predictable times and intervals. Deviations from the schedule – including early and late arrivals at stops – undermine reliability for transit passengers. On-time performance measures transit reliability and identifies locations that pose challenges to maintaining route schedules.

Why does it matter? RED Lanes are intended to confer travel time benefits to transit vehicles, reducing delays from congestion and enhancing travel time reliability along a route and potentially throughout the system. Measuring transit on-time performance helps to identify routes/segments where transit service is unreliable. These segments (and upstream segments as applicable) would likely see some of the greatest travel time reliability benefits from RED Lanes implementation as choke points are alleviated.

*Core Technical Team input
Focus on targets, peak hour
performance*

*Priority in evaluation
methodology: High*

How is it measured? On-time performance is generally measured by recording the number of times a transit vehicle arrives early or late at a given stop or by looking at the number of on-time departures from the start of a route and/or arrivals at the end of a route. This value can then be compared to the total trips serving that stop or made by that route to calculate the on-time performance rate. Criteria must be devised to determine when a trip is early or late, such as no more than one minute ahead of schedule and no more than five minutes behind schedule. In this report, route-level on-time performance is presented. This reflects the proportion of trips for a given route that leave the route's start point and arrive at its end point on time during a one-month analysis period. While on-time performance is a useful indicator of transit reliability, it is worth noting that route (re)design and scheduling can help routes stay "on time," even as operational issues pose delays that undermine the competitiveness of the transit mode.

What data and tools are needed? On-time performance is best analyzed using automatic vehicle location (AVL) data. AVL records are often developed differently by/for different transit agencies and may not always be collected or maintained in the same manner even for agencies operating in the same geographic region.

		Transit On-Time Performance	
DEMAND	OPERATIONS	CONTEXTS	DESIGN

Therefore, AVL metadata are important to support consistent application of the data across a region. Data cleaning and wrangling steps may be required to prepare all data for analysis, and this may be done using a variety of tools, such as R, Python, Excel, and/or GIS software. These tools are also suitable for analyzing on-time performance based on consolidated AVL records and generating findings. For this study, GoRaleigh and GoCary provided AVL-based on-time performance data at a route level. GoRaleigh data were provided for March 2019; GoCary data for September 2018. GoTriangle did not share on-time performance data for this study.

In the absence of robust AVL data, transit agency staff and vehicle operators can often provide meaningful insight into routes that struggle with on-time performance and specific locations that regularly contribute to delays. For this study, NCSU Wolfline staff identified three notable intersections and four segments that regularly affect on-time performance for Wolfline routes (see “Findings” section below for details).

Findings: Since the on-time performance data are provided at a route level, it is not possible to isolate specific segments as principal contributors to transit delays. However, it is apparent from the map that longer distance routes and those operating in suburban or exurban areas (especially as crosstown routes) are more prone to delays than shorter routes concentrated inside the I-440 beltline and focused on downtown Raleigh. In the RED Lanes evaluation methodology, route-level on-time performance information will likely need to be overlaid with segment-level traffic and delay information (discussed elsewhere in this report) to identify segments where RED Lanes can be expected to improve on-time performance. The routes with on-time performance rates of 85% or below are shown in Table 3 below. Table 4 lists the key intersections and segments that regularly introduce delays for the NCSU Wolfline services.

Table 3 Routes with On-Time Performance Rates of 85% or Lower

Route	On-Time Performance Rate
GoCary – 5X Kildaire Farm Express	59% ⁶
GoRaleigh – 18S Poole Rd	63%
GoRaleigh – FRX Fuquay-Varina Express	65%
GoRaleigh – 26 Edwards Mill	68%
GoRaleigh – Wake Forest Loop	69%
GoRaleigh – 27 Blue Ridge	70%
GoRaleigh – 63X (KDX) Knightdale Express	70%
GoRaleigh – 40X Wake Tech	70%
GoRaleigh – 70X Brier Creek Express	71%
GoRaleigh – ZWX Zebulon/Wendell Express	72%
GoRaleigh – 102 Garner	72%
GoRaleigh – 18 Poole-Barwell	73%
GoRaleigh – 23L Millbrook Crosstown	74%
GoCary - Route 5 - Kildaire Farm Road	75%
GoRaleigh - 5 BILTMORE HILLS	76%
GoCary - Route 4 - High House Road	76%

⁶ On time performance rate for August, 2019. September data showed an unexpectedly low on-time performance rate of 17%.

DEMAND	OPERATIONS	Transit On-Time Performance	
		CONTEXTS	DESIGN

Route	On-Time Performance Rate
GoCary - Route 3 - Harrison Ave	77%
GoRaleigh - 11I Buck Jones	77%
GoRaleigh - 24I North Crosstown	78%
GoRaleigh - 21 Caraleigh	78%
GoCary - Route 6 - Buck Jones Road	78%
GoRaleigh - 25I Triangle Town Center	79%
GoRaleigh - 36 Creedmoor	80%
GoRaleigh - 22 State Street	80%
GoRaleigh - 16 Oberlin Road	80%
GoRaleigh - 8 Six Forks	81%
GoRaleigh - 11 Avent Ferry	81%
GoRaleigh - 13 Chavis Heights	81%
GoRaleigh - Wake Forest Express (WFX)	81%
GoRaleigh - 55x Poole Road Express	82%
GoRaleigh - 4 Rex Hospital	83%
GoRaleigh - 2 Falls Of Neuse	83%
GoRaleigh - 17 Rock Quarry	84%

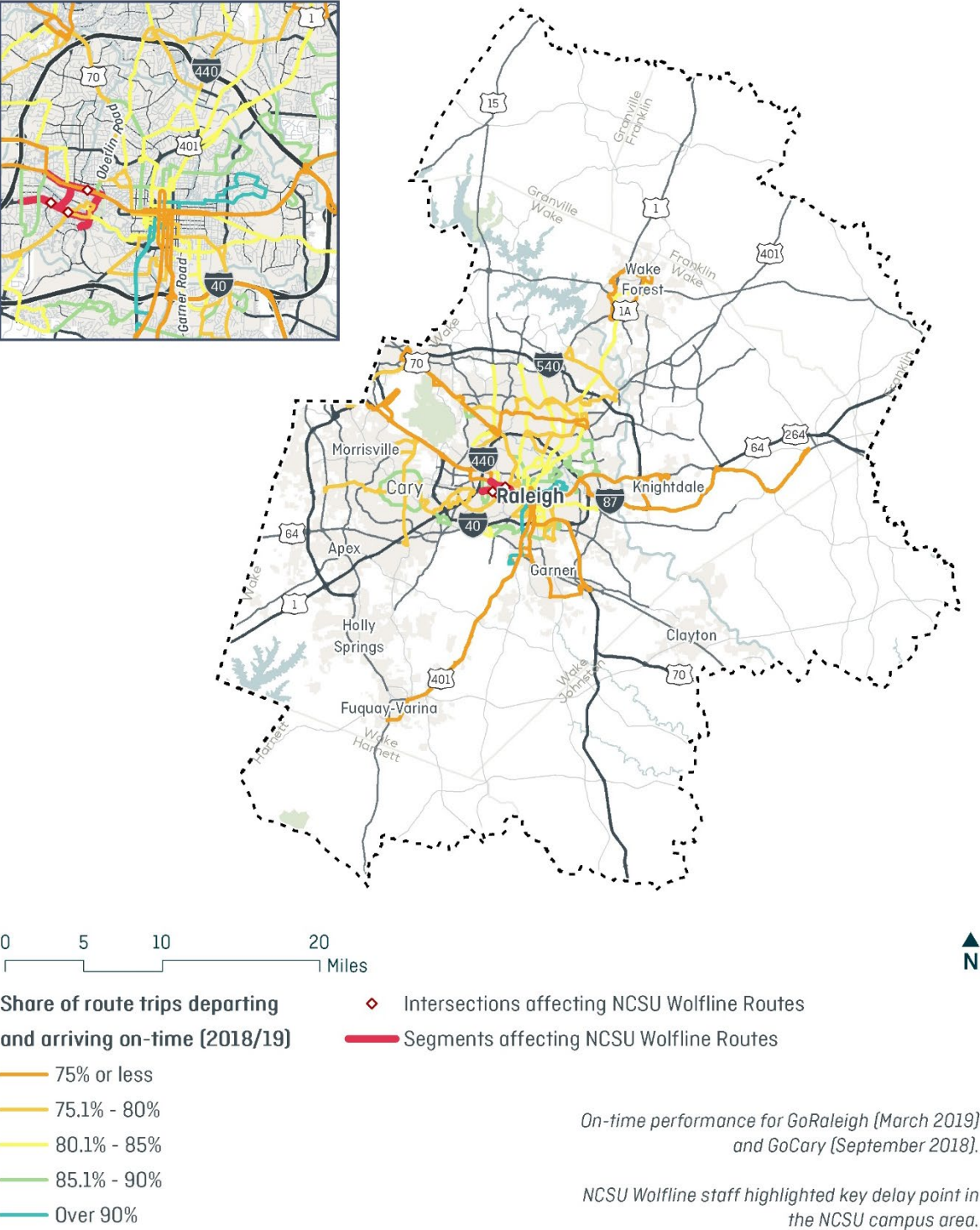
Table 4 NCSU Wolfline Locations that Impact On-Time Performance

Intersections	Segments
<ul style="list-style-type: none"> Avent Ferry Rd./Morrill Dr./Western Blvd. Hillsborough St./Horne St./Lampe Dr. Western Blvd./Varsity Dr 	<ul style="list-style-type: none"> Western Blvd. - Method Rd./Kent Rd. to Pullen Rd. Hillsborough St. - Faircloth Rd./Gorman St. to Pullen Rd. Dan Allen Dr. - Western Blvd. to Hillsborough St. (4:00 pm-6:00 pm) Pullen Rd. - Bilyeu St. to Stinson Dr.

Other notes: Challenges related to assessing or forecasting transit on-time performance include dependence on detailed travel modeling procedures; imprecise apportionment of observed delays along a route, complicating clear articulation of appropriate RED Lane implementation limits; and inconsistencies in detailed vehicle location data requiring substantial pre-processing, such as reported dates, organization of information, or metrics generated across all transit agencies. Developing uniformity in AVL datasets across all transit providers in the region could simplify the process of developing more detailed on-time performance metrics. Recommendations for developing such consistency is beyond the scope of this report. Forecasting on-time performance is difficult on a regionwide basis as schedule adherence issues often arise from fine-grained factors that are too minute to account for in regional forecasting models. Additionally, for routes that offer frequent service, headway adherence is often preferred over on-time performance for travel time reliability metrics. Headway adherence data were not made available from the region's transit providers for this study. Future enhancements to the RED Lanes evaluation methodology could include the use of stop-level on-time performance metrics to precisely locate the primary segments that cause certain routes to deviate from their schedules. This would create a more focused metric for RED Lane analysis.

		<i>Transit On-Time Performance</i>	
DEMAND	OPERATIONS	CONTEXTS	DESIGN

RED LANES | EXISTING CONDITIONS - ON TIME PERFORMANCE



		Transit On-Time Performance	
DEMAND	OPERATIONS	CONTEXTS	DESIGN

INDICATOR | TRANSIT SERVICE FREQUENCY

What is it? Transit service frequency describes the regularity and intervals at which a transit vehicle serves a stop location or traverses a street segment. Transit routes often operate at regular intervals (headways), such as “every 30 minutes” or “every 15 minutes.” When multiple routes serve a given corridor, connectivity between common stops will be more frequent than the route headways.

*Core Technical Team input
Focus on planned frequency*

*Priority in evaluation
methodology: Low*

Why does it matter? There is a strong consensus in the literature that RED Lanes are most appropriate in corridors and segments with transit service operating at high frequencies. The maximum recommended headway for RED lane applications is 15 minutes, but transit lanes are generally considered to be most effective at higher frequencies, when transit utilization of a lane becomes “self-enforcing” due to the high frequency of service. Further, more frequent transit service is associated with higher transit ridership. Therefore, identifying existing and planned high-frequency corridors is essential to understanding where RED Lane implementation is most appropriate.

How is it measured? Transit service frequency is most commonly measured as the number of buses per hour along a route or along a segment. Since RED Lanes are expected to serve multiple routes in many cases, this report focuses on segment-level frequency. Existing segment-level frequency is presented for current transit service during the PM peak travel period on a typical weekday. Service frequencies reflect bi-directional buses per hour, since RED Lanes will typically be implemented symmetrically. Rates above 8 buses per hour approximate the minimum suitable for RED Lanes.

For planned transit service, future high frequency services from the Wake Bus Plan (WBP) and Metropolitan Transportation Plan (MTP) have been mapped. Segments with planned headways of 15 minutes or less are highlighted based on the year in which the high-frequency service is planned to be implemented.

What data and tools are needed? Transit service frequency by route and time period can be readily calculated using GTFS transit data. GTFS feed nuances can present challenges, such as combining separate GTFS feeds and identifying overlapping routes and stops. For example, multiple bus routes from multiple transit agencies can traverse the same roadway segment. Therefore, in order to calculate a frequency analysis that incorporates more than one route, it is necessary to align all routes onto a common street network. Thus, a substantial portion of the analysis involves assigning trips represented in the GTFS feeds to a consistent array of roadway segments. This portion of the analysis was conducted by utilizing spatial scripts provided as part of an open source tool developed and published by U.S. Department of Transportation (USDOT).⁷ This tool contains spatial scripts that are designed to align GTFS networks, obtained from respective transit agencies and merged into a single SQLite database, with FHWA’s All Road Network of Linear Referenced Data (ARNOLD), a nationwide road network dataset that was obtained from USDOT staff. Although not completely comprehensive, the ARNOLD network represents most roadway segments in the CAMPO region suitable for RED Lanes analysis (features omitted from ARNOLD are generally

⁷ https://github.com/VolpeUSDOT/gtfs-measures/blob/master/docs/GTFS_Script_Documentation.md

		Transit Service Frequency	
DEMAND	OPERATIONS	CONTEXTS	DESIGN
Existing Conditions Report Indicators and Metrics			R-26 June 2020

local residential streets). After manually cleaning GTFS feeds and interpolating blank stop times, the USDOT scripts were utilized to ingest the various GTFS feeds reflecting all services in the CAMPO region and assign the routes to the ARNOLD network. The tool, which requires ArcGIS's Network Analyst extension and Python scripting knowledge to run, uses network routing algorithms to identify which ARNOLD segments the GTFS shapes and stops should be placed on. Finally, to calculate the frequency metric, trips per route shape were queried from the SQLite dataset of combined GTFS feeds created by the USDOT tool. These records were then able to be related to the number of trips scheduled on each ARNOLD segment during the peak period of 4:30 p.m. to 7 p.m. on a typical Wednesday. The resulting frequency estimates were joined to the ARNOLD road network and the results were mapped.

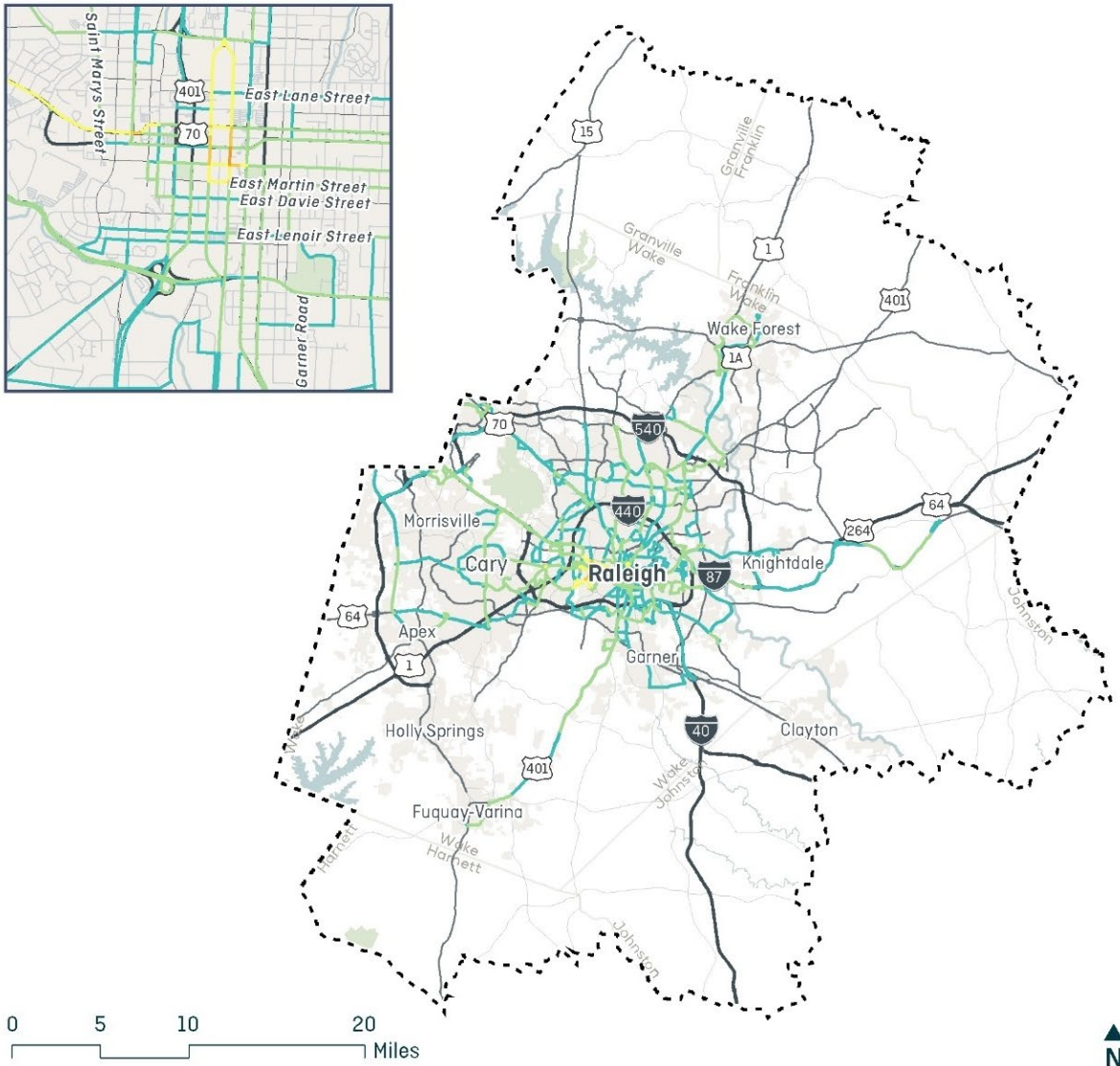
For planned service frequency, high frequency routes were selected from line features reflecting the WBP and MTP planned transit alignments.

Findings: During peak hours, a large portion of the network in the study area operates at rates of 1-4 buses per hour, or with one bus or fewer every 15 minutes on a bi-directional basis (i.e., one-bus per 30 minutes in each direction). As routes converge, particularly in Raleigh, cumulative frequencies begin to rise. In certain areas, the analyses show that isolated segments can see frequencies up to 22 buses per hour, or approximately one every 3 minutes on a bi-directional basis. While there is not a uniform threshold that is supportive of RED Lanes, it is generally recognized that transit lanes are most effective in areas where transit service is frequent enough to be self-reinforcing.

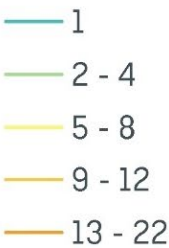
Planned high frequency service is concentrated in the urban heart of the CAMPO region, mostly within the I-440 beltline. The near-term frequent service priorities are on north-south and east-west urban axes through downtown Raleigh.

Other notes: The map of planned service frequency assumes bi-directional service on all segments overlaid on a future transit route alignment. In some cases, route alignments use loops or lariats that will only travel in a single direction. Accounting for these route components requires fracturing the original planned transit routes linework and denoting which line segments are bi-directional versus a single direction of travel. In light of the diverse indicators and data preparation needs for this report, this embellishment was not undertaken for the current analysis. Since most planned routes are predominantly comprised of bi-directional segments, there is minimal risk of the bi-directional assumption giving undue priority to a uni-directional segment in the RED Lanes evaluation methodology. However, future enhancements to the methodology may consider refining the future bus alignment data to differentiate bi-directional and uni-directional segments.

RED LANES | EXISTING CONDITIONS - TRANSIT SERVICE FREQUENCY

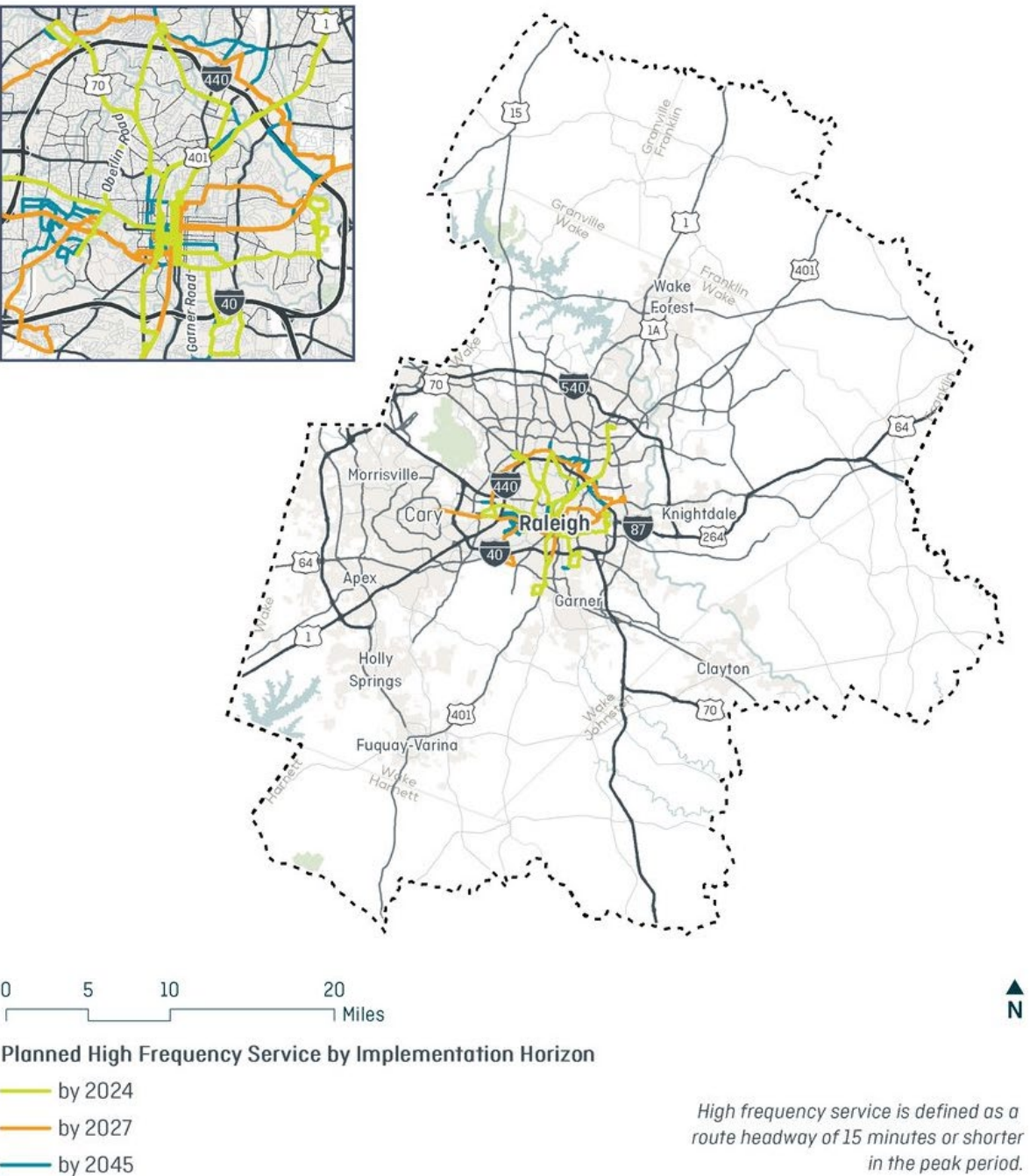


Peak Hour Service - Trips Per Hour



		Transit Service Frequency	
DEMAND	OPERATIONS	CONTEXTS	DESIGN

RED LANES | EXISTING CONDITIONS - PLANNED SERVICE FREQUENCY



		Transit Service Frequency	
DEMAND	OPERATIONS	CONTEXTS	DESIGN

INDICATOR | TRANSIT SIGNAL PRIORITY

What is it? Transit Signal Prioritization (TSP) is a method for increasing transit vehicle speed and improving reliability through the adjustment of signal timing at intersections. TSP typically extends a green phase or truncates a red phase if a transit vehicle is attempting to enter an intersection, thereby decreasing the delay likely to be experienced at a signalized intersection.

Core Technical Team input

*Priority in evaluation
methodology: Medium*

Why is it important? Transit signal priority (TSP) can be an effective supporting component alongside the implementation of a RED Lanes project. As a companion strategy to a transit priority lane, TSP can alleviate delays at intersections and improve travel time reliability. TSP is most effective along corridors with v/c ratios between 0.8 – 1.0 (see “Traffic Volume” above for more information).

How is it measured? Since TSP is primarily an operational improvement strategy rather than a factor determining RED Lane suitability, there is no typical metric quantifying TSP. The presence of TSP, and - more broadly - Intelligent Transportation Systems (ITS) signaling infrastructure could potentially inform the prioritization of candidate corridors for RED Lanes, as it indicates a planned or existing presence of supportive technology. However, data indicating where TSP or supporting ITS infrastructure are in-place or planned were unavailable for this report.

It may be possible to utilize other metrics generated for this report – transit on-time performance and traffic volume v/c ratios, specifically – to develop a coarse TSP suitability score for candidate corridors. This could help guide RED Lane design and implementation to consider TSP in appropriate contexts. The suitability score would highlight segments or intersections traversed by bus routes with observed downstream on-time performance issues and TSP-supportive v/c ratios. However, because this study is focused on RED Lanes and not TSP as a stand-alone improvement, developing a TSP suitability score is a low priority.

What data and tools are needed? Data identifying where TSP or TSP-supportive technologies are currently installed or planned within the region would ideally be available to inform the RED Lanes evaluation methodology. GIS software would be used to relate existing or planned ITS or TSP to study segments.

Challenges exist in developing an appropriate formulation of a TSP suitability score, as there is not a definitive best practice methodology prescribing how to combine diverse measures for this application. Data needs for a simplistic approach could include intersection LOS; segment v/c ratios; on-time performance rates; and a signals location dataset.

Findings: Several corridors are currently being studied for operational and transit-supportive strategies, including TSP. These include NC 54 from downtown Cary to Morrisville or an alternative route using McCrimmon Parkway; US 70 from Garner Station to Clayton; Western Boulevard in portions being studied for BRT; Wilmington Street in portions being studied for BRT; and along sections of Capital Boulevard.

Other notes: (None)

		Transit Signal Priority	
DEMAND	OPERATIONS	CONTEXTS	DESIGN
Existing Conditions Report Indicators and Metrics			R-30 June 2020

INDICATOR | PERSON/VEHICLE DELAY

What is it? Delays in transportation are disruptions of travel time expectations, often arising from degradations in travel conditions. For example, delays are created when highways become congested and operate at speeds significantly lower than their typical operating speeds or when a connection between two places is severed by construction activity or a train crossing. Delays usually impact all vehicles utilizing an effected corridor or segment, including buses. While some instances of delay arise from unusual events or circumstances, many are systematic and recurrent in nature – such as congestion-related delays during peak travel periods.

Core Technical Team input

*Priority in evaluation
methodology: Low*

Why is it important? Recurrent delay affects the efficiency and reliability of transit services. RED Lanes and related transit priority treatments are intended to improve the reliability and speed of transit services, and in many cases, they have been implemented specifically to address issues arising from systemic delays. According to the literature reviewed for the *RED Lane Fundamentals* report, RED Lanes are most effective when implemented in corridors with moderate-to-heavy congestion-related delay. In corridors with minimal delay, RED Lanes are unlikely to confer significant travel time savings.

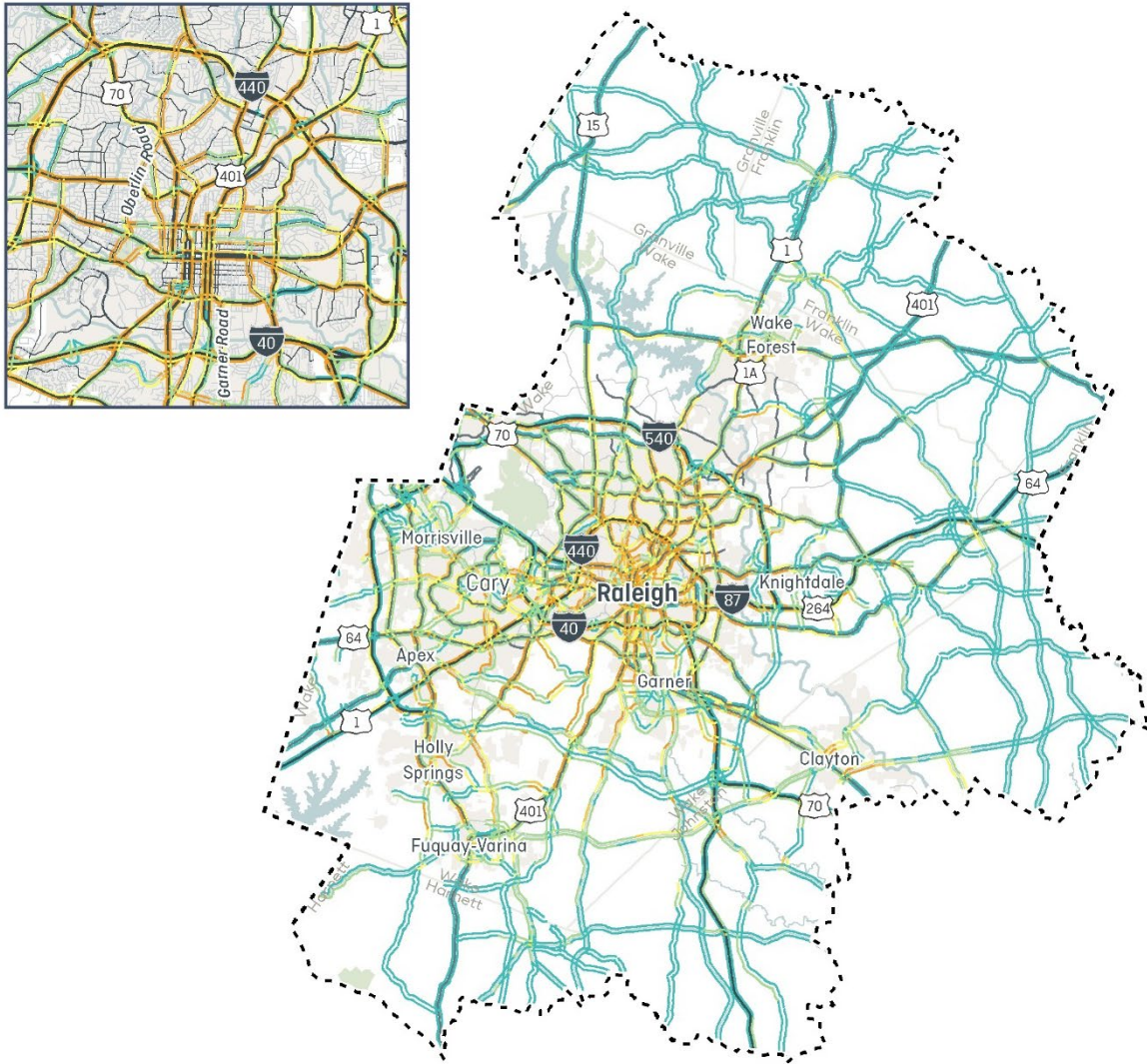
How is it measured? A simple formulation of delay is the ratio of congested speed to free flow speed on the highway network for 2045. This reflects anticipated systematic, recurrent delays consistently on a regionwide basis using readily available datasets and tools.

What data and tools are needed? Estimated congested and free flow highway speeds are generated by the Triangle Regional Model (TRM) and reported at a segment level on the loaded highway network.

Findings: The degree to which congestion degrades travel speeds relative to free-flow conditions can be expressed using a congested-to-free-flow (C:FF) speed ratio. The C:FF ratio for the CAMPO region in the AM peak period is shown in the map below, based on the TRM's 2045 loaded highway network. Arterial delays are most common in the heart of the region, focused on Raleigh and Cary. The area inside the beltline is most effected by congestion with many links operating at 75% of free flow speeds or slower. In many cases, the delays are expected in both travel directions. Other concentrations of delay can be seen in Northeast Raleigh, South Raleigh-Garner, and (to a lesser degree) southwestern Wake County. Select segments exhibit congestion-related delays throughout other part of the region. In most cases, delay is experienced in the peak commuting direction on facilities outside the beltline. In corridors with heavy peak directional flow, part time RED Lanes may be warranted.

		Person/Vehicle Delay	
DEMAND	OPERATIONS	CONTEXTS	DESIGN
Existing Conditions Report Indicators and Metrics			R-31 June 2020

RED LANES | EXISTING CONDITIONS - VEHICLE DELAY



0 5 10 20 Miles



2045 Congested-to-free-flow-speed ratio by direction (PM Peak Period)

- 65% or less
- 65.1% - 75%
- 75.1% - 85%
- 85.1% - 95%
- 95.1% - 100%

		Person/Vehicle Delay	
DEMAND	OPERATIONS	CONTEXTS	DESIGN

Other notes: There are many approaches to measuring delay metrics. Detailed approaches often require developing multiple underlying metrics for diverse modes, resulting in complex analyses and data coordination needs. Person delay is recommended for transit-oriented analyses by the American Association of State Highway and Transportation Officials (AASHTO) Transit Design Guide⁸ because it accounts for all passengers/travelers instead of focusing on vehicles only. Meanwhile, transit vehicle dwell time is delay metric that can provide insight into intersections causing significant delays, which can then be targeted for companion spot improvements such as TSP or queue bypasses.

In all cases, detailed delay metrics pose time and cost challenges related to the complexity of integrating multiple datasets, purchasing proprietary data sets, and accounting for variance between observed conditions and modeled data at specific locations. Some commonly used delay metrics include delay rate;⁹ relative delay rate;¹⁰ delay ratio;¹¹ total delay (measured in vehicle-minutes);¹² and transit vehicle dwell time at intersection (derived from AVL data). Supporting data sets could include TRM loaded networks; HERE Traffic Analytics (average historical speed); GTFS schedule (transit vehicle speed); NCDOT Traffic Segments (posted speed limit); and transit agency AVL data.

⁸ See *TCRP Report 183: A Guidebook on Transit-Supportive Roadway Strategies*, 2016. <https://www.nap.edu/download/21929> [section 4.2]

⁹ Actual travel rate (mins/mi) – acceptable travel rate (mins/mi)

¹⁰ Delay rate / acceptable travel time

¹¹ Delay rate / actual travel time

¹² Actual travel time (mins) - acceptable travel time (mins) x volume

INDICATOR | AVERAGE TRAVEL SPEED

What is it? Transit travel time is directly related to the typical speed maintained by transit vehicles. Transit travel speeds tend to be lower than those for adjacent cars as buses make stops to allow passengers to board and alight the vehicle. In some cases, agencies or regions adopt transit travel speed service standards to evaluate route performance. The standards and monitoring of travel speed can help support route planning and stop-placement decisions with a focus on maintaining competitive travel speeds.

Core Technical Team input

Priority in evaluation methodology: Low

Why is it important? RED Lanes are intended to enhance travel speed for transit vehicles without unduly impacting travel conditions for motorists. An average travel speed analysis is useful to identify corridors where transit vehicle speeds are expected to be slow and/or drop below service standard targets.

How is it measured? Travel speed service standards are typically applied at the route level, but segment-level analysis helps identify specific locations where speeds are reduced. In this report, peak-hour segment-level estimated transit speeds for 2045 are presented. Speed estimates are expressed in miles per hour.

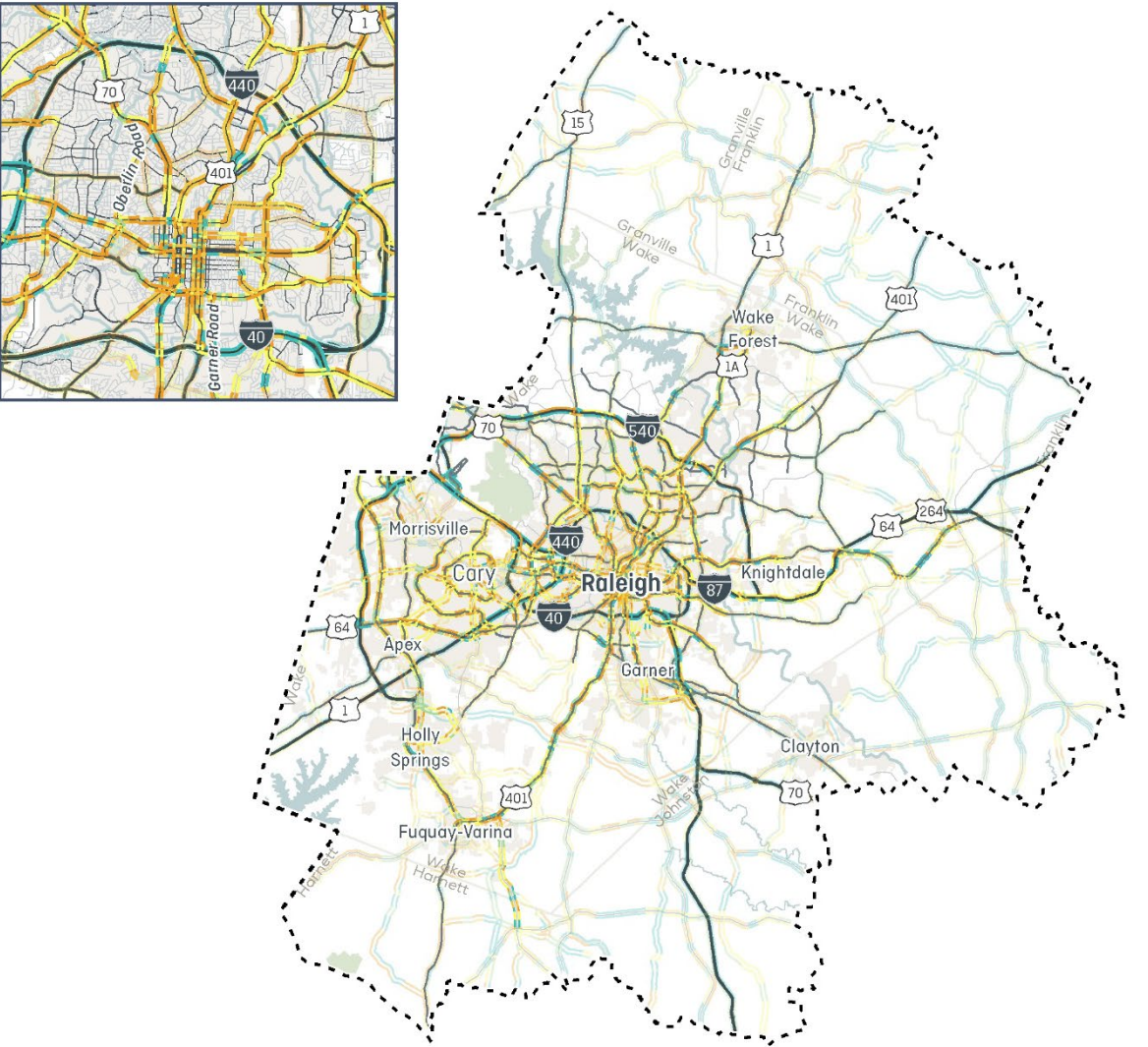
What data and tools are needed? Estimated peak-hour transit speeds are available from the Triangle Regional Model (TRM). Bus speeds are estimated based on TRM loaded highway network attributes, segment facility type, and speed curves used in the TRM. Bus speed estimates can be calculated for all segments in the TRM highway network but are most meaningful for segments utilized by transit vehicles. Results for all segments are presented here, but segments with no planned transit service in 2045 are muted in the map through opacity reductions. In this way, bus speeds can be seen for all roads that could potentially have transit operations, but the focus remains on roads that have existing or planned service.

Findings: Based on the TRM estimates, bus speeds are generally slow throughout the CAMPO region except on rural routes (most of which have no planned transit service) or on expressway segments. The Wake County Transit Plan's BRT Design Standards¹³ use a 16 mph standard for BRT projects, and most segments with planned transit in 2045 fall below that threshold. No specific RED Lanes service standard for travel speeds is envisioned, but average speeds between 12 and 16 mph are probably appropriate as loose targets. Segments estimated to operate below 12 mph may be most suitable for RED Lanes improvements to boost travel speeds, all else being equal. Most of these segments are found within the I-540/NC-540 loop.

Other notes: Other approaches to analyzing transit travel speeds are conceivable, though they typically require greater data and computational resources than the TRM-based estimates presented here. Existing speeds can be estimated based on schedule data from GTFS feeds or from observed trends using AVL and/or vehicle probe data sources. Microsimulation approaches could provide detailed insight into transit operating speeds within a corridor and the impacts of RED Lanes on operating speeds. However, these approaches are not suitable for a regionwide analysis like the evaluation methodology envisioned in this study.

¹³ <http://goforwardnc.org/wp-content/uploads/2018/11/Wake-MIS-BRT-Design-Standards-Performance-Measures-FINAL.pdf>

RED LANES | EXISTING CONDITIONS - TRANSIT TRAVEL SPEED



0 5 10 20 Miles



2045 Estimated bus travel speed by segment

- 0 - 8
- 9 - 12
- 13 - 16
- 17 - 20
- 21 - 70

Bus speed estimated for all segments in TRM 2045 highway network.

Segments without planned transit service by 2045 are muted.

		Average Travel Speed	
DEMAND	OPERATIONS	CONTEXTS	DESIGN

CONTEXTS

- Adjacent Land Uses
- Context Classification/Complete Streets
- Accessibility
- Facility Functional/Access Class

TOPIC | CONTEXTS

Indicators in the Contexts topic area focus on land uses and activity within or adjacent to a corridor, The corridor's role in the regional transportation system, and the relevant policies impacting general corridor improvement strategies and design approaches. In some cases, context considerations are applicable for prioritizing candidate corridors for RED Lanes suitability. For example, RED Lanes are most appropriate in areas with transit supportive land use characteristics, such as high density and diverse building types. In other cases, context considerations inform the appropriate implementation approaches for RED Lanes in a given

priority corridor. Contextual information should generally account for local plans and growth strategies in addition to current conditions to the extent feasible.

INDICATOR | ADJACENT LAND USES

What is it? Adjacent land use considerations describe how the area surrounding a corridor is developed, including the number and diversity of activities present. Areawide design considerations describe how these activities are organized and connected to each other.

Why does it matter? Adjacent land use analyses provide information that can inform which corridors traverse transit-supportive districts, which corridors are likely to offer the greatest benefits to the most users from transit-priority enhancements, and which corridors are in areas with RED Lanes supportive policy areas.

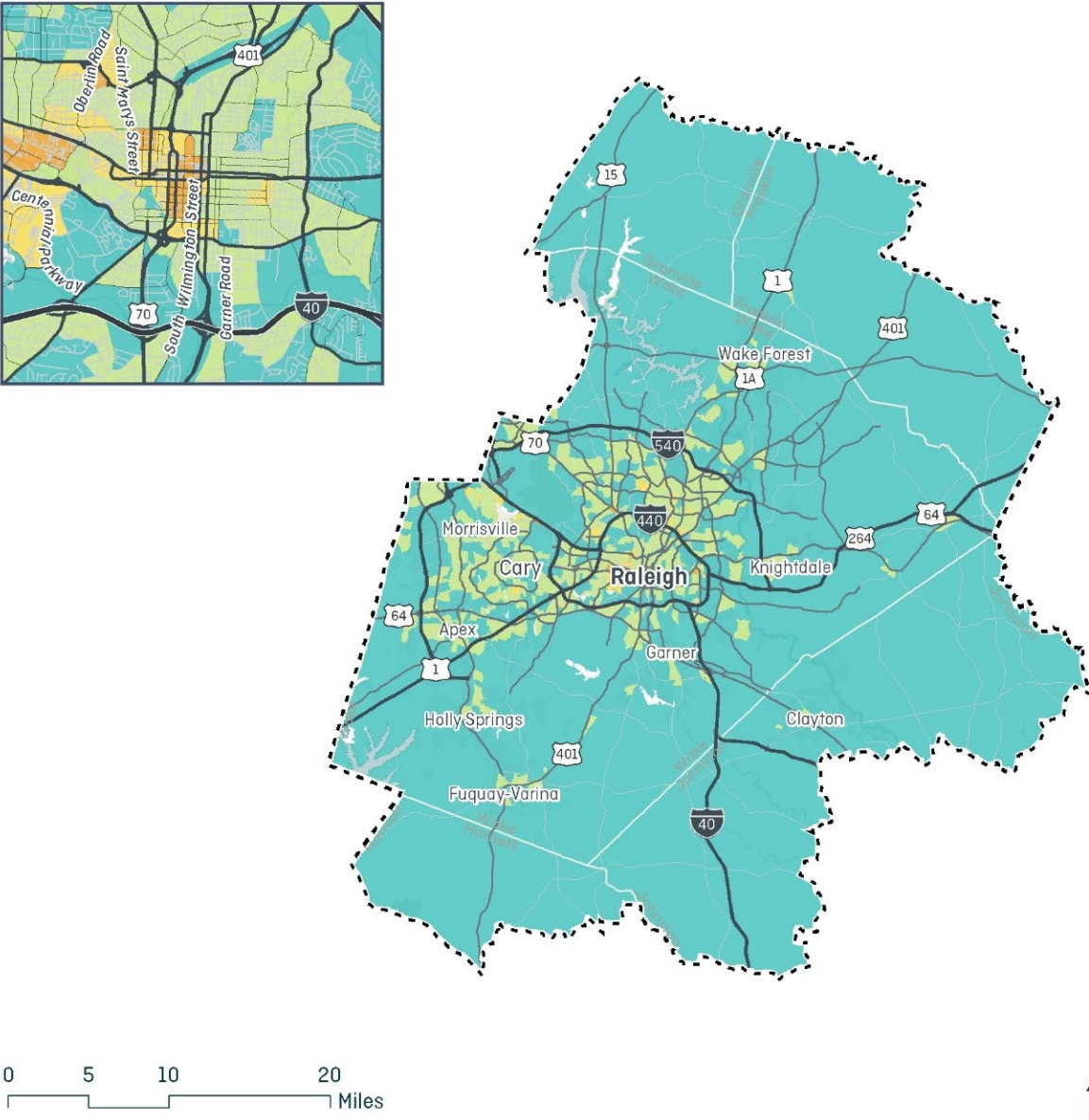
*Core Technical Team input
Focus on disadvantaged
populations*

*Priority in evaluation
methodology: Medium*

How is it measured? A variety of metrics can be used to measure adjacent land uses. For this report, activity unit density, or the number of jobs and people per acre, was selected as a simple metric that provides insight into the density of land uses along a corridor. Activity unit density is an indicator of a transit-supportive context. Intersection density is commonly used to describe neighborhood design and understand connectivity for pedestrians. Areas with higher intersection densities are generally more walkable, and more supportive of multimodal travel. For this report, thresholds for activity unit and intersection densities were derived from *TCRP Research Report 187: Livable Transit Corridors: Methods, Metrics, and Strategies*. This report identifies corridor typologies for "emerging," "transitioning," and "integrated" and provides guidelines which were used to identify the thresholds used in this report.¹⁴

¹⁴ National Academies of Sciences, Engineering, and Medicine. 2016. *Livable Transit Corridors: Methods, Metrics, and Strategies*. Washington, DC: The National Academies Press. <https://doi.org/10.17226/23630>.

RED LANES | EXISTING CONDITIONS - ACTIVITY UNIT DENSITY

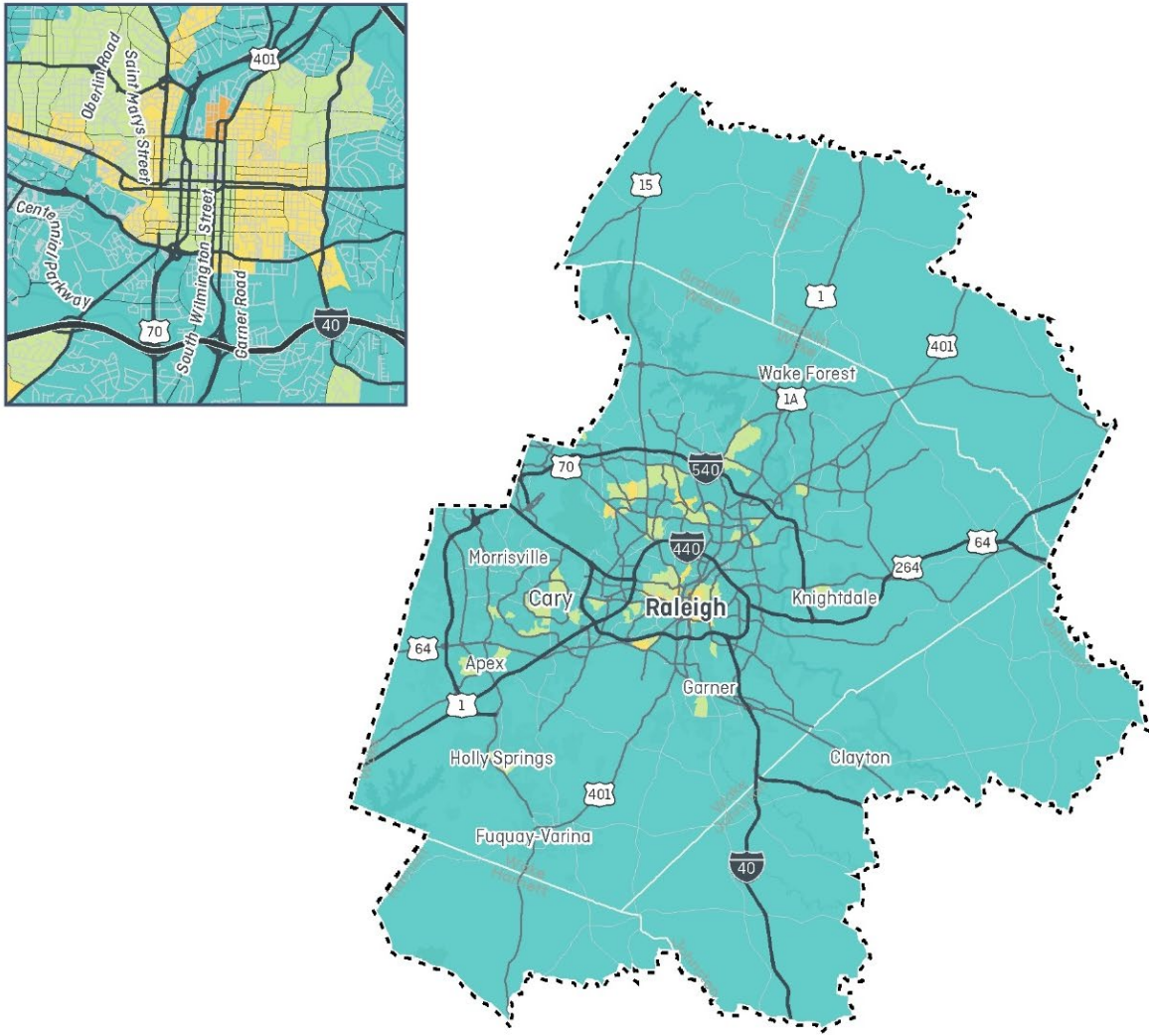


Transit Supportive Activity Unit Densities (Jobs+Pop Per Acre)

- Below Emerging (0-5)
- Emerging (6-21)
- Transitioning (22-49)
- Integrated (50-780)

Adjacent land uses			
DEMAND	OPERATIONS	CONTEXTS	DESIGN

RED LANES | EXISTING CONDITIONS - INTERSECTION DENSITY



Intersection Density Per Mile

- Below Emerging (0 - 70)
- Emerging (71 - 100)
- Transitioning (101 - 226)
- Integrated (227+)

Adjacent land uses			
DEMAND	OPERATIONS	CONTEXTS	DESIGN

What data and tools are needed? For activity unit density, the Triangle Regional Model (TRM) zonal data provides the number of jobs and population in each zone. The base 2013 land zonal data was utilized to calculate the number of activity units per acre. The EPA Smart Location Database¹⁵ contains intersection densities, with coverage of the full study area at a block group resolution. Thresholds derived from TCRP Research Report 187, a guidebook intended to support planning for livable transit corridors, are useful for plotting activity unit and intersection densities.

Findings: Activity unit densities reach the “emerging” and higher categories in several areas within the study area. The most prominent area is downtown Raleigh, which contains “Emerging,” “Transitioning,” and “Integrated” areas. Additionally, the area stretching north from Raleigh towards Wake Forest is notable. In addition, the centers of Cary, Morrisville, Apex, Holly Springs, Fuquay-Varina, Clayton, Knightdale, and Wake Forest also contain “Emerging” thresholds that are clearly visible on the map. The intersection density analysis reveals a similar pattern as activity unit density, with notabably fewer areas reaching the “Emerging” and above thresholds. Outside of Raleigh, notable areas that reach “Emerging” and above intersection densities are Apex, Carey, Knightdale, Garner, and areas northeast Raleigh stretching toward Wake Forest. These maps provide a simple but effective basis for identifying the areas in the CAMPO region that are the most transit-supportive based on existing adjacent land use factors.

Other notes: Activity unit (jobs + people) and intersection density are simple and powerful indicators for measuring the density and design along a corridor, thereby indicating how transit-supportive the built environment may be. Additional metrics can provide a deeper level of insight and can supplement the basic density indicators included in this report. TCRP Research Report 187 outlines a variety of more specific metrics, many of which can be derived from the same data sources outlined in this report.

¹⁵ <https://www.epa.gov/smartgrowth/smart-location-mapping>

INDICATOR | CONTEXT CLASSIFICATION/COMPLETE STREETS

What is it? Context Classification and Complete Streets are mutually supportive policy approaches that base roadway design decisions on contextual features, such as built environment characteristics adjacent to the roadway, and on the people that use a facility to safely and comfortably accommodate all users across modes.

Core Technical Team input
Priority in evaluation
methodology: Medium

Why is it important? By establishing transit priority lanes and allowing shared users as appropriate, RED Lanes are compatible with complete streets design principles. In appropriate contexts, RED Lane project design should incorporate facilities and/or amenities that enhance the travel experience for pedestrians and bicyclists in addition to transit riders.

How is it measured? Complete Streets design approaches are emerging as a new standard for roadway design. In years past, identifying corridors where Complete Streets policies were in-place would have been a useful metric contributing to the RED Lanes evaluation methodology. Given the broad adoption of Complete Streets approaches, this is no longer a meaningful differentiator among segments. Rather, Complete Streets help define how a RED Lane project should be designed and implemented in differing contexts.

Context classification is a separate analytical process that helps define the specific contexts in which a roadway is situated. Context classification often uses a “transect” scale to rank contexts on a rural-to-urban continuum and convey appropriate design strategies based on the local setting and facility characteristics, such as functional class. Context classification analyses typically rely on an array of diverse datasets and require substantial methodological development for local/regional application. As such, context classification measures are beyond the scope of this report.

What data and tools are needed? NCDOT adopted a “Complete Streets” policy in 2009 (described below). Since the policy impacts design approaches across the state, no additional data or tools are needed for the current report. Complete Streets principals are discussed briefly below and should be applied in RED Lane project designs.

Findings: According NCDOT’s Complete Streets policy, design engineers must consider and/or incorporate more than one mode of transportation for new projects or when making transportation improvements. The benefits of Complete Streets, identified by NCDOT include:

- making it easier for travelers to get where they need to go;
- encouraging the use of alternative forms of transportation;
- building more sustainable communities;
- increasing connectivity between neighborhoods, streets, and transit systems; and
- improving safety for pedestrians, cyclists, and motorists.¹⁶

¹⁶ <https://www.completestreetsnc.org/>

NCDOT issued “Complete Streets Planning and Design Guidelines¹⁷” in 2012 and in 2018 undertook a comprehensive evaluation of the State’s approach to Complete Streets at the direction of Transportation Secretary James H. Trogdon.¹⁸ A group of stakeholders representing communities across the state provided feedback on strengths, weaknesses, and opportunities to inform potential improvements to the State’s Complete Streets program. A series of statewide workshops are ongoing through 2019, supporting implementation of complete streets in North Carolina communities. Transit priority strategies like RED Lanes support the implementation of complete streets in the CAMPO region and set a precedent for other communities across North Carolina. Additionally, RED Lanes present a potentially cost-effective solution for improving transit operations and service reliability that can help meet growing transportation demand, improve transit operations, and diversify modal options for local and regional travel.

Other notes: As Complete Streets policies and practices mature, having a consistent and robust systemwide definition of context classifications can clarify and simplify the selection of appropriate improvement strategies and design options for various corridors. While developing such a context classification methodology is outside the scope of the RED Lanes study, future applications of or updates to the RED Lanes evaluation methodology could benefit from a systemwide context classification analysis.

¹⁷ http://www.completestreetsnc.org/wp-content/themes/CompleteStreets_Custom/pdfs/NCDOT-Complete-Streets-Planning-Design-Guidelines.pdf

¹⁸ <https://connect.ncdot.gov/projects/BikePed/BikePed%20Documents/complete-streets-evaluation-final-report.pdf>

INDICATOR | PARKING/CURB SPACE

What is it? Transit passengers board and alight buses along curbs and shoulders meaning buses must draw near to the curb for pickup and drop off at stops. However, on many streets, the curbside lane is also used for on-street parking, loading, access to off-street parking and businesses, ridesharing, and similar purposes. Parking strategies and curb space management policies effect which activities are permitted and during which hours.

Why does it matter? RED Lanes present several potential disruptions or limitations to parking and curb space management strategies. In some cases, RED Lanes may be implemented by replacing existing on-street parking and partially or completely restrict access to the curb. In cases where parking or loading areas need to be retained, an offset RED Lane can provide transit travel time savings and preserve access to the curb in recessed spaces. However, the ingress and egress of parking vehicles or trucks can disrupt bus flow on the offset lane and undermine the operational benefits of the RED Lane. On constrained urban streets with essential on-street parking or curb access needs, a RED Lane may be infeasible regardless of other attributes supporting its implementation.



Offset RED Lanes allow on-street parking spaces to be retained but limit curb access for buses.

How is it measured? Parking and curb space demand are difficult to measure and most measurements address areawide parking supply (number of spaces available), demand (number of spaces needed), and cost. In this report, no regionwide parking measure is provided. However, insight into urban parking policy is discussed based on a recent (2017) City of Raleigh Downtown Development and Future Parking Study¹⁹ (Downtown Parking Study). The parking study offers several notable considerations to guide RED Lane implementation based on parking and curb space needs.

What data and tools are needed? (None)

Findings: Locations of on-street parking are concentrated in downtown Raleigh and in the region's other downtown areas, such as Cary, Wake Forest, Apex, Fuquay-Varina, Zebulon, and Wendell. It is also found sporadically in regional mixed-use centers, such as North Hills and Brier Creek. RED Lane projects in these areas are likely to require detailed consideration of parking supply and demand in project design. Specific considerations vary by location, but the primary themes are encapsulated well by the major components of the City of Raleigh's Downtown Parking Study:

- **Curb Space Management Plan** – This component of the Downtown Parking Study emphasizes block face standardization as a policy approach to providing a consistent, predictable, and comfortable

¹⁹ <https://www.raleighnc.gov/services/content/PWksParkingMgmt/Articles/ParkLink.html>

user experience of curbside access and activities. On a standardized block face, various uses are grouped together to prevent fragmentation of the curb space. Understanding how a RED Lane supports or disrupts standard block faces will be an important consideration in project development and design.

- **Parking Policies to Support Economic Development** – This component addresses parking policies and pricing strategies to help the City support economic development. In general, parking demand outstrips supply, and augmenting supply is increasingly expensive. New developments are the primary providers of new parking spaces – most of them in off-street decks. Appropriately calibrating parking requirements for developers can help keep development costs competitive while helping the City meet growing parking demand. Additionally, parking strategies should focus on reducing parking demand through increased trip-making by modes that do not require parking, pricing for metered parking, and adopting human-scale community and facility design. RED Lanes support the expansion of transportation options to reduce parking demand. They could also provide opportunities for the City to strategically divest on-street spaces to allow market forces to play a larger role in setting parking rates (a recommendation of the study).
- **Assessment of Current and Projected Future Parking Demand** – This component focuses on current and future parking demand and existing parking supply. As demand outstrips supply over time, the City will likely need to explore strategies focused on structured parking accompanying new private development. Transient parking spaces (many of which are on-street spaces) make up about 19 percent of the parking inventory downtown. Greater shares of transient spaces are likely to be developed in off-street locations as the area’s parking inventory expands via structured parking, meaning the loss of on-street spaces for RED Lanes may become more palatable over time, though conditions on specific block faces will vary.
- **Urban Access Policy** – This component offers recommended standards to limit access points for off-street parking. It has limited applicability to RED Lane implementation.

Other notes: (None) While a regionwide inventory of on-street parking is not available to produce a metric for this report, parking considerations remain important in the specific design approaches to a given RED Lane project. Basic inventories of on-street parking along a specific corridor are easily developed, and these can inform how a RED Lane is implemented. In locations where on-street parking is available but demand is limited, the RED Lane could be implemented by taking the parking spaces or imposing time-of-day restrictions on parking. In locations where on-street parking is in high demand, offset RED Lanes with recessed parking should be considered. Where new transient parking is being developed in off-street locations, stakeholder outreach should include careful attention to community preferences related to on-street parking and the evolution of the curb space.

INDICATOR | ACCESSIBILITY

What is it? Accessibility is a metric representing the number of destinations that can be reached from a specific geographic point within a region. Accessibility can be tailored to measure the number of total destinations, people, jobs, or specific destination classes that can be reached on a network from a given place and during a set period.

*Core Technical Team input
Focus on disadvantaged
populations*

*Priority in evaluation
methodology: Medium*

Why does it matter? Accessibility provides a single measure that reflects land development patterns, travel network design and performance, and traveler sensitivities. Accessibility scores by mode can be compared to evaluate travel options and modal competitiveness. By calculating accessibility for different points of origin and accounting for the demographic characteristics of each, accessibility scores can be compared to understand how the transportation system connects different population groups to key destinations in varying degrees. Multimodal accessibility scores are correlated with mode choice decisions, where higher accessibility scores by diverse modes are related to higher shares of multimodal trips.

How is it measured? Travel times from each origin location are calculated to all destination locations using mode-specific travel networks. The activities at each destination location are summarized, applying travel time decay factors to weight nearby activities higher than distant activities to produce the origin location's accessibility score. This process is conducted for all origin locations in a study area and for each mode to be analyzed. For this report, transit and auto access to jobs was measured for each TRM TAZ in the CAMPO region. The measure highlighted for RED Lanes evaluation is the transit-to-auto access ratio (TAR). This measure describes the competitiveness of transit for reaching jobs throughout the region relative to driving.

The CTT expressed particular interest in understanding accessibility for disadvantaged population groups. Therefore, this section also highlights areas demarcated in CAMPO's Title VI, Minority, Limited English Proficiency (LEP), and Low Income Public Outreach Plan²⁰. These areas can be overlaid on areas underserved by transit to understand where transit improvements can help meet the needs of disadvantaged populations.

What data and tools are needed? Transit and highway travel skims and TAZ jobs data were obtained from the TRM to conduct the accessibility analysis. CAMPO's Title VI GIS data – tabulated at the block group level – were used to identify areas with disadvantaged population groups. This analysis identified “communities of concern” (CofC's), based on an analysis of Census information. The analysis identified concentrations of the following populations by analyzing Census data at the Block Group level:

- Non-white race
- Hispanic/Latino origin
- Individuals making less than 150% of the Federal Poverty Rate
- Individuals who speak English “Not at all” or “Not very well”
- Zero-car households
- Individuals Age 70 and older

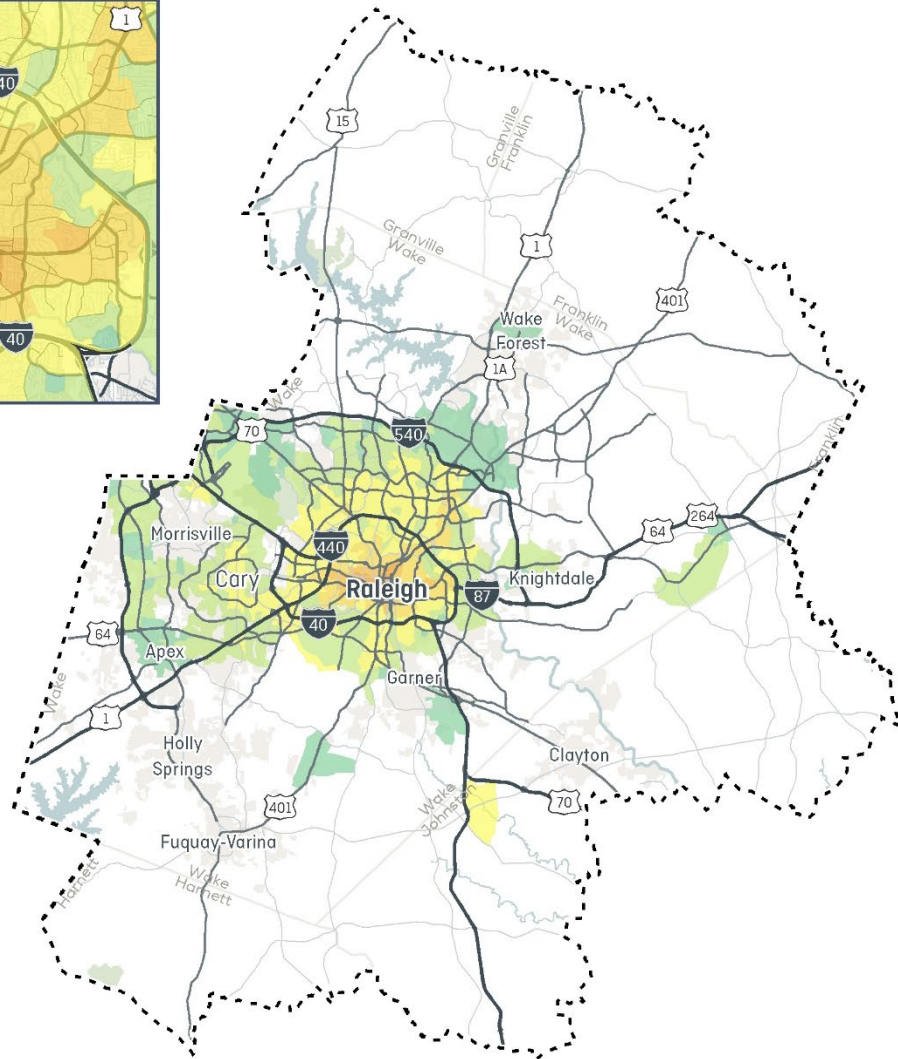
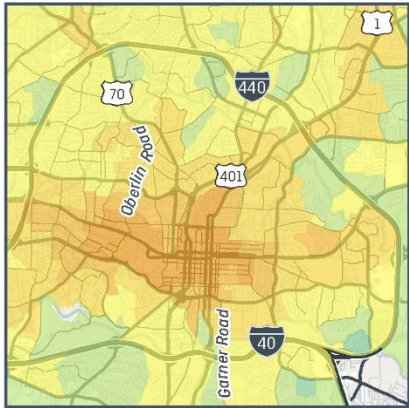
²⁰ http://files.www.campos-nc.us/get-involved/public-participation-plan/Title_VI_with_page_numbers_reduced.pdf

CAMPO's Title VI report developed thresholds for each of the six CofC categories. The number of CofC categories that reached the levels identified as part of the study were tabulated for each traffic analysis zone (TAZ) in the Triangle Regional Model (TRM). The composite output of this process is a map that identifies how many of the 6 CofC thresholds were present in each TAZ.

Findings: By reviewing both the transit-to-auto jobs accessibility ratio and CofC maps, it is possible to identify areas in the region where CofC populations are present that have poor access to transit access to jobs relative to auto access to jobs. Notable areas with CofC populations and limited transit accessibility are in the southern and eastern portions of the CAMPO region. These areas are difficult to serve by transit since many are low density areas distant from the urban core. In many urban communities with CofC populations, the TAR scores are relatively strong, although there are sporadic exceptions, notably in the western parts of the region. These zones, however, do not show a confluence of numerous CofC's in underserved transit areas.

<i>Accessibility</i>		CONTEXTS	
DEMAND	OPERATIONS		DESIGN

RED LANES | EXISTING CONDITIONS - ACCESSIBILITY



0 5 10 20
Miles



Transit Accessibility (TRM 2013)

Transit-to-auto jobs access ratio

0% (unshaded)

0.1% - 2%

2.1% - 5%

5.1% - 10%

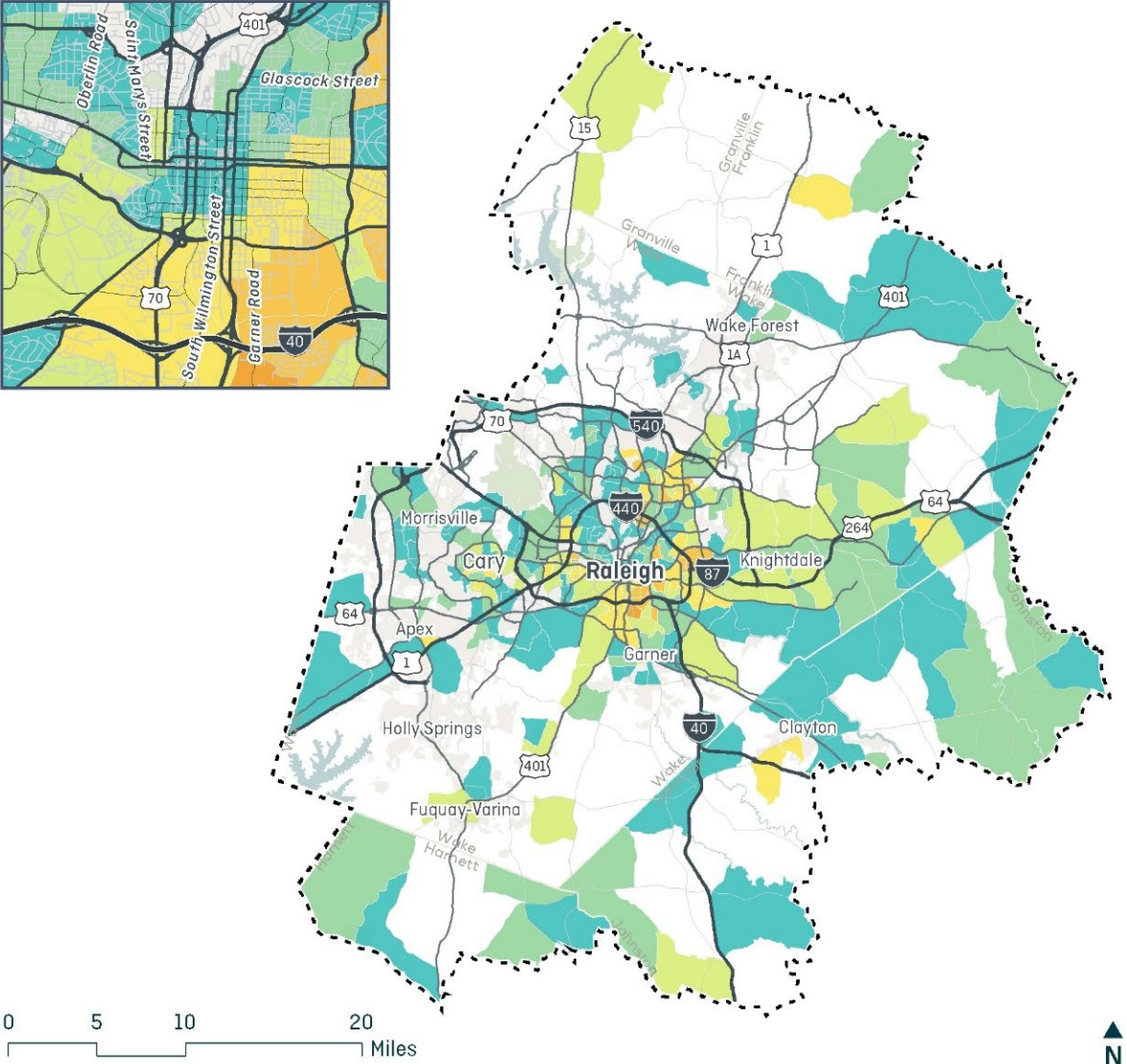
10.1% - 15%

15.1% - 20%

20.1% - 29.3%

Accessibility			
DEMAND	OPERATIONS	CONTEXTS	DESIGN

RED LANES | EXISTING CONDITIONS - COMMUNITIES OF CONCERN



Number of Regional 75th Percentile Indicators



Accessibility			
DEMAND	OPERATIONS	CONTEXTS	DESIGN

INDICATOR | FUNCTIONAL/ACCESS CLASS

What is it? Streets and highways are commonly grouped into distinct classes reflecting their roles in the transportation system (functional class) and the appropriate spacing of driveways, signals, median openings, etc. (access class). These classification systems indicate the intended function of a corridor and provide a basic sense of how traffic will flow through the corridor. Higher-order facilities – like expressways – are intended to carry large volumes of traffic at high speeds. Design conventions for these facilities focus on channelization for continuous flow. Access points are few, far between, and appropriately designed to maintain high speed movement. At the other end of the spectrum, lower-order facilities – like minor collectors and local streets – are specifically intended to carry low volumes of traffic at low speeds and provide access to homes, businesses, shopping, attractions, amenities, etc.

Core Technical Team input
Priority in evaluation
methodology: Low

Why does it matter? As transit priority improvements, RED Lanes are generally most appropriate on middle tier functional classes. Expressways and major highways often present inhospitable (and in some cases unsafe) environments for transit vehicles making stops, due to the high-speed traffic flowing around the transit vehicle and the uncomfortable pedestrian experience when boarding or alighting the vehicle curbside. However, RED Lanes aim, in part, to keep buses moving through busy corridors, which is at odds with the high-access role fulfilled by local streets and minor collectors. RED Lanes will ideally support the functional roles of the facilities on which they are implemented, meaning arterials and major collectors are generally the most suitable corridors.

Additionally, a RED Lane includes driveway access and right turns for motorists as part of its core definition. Therefore, RED Lane projects are likely to be most effective in corridors with intermediate-to-frequent spacing of access points and significant numbers of right turns. However, if these are too frequent, the benefits of the RED Lane to transit operations may be undermined.

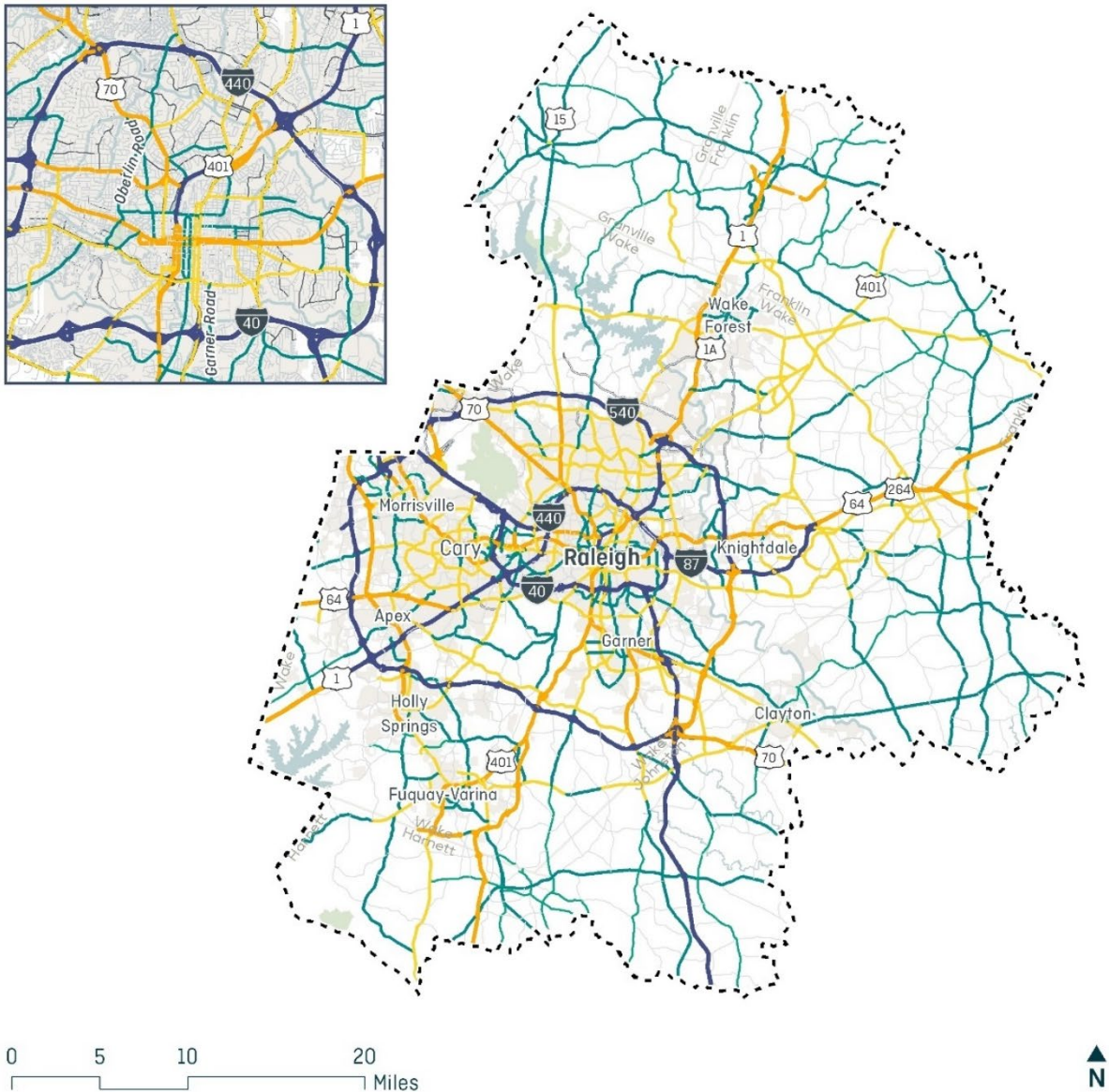
How is it measured? Functional classes are typically designated by numerical categories where 1 is the highest order facility type focused on inter-regional travel (interstate highways, e.g.) and ascending values reflect an increasingly local orientation. The number of categories varies by system, but the most common include interstate highways, other expressways, principal arterials, minor arterials, major collectors, minor collectors, and local streets.

What data and tools are needed? Functional classifications are available from a variety of sources, all broadly consistent with one another. For this report, functional class designations on the TRM 2045 network are shown to provide insight into the long-term functional class of each corridor.

Findings: Functional classes for the TRM 2045 network are shown in the map below. Most principal arterials are significant commuting corridors. The urban heart of the CAMPO region is served by numerous minor arterials and major collectors with transit service. These are likely to be leading candidates for RED Lanes.

Functional Class/Access Class		CONTEXTS	
DEMAND	OPERATIONS		DESIGN
Existing Conditions Report Indicators and Metrics			R-48 June 2020

RED LANES | EXISTING CONDITIONS - FUNCTIONAL CLASS



TRM 2045 Highway Network

Functional Class

- Freeways and Expressways
- Principal Arterials
- Minor Arterials
- Major Collectors
- Minor Collectors
- Local

Functional Class/Access Class			
DEMAND	OPERATIONS	CONTEXTS	DESIGN

Other notes: As noted above, there are multiple sources and systems for establishing functional class. These include NCDOT Functional Classifications, Federal Functional Class (FFC) from TRM, and Revised Functions Class for NCDOT from TRM. Although the functional classes are not a direct measure of access points (depending on functional classification criteria), limited generalizations can be made per segment classification type. Functional Class is included both independently and with the companion metric of average block size within the TRM TAZ. This supplemental metric provides the potential for additional contextual information leading to a more comprehensive assessment, although it does not reliably reflect access spacing along every road segment within TAZs.

Access class is not singularly tabulated in any of the NCDOT hosted maps in a way that is useful to RED Lanes analysis and therefore is not offered as a separate metric in this study. Opportunities may arise in future iterations of the RED Lanes evaluation methodology to supplement functional classification with access class information. However, it is likely for the foreseeable future that functional class will offer a suitable, readily available metric for understanding the role of a facility in the transportation system and approximating its access characteristics sufficiently to prioritize corridors for RED Lanes investment.

<i>Functional Class/Access Class</i>		CONTEXTS	
DEMAND	OPERATIONS		DESIGN

DESIGN

- Number of lanes/lane width/surface width (right-of-way)

TOPIC | DESIGN

Indicators in the Design topic focus on the physical characteristics of a roadway segment. RED Lanes require the dedication of existing space on a roadway segment or the addition of new lanes. Therefore, the Design topic is important in identifying the implementation feasibility of a RED Lane on a given segment.

INDICATOR | NUMBER OF LANES

What is it? The number of lanes, lane width, surface area width, and right-of-way characteristics describe the physical characteristics of a roadway segment and its right-of-way. These measurements are important in identifying the ability for an existing roadway segment to accommodate the addition of a RED Lane, either through expanding a roadway or replacing an existing lane.

Why does it matter? The implementation of RED Lanes typically requires either the dedication of space on an existing roadway or the widening of a roadway segment. The number of existing lanes in each direction provides insight into the capacity for dedicating existing space on a roadway for a RED Lane. The physical dimensions of an existing roadway segments can also be analyzed with building or parcel information to provide insight into the feasibility of expanding a roadway segment to accommodate the addition of a RED Lane. Corridors with limited numbers of lanes (2 in each direction or fewer) and limited opportunities for right-of-way expansion could be screened out or diminished in priority during the RED Lanes evaluation process.

How is it measured? Two metrics were developed to estimate the feasibility of RED Lane implementation. The number of travel lanes in each direction is an effective metric to identify which segments may have capacity to have a lane converted to a RED Lane. The second measure provides a coarse estimate of the feasibility to create RED Lanes by adding a travel lane in each direction on a segment. It expresses the number of existing buildings intersecting a 15-foot buffer either side of each segment on a per mile basis, highlighting areas where right-of-way limitations are most severe.

What data and tools are needed? For the number of lanes measure, the Triangle Regional Model (TRM) existing (2013) network was utilized to calculate the number of through lanes in each direction. This data was selected due to its comprehensive coverage of the study area. Segments designated as freeways were removed since these facilities are not candidates for RED Lanes, allowing surface streets with available lane capacity to feature prominently in mapping.

Different datasets were utilized for the right-of-way feasibility analysis. While precise right-of-way details are difficult to obtain and utilize regionally, the NCDOT roadway characteristics database provides general insight into the existing paved area of most roads and streets, and therefore was used for developing the expansion feasibility analysis metric. This allows a simple GIS analysis of expected roadway dimensions and

*Core Technical Team input
Focus on available right-of-way*

*Priority in evaluation
methodology: Medium*

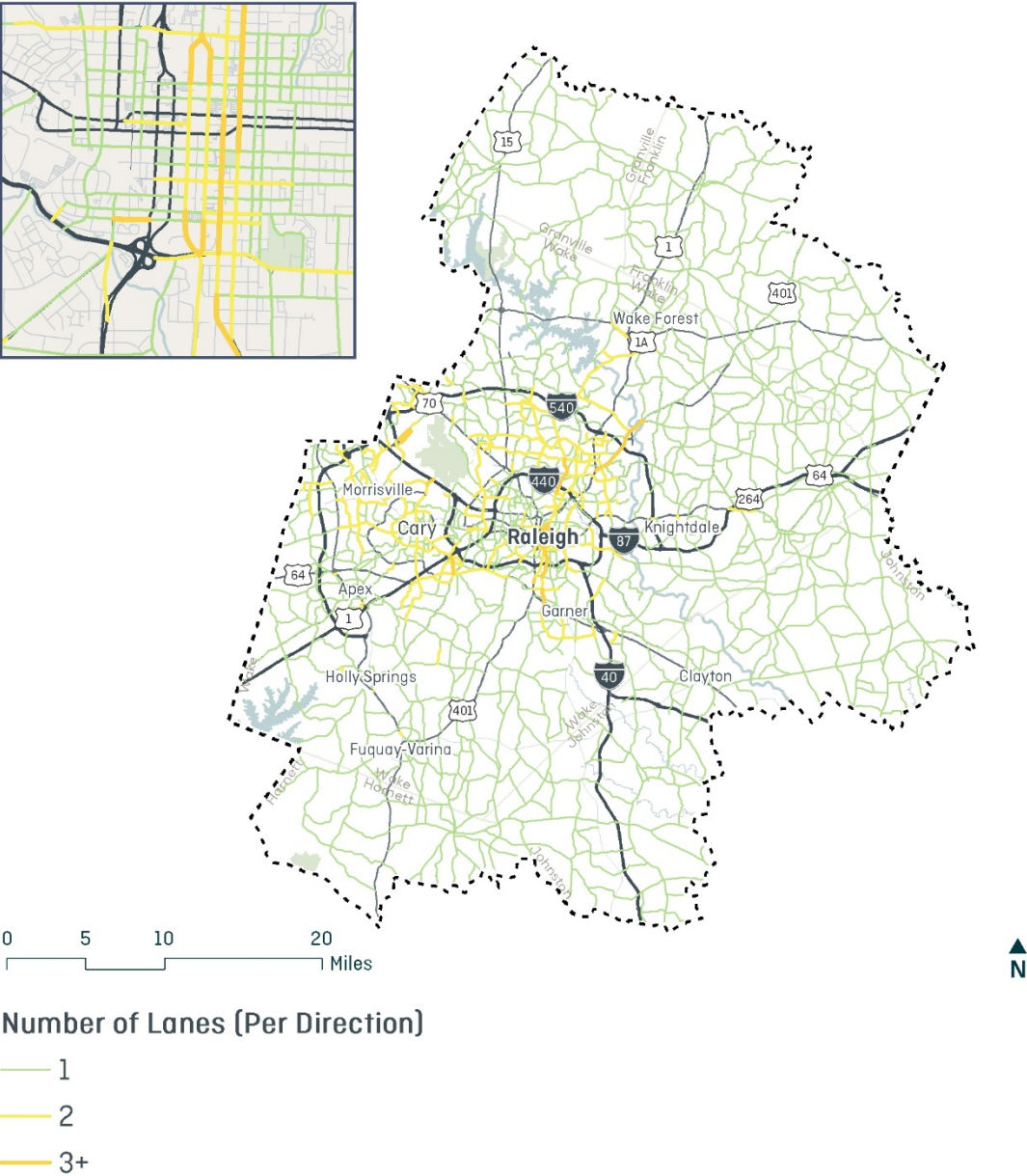
Number of Lanes			
DEMAND	OPERATIONS	CONTEXTS	DESIGN

potential ROW impacts that (a.) assumes additional paved area through the addition of a RED Lane in each travel direction; (b.) highlights segments where such expansions would impact existing buildings or private property boundaries; and (c.) flags segments with the lanes sufficient to potentially incorporate a RED lane by re-purposing existing lane space. Although the NCDOT roadway characteristics database does not contain complete ROW data, an analysis was conducted where data were available. Findings for this indicator are not definitive from a design perspective, but they are a potential screening factor and provide a loose approximation of ROW constraints that could appropriately influence RED Lanes scoring and ranking.

For this analysis, the roadway characteristics dataset was used to estimate the location of the current edge of each existing roadway segment. To do this, the total surface width was divided by two, and added as a dynamic buffer to the existing roadway centerline along with a 15-foot buffer in each travel direction to estimate [estimated based on the addition of one 11-foot travel lane and a 4-foot buffer]. This estimated expanded roadway area was then intersected with building footprint polygons from Microsoft's national building footprints dataset. From this analysis, the number of existing buildings that intersect with the estimated expanded roadway buffer was calculated on a per-centerline-mile basis. This process is illustrated in the graphic to the right, which shows the estimated expanded roadway surface areas and the building footprint dataset.

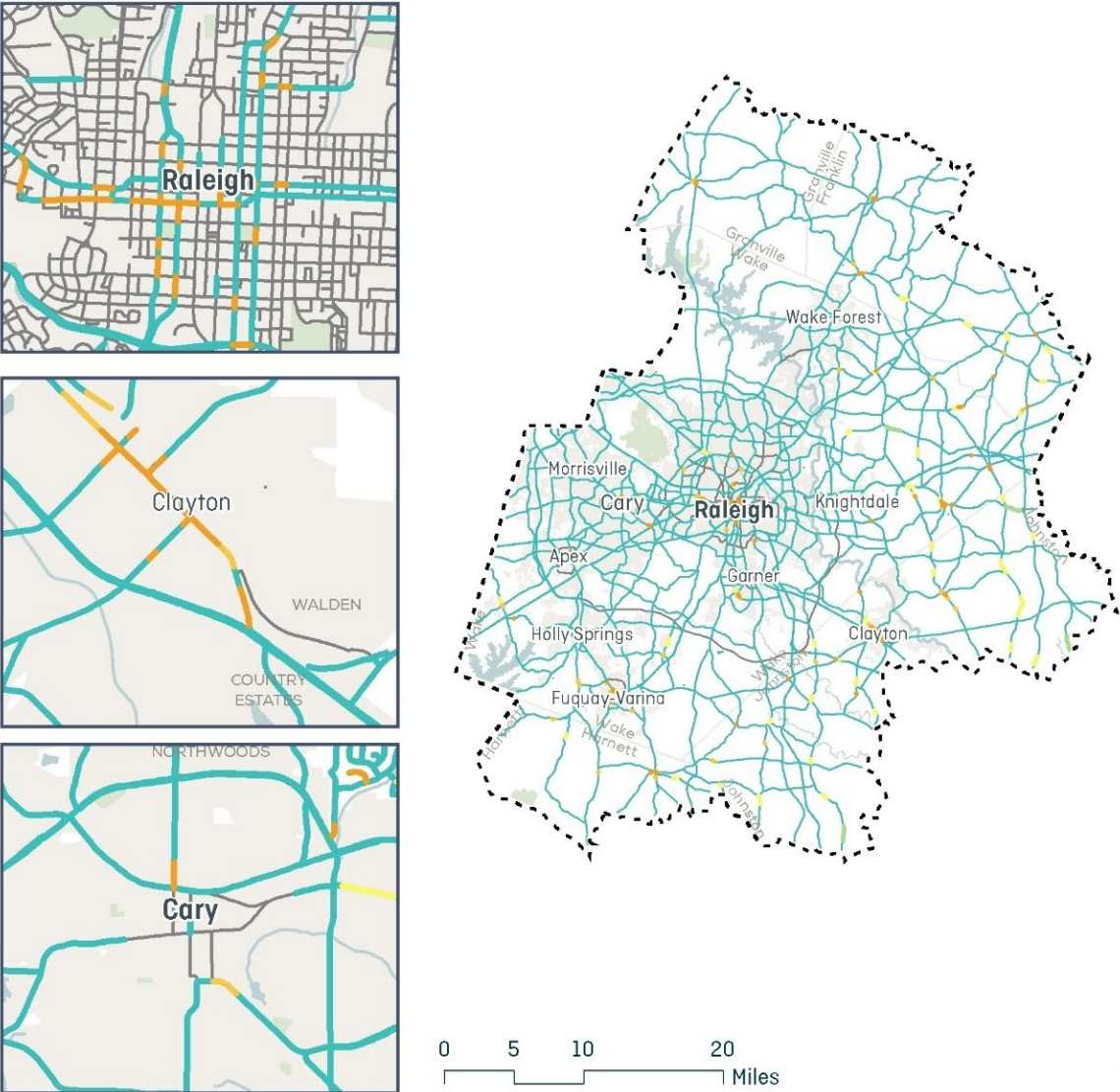


RED LANES | EXISTING CONDITIONS - NUMBER OF LANES



Number of Lanes			
DEMAND	OPERATIONS	CONTEXTS	DESIGN

RED LANES | EXISTING CONDITIONS - RIGHT-OF-WAY ANALYSIS



Number of Lanes			
DEMAND	OPERATIONS	CONTEXTS	DESIGN

Findings: The number of lanes on a roadway provides insight into the capacity for existing right-of-way to be utilized for the addition of a RED Lane. Although this dataset is best analyzed jointly with traffic volume and capacity data to identify segments that have both the space and capacity, in general segments with 2 and 3+ lanes have the greatest amount of potential for accommodating a RED lane. Segments with only a single lane would likely need to be expanded. The expansion feasibility analysis provides general planning-level estimates of where roadway expansions could prove to meet the most resistance. In general, the results are intuitive, with the highest rates of intersections with buildings occurring in downtown Raleigh as well as town centers such as Clayton and Garner.

Other notes: While these analyses can provide important estimates for the capacity for a RED Lane to be accommodated by an existing or expanded roadway, it is important to consider the limitations of these analyses. While the number of existing travel lanes provides insight into the capacity for an existing roadway to accommodate a RED Lane, the removal on a full-time or part-time basis of parking is another method to add a RED Lane where volume-to-capacity ratios may not accommodate the removal of an existing travel lane (see “Parking/Curb Space” section above).

INVENTORY OF DATA AND TOOLS

The development of indicators and metrics for this Existing Conditions Report depends on a variety of data sources and a few core analytical tools. This section identifies the key datasets utilized in developing this report in a simple, tabular format (Table 5). The table includes sources for obtaining each dataset, the relevant dates covered by the data, and key information in each dataset for indicator development. The inventory provides an at-a-glance reference for obtaining data to reproduce the indicators described in the “Indicators and Metrics” section. In this way, it also supports future applications of and/or enhancements to the RED lanes evaluation methodology as data are updated.

With future applications in mind, the inventory is organized into two major sections. The upper portion of the table highlights datasets utilized in developing indicators for this report. The lower section identifies potentially useful datasets that could not be operationalized effectively for the current analysis. They are listed here for consideration in potential future enhancements to the RED Lanes evaluation methodology.

Table 5. Inventory of Key Datasets

Dataset	Key Information for Indicator Development
DATASETS USED IN THIS REPORT	
Triangle Regional Model transit lines Source: http://www.campo-nc.us/mapsdata/triangle-regional-model Publication Date: 2017 Temporal Scope: 2013, 2045 Notes: Ridership estimates derived from TRM Summary Tool (a separate package that extends the TRM and is available by request from ITRE).	<ul style="list-style-type: none"> • Daily ridership by route • Peak hour ridership by route
Triangle Regional Model loaded networks Source: http://www.campo-nc.us/mapsdata/triangle-regional-model Publication Date: 2017 Temporal Scope: 2013, 2045 Notes: Model outputs include peak period transit speeds (Transit_line.dbd)	<ul style="list-style-type: none"> • Daily traffic volume • Traffic volume by time of day • v/c ratio by time of day • Free flow speed by time of day • Congested speed by time of day • Functional class • Number of lanes • Estimated bus speed by time of day
Triangle Regional Model zonal data Source: http://www.campo-nc.us/mapsdata/socio-economic-data Publication Date: 2017 Temporal Scope: 2013, 2045 Notes: (None)	<ul style="list-style-type: none"> • Population by TAZ • Employment by TAZ • Total activity (Population + Employment) • TAZ area
Triangle Regional Model travel skims Source: Not publicly available. Extracted by staff from TRM. Publication Date: 2018	<ul style="list-style-type: none"> • Origin zone • Destination zone • Travel time by mode

Dataset	Key Information for Indicator Development
<p>Temporal Scope: 2013, 2045</p> <p>Notes: Skims tabulate estimated travel times from origin zones to destination zones by mode.</p>	
<p>ACS Journey to work data</p> <p>Source: https://factfinder.census.gov/faces/nav/jsf/pages/download_center.xhtml</p> <p>Publication Date: 2018</p> <p>Temporal Scope: 2013 – 2017 (2017 ACS 5-year)</p> <p>Notes: (None)</p>	<ul style="list-style-type: none"> • Commute mode shares by block group
<p>University of Minnesota (UMN) Accessibility Observatory</p> <p>Source: http://ao.umn.edu/data/datasets/</p> <p>Publication date: 2015</p> <p>Temporal Scope: 2014</p> <p>Notes: Only covers Wake, Johnston, and Franklin Counties</p>	<ul style="list-style-type: none"> • Number of jobs reachable by walking within 30 minutes by block
<p>GoRaleigh On-Time Performance by Route</p> <p>Source: Direct share from GoRaleigh staff</p> <p>Publication date: May 2019</p> <p>Temporal Scope: March 2019</p> <p>Notes: Includes GoTriangle routes operated by GoRaleigh.</p>	<ul style="list-style-type: none"> • Percent of on-time trip departures and arrivals by route for a 1-month period.
<p>GoCary On-Time Performance by Route</p> <p>Source: Direct share from GoCary staff</p> <p>Publication date: May 2019</p> <p>Temporal Scope: July-September 2018</p> <p>Notes: Focused on September as a 1-month comparison to GoRaleigh data; on-time performance reported for normal weekday service (holiday and weekend on-time performance ignored).</p>	<ul style="list-style-type: none"> • Percent of on-time trip departures and arrivals by route for a 1-month period.
<p>NCSU Wolfline known locations contributing to operational delays</p> <p>Source: NCSU Wolfline staff direct data share</p> <p>Publication Date: May 2019</p> <p>Temporal Scope: 2019</p> <p>Notes: Wolfline routes are variable by semester so consistent route/stop level on-time performance data are difficult to obtain and interpret. Wolfline staff identified consistently problematic locations to support this study.</p>	<ul style="list-style-type: none"> • Intersections that pose on-time performance issues • Segments that pose on-time performance issues

Dataset	Key Information for Indicator Development
GTFS feeds Source: https://gotriangle.org/developer-resources Publication Date: Q1 2019 Temporal Scope: Q1 2019 Notes: Includes GoTriangle, GoRaleigh, GoCary, NCSU Wolfline	<ul style="list-style-type: none"> • Route locations • Stop locations • Current service frequencies by time of day (by route, segment, stop)
Transit Plans GIS Data Source: <i>MTP, Wake Bus Plan, etc. (spatial data consolidated in earlier phases of RED Lanes Study)</i> Publication Date: 2017-2019 Date: 2018 - 2045 Notes: Consolidated transit line files from various plans	<ul style="list-style-type: none"> • Planned service frequency by implementation year (2024, 2027, or 2045)
NC enhanced ARNOLD street network Source: <i>Obtained through direct coordination with USDOT staff.</i> Publication Date: 2017 Temporal Scope: 2017 Notes: For information on ARNOLD, see the FHWA website https://www.fhwa.dot.gov/policyinformation/hpms/arnold.cfm	<ul style="list-style-type: none"> • <i>Utilized to work with USDOT tools for locating GTFS route features on a street network.</i>
Smart Location Database Source: https://www.epa.gov/smartgrowth/smart-location-mapping Publication Date: 2013 Temporal Scope: Circa 2011 Notes: The Smart Location Database is a nationwide block-group-level inventory of numerous indicators reflecting built-environment conditions.	<ul style="list-style-type: none"> • Intersection density by block group (D3bmm4)
NCDOT Roadway Characteristics Source: https://connect.ncdot.gov/resources/gis/Lists/DataLayersTextAnnouncements/AllItems.aspx Publication Date: Q1 2019 Temporal Scope: Q1 2019 Notes: Key information listed is not available for all segments.	<ul style="list-style-type: none"> • Surface width (for right-of-way analysis)
Microsoft Building Footprints Source: https://github.com/Microsoft/USBuildingFootprints Publication date: 2018 Temporal Scope: circa 2016 Notes: Building dates depend on ortho imagery dates, which vary throughout the country. Visual inspection of the CAMPO region suggested the vast majority of the current building stock is reflected in this dataset.	<ul style="list-style-type: none"> • Nationwide building footprint polygons dataset (for right-of-way analysis)

Dataset	Key Information for Indicator Development
CAMPO Title VI Communities of Concern (EJ Block Groups) Map Package Source: http://www.campo-nc.us/mapsdata/mtp-data-download Publication Date: 2016 Temporal Scope: circa 2012 Notes: (None)	<ul style="list-style-type: none"> Community of concern Title VI indicators by block group
DATASETS FOR CONSIDERATION IN FUTURE UPDATES TO RED LANES EVALUATION METHODOLOGY	
HERE Traffic Analytics or similar Source: https://www.here.com/products/traffic-solutions/road-traffic-analytics Notes: Vendor data	<ul style="list-style-type: none"> Average historical speed by segment
LODES OD data Source: https://lehd.ces.census.gov/data/ Notes: 2015 is most current year available at time of writing	<ul style="list-style-type: none"> Commute origin-destination patterns by block or higher level of aggregation
Transit Agency APC data or other usage/reliability information Source: Direct share from agencies Notes: Stop-level boarding and alighting activity could support more robust segment level transit ridership analysis.	<ul style="list-style-type: none"> Stop boarding/alighting activity Headway adherence Travel time degradation
NC OneMap Parcel Data Source: http://data.nconemap.gov/downloads/vector/parcels/ Notes: Fine-grained parcel data could allow more robust exploration of adjacent land uses and/or support a context classification analysis that could inform RED Lane design choices.	<ul style="list-style-type: none"> Parcel boundaries Building square footage Land use category supporting LU diversity analysis

The data listed in Table 5 are generally available from national, state, or local/regional sources. In some cases, coordination with agencies generating the data may be required to obtain specific datasets. Mapping and analyzing diverse datasets requires GIS software, such as ArcGIS. Generating metrics from the Triangle Regional Model (TRM) requires TransCad software and TRM input and setup files. Some of the processing steps used to generate measures for this report utilize Python scripts and require a basic knowledge of how to edit and run a script to re-create the analyses presented here.

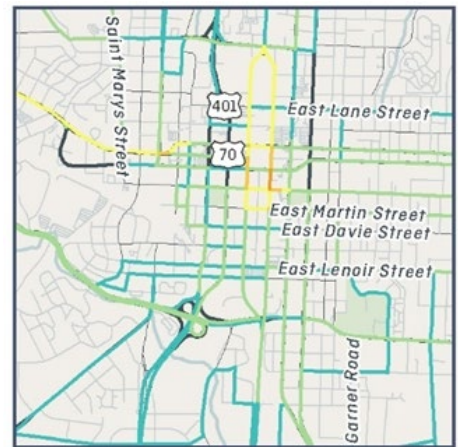
CANDIDATE CORRIDORS

In the development of candidate corridors, the indicators summarized in this report are presented at segment, corridor/route, and zone levels. These indicators are intended to support the RED Lanes evaluation process at a segment level to differentiate segments and corridors in terms of their suitability for RED Lanes implementation.

While this level of evaluation is appropriate for the purposes of the RED Lanes study, it is also valuable to consider individual corridors within the context of neighboring corridors. In some cases, one single corridor by itself may not appear to have attributes needed to support a RED Lane. However, a re-alignment of one or more routes onto a roadway might bring about levels of service and ridership that support RED Lane implementation. Opportunities like this are most likely to occur in more dense areas with higher levels of transit service, such as downtown Raleigh. For example, Wilmington Street, Person Street, and Blount Street are one-way facilities with modest existing transit service frequency. If RED Lanes were implemented on Blount Street, including a contra-flow lane, buses using any of the three corridors could be funnelled onto Blount.²¹ Keeping this in mind, application of the RED Lanes tool could include scenario testing to allow the effects of re-routing services along RED Lanes corridors to influence corridor suitability for project development purposes. In this way, RED Lanes candidate corridors could potentially include corridors with no existing or planned transit service that represent opportunities for service consolidation.

The development of the RED Lanes Evaluation Methodology will likely highlight additional candidate corridors beyond those presented in the *Key Plans in the CAMPO Region* report.

The next phase of the RED Lanes Study is the development of the RED Lanes Evaluation Methodology. The methodology will be focused on prioritizing corridors across the region for RED Lanes, highlighting those that are most suitable based on existing conditions and trends as presented in this report. The appropriate use and weighting of each indicator is part of the focus of CTT Workshop #2 (June 27, 2019) and will be tested and revised during the next phases of the study. Some indicators presented here may not be utilized in corridor prioritization but will be retained to appropriately guide RED Lane project design and implementation strategies on high priority corridors.



Existing transit service Frequency in central Raleigh

²¹ This is hypothetical proposition for illustrative purposes. Prioritization of RED Lanes and suggested implementation strategies and design approaches for select corridors will emerge during a later phase of the RED Lanes study.