



SYSTEM-WIDE RAIL CAPACITY STUDY

Over the last few decades, ridership on CTA rail lines has continued to grow. To evaluate the effect of this growth, CTA has conducted a system-wide study of rail line capacity that examined existing crowding on each rail line and identified segments that are currently at capacity or are expected to reach capacity limits in the near future. The study analyzed the relationship between capacity and physical constraints that impact CTA's ability to respond to crowded conditions. The study also identified a series of high-level potential solutions to be explored further that could address capacity and crowding on the rail system in the future.

WHAT IS CAPACITY?

On any rail line, the maximum number of passengers that can be carried per hour is based on three measurements: the number of trains per hour that can be operated on the line, the number of rail cars in each train, and the amount of usable square feet on each rail car. According to Federal Transit Administration (FTA) guidelines, a train is considered overcrowded if each passenger has less than 5.4 square feet of usable space. Under this metric, each CTA rail car has a comfortable capacity of approximately 61 passengers. The total line capacity (or amount of space that can be supplied) of each CTA line under this crowding metric equals 61 passengers per car, multiplied by the number of cars per train and the number of trains per hour that are possible to operate on that line.

The other component of capacity is passenger demand, or the total number of people that want to ride on the train. When passenger demand is greater than what the supply of the system can sustain, capacity has been reached.

WHAT LIMITS CAPACITY?

The potential limitations for train throughput along a branch include stations, the terminal station, junctions, signal system, speed restrictions, and yard capacity, as shown in **Figure 1**.

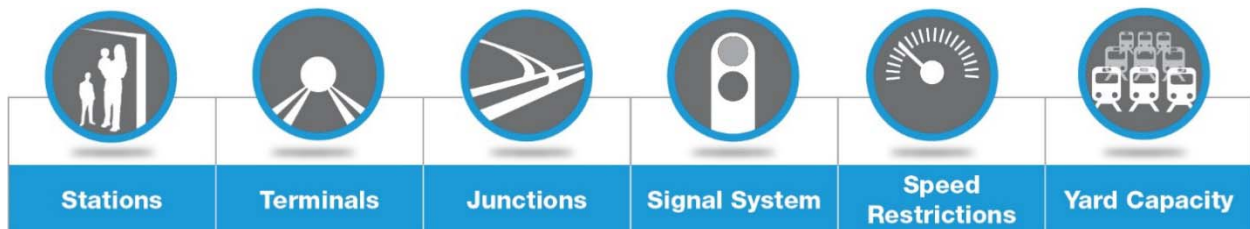


Figure 1: Types of Capacity Constraints

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- **Stations** with the longest dwell time on a line – the amount of time each train spends at the platform – typically control capacity. Station elements that prevent passengers from efficiently boarding trains, such as narrow platforms or crowded stairwells, also limit capacity.
- The time required to turn a train at **terminal stations** can present an additional capacity limitation, and complex movements in storage yards can negatively impact reliability. Efficient terminal design facilitates capacity on the line and the ability to meet future demand.
- **Junctions** can control the capacity of two or more lines that cross or merge with each other because as one train is passing through the junction, the train(s) on the conflicting line must wait.
- **Signal Systems** control safe train movements, though inefficiencies resulting from aging equipment or signal designs based on lower service levels can constrain capacity.
- Although it does not limit capacity in isolation, **speed restrictions** due to geometry or track condition can be a constraint when combined with long dwell times or limited train availability.
- **Yard capacity** limits line capacity when yards cannot store enough train cars to meet demand.

The constraint that causes the greatest capacity limitation on a line may be viewed as the “weakest link.” Like links in a chain, when the greatest capacity constraint along a rail line is resolved, service can be expanded, but only by the amount available before the capacity limitation shifts to the next “weakest link.” For example, if a problematic junction is redesigned to help increase train frequency, a station down the line with long dwell times might become the next primary limitation if it can’t accommodate more frequent trains.

An important concept for rail transit capacity analysis is the relationship between capacity, delay, and reliability. Calculated capacity is based on the frequency of trains that can be reliably operated, and so it is not a “hard and fast” upper limit. Random variations in passenger behavior and train operations can impact the movement of trains on a daily or even hourly basis. To address this, CTA, like all railways, includes an operating margin in its schedule. Without an operating margin, any delay would cascade upstream until after the peak hour when schedule recovery would occur.

WHERE DO CAPACITY CONSTRAINTS EXIST TODAY?

Federal capacity criteria were used to identify when and where CTA lines are at or near capacity today. Lines are most crowded during the morning and evening peak periods, or “rush hour.” **Figure 2** and **Figure 3** show where CTA lines are overcrowded for at least one hour during peak periods based on FTA’s capacity criteria and current service levels. All seven rail lines that serve the Loop area (including lines operating in the two subways) are crowded at some point during the peak period each day. **Table 1** presents a summary of the capacity constraints on each line.

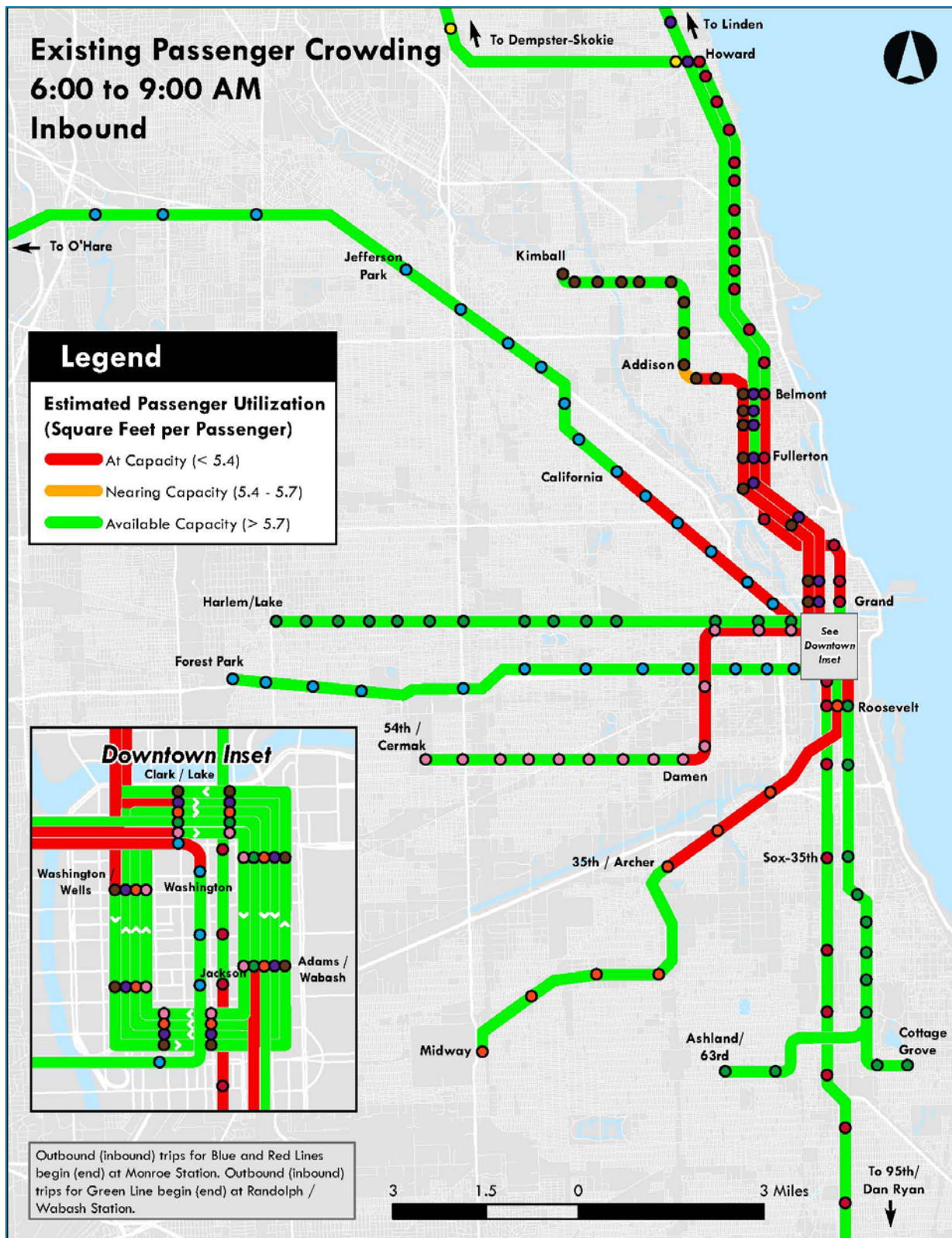


Figure 2: Passenger Crowding Based on 2018 Service Levels (Crowding levels derived using FTA guidelines); Revised February 2019

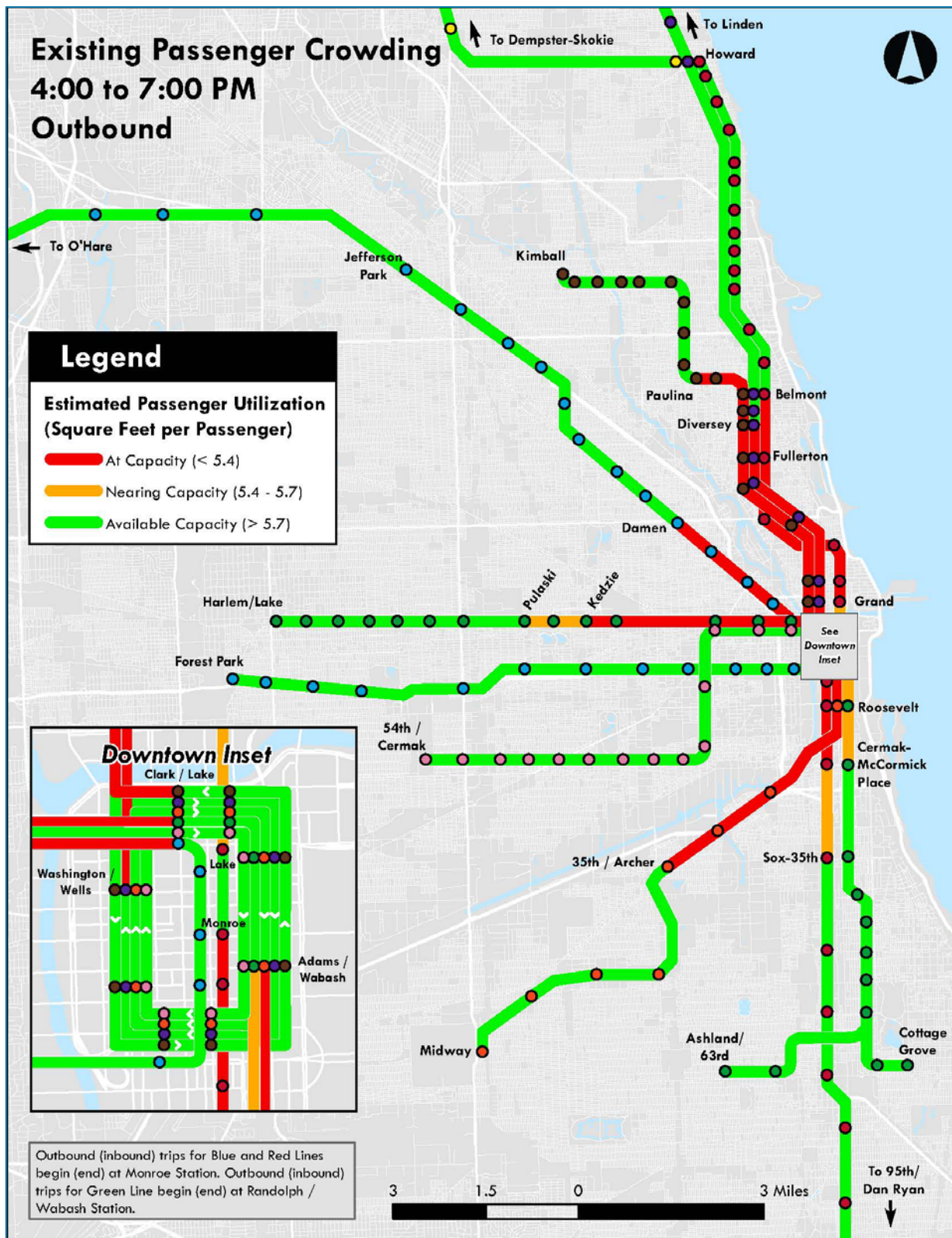


Figure 3: Passenger Crowding Based on 2018 Service Levels (Crowding levels derived using FTA guidelines); Revised February 2019

Table 1: Physical Capacity Constraints by Branch

CTA Line	Current Service Capacity Limitations – “Weakest Links”	Near Term Constraints – Next “Weakest Links”	Potential Future Constraints
Blue Line: O’Hare Branch	<ul style="list-style-type: none"> Limited traction power supply between Harlem and Grand due to wide substation spacing 	<ul style="list-style-type: none"> Forest Park Terminal and Yard limit northbound evening rush service for the O’Hare branch. Short turns at UIC-Halsted enable current service levels Station dwell time at Clark and Lake coupled with signal design capacity will ultimately limit capacity 	<ul style="list-style-type: none"> Platforms cannot accommodate trains longer than 8 cars
Blue Line: Forest Park Branch	<ul style="list-style-type: none"> <i>Trains are not at capacity at existing service levels</i> 	<ul style="list-style-type: none"> Forest Park Terminal and Yard storage capacity 	<ul style="list-style-type: none"> Platforms cannot accommodate trains longer than 8 cars
Red Line: Dan Ryan Branch	<ul style="list-style-type: none"> <i>Trains are not at capacity at existing service levels</i> 	<ul style="list-style-type: none"> Turnback capacity is limited at 95th Street. Increasing existing service levels is possible by supplying trains from the 98th Street Yard 	<ul style="list-style-type: none"> Platforms cannot accommodate trains longer than 8 cars
Red Line: North Main Line Branch	<ul style="list-style-type: none"> Clark Junction constrains Red Line service due to Brown Line crossing 	<ul style="list-style-type: none"> Fullerton and Belmont station dwell times Howard Terminal configuration limits turnbacks Howard Yard storage capacity 	<ul style="list-style-type: none"> Platforms cannot accommodate trains longer than 8 cars
Brown Line	<ul style="list-style-type: none"> Clark Junction constrains Brown Line service due to crossing Red and Purple lines Service requires more cars than can be stored at Kimball Yard, requiring 7 Brown Line trains to be stored at Midway Yard Brown/Purple shared track is constrained by dwell times at Fullerton and Belmont stations At-grade crossings limit the frequency of service 	<ul style="list-style-type: none"> Outer Loop capacity on Brown/Green shared track Aging signals and lower capacity signal design 	<ul style="list-style-type: none"> Platforms cannot accommodate trains longer than 8 cars Many speed restricted curves increase train cycle time
Purple Line	<ul style="list-style-type: none"> Clark Junction constrains Purple Line service due to the crossing Brown Line The Inner Loop currently operates at or near the capacity limit Brown/Purple shared track is constrained by dwell times at Fullerton and Belmont stations Platforms cannot accommodate trains longer than 6 cars 	<ul style="list-style-type: none"> Aging signals and lower capacity signal design 	

CTA Line	Current Service Capacity Limitations – “Weakest Links”	Near Term Constraints – Next “Weakest Links”	Potential Future Constraints
Orange Line	<ul style="list-style-type: none"> The Inner Loop currently operates at or near the capacity limit 	<ul style="list-style-type: none"> Orange/Green shared track is constrained by dwell times at Roosevelt station 	<ul style="list-style-type: none"> Platforms cannot accommodate trains longer than 8 cars
Green Line: Lake Branch	<ul style="list-style-type: none"> The Inner Loop currently operates at or near the capacity limit 	<ul style="list-style-type: none"> Outer Loop capacity on Brown/Green shared track Orange/Green shared track is constrained by dwell times at Roosevelt station Paulina Junction constrains both the Green and Pink lines 	<ul style="list-style-type: none"> Turnbacks at Harlem Terminal Green/Pink shared track is constrained by dwell times at Clinton station Platforms cannot accommodate trains longer than 8 cars
Green Line: South Branch	<ul style="list-style-type: none"> <i>Trains are not at capacity at existing service levels</i> 	<ul style="list-style-type: none"> The Inner Loop currently operates at or near the capacity limit Outer Loop capacity on Brown/Green shared track At Cottage Grove Terminal, 8 car trains are restricted to one platform. Orange/Green shared track is constrained by dwell times at Roosevelt station 	<ul style="list-style-type: none"> 59th Street Junction, where the 63rd/Ashland and 63rd/Cottage Grove branches merge
Pink Line	<ul style="list-style-type: none"> The Inner Loop currently operates at or near the capacity limit 	<ul style="list-style-type: none"> Paulina Junction constrains both the Green and Pink lines 	<ul style="list-style-type: none"> Turnback moves at 54th/Cermak Terminal Pink/Green shared track is constrained by dwell times at Clinton station
Yellow Line	<ul style="list-style-type: none"> <i>Trains are not at capacity at existing service levels</i> 	<ul style="list-style-type: none"> Howard Yard storage capacity Platforms cannot accommodate trains longer than 2 cars 	

WHERE ARE THE PRIMARY CAPACITY CONSTRAINTS AND HOW CAN THEY BE ADDRESSED?

Two measures were used to rank the top system-wide capacity constraints identified in **Table 1**. The first measure compares line capacity against scheduled trains per hour and identifies where service can or cannot be added. The second measure compares passenger utilization against currently scheduled passenger capacity and identifies where added service is needed to address growth in ridership (shown in **Figure 1**). These two measures yielded the primary system-wide capacity constraints. **Table 2** describes these constraints and lists potential solutions for each. Some solutions directly address a capacity constraint, while others either make use of surplus capacity elsewhere on the system or modify current operations to create surplus capacity where needed. **Figure 4** shows the locations of these capacity constraints.

Table 2: Primary Capacity Constraints and Potential Solutions

Constraint	Constraint Description	Potential Solution	Benefit
Clark Junction	<ul style="list-style-type: none"> Northbound Brown Line trains conflict with Red Line trains 	<ul style="list-style-type: none"> Red-Purple Bypass (<i>Funded as part of RPM Phase One</i>) 	<ul style="list-style-type: none"> Increases Red Line capacity by separating lines
Dwell Time at Belmont and Fullerton	<ul style="list-style-type: none"> High numbers of boardings, alightings, and transfers between Brown, Red, and Purple lines create long dwell times 	<ul style="list-style-type: none"> Dwell time control 	<ul style="list-style-type: none"> Increases capacity and reduces travel times for Red, Purple, and Brown lines
The Loop and Loop Junctions: Inner/Outer Loop Capacity, Clark/Lake, Loop Signal Blocks, (Tower 18 and Tower 12)	<ul style="list-style-type: none"> Capacity on the Loop is complex due to the combination of dwell times, merging of lines, signal blocks, and junctions The Inner Loop currently operates at or near the capacity limit; the Outer Loop is less constrained 	<ul style="list-style-type: none"> Clark/Lake signal block placement 	<ul style="list-style-type: none"> Adding distance between Clark/Lake and Tower 18 Junction increases Loop capacity
		<ul style="list-style-type: none"> Adjusting Loop routing patterns 	<ul style="list-style-type: none"> Simplifying movements at junctions increases trains possible on Loop
		<ul style="list-style-type: none"> Removing select routes from Loop 	<ul style="list-style-type: none"> Moving trains into State Street or Dearborn subways increases capacity on elevated segments
O'Hare Branch Traction Power	<ul style="list-style-type: none"> Traction power limitations impact capacity on the Blue Line 	<ul style="list-style-type: none"> Traction power improvements from load flow study 	<ul style="list-style-type: none"> Increases Blue Line capacity by expanding power availability
Evanston Branch Platform Lengths	<ul style="list-style-type: none"> Purple Line trains can't be longer than 6 cars due to limited platform length on the Evanston branch 	<ul style="list-style-type: none"> Lengthen platforms by rehabilitating or reconstructing stations 	<ul style="list-style-type: none"> Increases Purple Line capacity by operating longer trains, and increases capacity where Brown and Purple share tracks.
Forest Park Yard	<ul style="list-style-type: none"> Forest Park Terminal and Yard limit northbound evening rush service for the O'Hare branch Short turns at UIC-Halsted allow for current service levels 	<ul style="list-style-type: none"> Expanding yard capacity 	<ul style="list-style-type: none"> Increases O'Hare branch Blue Line capacity and improves service levels on Forest Park branch by reducing the need to short turn trains at UIC
Brown Line Terminal Vicinity: Kimball Yard, Kimball Terminal, and At-Grade Constraints	<ul style="list-style-type: none"> Slow-turning trains at Kimball Terminal limit line capacity Neighborhood traffic concerns at-grade crossings limits the number of trains that can be run at-grade 	<ul style="list-style-type: none"> Adding facility to turn trains to concentrate service in high-demand areas 	<ul style="list-style-type: none"> Improves capacity on most crowded segment by turning trains around and bypassing Kimball and the at-grade section
		<ul style="list-style-type: none"> Utilizing surplus yard capacity at another yard 	<ul style="list-style-type: none"> Increases Brown Line train availability
		<ul style="list-style-type: none"> Expanding Kimball Yard capacity 	<ul style="list-style-type: none"> Increases Brown Line train availability

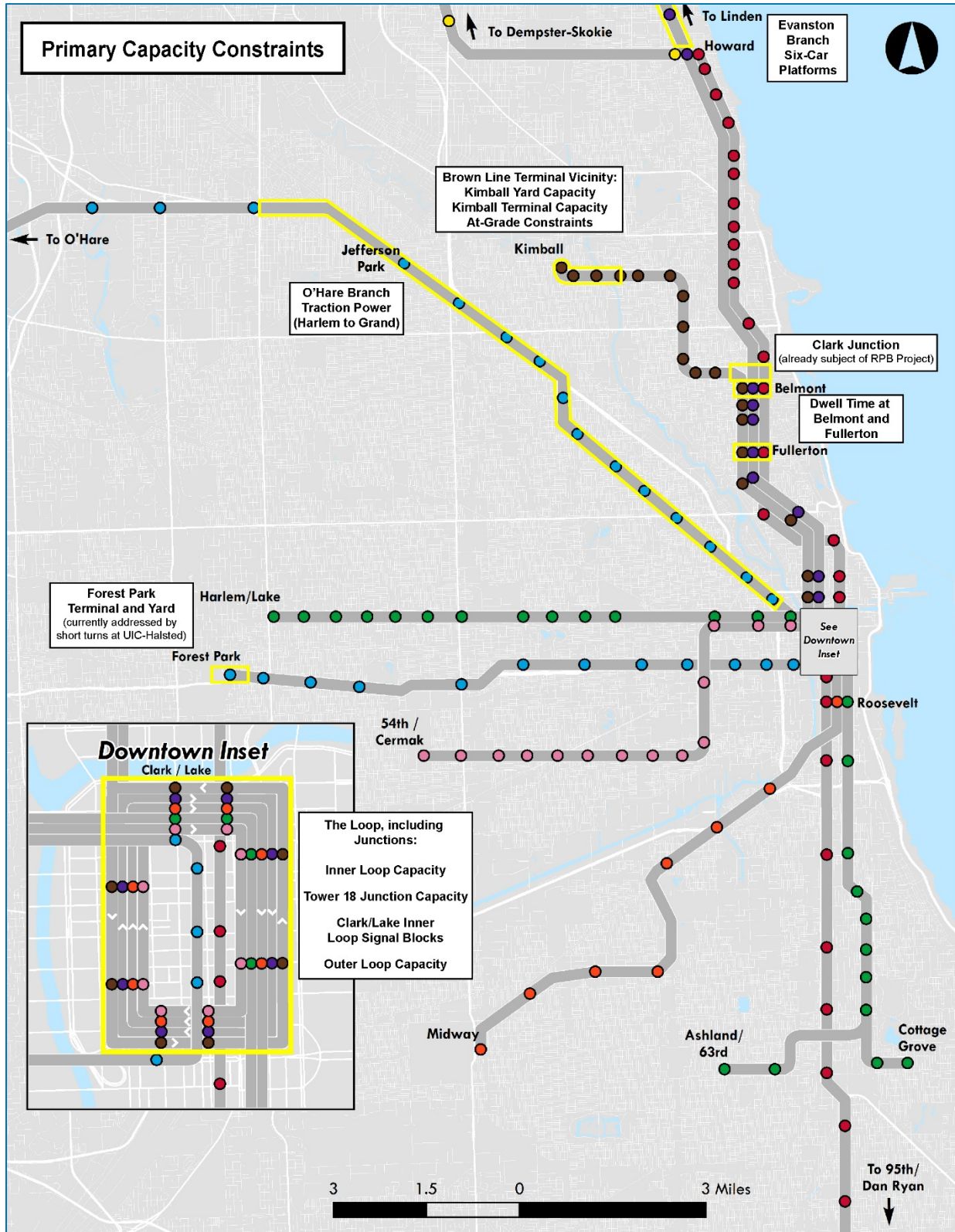


Figure 4: Primary Capacity Constraints

WHAT ARE POTENTIAL LONG-RANGE SOLUTIONS?

Long-range options are those with high cost, typically greater than several billion dollars, and complex implementation, requiring multiple years and perhaps a decade or more, for planning, design, construction and start-up.

SIGNALS

CTA uses fixed block signals, which cannot be easily adapted when station platforms are modified, train lengths are increased, or speeds are changed. Moving block signal systems would provide increased line capacity, including on the Loop, but would need to be implemented holistically on the system and would require changes to train car equipment.

TRAIN CARS

Several improvements to train cars would marginally improve overall passenger capacity:

- Automatic Passenger Counters
- Controls on both sides of the cabs
- Walk-through married-pair rail cars
- Built-in space for future signal upgrades

NEW LINES AND EXTENSIONS

Lines that share tracks, like the Brown and Purple lines, are constrained by shared sections. New infrastructure that separates the lines would increase the capacity of both. Extensions of existing lines should target branches with higher capacity than demand so as not to exacerbate existing constraints. The Red Line Extension, for example, would add riders on the Dan Ryan branch, which currently has capacity, while also increasing yard capacity and terminal turnback capacity.

OTHER CONSIDERATIONS

Long-range city and regional policies can be crafted to utilize available capacity on the existing CTA rail system. While policy initiatives are the responsibility of city or regional planning offices, not CTA, a coordinated effort between transit and land use will help to maximize the use of existing infrastructure.

Travel Demand Management (TDM) includes regional policies such as employer-based initiatives that help spread travel demand over a wider time period, decreasing the demand at peak times and utilizing available capacity on either side of the peak. TDM policies may include flex time, where employees can start early or start late, and other alternate work schedules.

Transit-Oriented Development (TOD) policies integrate land use and transportation planning strategy to help guide growth within the city and region. One principle of TOD is to focus development along existing transit lines. **Figure 5** shows potential development corridors that would increase ridership with current available capacity in the inbound and/or outbound directions. Parts of the Orange Line corridor are included because the line has available capacity during two out of three hours in both peak periods.

NEXT STEPS

This study helped CTA identify potential solutions to increase capacity by addressing the primary capacity constraints in **Table 2**. These potential solutions will require a detailed analysis to develop specific designs and identify capital and operating costs. CTA's next step is to seek funding to conduct the additional analysis that is required to develop the potential capacity constraint solutions into projects that can be implemented.

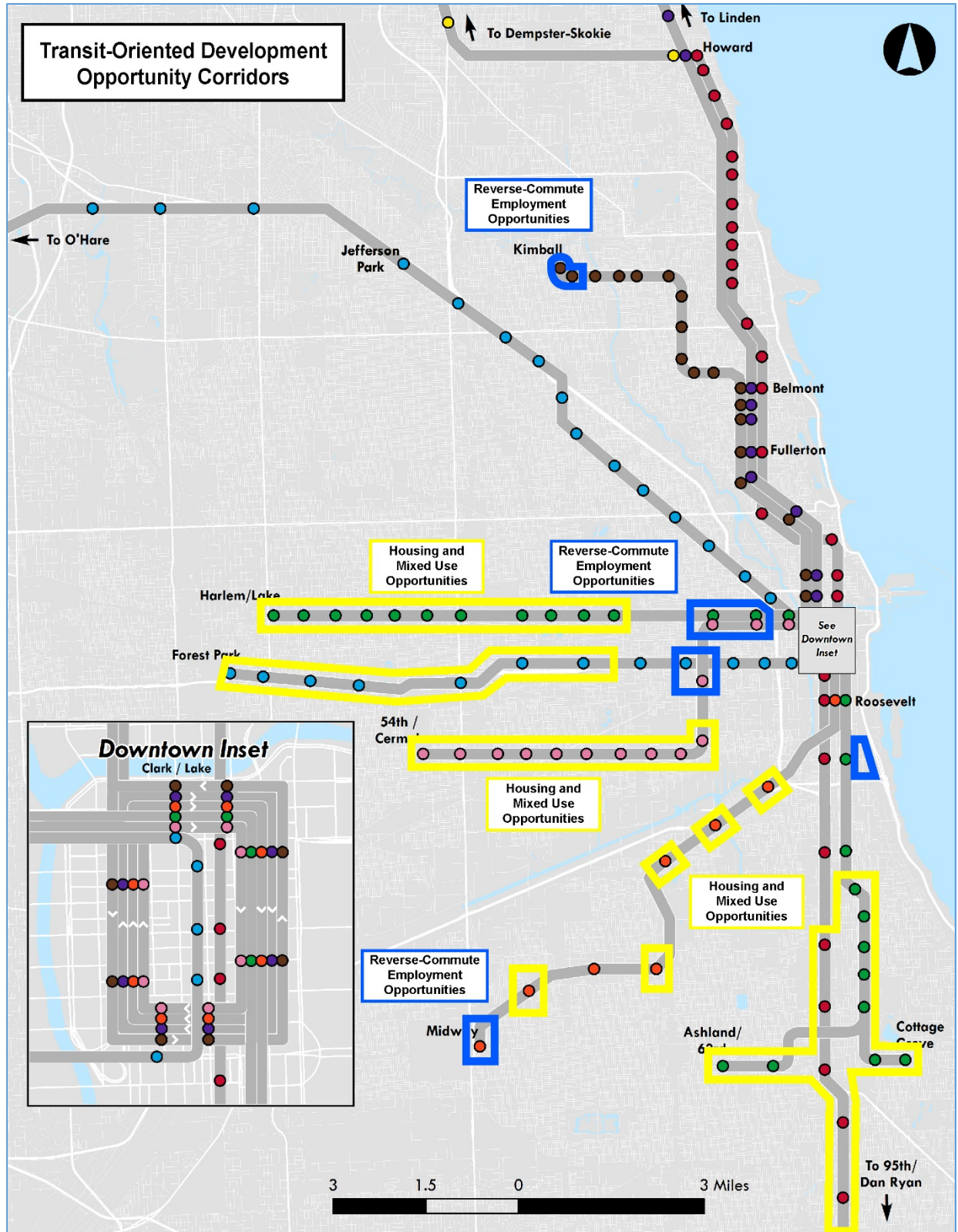


Figure 5: Transit-Oriented Development Opportunity Corridors