TCAR Report

JACKSONVILLE TRANSPORTATION AUTHORITY

APPENDIX C

Operational Analysis Technical Memorandum

ULTIMATE URBAN CIRCULATOR

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April 30, 2018

To: Suraya Teeple, JTA
Alexander Traversa, JTA
Cheryl Freeman, RS&H
Jeanette Berk, Gannett Fleming
Joel Rey, Tindale Oliver
From: Randall Farwell, Tindale Oliver

Re: U^2C Operating Demand to Capacity Analysis - 2020

This memorandum presents an analysis of estimated 2022 start-up needs using 2020 travel demand compared to 2022 service capacity for U^2C alternatives. The intent of the analysis is to assure that sufficient operating capacity exists to serve estimated travel demand. Ideally, a transit system is designed such that demand is not greater than 80% of the system capacity to serve expected demand. The modelled operating plans tested service line frequencies of between 2-minutes and 4-minutes resulting in effective vehicle headways at most stations of between 60-seconds and 90-seconds due to overlapping service lines. This analysis represents a robust service plan designed to attract high ridership. The results show that based on the operating plans tested, U^2C system and individual transit line demand in 2020 is significantly less than the robust operating plan service capacity. Therefore, in planning the U^2C system, a less robust operating plan, longer service frequencies, for example a vehicle arriving at the station every 4-8 minutes, depending on the service line, may be considered without expected adverse impacts to ridership or to demand capacity. This finding establishes flexibility for JTA in deploying and phasing AV services and capital programming.

Methodology

The methodology employed is described here. Operating plans were developed for four build alternatives. The build alternatives include the same operating and transit network assumptions with two exceptions. Build Alternative 1 does not include a Brooklyn station while Build Alternative 2 does include a Brooklyn station. In addition, the service line frequencies vary as noted for each alternative. The ridership demand estimates are based on these distinct service plans. Schematics of the alternatives are attached to help illustrate the alternative proposed AV networks. The alternatives tested are:

- Build Alternative 1A – AV operation along the existing ASE guideway footprint w/o the I-beam plus the bus network as coded for SW BRT submittal, expanded weekday service span from 4AM to 1AM. This alternative does not include the Brooklyn station. Service line frequency is a 3-minute headway.
- Build Alternative 1B – Same as Alternative 1A except service line frequency is a 2-minute headway.
- Build Alternative 2A – AV operation along the existing ASE guideway footprint w/o the I-beam plus the bus network as coded for SW BRT submittal, expanded weekday service span from 4AM to 1AM. This alternative does include the Brooklyn station. Service line frequency is a 4-minute headway.
- Build Alternative 2B – Same as Alternative 2A except service line frequency is a 3-minute headway.

Operating capacity and demand need only to be calculated for the peak hour of service to assure demand does not exceed service capacity. Peak operating capacity is a function of the available seats and the number of vehicle trips per peak hour. The number of seats is calculated as peak vehicles multiplied by seats on each vehicle. Vehicle trips is calculated as 60-minutes divided by service frequency. The equation for Peak Capacity is:

*Peak Capacity = (Vehicles*Seats)*(Trips/Hour) where Trips/Hour is [60/service frequency]*

Hourly demand was calculated based on an average of daily demand divided by daily service span (21 hours) to yield an average number of passenger trips per hour. However, an average demand per hour is not what is observed in transit or traffic volumes due to well established commuting patterns. Rather, the peak demand is required to assess demand to capacity. Peak demand was calculated as 10% of daily travel volume based on historical observations of diurnal transit and traffic patterns as reported by the *Texas Transportation Institute (2011)*. Therefore, applying a 10% factor to 2040 daily demand estimates, by system and by individual service line, yields an estimate of peak demand.

Calculating peak demand to peak capacity is a simple function of dividing demand by capacity.

Findings

Our analysis was conducted for the system capacity as well as for individual service lines as reflected in the tables below. Presented first are the system demand to capacity findings for each alternative for startup year 2022. System-wide peak hour demand to capacity ratios range between 9% and 21%.

System Alternative	Service Line Headway	Peak Vehicles	Vehicle Capacity	Daily Service Hours	2020 Daily Demand	Capacity per Hour[1]	Demand per Hour[2]	Demand to Capacity	Peak Capacity	Peak Demand[3]	Peak Demand to Capacity
2022 Build Alt. 1 A - no Brooklyn	3-minutes	14	12	294	6,765	3360	322	9.6%	3360	677	20%
2022 Build Alt. 1 B - no Brooklyn	2-minutes	21	12	441	6,980	7560	332	4.4%	7560	698	9%
2022 Build Alt. 2 A - Brooklyn	4-minutes	19	12	399	7,038	3420	335	9.8%	3420	704	21%
2022 Build Alt. 2 B - Brooklyn	3-minutes	25	12	525	7,371	6000	351	5.9%	6000	737	12%

1. Capacity per Hour = [(Vehicles*Seats)*(Trips/Hour)] where Trips/Hour = 60/Headway
2. Demand per Hour = Demand/Service Span where service span is 21 hours Monday-Friday
3. Peak Hour Demand = 10 percent of Daily Demand based on Texas Transportation Institue (2011).

The demand to capacity ratio for Alternative 1A, without a Brooklyn station, operating at 3-minute service line frequencies is reflected below. Demand to capacity ranges from 10% to 38%.

Alternative Detail	Service Line Headway	Peak Vehicles	Vehicle Capacity	Daily Service Hours	2020 Daily Demand	Capacity per Hour[1]	Demand per Hour[2]	Demand to Capacity	Peak Capacity	Peak Demand[3]	Peak Demand to Capacity
2022 Build Alt. 1 A - no Brooklyn											
JTRC to Rosa Parks	3-minutes	4	12	84	1,069	960	51	5.3%	960	107	11%
Kings Ave to Rosa Parks	3-minutes	5	12	105	4,516	1200	215	17.9%	1200	452	38%
JRTC to Kings Ave	3-minutes	5	12	105	1,180	1200	56	4.7%	1200	118	10%

1. Capacity per Hour = [(Vehicles*Seats)*(Trips/Hour)] where Trips/Hour = 60/Headway
2. Demand per Hour = Demand/Service Span where service span is 21 hours Monday-Friday
3. Peak Hour Demand = 10 percent of Daily Demand based on Texas Transportation Institue (2011).

The demand to capacity ratio for Alternative 1B, without a Brooklyn station, operating at 2-minute service line frequencies is below. Demand to capacity ranges from 5% to 16%.

Alternative Detail	Service Line Headway	Peak Vehicles	Vehicle Capacity	Daily Service Hours	2020 Daily Demand	Capacity per Hour[1]	Demand per Hour[2]	Demand to Capacity	Peak Capacity	Peak Demand[3]	Peak Demand to Capacity
2022 Build Alt. 1 B - no Brooklyn											
JTRC to Rosa Parks	2-minutes	5	12	105	1,132	1800	54	3.0%	1800	113	6%
Kings Ave to Rosa Parks	2-minutes	8	12	168	4,543	2880	216	7.5%	2880	454	16%
JRTC to Kings Ave	2-minutes	8	12	168	1,305	2880	62	2.2%	2880	131	5%

1. Capacity per Hour = [(Vehicles*Seats)*(Trips/Hour)] where Trips/Hour = 60/Headway
2. Demand per Hour = Demand/Service Span where service span is 21 hours Monday-Friday
3. Peak Hour Demand = 10 percent of Daily Demand based on Texas Transportation Institue (2011).

The demand to capacity ratio for Alternative 2A, with a Brooklyn station, operating at 4-minute service line frequencies is below. Peak demand to capacity is highest on the Kings Avenue Station to Rosa Parks Station line at 56% and otherwise ranges from 9% to 14%.

Alternative Detail	Service Line Headway	Peak Vehicles	Vehicle Capacity	Daily Service Hours	2020 Daily Demand	Capacity per Hour[1]	Demand per Hour[2]	Demand to Capacity	Peak Capacity	Peak Demand[3]	Peak Demand to Capacity
2022 Build Alt. 2 A - Brooklyn											
JTRC to Rosa Parks	4-minutes	3	12	63	743	540	35	6.6%	540	74	14%
Kings Ave to Rosa Parks	4-minutes	4	12	84	4,053	720	193	26.8%	720	405	56%
JRTC to Kings Ave	4-minutes	4	12	84	610	720	29	4.0%	720	61	8%
Brooklyn to Kings Ave	4-minutes	4	12	84	865	720	41	5.7%	720	87	12%
Brooklyn to Rosa Parks	4-minutes	2	12	42	454	360	22	6.0%	360	45	13%
Brooklyn to JRTC	4-minutes	2	12	42	313	360	15	4.1%	360	31	9%

1. Capacity per Hour = [(Vehicles*Seats)*(Trips/Hour)] where Trips/Hour = 60/Headway
2. Demand per Hour = Demand/Service Span where service span is 21 hours Monday-Friday
3. Peak Hour Demand = 10 percent of Daily Demand based on Texas Transportation Institue (2011).

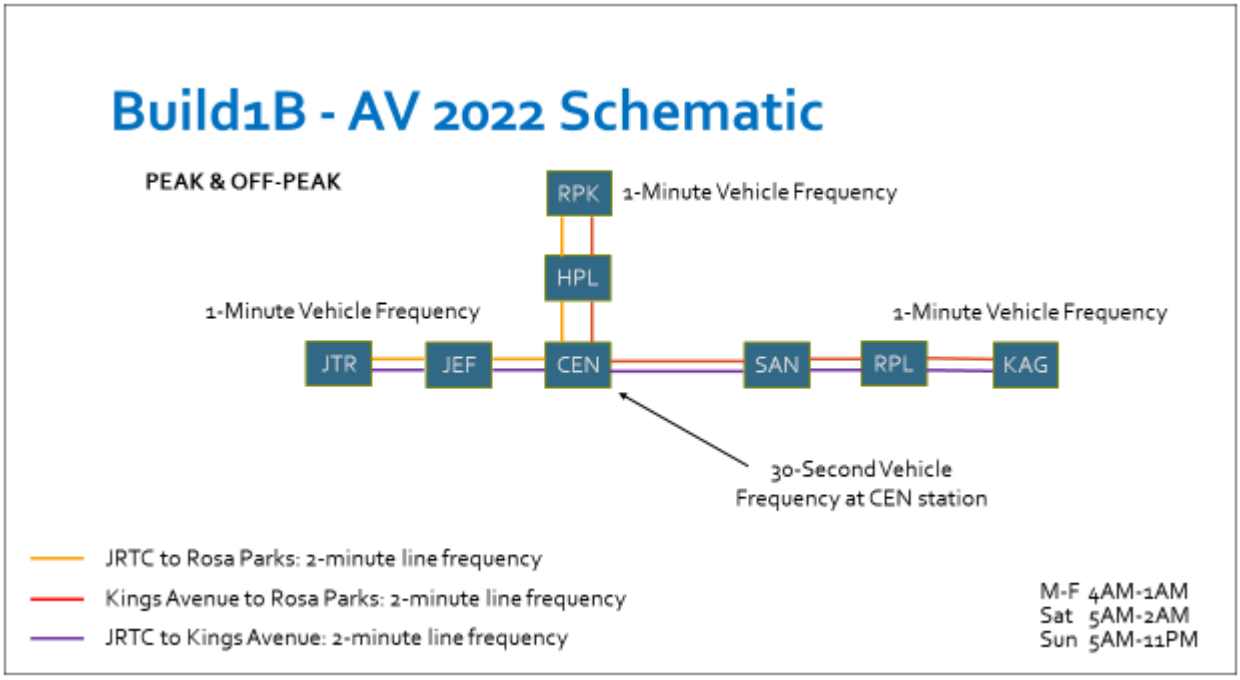
The demand to capacity ratio for Alternative 2B, with a Brooklyn station, operating at 3-minute service line frequencies is below. Peak demand to capacity is highest on the Kings Avenue Station to Rosa Parks Station line at 36% and otherwise ranges from 5% to 8%.

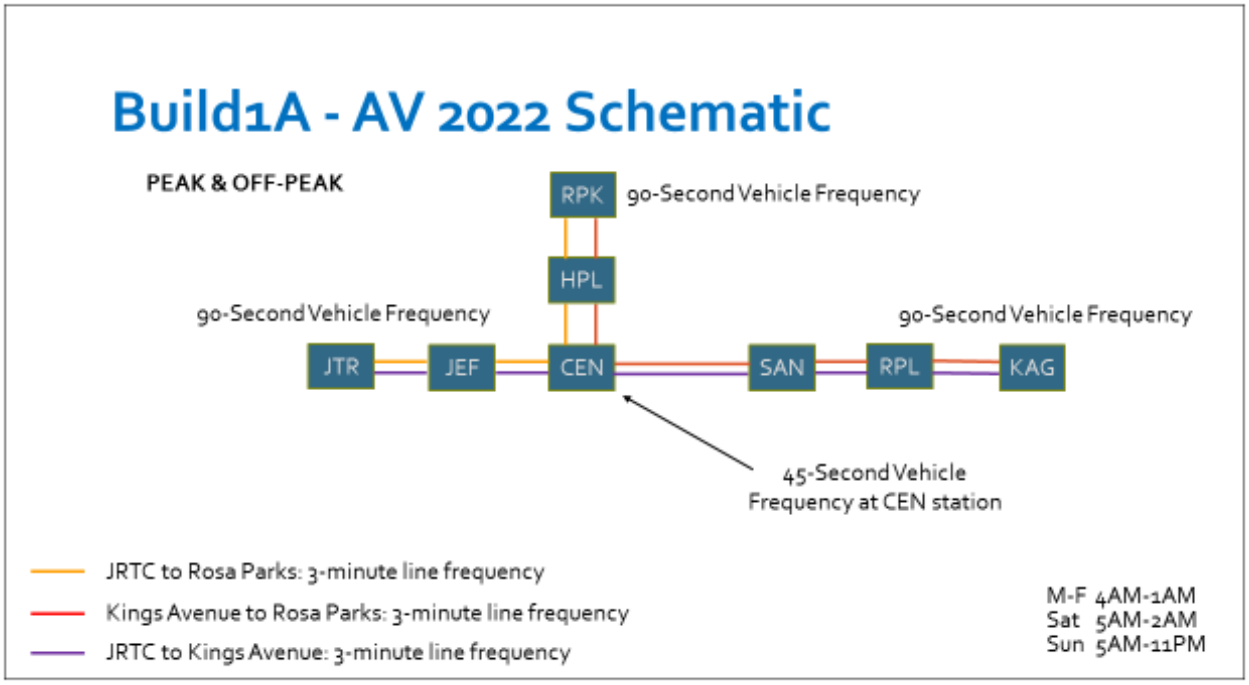
Alternative Detail	Service Line Headway	Peak Vehicles	Vehicle Capacity	Daily Service Hours	2020 Daily Demand	Capacity per Hour[1]	Demand per Hour[2]	Demand to Capacity	Peak Capacity	Peak Demand[3]	Peak Demand to Capacity
2022 Build Alt. 2 B - Brooklyn											
JTRC to Rosa Parks	3-minutes	4	12	84	755	960	36	3.7%	960	76	8%
Kings Ave to Rosa Parks	3-minutes	5	12	105	4,317	1200	206	17.1%	1200	432	36%
JRTC to Kings Ave	3-minutes	5	12	105	610	1200	29	2.4%	1200	61	5%
Brooklyn to Kings Ave	3-minutes	5	12	105	865	1200	41	3.4%	1200	87	7%
Brooklyn to Rosa Parks	3-minutes	3	12	63	459	720	22	3.0%	720	46	6%
Brooklyn to JRTC	3-minutes	3	12	63	365	720	17	2.4%	720	37	5%

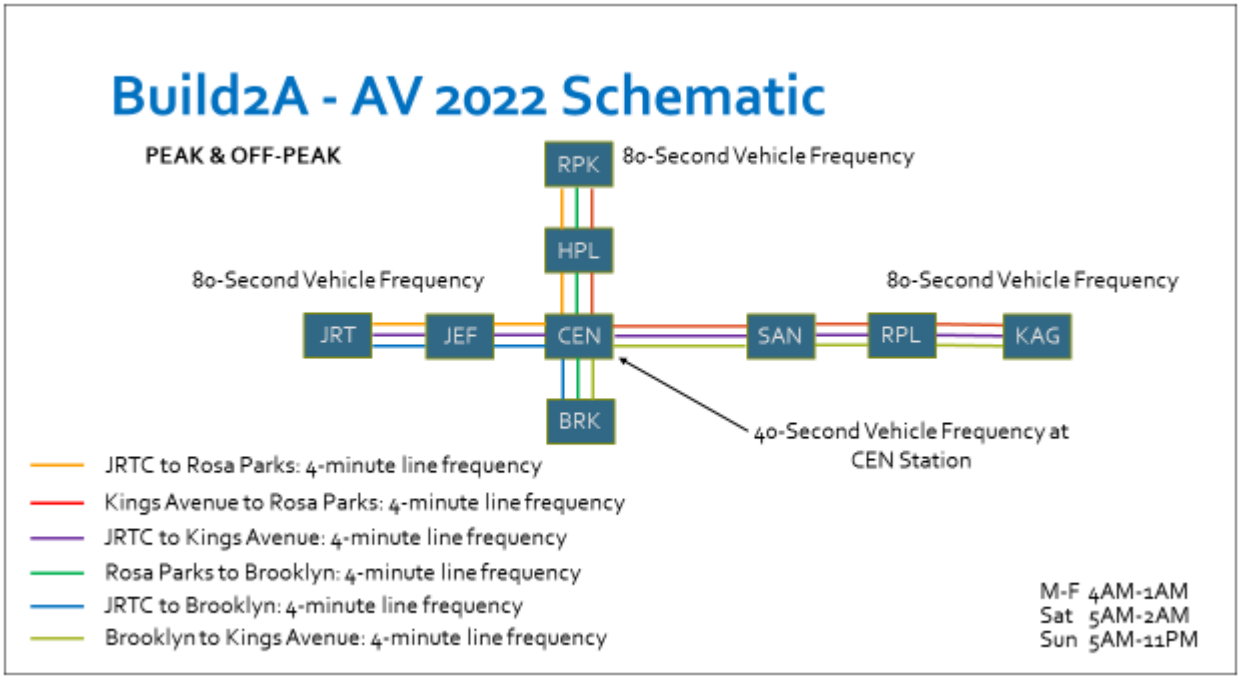
1. Capacity per Hour = [(Vehicles*Seats)*(Trips/Hour)] where Trips/Hour = 60/Headway
2. Demand per Hour = Demand/Service Span where service span is 21 hours Monday-Friday
3. Peak Hour Demand = 10 percent of Daily Demand based on Texas Transportation Institue (2011).

Based on this analysis, the service capacity planned for a 2022 startup is more than sufficient to meet estimated 2020 service demand. This finding suggest a less robust service plan, longer service line frequencies, would easily accommodate estimated ridership and by comparing the changes in demand between the less frequent scenarios of the more frequent scenarios, the impact on demand is not likely to result in a meaningful adverse impact on ridership assuming service frequencies are operated at an attractive level, a service line headway of at least every 4-8 minutes.

Service Line Schematics



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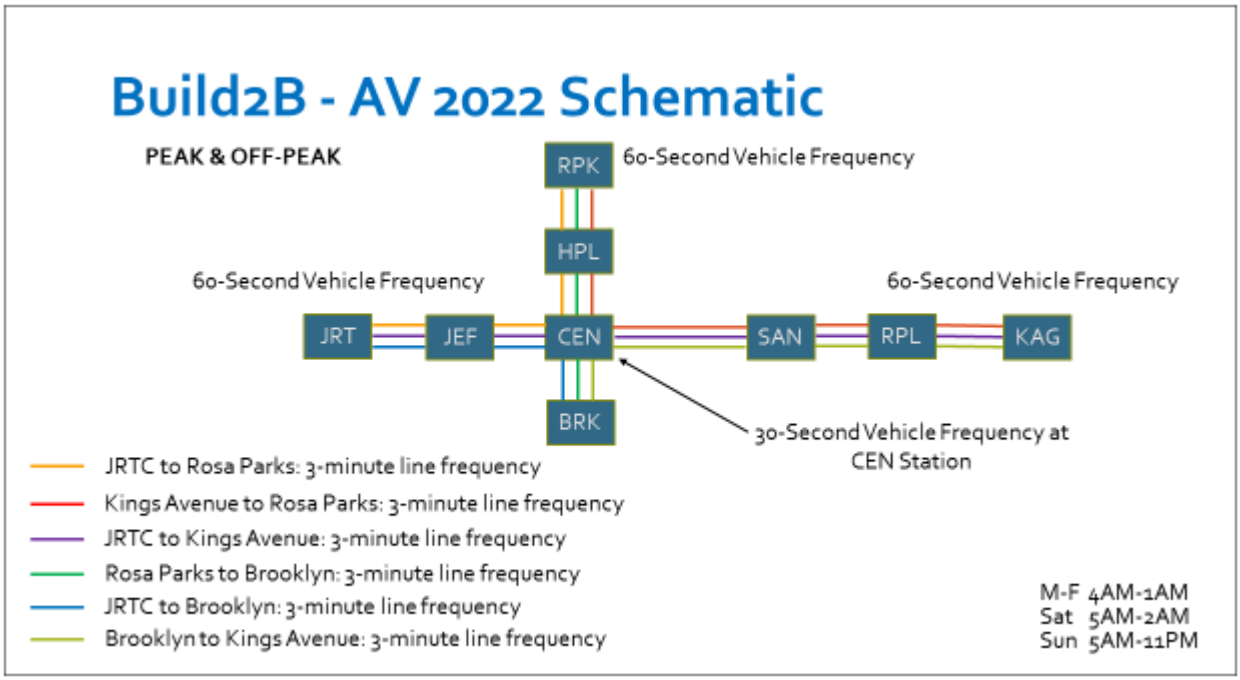
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Re: U^2C Operating Demand to Capacity Analysis - 2040

This memorandum presents an analysis of estimated travel demand compared to service capacity for U^2C alternatives for demand year 2040. The intent of the analysis is to assure that sufficient operating capacity exists to serve estimated travel demand. Ideally, a transit system is designed such that demand is not greater than 80% of the system capacity to serve expected demand. The modelled operating plans tested service line frequencies of between 2-minutes and 4-minutes resulting in effective vehicle headways at most stations of between 60-seconds and 90-seconds due to overlapping service lines. This analysis represents a robust service plan designed to attract high ridership. The results show that based on the operating plans tested, U^2C system and individual transit line demand in 2040 is significantly less than the robust operating plan service capacity. Therefore, in planning the U^2C system, a less robust operating plan, longer service frequencies, for example a vehicle arriving at the station every 4-8 minutes, depending on the service line, may be considered without expected adverse impacts to ridership or to demand capacity. This finding establishes flexibility for JTA in deploying and phasing AV services and capital programming.

Methodology

The methodology employed is described here. Operating plans were developed for four build alternatives. The build alternatives include the same operating and transit network assumptions with two exceptions. Build Alternative 1 does not include a Brooklyn station while Build Alternative 2 does include a Brooklyn station. In addition, the service line frequencies vary as noted for each alternative. The ridership demand estimates are based on these distinct service plans. Schematics of the alternatives are attached to help illustrate the alternative proposed AV networks. The alternatives tested are:

- Build Alternative 1A – AV operation along the existing ASE guideway footprint w/o the I-beam plus the bus network as coded for SW BRT submittal, expanded weekday service span from 4AM to 1AM. This alternative does not include the Brooklyn station. Service line frequency is a 3-minute headway.
- Build Alternative 1B – Same as Alternative 1A except service line frequency is a 2-minute headway.
- Build Alternative 2A – AV operation along the existing ASE guideway footprint w/o the I-beam plus the bus network as coded for SW BRT submittal, expanded weekday service span from 4AM to 1AM. This alternative does include the Brooklyn station. Service line frequency is a 4-minute headway.
- Build Alternative 2B – Same as Alternative 2A except service line frequency is a 3-minute headway.

Operating capacity and demand need only to be calculated for the peak hour of service to assure demand does not exceed service capacity. Peak operating capacity is a function of the available seats and the number of vehicle trips per peak hour. The number of seats is calculated as peak vehicles multiplied by seats on each vehicle. Vehicle trips is calculated as 60-minutes divided by service frequency. The equation for Peak Capacity is:

*Peak Capacity = (Vehicles*Seats)*(Trips/Hour) where Trips/Hour is [60/service frequency]*

Hourly demand was calculated based on an average of daily demand divided by daily service span (21 hours) to yield an average number of passenger trips per hour. However, an average demand per hour is not what is observed in transit or traffic volumes due to well established commuting patterns. Rather, the peak demand is required to assess demand to capacity. Peak demand was calculated as 10% of daily travel volume based on historical observations of diurnal transit and traffic patterns as reported by the *Texas Transportation Institute (2011)*. Therefore, applying a 10% factor to 2040 daily demand estimates, by system and by individual service line, yields an estimate of peak demand.

Calculating peak demand to peak capacity is a simple function of dividing demand by capacity.

Findings

Our analysis was conducted for the system capacity as well as for individual service lines as reflected in the tables below. Presented first are the system demand to capacity findings for each alternatives. As noted, system-wide peak hour demand to capacity ratios range between 10% and 22%.

System Alternative	Service Line Headway	Peak Vehicles	Vehicle Capacity	Daily Service Hours	2040 Daily Demand	Capacity per Hour[1]	Demand per Hour[2]	Demand to Capacity	Peak Capacity	Peak Demand[3]	Peak Demand to Capacity
2022 Build Alt. 1 A - no Brooklyn	3-minutes	14	12	294	7,289	3360	347	10.3%	3360	729	22%
2022 Build Alt. 1 B - no Brooklyn	2-minutes	21	12	441	7,518	7560	358	4.7%	7560	752	10%
2022 Build Alt. 2 A - Brooklyn	4-minutes	19	12	399	7,536	3420	359	10.5%	3420	754	22%
2022 Build Alt. 2 B - Brooklyn	3-minutes	25	12	525	7,931	6000	378	6.3%	6000	793	13%

1. Capacity per Hour = [(Vehicles*Seats)*(Trips/Hour)] where Trips/Hour = 60/Headway
2. Demand per Hour = Demand/Service Span where service span is 21 hours Monday-Friday
3. Peak Hour Demand = 10 percent of Daily Demand based on Texas Transportation Institue (2011).

The demand to capacity ratio for Alternative 1A, without a Brooklyn station, operating at 3-minute service line frequencies is reflected below. Demand to capacity ranges from 10% to 41%.

Alternative Detail	Service Line Headway	Peak Vehicles	Vehicle Capacity	Daily Service Hours	2040 Daily Demand	Capacity per Hour[1]	Demand per Hour[2]	Demand to Capacity	Peak Capacity	Peak Demand[3]	Peak Demand to Capacity
2022 Build Alt. 1 A - no Brooklyn											
JTRC to Rosa Parks	3-minutes	4	12	84	1,120	960	53	5.6%	960	112	12%
Kings Ave to Rosa Parks	3-minutes	5	12	105	4,923	1200	234	19.5%	1200	492	41%
JRTC to Kings Ave	3-minutes	5	12	105	1,246	1200	59	4.9%	1200	125	10%

1. Capacity per Hour = [(Vehicles*Seats)*(Trips/Hour)] where Trips/Hour = 60/Headway
2. Demand per Hour = Demand/Service Span where service span is 21 hours Monday-Friday
3. Peak Hour Demand = 10 percent of Daily Demand based on Texas Transportation Institue (2011).

The demand to capacity ratio for Alternative 1B, without a Brooklyn station, operating at 2-minute service line frequencies is below. Demand to capacity ranges from 5% to 17%.

Alternative Detail	Service Line Headway	Peak Vehicles	Vehicle Capacity	Daily Service Hours	2040 Daily Demand	Capacity per Hour[1]	Demand per Hour[2]	Demand to Capacity	Peak Capacity	Peak Demand[3]	Peak Demand to Capacity
2022 Build Alt. 1 B - no Brooklyn											
JTRC to Rosa Parks	2-minutes	5	12	105	1,191	1800	57	3.2%	1800	119	7%
Kings Ave to Rosa Parks	2-minutes	8	12	168	4,938	2880	235	8.2%	2880	494	17%
JRTC to Kings Ave	2-minutes	8	12	168	1,389	2880	66	2.3%	2880	139	5%

1. Capacity per Hour = [(Vehicles*Seats)*(Trips/Hour)] where Trips/Hour = 60/Headway
2. Demand per Hour = Demand/Service Span where service span is 21 hours Monday-Friday
3. Peak Hour Demand = 10 percent of Daily Demand based on Texas Transportation Institue (2011).

The demand to capacity ratio for Alternative 2A, with a Brooklyn station, operating at 4-minute service line frequencies is below. Peak demand to capacity is highest on the Kings Avenue Station to Rosa Parks Station line at 61% and otherwise ranges from 9% to 15%.

Alternative Detail	Service Line Headway	Peak Vehicles	Vehicle Capacity	Daily Service Hours	2040 Daily Demand	Capacity per Hour[1]	Demand per Hour[2]	Demand to Capacity	Peak Capacity	Peak Demand[3]	Peak Demand to Capacity
2022 Build Alt. 2 A - Brooklyn											
JTRC to Rosa Parks	4-minutes	3	12	63	784	540	37	6.9%	540	78	15%
Kings Ave to Rosa Parks	4-minutes	4	12	84	4,393	720	209	29.1%	720	439	61%
JRTC to Kings Ave	4-minutes	4	12	84	645	720	31	4.3%	720	65	9%
Brooklyn to Kings Ave	4-minutes	4	12	84	915	720	44	6.1%	720	92	13%
Brooklyn to Rosa Parks	4-minutes	2	12	42	468	360	22	6.2%	360	47	13%
Brooklyn to JRTC	4-minutes	2	12	42	331	360	16	4.4%	360	33	9%

1. Capacity per Hour = [(Vehicles*Seats)*(Trips/Hour)] where Trips/Hour = 60/Headway
2. Demand per Hour = Demand/Service Span where service span is 21 hours Monday-Friday
3. Peak Hour Demand = 10 percent of Daily Demand based on Texas Transportation Institue (2011).

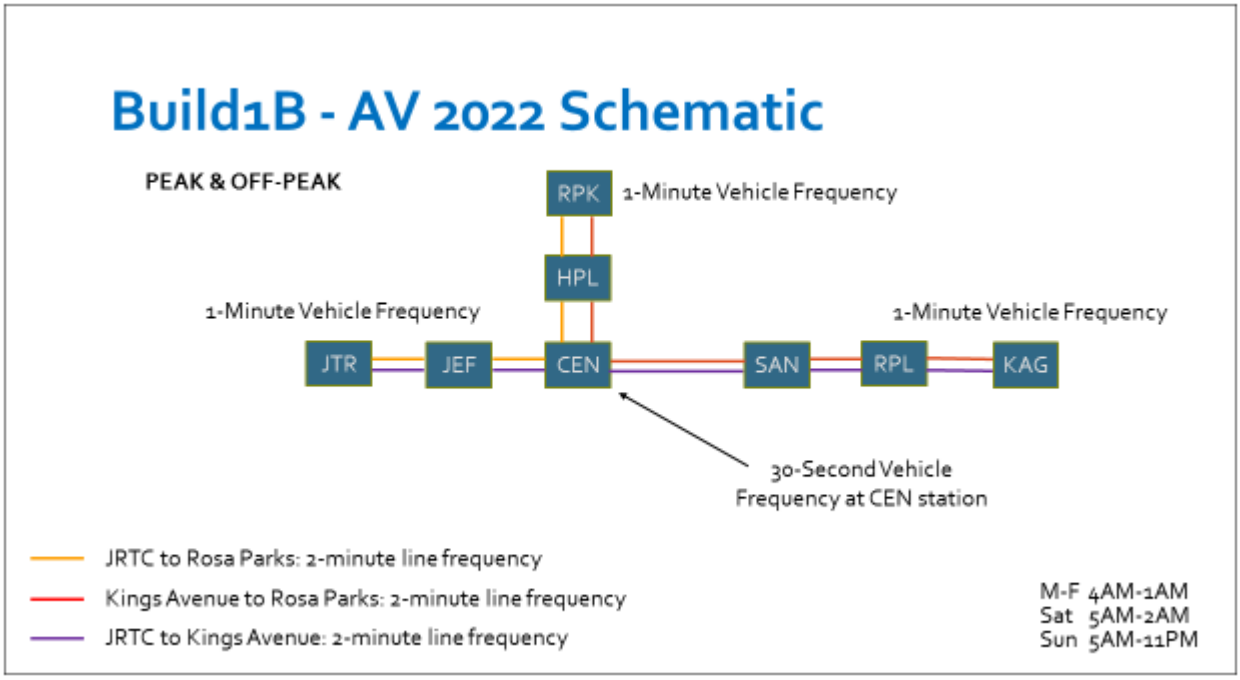
The demand to capacity ratio for Alternative 2B, with a Brooklyn station, operating at 3-minute service line frequencies is below. Peak demand to capacity is highest on the Kings Avenue Station to Rosa Parks Station line at 39% and otherwise ranges from 5% to 8%.

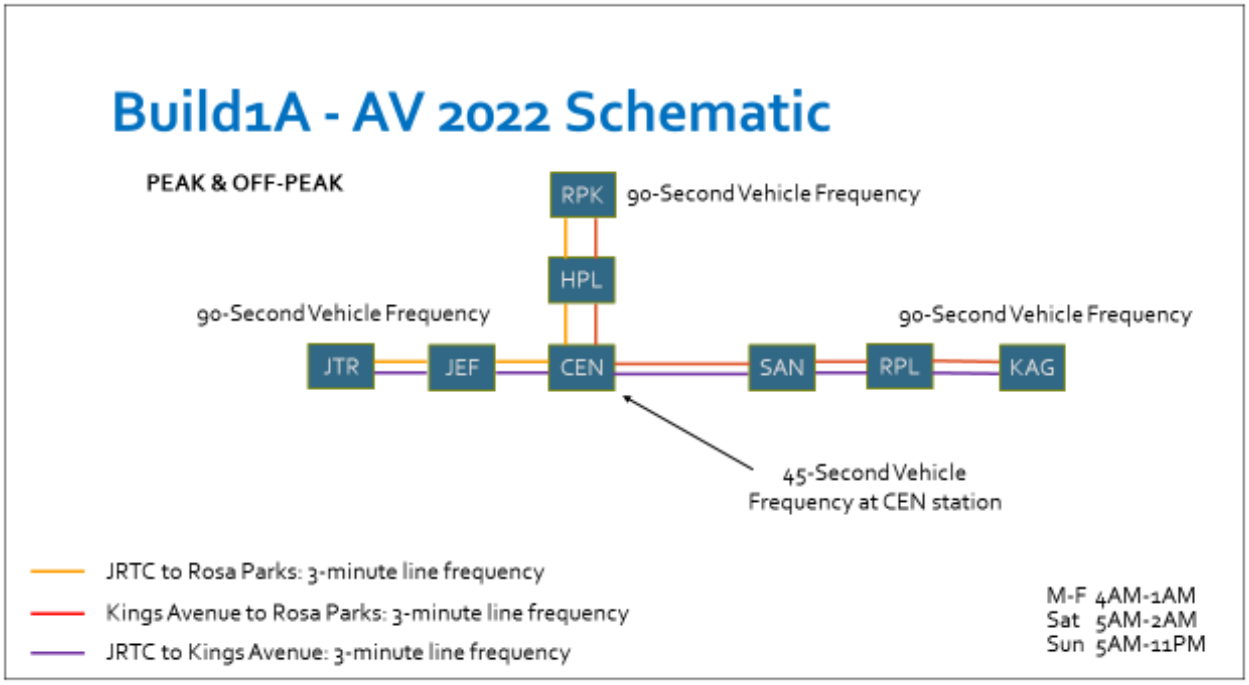
Alternative Detail	Service Line Headway	Peak Vehicles	Vehicle Capacity	Daily Service Hours	2040 Daily Demand	Capacity per Hour[1]	Demand per Hour[2]	Demand to Capacity	Peak Capacity	Peak Demand[3]	Peak Demand to Capacity
2022 Build Alt. 2 B - Brooklyn											
JTRC to Rosa Parks	3-minutes	4	12	84	798	960	38	4.0%	960	80	8%
Kings Ave to Rosa Parks	3-minutes	5	12	105	4,707	1200	224	18.7%	1200	471	39%
JRTC to Kings Ave	3-minutes	5	12	105	645	1200	31	2.6%	1200	65	5%
Brooklyn to Kings Ave	3-minutes	5	12	105	915	1200	44	3.6%	1200	92	8%
Brooklyn to Rosa Parks	3-minutes	3	12	63	479	720	23	3.2%	720	48	7%
Brooklyn to JRTC	3-minutes	3	12	63	387	720	18	2.6%	720	39	5%

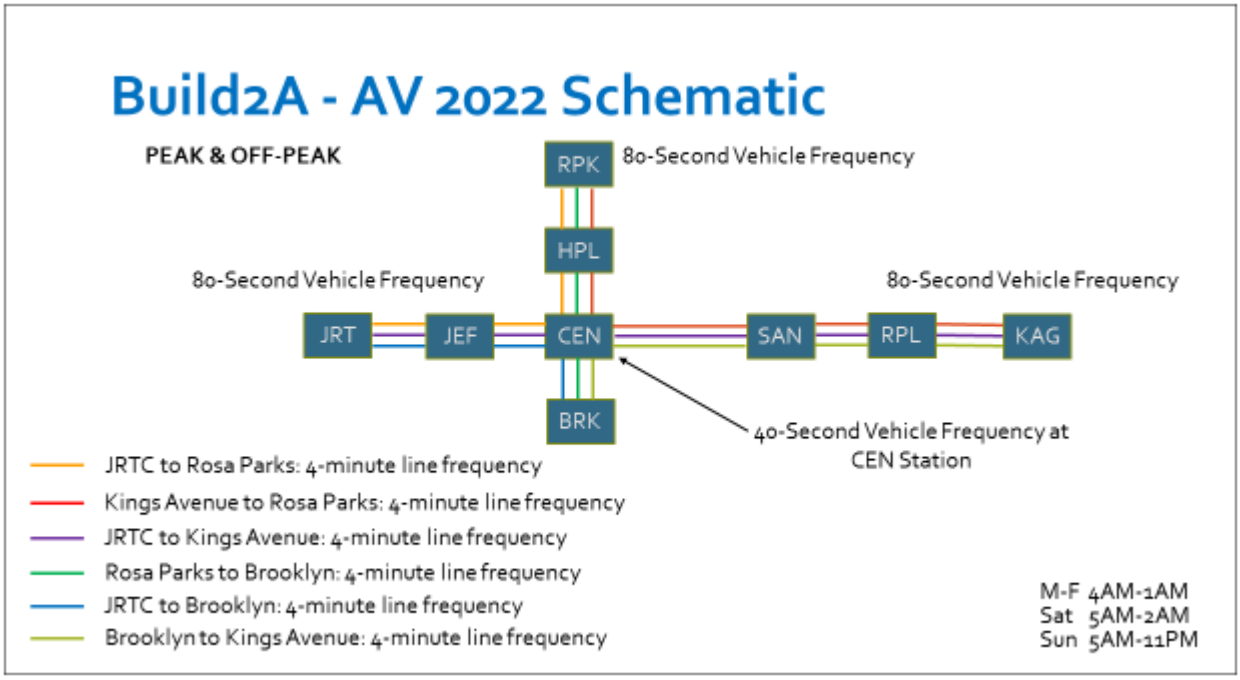
1. Capacity per Hour = [(Vehicles*Seats)*(Trips/Hour)] where Trips/Hour = 60/Headway
2. Demand per Hour = Demand/Service Span where service span is 21 hours Monday-Friday
3. Peak Hour Demand = 10 percent of Daily Demand based on Texas Transportation Institue (2011).

Based on this analysis, the service capacity planned is more than sufficient to meet estimated service demand in design year 2040. This finding suggest a less robust service plan, longer service line frequencies, would easily accommodate estimated ridership and by comparing the changes in demand between the less frequent scenarios of the more frequent scenarios, the impact on demand is not likely to result in a meaningful adverse impact on ridership assuming service frequencies are operated at an attractive level, a service line headway of at least every 4-8 minutes.

Service Line Schematics



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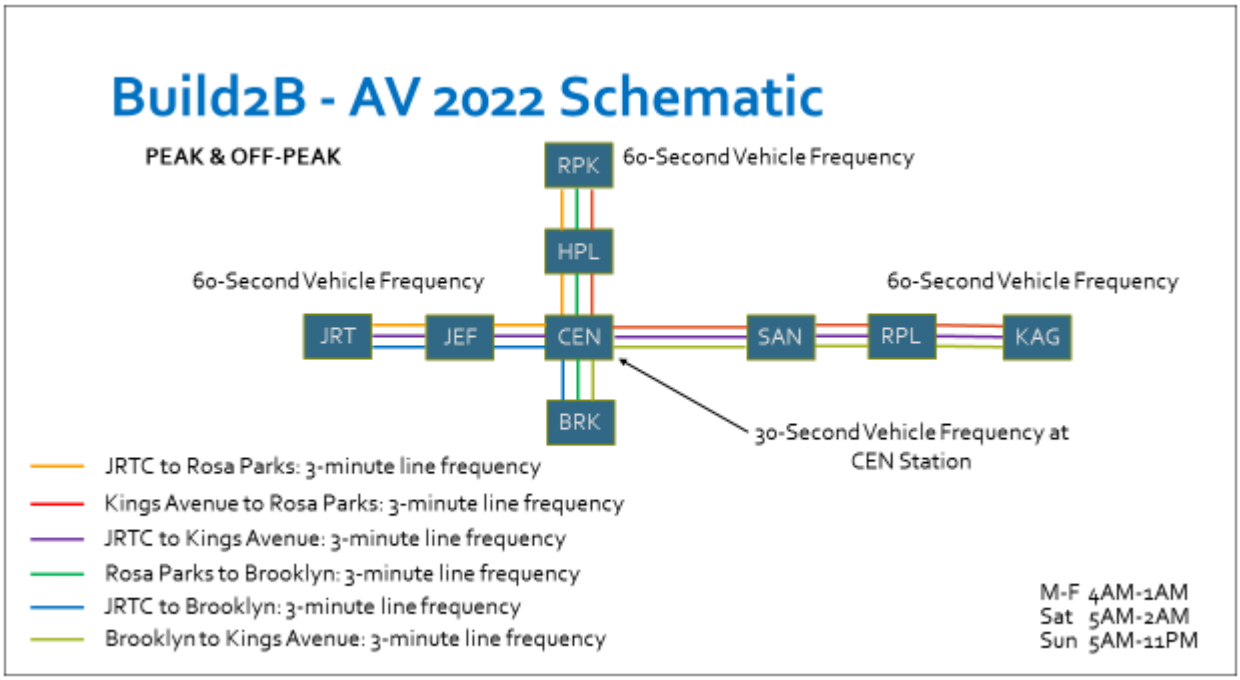
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