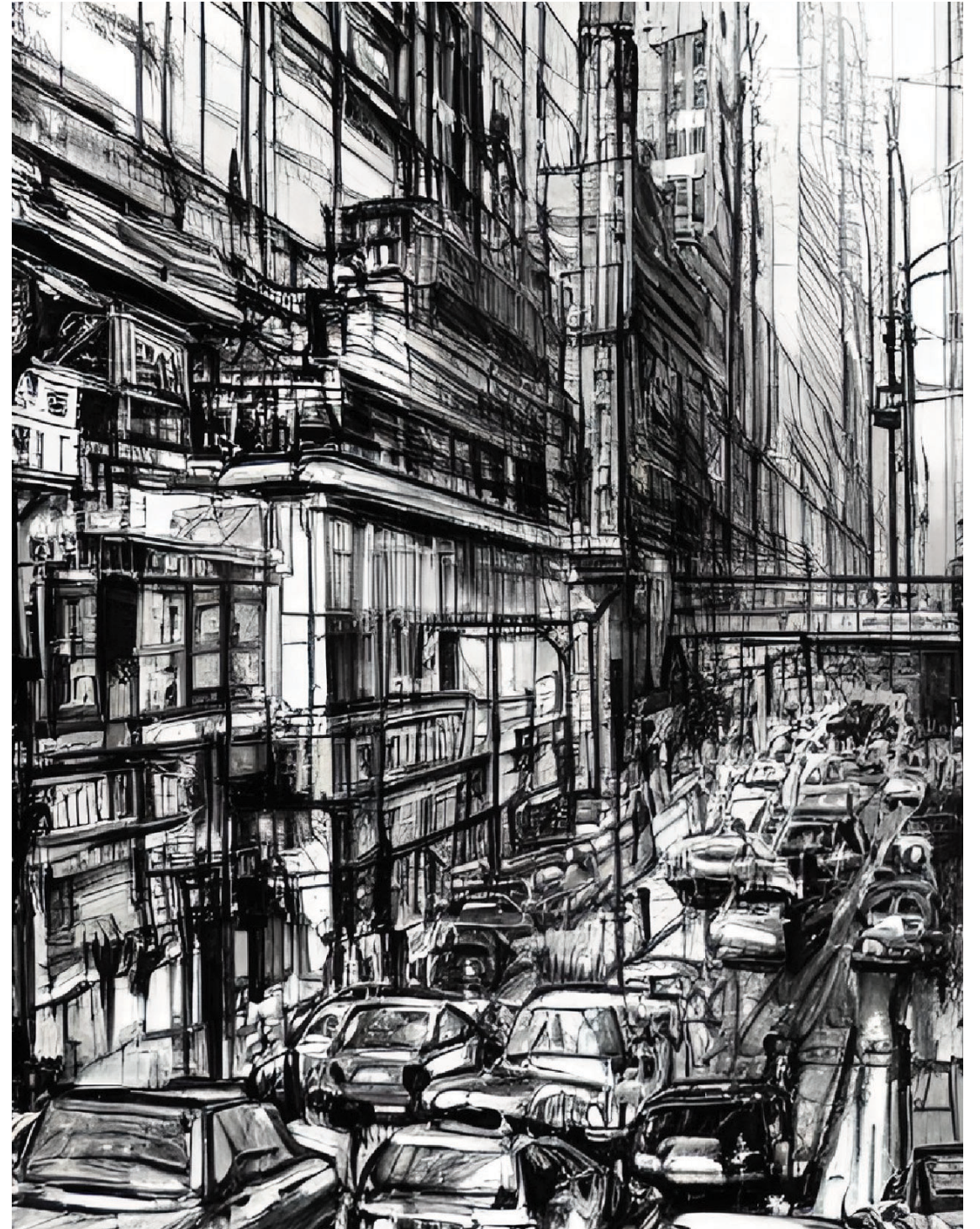


Smart City Modeling: Using GIS Capabilities to Simulate Urban Areas and Events



Thesis Questions

- What methods can established or newer cities use to become smart cities?

- How can the data collected by a smart city be used to better the lives of the urban inhabitants?

- How can computer modeling aid in overall wellness and accessibility of urban inhabitants?

- How can we ensure that the development of smart cities is inclusive and beneficial for all residents?

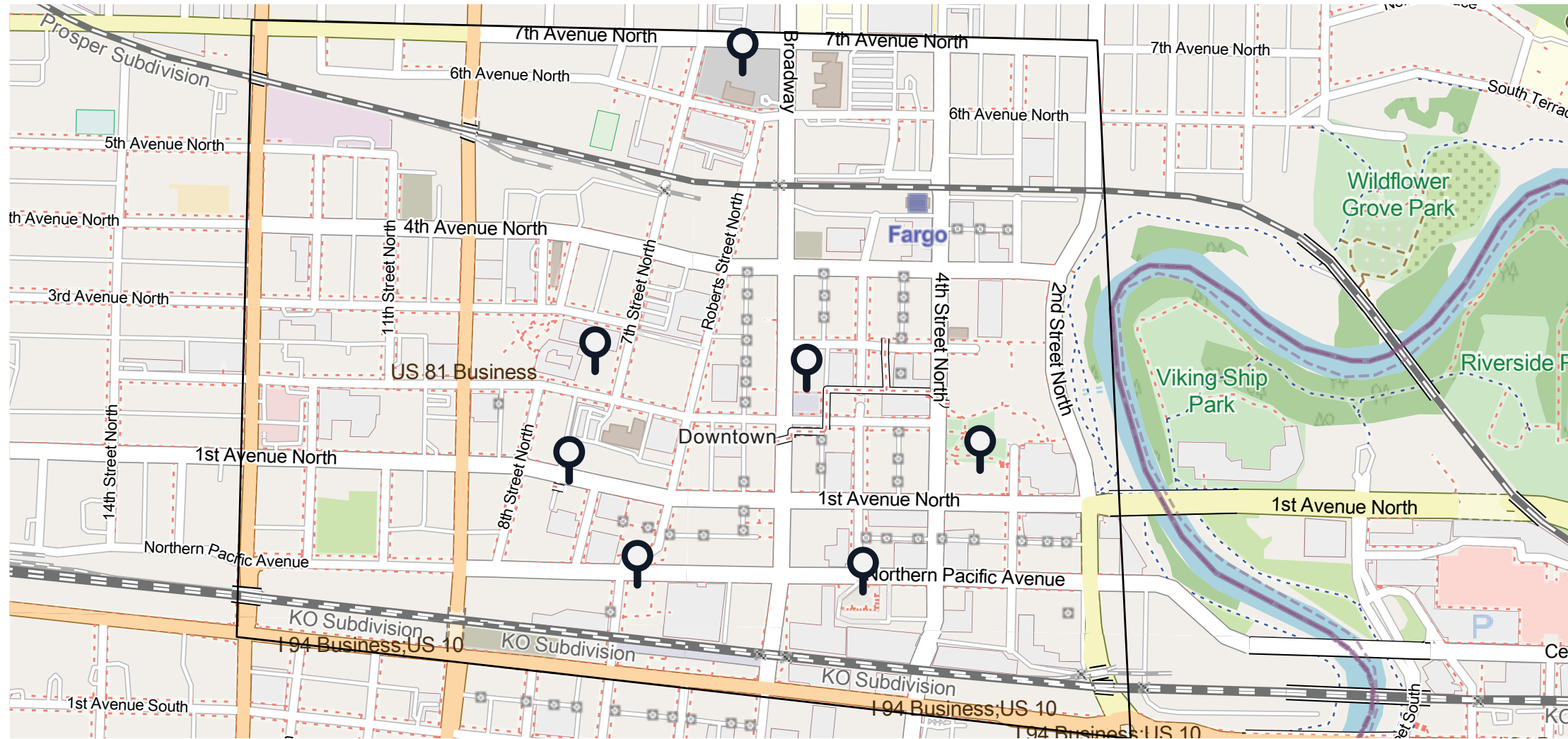
Project Background: Applications



ArcGIS



Project Background: Area of Research



Project Background: Area of Research



Project Background: Area of Research

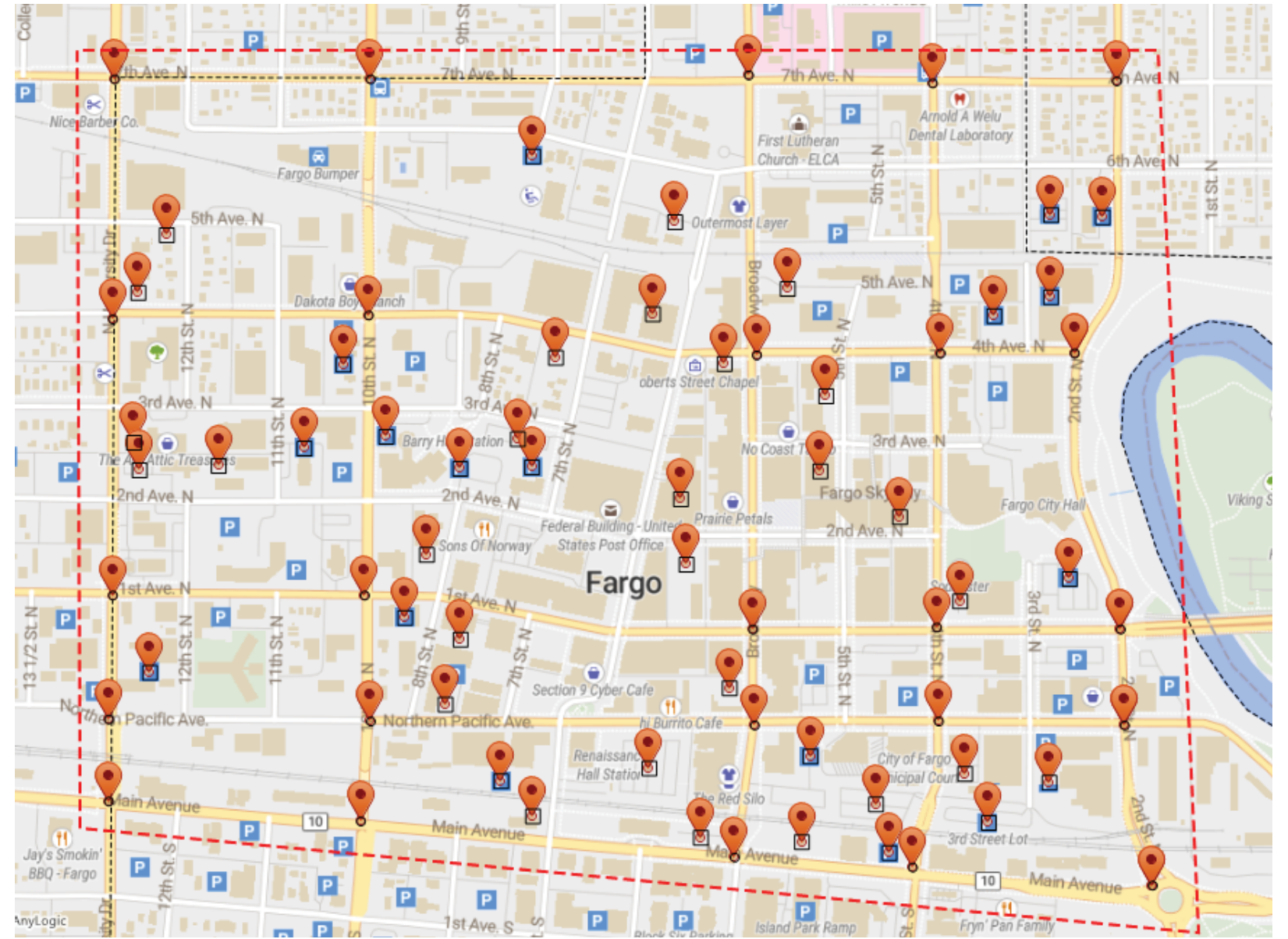
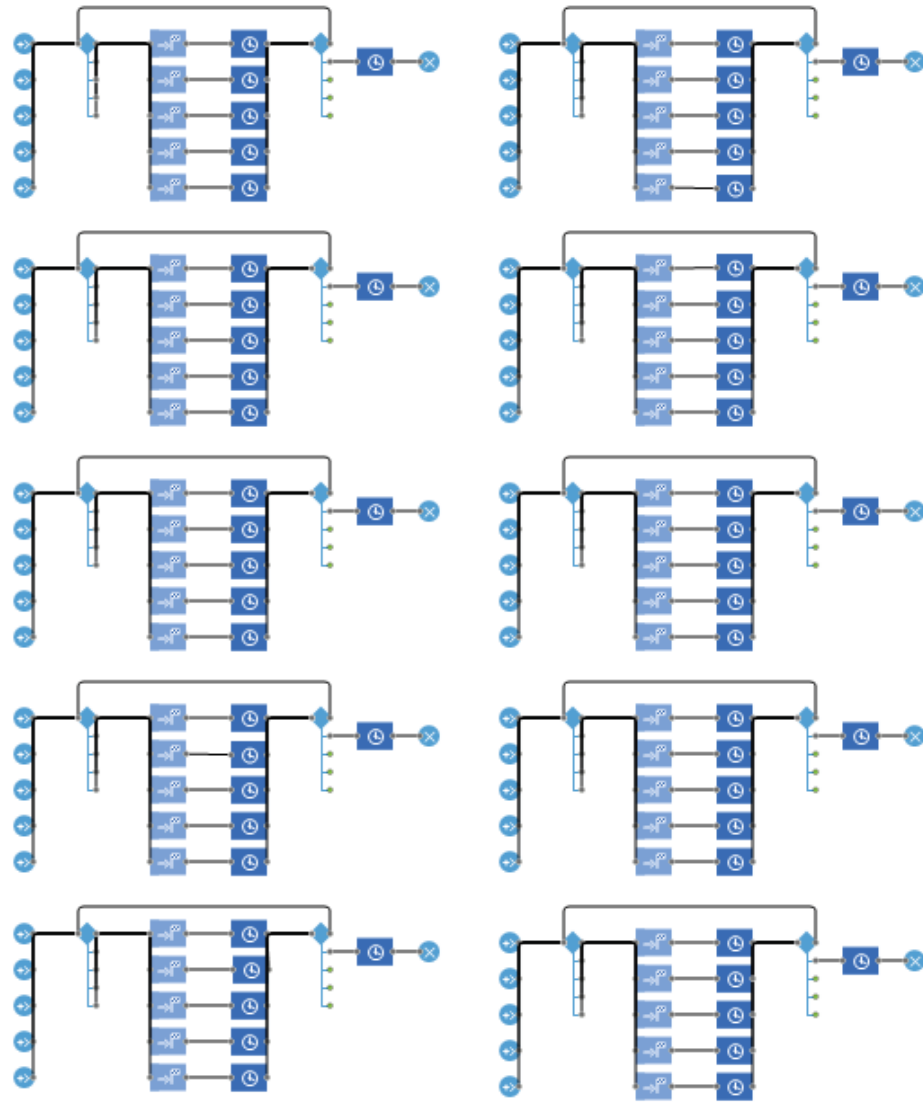


Fall Research: Public Occupancy Information

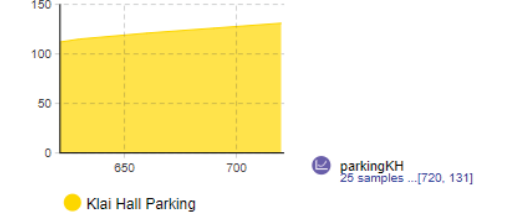
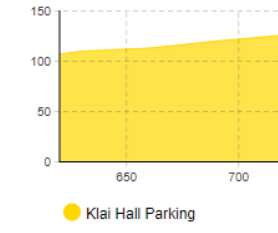
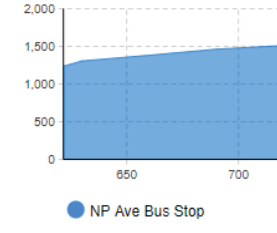
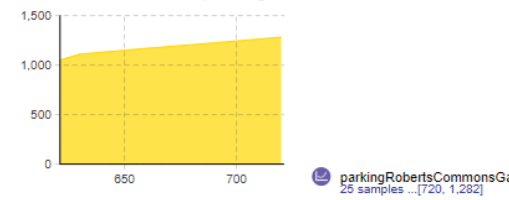
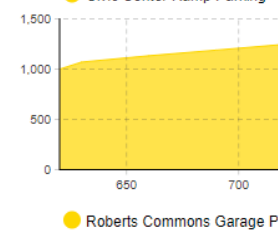
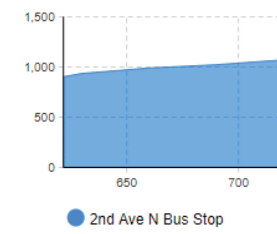
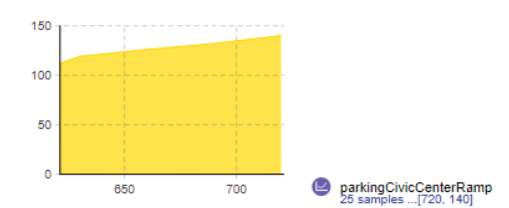
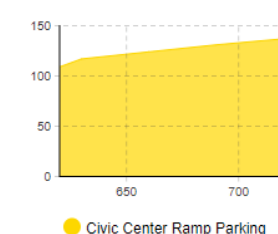
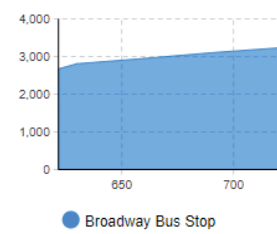
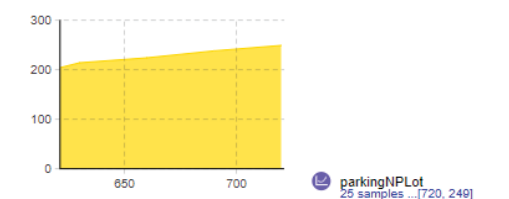
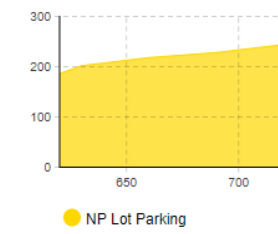
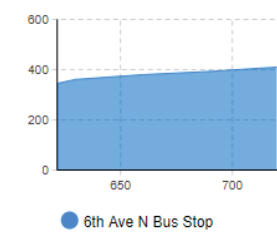
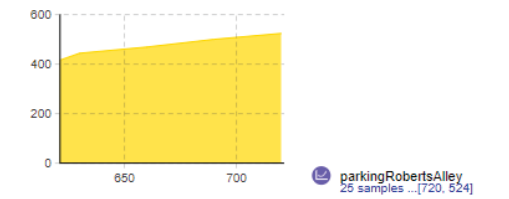
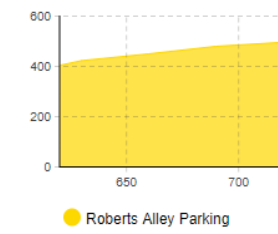
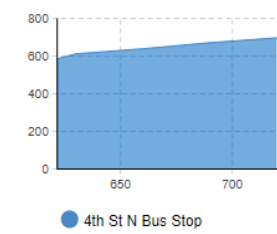
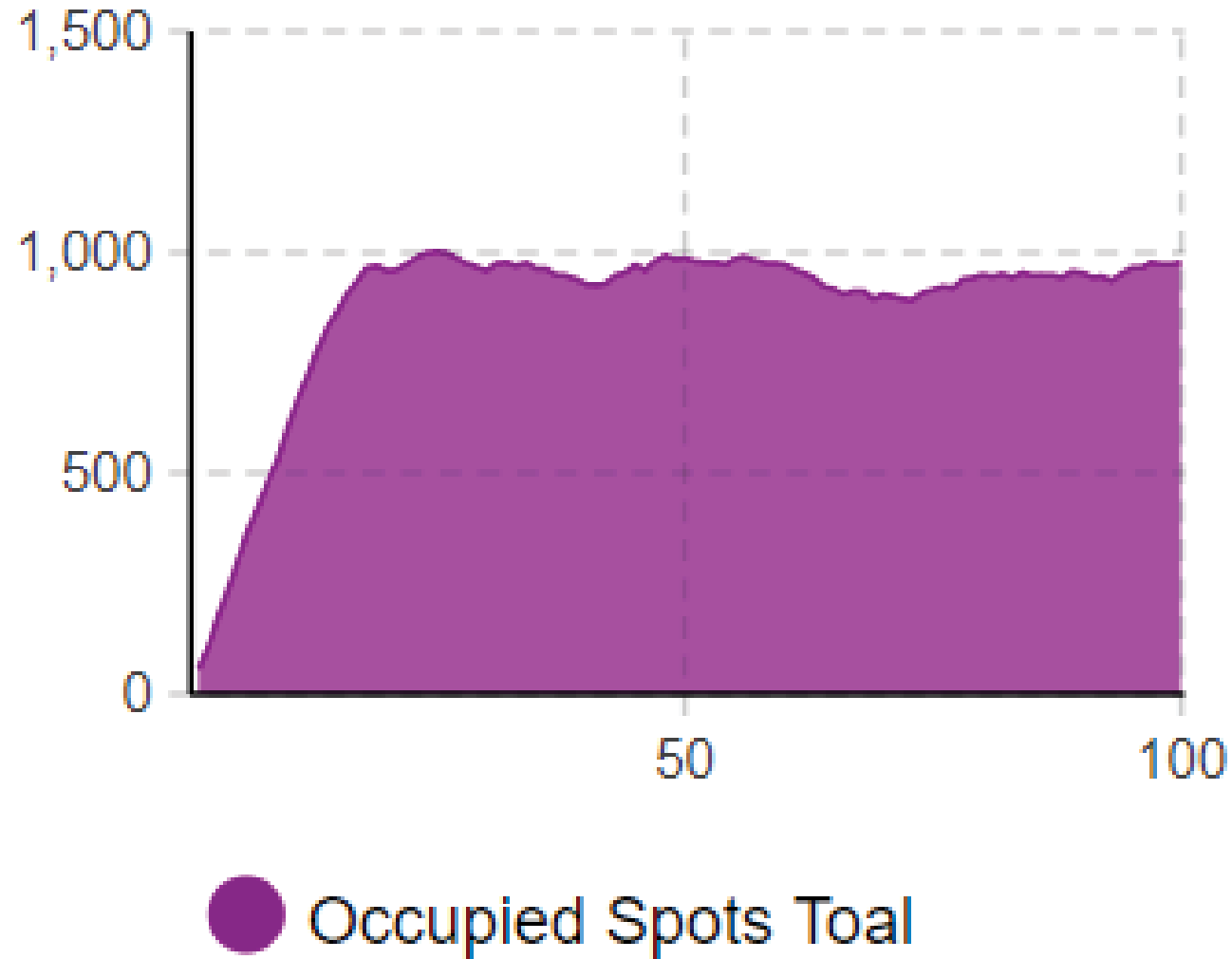
PERMIT NUMBER	DATE	OCCUPANT	ADDRESS	Permit	TYPE
23892	1/1/2023	Wasabi/Poke Bowl	560 2 Ave N	To operate a place of assembly as per Section 105.5.39 IFC 2021 Edition. Occupant Load = 81	PA
23904	1/1/2023	Wild Terra Cider and Brewery	6 12 St N	To operate a place of assembly as per Section 105.5.39 IFC 2021 Edition. Occupant Load = 80	PA
23001	1/1/2023	48 N Pints & Provisions	635 2 Ave N	To operate a place of assembly as per Section 105.5.39 IFC 2021 Edition. Occupant Load 216	PA
23643	1/1/2023	Pixelated Brewing Co.	1100 NP Ave, Ste 101	To operate a place of assembly as per Section 105.5.39 IFC 2021 Edition. Occupant Load 217	PA
23261	1/1/2023	Drunken Noodle	414 Broadway N	Occupant Load 1st Floor 58 Rooftop 49	PA
23093	1/1/2023	Black Coffee & Waffle Bar	550 2 Ave N	To operate a place of assembly as per Section 105.5.39 IFC 2021 Edition. OL=136	PA
23081	1/1/2023	BernBaum's	402 Broadway N	To operate a place of assembly as per Section 105.5.39 IFC 2021 Edition. OL=90	PA
23189	1/1/2023	Cowboy Jacks	506 Broadway N	To operate a place of assembly as per Section 105.5.39 IFC 2021 Edition. Occupant Load: 1st and 2nd Floor - 350 Outdoor patio - 106	PA
23075	1/1/2023	Beer and Fish Company	230 Roberts Aly N	To operate a place of assembly as per Section 105.5.39 IFC 2021 Edition. Occupant Load = 198	PA
23821	1/1/2023	Taco Shop	117 Broadway	To operate a place of assembly as per Section 105.5.39 IFC 2021 Edition. OL 94	PA
23709	1/1/2023	Rough Cut Ave Throwing Bar (Rough Cut Social)	1100 NP Ave Suite 102	To operate a place of assembly as per Section 105.5.39 IFC 2021 Edition. Occupant Load = 134	PA
23888	1/1/2023	Vinyl Taco	520 1 Ave N	To operate a place of assembly as per Section 105.5.39 IFC 2021 Edition. Occupant Load = 77	PA
23795	1/1/2023	Stone Event Center	613 1 Ave N	Occupant load 1st Floor - 281 2nd Floor - 235	PA
23251	1/1/2023	District 64	64 Broadway N	To operate a place of assembly as per Section 105.5.39 IFC 2021 Edition. Occupant Load = 1st Floor - 204 2nd Floor - 80	PA
23105	1/1/2023	Boss Pizza & Chicken	228 Broadway	Occupant Load Upper Level - 116 Lower Level - 82	PA
23373	1/1/2023	Havoc House	222 Broadway N #200	To operate a place of assembly as per Section 105.5.39 IFC 2021 Edition. Occupant Load - 193	PA
23480	1/1/2023	Little Brother	117 Broadway N	To operate a place of assembly as per Section 105.5.39 IFC 2021 Edition. Occupant Load - 94	PA
23696	3/20/2023	Dempsey's expansion	222 Broadway N	To operate a place of assembly as per Section 105.5.39 IFC 2021 Edition. Occupant Load = 120	PA
23944	7/19/2023	Mezzaluna	309 Roberts St N	To operate a place of assembly as per Section 105.5.39 IFC 2021 Edition. Maximum Occupant Load - 99	PA
23948	8/7/2023	The Four & Four	404 4 Ave N, #203	To operate a place of assembly as per Section 105.5.39 IFC 2021 Edition. OL - 209	PA
23719	1/1/2023	Sanctuary Events Center	670 4 Ave N	Occupant Load Basement reception - 438 First floor events center - 476	PA
23833	1/1/2023	Teddy's Eatery and Parlor	212 Broadway	To operate a place of assembly as per Section 105.5.39 IFC 2021 Edition. OL=69	PA
23666	1/1/2023	Proof Artisan Distillers	414 4 Ave N	To operate a place of assembly as per Section 105.5.39 IFC 2021 Edition. Occupant Load = 88	PA
23887	1/1/2023	VFW Club	607 2 Ave N	To operate a place of assembly as per Section 105.5.39 IFC 2021 Edition. Occupant Load Lower Level - 185 Main level - 179	PA
23094	1/1/2023	Blackbird Woodfire	206 Broadway N	To operate a place of assembly as per Section 105.5.39 IFC 2021 Edition. OL 67	PA
23571	1/1/2023	No Bull	609 NP Ave N	To operate a place of assembly as per Section 105.5.39 IFC 2021 Edition. OL=63	PA
23641	1/1/2023	Pho D'Licious	623 Northern Pacific Ave N	To operate a place of assembly as per Section 105.5.39 IFC 2021 Edition. Occupant Load 66 (39 East dining, 27 West dining)	PA
23653	8/9/2023	Pounds	6 Broadway N #100	To operate a place of assembly as per Section 105.5.39 IFC 2021 Edition. OL - 104	PA

23844	1/1/2023	The Toasted Frog	305 Broadway N	To operate a place of assembly as per Section 105.5.39 IFC 2021 Edition. OL=120	PA
23708	1/1/2023	Rooter's Bar	107 Broadway N	To operate a place of assembly as per Section 105.5.39 IFC 2021 Edition. Occupant Load=200	PA
23775	1/1/2023	Sons of Norway	722 2 Ave N	OL - Lounge 61 Dining 121	PA
23646	1/1/2023	PLAINS ART MUSEUM	704 1 Ave N	To operate a place of assembly as per Section 105.5.39 IFC 2015 Edition. To store and use flammable or combustible Liquids as per Section 5701.4 IFC 2015 Edition.	PA/FL/SP
23843	1/1/2023	The Northern	325 10 ST N	To operate a place of assembly as per Section 105.5.39 IFC 2021 Edition. Occupant load=265 upper, 150 lower	PA
23756	1/1/2023	Sidestreet Bar and Grill	404 4 Ave N	To operate a place of assembly as per Section 105.5.39 IFC 2021 Edition. OL - 314	PA
23914	1/1/2023	Wurst Bier Hall	630 1 Ave N - Suite 1	To operate a place of assembly as per Section 105.5.39 IFC 2021 Edition. Occupant Load = 128 East Room Occupant Load = 100 West Room	PA
23339	1/1/2023	Fort Noks	52 Broadway N	To operate a place of assembly as per Section 105.5.39 IFC 2021 Edition. Occupant Load=103	PA
23241	1/1/2023	Dempsey's Public House	226 Broadway N	Occupant Load: Main Floor 209 Second Floor 258	PA
23091	1/1/2023	Bismarck Tavern	522 Broadway N	To operate a place of assembly as per Section 105.5.39 IFC 2021 Edition. Occupant Load 104	PA
23297	1/1/2023	Fargo Civic Memorial Auditorium	207 4 ST N	To conduct hot work as per Section 3501.2 IFC 2021 Edition. Civic Memorial Auditorium - 3337	PA
23276	1/1/2023	Empire Tavern	424 Broadway N	To operate a place of assembly as per Section 105.5.39 IFC 2021 Edition. Occupant Load = 85	PA
23161	1/1/2023	CHUB'S PUB & PACKAGE PLACE	421 University Dr N	To operate a place of assembly as per Section 105.5.39 IFC 2021 Edition. Occupant load=185	PA
23320	1/1/2023	FARGO THEATER	314 Broadway N	To operate a place of assembly as per Section 105.5.39 IFC 2021 Edition. Occupant load = 870	PA
23609	1/1/2023	OLD BROADWAY CORP	22 Broadway N	City Club = 310 OL Grill = 151 OL Sports zone = 70 OL	PA
23788	1/1/2023	Spicy Pie	322 Broadway N	To operate a place of assembly as per Section 105.5.39 IFC 2021 Edition. Occupant load=72	PA
23790	1/1/2023	Sports Bar Inc	619 Northern Pacific Ave N	To operate a place of assembly as per Section 105.5.39 IFC 2021 Edition. Occupant load = 165	PA
23625	1/1/2023	Paradox Event Center	26 Roberts St N - Suite A-117	To operate a place of assembly as per Section 105.5.39 IFC 2021 Edition. Occupant load = 120	PA
23837	1/1/2023	The Boiler Room	210 Broadway	To operate a place of assembly as per Section 105.5.39 IFC 2021 Edition. Occupant Load = 280	PA
		Renaissance Hall			200
		Klail Hall			200
		Barry Hall			150
		First Lutheran Church			3000

Fall Research: GIS Map



Fall Research: Results



Fall Research: Moving Forward

Four Main Challenges:

- Production Time
- Computational Limitations
- Accessible Information
- Zoning

Coding:

- 1. agent.moveToNearestAgent(parkingSpots);***
- 2. if (agent.distanceTo(RobertsAlley) <= 0)
RobertsAlley.occupiedSpots++;***
- 3. if (regionClosedArea.isVisible())
 agent.moveToNearestAgent(collection-
Parking1);
else
 agent.moveToNearestAgent(collection-
Parking)***

Spring Research: Topics of Analysis

Topic	Data to be analyzed	What data is produced?	How can the data be used?
Transportation	Monitoring optimal routes	Fastest route of the least miles and time required	Provide estimations on time of travel
	Road congestions	Number of vehicles at a given location	Provide areas of congestion to be optimized or reorganized
	Road construction and accident sites	Efficiency of travel of alternate paths of travel	Provide alternate routes to possible road closures
	Public transportation efficiency	Efficiency of travel Areas of use Cost of use	Provide the efficiency of public transportation in a large or small scale
	Snow or emergency routes	Efficiency of a given route, response time	Provides the city the means to plan smarter routes for response teams for emergencies or weather conditions
	Alternate means of travel	Cost of use/upkeep Areas of use Efficiency of travel Percentage used by population	Provide the efficiency and feasibility of alternate means of travel
Pedestrian	Safety of urban environment	Track areas of crime and closed off areas	Find and reduce areas of crime to make them more safe for pedestrians, or track change of pedestrian flow due to closed off areas
	Walkability of urban environment	Sidewalk layout efficiency	Is a "15-minute city" achievable in the given area? Provide information on what can be changed to achieve this goal.
	Accessibility of amenities	Time or distance from a given location required for living	Provide information of distance of amenities like stores, work, education, or housing
	Accessibility of public transportation	Distance from a bus route/assembly or a subway station entry	Provide optimal locations for public transportation with high areas of use
	Accessibility of nightlife	Lighting feasibility Number of places of interest or amenities for nightlife	Provide the number of street lights needed for nightlife Provide information of open or closed amenities for nightlife

Infrastructure	Water and power supply	Amount of water and power supply used or needed	Provide the cost and amount required in a given location
	Waste Management	Efficiency of waste collection and tracking the amount collected	Provide information of waste collection and its efficiency
	Infrastructure placement	Efficiency and accessibility of infrastructure	Provide optimal locations of law enforcement, education, and healthcare for response times and accessibility
Environment	Healthcare	Areas of disease spreading or high pedestrian count	Provide information of disease spreading and other health concerns
	Air and water pollution	Areas of high pollutants and the causes	Provide information on the amount of pollution in an urban setting to find an efficient solution
	Green Spaces	Amount of green spaces in a given urban environment	Provide information on whether more green spaces, such as parks or fields, are needed

Logic: Source Blocks

In AnyLogic, blocks are used to define where the pedestrian starts, moves, waits, and stays. The Source Block, for example, defines where the pedestrian begins in the simulation. They can start from a certain point of the map (building) or in a defined area (downtown area). In the Source Block, we can set parameters that define how the pedestrian acts or moves, such as arrival rate and speed.

sourceWRestaurantsAndBars - Source

Name: Show name Ignore

Arrivals defined by:

Arrival rate:

Set agent parameters from DB:

Multiple agents per arrival:

Limited number of arrivals:

Location of arrival:

Node:

Speed:

Agent

Advanced

Custom time of start:

Add agents to: default population custom population

Forced pushing:

Actions

On before arrival:

On at exit:

On exit:

```
if ( regionClosedArea.isVisible() )
agent.moveToNearestAgent(collectionRestaurantsAndBars1);
else
agent.moveToNearestAgent(collectionRestaurantsAndBars)
```

Advanced

Agent type:

Logic: Structure

Altogether, these blocks can be connected to simulate pedestrian movement. Additional coding is used to simulate pedestrian movement to the nearest destination.

Accessibility of Public Transportation

Bus Stops to GTC



sourceWParking - Source

Name: Show name Ignore

Arrivals defined by:

Arrival rate:

Set agent parameters from DB:

Multiple agents per arrival:

Limited number of arrivals:

Location of arrival:

Node:

Speed:

Agent

Advanced

Custom time of start:

Add agents to: default population custom population

Forced pushing:

Actions

On before arrival:

On at exit:

On exit:

```
if ( regionClosedArea.isVisible() )
agent.moveToNearestAgent(collectionParking1);
else
agent.moveToNearestAgent(collectionParking)
```

Walkability of Urban Environment

Downtown University



Downtown Gas Station



Downtown Green Spaces



Downtown Misc Commercial Private



Downtown Bus Stations



Downtown Bike Parking



Downtown Parking



Downtown Hotels



Downtown Church



Downtown Stoplight Intersections



Downtown Restaurants and Bars



Downtown Apartments



Downtown Misc Federal State

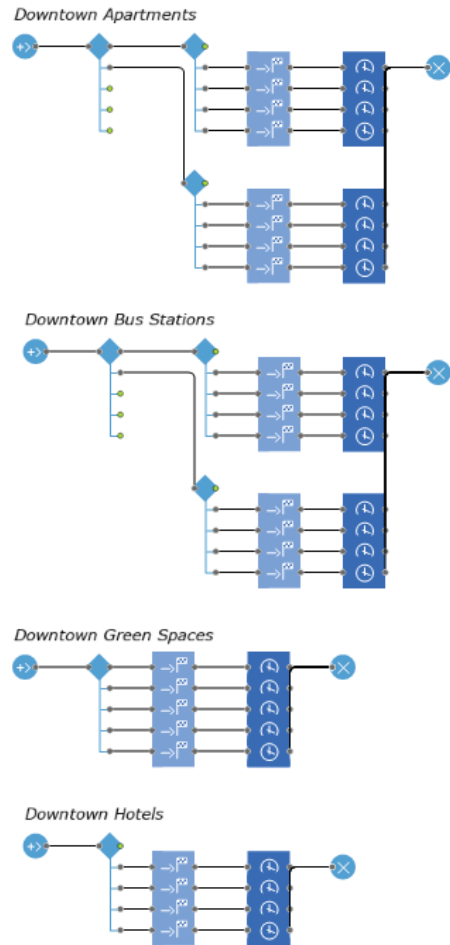


Downtown Misc Commercial Public

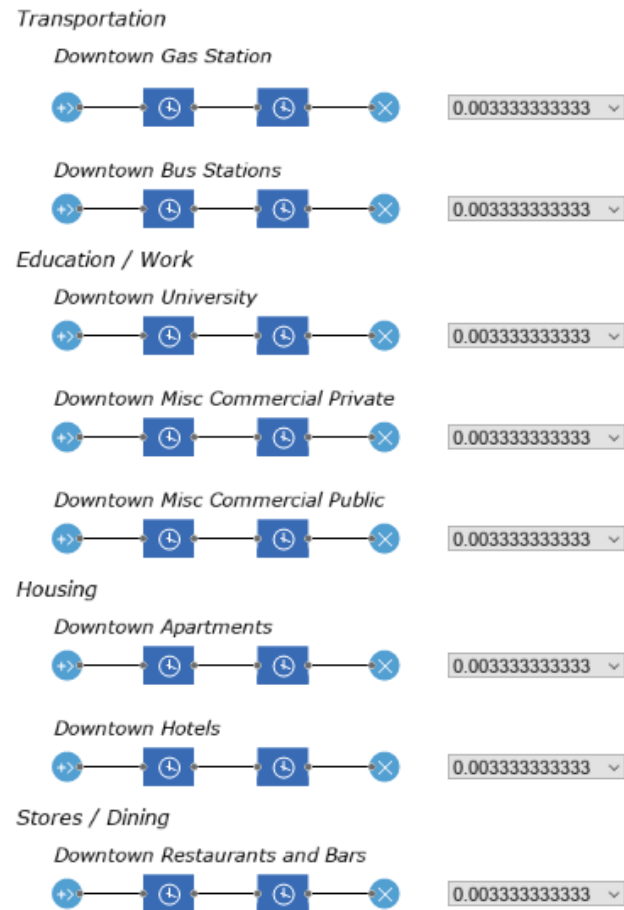


Logic: Structure

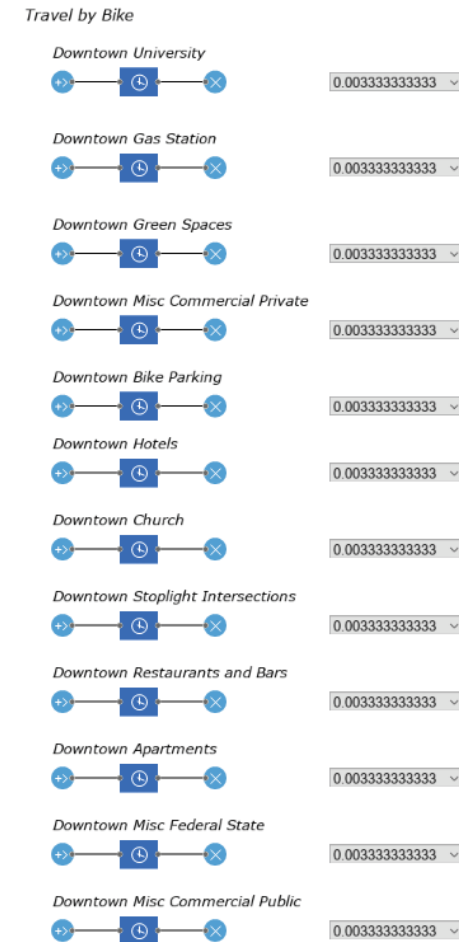
Accessibility of Amenities (cont)



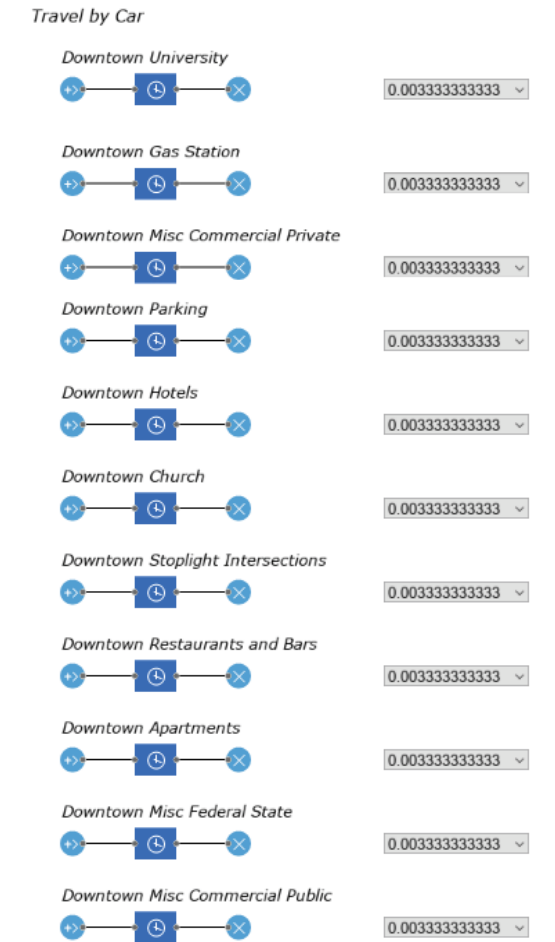
Accessibility of Amenities



Alternate Means of Travel (Bike)



Alternate Means of Travel (Car)



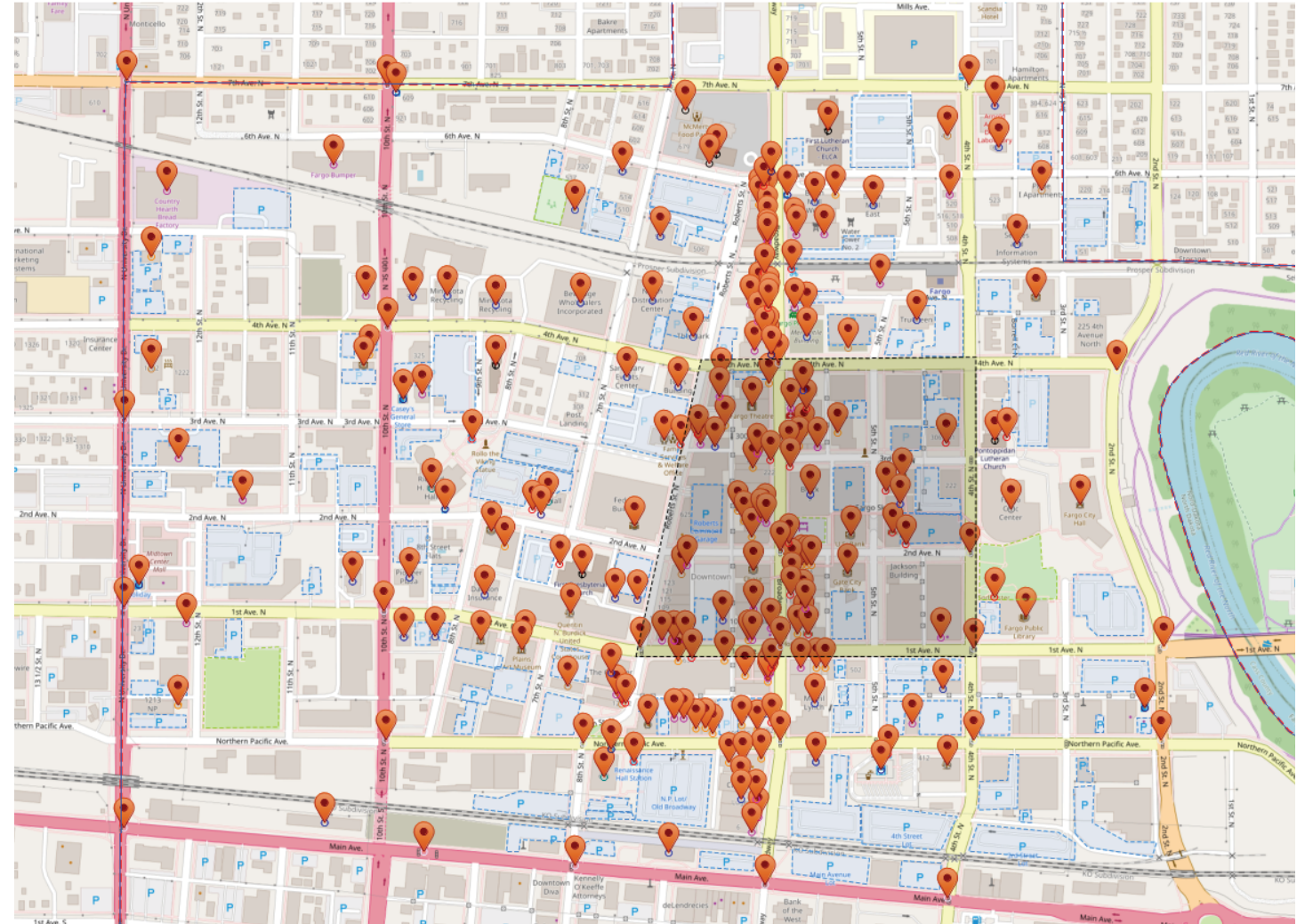
Results: Conclusions

By examining multiple pedestrian simulations, the model during simulation exhibits plenty of movement in the downtown area. In addition, these studies were documented through a dataset that could record the pedestrians' movement and travel distance. Through this data, diagrams can be created to dictate the walkability or efficiency of the urban area. In this case, downtown Fargo meets expectations of a walkable urban environment while also providing accessible alternate means of transportation.

block_type	block	activity_type	mean (seconds)	total (seconds)	min (seconds)	max (seconds)
MoveTo	destination46NorthPints	MOVE	131.5287336	30120.08	100.687	165.552
MoveTo	destinationBarryHall	MOVE	167.7798768	35401.554	102.594	276.938
MoveTo	destinationBeerAndFishCompany	MOVE	49.50198333	11880.476	4.465	171.758
MoveTo	destinationBernBaums	MOVE	75.30973636	16568.142	30.03	110.041
MoveTo	destinationBismarckTavern	MOVE	109.9269327	22864.802	35.763	221.943
MoveTo	destinationBlackBirdWoodFirePizza	MOVE	80.29126471	16379.418	17.512	148.04
MoveTo	destinationBlackCoffeeAndWaffleBar	MOVE	226.1117214	45448.456	8.716	359.631
MoveTo	destinationBossPizzaAndChicken	MOVE	52.58664352	11358.715	6.751	183.719
MoveTo	destinationChubsPub	MOVE	520.0352098	116487.887	322.428	607.376
MoveTo	destinationCowboyJacks	MOVE	93.7794901	18943.457	35.763	257.706
MoveTo	destinationDempseys	MOVE	46.93623853	10232.1	5.209	176.968
MoveTo	destinationDistrict64	MOVE	90.93590871	21915.554	31.118	134.567
MoveTo	destinationDrunkenNoodle	MOVE	116.8180221	26400.873	16.743	321.845
MoveTo	destinationEmpireTavern	MOVE	120.999379	26498.864	16.743	305.101
MoveTo	destinationFargoCivicCenter	MOVE	207.0845799	45351.523	199.94	215.54
MoveTo	destinationFargoTheatre	MOVE	83.79044976	17512.204	17.139	141.798
MoveTo	destinationFirstLutheranChurch	MOVE	276.3427281	59966.372	221.942	321.845
MoveTo	destinationFortNoks	MOVE	96.32476623	22251.021	40.631	137.431
MoveTo	destinationHavocHouse	MOVE	47.69737383	10207.238	4.465	167.293
MoveTo	destinationKlailHall	MOVE	113.4612511	26663.394	40.57	174.344
MoveTo	destinationLittleBrother	MOVE	525.4494578	87224.61	484.605	562.041
MoveTo	destinationMezzaluna	MOVE	97.98695455	21557.13	17.139	158.937
MoveTo	destinationNoBullSmokehouse	MOVE	125.079657	30269.277	40.631	178.063
MoveTo	destinationOldBroadway	MOVE	151.549608	30158.372	46.762	289.891
MoveTo	destinationParadoxEventCenter	MOVE	272.1477917	52252.376	171.962	397.843
MoveTo	destinationPhoDLicious	MOVE	141.3803211	26862.261	46.762	243.129
MoveTo	destinationPixedBrewing	MOVE	298.7729686	66626.372	15.12	598.95
MoveTo	destinationPlainsArtMuseum	MOVE	171.5644974	33455.077	91.759	306.673
MoveTo	destinationPokeBowl	MOVE	246.1937903	61056.06	8.716	368.348
MoveTo	destinationPounds	MOVE	218.3096221	47373.188	107.953	397.843
MoveTo	destinationProofArtisanDistillers	MOVE	174.9816283	39545.848	167.292	183.719
MoveTo	destinationRenaissanceHall	MOVE	173.2403143	36380.466	126.629	240.618
MoveTo	destinationRootersBar	MOVE	285.3479028	61635.147	78.761	484.606
MoveTo	destinationRoughCutSocial	MOVE	278.2902454	60110.693	15.12	607.376
MoveTo	destinationSanctuaryEventsCenter	MOVE	238.4113767	51258.446	174.343	306.673
MoveTo	destinationSidestreetBarAndGrill	MOVE	243.7979778	54854.545	8.608	368.348
MoveTo	destinationSonsOfNorway	MOVE	108.1000846	21728.117	40.57	214.913
MoveTo	destinationSpicyPie	MOVE	70.97478505	15188.604	30.03	113.219
MoveTo	destinationSportsBar	MOVE	115.2405556	26966.29	31.118	165.685
MoveTo	destinationStoneEventCenter	MOVE	287.0056887	60845.206	38.835	524.667
MoveTo	destinationTacoShop	MOVE	522.1213846	74663.358	484.605	562.041
MoveTo	destinationTeddysEateryAndParlor	MOVE	88.69741558	20489.103	17.512	165.552
MoveTo	destinationTheBoilerRoom	MOVE	90.95609048	19100.779	47.4	112.266
MoveTo	destinationTheFourAndFour	MOVE	230.9032747	53800.463	8.608	359.739
MoveTo	destinationTheNorthernGentlemansClub	MOVE	477.6596364	105085.12	322.428	537.389
MoveTo	destinationTheToastedFrog	MOVE	108.6904554	24346.662	45.717	158.937
MoveTo	destinationVFW	MOVE	65.31787665	14827.158	47.352	100.688
MoveTo	destinationVinyITaco	MOVE	138.6062949	30077.566	104.558	178.063
MoveTo	destinationWildTerraCider	MOVE	344.3388263	73344.17	78.943	537.389
MoveTo	destinationWurstBierHall	MOVE	307.4290087	71016.101	38.835	562.041

Results: Moving Forward

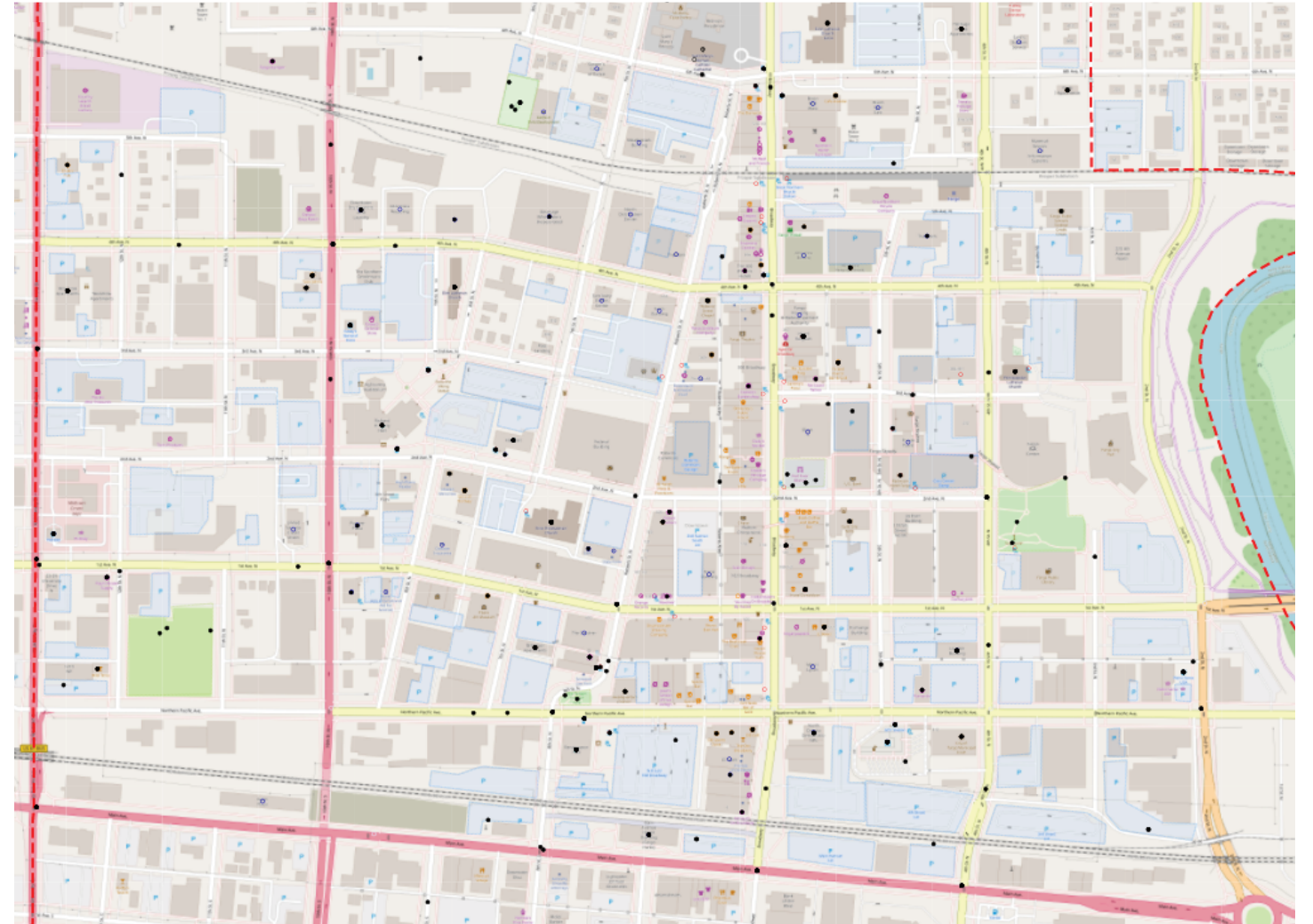
Real world uses such as showing the distance to necessary or common building types are important to show the walkability of urban environments. While the models only simulate the downtown Fargo area, future models could perhaps simulate an entire city. This would result in a more advanced and accurate model.



Results: Simulation

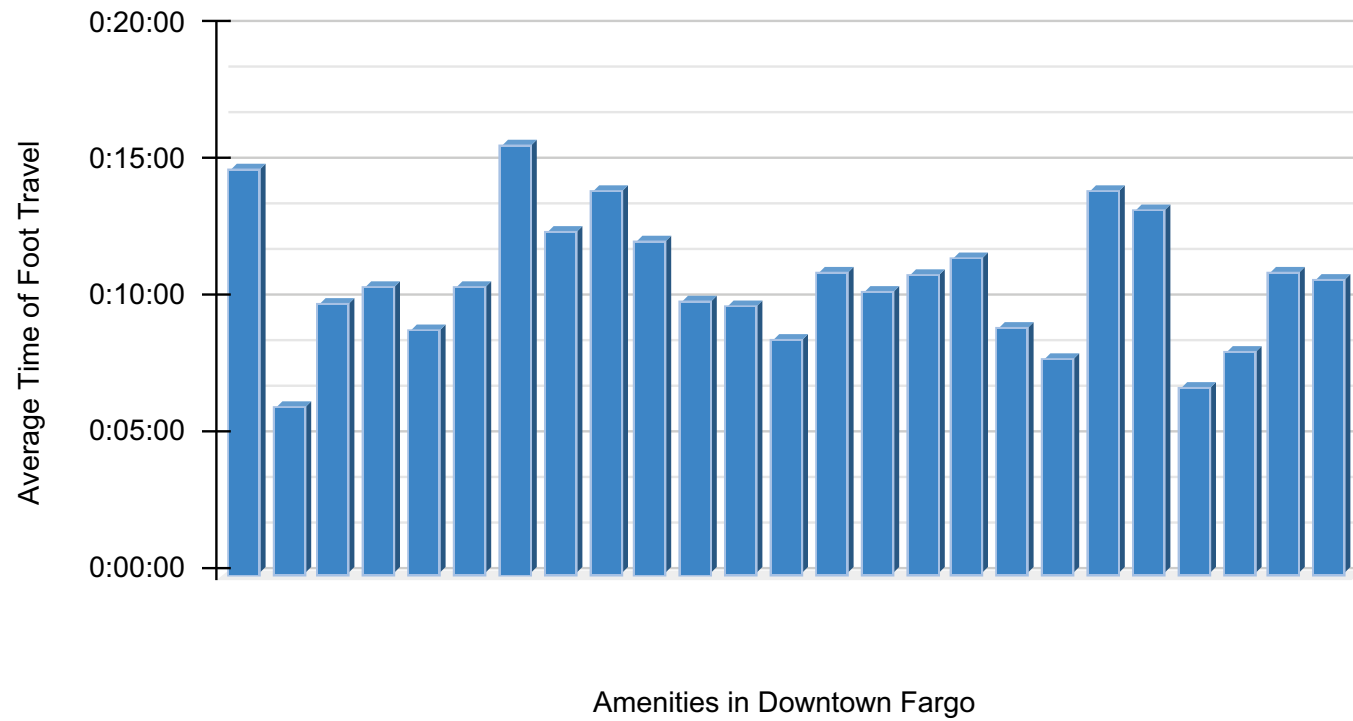
Using GIS integration with AnyLogic provided accurate locations and distances which helped with overall organization and efficiency.

However, new city designs can still use this workflow, but sidewalks, roads, and buildings would have to be modeled from the ground up.

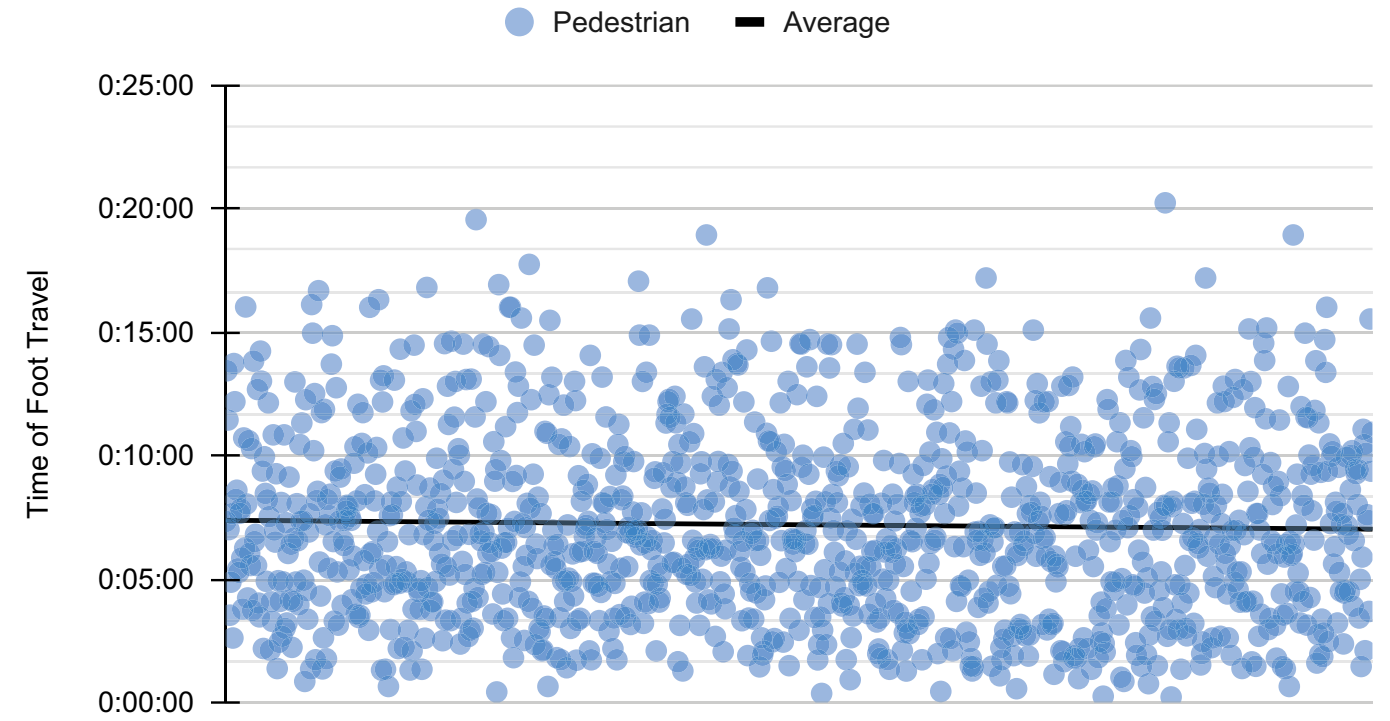


Results: Accessibility of Amenities

Accessibility of Amenities in Downtown Fargo

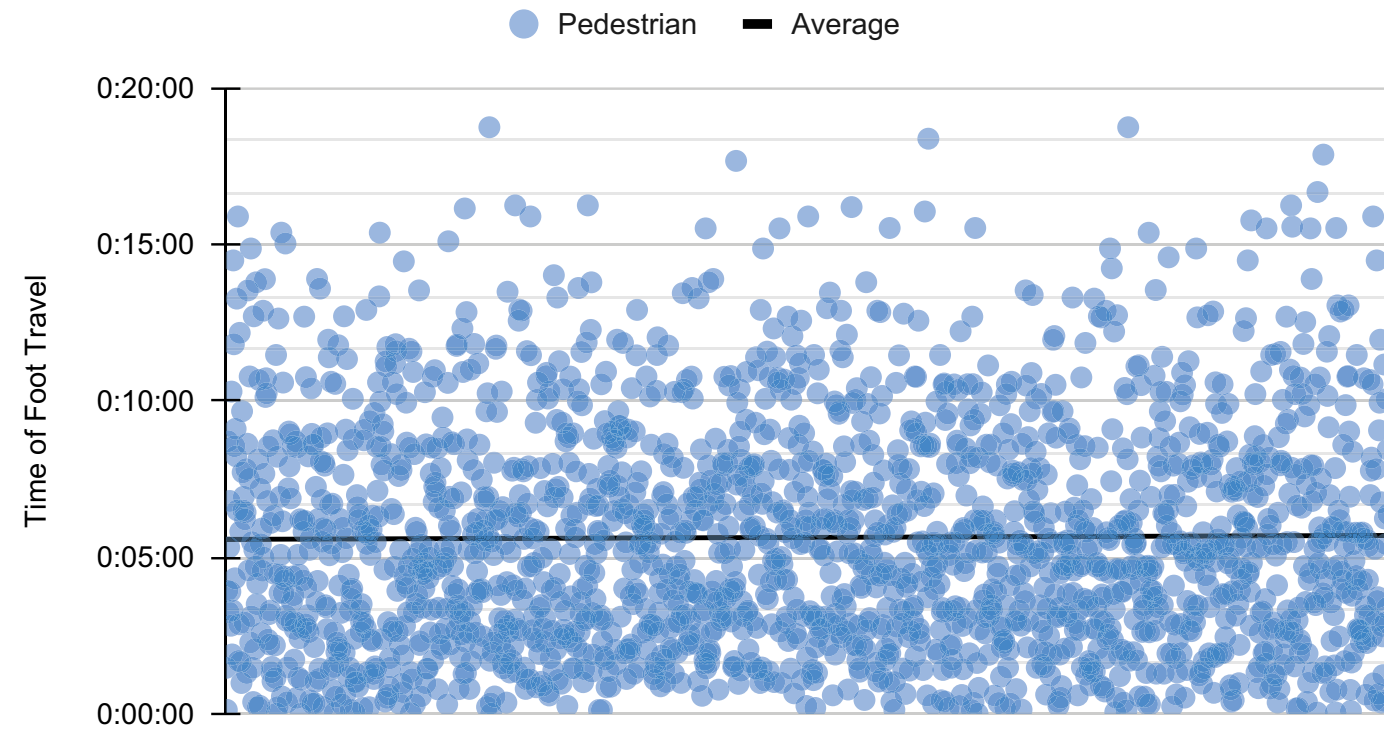


Accessibility of Amenities in Downtown Fargo

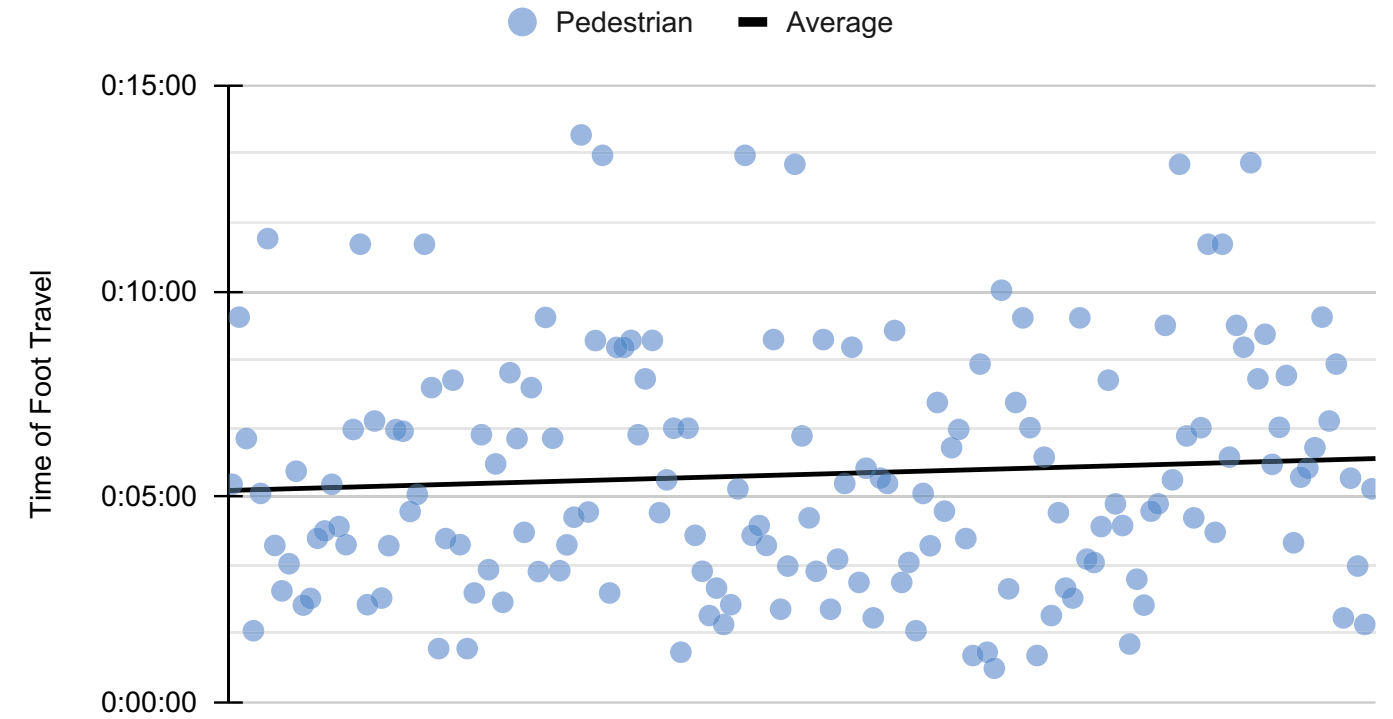


Results: Foot Travel

Foot Travel in Downtown Fargo

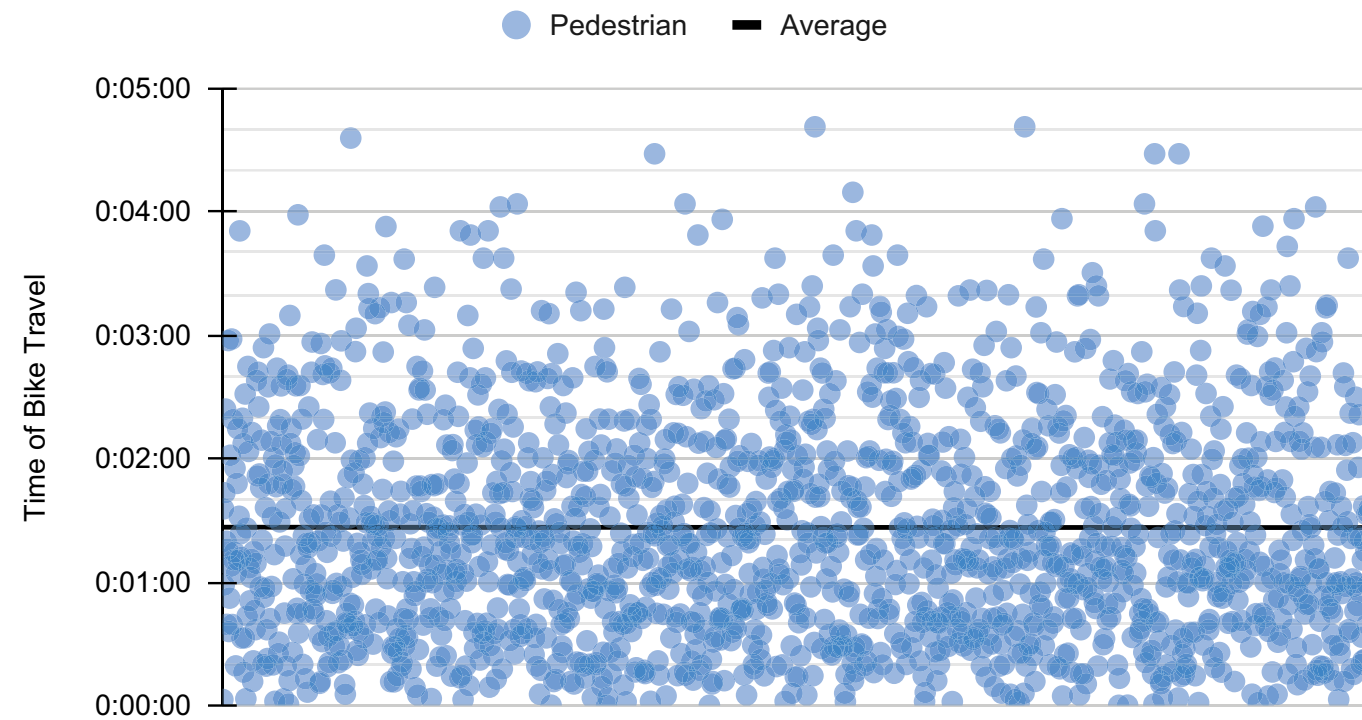


Foot Travel to a Bus Station in Downtown Fargo

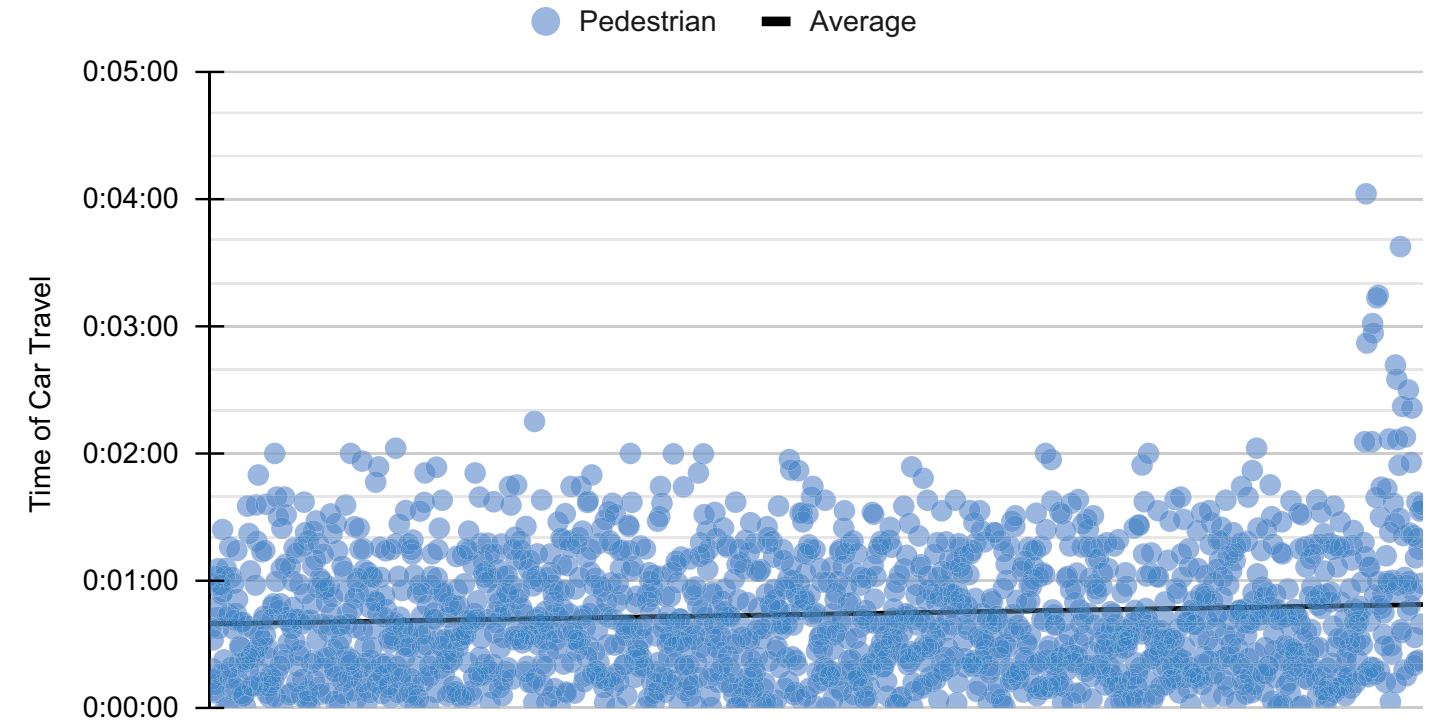


Results - Alternate Means of Travel

Bike Travel in Downtown Fargo



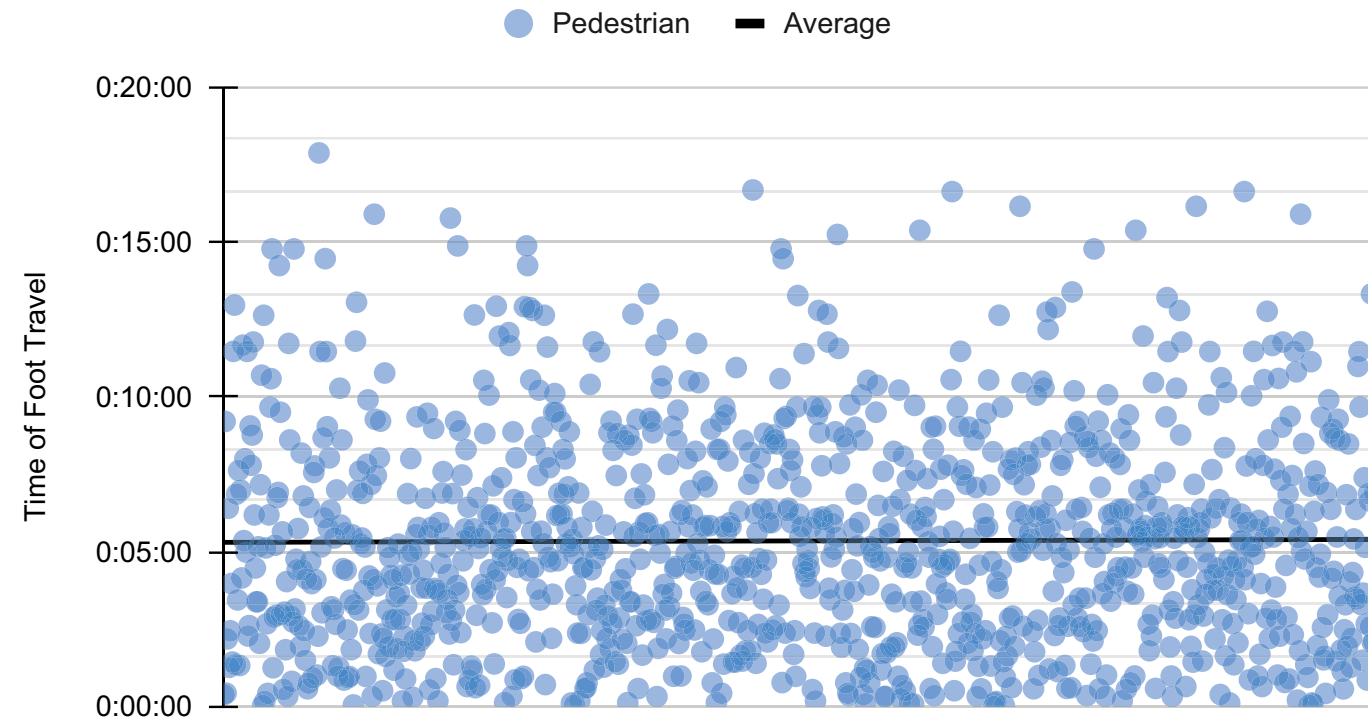
Car Travel in Downtown Fargo



*Current results do not consider real world circumstances such as traffic congestions or waiting at intersections.

Results: Event-Based Foot Travel

Foot Travel in Downtown Fargo - Event



Foot Travel in Downtown Fargo - No Event

