Smart Multi-modal Transportation Solutions for North Huntingdon Township in Response to Roadway Construction Projects on Route-30

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Smart Multi-modal Transportation Solutions for North Huntingdon Township in Response to Roadway Construction Projects on Route-30

Submitted to Smart Mobility Challenge with North Huntingdon Township

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Executive Summary

U.S. Route 30 (US30) in the North Huntingdon Township (NHT) serves as a main commercial corridor as well as a regional arterial. Part of a growing area, there are significant challenges in regards to congestion, safety, travel demand and mobility. There is a great need to provide a holistic mobility solution including driving, transit usage, park-and-ride lots, and existing and projected land use development. PennDOT is well into the design phase for a redesign and rebuild of US30 to include major utility relocations, drainage, and alignment redesign that will create significant construction-related congestion for multiple years so that a multi-modal plan for construction, as well as long term operations, can and should be incorporated into the multi-year construction project.

This research project conducts an in-depth analysis of the potential traffic impact of the US30 project to the North Huntingdon Township (NHT) and its proximity areas in high temporal and spatial resolutions, utilizing a data-driven dynamic network model developed by CMU's Mobility Data Analytics Center (MAC). Using the multi-modal data collected in the Southwestern Pennsylvania region, we simulate individual cars and trucks in the region including those travel through or near the NHT area. Each of those vehicles is simulated with their respective route choice and travel time through the region. The result includes system-level performance metrics, such as travel time, travel delay, vehicle-mile-traveled (VMT) and emissions, as well as delay/VMT for each road segment and intersection in the area by time of day. The established model can predict the impact on traffic conditions due to the near-future US30 construction projects, and potential traffic management strategies are further evaluated. The overall findings are,

- US30 construction projects will increase the average delay by around ***0.5 min per intersection***, accounting for ***15%~20% delay increase in the NHT area***. (Using Phase A as example, AM peak: in all 1.7 mins to 2.2mins in the NHT area; PM peak: in all 2.4 mins to 2.9 mins in the NHT area)
- <u>AM peak:</u>
  - ❑ ***Lincoln Way and 993*** are heavily impacted during phases A and B
  - ❑ ***Local neighborhoods*** are heavily impacted during phases C and D
- <u>PM peak:</u>
  - ❑ ***Lincoln Way and 993*** are heavily impacted throughout the course of the construction period.
  - ❑ ***Local neighborhoods*** are heavily impacted during phases C and D
- The following strategies would share similar effects on effectively mitigating the impact of US30 construction project:
  - ❑ Increasing ***10% adaptive travelers.***
  - ❑ Allowing ***5% travelers to work from home.***
  - ❑ Allowing ***10~15% travelers to have flexible working hours.***
  - ❑ Increasing ***50%~100% transit usage.***

- ❑ Allowing ***5~10% travelers to have flexible working hours*** and increasing ***5% more adaptive travelers.***

- Scenarios that should be avoided:
  - ❑ ***Little information provision and fewer travelers who are adaptive to real-time traffic.*** (up to 50% delay increase)

Based on findings, we suggest the followings,

- North Huntingdon township could work with PennDOT to adjust the traffic signal timing along US30 to avoid extra delays caused by detour demands during the US30 project.
- Turning movements at all intersections along US-30 will be hindered during the construction period. It is suggested to particularly analyze the turning phases of traffic signals and adjust them accordingly in order to alleviate bottlenecks. The adjustment will largely depend on the work zone settings. In particular, it is suggested to construct jughandles for improving access to any intersection side street first as it will assist as construction alternate route and help with congestion mitigation.
- NHT could use real-time traffic information, such as INRIX traffic speed (available to SPC and PennDOT) and traffic surveillance cameras, in order to adjust the signal timings or adopt other real-time traffic control strategies.
- NHT could take measures of better information provision to regional commuters (including local residents) to increase the number of drivers who are adaptive to real-time traffic during the US30 construction, as it appears the most cost-effective management strategies in mitigating the impact of the US30 construction projects. Related measures include, but are not limited to, building a real-time information dissemination webpage with all construction and traffic information updated on a regular basis, media campaign of congestion implications of construction projects, and handing out flyers to inform the community of the construction projects ahead of time. In particular, it is suggested to use dynamic message signs (DMS) to help travelers detour towards 993 and Lincoln Way.
- It is also suggested to encourage people to work from home or commute during flexible hours. Because many regular workers have just experienced working from home during the recent outbreak of COVID-19, this management strategy may become much easier to implement than before.
- During the course of the entire US30 construction project, Lincoln Way and 993 are heavily impacted and utilized. Because both roads are one-lane, it is strongly suggested to avoid any concurrent construction projects or events along those roads. Due to the high traffic volumes on both roads, the risks of car crashes may be high, and the resulted traffic congestion is likely severe during peak hours. Public agencies need to prepare for quick responses to any anomalies on those essential roads during the US30 construction project.
- This study does not model the congestion impact by unplanned incidents during US30 construction projects. It is projected that the increased congestion would be more pronounced under incidents in the NHT area, particularly along those alternative routes to the US-30. It is suggested to study Traffic Incident Management for the region and coordinate among relevant stakeholders.

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1. Introduction

1.1 Project background

U.S. Route 30 (US30) in the North Huntingdon Township serves as a main commercial corridor as well as a regional arterial. Part of a growing area, there are significant challenges in regards to congestion, safety, travel demand and mobility. There is a great need to provide a holistic mobility solution including driving, transit usage, park and ride lots, and existing and projected land use development. This corridor offers all the challenges to developing a transportation corridor multi-modal plan. In addition, PennDOT is well into the design phase for a redesign and rebuild of US30 to include major utility relocations, drainage, and alignment redesign that will create significant construction-related congestion for multiple years so that a multi-modal plan for construction, as well as long term operations, can and should be incorporated into the multi-year construction project.

This research project conducts an in-depth analysis of the potential traffic impact of the US30 project to the North Huntingdon Township (NHT) and its proximity areas in high temporal and spatial resolutions. Using the data collected in the previous US30 project and other relevant data sets possessed by CMU's Mobility Data Analytics Center (MAC), we simulate individual cars and trucks in the Southwestern Pennsylvania Commission (SPC) region, and model their route choices, travel times and other network performance metrics. The result includes the travel time, travel delay, vehicle-mile-traveled (VMT) and emissions for each road segment and intersection in the area by time of day. The established model could predict the impact on traffic conditions due to near-future US30 projects, and various management strategies are evaluated to effectively mitigate the impact.

1.2 Tasks

This project is divided into three major tasks.

- *<u>Task 1: Identify various data sources for in-depth data analytics</u>*

The following data are collected, processed, and integrated for network modeling and further analysis:

  - Network data (GIS model) for the SPC region
  - Traffic volume data for the SPC region
  - Traffic speed data for the SPC region
  - Project information
  - Transit and park-and-ride usage data

- *<u>Task 2: Establishing a dynamic network model for the North Huntingdon Township Region</u>*

We use mesoscopic traffic flow models to conduct this research task. We develop a dynamic network model that provides estimated day-to-day origin-destination demand among all Traffic Analysis Zones (TAZs) that vary by time of day. The route choices and modal choices for all travelers in the region are examined and carefully calibrated using data sets collected in Task 1. The network model is capable of estimating network-wide traffic impact caused by any incident based upon a generic regional network consisting of freeway and major arterials. It has the capacity to model dynamic traffic evolution with the consideration of real-time travel control and traffic demand management. It adopts state-of-the-art traffic models and is much more computationally efficient than other microscopic models that are extremely labor-intensive to build.

The regional network, together with construction plans for Route 30, is then coded into the dynamic network model. Baseline travel demand is estimated in the first place using the integrated traffic data on typical weekdays without the presence of construction projects (nor unplanned incidents).

In addition, the overall traffic impact for each scenario can be measured by time-of-day traffic evolution in the region, as well as performance metrics, such as total traffic delay, average travel time, emissions, energy use, vehicle-miles traveled, and so on.

- *Task 3: Modeling construction projects and multi-modal solutions to mitigate impacts*

The scenarios of roadway closures will be modeled based on the calibrated regional network model. The simulation adopts the historical traffic demand and their pre-scribed route/modal choices from the dynamic network model built in Task 2.

For each of the scenarios, we propose a holistic traffic management solution to mitigate the impact of construction projects. The management plans include traffic detour plans, encouraging to work from home on major intersections, encouraging to have flexible working time, and public transit solutions.

2. Data Collection and Pre-processing

In this section, we describe the data sources used in this project, which includes network topological data, traffic counts and speed data, transit data. In the following sections, we briefly discuss their formats and contents.

2.1 Network description

The network topological data is provided by the Southwestern Pennsylvania Commission (SPC), and it covers ten counties in the southwestern Pennsylvania region with the Pittsburgh city in the central area, as shown in Figure 1. The network model contains 16,144 road segments, 6,317 intersections, and 290 traffic analysis zones (TAZs). We trim the network such that there are no isolated nodes and links. The isolated nodes and links represent the parkways in the real-world, and the absence of such nodes and links does not affect the network analysis. We further consolidated neighboring links with small lengths and the same speed limit. This process substantially reduced the network scale. More importantly, network consolidation has great potential in improving the accuracy of the network analysis.

Among TAZs, we consider 14,084 OD pairs. The considered OD pairs are either in the NHT areas or 9,000 meters apart, which indicates that we only consider the long-distance commute travel demand in this project.

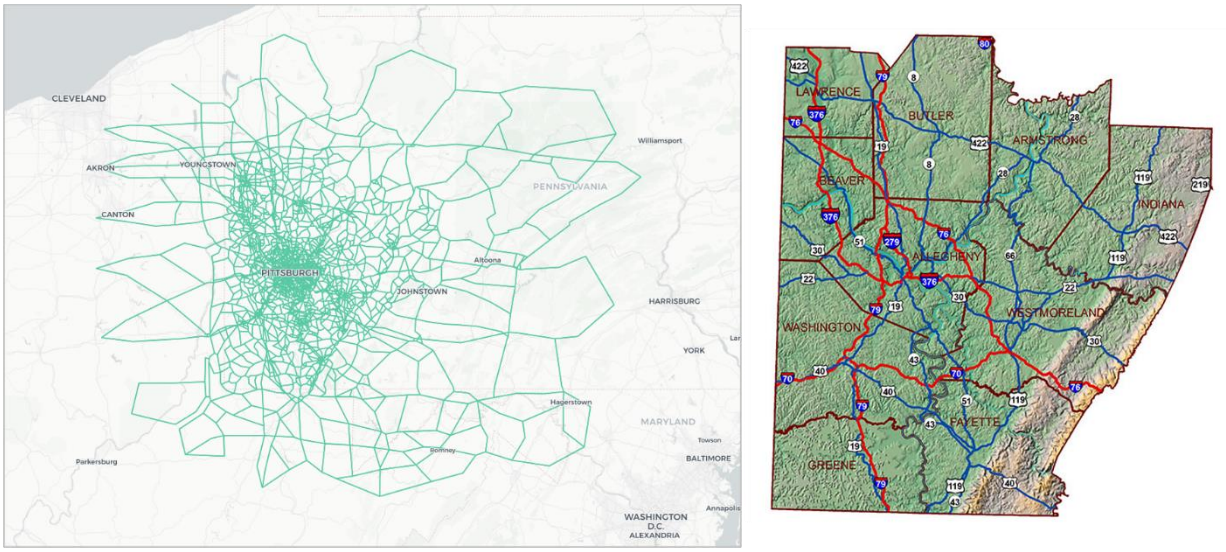


Figure 1 An overview of the SPC network.

For the North Huntingdon Township (NHT) and its surrounding areas, we further refine the model by adding local roads and verifying the number of lanes, road lengths, and speed limits. Figure 2 highlights the NHT area and US30.

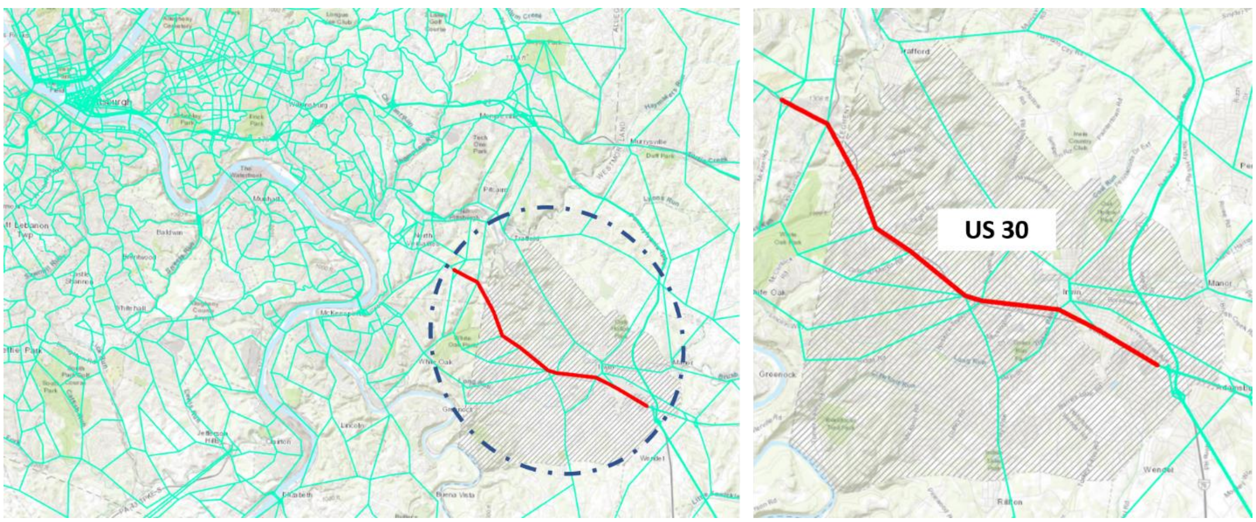


Figure 2 An overview of the NHT area and US30.

2.2 Traffic counts

Traffic count data indicate the vehicle counts passing by a certain location, and it is usually collected by loop detectors, tubes or manual counting. In this project, two data sources are utilized: 1) Pennsylvania Department of Transportation (PennDOT) hourly counts data; 2) US30 – North Huntingdon Township SINC-UP project.

2.2.1 PennDOT traffic count

The PennDOT count data contains hourly traffic volume count for one day at selected locations on state routes in Pennsylvania. Different vehicle types: cars and trucks, are counted separately in the data. All traffic counts are measured in hours, and we impute and smooth the data into 15-

min intervals. In total, there are 1,430 locations with valid car and truck volumes, as shown in Figure 3.

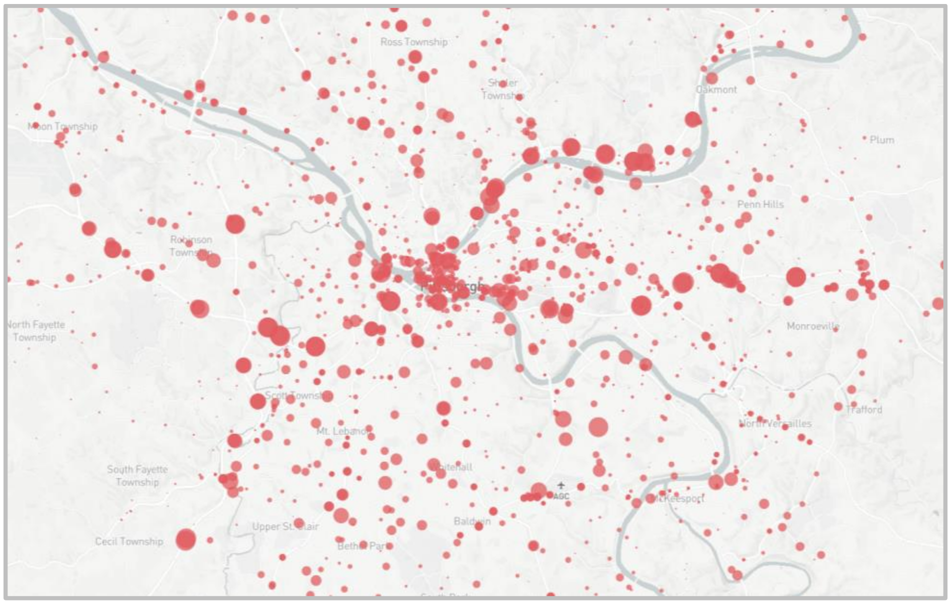


Figure 3 An overview of the PennDOT traffic count locations.

2.2.2 SINC-UP project

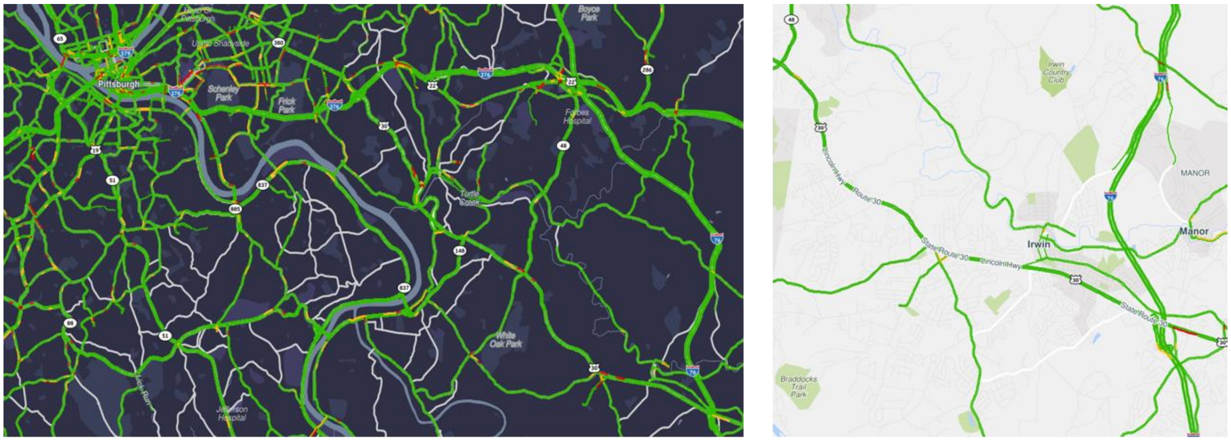
The SINC-UP project provides the traffic counts data collected through Automatic Traffic Recorder (ATR) and video intersection turning movement counts (TMCs). Vehicle types are not differentiated in the data. All traffic counts are measured in hours, and we smooth the data into 15-min intervals. An example of the TMC data is presented in Table 1.

Table 1 An example of the turning movement data.

Start Time	**US30 EB**				**US30 WB**				
	Left	Thru	Right	Total	Left	Thru	Right	Total	Total
07:15AM	6	215	1	222	2	284	15	301	569
07:30AM	6	255	2	263	1	293	5	299	630
07:45AM	11	245	1	257	0	275	11	286	597
08:00AM	4	242	1	247	0	241	1	242	538

2.3 Traffic speeds

Traffic speed data is obtained from INRIX for year 2016. Speeds of different vehicle types are measured separately, and hence both passenger car speeds and freight truck speeds are available. All the speed data is measured for every 5-minutes of each day, and we average the data for different days in 2016 and aggregate the data to 15-min intervals. There are totally 945 locations with valid car and truck speed measurements, as shown in Figure 4. Figure 4(a) represents the speed data for downtown Pittsburgh and NHT, and Figure 4(b) shows the speed data in NHT.



(a) Downtown Pittsburgh and NHT (b) NHT

Figure 4 An overview of the speed data.

2.4 Transit data

The transit data is obtained from Westmoreland County Transit Authority (WCTA), which includes the ridership counts for all transit services passing through the NHT areas. The data was collected through manual counting in the year 2018, and the bus lines include 1-F, 3-F, 4, 4-S, and 6. For example, the ridership counts for 1-F in the morning peak are presented in Figure 5.

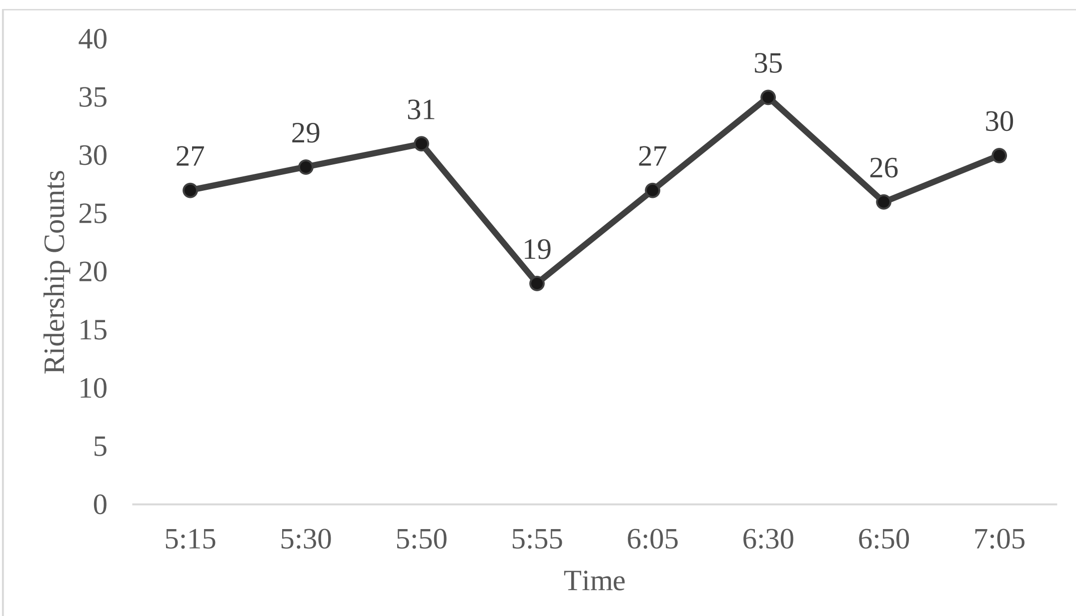


Figure 5 An overview of the ridership data.

3. Modeling Current Traffic Conditions

In this section, we describe the modeling efforts for traffic dynamics in the morning and afternoon peaks. We first briefly discuss the traffic simulation package used in this project, then we conduct the network calibration such that the traffic simulation replicates the real-world traffic.

3.1 Mesoscopic traffic simulation

In this project, we simulate the traffic dynamics in the region in high spatio-temporal resolutions. The regional model simulates millions of vehicles that depart from their respective origins, arrive at their destinations, and follow different routes. The CMU Mobility Data Analytics Center develops a dynamic network tool (MAC-POSTS) which is capable of simulating network-wide traffic dynamics for any general networks consisting of freeway, arterials and local streets (Ma, 2019). MAC-POSTS adopts the state-of-art mesoscopic traffic flow model and it can scale to regional level transportation networks. MAC-POSTS can be calibrated to replicate real-world traffic conditions and predict the impact of different traffic scenarios, such as work zones, events, and incidents.

In MAC-POSTS, we assume reasonable signal timing plans are adjusted for different traffic scenarios, and travelers are insensitive to the I-76 toll given the study scope of NHT. The recurrent and stabilized traffic conditions are considered in MAC-POSTS, while the non-recurrent events such as crashes are not considered.

Both AM peak hours (5:00 AM - 12:00 PM) and PM peak hours (2:00 PM - 8:00 PM) are considered for simulation. MAC-POSTS simulates movements of all vehicles in the studied network with high spatial (~50 meters) and temporal (5 seconds) resolution. As with the information provision, we assume 60% of travelers are adaptive to the traffic information, while 40% of travelers will stick to the pre-determined route when they travel.

3.2 Network calibration

In this section, we discuss the model calibration efforts using data collected in Task 1.

3.2.1 Overview

Before applied to practical applications, MAC-POSTS needs to be calibrated such that it approximately re-produces the actual traffic conditions. To this end, multiple data sources collected in Section 2 are used and a data-driven calibration framework is adopted to calibrate MAC-POSTS, as presented in Figure 6. The adopted framework estimates the time-dependent traffic demands and travelers' behaviors, which are the two critical inputs to MAC-POSTS, and the traffic conditions (e.g. traffic volumes, traffic speed, delays) outputted by MAC-POSTS can reflect the reality. To be precise, the performance of MAC-POSTS is measured by how well it can replicate the observed traffic data. Details of the calibration framework are omitted, and readers are referred to previous studies (Ma et al., 2019).

Figure 6 An overview of the network calibration.

The dynamic regional model MAC-POSTS is calibrated separately for AM peak and PM peak, and the following sub-sections discuss the calibration results separately.

3.2.2 AM peak

During the AM peak, around 0.4 million vehicles travel on the studied regional network. Traffic conditions on NHT areas are particularly calibrated to match the observed data. For example, Figure 7 presents the comparison between simulated traffic volumes and observed traffic volumes overtime on US-30. As can be seen, the simulated counts can perfectly replicate the observed counts, and hence the developed model is capable of generating the actual traffic conditions on US30 during the AM peak.

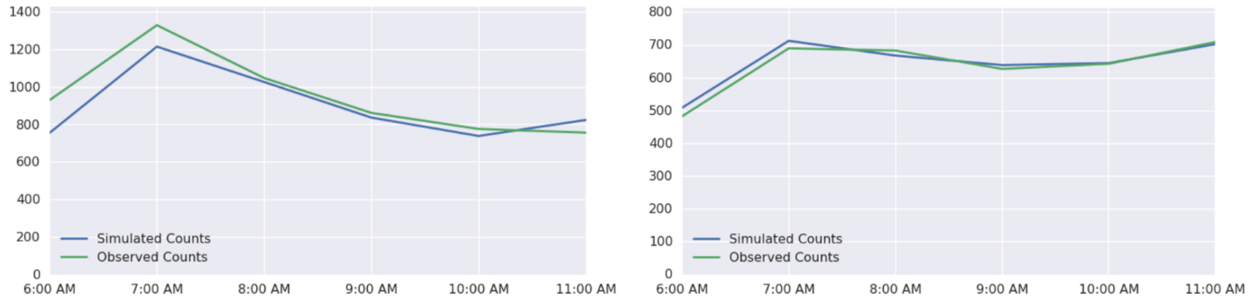


Figure 7 Traffic count calibration on US30 in AM peak.

The overall fitting of all the observed data in the studied SPC network is presented in Figure 8, in which the x-axis is the simulated counts and y-axis is the observed counts. One can see the data points are centered around the $x = y$ line, and the Pearson correlation coefficient is 0.86.

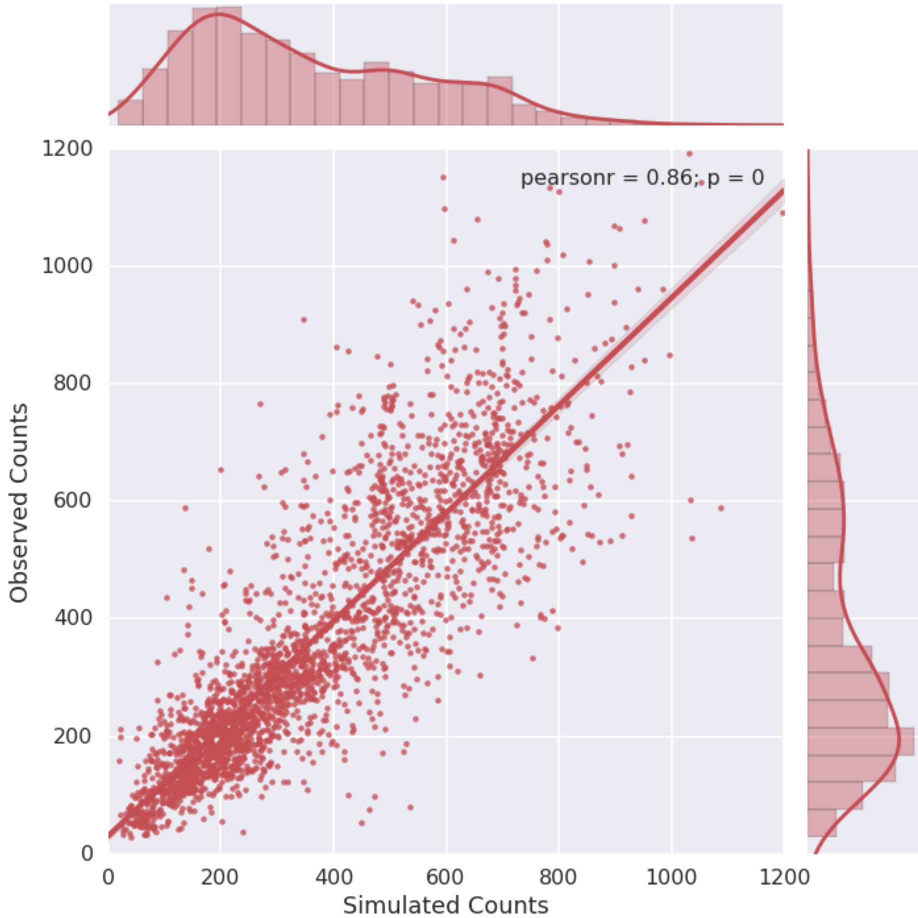


Figure 8 Overall count calibration in AM peak.

3.2.3 PM peak

During the PM peak, around 0.5 million vehicles travel on the studied network. Traffic conditions on the NHT areas are particularly calibrated to reflect real-world traffic. For example, the comparisons between the simulated counts and observed counts on US-30 during the PM peak is demonstrated in Figure 9.

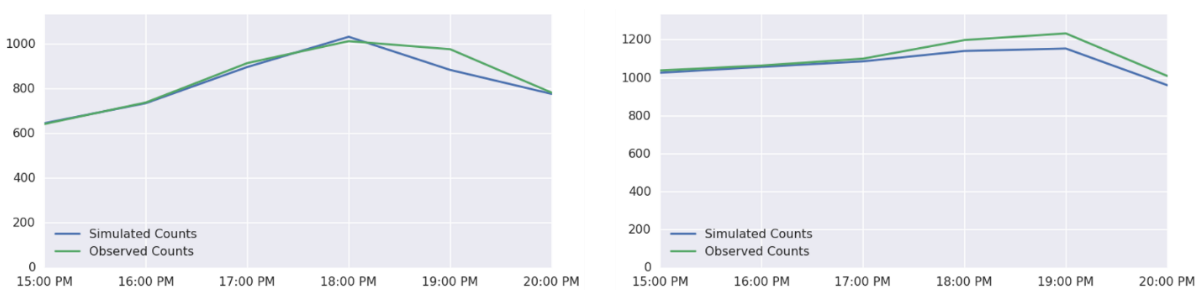


Figure 9 Traffic count calibration on US30 in PM peak.

Figure 10 demonstrates the overall comparisons between simulated and observed counts in the entire studied network. One can see the simulated counts replicate the observed counts well, and the Pearson correlation coefficient is 0.87.

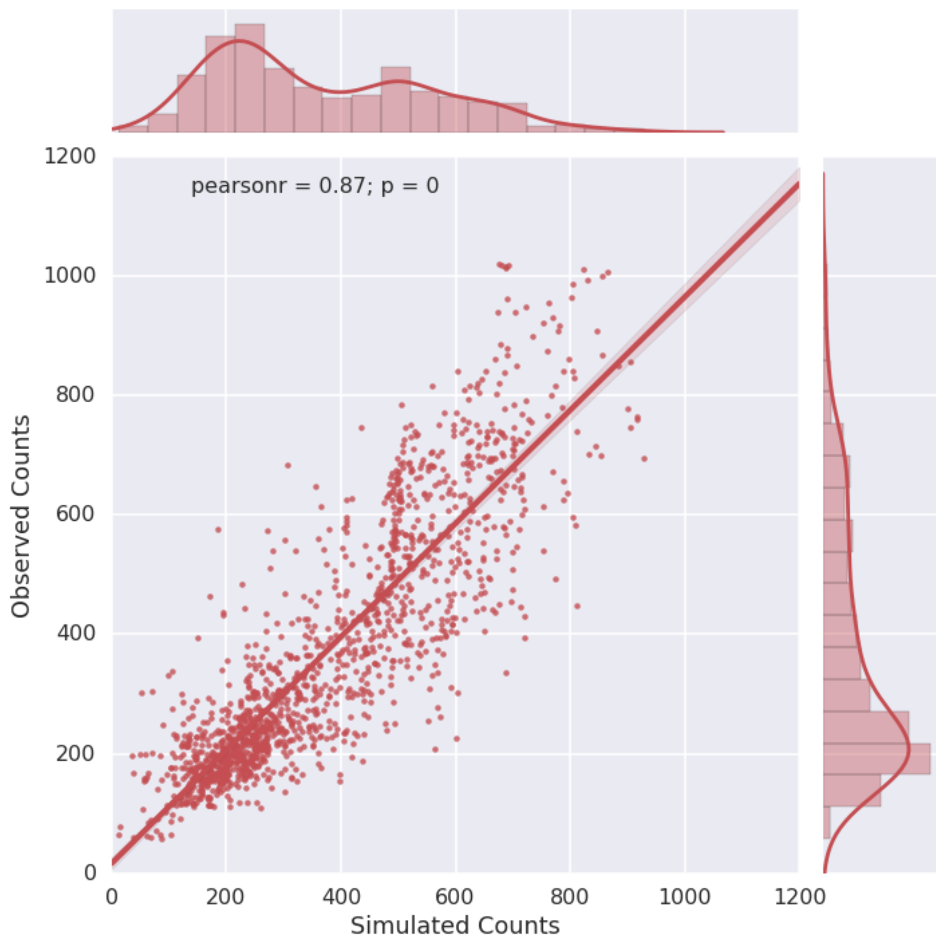


Figure 10 Overall count calibration in PM peak.

Calibration results for both the AM peak and PM peak indicate that the proposed regional model can accurately model the actual traffic dynamics in the whole SPC region, especially in the HNT areas.

4. Traffic Impact Analysis for US30 Construction Project

In this section, we conduct the traffic impact analysis for the future US30 construction project. We first describe the work zone settings in different phases of the US30 project, then the predicted traffic conditions during the US30 project are presented for both AM peak and PM peak.

4.1 Work zone settings

In the preliminary project plans, the US30 project will be divided into four phases, as presented in Figure 11. In Phase A, the construction site is around US30@Carpenter Ln; in Phase B, the construction site is around US30@Robbins Station Rd; in Phase C, the construction location is around US30@Buttermilk Hollow Rd; and in Phase D, the construction site is near US30@Oakmont St. The affected roads and intersections are matched in our regional model, as shown in Figure 12.

Figure 11 Locations of the four phases.

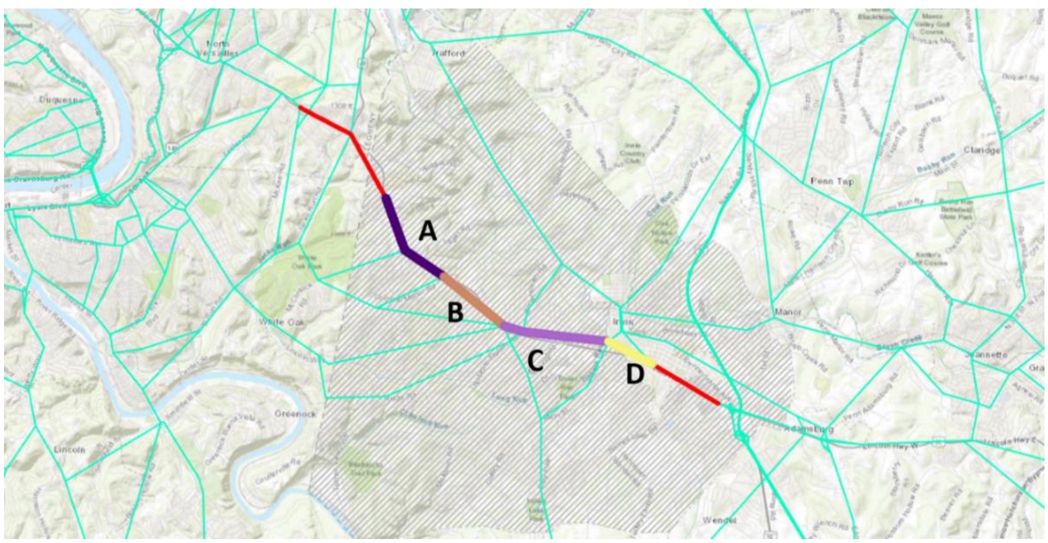


Figure 12 Work zone setups in MAC-POSTS.

Since the construction plans have not been finalized, assumptions need to be made about the work zone setups. We assume the construction will affect roads in both directions. US30 E/W is a two-lane road, and we assume one lane is closed during the construction. The other lane will endure a 10 MPH speed limit reduction and a 30% capacity reduction. The work zone settings are subject to change if the construction plan gets finalized, and the developed analytical framework in this project can quickly adapt to the changes.

In the following two sub-sections, we present the results of the traffic impact analysis of the four phases of US30 construction for AM and PM peaks, respectively.

4.2 AM peak

In this section, we discuss the traffic impact of four construction phases in the US30 project during the AM peak.

4.1.1 General metrics

We first present the aggregated traffic metrics within the NHT area, and the metrics include travel time, delays, Vehicle Miles Traveled (VMT) and emissions. Table 2 shows the metrics for the base case scenario and four construction phases. The base case represents the recurrent traffic scenario in which no construction project is conducted. To highlight the metric changes from basic scenario to different construction phases, we plot the heatmap of the percentage changes in Table 3. In each table, the average (total) travel time indicates the average (total) time spent within the NHT area, and the average delay represents the average waiting time at each intersection in the NHT area.

Table 2 General metrics in AM peak within the NHT area.

		Total vehicles	**Total travel time**	**Average travel time**	**Average delay**	**VMT**	**Fuel**	**CO2**	**CO**	**HC**	**NOX**
		#	hour	min	min	mile	Gallon	kg	Kg	kg	kg
Base	Car	23248.0	1685.5	4.3	***1.7***	64935.8	2077.6	18463.5	74.8	49.4	70.1
	Truck	382.6	27.6	4.3	2.1	1113.4	53.5	475.8	3.7	2.0	7.3
A	Car	22849.4	2240.6	5.9	***2.2***	65883.8	2161.3	19207.2	74.3	53.9	71.1
	Truck	368.6	36.4	5.9	2.5	1157.5	57.2	508.1	3.7	2.2	7.6
B	Car	23011.6	1940.2	5.1	***1.9***	64866.7	2094.6	18614.5	72.9	51.7	69.6
	Truck	369.2	31.6	5.1	2.3	1119.6	54.3	482.6	3.5	2.1	7.3
C	Car	21458.8	1639.6	4.6	***2.1***	59514.6	1912.0	16992.2	67.9	46.9	64.4
	Truck	357.2	27.6	4.6	2.3	1036.4	50.0	444.5	3.3	1.9	6.9
D	Car	22634.6	1861.2	4.9	***1.8***	64158.6	2076.7	18455.2	73.9	50.2	69.6
	Truck	365.0	29.1	4.8	2.0	1078.4	52.1	462.8	3.5	1.9	7.1

Table 3 Percentage change of general metrics in AM peak within the NHT area.

		Total vehicles	**Total travel time**	**Average travel time**	**Average delay**	**VMT**	**Fuel**	**CO2**	**CO**	**HC**	**NOX**
Base	Car	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Truck	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
A	Car	-1.7%	32.9%	35.3%	24.9%	1.5%	4.0%	4.0%	-0.7%	9.0%	1.4%
	Truck	-3.7%	32.1%	37.1%	21.8%	4.0%	6.8%	6.8%	1.1%	12.7%	4.2%
B	Car	-1.0%	15.1%	16.3%	9.1%	-0.1%	0.8%	0.8%	-2.5%	4.6%	-0.7%
	Truck	-3.5%	14.7%	18.8%	11.9%	0.6%	1.4%	1.4%	-3.9%	6.0%	0.0%
C	Car	-7.7%	-2.7%	5.4%	21.1%	-8.3%	-8.0%	-8.0%	-9.2%	-5.2%	-8.1%
	Truck	-6.6%	0.1%	7.2%	12.1%	-6.9%	-6.6%	-6.6%	-11.3%	-3.5%	-6.2%
D	Car	-2.6%	10.4%	13.4%	2.2%	-1.2%	0.0%	0.0%	-1.1%	1.6%	-0.6%
	Truck	-4.6%	5.5%	10.6%	-2.9%	-3.1%	-2.7%	-2.7%	-4.3%	-1.5%	-2.6%

As can be seen, the number of total vehicles appear in the NHT area during AM peak reduces, as a result of delay increase and adaptive detours. Both travel time and delay increase significantly during US30 project, especially in Phase A. The increase of travel time is attributed to two reasons: 1) traffic gets more congested due to the road capacity reduction; 2) travelers may choose a longer route to avoid congestion, while the increase of delay is largely attributed to the road capacity reductions. Hence, the percentage change of travel time is generally greataer than that of average delay. The emissions increase in Phase A because of the stop-and-go traffic, and the model predicts that emissions will drop in Phase C and D, probably due to the reduction of total vehicles within the NHT area.

4.1.2 Vehicle detours

This sub-section focuses on the primary vehicle detour routes due to the US30 construction, in order to help public agencies understand how the travelers' behavior changes during the construction. The accurate prediction of vehicle detours could help the general public understand the potential impact of US30 construction project on the neighborhood community in terms of safety, noise and air quality, it also enables the quick response and full preparations for public sectors to mitigate the impact. The four construction phases will be discussed separately. The traffic flow on all the roads without annotations does change significantly.

Phase A

In Phase A, capacities of roads and intersections around US30@Carpenter Ln will be affected. As a result, traffic volumes in US30 Westbound reduce. Three major detour routes will be utilized by travelers, as shown in Figure 13. The first route is through Lincoln Way, and the second route is through 993 Westbound. In the third route, drivers will follow the reverse direction of US30 and take I-76 Northbound. Note I-76 is a toll road, hence the usage of I-76 depends on travelers' sensitivity to tolls. The current model does not include the effect of tolls since the toll for a detoured trip may be minimal (e.g. $1), while the usage of I-76 will reduce if travelers are sensitive to road tolls. In that case, both Lincoln Way and 993 W are expected to attract more vehicles.

Phase B

In Phase B, roads and intersections around US30@Robbins Station Rd are affected. Similar to Phase A, vehicle volumes on US30 Westbound reduce since travelers tend to choose alternative routes to avoid congestions. There are primarily two alternative routes, the first one is through Lincoln Way and the other one is through 993 W. The detailed volume change and percentage change are presented in Figure 14.

Phase C

In Phase C, roads and intersections around US30@Buttermilk Hollow Rd are affected. Different from the detour patterns in Phase A and B, travelers tend to detour locally in Phase C. As shown in Figure 15, the traffic volume decreases by 15% on US30 Westbound, and travelers detour on a local road to avoid passing the construction site.

Phase D

In Phase D, the intersections and roads around US30@Oakmont St will be affected. Similar to Phase C, travelers tend to use local detours instead of 993 and Lincoln Way. As shown in Figure 16, traffic volume will increase by 124% on local roads around the construction site. We notice the traffic volumes on US30 when exiting the NHT area stay unchanged, which indicates the travelers return to US30 after taking the detour.

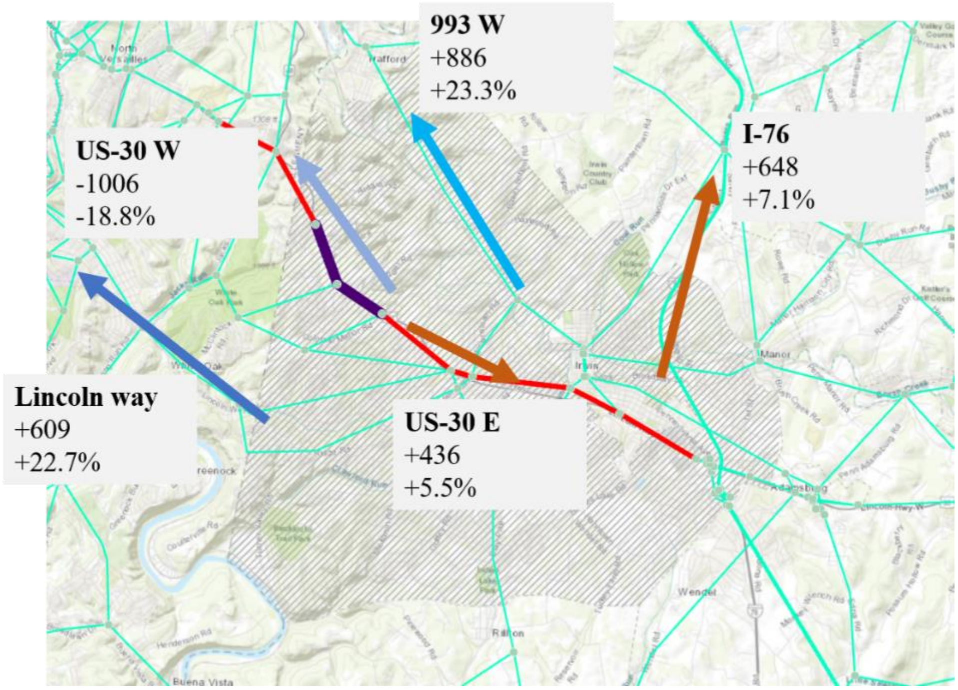


Figure 13 Vehicles detours in phase A during AM peak.

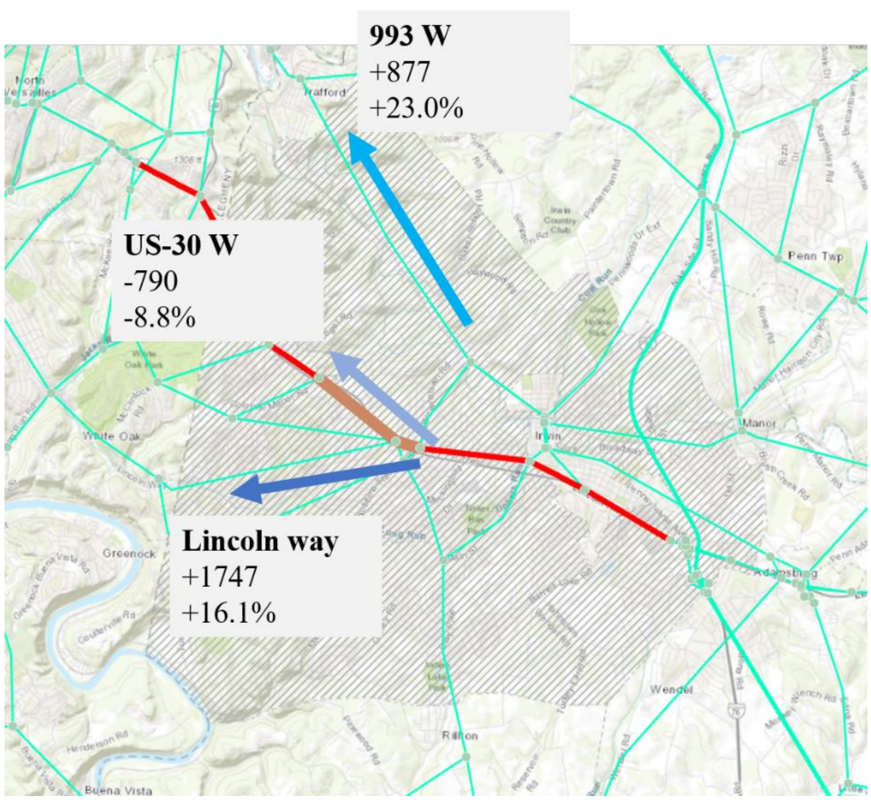


Figure 14 Vehicles detours in phase B during AM peak.

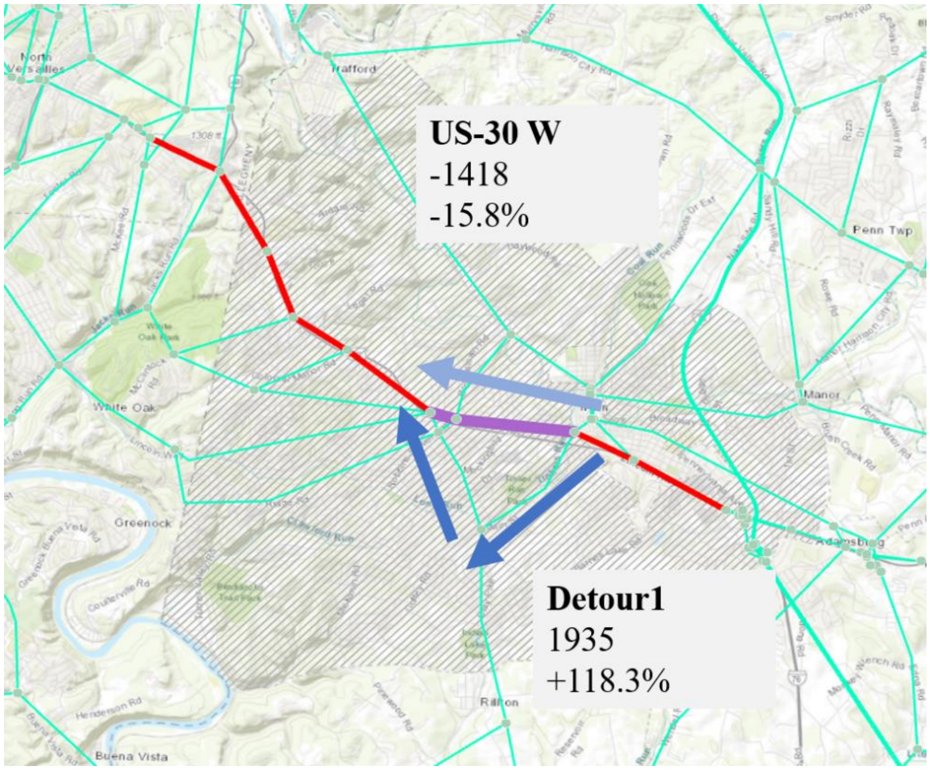


Figure 15 Vehicles detours in phase C during AM peak.

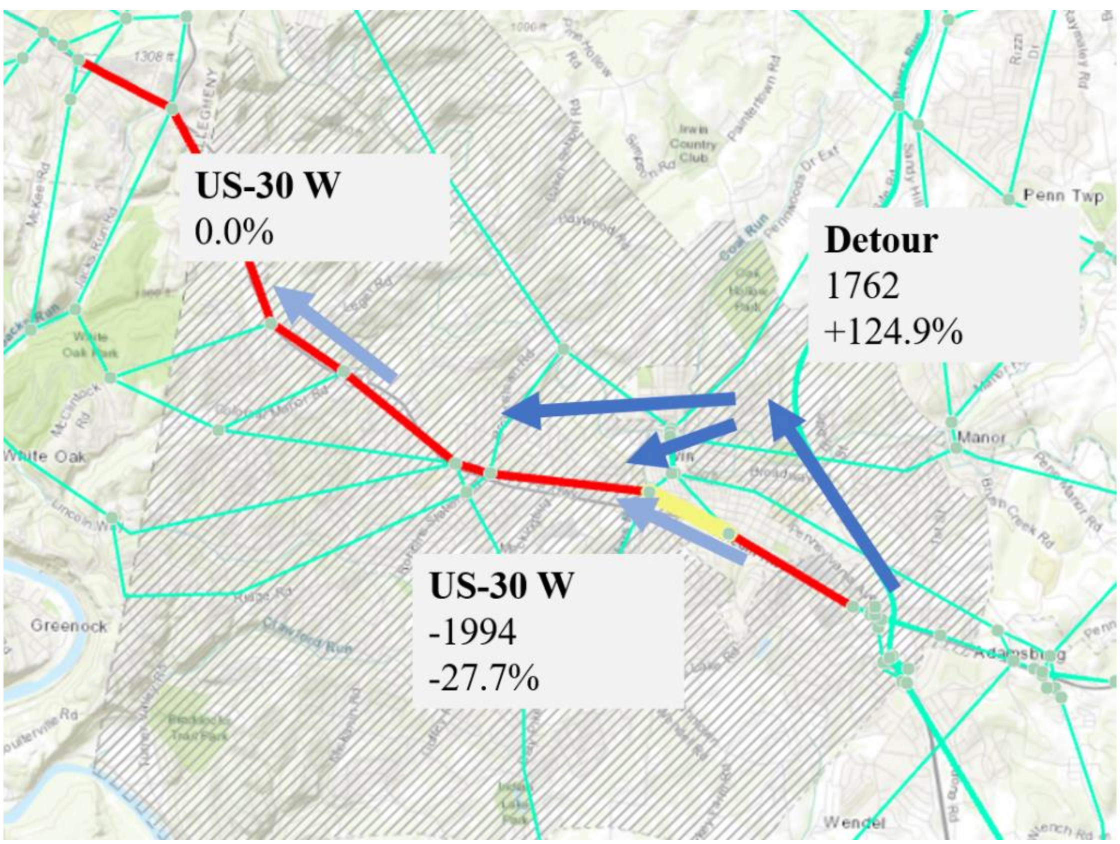


Figure 16 Vehicles detours in phase D during AM peak.

4.1.3 Intersection delay

We present the change of intersection delays on four major roads around US30. In AM peak, we focus on the westbound and northbound traffic. The average intersection delay is presented in Table 4, and the corresponding percentage change is presented in Table 5.

Table 4 Average intersection delay in AM peak (unit: mins).

Road	Base	A	B	C	D
993W	2.1	3.2	2.8	2.4	2.2
I76N	3.3	3.7	3.7	3.8	3.8
Lincoln Way W	5.3	5.8	5.3	5.8	5.8
US30W	6.7	8.1	7.7	7.8	8.0

Table 5 Percentage change of average intersection delay in AM peak.

Road	Base	A	B	C	D
993W	0.0%	54.6%	35.1%	14.8%	5.4%
I76N	0.0%	12.9%	13.6%	15.3%	14.4%
Lincoln Way W	0.0%	8.8%	0.4%	8.8%	8.8%
US30W	0.0%	21.4%	14.2%	15.8%	20.1%

The average delay of the four roads increases significantly, especially for 993W. Phase A will induce the most delays, and Phase C/D will induce relatively less intersection delays.

4.1.4 Travel time

This sub-section focuses on the travel time change under different US30 construction phases. Figure 17 shows the Point-of-Interests (POIs) in this project. We investigate the travel time from NHT to these POIs in the AM peak. One noteworthy point is that we choose North Braddock as one destination because US30 is the major road that connects NHT area and North Braddock, and hence the travel time between these two locations indicate the traffic conditions on US30.

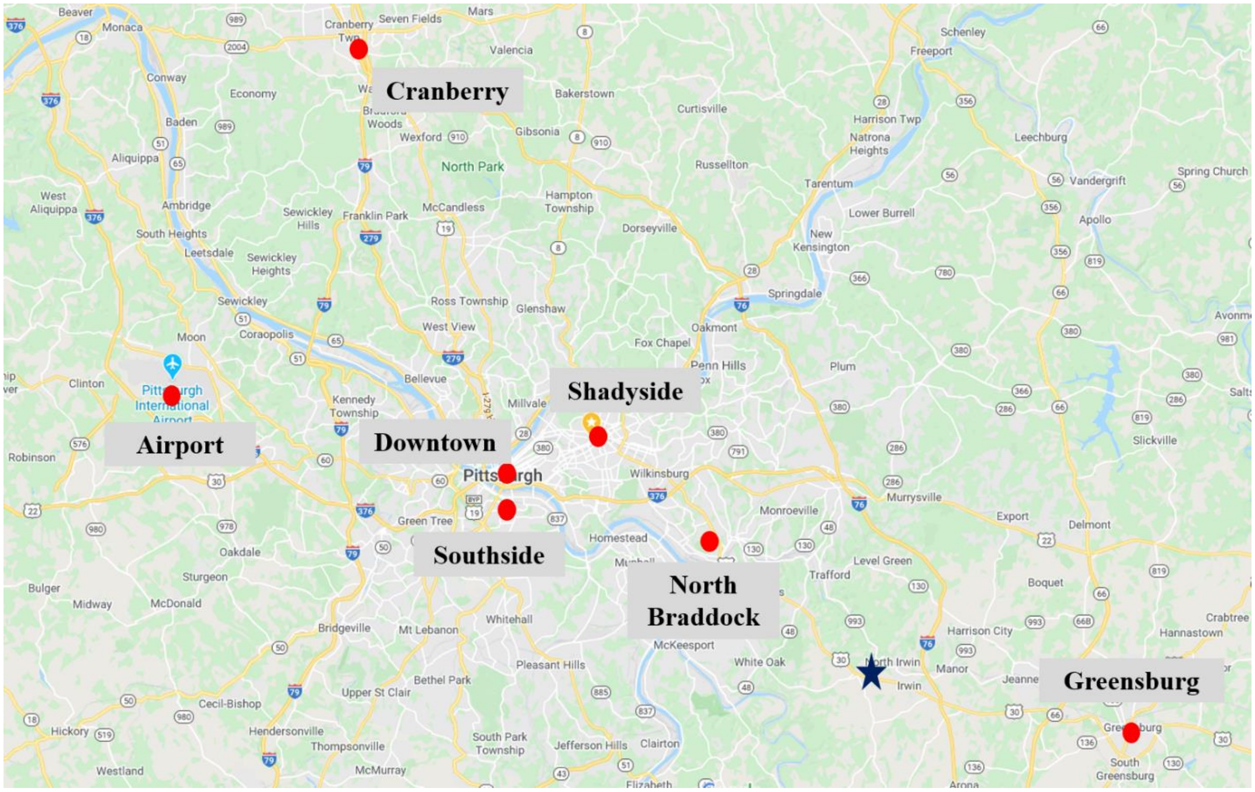


Figure 17 An overview of the POIs.

The average travel time from NHT township to the POIs are presented in Table 6, and the corresponding percentage change is presented in Table 7.

Table 6 Travel time in AM peak (unit: mins).

From	To	Base	A	B	C	D
NHT	Airport	45.1	46.6	44.5	45.9	44.2
	Pittsburgh Downtown	37.7	37.9	38.4	37.1	38.9
	Greensburg	31.9	30.8	29.8	31.9	32.3
	North Braddock	8.3	9.9	9.4	9.6	9.2
	Shadyside	12.7	13.0	12.8	12.9	12.7
	Southside	17.1	17.5	17.5	18.0	17.3
	Cranberry	32.0	31.1	32.8	32.1	31.6

Table 7 Percentage change of travel time in AM peak.

From	To	Base	A	B	C	D
NHT	Airport	0.0%	3.4%	-1.3%	1.7%	-2.0%
	Pittsburgh Downtown	0.0%	0.6%	1.9%	-1.6%	3.4%
	Greensburg	0.0%	-3.3%	-6.5%	0.0%	1.3%
	North Braddock	0.0%	19.8%	14.3%	16.0%	12.0%
	Shadyside	0.0%	2.5%	0.7%	1.6%	0.0%
	Southside	0.0%	2.7%	2.7%	5.4%	1.3%
	Cranberry	0.0%	-2.7%	2.7%	0.5%	-1.2%

Travel time from NHT to North Braddock increases significantly for all four phases, while the US30 construction does not impact the travel time from NHT to Greensburg. For other OD pairs, the US30 construction will increase the travel time, but the impact is marginal because alternatives routes exist for travelers to avoid US30 congestion.

4.2 PM peak

In this section, we discuss the traffic impact of four construction phases in the US30 project during the PM peak. In particular, we highlight the differences between AM and PM peak.

4.2.1 General metrics

We first present the general metrics of the base case and four construction phases in PM peak, as shown in Table 8. The corresponding percentage change is presented in Table 9.

Table 8 General metrics in PM peak.

		Total vehicles	**Total travel time**	**Average travel time**	**Average delay**	**VMT**	**Fuel**	**CO2**	**CO**	**HC**	**NOX**
		#	hour	min	min	mile	gallon	kg	Kg	kg	kg
Base	Car	20566.2	2092.4	6.1	***2.4***	58895.1	1934.8	17194.1	67.8	47.7	64.3
	Truck	335.0	30.5	5.5	2.6	1018.9	49.9	443.0	3.4	1.9	6.8
A	Car	20508.0	2426.0	7.1	***2.9***	61198.1	2011.2	17873.2	68.7	50.4	66.0
	Truck	356.6	38.2	6.4	3.0	1139.3	56.0	497.8	3.7	2.2	7.5
B	Car	20212.4	2270.7	6.7	***2.7***	59179.5	1965.4	17466.6	66.9	50.2	64.5
	Truck	355.0	36.9	6.2	3.0	1135.0	55.8	495.7	3.6	2.2	7.5
C	Car	19561.4	2092.4	6.4	***2.7***	56314.8	1849.8	16439.0	64.3	46.6	61.5
	Truck	340.0	33.3	5.9	2.9	1027.5	50.3	447.3	3.3	1.9	6.9
D	Car	20474.8	2133.7	6.3	***2.6***	59239.9	1950.6	17335.1	68.4	48.3	64.9
	Truck	355.6	31.8	5.4	2.8	1078.0	52.7	468.4	3.6	2.0	7.2

Table 9 Percentage change of general metrics in PM peak.

		Total vehicles	Total travel time	Average travel time	Average delay	VMT	Fuel	CO2	CO	HC	NOX
Base	Car	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Truck	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
A	Car	-0.3%	15.9%	16.3%	21.4%	3.9%	3.9%	3.9%	1.3%	5.6%	2.6%
	Truck	6.4%	25.5%	17.9%	15.7%	11.8%	12.4%	12.4%	7.9%	16.9%	9.8%
B	Car	-1.7%	8.5%	10.4%	12.6%	0.5%	1.6%	1.6%	-1.4%	5.1%	0.3%
	Truck	6.0%	21.1%	14.3%	14.2%	11.4%	11.9%	11.9%	6.2%	16.8%	10.4%
C	Car	-4.9%	0.0%	5.1%	15.1%	-4.4%	-4.4%	-4.4%	-5.2%	-2.4%	-4.3%
	Truck	1.5%	9.4%	7.8%	9.7%	0.8%	1.0%	1.0%	-3.7%	3.9%	1.4%
D	Car	-0.4%	2.0%	2.4%	9.8%	0.6%	0.8%	0.8%	0.8%	1.2%	0.9%
	Truck	6.1%	4.5%	-1.6%	7.6%	5.8%	5.7%	5.7%	4.5%	6.5%	5.8%

In general, travelers experience more delays in the PM peak than in the AM peak. For example, the average intersection delay is 2.4 mins in PM peak, and the same quantity is 1.7mins in AM peak. Phase A is still impacted most severely during the whole project, and Phase D is impacted the least. Different from the AM peak, emissions generally increase in the PM peak, as a result of heavier congestion and more stop-and-go traffic.

4.2.2 Vehicle detours

Phase A

Different from the AM peak, the traffic volumes decrease on both US30 Eastbound and Lincoln Way eastbound. Traffic is largely shifted to 993E during the PM peak, as shown in Figure 18. One reason is that Lincoln Way in PM peak is more congested than in AM peak, and hence it cannot accommodate more traffic detours. On the contrary, the severe delay on Lincoln Way will encourage some travelers to use alternative routes.

Phase B

Similar to Phase A during the PM peak, the most impacted road in Phase B is still 993E. Traffic on both US30 Eastbound and Lincoln Way Eastbound will shift to 993E. As a result, the traffic flow increases by 17.8% due to construction phase B in the PM peak, as shown in Figure 19.

Phase C

The traffic impact of Phase C construction in the PM peak is similar to that in the AM peak, in the sense that most of the detours are local detours. However, we still see an increase in vehicles flow on 993E, possibly because the local detour is not enough to accommodate the traffic demand in the PM peak. As shown in Figure 20, the traffic volumes on local roads increase by 70.3%, and there are also 13.2% more vehicles on 993E.

Phase D

Following the same pattern in the AM peak, phase D is also similar to phase C in the PM peak. Most of the vehicles detour locally around the construction site, resulting in an 88.8% traffic increase on the local road. Additionally, vehicles on US30 eastbound also shift to 993E to avoid the heavy congestion caused by the construction, as demonstrated in Figure 21.

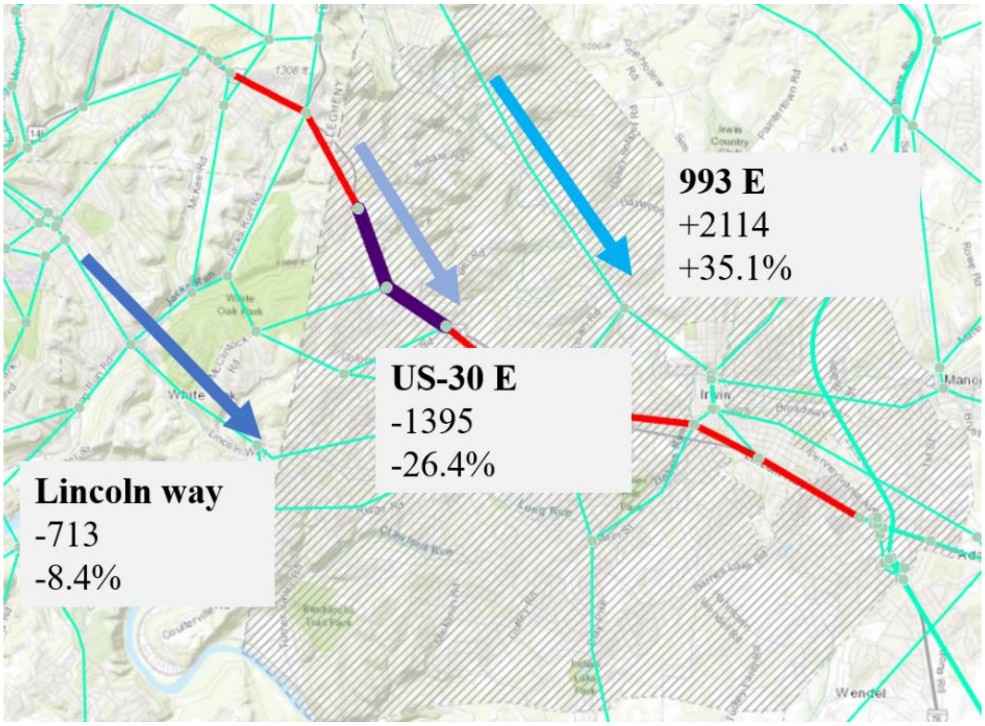


Figure 18 Vehicles detours in phase A during PM peak.

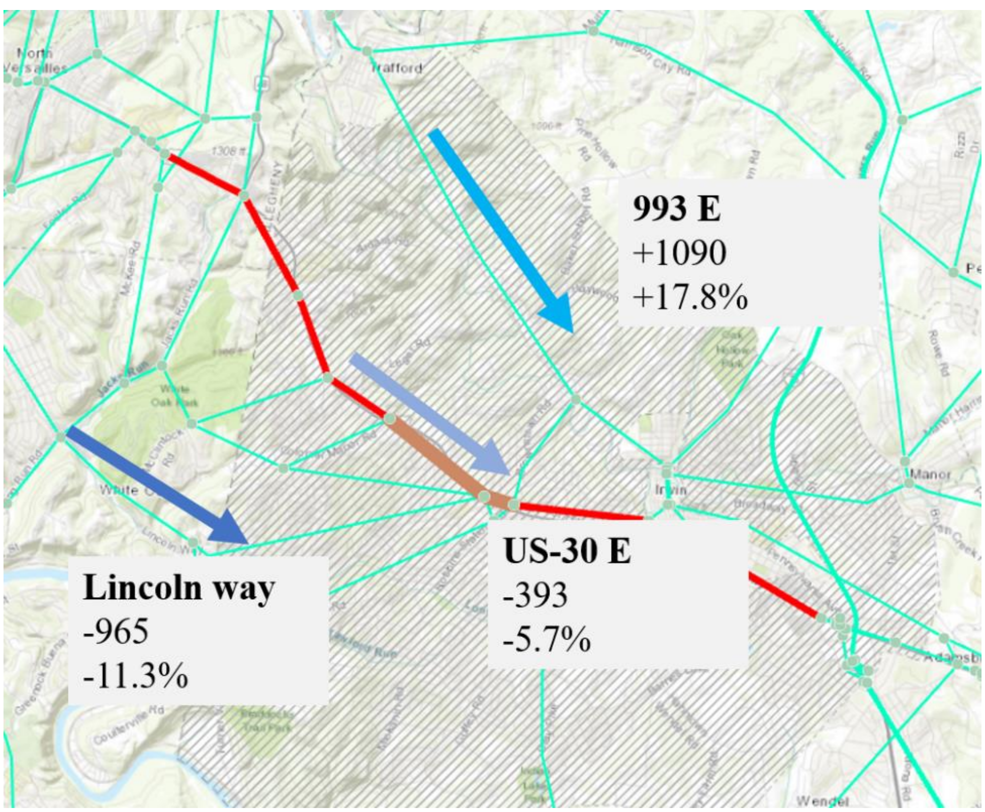


Figure 19 Vehicles detours in phase B during PM peak.

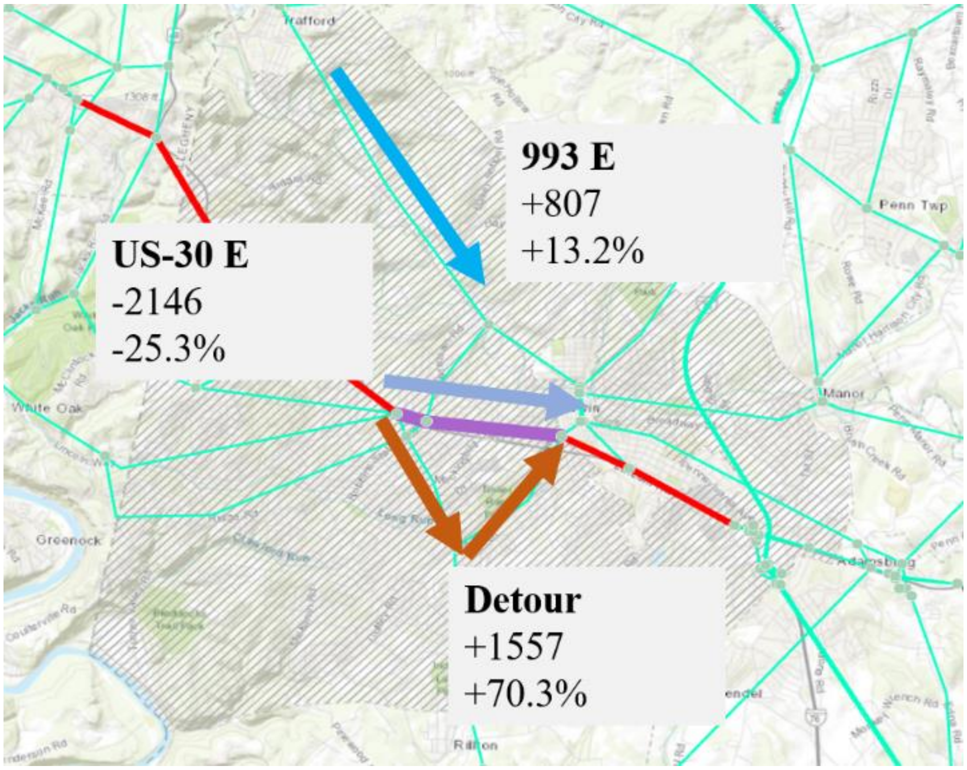


Figure 20 Vehicles detours in phase C during PM peak.

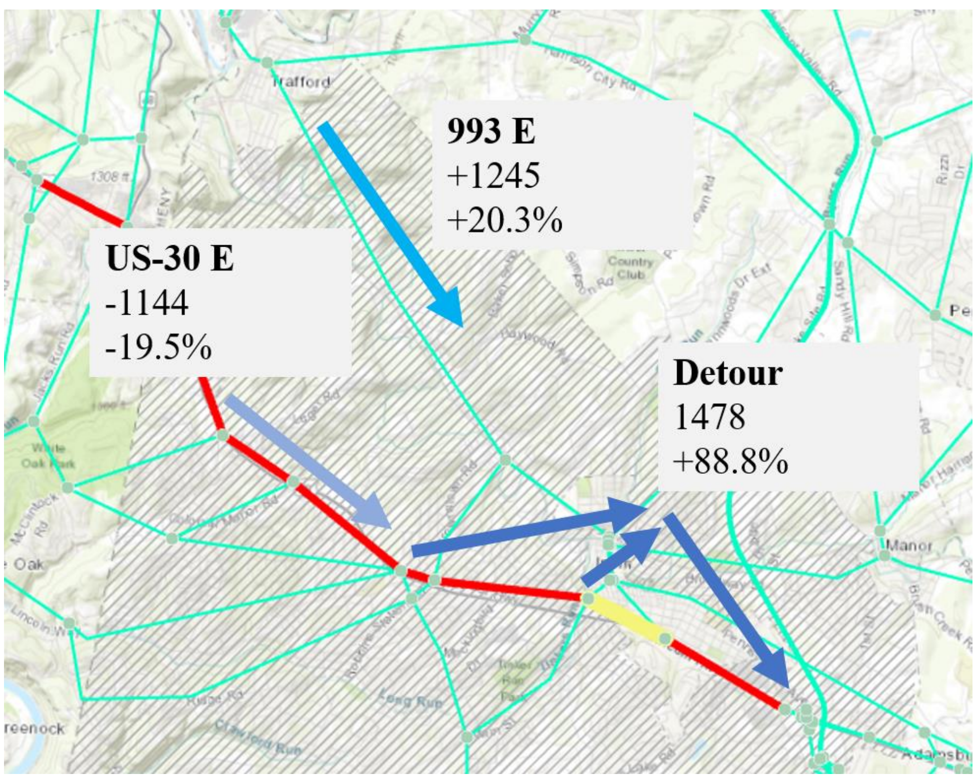


Figure 21 Vehicles detours in phase D during PM peak.

4.2.3 Intersection delay

In the PM peak, we focus on the eastbound and southbound traffic. The average intersection delay is presented in Table 10 and the corresponding percentage change is presented in Table 11.

Table 10 Average intersection delay in PM peak (unit: mins).

Road	Base	A	B	C	D
993E	2.3	3.2	3.3	2.4	2.3
I76S	3.3	4.1	4.9	5.3	4.0
Lincoln Way E	5.8	5.8	9.5	7.4	7.4
US30E	7.2	7.5	7.9	7.8	7.6

Table 11 Percentage change of average intersection delay in PM peak.

Road	Base	A	B	C	D
993E	0.0%	40.0%	42.1%	3.8%	1.8%
I76S	0.0%	24.7%	48.6%	59.2%	20.4%
Lincoln Way E	0.0%	0.2%	64.6%	26.9%	27.7%
US30E	0.0%	3.5%	10.2%	8.3%	6.0%

The average intersection delay will increase during the entire four construction phases. Many major roads, such as 993E and I76S, are impacted severely during the construction project, and the most severe traffic congestions are induced during phase B. On the contrary, phase D endures the least impact on the intersection delays.

4.2.4 Travel time

Using the same POIs presented in Figure 17, we investigate the travel time from these POIs to NHT township in the PM peak. The average travel times from POIs to NHT township are presented in Table 12, and the corresponding percentage change is presented in Table 13.

Table 12 Travel time in PM peak (unit: mins).

From	To	Base	A	B	C	D
Airport	NHT	53.0	52.9	51.2	58.4	52.1
Pittsburgh Downtown	NHT	41.1	43.2	41.5	46.5	43.4
Greensburg	NHT	29.8	31.9	30.8	39.1	33.9
North Braddock	NHT	15.4	16.8	17.9	21.6	17.1
Shadyside	NHT	24.5	25.3	25.8	28.3	26.8
Southside	NHT	39.0	45.3	38.8	44.3	36.2
Cranberry	NHT	42.2	42.5	44.1	46.0	46.3

Table 13 Percentage change of travel time in PM peak.

From	To	Base	A	B	C	D
Airport	NHT	0.0%	-0.2%	-3.4%	10.3%	-1.7%
Pittsburgh Downtown		0.0%	5.2%	0.9%	13.3%	5.7%
Greensburg		0.0%	7.0%	3.5%	31.5%	14.0%
North Braddock		0.0%	9.1%	16.7%	40.6%	11.3%
Shadyside		0.0%	3.3%	5.2%	15.4%	9.3%
Southside		0.0%	16.0%	-0.7%	13.3%	-7.4%
Cranberry		0.0%	0.9%	4.5%	9.2%	9.8%

In general, average travel time increases for all origin-destination pairs during the entire construction period, especially from North Braddock to NHT. Different from the AM peak, the travel time from Greensburg to NHT also increases. Overall, the travel time percentage increases for PM peak is higher than that for AM peak.

5. Traffic Mitigation Strategies

In this section, we investigate several traffic management strategies to mitigate the impact of the US30 project on traffic delays and congestions. We consider various strategies as follows:

- Better information provision
- Working from home
- Flexible working hours
- Increasing transit services
- Mixed strategies

Details of the management strategies and the mitigation effects are discussed in the following sections.

5.1 Information provision

In the current model, we assume that 60% of travelers are adaptive, meaning they are reactive to the traffic conditions and scenario changes. The rest of 40% of travelers stick to the pre-determined route regardless of any change in traffic congestion. The percentage of adaptive travelers depends on the information provision scheme. For example, if travelers are informed before the construction project starts, they could be more adaptive to route selection. We analyze the traffic conditions in which there are 10% more or fewer travelers being adaptive, and the results are presented in Table 14. For all the experiments, we assume the total traffic demand does not change, and the average intersection delay is used as an indicator to demonstrate the traffic condition in different scenarios.

Table 14 Effects of better information provision in terms of average delay (mins).

Time	Adaptive Drivers	Base	A	B	C	D
AM	Current	***1.7***	2.2	1.9	2.1	1.8
	-10%	1.8	2.4	2.0	2.3	2.2
		5%	40%	13%	33%	26%
	10%	1.4	2.0	1.7	1.6	1.5
		-18%	15%	-1%	-8%	-14%
PM	Current	***2.4***	2.9	2.7	2.7	2.6
	-10%	4.0	3.8	3.8	3.9	3.7
		67%	57%	59%	64%	55%
	10%	2.2	2.7	2.4	2.4	2.5
		-7%	14%	2%	1%	5%

As can be seen from Table 14, having 10% travelers being less adaptive to traffic will significantly increasing the delays. On the contrary, the impact of US30 project can be mitigated if there are 10% more adaptive travelers. For example, the average delay during phase A in the AM peak is originally 2.2 minutes, while it decreases to 1.7 minutes when travelers being adaptive increase by 10%. The experimental results show it is critical to provide traffic information in order to mitigate the traffic impact of US30 project. Related strategies include, but are not limited to, encouraging travelers using real-time routing applications, handing out flyers to make the community aware of the construction project ahead of time, and building an online information dissemination webpage with all traffic detour suggestions open to the public.

5.2 Working from home

Allowing people to work from home could significantly reduce the traffic demand, and hence effectively alleviate traffic congestion. Strong evidence has also been shown from the recent COVID-19 lockdown. Based on a recent study related to COVID-19, the maximum percentage of people who can work from home is around 29% (Derek Thompson, 2020). In this project, we examine that there are 5% or 10% people in the NHT area working from home during the US30 project, and their respective traffic impact is presented in Table 15. For all the experiments, we assume the information provision does not change (namely 60% of travelers are adaptive to traffic while 40% stick to the pre-scribed routes/time), and the average intersection delay is used as an indicator to measure the traffic conditions in different scenarios.

Table 15 Effects of working from home in terms of average delay (mins).

Time	WFH	Base	A	B	C	D
AM	Current	***1.7***	2.2	1.9	2.1	1.8
	5%	1.6	1.7	1.9	1.7	1.7
		-5%	-1%	8%	-1%	-5%
	10%	1.4	1.6	1.6	1.6	1.6
		-17%	-10%	-9%	-9%	-9%
PM	Current	***2.2***	2.7	2.4	2.4	2.5
	5%	2.2	2.0	2.2	2.1	2.2
		-3%	-8%	-1%	-4%	-2%
	10%	1.7	2.0	1.9	2.0	1.9
		-22%	-12%	-13%	-12%	-14%

One can see that working from home could effectively reduce traffic congestions, and even allowing 5% of travelers to work from home can almost offset the impact of US30 constructions. In most scenarios, the traffic conditions during the US30 project are even better than current traffic conditions, if 10% of people choose to work from home.

5.3 Flexible working hours

Different from working from home, the strategies to allow people to have flexible working hours are more plausible. Flexible workers could choose to depart early or late to avoid peak hours, hence the traffic demand curve would be flattened, as shown in Figure 22. If the flattened curve is close to or below the road capacities, then the congestion could be largely reduced.

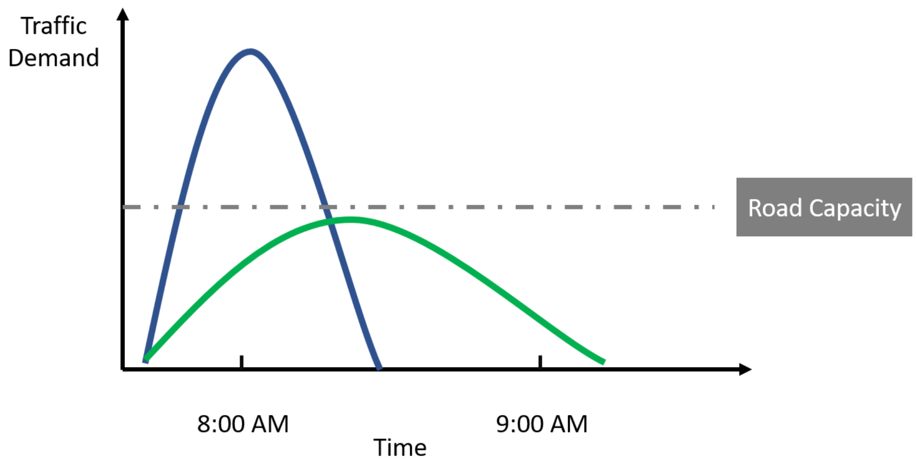


Figure 22 Illustration of "flattening the demand curve".

In the study, we examine that there are 5%, 10%, and 15% travelers in NHT area who can choose their departure times flexibly during the US30 project, and the corresponding traffic conditions are presented in Table 16. For all the experiments, we assume the information provision and total travel demand do not change, and the average intersection delay is used as an indicator to measure the traffic conditions in different scenarios.

Table 16 Effects of flexible working time in terms of average delay (unit: mins).

Time	Flexible Workers	Base	A	B	C	D
AM	Current	***1.7***	2.2	1.9	2.1	1.8
	5%	1.7	2.1	1.9	2.0	2.1
		-1%	20%	9%	12%	19%
	10%	1.7	2.0	1.7	1.9	1.9
		-2%	17%	-4%	9%	12%
	15%	1.7	1.7	1.6	1.7	1.8
		-4%	0%	-9%	-2%	5%
PM	Current	***2.2***	2.7	2.4	2.4	2.5
	5%	2.2	2.5	2.4	2.2	2.4
		0%	10%	7%	0%	7%
	10%	2.0	2.3	2.2	2.3	2.1
		-9%	5%	-1%	2%	-4%
	15%	2.0	1.9	2.0	2.1	2.1
		-10%	-13%	-8%	-5%	-6%

In the AM peak, allowing 15% flexible workers could offset the delay induced by US30 construction. In the PM peak, allowing 10% flexible workers is sufficient to achieve similar mitigation effects.

5.4 Increasing public transit ridership

Encouraging more commuters to use public transit also could great potential in reducing traffic congestion. Westmoreland Transit Authority provides park-and0-ride services in the NHT area, and the routes include 1F, 3F, 4, 4S, and 6. In this study, we examine the number of commuters using the public transit increases by 50% or 100% in the NHT area, respectively. Note that the strategy of moving commuters away from driving can be generalized to offer not only increased frequencies of the public transit services, but also other multi-modal commuting options, such as carpooling and vanpooling services. After increasing the usage of multi-modal options, we expect to see fewer long-distance commuting vehicles, but there could also be more local traffic to the park-and-ride lot. For all the experiments, we assume the information provision and traffic demand does not change, and the average intersection delay is used as an indicator to measure the traffic condition in different scenarios, as presented in Table 17.

Table 17 Effects of increasing public transit ridership in terms of average delay (unit: mins).

Time	Increasing Transit Ridership	Base	A	B	C	D
AM	Current	***1.7***	2.2	1.9	2.1	1.8
	50%	1.7	2.0	1.9	1.9	1.7
		-2.6%	11.9%	7.8%	10.6%	-4.5%
	100%	1.6	1.7	1.8	1.6	1.4
		-8.6%	-3.0%	4.4%	-5.4%	-17.9%
PM	Current	***2.2***	2.7	2.4	2.4	2.5
	50%	2.2	2.3	2.1	2.2	2.2
		-0.6%	5.2%	-4.6%	-2.0%	0.8%
	100%	2.1	2.1	2.2	2.1	2.1
		-3.9%	-7.3%	-2.3%	-4.5%	-7.7%

In general, one can see that increasing 50%~100% transit ridership can considerably mitigate the impact of US30 project. For example, the additional traffic delay can be offset by adding 100% transit ridership in phase A during the AM peak.

5.5. Mixed strategies

Implementing one specific strategy to completely offset the impact of the US30 project seems practically challenging and risky, hence we also investigate the effects of a mixture of those strategies. In this sub-section, we choose the combination of better information provision and flexible working hours. Specifically, we assume there are 5% more travelers become adaptive to real-time traffic, and 5% or 10% more workers in the NHT area are flexible in shifting their respective working hours. For the experiments, we assume the total travel demand does not change, and the average intersection delay is used as an indicator to demonstrate the traffic conditions in different scenarios, as shown in Table 18.

Table 18 Effects of mixed strategies in terms of average delay (unit: mins).

Time	Adaptive Drivers	Flexible Workers	Base	A	C	D	E
AM	Current	1.7	2.2	1.9	2.1	1.8	
	+5%	5%	1.6	1.9	1.7	1.7	1.7
			-8%	6%	-2%	-3%	-2%
		10%	1.5	1.6	1.5	1.5	1.5
			-16%	-6%	-12%	-16%	-15%
PM	Current	2.2	2.7	2.4	2.4	2.5	
	+5%	5%	2.0	2.2	2.1	2.3	2.0
			-9%	-3%	-8%	5%	-10%
		10%	1.9	2.1	2.0	1.9	2.0
			-15%	-7%	-10%	-15%	-12%

For both the AM and PM peaks, increasing 5% flexible workers and 5% adaptive travelers will offset the impact of the US30 project. In most scenarios, the traffic conditions in the managed scenarios are better than the current base scenario. The experiment results show great potential in combining various management strategies together to mitigate the traffic impact of the US30 project.

6. Summary and Suggestions

Finally, we summarize the findings in this project, and suggestions to mitigate the traffic impact of the US30 project are provided.

6.1 Findings

- US30 construction projects will increase the average delay by around ***0.5 min per intersection***, accounting for ***15%~20% delay increase in the NHT area***. (Using Phase A as an example, AM peak: in all 1.7 mins to 2.2mins in the NHT area; PM peak: in all 2.4 mins to 2.9 mins in the NHT area)
- AM peak:
    - ❑ ***Lincoln Way and 993*** are heavily impacted during phases A and B
    - ❑ ***Local neighborhoods*** are heavily impacted during phases C and D

- PM peak:
    - ❑ ***Lincoln Way and 993*** are heavily impacted throughout the course of the construction period.
    - ❑ ***Local neighborhoods*** are heavily impacted during phases C and D
- The following strategies would share similar effects on effectively mitigating the impact of US30 construction project:
    - ❑ Increasing ***10% adaptive travelers.***
    - ❑ Allowing ***5% travelers to work from home.***
    - ❑ Allowing ***10~15% travelers to have flexible working hours.***
    - ❑ Increasing ***50%~100% transit usage.***
    - ❑ Allowing ***5~10% travelers to have flexible working hours*** and increasing ***5% more adaptive travelers.***
- Scenarios that should be avoided:
    - ❑ ***Little information provision and fewer travelers who are adaptive to real-time traffic.*** (up to 50% delay increase)

6.2 Suggestions

- North Huntingdon township could work with PennDOT to adjust the traffic signal timing along US30 to avoid extra delays caused by detour demands during the US30 project.
- Turning movements at all intersections along US-30 will be hindered during the construction period. It is suggested to particularly analyze the turning phases of traffic signals and adjust them accordingly in order to alleviate bottlenecks. The adjustment will largely depend on the work zone settings. In particular, it is suggested to construct jughandles for improving access to any intersection side street first as it will assist as construction alternate route and help with congestion mitigation.
- NHT could use real-time traffic information, such as INRIX traffic speed (available to SPC and PennDOT) and traffic surveillance cameras, in order to adjust the signal timings or adopt other real-time traffic control strategies.
- NHT could take measures of better information provision to regional commuters (including local residents) to increase the number of drivers who are adaptive to real-time traffic during the US30 construction, as it appears the most cost-effective management strategies in mitigating the impact of the US30 construction projects. Related measures include, but are not limited to, building a real-time information dissemination webpage with all construction and traffic information updated on a regular basis, media campaign of congestion implications of construction projects, and handing out flyers to inform the community of the construction projects ahead of time. In particular, it is suggested to use dynamic message signs (DMS) to help travelers detour towards 993 and Lincoln Way.
- It is also suggested to encourage people to work from home or commute during flexible hours. Because many regular workers have just experienced working from home during

the recent outbreak of COVID-19, this management strategy may become much easier to implement than before.

- During the course of the entire US30 construction project, Lincoln Way and 993 are heavily impacted and utilized. Because both roads are one-lane, it is strongly suggested to avoid any concurrent construction projects or events along those roads. Due to the high traffic volumes on both roads, the risks of car crashes may be high, and the resulted traffic congestion is likely severe during peak hours. Public agencies need to prepare for quick responses to any anomalies on those essential roads during the US30 construction project.
- This study does not model the congestion impact by unplanned incidents during US30 construction projects. It is projected that the increased congestion would be more pronounced under incidents in the NHT area, particularly along those alternative routes to the US-30. It is suggested to study Traffic Incident Management for the region and coordinate among relevant stakeholders.

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