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Evaluating the Mobility Impacts of American Dream Complex Using Probe Vehicle Data

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ABSTRACT

Traffic congestion and motor vehicle crashes are perceived as pivotal concerns that are particularly difficult to manage in high-density urban areas. Thus, mitigating traffic congestion and improving users' safety on roadways are top priorities of the United States Department of Transportation (USDOT). American Dream Complex, located outside New York City, is an entertainment and retail center that was officially opened in October 2019. The complex is expected to attract over 40 million annual visitors once fully operational, which may potentially result in substantial mobility and safety issues for road users in the area. The present research work evaluates the mobility concerns of the transportation network in the vicinity of the American Dream Complex due to its partial official opening. To achieve this goal, firstly, the performance of four surrounding corridors was explored by incorporating travel time inflation (TI) as a performance measure. In addition, to have a better visualization of the congestion, day-by-day heatmaps were developed. Based on the results obtained from the Corridor Increase in Mean Travel Time (CIMTT) heatmaps, it was shown that no considerable congestion was observed on the opening day of the American Dream Complex on surrounding corridors.

Keywords: American dream complex, mobility impact, travel time inflation, surrounding corridors

1. INTRODUCTION

Traffic congestion and motor vehicle crashes are major global challenges being faced every day. This is especially problematic in urban areas, where infill development will increase traffic volume in the region, thus impacting both congestion and crash frequency. Even as new developments are being constructed, reducing congestion and enhancing traffic safety on America's transportation roads remain top priorities of the United States Department of Transportation (USDOT). According to the American Transportation Research Institute (ATRI), New Jersey has the worst traffic bottleneck in the country [*1*]. Moreover, the state of New Jersey ranked second in the nation with respect to the ratio of pedestrian fatalities to the total number of motor vehicle deaths, necessitating further investigations. Therefore, it is especially important to understand on a quantitative level how a major commercial development will impact densely populated, highly congested region. The American Dream Complex, once complete, will be the second-largest retail and entertainment complex in the nation. The ongoing commercial development is located in East Rutherford, New Jersey, about 10 miles west of New York, NY. This complex officially opened at about 10% capacity to the public on October 25, 2019 [*2*]. Once fully open it is expected to attract over 40 million visitors annually. This will potentially result in substantial mobility and safety issues for pedestrians and motorists in the area.

In order to assess the mobility issues, probe vehicle data can be used to evaluate the congestion performance of roadways going to and coming from the American Dream Complex. This type of data is being used as a common data source for measuring the regional performance of roadway networks. By developing a performance evaluation method based on these data, the health of the roadway system can be monitored, and future improvement plans can be established. Probe data is a valuable source of speed information in terms of temporal and spatial coverage [*3*]. This type of data is increasingly incorporated in transportation analytics. Application of probe vehicle data in traffic congestion assessment, performance evaluation of highways and arterial roads, and travel time estimation has drawn considerable research interest over the last decades [*3*, *4*, *5*, *6*, *7*, *8*, *9*, *10*, *11*, *12*, *13*, *14*, *15*, *16*, *17*]. The main objective of this study is to visually quantify the baseline performance of arterials located around the American Dream Complex by determining Travel Time Inflation as a performance measure. Once established, a yearly evaluation of the regional congestion will be conducted to correspond to phased opening of the American Dream Complex. Future work will statistically compare specific time periods to determine changes in congestion patterns, but for this study only the baseline visualizations are discussed.

2. DATA

Probe vehicle data requires both a spatial component and temporal component. The spatial attributes are defined by Traffic

Message Channels (TMCs), which are pre-defined locations along roadways. (Table 1). As telematics device traverses a TMC the vehicle speed is captured along with a number of other attributes include TMC code, vehicle speeds, date-time stamp, c-value, and confidence score (Table 2). In this study, probe vehicle data for four major routes consisting of state routes, interstate highway/turnpike, and major arterials were obtained from the Regional Integrated Transportation Information System (RITIS) [*18*]. Figure 1 presents the selected TMCs along the four corridors. A total of 60 TMCs were selected surrounding the American Dream Complex covering RITIS data for 24-hours a day from September 1, 2019, to January 31, 2021. Based on previous studies [*11, 14*], only speed data with a confidence score value of 30 and a c-value of 100 were considered.

Table 1. Example of obtained TMCs attributes for Interstate 95

TMC Code	Road	Direction	State	Start Latitude	Start Longitude	End Latitude	End Longitude	Length (miles)
120+04603	I-95	NORTHBOUND	NJ	40.75777	-74.1166	40.79844	-74.0774	3.488163
120-04603	I-95	SOUTHBOUND	NJ	40.80966	-74.0634	40.802	-74.0733	0.741292
120-04604	I-95	SOUTHBOUND	NJ	40.81378	-74.056	40.81363	-74.0563	0.021945

Table 2. Example of TMCs recorded speed data for Interstate 95

TMC Code	Date Time Stamp	Speed	Average Speed	Confidence Score	C-Value
120+04603	9/1/2019 0:00	65.99	60	30	100
120-04603	9/1/2019 0:00	61.28	57	30	100
120-04604	9/1/2019 0:00	60.9	58	30	100

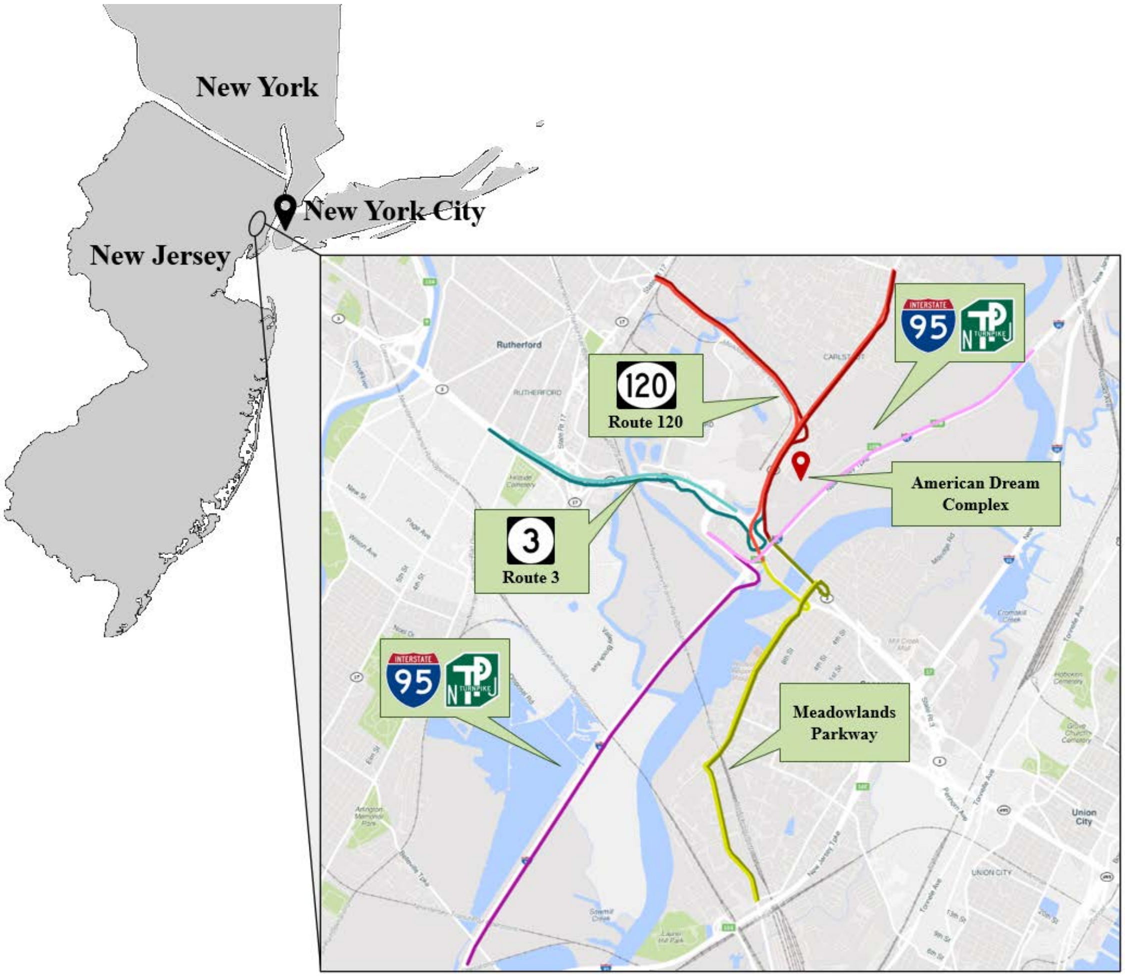

Figure 1. Study area around the American Dream Complex with 60 TMC segments

3. TRAFFIC PERFORMANCE MEASURE

Generally, congestion for a TMC can be defined as "70% of the average segment speed during periods where congestion is unlikely" [*11*]. In this study, a variable speed threshold is considered. This threshold can be calculated as 70% of the base free-flow speed (BFFS). BFFS can be determined using the following equation [*14*]:

$$v_{ia} = 0.7\frac{1}{n_j}\sum_{j\in F} v_{ij} \tag{1}$$

v_{ia}: *Variable speed threshold for TMC i*
n_j: *Total number of 15-intervals within free-flow time F*
v_{ij}: *Recorded speed for each TMC i*

As part of this study, instead of using a benchmark base free-flow time, this research calculated a variable speed threshold for each corridor by considering the whole study period. A base travel time (BTT) was then calculated for each TMC. BTT can be calculated using the following equation [*14*]:

$$BTT_i = \frac{x_i}{v_{ia}} \tag{2}$$

BTT_i: *Base travel time for each TMC i (hours)*
x_i: *Length of each TMC i (miles)*

Travel time for each TMC can be determined as follows [*14*]:

$$TT_{ij} = \begin{cases} \frac{x_i}{v_{ia}}, & v_{ij} < v_{ia} \\ 0, & v_{ij} \geq v_{ia} \end{cases} \tag{3}$$

TT_{ij}: *Travel time for each TMC i (hours) during the time period j*

In this study, travel time inflation (TI) was selected as a performance measure. TI can be defined as the difference between the TT and the BTT. TI can be calculated as follows [*14*]:

$$TI_i = \sum_{j\in K}(TT_{ij} - BTT_i); \quad for\, TT_{ij} > 0 \tag{4}$$

TI_i: *The total travel time inflation for each TMC i (hours) for all the 15-min time period j during the analysis period K*

In order to have a better view of daily congestion during the entire study period, a normalized form of the TI named the Corridor Increase in Mean Travel Time (CIMTT) is considered. To calculate CIMTT, the TI is divided by the travel time calculated for each TMC as reflected in the following equation [*14*]:

$$CIMTT_{ij} = \sum_n \frac{TI_i}{BTT_i} \tag{6}$$

$CIMTT_{ij}$: *The corridor increase in mean travel time for all TMCs (min)*

4. DISCUSSION

The CIMTT for each study corridor is visualized in the heatmaps shown in Figures 2, 3, 4, and 5. In these heatmaps, y-axis represents the hour of the day (15-min bin), and x-axis represents the day of the week. Generally, it is expected that an increase in congestion will be observed due to the opening of any new development. Based on the ITE Trip Generation Manual, an equivalent land use (LU-820 'Shopping Center') would generate about 46.12 and 21.10 trips on Saturday and Sunday, respectively, for every 1,000 Square feet of retail space. For this case, the increase will be phased, which offers a unique perspective on gradual opening of a major development impacts the surrounding area.

As illustrated in Figure 2, for both northbound and southbound of Interstate 95, major congestions occurred during PM Peak hours, and no considerable congestion was observed during the AM Peak hours. Based on the graphs, the partial opening of the complex did not have an immediate impact on the congestion for this corridor since the congestion pattern on this day is almost visually the same as other days. Although this is not statistical proven, further research will document the statistical differences in the visualizations.

Based on Figure 3, there is not a considerable congestion pattern for the northbound of Meadowlands Pkwy during AM Peak hours; however, a steady pattern of congestion was observed for the PM Peak hours of the northbound direction. For the Southbound, interestingly, no considerable congestion was observed for both AM and PM Peak hours. The partial opening of the complex did not have a considerable effect on the congestion pattern for both AM and PM Peak hours in the Meadowlands Pkwy.

According to Figure 4, NJ Route 3, Eastbound, experienced only some minor congestions on some specific days. A steady pattern of very high congestion was recorded during the PM Peak hours for NJ Route 3, westbound. Similar to the other corridors, the partial opening did not affect the congestions pattern at NJ Route 3.

And finally, as shown in Figure 5, a steady pattern of congestion was only observed for PM Peak hours of NJ Route 120, northbound. For southbound of this route almost no congestions were observed. The same as the other corridors, the congestion on NJ Route 120 was not affected by the partial opening of the complex. Data loss from about 10 pm at night to 6 am in the morning for all corridors was another notable observation from these heatmaps. Also, some data loss during the entire day was observed for Meadowlands Pkwy specifically.

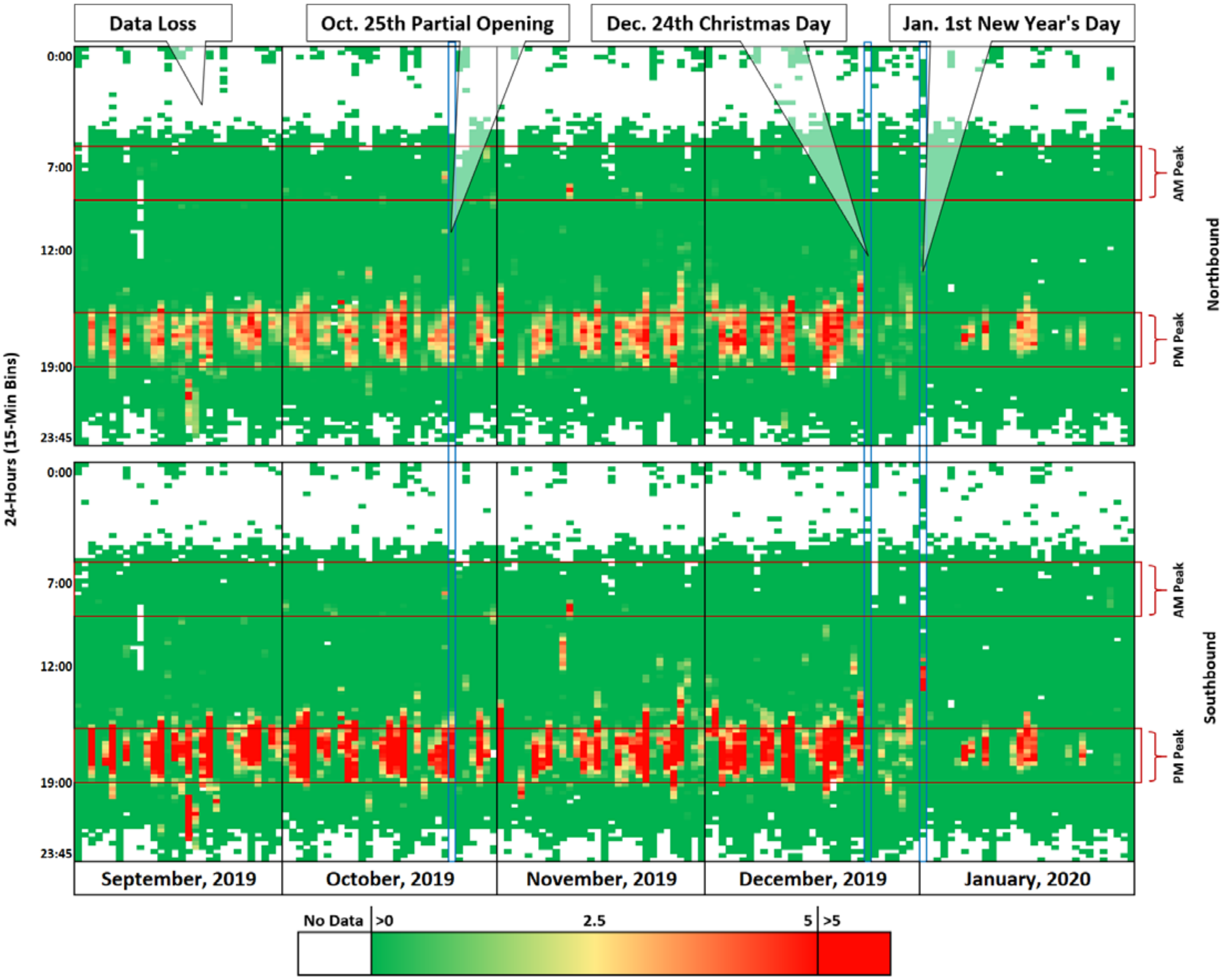

Figure 2 Daily CIMTT for Interstate 95 in 15-min bin

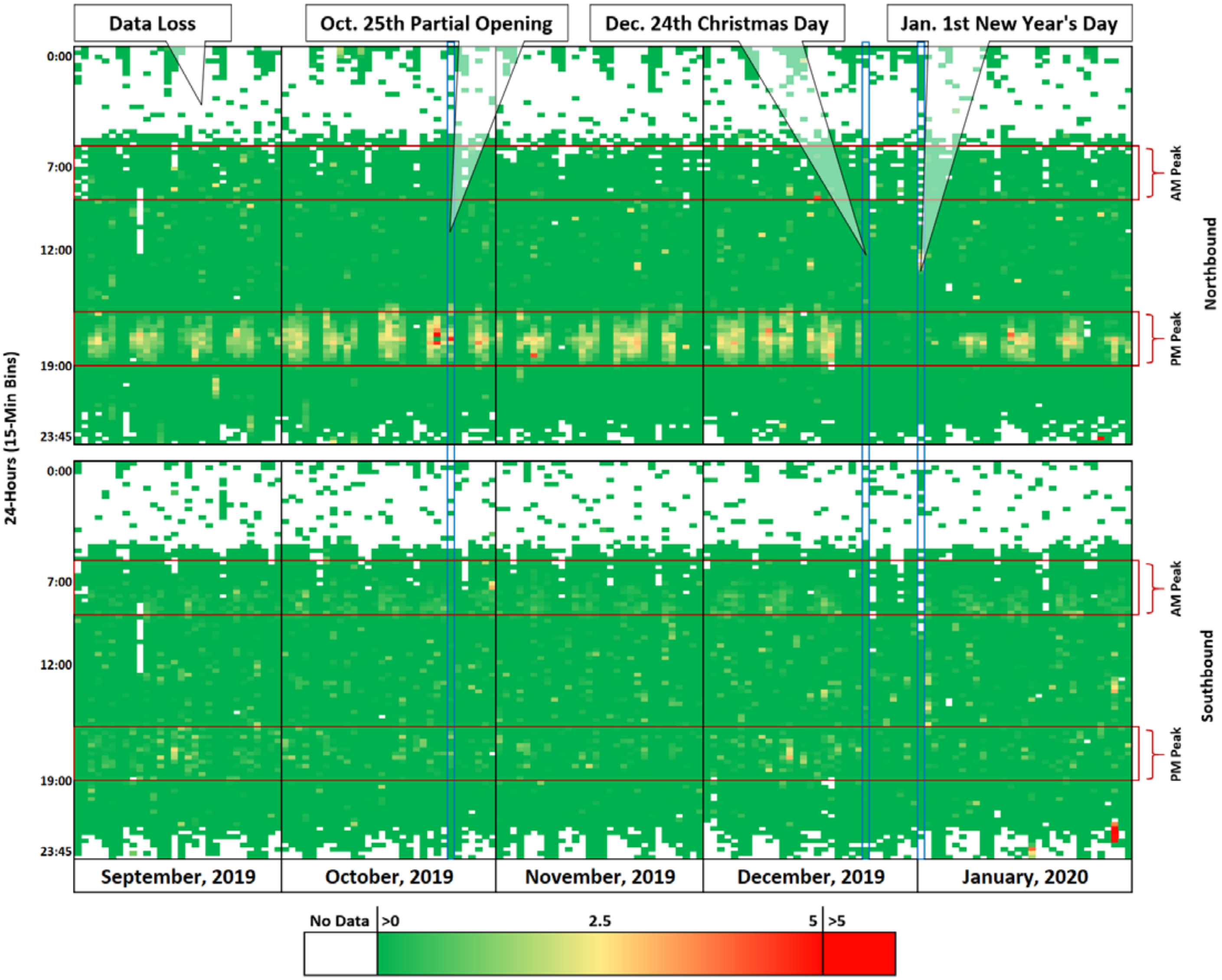

Figure 3. Daily CIMTT for Meadowlands Pkwy in 15-min bin

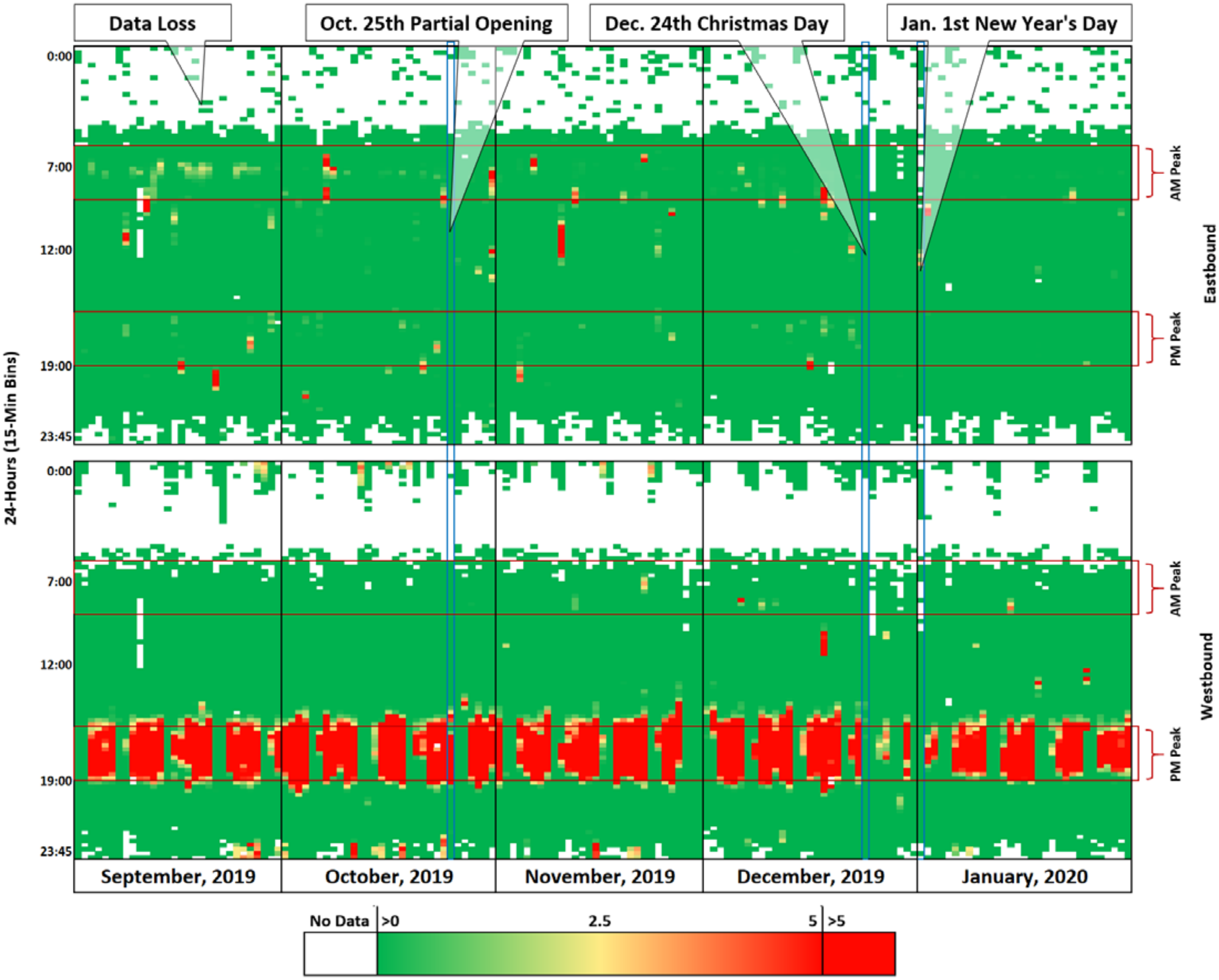

Figure 4. Daily CIMTT for NJ Route 3 in 15-min bin

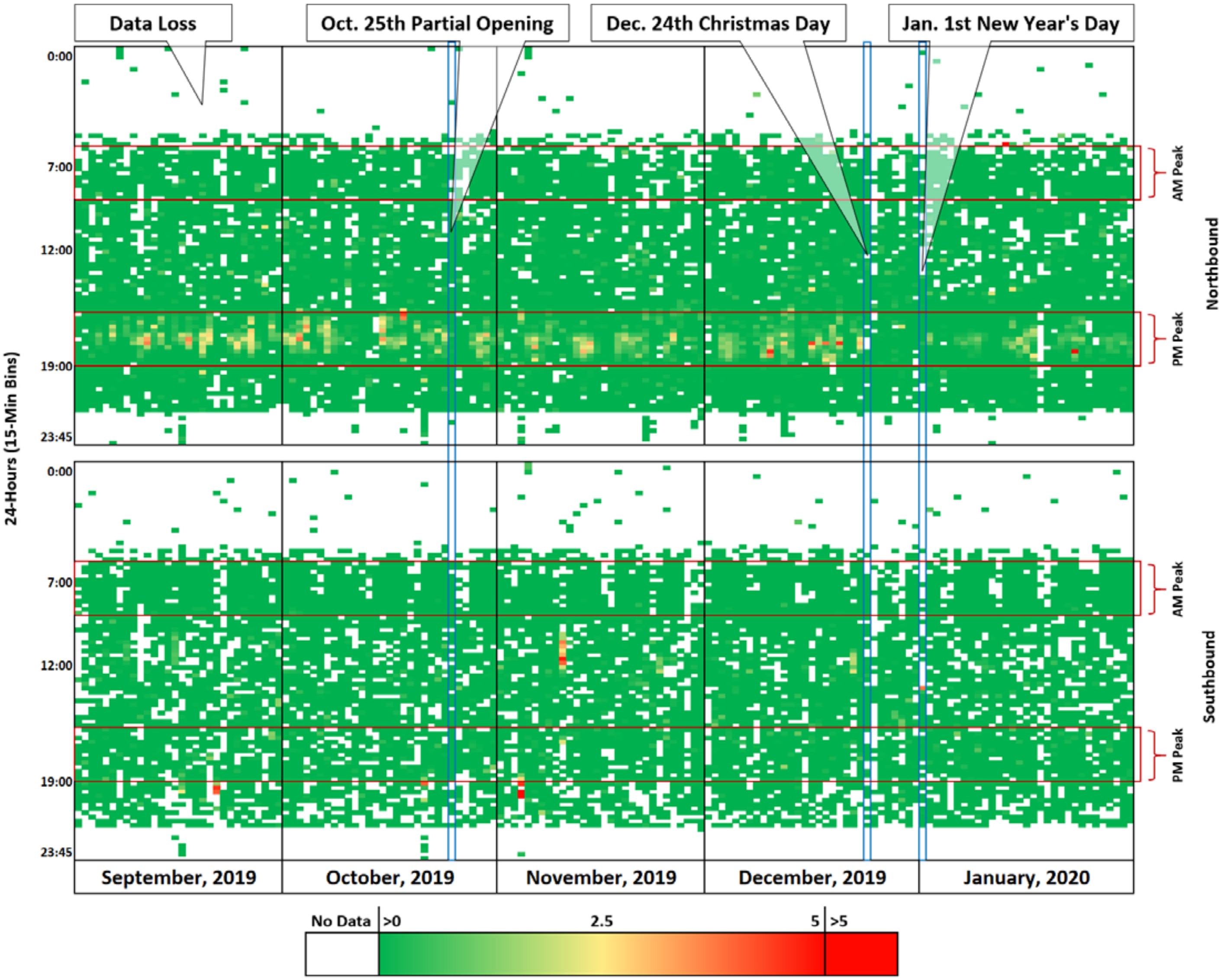

Figure 5. Daily CIMTT for NJ Route 120 in 15-min bin

5. CONCLUSIONS

The main objective of this research is to evaluate the mobility and safety concerns of the transportation network in the vicinity of this complex due to its partial official opening. For this goal, the performance of four surrounding corridors was explored by incorporating travel time inflation (TI) as a performance measure using probe vehicle data.

Results obtained from developed CIMTT heatmaps showed that the partial opening of the complex did not considerably affect the congestion of the surrounding corridors since no obvious decrease or increase in congestion was recorded following the opening of the complex. This result can be attributed to the fact that the complex was only partially opened and was not operated in full capacity. Also, there were many delays in the complex's opening schedule, and it could have been a reason why there were not any considerable changes in congestion in terms of visitors coming to the complex. It is noted that the complex was also shut down in March due to COVID 19 pandemic, and that during that time there was a dramatic decrease in congestion in the region [*19*].

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