Integrated Modeling for Road Condition Prediction – Phase 4
Evaluation Report – Ohio

June 1, 2020

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LIST OF ABBREVIATIONS

°F	degree Fahrenheit
DPHSN	add definition
ET	eastern time
FHWA	Federal Highway Administration
I–670	Interstate 670
I–71	Interstate 71
I–90	Interstate 90
IMRCP	Integrated Modeling for Road Condition Prediction
MAE	mean absolute error
METRo	Model of the Environment and Temperature of Roads
MLPA	machine learning-based prediction model
NWS	National Weather Service
ODOT	Ohio Department of Transportation
PCCAT	precipitation category
RAE	relative absolute error
RAP	rapid refresh
RMSE	root mean square error
RTMA	real-time mesoscale analysis
TMC	traffic management center
TPVT	temperature of pavement
VIS	visibility of surface
VSL	variable speed limit

CHAPTER 1. INTRODUCTION

In 2015, the Federal Highway Administration (FHWA) began efforts to describe and develop a tool that fuses real-time and archived data with results from an ensemble of forecast and probabilistic models. The tool's objective is to predict current and future overall road and travel conditions for the benefit of travelers, transportation system operators, and maintenance providers.

The Integrated Modeling for Road Condition Prediction (IMRCP) system provides a framework for integrating road condition monitoring and forecast data to support decisions by travelers, transportation system operators, and maintenance providers. IMRCP is a prototype system that collects and integrates environmental and transportation operations data, collects forecast weather data, initiates road weather and traffic forecasts, and generates advisories and warnings. The model could become a practical tool for transportation agencies to support traveler advisories, maintenance plans, and operational decisions at strategic and tactical levels. The tool also retains the data so users can review and assess past events.

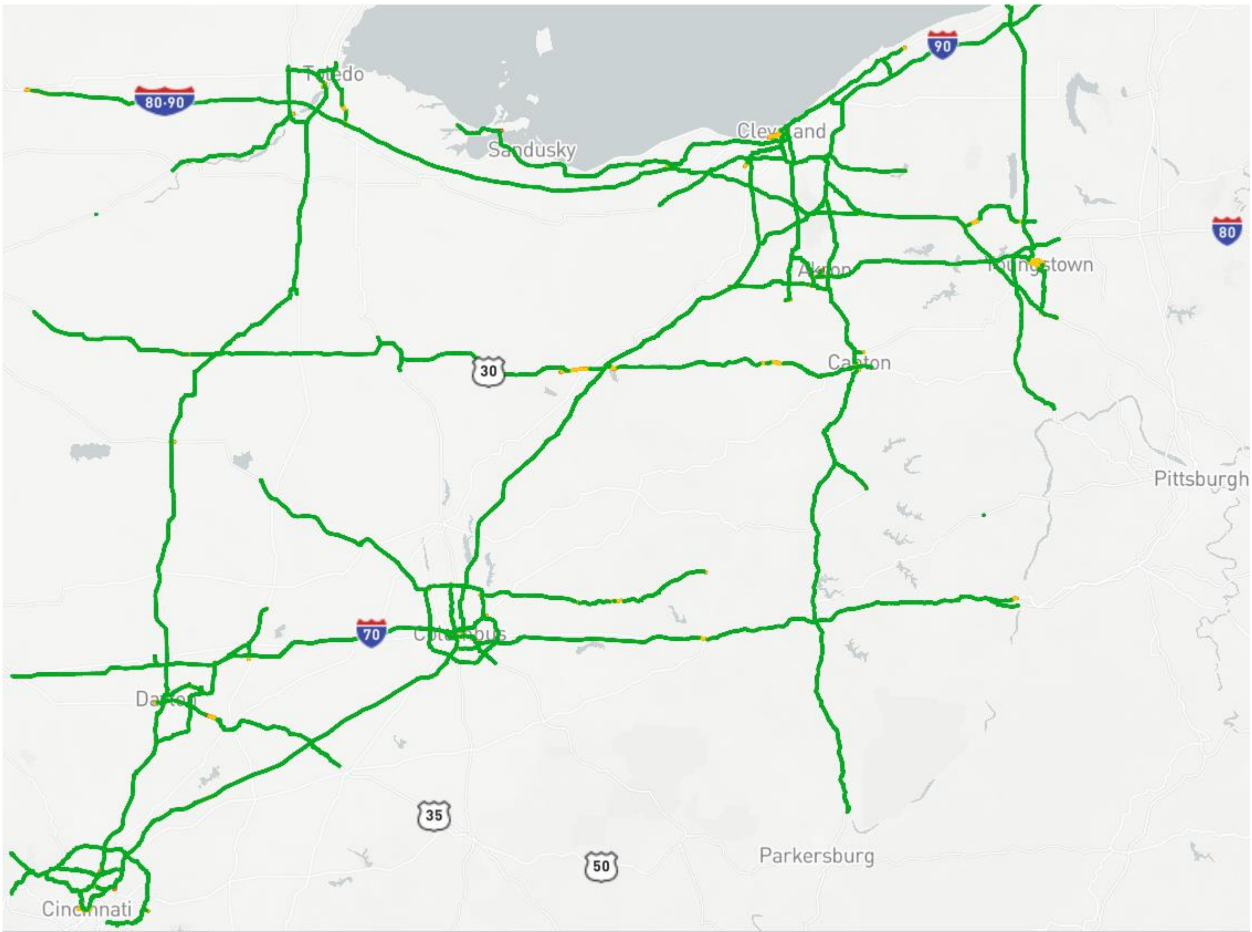
IMRCP phase 1 included development of a concept of operations and requirements. In IMRCP phase 2, the research team specified, implemented, tested, and evaluated the IMRCP concept in part of the Kansas City metropolitan area. In IMRCP phase 3, the coverage area was increased to include the entire Kansas City metropolitan area highways.

For IMRCP phase 4, the Ohio Department of Transportation (ODOT) and Louisiana Department of Transportation and Development were chosen to deploy IMRCP with enhanced capabilities. For Ohio, the primary focus is the winter season (i.e., December 2021–April 2022). For Louisiana, the primary focus is the hurricane/tropical storm season (i.e., May–August 2022).

PROJECT DESCRIPTION

The purpose of IMRCP is to integrate weather, traffic, and other operations data sources with analytical methods to effectively predict road and travel conditions. Research, development, and operations stakeholders have been involved throughout the IMRCP effort. Stakeholders in operations helped identify system functions and interfaces and provided feedback on the usefulness of the system.

Ohio's IMRCP system provides an integrated view of forecast road weather and traffic conditions for a given road network. Figure 1 shows the Ohio IMRCP road network. The IMRCP model draws input from traffic, weather, and hydrological data sources to estimate current conditions and forecast future conditions. Forecasts are available via a web interface on maps, in reports, and in subscriptions. Traffic data sources (e.g., advanced transportation management systems) provide volumes, speeds, freeway control and traffic signal operations data, incident reports, and plans for work zones and special events. Current and forecast atmospheric and hydrological conditions are drawn from National Weather Service (NWS) sources. State and local agencies provide specialized road weather conditions, such as pavement temperatures. Data collected from the various sources are indexed, stored, and archived in a heterogeneous data store by the system.



Source: Federal Highway Administration; © OpenStreetMap contributors.

Figure 1. Screenshot. Integrated Model for Road Condition Prediction phase 4 Ohio deployment.

While atmospheric and hydrological forecasts, work zones, and special events data are taken from external sources, the IMRCP system synthesizes road weather and traffic condition predictions with embedded best-in-class forecast models. The IMRCP system estimates road weather conditions across the network using field measurements of conditions and predicts conditions based on atmospheric forecasts using the Model of the Environment and Temperature of Roads (METRo). The system estimates current traffic conditions from detector stations and demand models and predicts conditions from road weather, incident, and demand forecasts using a machine learning-based traffic prediction model (MLPA).

PURPOSE AND OVERVIEW

This report describes the evaluation of the IMRCP deployment in Ohio. The purpose of the evaluation is to explore whether IMRCP could have an impact on Ohio operations and to assess whether the information was useful to Ohio operators and supervisors. The evaluation also assessed the accuracy of the traffic and road weather predictions. The findings from this evaluation could inform others who may be considering similar deployments and provide FHWA with information to help determine next steps for IMRCP.

This evaluation report consists of five chapters:

- **Chapter 1. Introduction** provides a description of the project, the evaluation purpose, and an overview of the document.
- **Chapter 2. Evaluation Approach** describes the evaluation objectives and approach.
- **Chapter 3. Results** describes the results from the IMRCP qualitative and quantitative data analyses and operator questionnaires and interviews.
- **Chapter 4. Findings** discusses the implications of the analyses related to operator perspectives, attitudes, and feedback and the accuracy of the IMRCP road conditions and speed forecasts.
- **Chapter 5. Conclusion** summarizes key results that support the findings.

CHAPTER 2. EVALUATION APPROACH

The project team developed the evaluation approach based on reviews of project documents, meetings with ODOT staff, and discussions with the development team and the FHWA Road Weather Management Program.

The primary users of IMRCP for this deployment are staff at the Ohio traffic management center (TMC) and staff overseeing road weather maintenance. TMC users monitor traffic speeds, cameras, and weather to identify traffic issues. The speeds and predicted speeds of the models in IMRCP need to be relatively accurate for operators to have confidence in using the system; therefore, the evaluation approach examined quantitative data such as speeds and speed predictions to determine the accuracy. Road weather maintenance staff make decisions relating to timing and locations for plowing during winter weather events. The evaluation approach examined data for current and predicted pavement condition accuracy.

Once Ohio users became familiar with IMRCP through training and experience, their perspectives helped the project team understand user perceptions of IMRCP. Questions were developed to investigate qualitative factors such as: 1) Are IMRCP capabilities/features easy to use? and 2) What features were most helpful in IMRCP? The following sections describe the evaluation objectives, approach, and methodology.

EVALUATION OBJECTIVES

The project team developed evaluation objectives to guide the evaluation approach. The following key objectives guided the development of evaluation questions:

- Investigate if IMRCP functionality and capabilities provide users an enhanced ability to predict traffic and road conditions to analyze and manage traffic (planning, real-time, post-event assessment) during adverse weather conditions.
- Investigate IMRCP user perspectives to determine if IMRCP capabilities/benefits are easy to use and could improve traffic management and public safety before, during, and after emergency or adverse weather conditions.

APPROACH

The project team collected evaluation data that consisted of qualitative data from questionnaires, interviews, and discussions, and quantitative data from IMRCP data logs and Road Weather Information System Environmental Sensor Stations. The following sections describe data collection and analysis for both types of data.

Qualitative Data Collection and Analysis

The project team used questionnaires and group interviews to investigate operator/supervisor perspectives and attitudes related to the usefulness of IMRCP information. The questionnaires and interviews recorded user feedback on how IMRCP is used, when the system is used, and how the information from IMRCP helped to impact how decisions are made during an event. The information helped the project team understand what information was used, what users liked about it, and what possible improvements could be made in future system enhancements to increase the usefulness of the information. Specifically, users were asked:

- Which IMRCP capabilities and features were used?
- Which features were most helpful?
- Did IMRCP data help predict traffic and road conditions?
- (For Ohio) Did IMRCP help with winter maintenance practices?
- Were the features and functions easy to use?
- Which features are needed to help support operations decision-making?
- For TMC staff, can IMRCP's design and/or information sources be bundled or packaged to make it easier for operations decision-making?

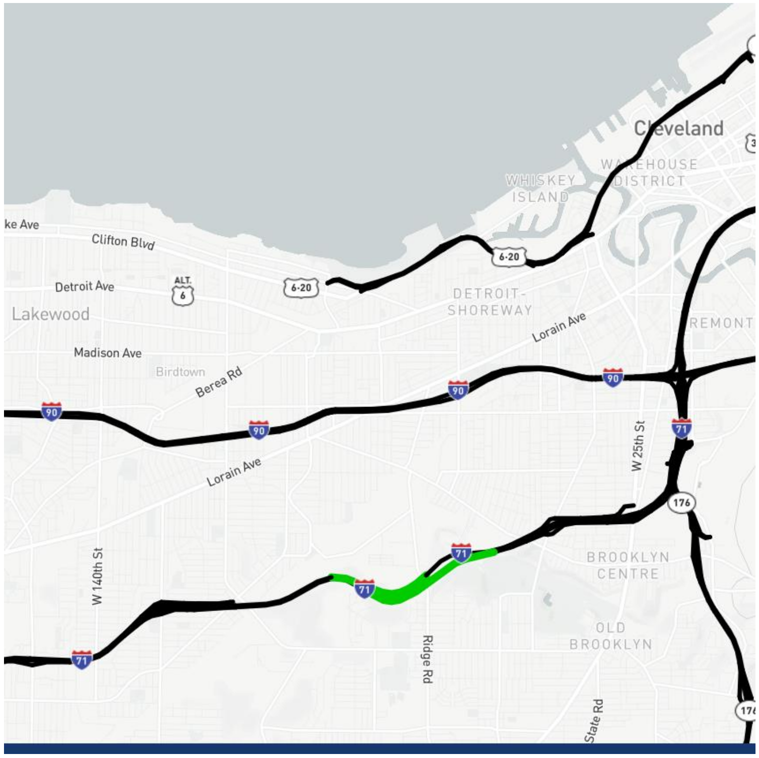
For the evaluation, winter weather events were selected by monitoring NWS alerts and talking with TMC operator and maintenance personnel. For each occurrence of an event, the evaluation team asked users to complete a questionnaire within approximately 5 business days after the conclusion of the event. The team sent an email a few days after the event cancellation as a reminder.

After the evaluation team received a completed questionnaire, the team contacted the IMRCP users to schedule a post-event group discussion to review responses and gather feedback from their use of the system. The team sent an email with summarized responses (as a reminder of their questionnaire answers) and a short guide with points to be discussed during the focus group. Appendix A shows the Ohio post-event questionnaire.

Quantitative Data Collection and Analysis

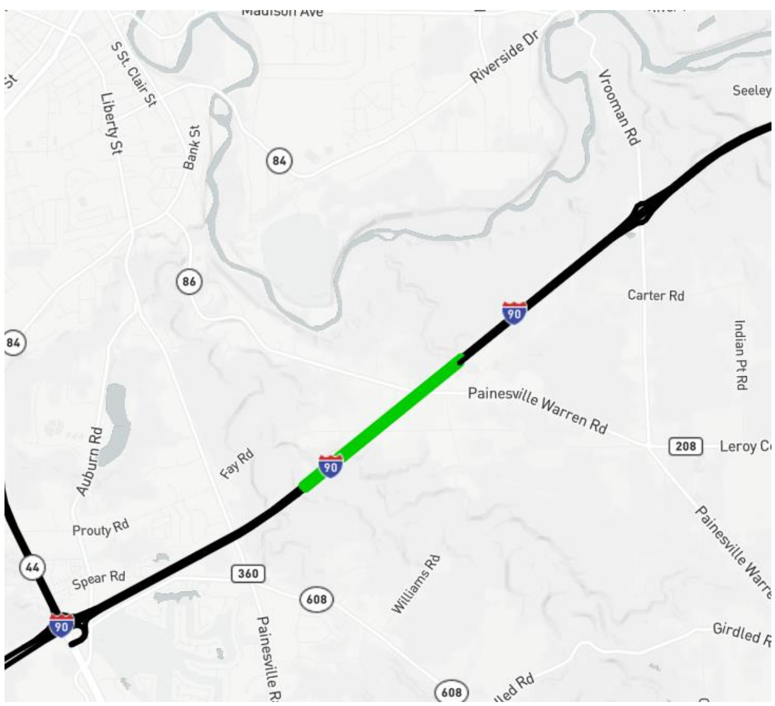
Quantitative data collected by IMRCP included road conditions, traffic conditions, and weather. The project team requested input from the State representatives about specific roadways and regions in the State for conducting the analysis. Using this approach, the team's analyses focused on the Cleveland and Columbus areas that have typically (and historically) been impacted most by storms.

In Cleveland, the project team focused on two regions near Lake Erie: Interstate 71 (I–71) near Ridge Road and Interstate 90 (I–90) near Painesville Warren Road. Figures 2 and 3 show the locations of the road segments that were examined.



Source: Federal Highway Administration; © OpenStreetMap contributors.

Figure 2. Screenshot. Interstate 71 northbound segment location near Cleveland.



Source: Federal Highway Administration; © OpenStreetMap contributors.

Figure 3. Screenshot. Interstate 71 southbound segment location near Cleveland.

In Columbus, the focus was on Interstate 670 (I–670) close to the John Glenn Columbus International Airport. Figure 4 shows the location of the road segment that was examined.

Source: Federal Highway Administration; © OpenStreetMap contributors.

Figure 4. Screenshot. Interstate 670 southbound segment location near Columbus.

Analyses included:

- Examining the reported IMRCP speeds versus the historical ODOT speeds
- Checking the reported supplemental data, including pavement temperature, snow depth, visibility, and precipitation
- Comparing the IMRCP speed forecasts including 15-, 30-, and 60-minute predictions to the actual ODOT speeds and assessing the forecast error (mean absolute error [MAE], relative absolute error [RAE], and root mean square error [RMSE])
- Comparing the IMRCP pavement temperature forecasts including 15-, 30-, and 60-minute to the reported IMRCP pavement temperatures and assessing the forecast error (MAE, RAE, and RMSE)

Table 1 lists the locations, time periods, and corresponding road and weather conditions that were studied in the Cleveland and Columbus areas.

Table 1. Weather conditions by location and date.

Location	January 1, 2022, 3 p.m. Eastern Time (ET) to January 17, 2022, 3 p.m. ET
I–71 northbound/southbound at Ridge Road	Light to moderate snow/wind gusts
I–90 eastbound/westbound at Painesville Road	Light to moderate snow/wind gusts
I–670 near John Glenn Columbus International Airport	Moderate snow and freezing rain

I–71 = Interstate 71. I–90 = Interstate 90. I–670 = Interstate 670.

The evaluation team completed the following analyses for each location and date.

Forecast Error Analyses

Forecast data were gathered in the same manner as the historical data using the reports page on the IMRCP web application. To evaluate forecast accuracy, the following forecast lead time values were selected: 15, 30, and 60 minutes.

Forecast values were generated for a 1-hour duration into the future, with reference values being each time stamp, which is each quarter of the hour for each hour of dates of interest. Curves for each of the forecast lead times were constructed and plotted along with the real time. The 15-minute forecast plot shows the forecast values for each time point predicted at a reference time 15 minutes before each time point. The 30-minute and 60-minute forecast plots follow the same logic.

Three metrics were used to calculate and compare the forecast errors: 1) MAE was calculated to measure the average difference between the forecasts and the actual values, 2) RAE was calculated to measure the absolute error of the predictions relative to a naive model, which predicted the mean for every data point, and 3) RMSE was calculated to measure the spread (or concentration) between forecasts and actual speeds. For all three metrics, lower numbers mean forecast and actual speeds are a better match. MAE is defined in Figure 5.

$$MAE_l = \frac{1}{n}\sum_{t=1}^{n} |y_t - \hat{y}_{t,l}|$$

Source: Federal Highway Administration

Figure 5. Equation. Mean absolute error equation.

where y_t is the observation at the time stamp t; $\widehat{y_{t,l}}$ represents the l lead time forecast from the time stamp t; and n is the total number of observations during 24-hour window. RAE is defined in Figure 6.

$$RAE_l = \frac{\sum_{t=1}^{n} |y_t - \hat{y}_{t,l}|}{\sum_{t=1}^{n} |y_t - \bar{y}|}$$

Source: Federal Highway Administration

Figure 6. Equation. Relative absolute error equation.

where y_t is the observation at the time stamp *t*; $\widehat{y_{t,l}}$ represents the l lead time forecast from the time stamp *t*; and $\bar{y}$ is the average of observations and *n* is the total number of observations during 24-hour window. RMSE is defined in Source: Federal Highway Administration

Figure 7.

$$RMSE_l = \sqrt{\frac{1}{n}\sum_{t=1}^{n}(y_t - \hat{y}_{t,l})^2}$$

Source: Federal Highway Administration

Figure 7. Equation. Root mean square error equation.

where y_t is the observation at the time stamp *t*; $\widehat{y_{t,l}}$ represents the l lead time forecast from the time stamp *t*; and $\bar{y}$ is the average of observations and *n* is the total number of observations during 24-hour window.

CHAPTER 3. RESULTS

This chapter presents the analyses for the IMRCP reported speeds, the IMRCP speed and pavement temperature forecasts, and user satisfaction interviews.

OPERATIONAL ACCURACY STUDY

Interstate 71 Northbound at Ridge Road (Lake Erie Area)

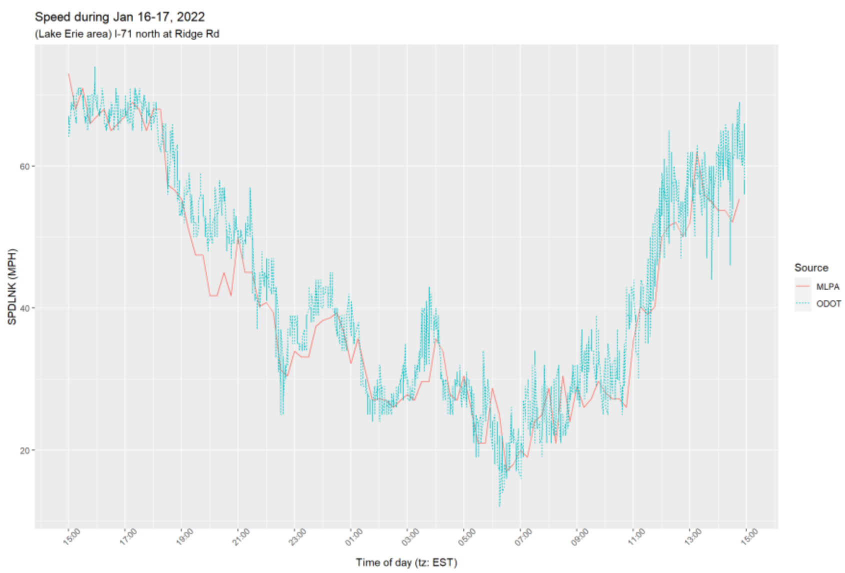
Reported Speeds versus Historical Observations and Weather and Road Conditions

Figure 8 displays the MLPA predicted speeds and historical ODOT real-time speeds obtained for I–71 northbound and Ridge Road from January 16, 2022, 3 p.m. eastern time (ET), to January 17, 2022, 3 p.m. ET. The MLPA speed predictions and the ODOT actual speeds appeared to have a similar pattern during the time period. The plots in figure 9 depict, from top to bottom, temperature of pavement (TPVT), DPHSN, visibility of surface (VIS), and precipitation category (PCCAT) obtained for the same location from the same time period.

The four plots present a snapshot of the road and weather conditions:

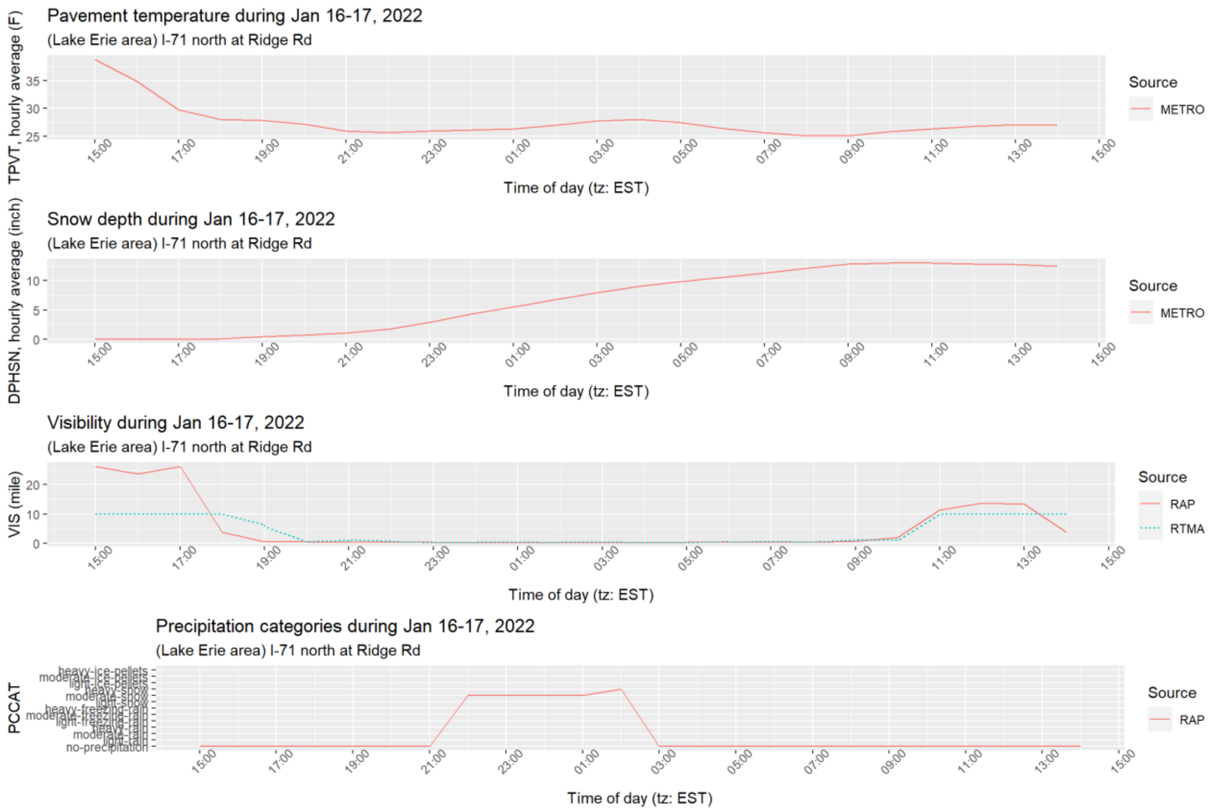
- Pavement temperature dropped below 30 degrees Fahrenheit (°F) at about 5 p.m. and remained throughout the rest of the period according to the METRo.
- Visibility was reduced starting at about 5 p.m. and reached zero visibility at about 8 p.m. according to the rapid refresh (RAP) and real-time mesoscale analysis (RTMA) sources.

The road and weather conditions corresponded to the decreasing trend in speed from 5 p.m. on January 16 to 7 a.m. on January 17.



Source: Federal Highway Administration

Figure 8. Graph. Machine learning-based prediction model predicted speeds and historical Ohio Department of Transportation real-time speeds.



Source: Federal Highway Administration

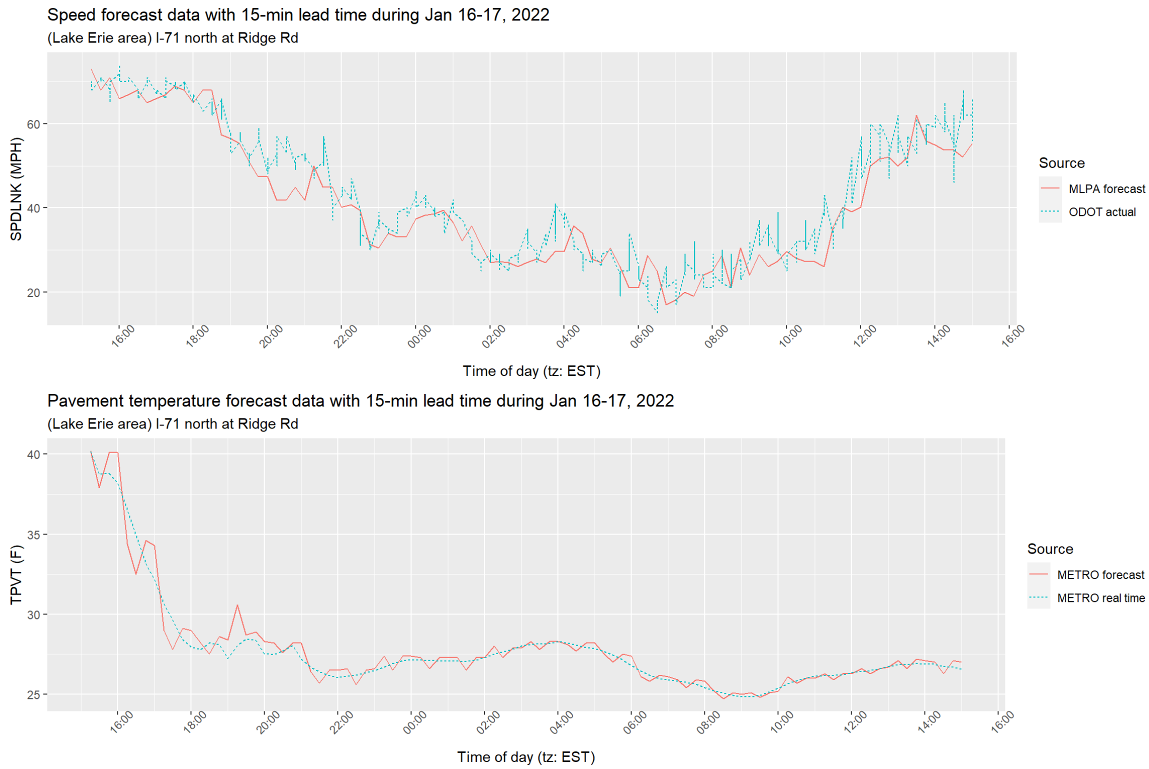
Figure 9. Graph. Weather and road conditions.

Speed and Pavement Temperature Forecasts

The plots in figures 10-12 display the forecast speeds and pavement temperatures for I–71 northbound and Ridge Road from January 16, 2022, 3 p.m. ET, to January 17, 2022, 3 p.m. ET.

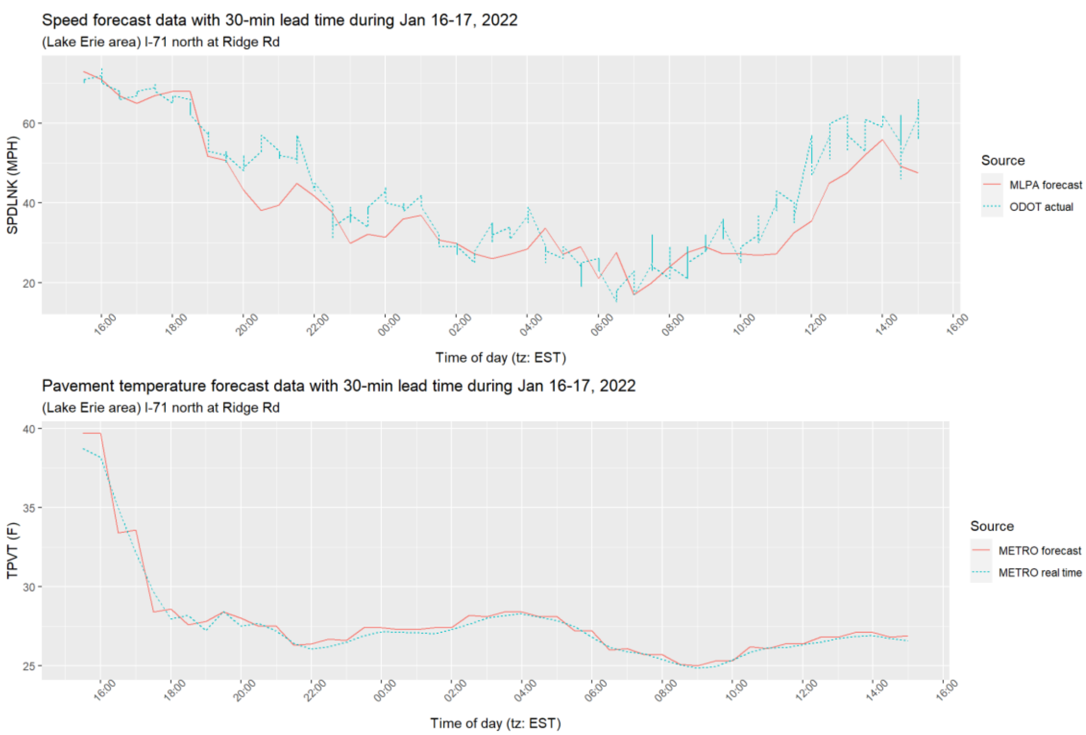
The plots show:

- MLPA speed forecasts and ODOT actual speeds showed similar patterns. The deviations appeared to grow larger with longer forecasts.
- METRo pavement temperature forcasts and METRo real-time pavement temperature predictions had similar patterns. The deviations seemed to be minimal regardless of the lead time length.



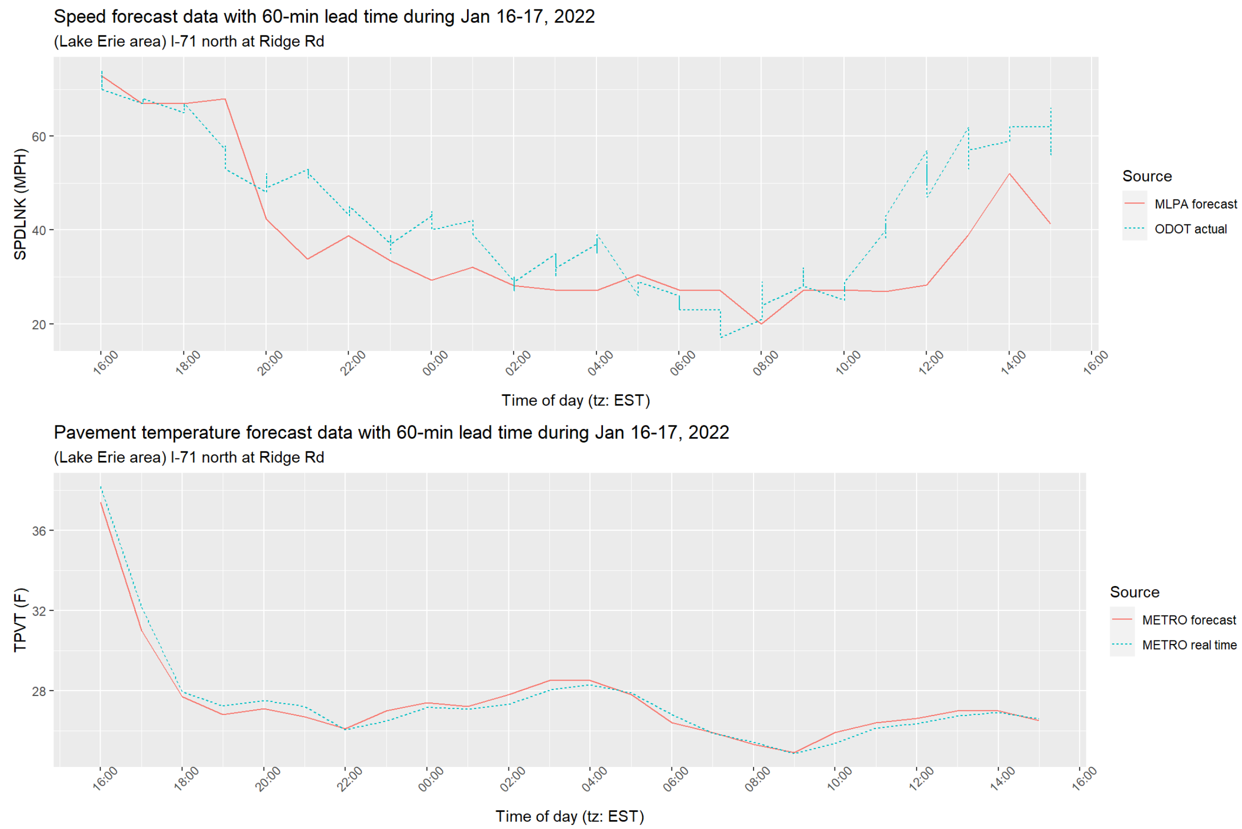
Source: Federal Highway Administration

Figure 10. Graph. Forecast speeds and pavement temperatures for 15-minute lead time.



Source: Federal Highway Administration

Figure 11. Graph. Forecast speeds and pavement temperatures for 30-minute lead time.



Source: Federal Highway Administration

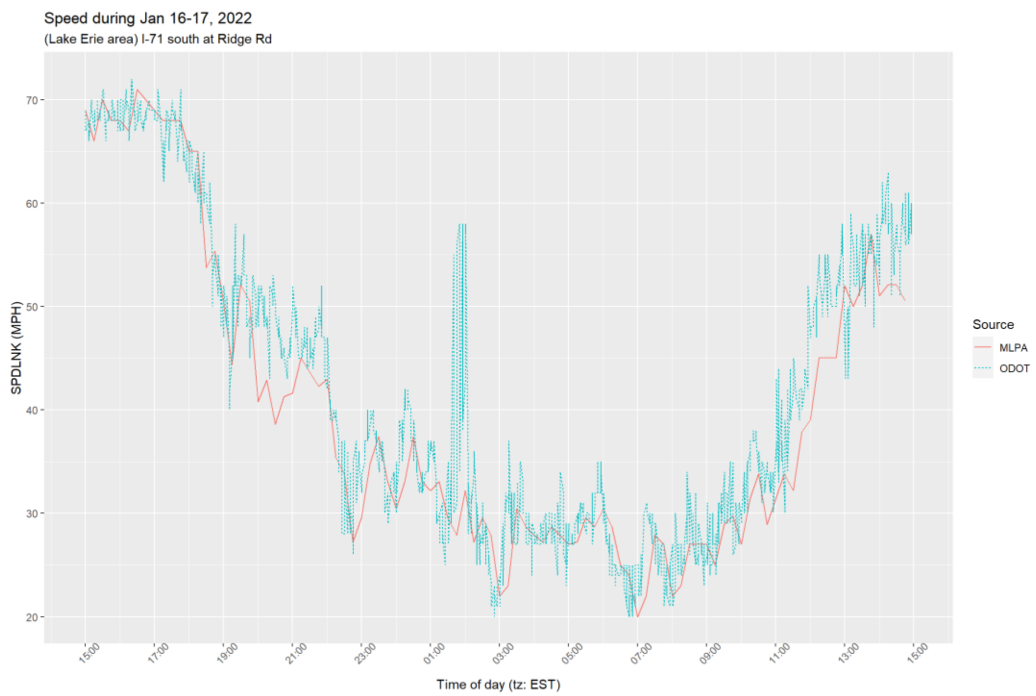
Figure 12**. Graph. Forecast speeds and pavement temperatures for 60-minute lead time.**

Interstate 71 Southbound at Ridge Road (Lake Erie Area)

Reported Speeds versus Historical Observations and Weather and Road Conditions

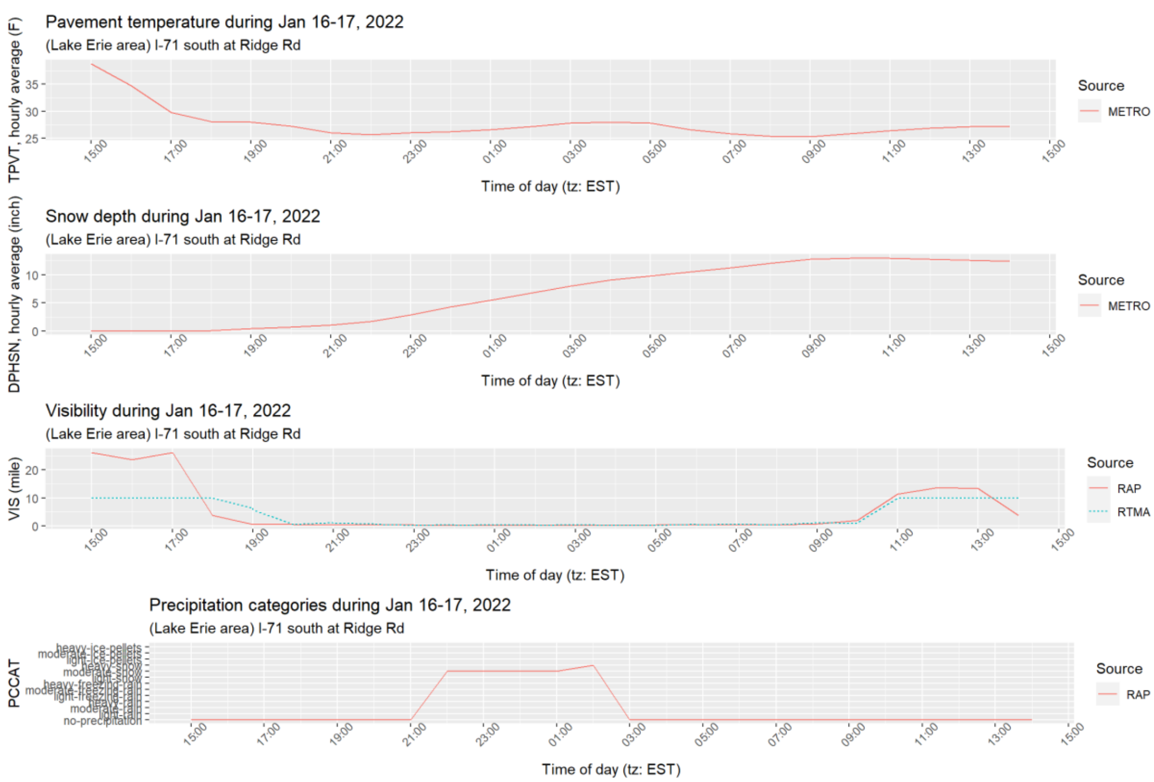
Figure 13 displays the MLPA predicted speeds and historical ODOT real-time speeds obtained for I–71 southbound and Ridge Road from January 16, 2022, 3 p.m. ET, to January 17, 2022, 3 p.m. ET. There was a spike in ODOT actual speeds around 2 a.m. Otherwise, the MLPA predictions and the ODOT actual speeds showed a similar pattern.

The plots in figure 14 depict, from top to bottom, TPVT, DPHSN, VIS, and PCCAT obtained for the same location from the same time period. The four plots present a snapshot of the road and weather conditions, which are similar to the northbound segment. They also correspond to the overall decreasing trend in speed from 5 p.m. on January 16 to 7 a.m. on January 17.



Source: Federal Highway Administration

Figure 13. Graph. Machine learning-based prediction model predicted speeds and historical Ohio Department of Transportation real-time speeds.



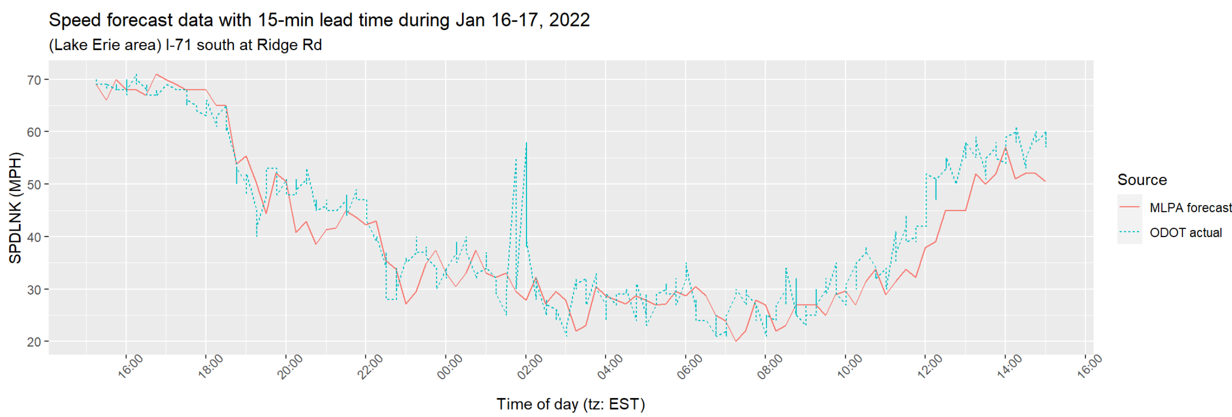
Source: Federal Highway Administration

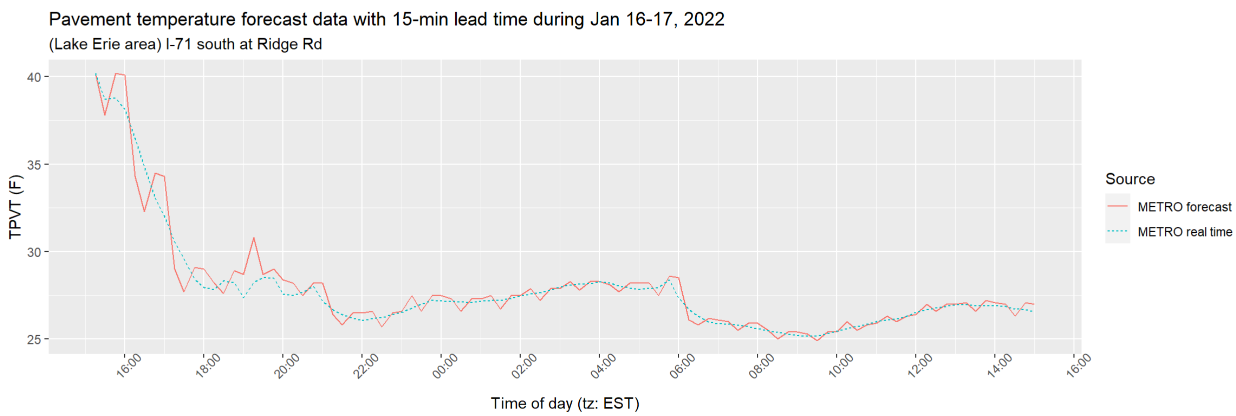
Figure 14. Graph. Weather and road conditions.

Speed and Pavement Temperature Forecasts

The plots in figures 15-17 display the forecast speeds and pavement temperatures for I–71 southbound and Ridge Road from January 16, 2022, 3 p.m. ET, to January 17, 2022, 3 p.m. ET. The plots show:

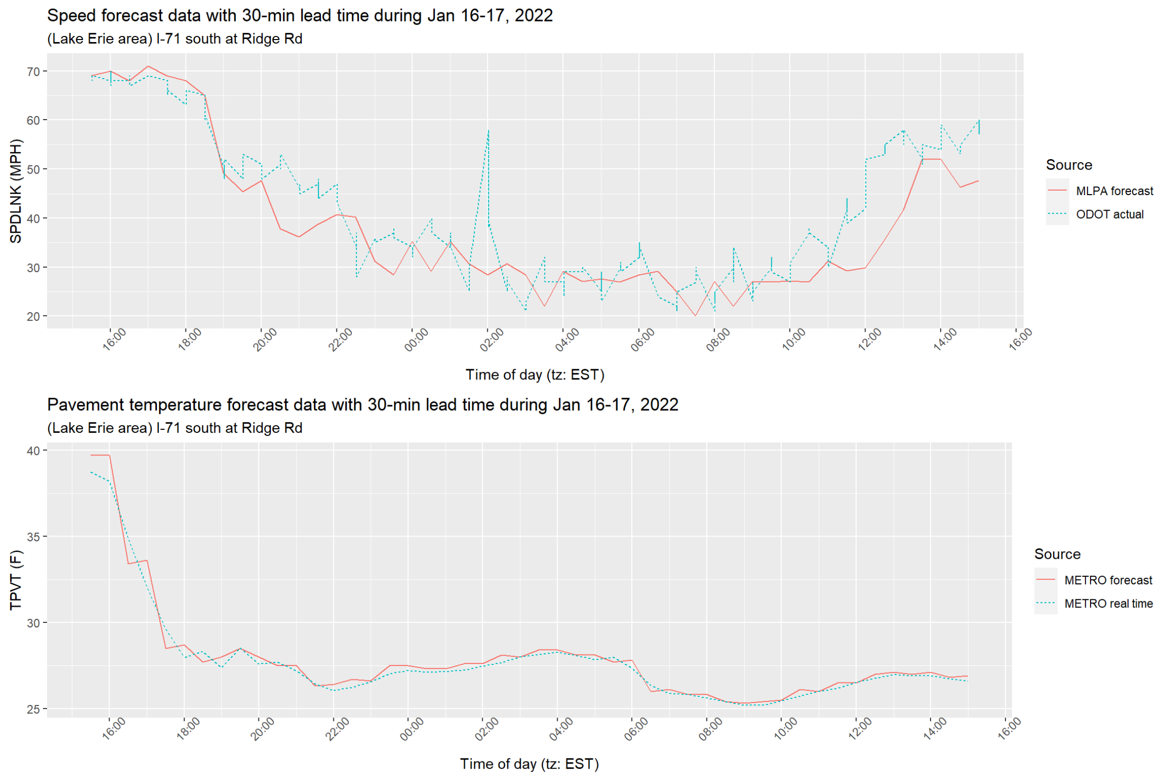
- MLPA speed forecasts and ODOT actual speeds generally had similar patterns, except for the large deviations showing at around 2 a.m. The deviations appeared to grow larger with longer forecasts.
- METRo pavement temperatures forecasts and METRo real-time pavement temperatures predictions had similar patterns. The deviations seemed to be minimal regardless of the lead time length.





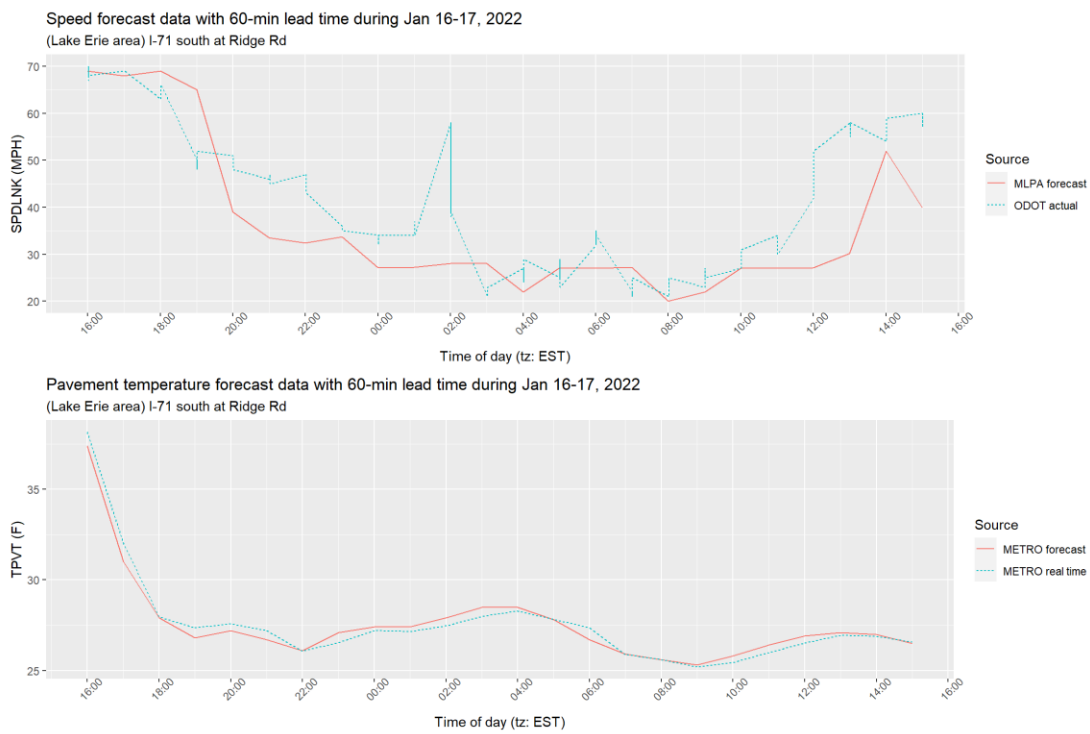
Source: Federal Highway Administration

Figure 15. Graph. Forecast speeds and pavement temperatures for 15-minute lead time.



Source: Federal Highway Administration

Figure 16. Graph. Forecast speeds and pavement temperatures for 30-minute lead time.



Source: Federal Highway Administration

Figure 17. Graph. Forecast speeds and pavement temperatures for 60-minute lead time.

Interstate 90 Eastbound at Painesville Warren Road (Lake Erie Area)

Reported Speeds versus Historical Observations and Weather and Road Conditions

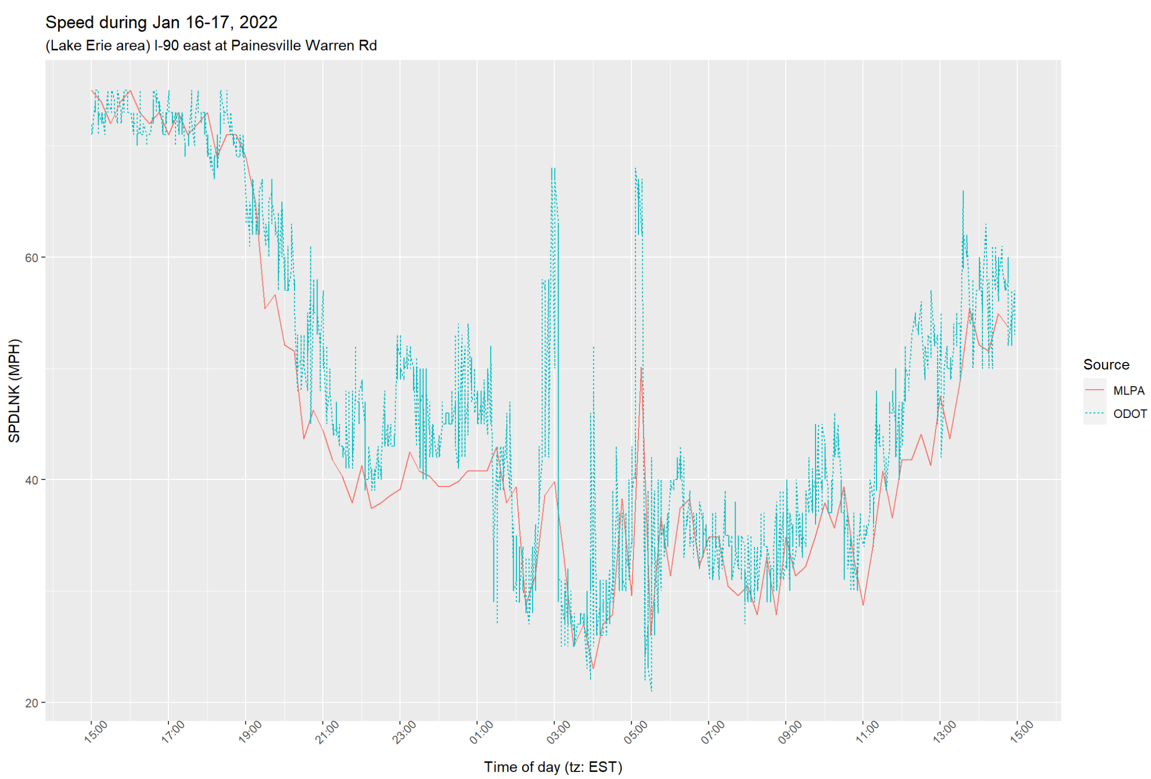
Figure 18 displays the MLPA predicted speeds and historical ODOT real-time speeds obtained for I–90 eastbound and Painesville Warren Road from January 16, 2022, 3 p.m. ET, to January 17, 2022, 3 p.m. ET. The MLPA speed predictions and the ODOT actual speeds generally shared a similar pattern. There were, however, a few large spikes in ODOT actual speeds between 3 and 5 a.m.

The plots in figure 19 depict, from top to bottom, TPVT, DPHSN, VIS, and PCCAT obtained for the same location from the same time period.

The four plots present a snapshot of the road and weather conditions:

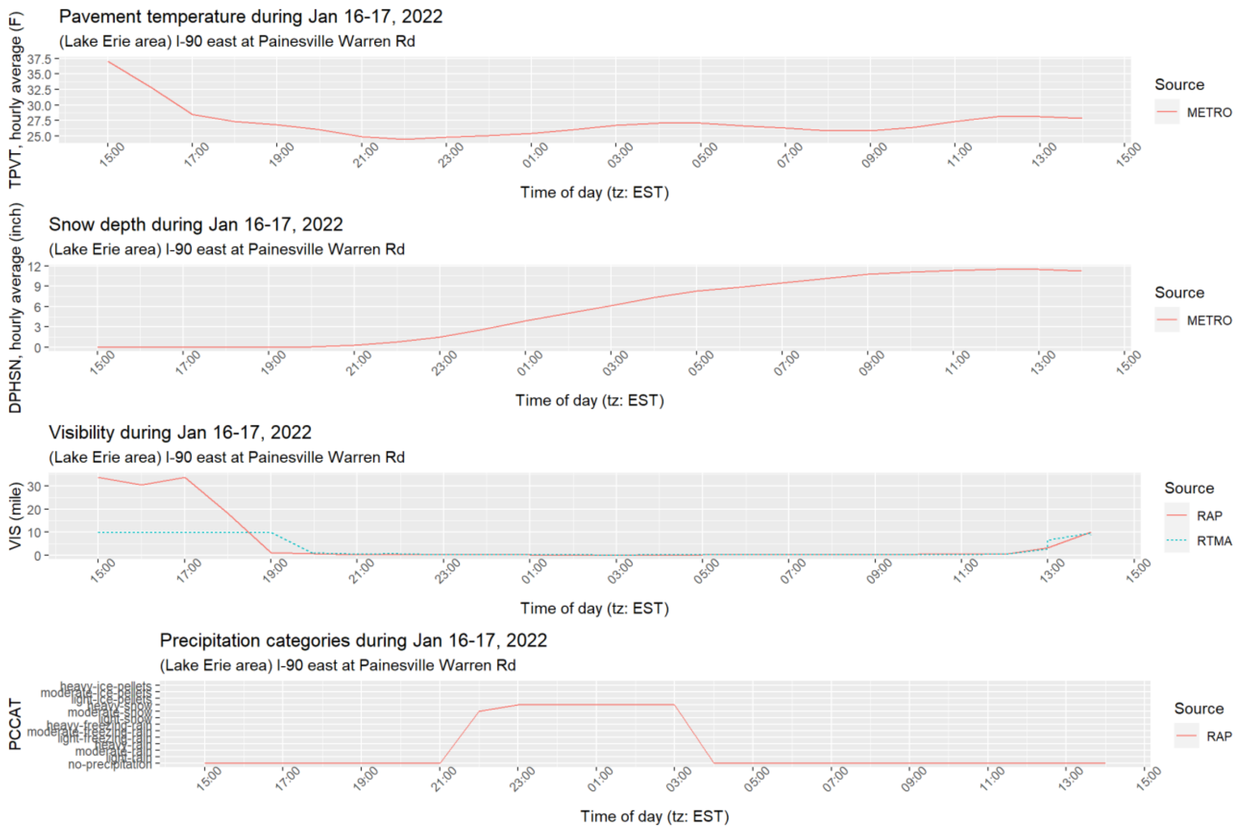
- Pavement temperature dropped below 30 °F at around 5 p.m. and remained throughout the rest of the period according to the METRo.
- Visibility was reduced starting at about 5 p.m. and reached zero visibility at about 8 p.m. according to the RAP and RTMA sources.

The road and weather conditions corresponded to the decreasing trend in speed from 5 p.m. on January 16 to 7 a.m. on January 17.



Source: Federal Highway Administration

Figure 18. Graph. Machine learning-based prediction model predicted speeds and historical Ohio Department of Transportation real-time speeds.



Source: Federal Highway Administration

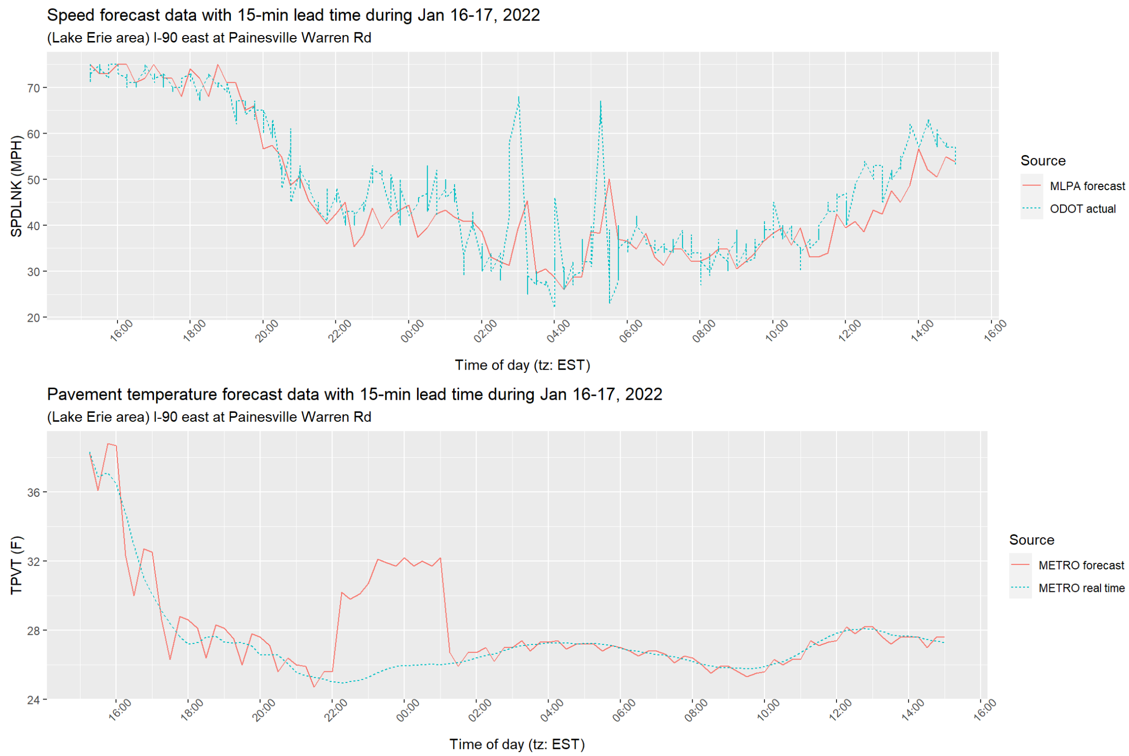
Figure 19. Graph. Weather and road conditions.

Speed and Pavement Temperature Forecasts

The plots in figure 20-22 display the forecast speeds and pavement temperatures for I–90 eastbound and Painesville Warren Road from January 16, 2022, 3 p.m. ET, to January 17, 2022, 3 p.m. ET.

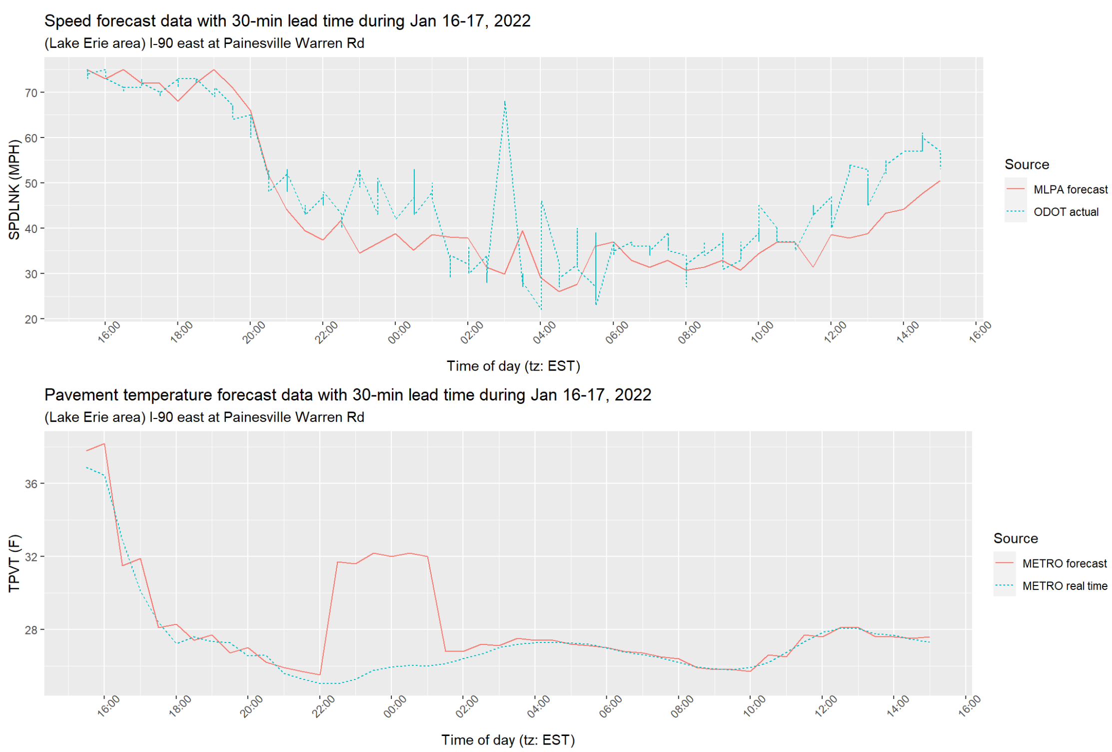
The plots show:

- MLPA speed forecasts and ODOT actual speeds generally had similar patterns, except for the large deviations showing between 2 and 5 a.m. The deviations appeared to grow larger with longer forecasts.
- METRo pavement temperatures forecasts showed higher pavement temperatures between 10 p.m. and 1 a.m. Otherwise, its pattern was similar to the METRo real-time pavement temperatures predictions.



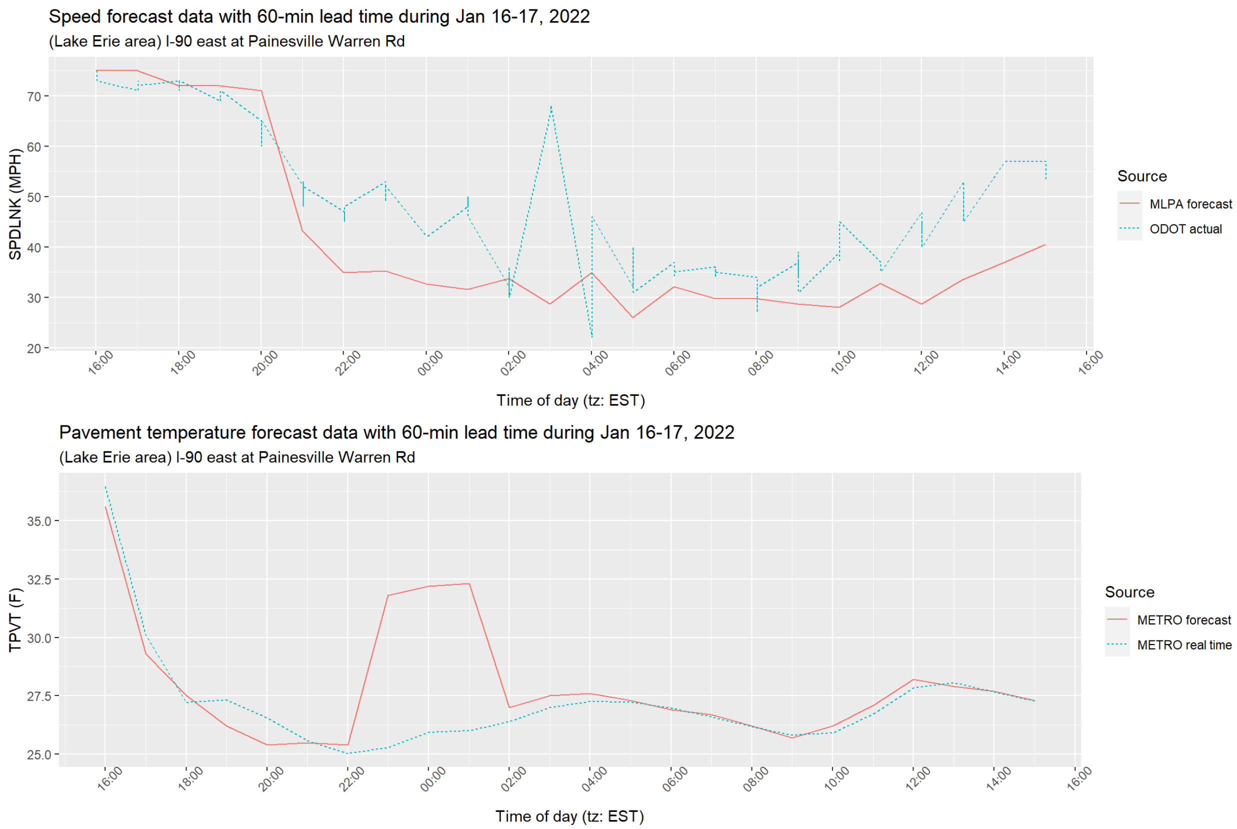
Source: Federal Highway Administration

Figure 20. Graph. Forecast speeds and pavement temperatures for 15-minute lead time.



Source: Federal Highway Administration

Figure 21. Graph. Forecast speeds and pavement temperatures for 30-minute lead time.



Source: Federal Highway Administration

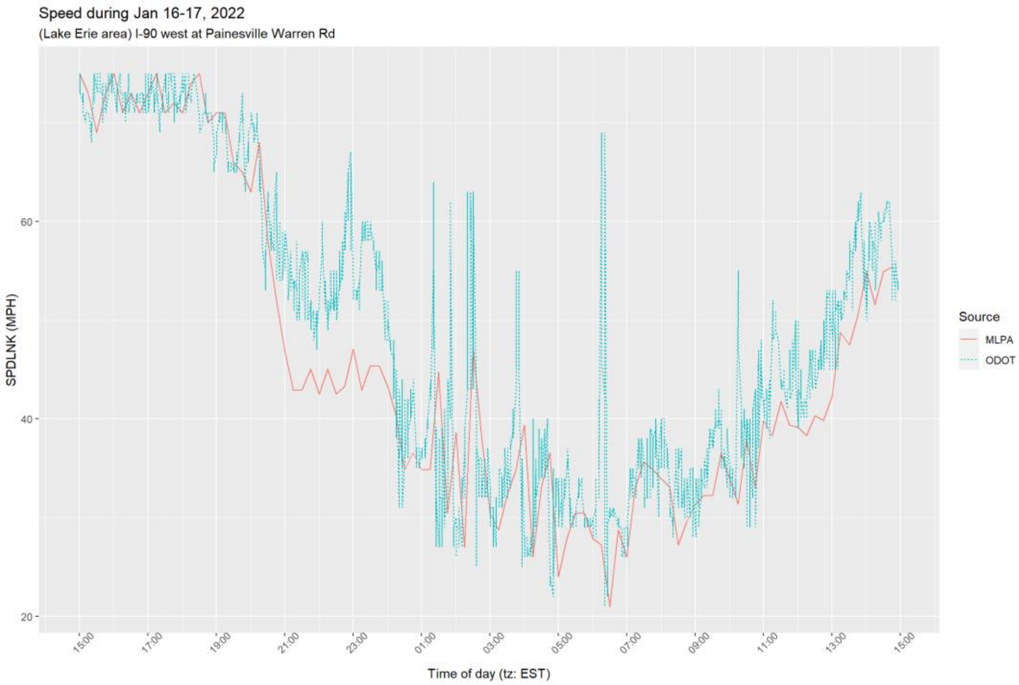
Figure 22. Graph. Forecast speeds and pavement temperatures for 60-minute lead time.

Interstate 90 Westbound at Painesville Warren Road (Lake Erie Area)

Reported Speeds versus Historical Observations and Weather and Road Conditions

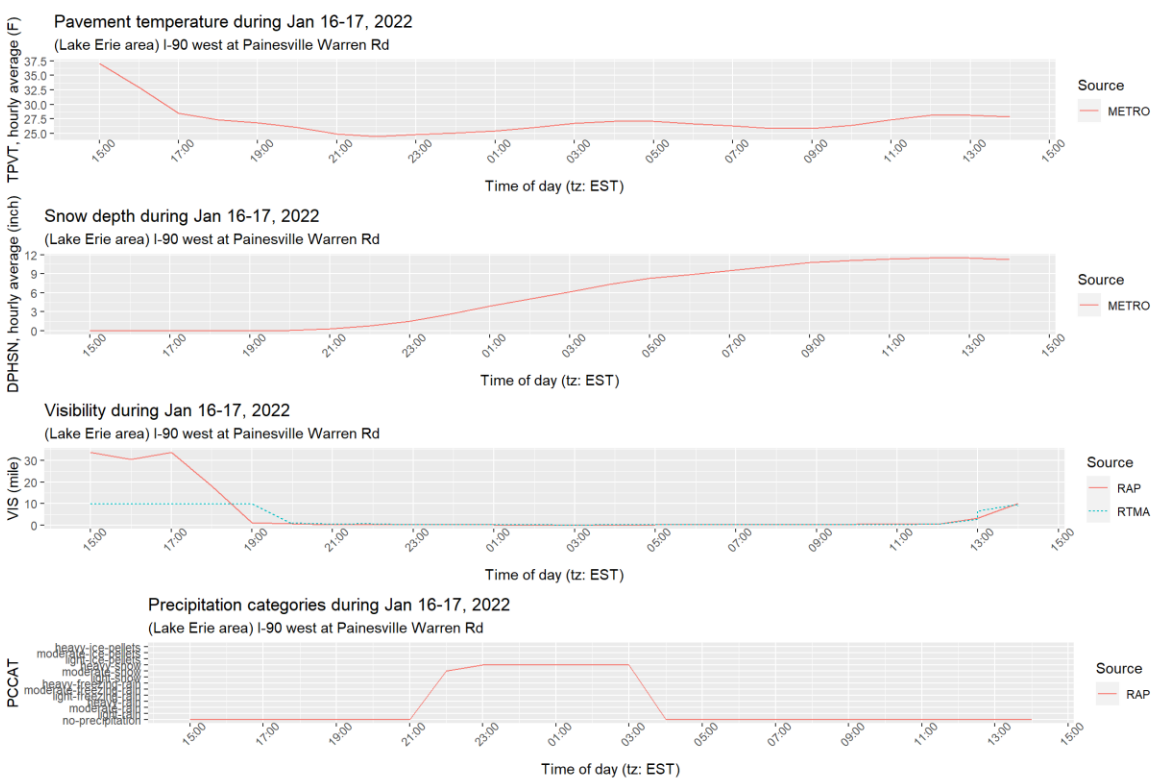
Figure 23 displays the MLPA predicted speeds and historical ODOT real-time speeds obtained for I–90 eastbound and Painesville Warren Road from January 16, 2022, 3 p.m. ET, to January 17, 2022, 3 p.m. ET. MLPA predictions and the ODOT actual speeds generally showed a similar pattern; however, there appeared to be large deviations between 11 p.m. and 6 a.m.

The plots in figure 24 depict, from top to bottom, TPVT, DPHSN, VIS, and PCCAT obtained for the same location from the same time period. The four plots present a snapshot of the road and weather conditions, which are similar to the eastbound segment. They also correspond to the overall decreasing trend in speed from 5 p.m. on January 16 to 7 a.m. on January 17.



Source: Federal Highway Administration

Figure 23. Graph. Machine learning-based prediction model predicted speeds and historical Ohio Department of Transportation real-time speeds.



Source: Federal Highway Administration

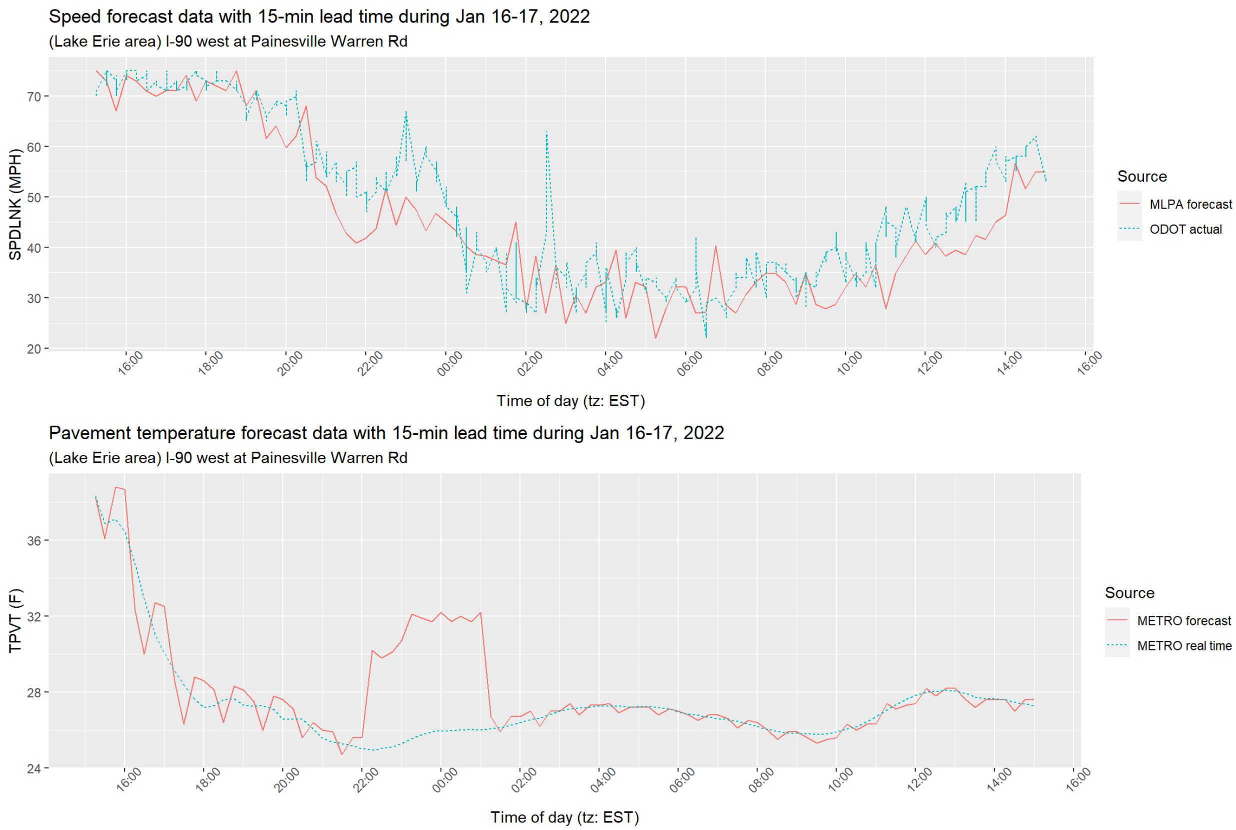
Figure 24. Graph. Weather and Road Conditions.

Speed and Pavement Temperature Forecasts

The plots in figure 25-27 display the forecast speeds and pavement temperatures for I–90 westbound and Painesville Warren Road from January 16, 2022, 3 p.m. ET, to January 17, 2022, 3 p.m. ET.

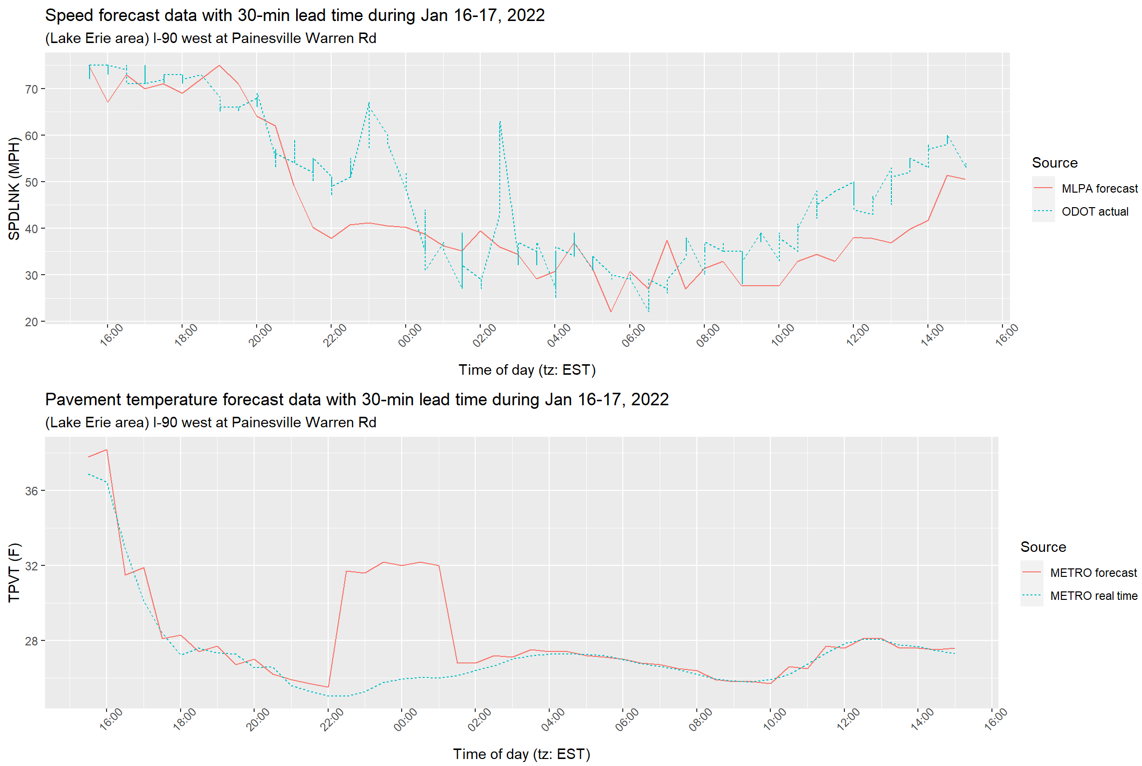
The plots show:

- MLPA speed forecasts and ODOT actual speeds generally had similar patterns, except for the large deviations showing at around 11 p.m. and 3 a.m. The deviations appeared to grow larger with longer forecasts.
- METRo pavement temperatures forecasts and METRo real-time pavement temperatures predictions generally had similar pattern, except for the period between 10 p.m. and 1 a.m.



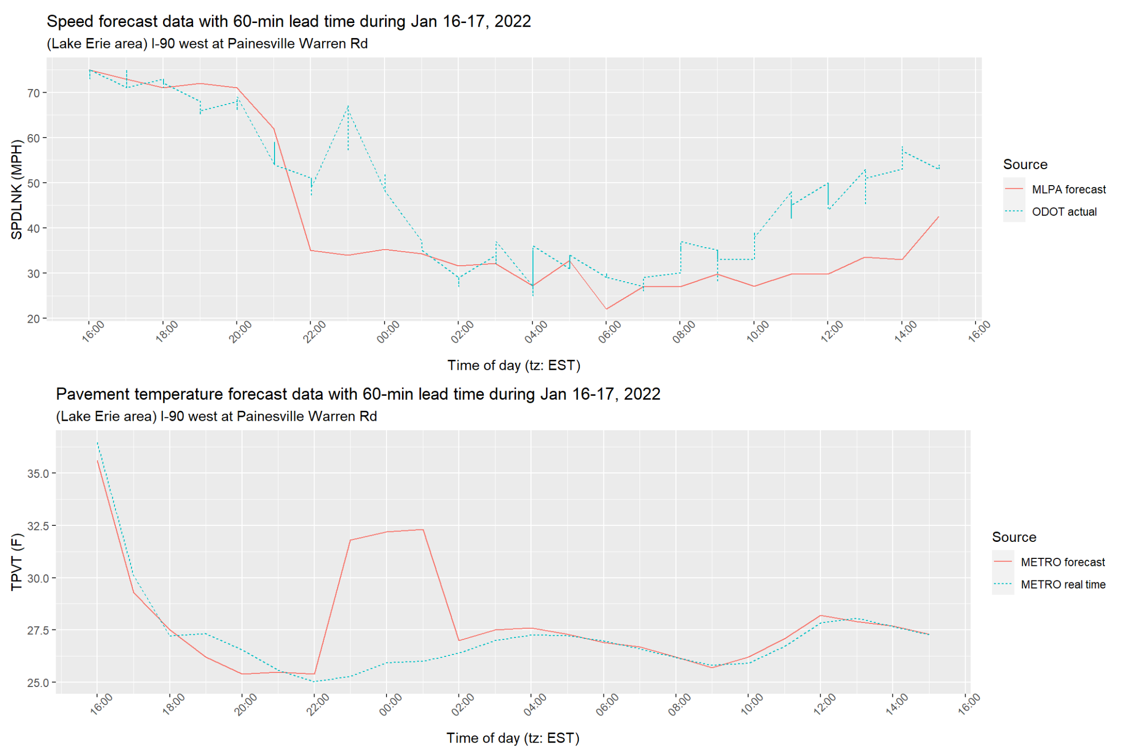
Source: Federal Highway Administration

Figure 25. Graph. Forecast speeds and pavement temperatures for 15-minute lead time.



Source: Federal Highway Administration

Figure 26. Graph. Forecast speeds and pavement temperatures for 30-minute lead time.



Source: Federal Highway Administration

Figure 27. Graph. Forecast speeds and pavement temperatures for 60-minute lead time.

Interstate 670 Eastbound near the John Glenn Columbus International Airport (Columbus Area)

Reported Speeds versus Historical Observations and Weather and Road Conditions

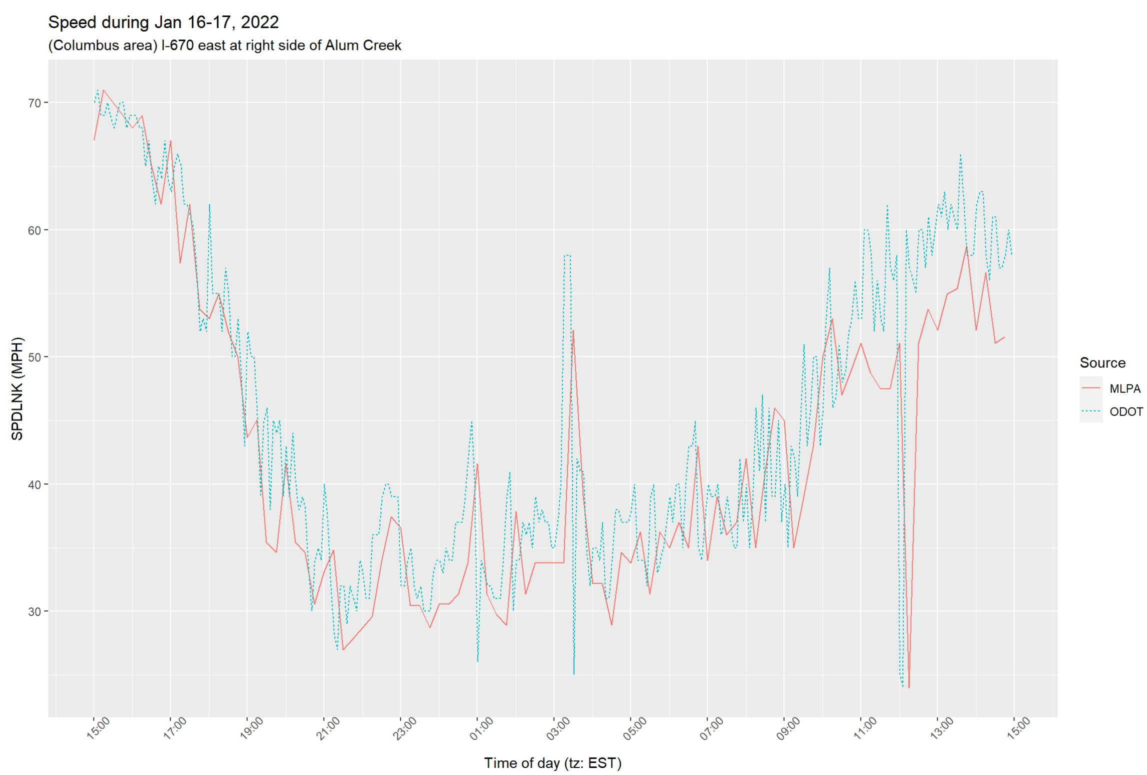
Figure 28 displays the MLPA predicted speeds and historical ODOT real-time speeds obtained for I–670 eastbound near the John Glenn Columbus International Airport from January 16, 2022, 3 p.m. ET, to January 17, 2022, 3 p.m. ET. The MLPA speed predictions and the ODOT actual speeds appeared to have a similar pattern during the time period.

The plots in figure 29 depict, from top to bottom, TPVT, DPHSN, VIS, and PCCAT obtained for the same location from the same time period.

The four plots present a snapshot of the road and weather conditions:

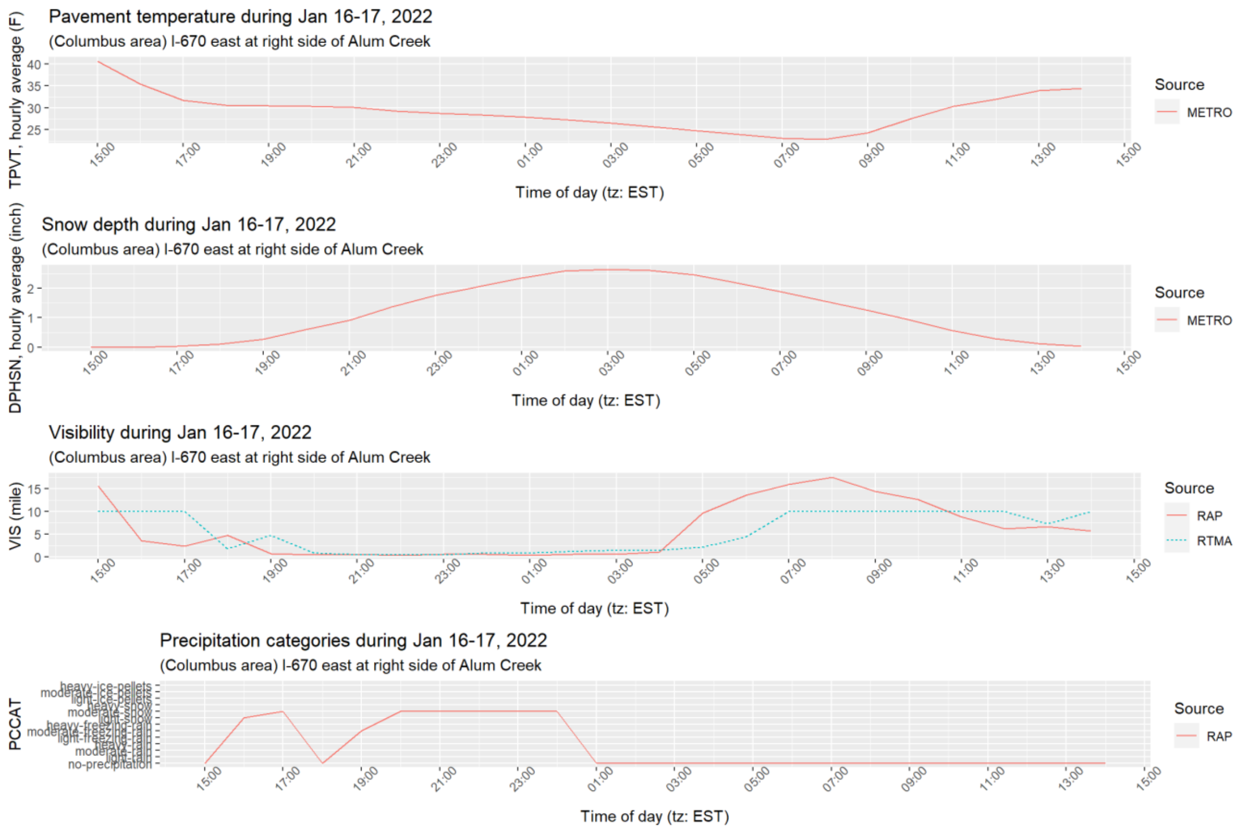
- Pavement temperature dropped below 30 °F at about 7 p.m. and remained throughout the rest of the period according to the METRo.
- Visibility was reduced starting at about 3 p.m. and reached zero visibility at about 7 p.m. according to the RAP and RTMA sources.

The road and weather conditions corresponded to the decreasing trend in speed starting from 3 p.m. on January 16.



Source: Federal Highway Administration

Figure 28. Graph. Machine learning-based prediction model predicted speeds and historical Ohio Department of Transportation real-time speeds.

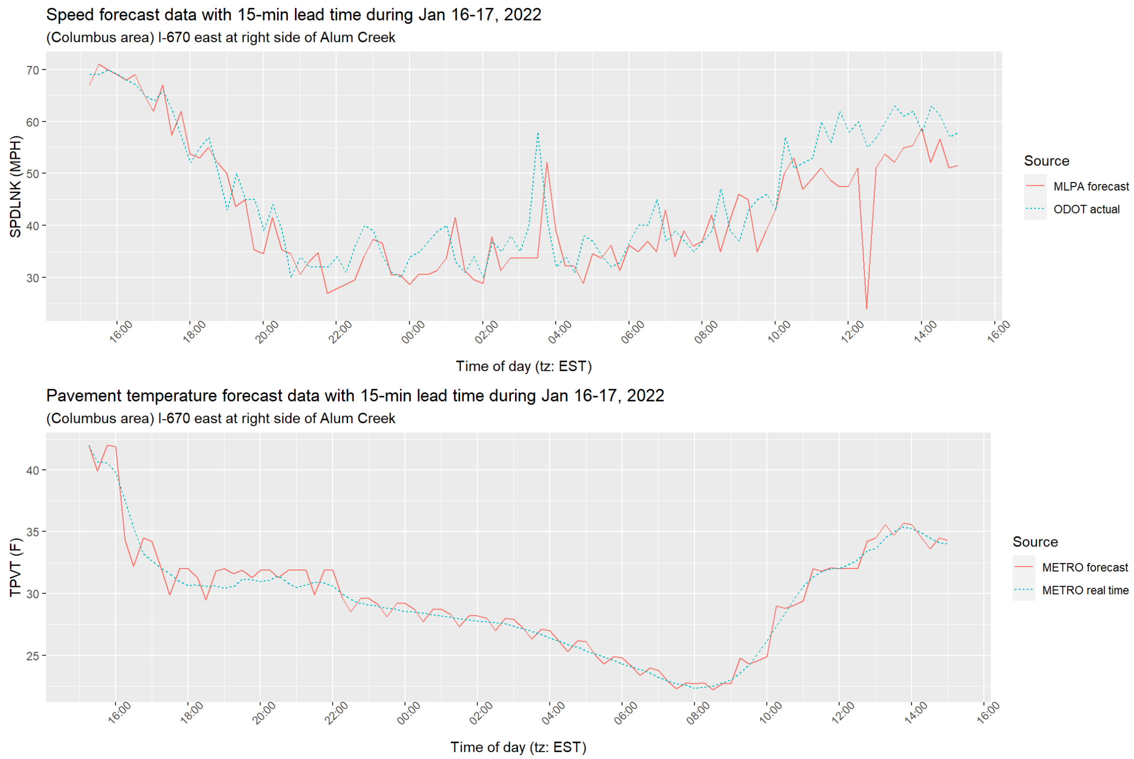


Source: Federal Highway Administration

Figure 29. Graph. Weather and road conditions.

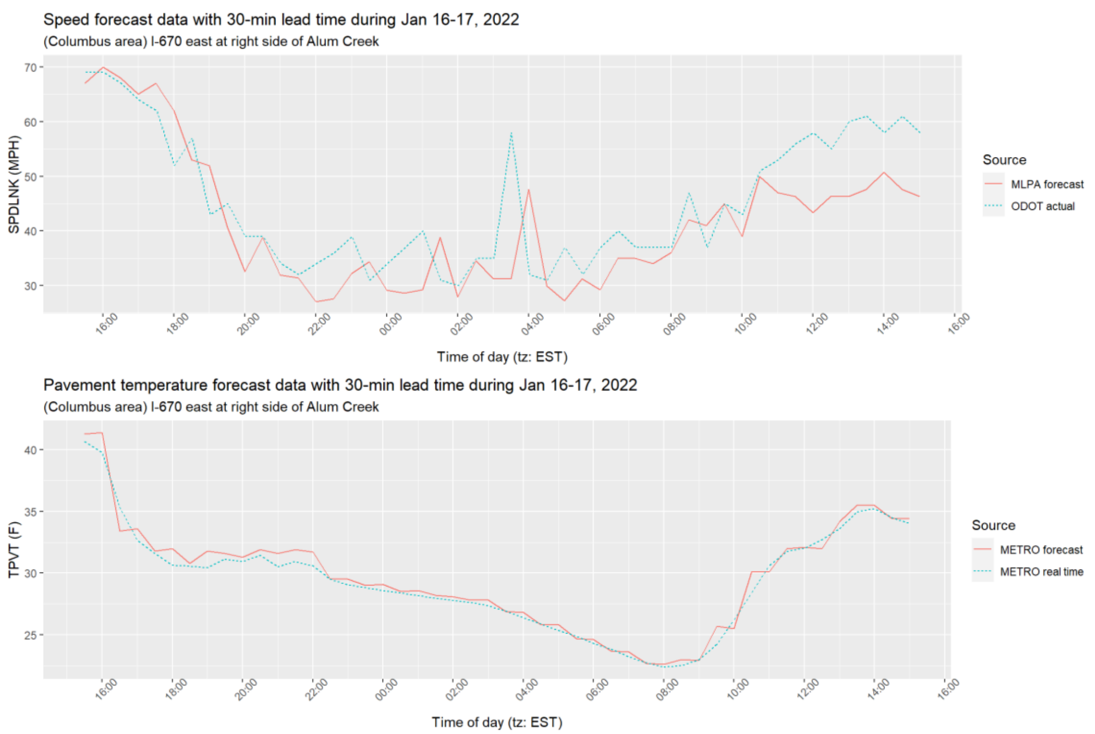
Speed and Pavement Temperature Forecasts

The plots in figures 30-32 display the forecast speeds and pavement temperatures for I–670 eastbound near the John Glenn Columbus International Airport from January 16, 2022, 3 p.m. ET, to January 17, 2022, 3 p.m. ET. MLPA speed forecasts and ODOT actual speeds generally had similar patterns, except for the large deviations showing at around noon on January 17. The deviations appeared to grow larger with longer forecasts. METRo pavement temperatures forecasts and METRo real-time pavement temperatures predictions had similar patterns. The deviations seemed to be minimal regardless of the lead time length.



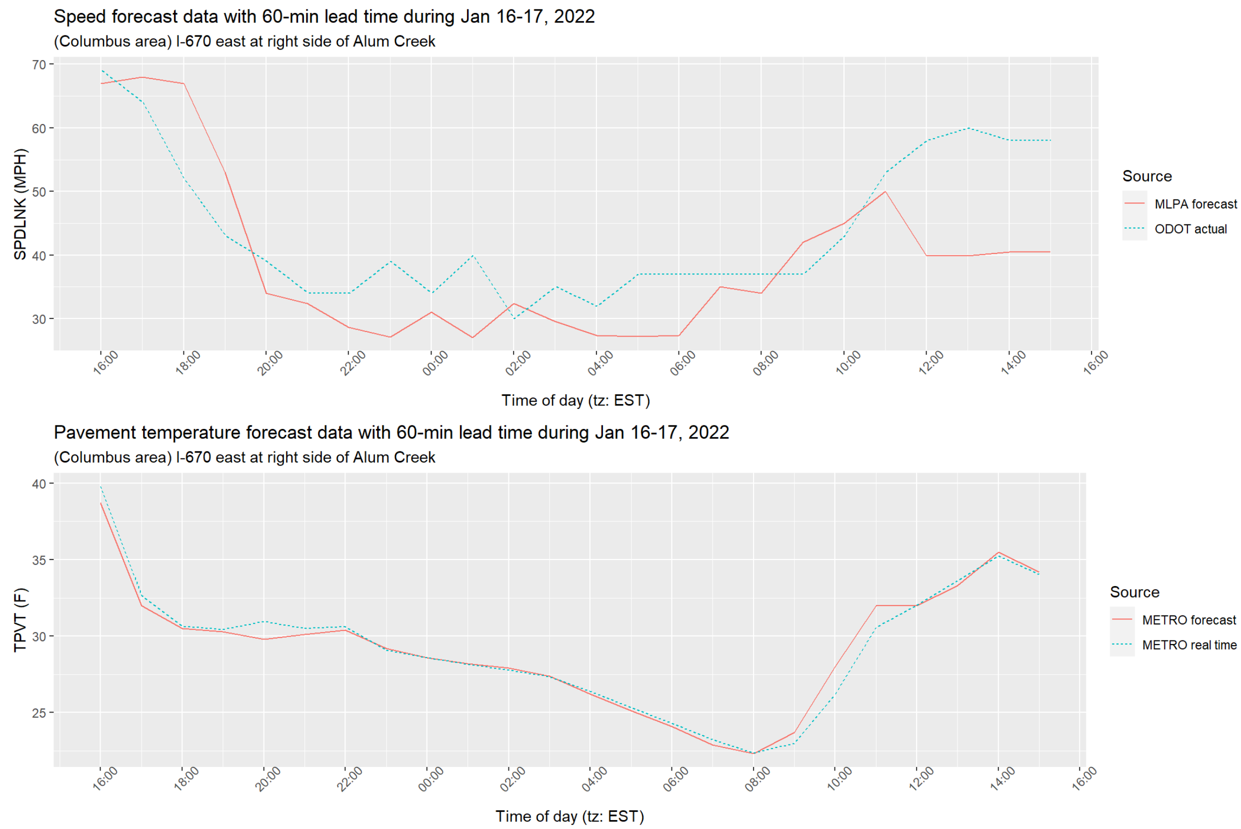
Source: Federal Highway Administration

Figure 30. Graph. Forecast speeds and pavement temperatures for 15-minute lead time.



Source: Federal Highway Administration

Figure 31. Graph. Forecast speeds and pavement temperatures for 30-minute lead time.



Source: Federal Highway Administration

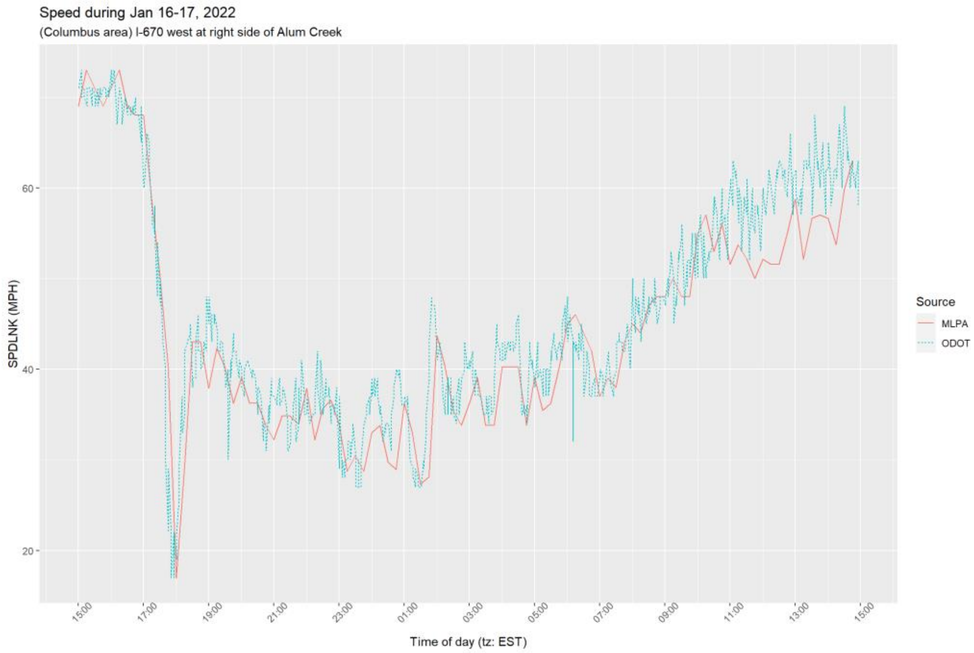
Figure 32. Graph. Forecast speeds and pavement temperatures for 60-minute lead time.

Interstate 670 Westbound near the John Glenn Columbus International Airport (Columbus Area)

Reported Speeds versus Historical Observations and Weather and Road Conditions

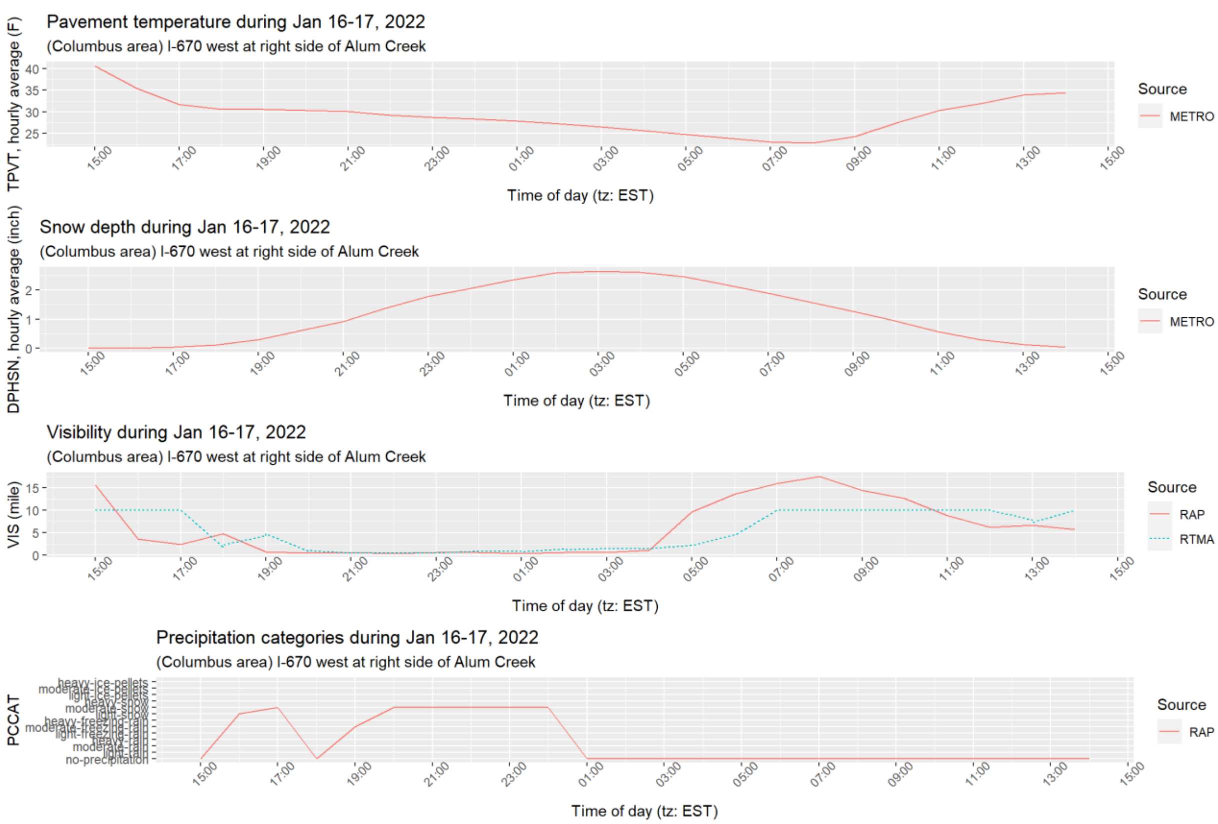
Figure 33 displays the MLPA predicted speeds and historical ODOT real-time speeds obtained for I–670 westbound near the John Glenn Columbus International Airport from January 16, 2022, 3 p.m. ET, to January 17, 2022, 3 p.m. ET. The MLPA speed predictions and the ODOT actual speeds showed a similar pattern during the time period.

The plots in figure 34 depict, from top to bottom, TPVT, DPHSN, VIS, and PCCAT obtained for the same location from the same time period. The four plots present a snapshot of the road and weather conditions, which are very similar to the eastbound segment. They also correspond to the overall decreasing trend in speed starting from 3 p.m. on January 16.



Source: Federal Highway Administration

Figure 33. Graph. Machine learning-based prediction model predicted speeds and historical Ohio Department of Transportation real-time speeds.



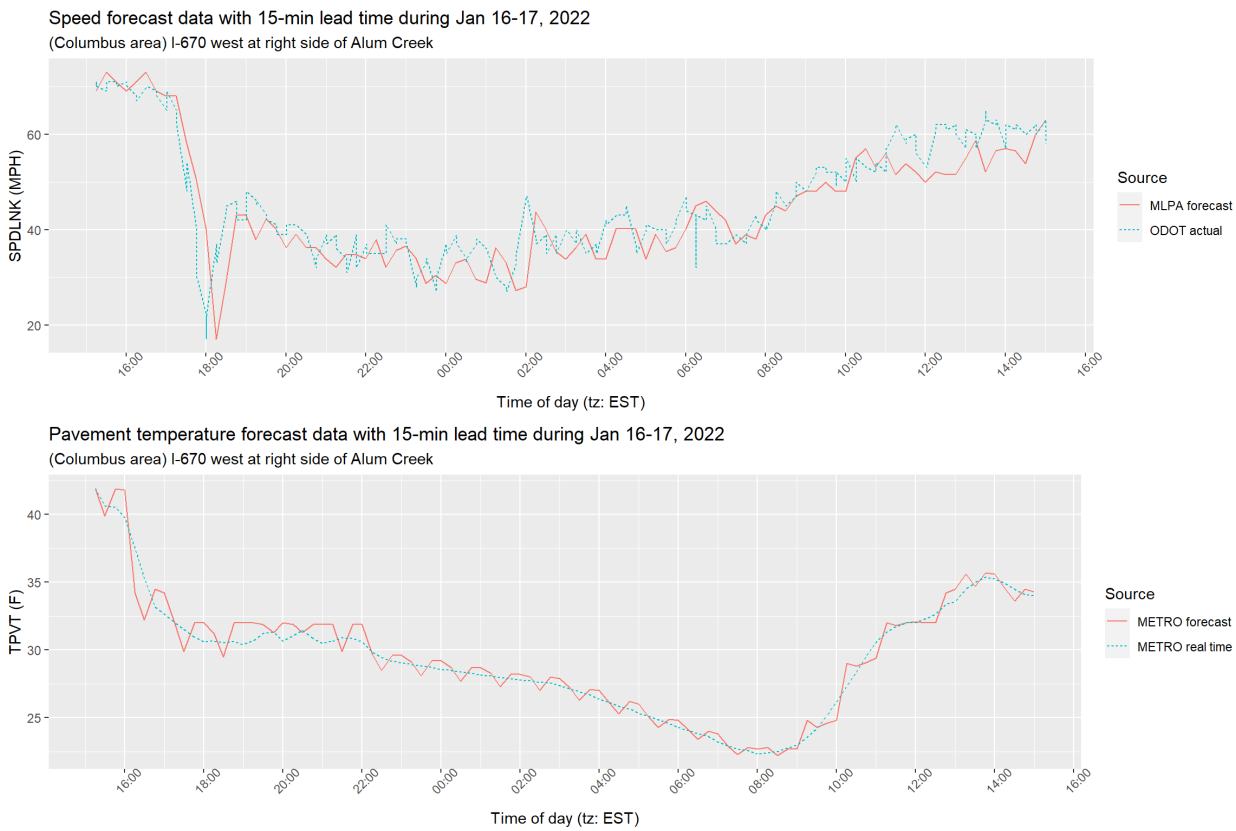
Source: Federal Highway Administration

Figure 34. Graph. Weather and road conditions.

Speed and Pavement Temperature Forecasts

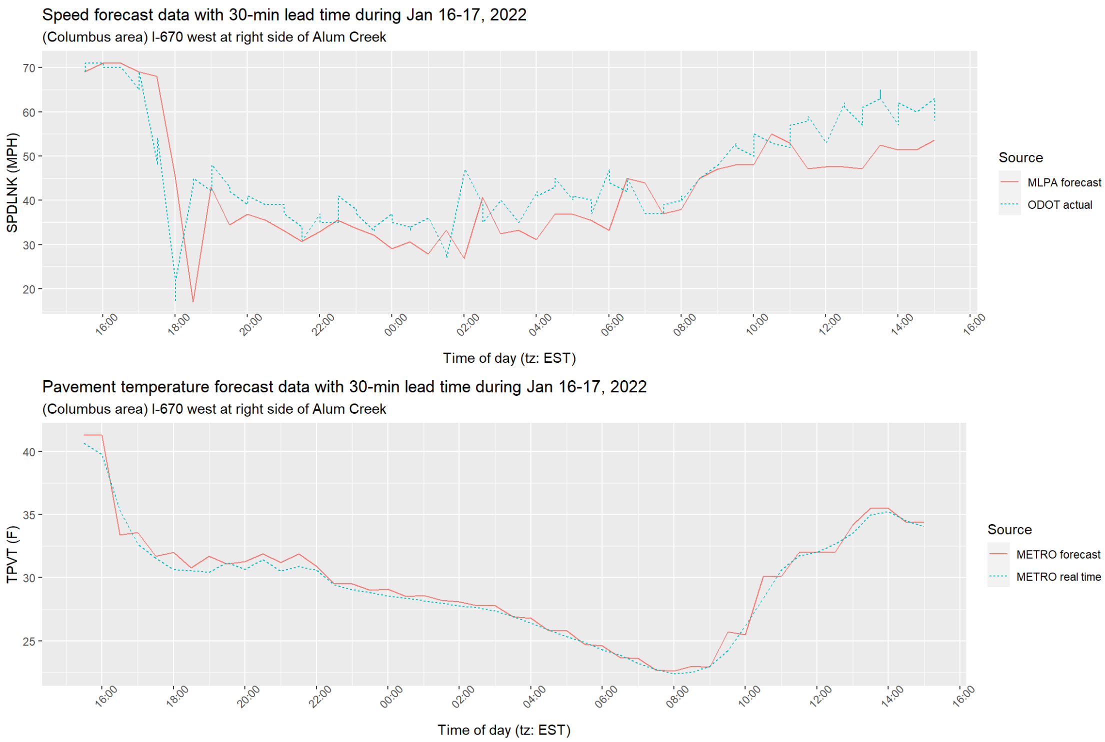
The plots in figures 35-37 display the forecast speeds and pavement temperatures for I–670 westbound near the John Glenn Columbus International Airport from January 16, 2022, 3 p.m. ET, to January 17, 2022, 3 p.m. ET.

MLPA speed forecasts and ODOT actual speeds generally had similar patterns. The deviations appeared to grow larger with longer forecasts. METRo pavement temperatures forecasts and METRo real-time pavement temperatures predictions appeared to be similar. The deviations seemed to be minimal regardless of the lead time length.



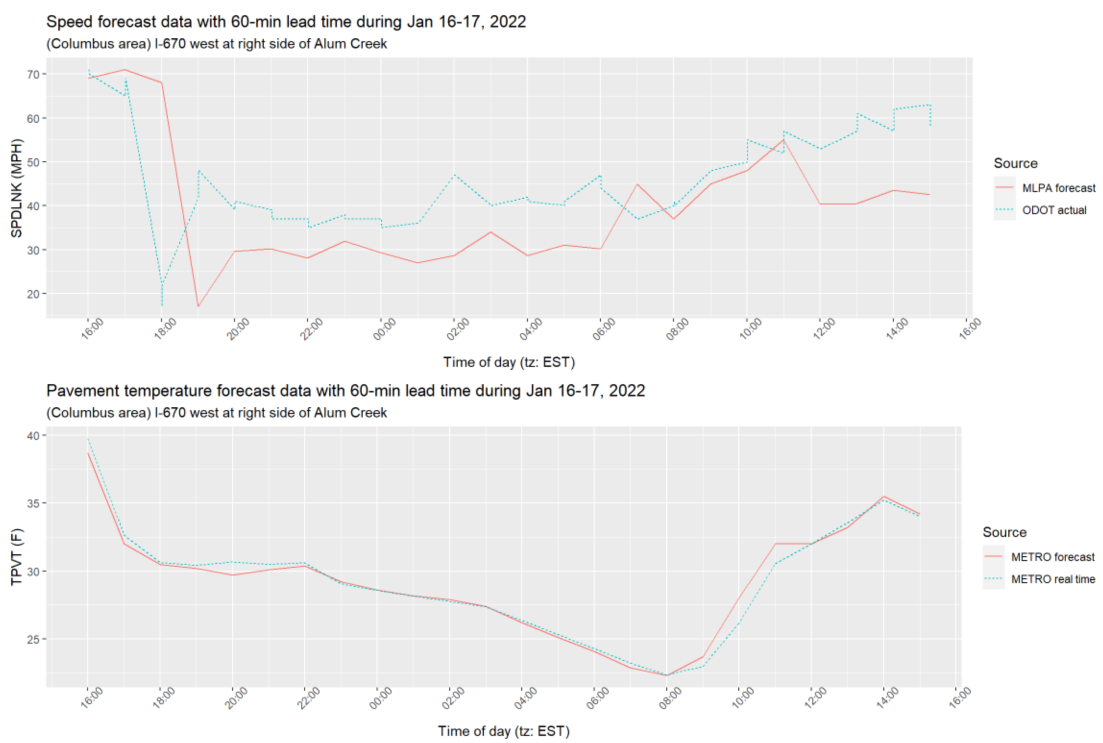
Source: Federal Highway Administration

Figure 35. Graph. Forecast speeds and pavement temperatures for 15-minute lead time.



Source: Federal Highway Administration

Figure 36. Graph. Forecast speeds and pavement temperatures for 30-minute lead time.



Source: Federal Highway Administration

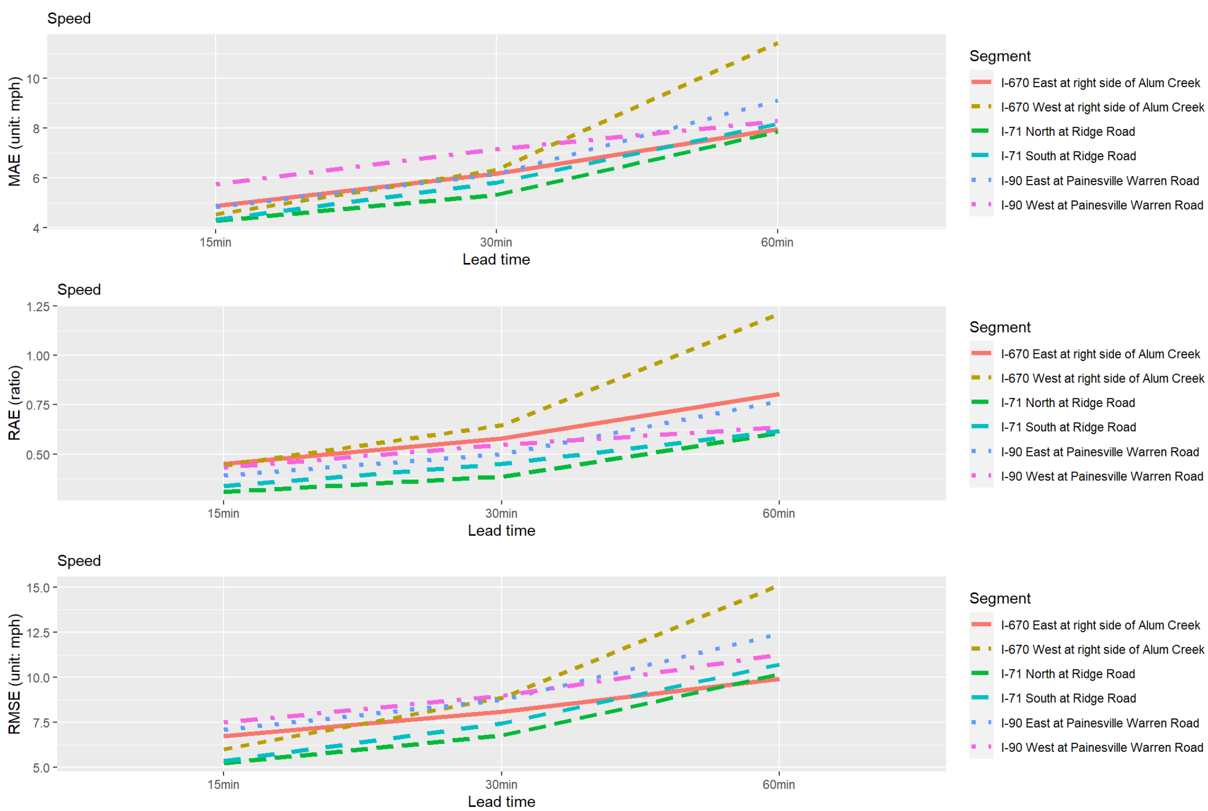
Figure 37. Graph. Forecast speeds and pavement temperatures for 60-minute lead time.

Forecast Error Analyses

Speed

The plots in figure 38 depict, from top to bottom, MAE, RAE, and RSME for the 15, 30, and 60-minute MLPA speed forecasts from January 16, 2022, 3 p.m. ET, to January 17, 2022, 3 p.m. ET, from all six selected segments.

The three metrics show that shorter-term forecasts tended to have smaller errors than longer-term forecasts. In other words, the shorter-term forecasts tended to be more accurate. The 60-minute speed forecasts for I–670 westbound near the John Glenn Columbus International Airport segment had the largest deviations.



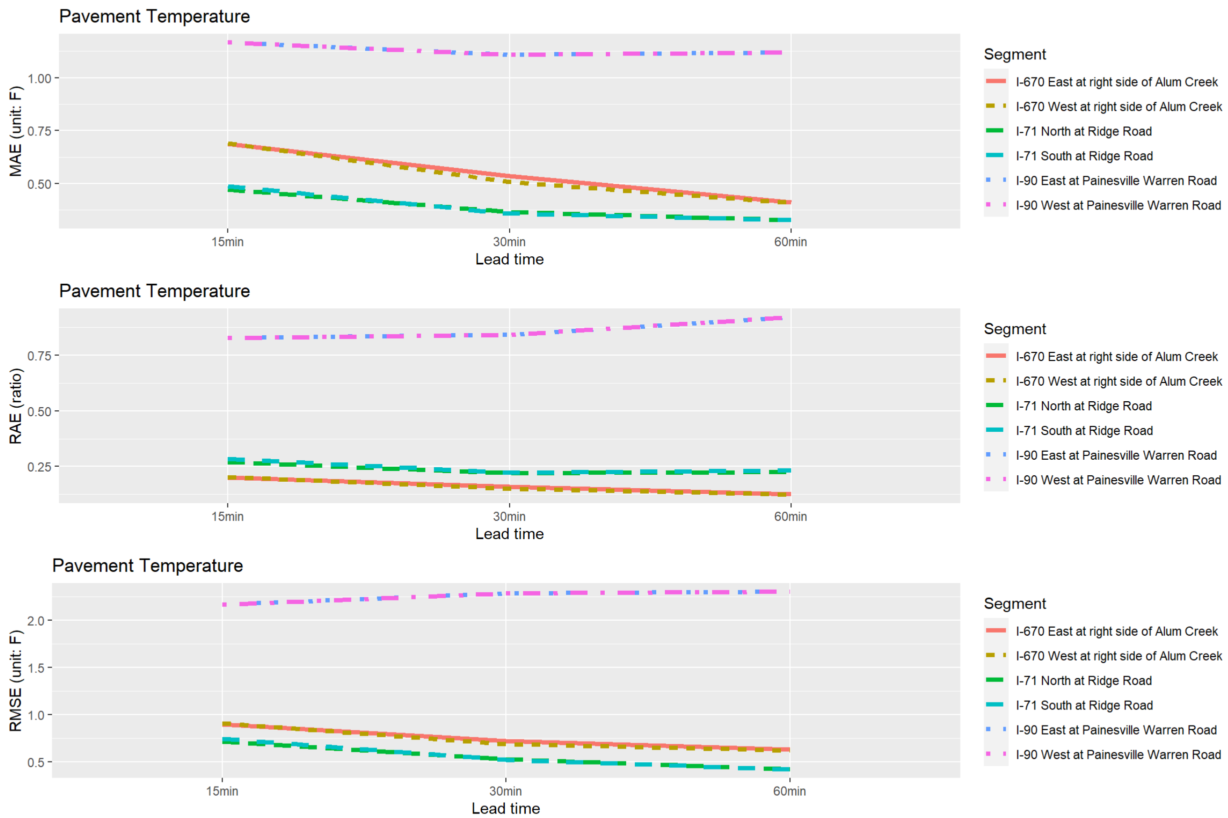
Source: Federal Highway Administration

Figure 38. Graph. Speed forecast error measures for 15-, 30-, and 60-minute lead times.

Pavement Temperature

The plots in figure 39 depict, from top to bottom, MAE, RAE, and RMSE for the 15, 30, and 60-minute METRo pavement temperature forecasts from January 16, 2022, 3 p.m. ET, to January 17, 2022, 3 p.m. ET, from all six selected segments.

The three metrics show the deviations appeared to be minimal regardless of the lead time length. Segments from the adjacent location had similar results. The segments from I–90 at Painesville Warren Road had larger deviations.



Source: Federal Highway Administration

Figure 39. Graph. Pavement temperature forecast error measures for 15-, 30-, and 60-minute lead times.

USER EXPERIENCES AND PERCEPTIONS STUDY

The usefulness study investigated staff perceptions and attitudes about the IMRCP system and the information sources available. The goals of the questionnaires and discussions with Ohio operators/users were to learn about their experiences and perceptions relating to:

- Use of IMRCP during and after weather events
- Accuracy of IMRCP information and forecasts
- Integration of IMRCP into processes
- Perspectives of IMRCP, overall
- Features needed to help support operations decision-making
- For TMC staff, whether IMRCP's design and information sources should be bundled or packaged to make it easier for operations decision-making

Ohio users returned three questionnaires—one each for the events that occurred on January 16–17, January 23, and March 11. One user is the TMC project manager and the other user is a snow and ice coordinator. Each user reported having 1–5 hours of experience with the IMRCP system. Two members of the evaluation team also conducted a follow-up telephone meeting with the project manager and snow and ice coordinator. The following discussion summarizes the users' responses to the questionnaires and the follow-up meeting.

In terms of traffic-related information, ratings were somewhat discrepant between the two respondents. The snow and ice coordinator rated the timeliness, relevance, clarity, and accessibility attributes of the IMRCP data primarily neutral (“Neither Agree nor Disagree”). The TMC project manager rated the attributes of the IMRCP data very positively (“Strongly Agree”). Further discussion showed that the differences between their ratings may have been due to their different roles and responsibilities. The TMC project manager said he was interested in using IMRCP forecasts to help anticipate upcoming changes to traffic and weather conditions. The snow and ice coordinator, who had been plowing during the event, looked at IMRCP afterward to compare the tool’s predicted road conditions with what he had experienced while plowing the road.

The only other information source that each user rated was weather and pavement conditions. The same pattern was obtained. For the most part, the snow and ice coordinator’s ratings of this source across the attributes were primarily neutral. The TMC project manger’s ratings were very positive. The only difference for this source was the snow and ice coordinator’s positive rating for the relevance of the weather and pavement conditions. He explained that he thought this information was the real asset of the system and could be used to monitor icing conditions and decisions for treating roads.

Neither respondent indicated they used the traffic alerts and notifications or the scenario tool functions. They also mentioned they do not use other systems or tools for running scenarios. For traffic alerts and notifications, they relied on other systems and sources. In addition, neither respondent used the IMRCP information sources or functions in decision-making. The snow and ice coordinator reported he was not a decision maker and therefore would not use the information for that. This observation could be the case that they are more comfortable with and possibly trust the information and interfaces of the systems and sources that they know and have used in the past. However, it may also indicate that with minimal experience with IMRCP (both reported 1–5 hours experience) they may not be as familiar with IMRCP; therefore, they are not as aware of what data can be extracted and used in decision-making, including how IMRCP data could be integrated into a snow and ice decision-making process for managers. The snow and ice coordinator also indicated that, in addition to becoming more comfortable with the system, it would be good to know how to apply the information presented in IMRCP to improve snow and ice control measures.

Further discussion on the IMRCP showed that the TMC project manager would not use the scenario tool to help make variable speed limit (VSL) decisions. The VSL corridor already has automatic mechanisms built in to recommend VSL changes. However, the TMC project manager noted that TMC staff does not solely rely on those mechanisms and typically changes the signs ahead of when the system recommends it (based on their experience).

In addition to IMRCP operational information, the discussion also included topics such a potential IMRCP dashboard. When discussing ideas for the dashboard, the snow and ice coordinator suggested getting information similar to what they receive through a weather service called DTN, (specifically the pavement forecasts) would be helpful. (Again, this could relate to the users using the systems they are most comfortable with.)

The project manager and the snow and ice coordinator provided the following recommendations for IMRCP:

- Provide for the ability to upload IMRCP (or parts of IMRCP) into other maps (i.e., merging what the users know and use with the additional IMRCP data).
- Consider limiting the number of sources for some data (e.g., there are several options with a range of values for air temperature).
- Update the current user manual (at the time of the interview, it was not finalized).

Finally, they suggested the IMRCP development and evaluation team review some of the features and information of the following sites to help the team compare and assess the IMRCP:

- Check ODOT's OHGO[1] to access the traffic cameras to confirm pavement state or traffic conditions visually.
- Access WeatherSentry[2] to become familiar with the interface and the site's functions.
- Access Vaisala Wx Horizon[3] to view what the program offers. The team would need to contact Vaisala to receive a username and password.

[1] Ohio Department of Transportation, https://ohgo.com/.
[2] DTN, http://weather.dtn.com/dtnweather/.
[3] Vaisala, https://wxhorizon.vaisala.com.

CHAPTER 4. FINDINGS

The purpose of the evaluation is to explore whether IMRCP could have an impact on Ohio operations and to assess whether the information was useful to Ohio operators and supervisors. The evaluation also assessed the accuracy of the traffic and road weather predictions. The findings in this section describe the outcomes of investigating speed and speed forecast accuracy and user perceptions of IMRCP's operational impact and usefulness.

Quantitative Findings

By examining the reported IMRCP speeds versus the historical ODOT speeds, IMRCP appeared to be capable of providing reliable real time predictions most of the time during a major snowstorm. Although there were times that the predictions were not as accurate, it usually happened in early morning around 2 a.m. which happened to be the time that is prone to more fluctuations given the low traffic volume. The road and weather conditions reported by IMRCP appeared to be useful and valuable since it corresponded well to the speed data that was examined.

Speed forecast error analyses showed that the MLPA provided more accurate predictions when forecasting for the nearer future. The segment from I-670 Westbound had the largest deviations for 60-min lead time. Nonetheless, all the other observed errors were still reasonable and tolerable. For the pavement temperature forecasts, the METRo was able to provide accurate predictions regardless of the lead time lengths that were examined. However, the segments from I-90 had relatively larger deviations comparing to the other selected locations.

Qualitative Findings

The roles and responsibilities of a user may influence what aspects of IMRCP are used and helpful per the user. For example, the TMC project manager said he was interested in using IMRCP forecasts to help anticipate upcoming changes to traffic and weather conditions. The snow and ice coordinator, who had been plowing during the event, looked at IMRCP afterward to compare the tool's predicted road conditions with what he had experienced while plowing the road. The snow and ice coordinator also reported that the weather and pavement conditions were a valuable asset of the system and could be used to monitor icing conditions and decisions for treating roads.

Neither respondent indicated they used the scenario tool functions. They also mentioned they do not use other systems or tools for running scenarios. Based on this, it is unclear whether the current scenario tool within IMRCP could be helpful for users based on the Ohio deployment and evaluation.

Both users reported they rely on other systems and sources for much of the information that IMRCP is providing. Each user had reported 1-5 hours of experience with IMRCP, so therefore they may be more comfortable with the information and interfaces of the systems and sources that they know and have used consistently in the past. It is unclear whether more experience and use of IMRCP would affect the users' perspectives and choice of system or sources of information.

The users provided the following recommendations for IMRCP:

- Provide for the ability to upload IMRCP (or parts of IMRCP) into other maps (i.e., merging what the users know and use with the additional IMRCP data).
- Consider limiting the number of sources for some data (e.g., there are several options with a range of values for air temperature).
- Ensure the user manual is updated during deployment.

APPENDIX A. OHIO POST-EVENT QUESTIONNAIRE

INTEGRATED MODELING for ROAD CONDITION PREDICTION (IMRCP) POST-EVENT QUESTIONNAIRE

OHIO

PROCESS

Thank you for agreeing to participate in the evaluation of the IMRCP system. Please be assured that this is an evaluation of the system; it is not an evaluation of you, the operator/user, or the local/regional/State operations and processes. Our team's intent is to gather feedback on how the system was used, when the system was used, and how the information from the system helped to impact how decisions were made during an event. This feedback will help us in understanding what information you used, what you liked about it, and what possible improvements could be made in future system enhancements to increase the usefulness of the information.

For the evaluation, an event might be initiated by an alert issued by NWS; for example, warnings for storm, flooding, winter weather, etc., but could also be initiated by maintenance personnel or an operator. An event is considered concluded when all ODOT activities are completed.

For each occurrence of an event, we would like you to complete the questionnaire within approximately three business days after the conclusion of the event. If we are aware of the event, our team will send you an email a few days after the event cancellation as a reminder. The email will contain the information you need to access the questionnaire.

In addition, approximately one week after you have completed the questionnaire, our team will contact you and others that used IMRCP during the event to schedule a short post-event focus group discussion to review responses and gather feedback from your use of the system. The team will send you an email with your summarized responses (as a reminder of your questionnaire answers) and a short guide with the points we will discuss during the focus group.

Please do not hesitate to call or write the team members if you have any questions regarding the questionnaire, focus group, or this approach. Thank you for your time and assistance in this effort.

Gary Golembiewski, Evaluation Lead
gary.a.golembiewski@leidos.com
703-318-4718

Michelle Neuner, Project Manager
michelle.l.neuner@leidos.com
573-453-0073

For IMRCP technical assistance, support@synesis-partners.com

POST-EVENT QUESTIONNAIRE – IMRCP USE AND PERCEPTIONS

OHIO

Name:
Job/Position:
Location (City, State, Facility):
Brief Description of Role(s) and Responsibilities:

ESTIMATED EXPERIENCE WITH THE IMRCP SYSTEM (please check):

1-5 Hours	**6-20 Hours**	**21-40 hours**	**Over 40 hours**

MOST RECENT NATIONAL WEATHER SERVICE EVENT (please check all that apply):

Storm or Tornado	**Flood**	**Winter Storm**	**Freeze**	**Wind, Fog, or Smoke**	**Other (please describe):**

DATE EVENT WAS INITIATED: ____________________

DATE EVENT WAS CANCELED: **____________________**

In the table below, please indicate the degree to which you agree with each of the statements regarding the type of information provided by IMRCP **<u>DURING THE EVENT</u>**

Information Type	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	N/A – Did not use the information
TRAFFIC-RELATED INFORMATION was …						
Timely						
Relevant						
Clear/understandable						
Accessible						
Used in decision-making						
ALERTS AND NOTIFICATIONS were…						
Timely						
Relevant						
Clear/understandable						
Accessible						
Used in decision-making						
WEATHER AND PAVEMENT CONDITIONS were …						
Timely						
Relevant						
Clear/understandable						
Accessible						
Used in decision-making						
SCENARIO ANALYSIS RESULTS were …						
Timely						
Relevant						
Clear/understandable						
Accessible						
Used in decision-making						

In the table below, please indicate the degree to which you agree with each of the statements regarding the type of information provided by IMRCP **AFTER THE EVENT**

Information Type	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	N/A – Did not use the information
TRAFFIC-RELATED INFORMATION was …						
Timely						
Relevant						
Clear/understandable						
Accessible						
Used in decision-making						
ALERTS AND NOTIFICATIONS were**…**						
Timely						
Relevant						
Clear/understandable						
Accessible						
Used in decision-making						
WEATHER AND PAVEMENT CONDITIONS were …						
Timely						
Relevant						
Clear/understandable						
Accessible						
Used in decision-making						
SCENARIO ANALYSIS RESULTS were …						
Timely						
Relevant						
Clear/understandable						
Accessible						
Used in decision-making						

PLEASE PROVIDE ANY COMMENTS OR FURTHER INFORMATION THAT WOULD HELP US TO IMPROVE THE IMRCP SYSTEM, SUCH AS YOUR EXPERIENCE REGARDING THE EASE OF INFORMATION ACCESS, DESIGN OF THE INFORMATION SCREENS, INTEGRATION OF THE DIFFERENT SYSTEMS, ETC.:

THANK YOU!