Integrated Modeling for Road Condition Prediction – Phase 4
Final Evaluation Report – Louisiana

November 29, 2022

U.S. Department of Transportation
Federal Highway Administration

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LIST OF ABBREVIATIONS

AAR	after-action review
DPHLIQ	surface inundation depth
ET	eastern time
FHWA	Federal Highway Administration
GSTWND	wind gust speed
I–10	Interstate 10
I–12	Interstate 12
IMRCP	Integrated Modeling for Road Condition Prediction
IT	information technology
ITS	intelligent transportation system
LaDOTD	Louisiana Department of Transportation and Development
MAE	mean absolute error
MAP	Motorist Assistance Program
METRo	Model of the Environment and Temperature of Roads
MLPH	machine learning-based prediction hurricane model
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
STPVT	pavement state
TMC	traffic management center
VIS	visibility of surface

CHAPTER 1. INTRODUCTION

In 2015, the Federal Highway Administration (FHWA) began developing the Integrated Modeling for Road Condition Prediction (IMRCP) system, 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 IMRCP system provides a framework for integrating road condition monitoring and forecast data to support decisions made 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.

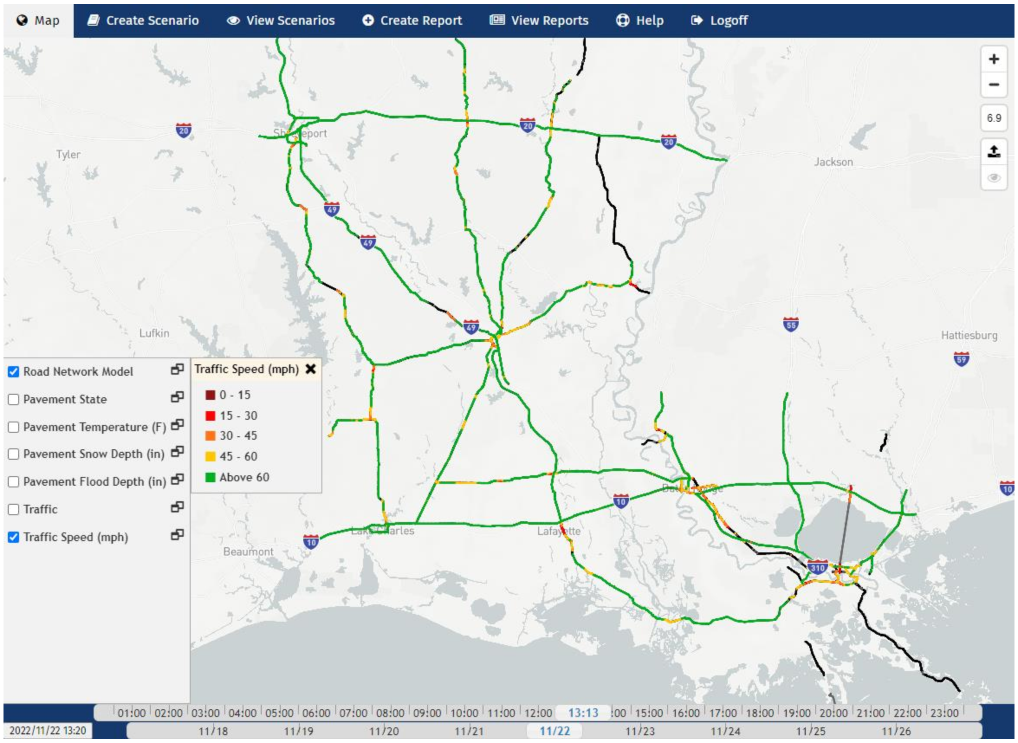
IMRCP phase 1 included developing a concept of operations and requirements. In IMRCP phase 2, the research team specified, implemented, tested, and evaluated the IMRCP concept in an area of the Kansas City metropolitan area. In IMRCP phase 3, coverage was expanded to include all Kansas City metropolitan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

For IMRCP phase 4, the Ohio Department of Transportation (ODOT) and Louisiana Department of Transportation and Development (LaDOTD) were chosen to deploy IMRCP with enhanced capabilities. The project team completed evaluations for each deployment. For Ohio, the primary focus is the winter season. For Louisiana, the primary focus is the hurricane/tropical storm season.

PROJECT DESCRIPTION

The objective of the Louisiana IMRCP deployment is to deliver all the capabilities of prior weather-related IMRCP deployments and to deploy and test its capabilities under emergency and severe weather conditions in a Transportation Management Center (TMC) to improve public safety and emergency evacuation and response capabilities at a metro/regional/State level (Emergency Planning Transportation Data Initiative).

IMRCP in Louisiana provides an integrated view of road weather and traffic condition forecasts and shifts the emphasis from winter operations to regional emergencies and evacuation. Figure 1 shows the Louisiana IMRCP road network.



Source: FHWA. © OpenStreetMap contributors.

Figure 1. Screenshot. Integrated Modeling for Road Condition Prediction phase 4 Louisiana deployment.

The IMRCP model draws input from traffic, weather, and hydrological data sources to estimate current conditions and to forecast future conditions. Forecasts are available via a web interface on maps, in reports, and in subscription results. 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 sources. State and local agencies can also provide atmospheric, surface (i.e., pavement and soil), and hydrologic condition data. Data collected from the various sources are indexed, stored, and archived in data stores by the system.

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 IMRCP 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.

PURPOSE AND OVERVIEW

This report describes the evaluation of the IMRCP deployment in Louisiana. The purpose of the evaluation is to explore whether IMRCP could have an impact on LaDOTD operations and to gather feedback on the usability and capabilities that could be beneficial to LaDOTD users of IMRCP. The evaluation also assessed the accuracy of the traffic and road weather predictions. The evaluation findings could inform others who may be considering similar deployments and could 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 IMRCP system walk-through sessions and system accuracy data analyses.
- **Chapter 4. Findings** discusses the implications of the analyses related to LaDOTD staff ratings and perspectives and the accuracy of the IMRCP road conditions and speed forecasts.
- **Chapter 5. Conclusions** summarizes key results that support the findings.

CHAPTER 2. EVALUATION APPROACH

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

The evaluation consisted of two research activities: system walk-through sessions and system accuracy analyses. The walk-throughs were used to investigate staff perspectives of IMRCP. The system accuracy analyses assessed the accuracy of the current and predicted IMRCP road and weather data.

LaDOTD staff perspectives helped the project team understand perceptions of IMRCP functionality, features, and capabilities. The project team developed questions to investigate user interface (e.g., Are IMRCP capabilities/features easy to use?) and functional factors (e.g., What functionality could be improved?). The following sections describe the evaluation objectives and approach for the walk-through and system accuracy analyses.

EVALUATION OBJECTIVES

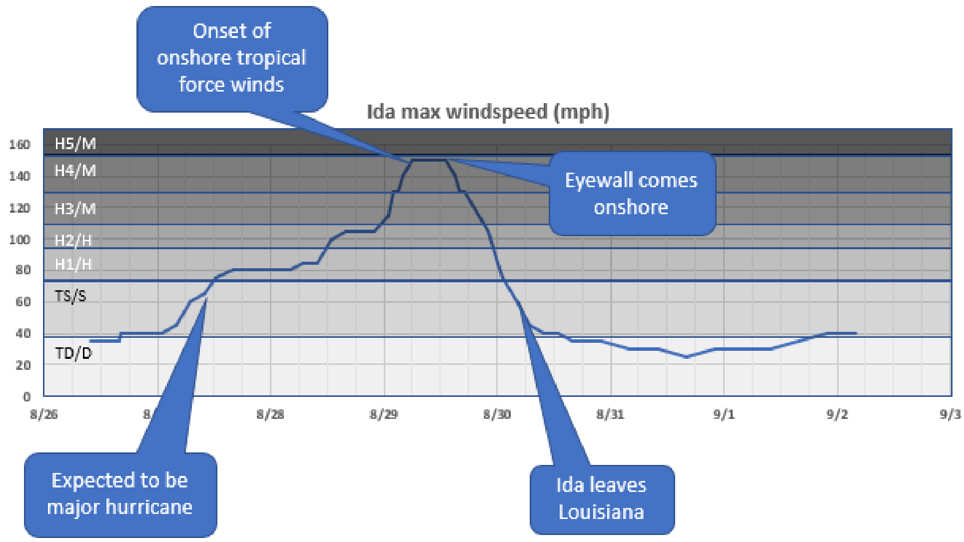
The project team developed the following evaluation objectives to guide the evaluation approach:

- Investigate staff perspectives about the ease of use, usefulness, and the capabilities and benefits of the IMRCP decision support tool for adverse weather conditions.
- Investigate if IMRCP functionality and capabilities provide users with accurate information for predicting traffic, road, and weather conditions during adverse weather conditions.

APPROACH

The project team developed and conducted walk-through sessions with LaDOTD staff to complete a variety of tasks and obtain their opinions and perspectives. To assess system accuracy, system data were extracted and analyzed from IMRCP data logs.

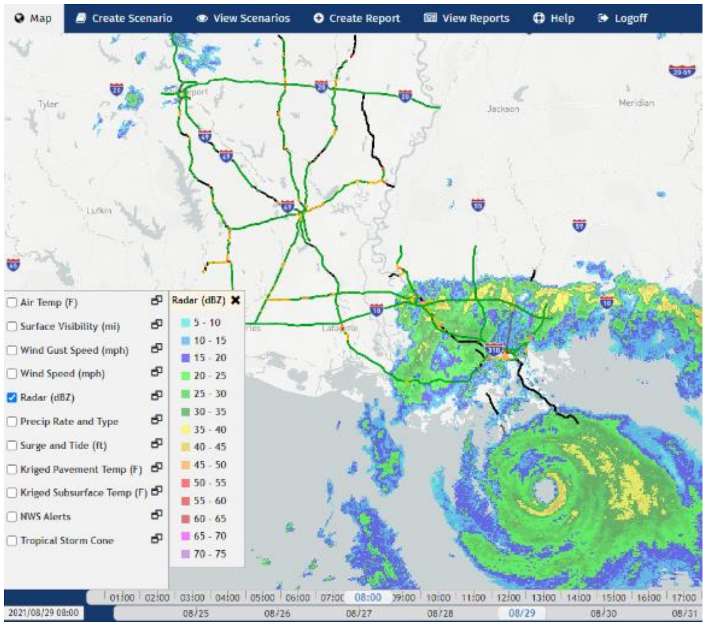
Louisiana did not experience any significant weather events between March and August 2022. Consequently, for evaluation purposes conditions and data during Hurricane Ida (August 28–30, 2021) were used for the evaluation. Figure 2 shows the wind speeds and timeline of Hurricane Ida. Figure 3 shows the IMRCP map with radar imagery overlay.



Source: FHWA.

mph = mile per hour; TD/D = Tropical Depression; TS/S = Tropical Storm; H1/H = Hurricane, Category 1; H2/H = Hurricane, Category 2; H3/M = Hurricane, Major, Category 3; H4/M = Hurricane, Major, Category 4; H5/M = Hurricane, Major, Category 5.

Figure 2. Graph. Wind speed timeline of Hurricane Ida.



Source: FHWA.

Figure 3. Screenshot. Integrated Modeling for Road Condition Prediction map with radar overlay at 8 a.m. on August 29, 2021.

The following sections describe the approach for the walk-through and system accuracy assessments.

Walk-Through Data Collection and Analysis

The evaluation team selected August 29, 2021, at 8 a.m. as the basis for all tasks and activities in the walk-through. This time period was chosen because it was during the onset of onshore maximum winds and prior to Hurricane Ida eyewall coming onshore (see Figure 2).

The walk-through sessions lasted approximately 90 minutes. The sessions guided participants through specific portions of IMRCP to review road and weather information during Hurricane Ida. Three tasks were completed during the session. See appendix A for the walk-through instructions, background form, and tasks 1–3 screens and activities.

- Task 1 – setup reference time, map layers, road segment data, field sensor data
- Task 2 – traffic speed forecasts (2- and 8-hour predictions)
- Task 3 – weather alerts and precipitation forecasts (2- and 8-hour predictions)

The session was periodically paused to reflect on the IMRCP tasks and information. Participants were asked to provide ratings and share insights for ease of use, understandability, usefulness to support decision-making, and needed improvements. Participants were asked open-ended questions to obtain more in-depth opinions and perspectives. Questions probed such topics as how information is organized, ease of finding and accessing information, what additional information or functionality would be useful, suggestions to improve, etc.

The project team conducted the walk-through via webinar with six LaDOTD participants with diverse roles and responsibilities at LaDOTD. All were novice IMRCP users and none had used IMRCP for operations or analyses. Table 1 summarizes participants' roles and responsibilities.

Table 1. Walk-through participant roles and responsibilities.

Participant #	LaDOTD Role – Responsibilities
1	Information technology (IT) manager – IT supervision, systems integration, and system administration
2	Research associate – intelligent transportation system (ITS) and traffic analysis and research
3	Engineer 6 – TMC and Motorist Assistance Program (MAP) management
4	ITS operations and management – oversees TMC and MAP operations and services; ITS project planning, design, construction, and information requests
5	Assistant district administrator, operations – road closures, response plans, recovery plans, and resource plans
6	Assistant district administrator, operations – road closures, preparation of materials/staff to cover events, coordination during events, and winter maintenance

A slide presentation guided users through tasks and activities that were the basis for collecting user perspectives related to features and capabilities. The walk-through consisted of the following steps:

1. Review participant background form.
2. Ensure participant was logged in to IMRCP and had walk-through sheets printed.
3. Give introduction presentation.
4. Have participant share their IMRCP screen.
5. Conduct walk-through session.
    a. Follow activities/steps described in walk-through sheets.
    b. Collect ratings data.
    c. Ask questions and collect participant feedback.

After completing the session, the project team averaged the participants' ratings and analyzed and summarized their comments for use in this report.

System Accuracy Data Collection and Analysis

The evaluation team examined data from August 28 to 30, 2021, for the system accuracy analyses. The time period was chosen to coincide with the arrival and departure of Hurricane Ida through Louisiana.

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 New Orleans and Baton Rouge areas.

In the New Orleans area, the project team focused on two regions near Lake Pontchartrain: Interstate 10 (I–10) in New Orleans East area and Interstate 12 (I–12) near the Tangipahoa River. Figure 4 and Figure 5 show the locations of the road segments that were examined.

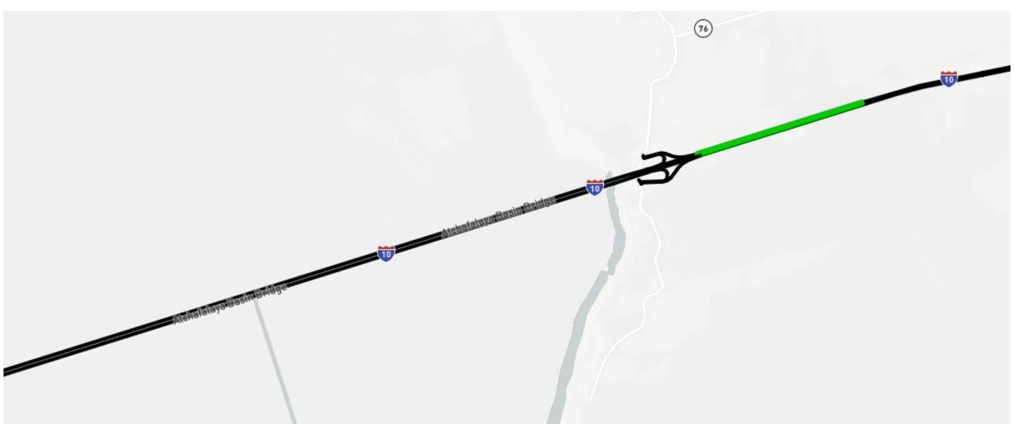
Source: FHWA. © OpenStreetMap contributors.

Figure 4. Screenshot. Interstate 10 eastbound segment location near New Orleans.

Source: FHWA. © OpenStreetMap contributors.

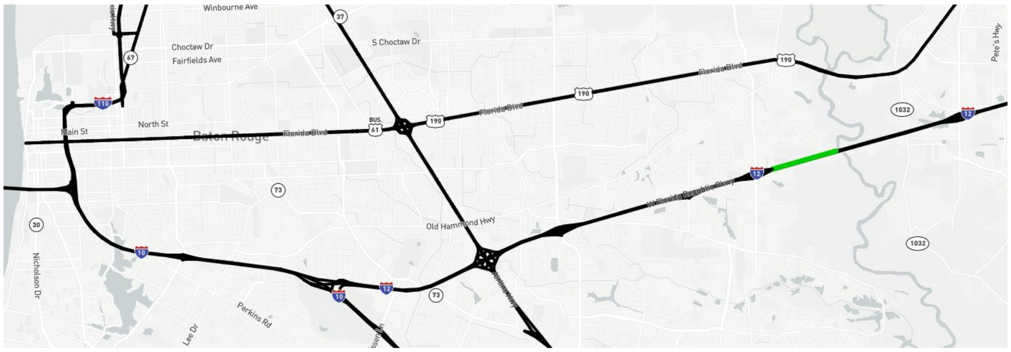
Figure 5. Screenshot. Interstate 12 eastbound segment location near New Orleans.

In the Baton Rouge area, the focus was on I–10 close to the Atchafalaya Basin Bridge and on I–12 near the Amite River. Figure 6 and Figure 7 show the locations of the road segment that were examined.



Source: FHWA. © OpenStreetMap contributors.

Figure 6. Screenshot. Interstate 10 westbound segment location near Baton Rouge.



Source: FHWA. © OpenStreetMap contributors.

Figure 7. Screenshot. Interstate 12 westbound segment location near Baton Rouge.

The evaluation team's analyses included:

- Examining the reported IMRCP predicted speeds versus the historical LaDOTD speeds
- Checking the reported supplemental data that were from METRo or RAP/RTMA. The supplemental data included precipitation category (PCCAT), surface inundation depth (DPHLIQ), pavement state (STPVT), visibility of surface (VIS), and wind gust speed (GSTWND).
- Comparing the IMRCP speed forecasts, including 60- and 120-minute predictions, to the actual LaDOTD speeds and assessing the forecast error (mean absolute error [MAE], relative absolute error [RAE], and root mean square error [RMSE])

The first two focused on the retrospective data while the third focused on the traffic speed forecasts. Forecast error analyses were conducted for each location and date.

Forecast values were generated for 1 hour at a time for the next 12 hours, with reference values being each time stamp, which is each hour of dates of interest. Curves for each of the forecast lead times were constructed and plotted along with the real time. The 60-minute forecast plot shows the forecast values for each time point predicted at a reference time 60 minutes before each time point. The 120-minute forecast plot follows 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. Figure 8 defines MAE, Figure 9 defines RAE, and Figure 10 defines RMSE. figure 9 defines RAE, and defines RMSE. figure 9 defines RAE, and defines RMSE. figure 9 defines RAE, and defines RMSE.

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

Source: FHWA.

Figure 8. Equation. Mean absolute error.

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 the 48-hour window.

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

Source: FHWA.

Figure 9. Equation. Relative absolute error.

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, $\bar{y}$ is the average of observations, and n is the total number of observations during the 48-hour window.

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

Source: FHWA.

Figure 10. Equation. Root mean square error.

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, $\bar{y}$ is the average of observations, and n is the total number of observations during the 48-hour window.

CHAPTER 3. RESULTS

This chapter describes the results of the walk-through sessions and system accuracy analyses. The walk-through results present staff perspectives about the ease of use, usefulness, and the capabilities and benefits of the IMRCP decision support tool for adverse weather conditions. The system accuracy results present an assessment of IMRCP traffic, road, and weather conditions predictions during adverse weather conditions.

WALK-THROUGH RESULTS

Participants were asked to complete tasks in six IMRCP topic areas. For each task, participants rated IMRCP as: Easy to Use, Easy to Understand, Useful to Support Decision-Making, and Could be Improved. Table **2** shows the average ratings by topic area. The rating scale was an interval scale that ranged from 1 to 5: 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree or Disagree (or Don't Know), 4 = Agree, and 5 = Strongly Agree.

Table 2**. Average ratings by topic area.**

Topic Area	Easy to Use	Easy to Understand	Useful to Support Decision-Making	Could be Improved
Setup, map layers, data tables	4.5	4.7	4.0	3.2
Traffic speed forecasts (2- and 8-hour predictions)	4.8	4.7	4.0	3.3
Weather alerts	4.8	4.4	4.0	3.8
Setting up precipitation rate and type	4.6	4.2	4.0	3.8
Current weather data	4.8	4.5	4.2	3.5
Weather forecasts (2- and 8-hour predictions)	4.8	4.5	4.2	3.5

With only a few exceptions, participants rated all six IMRCP topic areas as Easy to Use, Easy to Understand, and Useful to Support Decision-Making. Ratings were slightly lower for Could be Improved because more participants gave a rating of "Don't Know" and a couple of participants gave a rating of "Disagree." The following sections describe these results in more detail.

Easy-to-Use Ratings

The average ratings for Easy to Use were 4.5 or greater for all topic areas. This suggests that participants strongly agreed that all six IMRCP areas were easy to use. Seventy-five percent of the ratings were 5's, 25 percent were 4's, and no ratings were 3 or lower.

Easy-to-Understand Ratings

The average ratings for Easy to Understand ranged from 4.2 to 4.7. This indicates that participants strongly agreed that all six IMRCP areas were easy to understand. Of the six areas, the ratings for Precipitation Rate and Type were slightly lower (the following sections will describe reasons for the lower rating). Nevertheless, about 50 percent of the ratings were 5's, 50 percent were 4's, and no ratings were 3 or lower.

Useful to Support Decision-Making Ratings

For Useful to Support Decision-Making, the average ratings were 4.0–4.2. Though this rating indicates agreement, the ratings (and comments) from a couple of participants indicated a more cautious agreement. When providing a rating, participants' responses tended to be either a rapid definite yes (about 40 percent of the ratings were 5's), a slower, more thoughtful yes (about 25 percent were 4's), or a slower, more cautious not really sure (about 35 percent were 3's). These latter ratings came from two participants who did not have decision-making responsibilities. One participant had a supervisory role that did not involve daily operational decision-making, and another participant had just started working at LaDOTD. Both participants remarked they were not involved in decision-making, so they were not really sure.

Could be Improved Ratings

For Could be Improved, the average ratings for all topic areas ranged from 3.2 to 3.8. In conjunction with the lower average ratings, the ratings showed more 4's (56 percent "Agree"), 3's (38 percent "Don't Know"), and even 2's (6 percent "Disagree"). None of the ratings were 5's (Strongly Agree) or 1's (Strongly Disagree). Two participant ratings contributed to most of the "Don't Know" and "Disagree" ratings. One participant had a management role and was not sure what improvements would be suitable for operational decision-makers and therefore gave all not sure ratings. The one participant who provided the 2 (i.e., "Disagree") rating mentioned that the setup, map layers, data tables and the traffic speed forecasts looked good and "No improvements come to mind."

Participant Perspectives on Capabilities and Benefits, User Interface, and Suggested Improvements

Participants were asked open-ended questions to supplement their ratings and investigate their perspectives and opinions on IMRCP features, capabilities and benefits, and functionality. The participants' comments and responses to the open-ended questions are described below.

Comments about Integrated Modeling for Road Condition Prediction Capabilities and Benefits

Participants shared their perspectives on IMRCP capabilities and benefits. The participants commented on four areas:

- IMRCP appears to have good information that is useful for public information requests and for after-action reviews (AARs). For post-event analyses, adjusting the date and time is key for seeing how a storm progresses and where was rain/wind. It is useful to go back and see: (1) what the road condition was and check where there were weather-related issues; (2) what the conditions were at the time of an accident; and (3) historical speed, pavement condition, and weather condition.

- IMRCP may be useful for winter weather predictions. District 5 has nine parishes and three area engineers. Engineers get information from calls, experience, emergency operations, and people out scouting. Monroe gets winter snow/sleet, icy roads, and applies salt in winter, so it is good to know which areas will be impacted. IMRCP may be a good application for district traffic operation engineers, area engineers, emergency operations center (wind and land fall forecasts). The map is fairly intuitive; using a laptop touchpad seems OK without using a mouse; colors/symbols seem OK.

- Flood data are useful but other useful parameters could be added to WxAlerts. LaDOTD is concerned about flooding and would like to monitor water levels to send out crews and put out message signs. Participants liked having all the information in one location because they would otherwise have to get information from weather sites, gauge sites, and traffic sites.

- In terms of capabilities, data and information accuracy is very important to ensure LaDOTD users continue to use the system. IMRCP needs to show it is adding value and users need to have confidence in the system. Participants thought that if IMRCP was integrated then more users would access the system. If IMRCP is not integrated then only one person would probably access the system.

Comments about the User Interface

Participants indicated that the user interface is generally easy to use and understand, but they also mentioned specific issues. The following participant comments are organized by IMRCP screen element:

- **Area Tab.** The order of the tab items seems counterintuitive and participants had to repeatedly browse the list to look for specific items.
- **Road Segment Data Table.** The different data sources for ObsType can be confusing. Participants noticed the IMRCP traffic speed color-code do not match LaDOTD color scheme. This was confusing and gave the impression that speed data are not matching. Also, this mismatch could cause a loss in confidence in IMRCP. Participants thought the different average speeds (5 minutes versus 1 hour) can cause confusion.
- **Field Sensor Data Table.** Participants were unsure what the flood values mean and did not know the difference between Flood Stage Action and Flood Stage Flood.
- **WxAlerts.** Participants thought Med/Heavy Precip have similar colors and can be hard to distinguish. They did not know where to find the definition of weather alert categories and precipitation categories.
- **Precip Rate & Type.** Participants thought the colors were very similar and the color-code does not tell much about the underlying rate or intensity. The Precip Rate & Type legend colors sometimes look gray.
- **Weather Data Table.** There are lots of data sources and values, which participants thought could be confusing. The table has a little too much information from multiple sources and adds clutter. It can be hard to tell which values are actual and which are predicted. The alphabetical order of ObsType is good. Participants had some questions and confusion about what the sources were, the definition of ObsTypes, and valid values.

Comments about Suggested Improvements

Participants shared the following suggested improvements that would enhance the functionality for users:

- The user interface is generally easy to use but would like IMRCP to implement:
    - An enhanced favorites feature to save settings for map shortcuts and direct access to map locations, road network, and statewide sensor and precipitation settings
    - A zoom feature using a rectangular box to allow selecting (and zooming into) an area of the map
    - An autocomplete feature for typing an hour number in a drop-down menu and jumping to the hour to make entry faster and easier
    - A hover feature to quickly display the data table (and reduce the number of clicks)

- The user interface is generally easy to understand but may want to consider:
    - Providing an alert for things that are beyond certain thresholds instead of searching for them
    - Hourglass or spinner to indicate the system is working, especially when map refresh is slow
    - Not replacing the IMRCP window when clicking links; instead, open a new browser window

Participants suggested the following improvements for specific IMRCP elements:

- **Road Segment Data Table.** May want to find out which sources are used or most useful to users. Participants would like to see route designation and direction of travel, and for winter, information on road grip and sensors on certain bridges would be useful and could be added to the data table.
- **Field Sensor Data Table.** Flooding is something LaDOTD is concerned about and would like to monitor water levels at locations where LaDOTD engineers have a list of known locations that have frequent floods. It would be helpful to know or find what the values mean. Participants would find it useful to know the velocity of water in streams and have the information added to the data table.
- **WxAlerts.** May want to adjust colors for Med/Heavy Precip because they have similar colors, which can be hard to distinguish. Crews have 12-hour shifts, so participants would like to have 12- and 24-hour forecasts to know what to anticipate.
- **Precip Rate & Type.** May want to adjust colors because they are very similar. Participants are interested in precipitation rate and wind speed but the colors sometimes look gray. Participants would like inches per hour or clarification in how it is defined in terms of intensity, as the legend color-code does not tell much.

OPERATIONAL ACCURACY STUDY

The evaluation of the IMRCP system accuracy consisted of the following two parts:

1. Examining reported speeds versus historical observations and weather and road conditions; and

2. Examining speed forecasts.

Above were applied to each of the four selected road segments.

Interstate 10 Eastbound in New Orleans East Area (New Orleans Area)

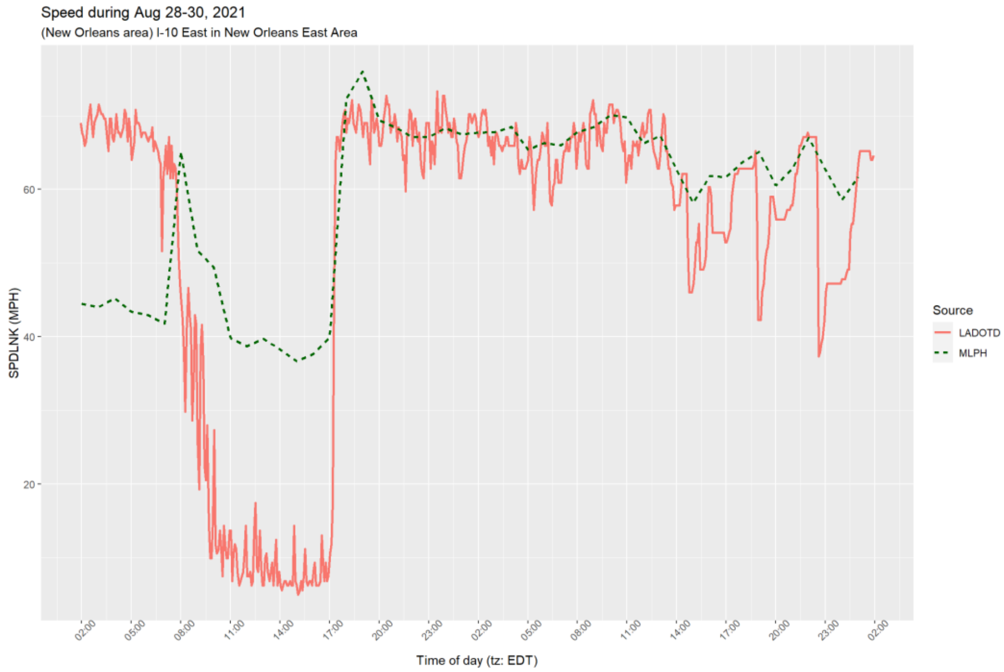
Reported Speeds versus Historical Observations and Weather and Road Conditions

Figure 11 displays the machine learning-based prediction hurricane model (MLPH) predicted speeds and historical LaDOTD observed speeds obtained for I–10 eastbound in the New Orleans East area from August 28, 2021, 2 a.m. eastern time (ET), to August 30, 2021, 2 a.m. ET. Large deviations were observed between 2 a.m. and 5 p.m. on August 28. There was a big drop in real-time speed such that MLPH predictions did not pick up. In general, LaDOTD actual speeds had bigger fluctuations than MLPH predictions.

The plots in Figure 12 depict the supplemental road and weather conditions that provide context for interpretating the predicted and historical speeds. The supplemental data are, from top to bottom, precipitation category (PCCAT), surface inundation depth (DPHLIQ), pavement state (STPVT), visibility of surface (VIS), and wind gust speed (GSTWND) obtained for the same location from the same time period. The five plots present a snapshot of the road and weather conditions:

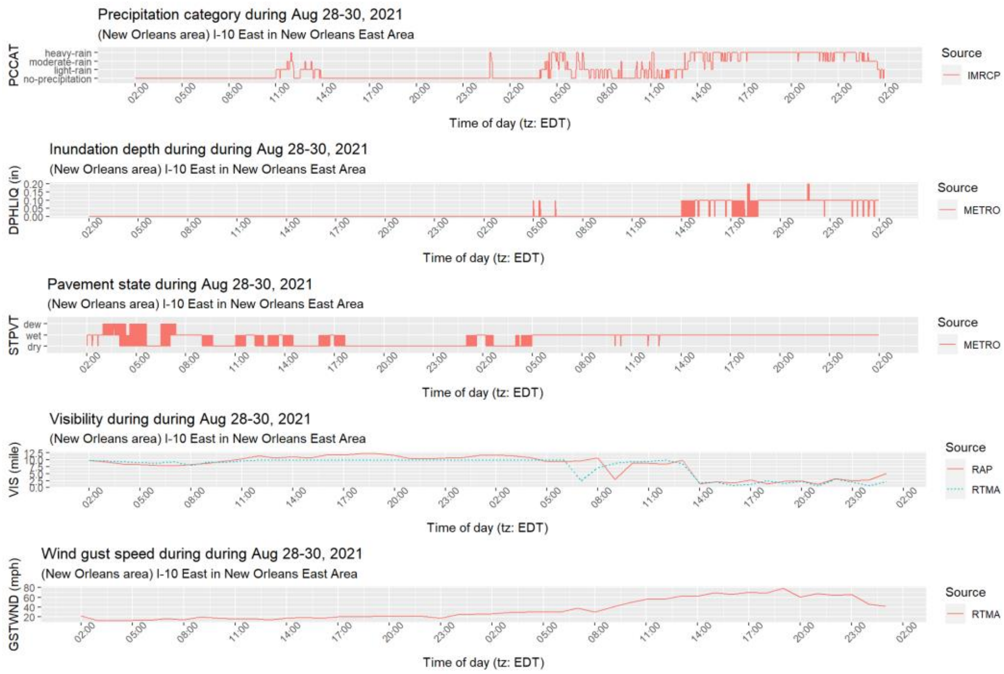
- Consistent moderate-to-heavy rain was observed after 1 p.m. on August 29 according to IMRCP.
- Visibility remained very low starting at about 1 p.m. on August 29 according to rapid refresh (RAP) and real-time mesoscale analysis (RTMA) sources.
- Wind gust speed reached 60 mph at about 1 p.m. on August 29 according to the RTMA.

The road and weather conditions corresponded to the decreasing trend in speed starting at about 1 p.m. on August 29. Unidentified factors that possibly caused the speed drop on August 28 require further investigation.



Source: FHWA.

Figure 11. Graph. Machine learning-based prediction model predicted speeds and historical Louisiana Department of Transportation and Development observed speeds.



Source: FHWA.

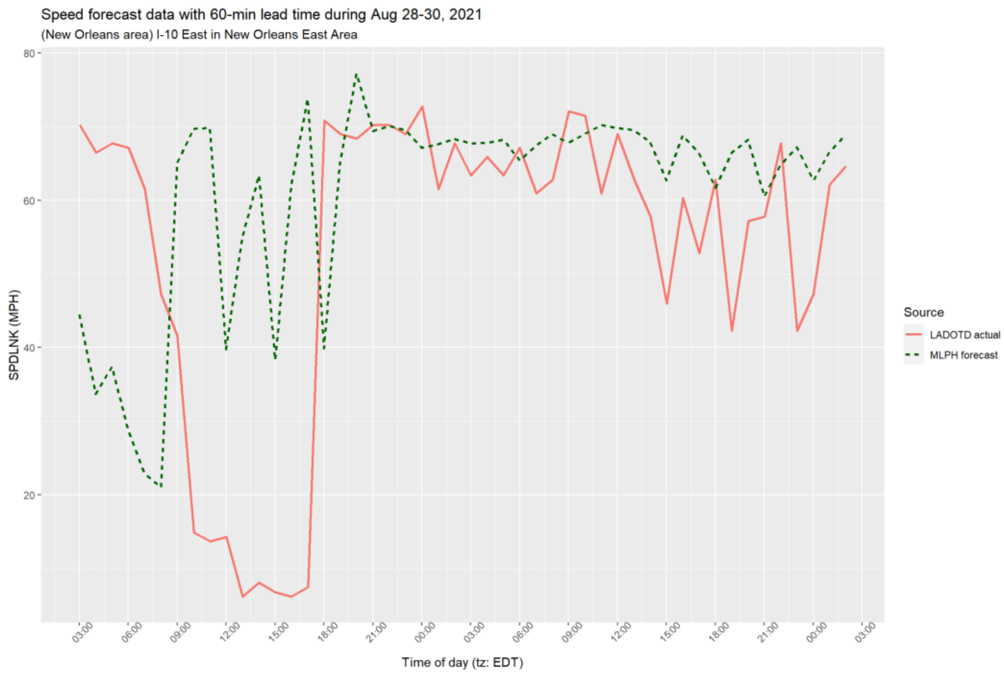
Figure 12. Graph. Weather and road conditions.

Speed Forecasts

The plots in Figure 13 and Figure 14 display the forecast speeds for I–10 eastbound in the New Orleans East area from August 28, 2021, 2 a.m. ET, to August 30, 2021, 2 a.m. ET.

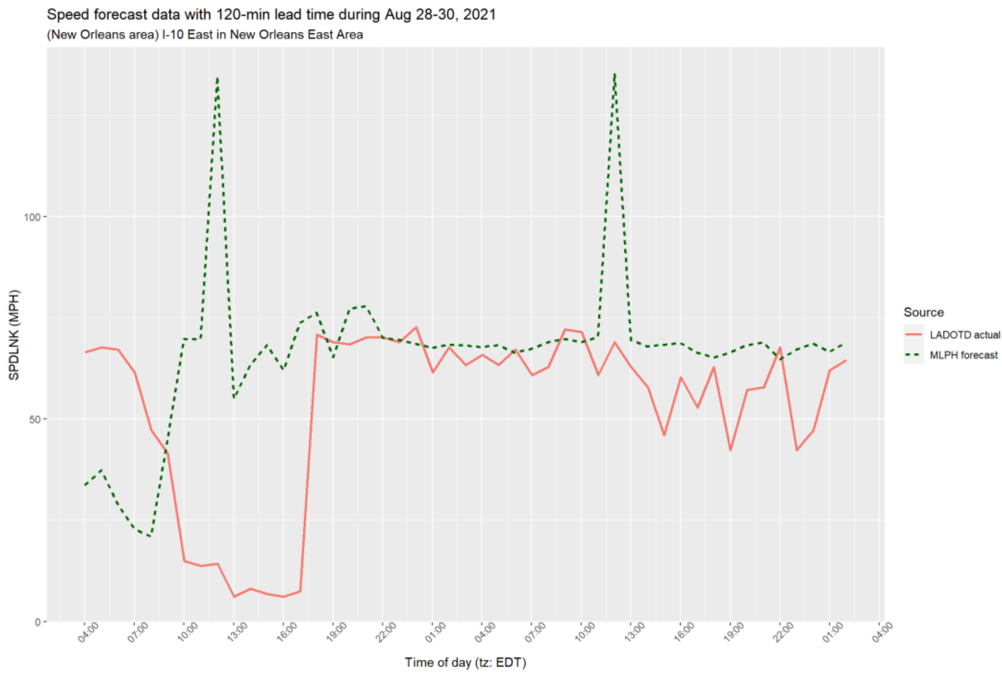
The plots show:

- MLPH speed forecasts and LaDOTD had larger discrepancies in the begining, but then the gap decreased substantially after 6 p.m. on August 28.
- Longer forecasts might produce unexpected predictions, as seen from the two spikes in figure 13 showing the forecast speeds for 120-minute lead time.



Source: FHWA.

Figure 13. Graph. Forecast speeds for 60-minute lead time.



Source: FHWA.

Figure 14. Graph. Forecast speeds for 120-minute lead time.

Interstate 12 Eastbound near Tangipahoa River (New Orleans Area)

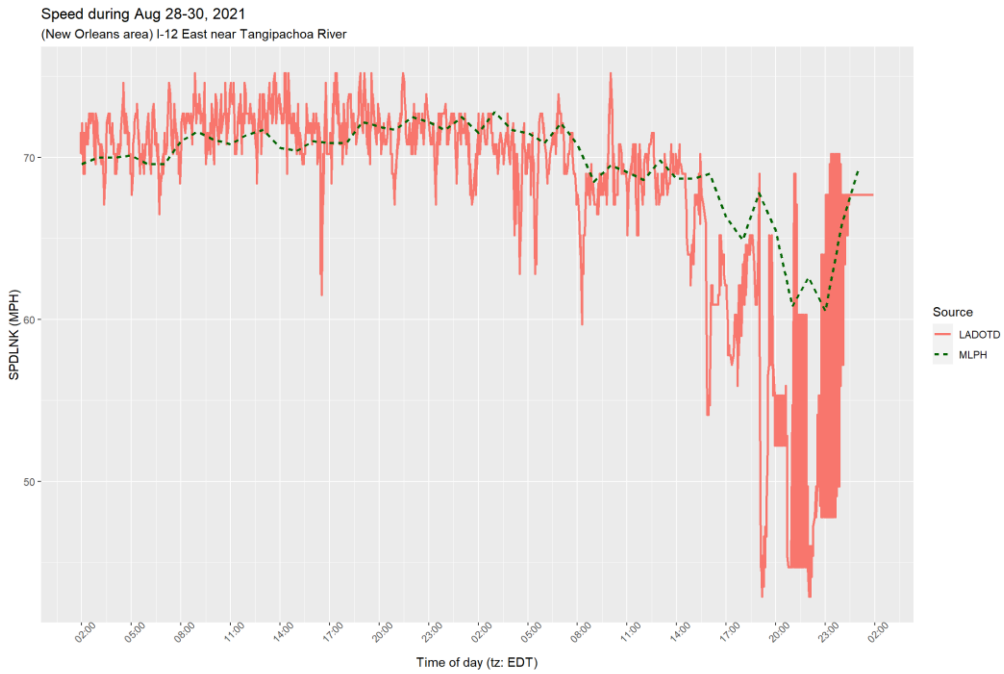
Reported Speeds versus Historical Observations and Weather and Road Conditions

Figure 15 displays the MLPH predicted speeds and historical LaDOTD observed speeds obtained for I–12 eastbound near Tangipahoa River from August 28, 2021, 2 a.m. ET, to August 30, 2021, 2 a.m. ET. The MLPH predictions and the LaDOTD actual speeds generally showed a similar pattern; however, large deviations were observed after 2 p.m. on August 29.

The plots in Figure 16 depict the supplemental road and weather conditions that provide context for interpreting the predicted and historical speeds. The supplemental data are, from top to bottom, precipitation category (PCCAT), surface inundation depth (DPHLIQ), pavement state (STPVT), visibility of surface (VIS), and wind gust speed (GSTWND) obtained for the same location from the same time period. The five plots present a snapshot of the road and weather conditions:

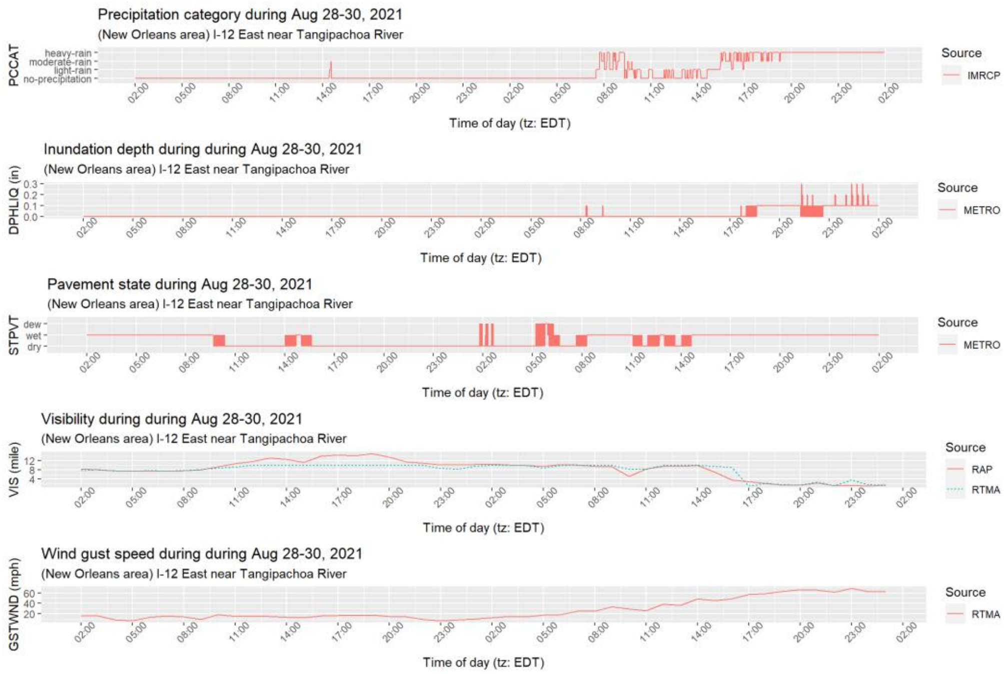
- Constant moderate-to-heavy rain was observed after 3 p.m. on August 29 according to IMRCP.
- Visibility started to decrease at about 2 p.m. and remained very low after 5 p.m. on August 29 according to RAP and RTMA sources.
- Wind gust speed reached 60 mph at about 6 p.m. on August 29 according to RTMA.

The road and weather conditions corresponded to the huge drop in speed after 6 p.m. on August 29.



Source: FHWA.

Figure 15. Graph. Machine learning-based prediction model predicted speeds and historical Louisiana Department of Transportation and Development observed speeds.



Source: FHWA.

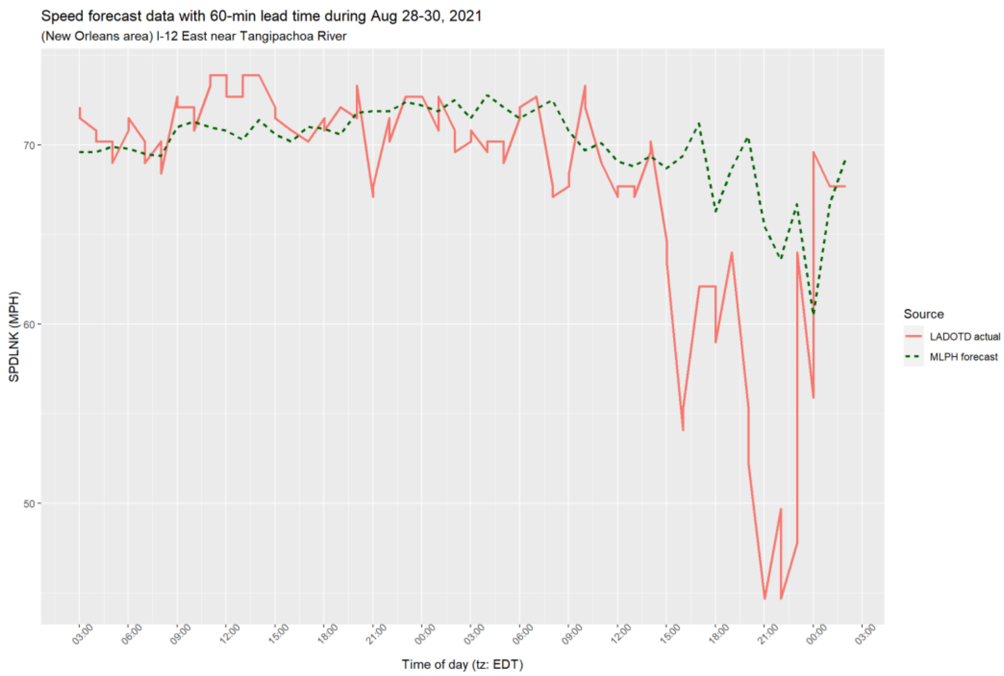
Figure 16. Graph. Weather and road conditions.

Speed Forecasts

The plots in Figure 17 and Figure 18 display the forecast speeds for I–12 eastbound near Tangipahoa River from August 28, 2021, 2 a.m. ET, to August 30, 2021, 2 a.m. ET.

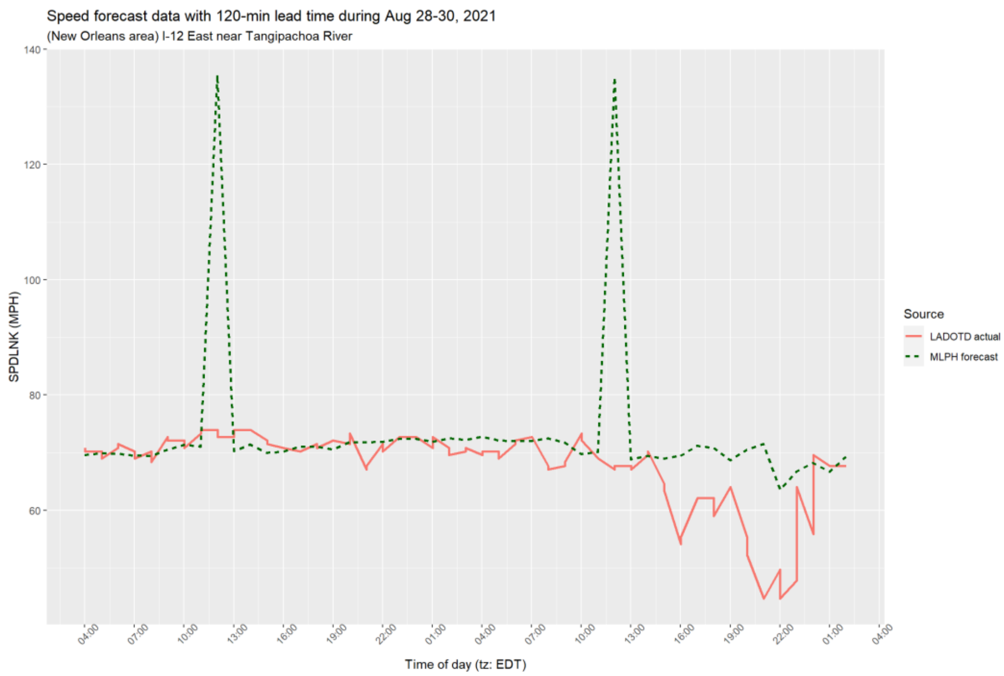
The plots show:

- MLPH 60-minute speed forecasts and LaDOTD generally had similar patterns, though large deviations were observed at around 3 p.m. and 9 p.m. on August 29.
- MLPH 120-minute speed forecasts generally matched LaDOTD but two instances of very high predicted speeds were observed at around noon on August 28 and August 29.



Source: FHWA.

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



Source: FHWA.

Figure 18. Graph. Forecast speeds for 120-minute lead time.

Interstate 10 Westbound near Atchafalaya Basin Bridge (Baton Rouge Area)

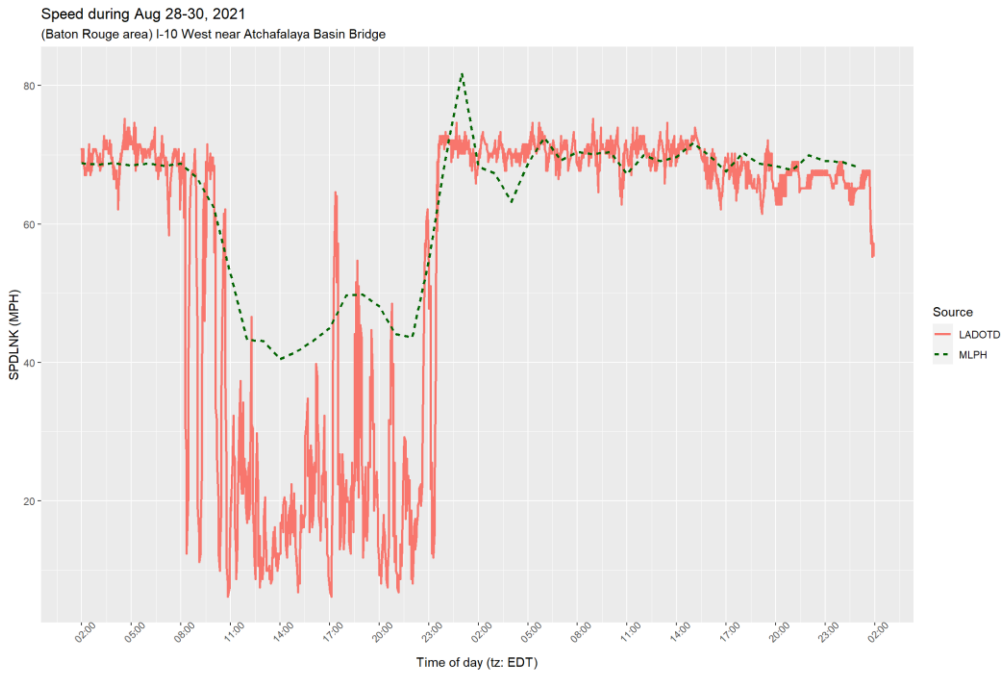
Reported Speeds versus Historical Observations and Weather and Road Conditions

Figure 19 displays the MLPH predicted speeds and historical LaDOTD observed speeds obtained for I–10 westbound near Atchafalaya Basin Bridge from August 28, 2021, 2 a.m. ET, to August 30, 2021, 2 a.m. ET. The MLPH predictions and the LaDOTD actual speeds generally showed a similar pattern. Large deviations were observed between 8 a.m. and 11 p.m. on August 28.

The plots in Figure 20 depict the supplemental road and weather conditions that provide context for interpreting the predicted and historical speeds. The supplemental data are, from top to bottom, precipitation category (PCCAT), surface inundation depth (DPHLIQ), pavement state (STPVT), visibility of surface (VIS), and wind gust speed (GSTWND) obtained for the same location from the same time period. The five plots present a snapshot of the road and weather conditions:

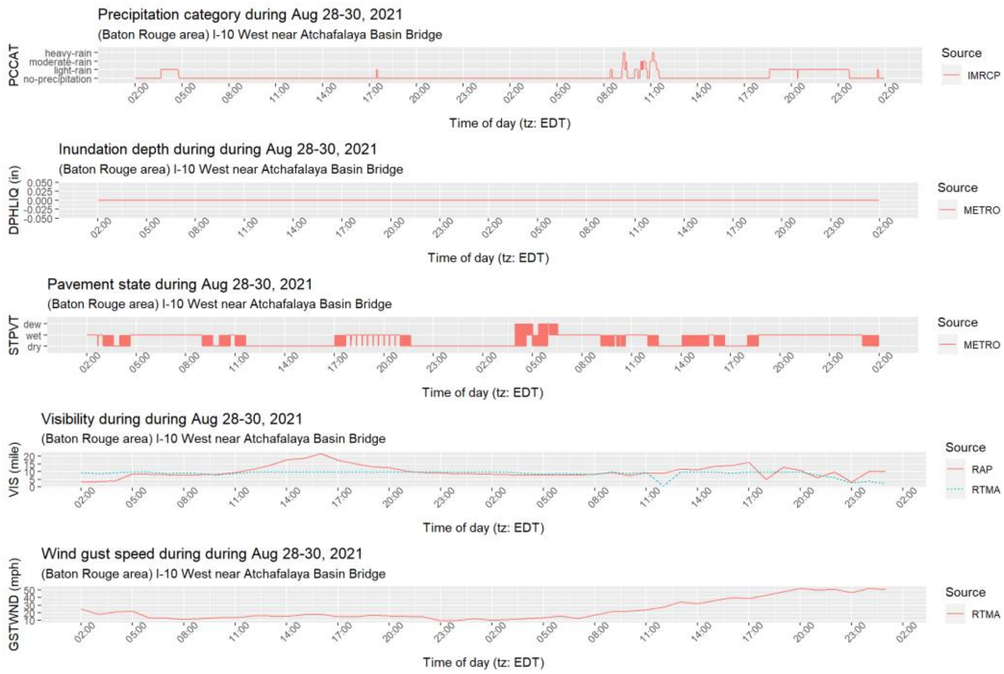
- Moderate-to-heavy rain only happened between 9 and 11 a.m. on August 29 according to IMRCP.
- Wind gust speed reached 50 mph at about 8 p.m. on August 29 according to RTMA.

The road and weather conditions did not seem to be relevant to the decreasing in speed on August 28.



Source: FHWA.

Figure 19. Graph. Machine learning-based prediction model predicted speeds and historical Louisiana Department of Transportation and Development observed speeds.



Source: FHWA.

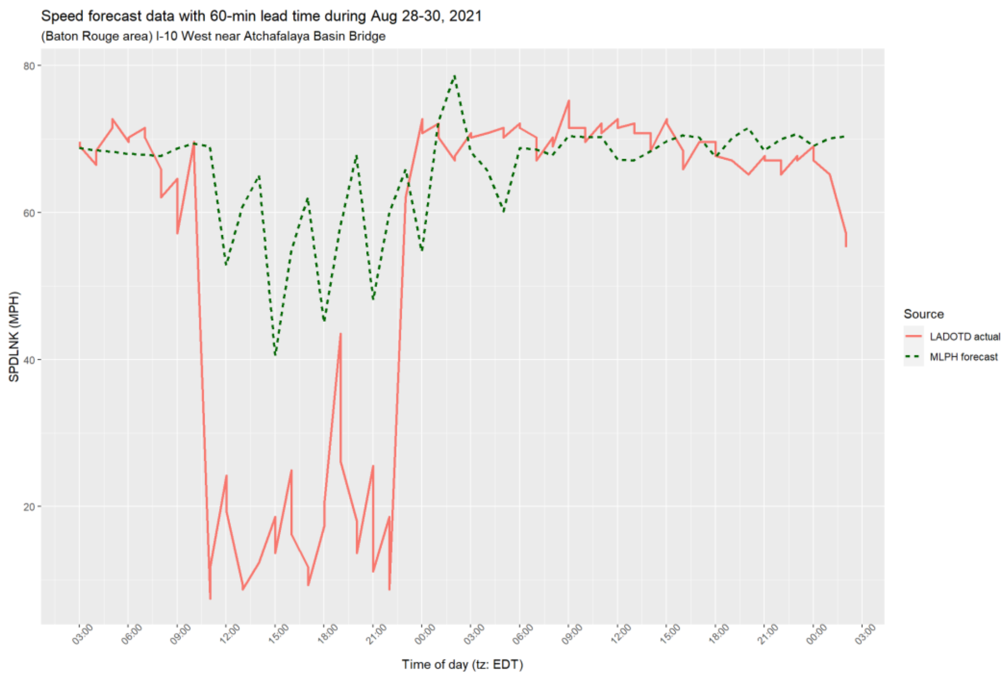
Figure 20. Graph. Weather and road conditions.

Speed Forecasts

The plots in Figure 21 and Figure 22 display the forecast speeds for I–10 westbound near Atchafalaya Basin Bridge from August 28, 2021, 2 a.m. ET, to August 30, 2021, 2 a.m. ET.

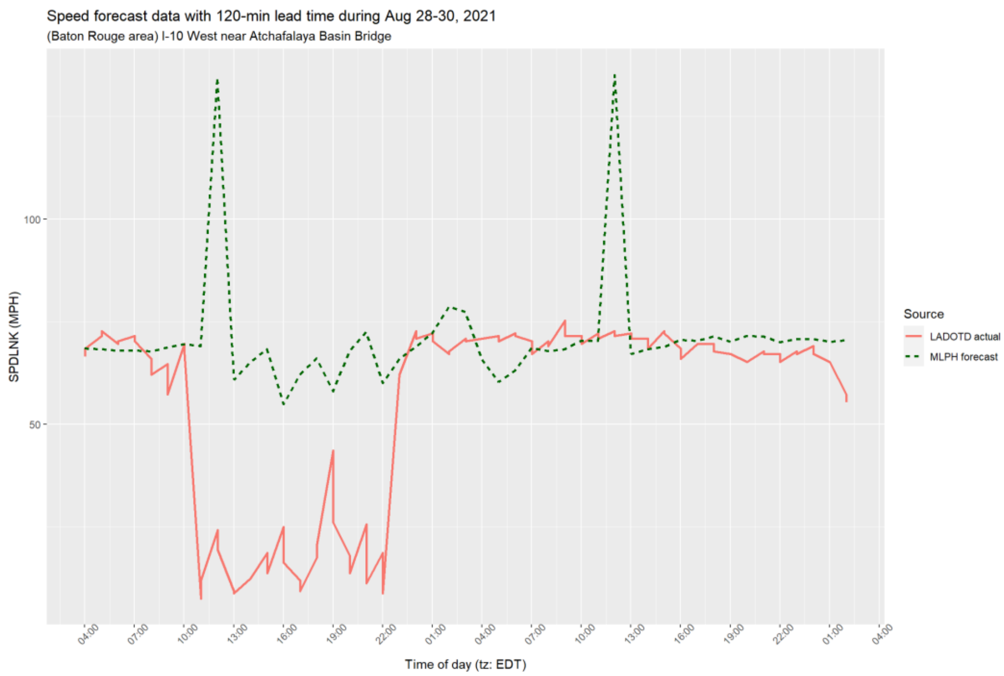
The plots show:

- Large deviations were observed between 11 a.m. and 11 p.m. on August 28. Otherwise, MLPH speed forecasts and LaDOTD generally had similar patterns.
- Longer forecasts produced wild predictions, as seen from the two spikes in figure 21.



Source: FHWA.

Figure 21. Graph. Forecast speeds and pavement temperatures for 60-minute lead time.



Source: FHWA.

Figure 22. Graph. Forecast speeds and pavement temperatures for 120-minute lead time.

Interstate 12 Westbound near Amite River (Baton Rouge Area)

Reported Speeds versus Historical Observations and Weather and Road Conditions

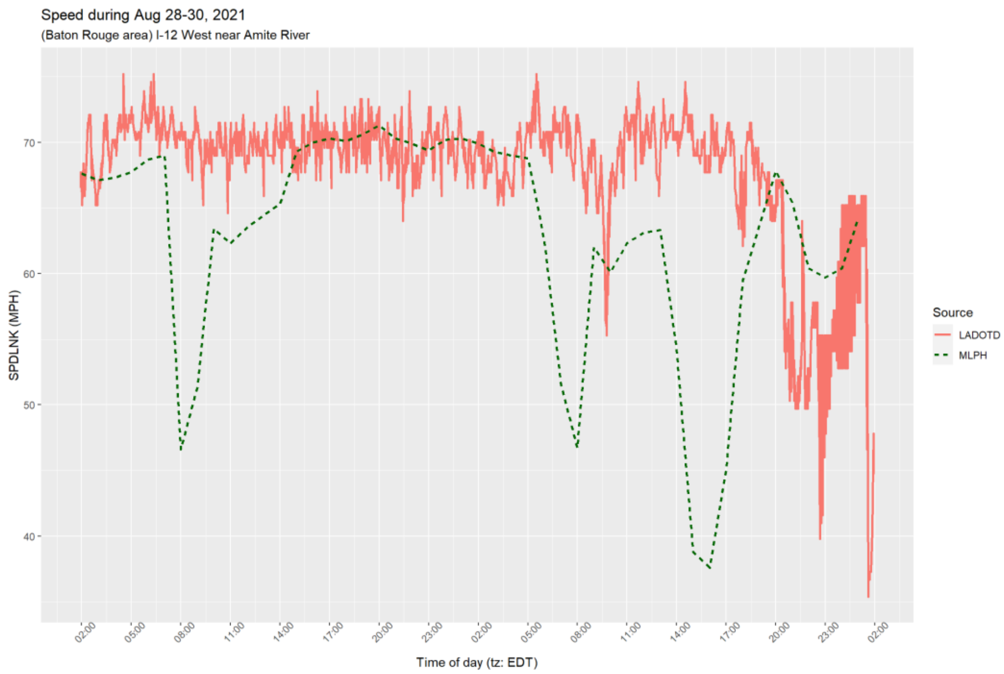
Figure 23 displays the MLPH predicted speeds and historical LaDOTD observed speeds obtained for I–12 West near Amite River from August 28, 2021, 2 a.m. ET, to August 30, 2021, 2 a.m. ET. Large deviations were observed at 8 a.m. on August 28 and August 29 and at around 4 p.m. on August 29. Otherwise, the MLPH predictions and the LaDOTD actual speeds generally showed a similar trend.

The plots in Figure 24 depict the supplemental road and weather conditions that provide context for the interpretation of the predicted and historical speeds. The supplemental data are, from top to bottom, precipitation category (PCCAT), surface inundation depth (DPHLIQ), pavement state (STPVT), visibility of surface (VIS), and wind gust speed (GSTWND) obtained for the same location from the same time period. The five plots present a snapshot of the road and weather conditions:

- Moderate-to-heavy rain was observed more often after 8 a.m. on August 29 according to IMRCP.

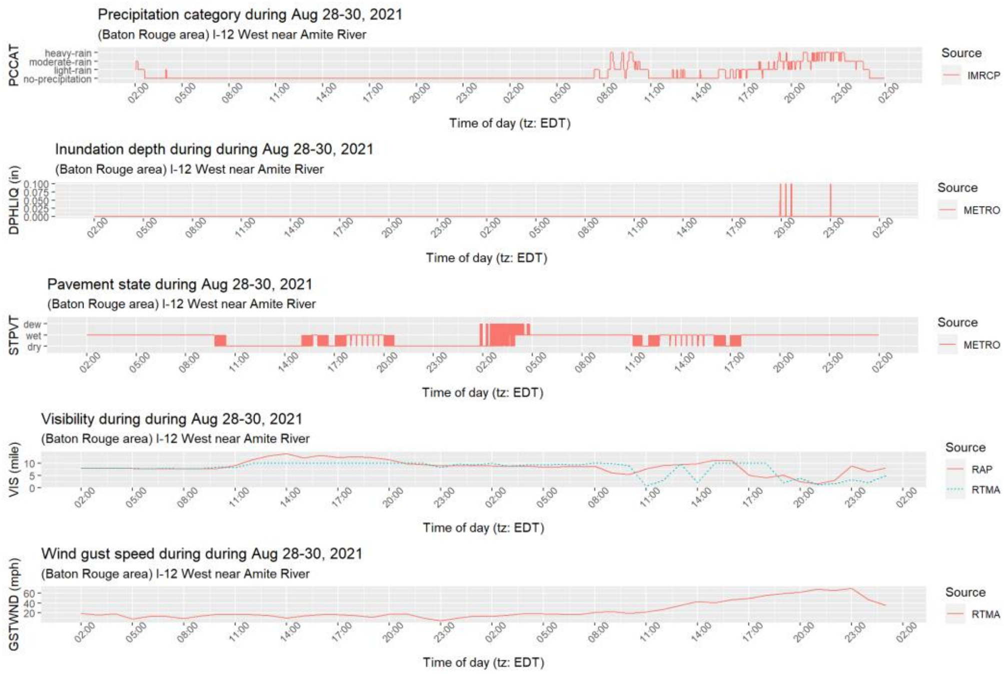
- Visibility was very low at about 8 p.m. on August 29 according to RAP and RTMA sources.
- Wind gust speed reached 60 mph at about 8 p.m. on August 29 according to the RTMA.

The road and weather conditions corresponded to the decreasing in speed at about 8 p.m. on August 29. Unidentified factors that potentially caused the other speed drops need further investigation.



Source: FHWA

Figure 23. Graph. Machine learning-based prediction model predicted speeds and historical Louisiana Department of Transportation and Development observed speeds.



Source: FHWA.

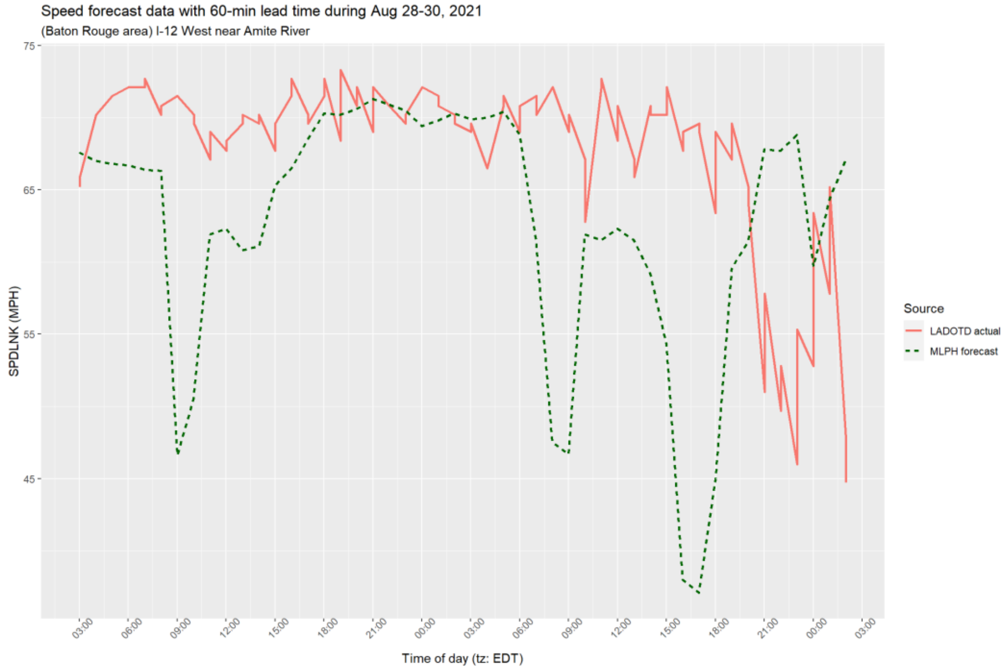
Figure 24. Graph. Weather and road conditions.

Speed Forecasts

The plots in Figure 25 and Figure 26 display the forecast speeds for I–12 West near Amite River from August 28, 2021, 2 a.m. ET, to August 30, 2021, 2 a.m. ET.

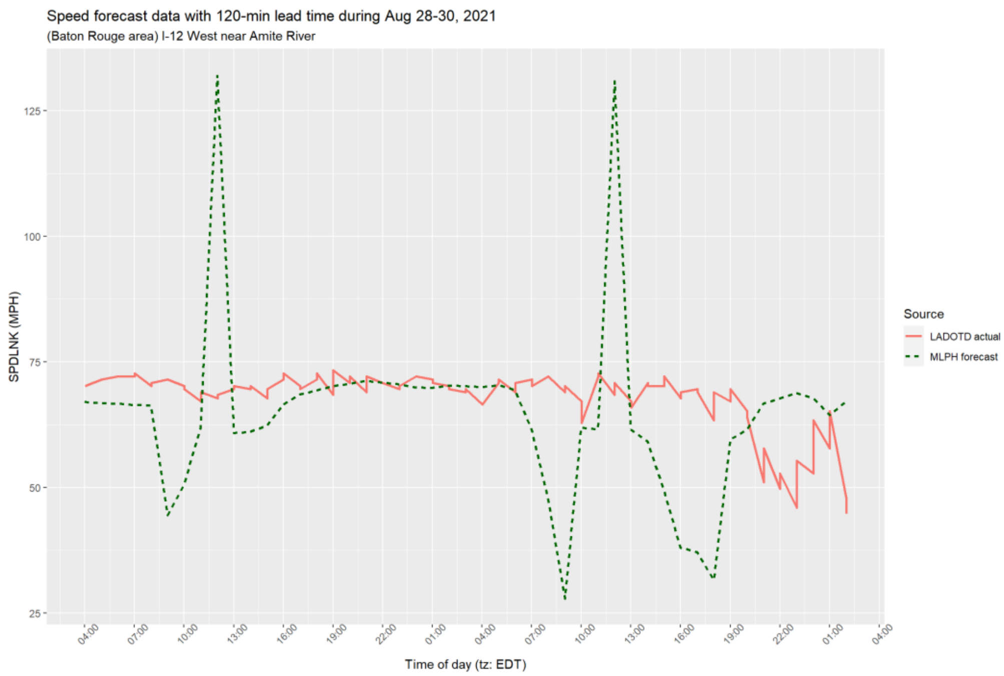
The plots show:

- Large deviations were observed more often for this segment.
- Longer forecasts produced wild predictions, as seen from the two spikes in figure 25 showing the forecast speeds for 120-minute lead time.



Source: FHWA.

Figure 25. Graph. Forecast speeds for 60-minute lead time.



Source: FHWA.

Figure 26. Graph. Forecast speeds for 120-minute lead time.

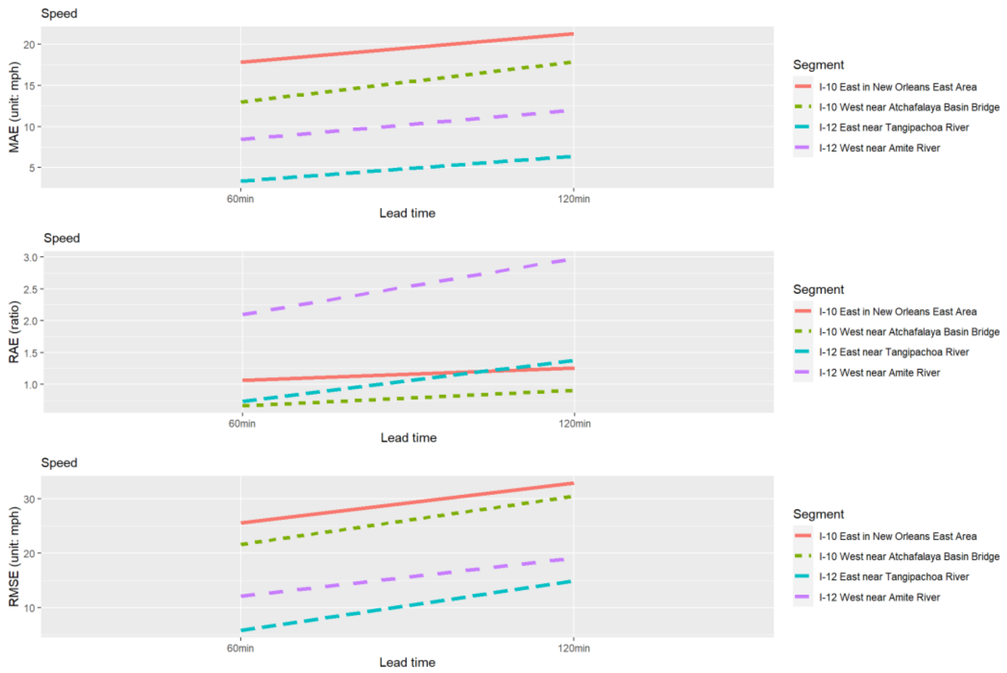
Forecast Error Analyses

For the speed forecasts, three error measurements were further calculated to assess the performance.

Speed

The plots in Figure 27 depict, from top to bottom, MAE, RAE, and RMSE for the 60- and 120-minute MLPH speed forecast error from August 28, 2021, 2 a.m. ET, to August 30, 2021, 2 a.m. ET.

The three metrics show that shorter-term forecasts tended to have smaller errors than longer-term forecasts (i.e., the shorter-term forecasts tended to be more accurate). Based on the MAE and RMSE results, I–10 East in the New Orleans East area segment had the largest deviations. However, if looking at the RAE results, the forecast performance for I–12 West near the Amite River segment was relatively poor.



Source: FHWA.

Figure 27. Graph. Speed forecast error measures for 60- and 120-minute lead times.

CHAPTER 4. FINDINGS

The Louisiana IMRCP evaluation conducted a walk-through and analyses to: (1) explore staff perspectives about the usability, usefulness, and capabilities and benefits of IMRCP and (2) investigate the accuracy of IMRCP traffic, road, and weather predictions.

Two objectives guided the evaluation:

- Investigate staff perspectives about the ease of use, usefulness, and the capabilities and benefits of IMRCP decision support tool for adverse weather conditions.
- Investigate if IMRCP functionality and capabilities provide users with accurate information for predicting traffic, road, and weather conditions during adverse weather conditions.

The following sections describe the findings of the walk-through sessions with LaDOTD participants and the analysis of IMRCP data.

WALK-THROUGH FINDINGS

All participants were novice IMRCP users, and none had used IMRCP for operations or analyses. Despite participants' lack of familiarity with IMRCP, their ratings were generally positive for the IMRCP topics covered in the walk-through (i.e., setup, map layers, data tables, traffic speed and weather forecasts).

When asked whether IMRCP was easy to use, all participants agreed, and a majority strongly agreed. When asked whether IMRCP was easy to understand, all participants agreed, and half strongly agreed. When asked whether IMRCP was useful for decision-making, about two-thirds of participants agreed and about one-third were unsure. These results were unsurprising, given the variety of participant roles and responsibilities (as shown in Table 1). Two of the participants did not have decision-making responsibilities and remarked they were not involved in decision-making, so they were not sure. When asked whether IMRCP could be improved, about half the participants agreed (no one strongly agreed) improvements could be made to IMRCP. All participants provided a variety of suggestions.

Participants' comments and perspectives provided deeper insight into their views and experiences using IMRCP. Participants cited that:

- **IMRCP would be useful for public information requests and for AARs.** Having the ability to adjust the date and time would be useful to go back and see: (1) what the road condition was and check where there were weather-related issues; (2) what the conditions were at the time of a crash; and (3) historical speed, pavement condition, and weather condition.

- **IMRCP may be useful for winter weather predictions and flooding.** Having all the information in one location instead of having to get information from weather sites, gauge sites, and traffic sites would be desirable to engineers, who usually get information from calls, experience, emergency operations, and people out scouting. They want to know which areas will be impacted. Also, since LaDOTD is concerned about flooding, IMRCP would be useful to monitor water levels to help with sending out crews and putting out message signs.

- **The accuracy of IMRCP data and information is important to ensure LaDOTD users continue to use the system.** IMRCP needs to show it is adding value and users need to have confidence in the system. It was believed that if IMRCP was integrated then more users would access the system. If IMRCP was not integrated then only one person would likely access the system.

Participants also noted a variety of user interface issues and suggested improvements. One of the most important issues mentioned was that the IMRCP traffic speed color-coding did not match the LaDOTD color scheme. This gave the impression that the IMRCP traffic speed was inaccurate. According to the participant, this was confusing and could cause a loss of confidence in IMRCP.

Given that the walk-through participants were novice users, some of their comments may be correctable with additional training and familiarity with IMRCP. For example, the order of tab items, confusion about different data sources and values, quantity of data displayed in data tables, knowing where to find definitions of weather alert categories, etc. Concerns about too much data causing clutter (and confusion), incompatible color-coding schemes, and the perception of colors being similar were an issue for some users.

Participants provided the following suggestions for features that could make IMRCP easier to use and understand:

- Enhancing the save favorite settings for map shortcuts and direct access to map locations, road network, and statewide sensor and precipitation settings
- Alerts for things (e.g., water levels or velocity) that exceed certain thresholds
- Hourglass or spinner indicator so user knows to wait for the system to finish processing data
- A zoom feature (click and drag over an area) to allow selecting (and zooming) the map
- An autocomplete feature for typing an hour number in a drop-down menu and jumping to the hour to make entry faster and easier
- A hover feature to quickly display the data table
- Adding route designation and direction of travel in road segment data tables
- When available, adding information on road grip and sensors on certain bridges for grip
- Adding precipitation rate per hour to the legend to make colors more meaningful
- When clicking links, opening a new browser window instead of replacing the IMRCP window
- Disabling weather event links that do not work

SYSTEM ACCURACY FINDINGS

The system accuracy findings discuss whether IMRCP provides users with accurate information for predicting traffic, road, and weather conditions during adverse weather conditions. By examining the reported IMRCP speeds versus the historical LaDOTD speeds from the four selected segments, IMRCP appeared to be capable of providing reliable real-time predictions for the majority of time after Hurricane Ida made landfall on August 29, 2021. During the day before the landfall of Hurricane Ida, there appeared to be more times that the predictions were off. This might indicate there could be factors that potentially affected the speed that had not been considered. As for the road and weather conditions reported by IMRCP, they appeared to be useful and valuable since they often corresponded to the speed data the team examined especially after Hurricane Ida arrived.

Speed forecast error analyses showed that the MLPH provided more accurate predictions when forecasting for the nearer future, which was expected. Based on the results, speed forecast performance for I–10 East in the New Orleans East area segment and for I–12 West near Amite River segment appeared to be relatively poor compared to the other two segments. Since the MLPH model learns from historical data, an investigation into the MLPH model and the amount of data to train the model may be helpful to improve the accuracy of speed forecasts.

Comment [NML[U1]: Sentence revised slightly to clarify.

CHAPTER 5. CONCLUSIONS

The Louisiana IMRCP evaluation conducted a walk-through and analyses to: (1) explore LaDOTD staff perspectives about the usability, usefulness, and capabilities and benefits of the IMRCP decision support tool and (2) investigate the accuracy of IMRCP traffic, road, and weather predictions. The LaDOTD walk-through participants indicated that IMRCP was easy to use, easy to understand; a majority of participants indicated that IMRCP was useful for decision-making and provided suggestions to improve the user interface and functionality. The system accuracy analysis showed that despite a few anomalies, IMRCP could provide generally reliable traffic information on the road and important weather information in the event of a hurricane.

The development team confirmed that the MLPH prediction accuracy could be improved and further enhanced with additional data. This model was developed and trained based on data from seven hurricanes.

Comment [NML[U2]: Added this.

APPENDIX A. LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT WALK-THROUGH

IMRCP WALK-THROUGH INSTRUCTIONS

Thank you for agreeing to participate in the IMRCP walk-through. 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. You and I will take turns sharing our screens during the walk-through. Here are some helpful instructions and information for our walk-through session.

Prior to our call, please do the following:

1. Make sure you have an IMRCP username and password. If not, please contact me or Michelle for help.
2. Complete the background information form (on page 2) and email it back to me.
3. Print the walk-through sheets (pages 3-11). Having a printed copy will make it easier to stay on track.
4. Please call in a few minutes prior to the meeting to ensure we can establish phone and computer connections.

During the walk-through session:

1. I will be sharing my desktop to display a slide presentation of introductory material (included in the email).
2. You will be sharing your desktop as we walk through the screens and activities.
3. We will periodically pause so I can ask you to provide ratings and answer relevant questions.
4. Please do not hesitate to call or write me or Michelle if you have any questions. Thank you for your time and assistance in this effort.

Bob Sanchez, Evaluation Lead
robert.r.sanchez@leidos.com
417-536-8767

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

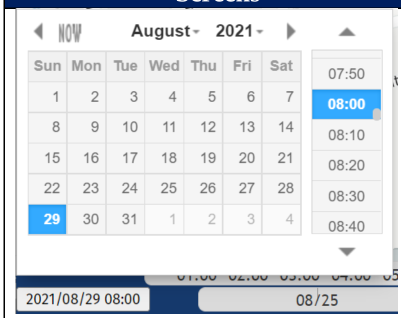
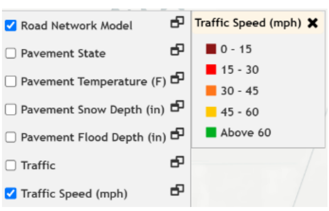
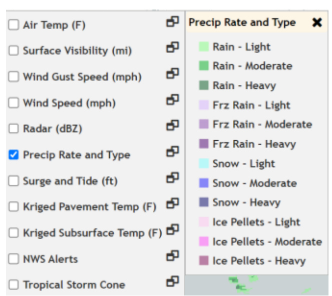
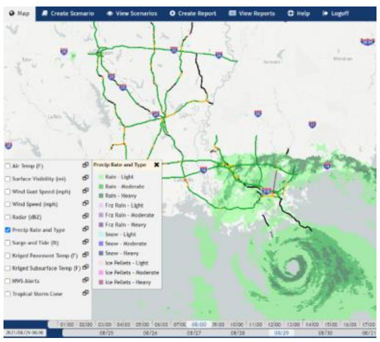
WALK-THROUGH PARTICIPANT BACKGROUND FORM

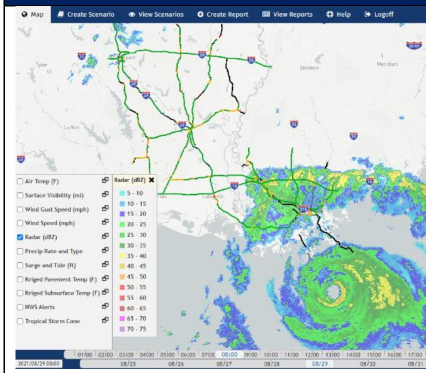
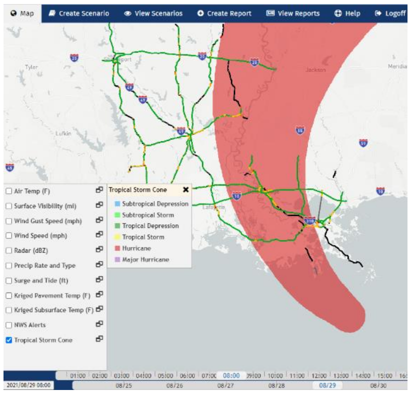
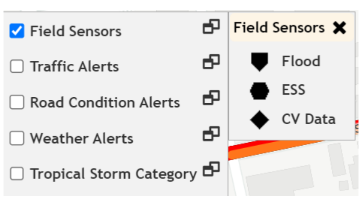
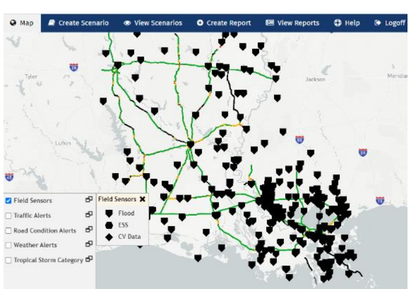
Before our call please complete & return to: Robert.R.Sanchez@leidos.com

Name:	Date:
Contact information for any follow-up questions:	
What is your role at LaDOTD?	
Provide your title and a brief description of your daily job and responsibilities.	
If applicable, what decisions do you need to make in your work to deal with extreme weather events (e.g., road closure and issuing evacuation order)?	
If applicable, what is your decision-making time window (e.g., 1 hour, 1 day, or 1 week)?	
If applicable, what tools do you typically use to assist in your decision-making?	
Does IMRCP provide new information and/or have enhanced capabilities in assisting your decision-making (circle one) ? Yes No Don't Know	
How often have you used IMRCP? Why did you use IMRCP? When did you last use IMRCP?	

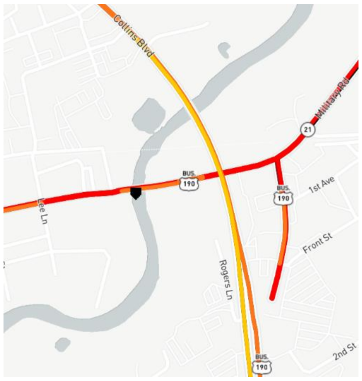
WALK-THROUGH TASKS

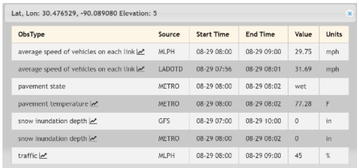
Walk-Through Task 1: Setup Reference Time, Map Layers, Road Segment Data, Field Sensor Data

Screens	Activity
	1. Log-in 2. Set Reference Time to 8/29/2021, 08:00, using the Date/Time display in bottom-left corner 2a. Select Year drop-down, choose 2021 2b. Left-click 29 2c. Scroll times and left-click 08:00
	3. Left-click Road Tab to check map layers 3a. Ensure Road Network Model is selected 3b. Ensure Traffic Speed is selected 4. Left-click Traffic Speed legend icon, notice colors 4a. Observe legend colors and speeds 5. Close legend 6. Close Road tab
	7. Left-click Area tab 7a. Left-click Precip Rate and Type 7b. Left-click Legend icon, notice colors and categories
	8. Explore map, zoom in/out using scroll wheel 8a. Notice Ida precipitation 8b. Close legend 8c. Left-click Precip Rate and Type to remove map layer

Screens	Activity
	9. Left-click Radar to add/remove map layer 9a. Left-click to remove map layer 9b. Left-click Wind Speed to add/remove map layer
	10. Left-click Tropical Storm to add/remove map layer 10a. Close Area tab
	11. Left-click Points tab 11a. Select Field Sensors 12. Left-click Legend icon 12a. Observe legend symbols and sensor types
	12b. Notice Field Sensors and Traffic Speeds 12c. Close legend 12d. Close Points tab

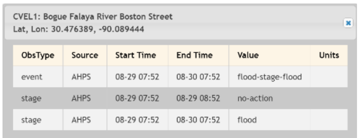
Screens	Activity





Lat, Lon: 30.476529, -90.089080 Elevation: 5

ObsType	Source	Start Time	End Time	Value	Units
average speed of vehicles on each link	MLPH	08-29 08:00	08-29 09:00	29.75	mph
average speed of vehicles on each link	LADOTD	08-29 07:56	08-29 08:01	31.69	mph
pavement state	METRO	08-29 08:00	08-29 08:02	wet	
pavement temperature	METRO	08-29 08:00	08-29 08:02	77.28	F
snow inundation depth	GFS	08-29 07:00	08-29 10:00	0	in
snow inundation depth	METRO	08-29 08:00	08-29 08:02	0	in
traffic	MLPH	08-29 08:00	08-29 09:00	45	%



CVEL1: Bogue Falaya River Boston Street
Lat, Lon: 30.476389, -90.089444

ObsType	Source	Start Time	End Time	Value	Units
event	AHPS	08-29 07:52	08-30 07:52	flood-stage-flood	
stage	AHPS	08-29 07:52	08-29 08:52	no-action	
stage	AHPS	08-29 07:52	08-30 07:52	flood	

13. Center map (Covington, 190 & 21),
13a. Use scroll wheel to Zoom in and see road segments

14. Notice color-coded traffic speeds on road segments over the Bogue Falaya River

15. Left-click EB link over the Bogue Falaya River

15a. Observe pop-up table
15b. Observe MLPH average speed is 29.75 from 08:00 to 09:00
15c. Observe LaDOTD average speed is 31.99 mph from 07:56 to 08:01
15d. Observe other road segment data
15e. Left-click to close table

16. Left-click Flood Sensor near Bus 190 and the Bogue Falaya River
16a. Observe pop-up table
16b. Observe other sensor data
16c. Left-click to close table

16d. <Provide ratings for Setup Reference Time, Looking at Map Layers, Road Segment Data, and Field Sensor Data>

Question	Rating
Easy to Use?	
Easy to Understand?	
Useful to Support Decision-Making?	
Could be Improved?	

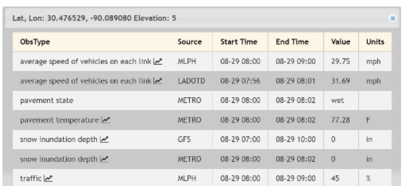
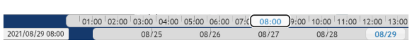
Rating: 1 to 5 where 1= Strongly Disagree, 2= Disagree, 3 = Neither Agree or Disagree, 4 = Agree, 5 = Strongly Agree
16e. <Answer Questions>

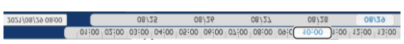
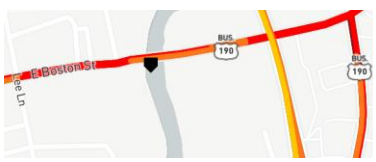
Topics covered: reference time, side tabs for map layers, map and road segments, road segment data table, field sensor data table.

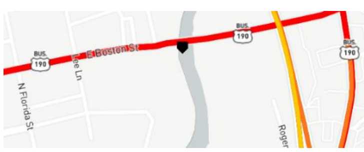
- Reference time: Was it easy to understand and use? Any suggested changes or

Screens	Activity
improvements? • Side tabs for map layers: Was the organization of the layers meaningful and easy to use? Do you like the speeds and colors in the traffic speed legend? Were the field sensor symbols useful? Any improvements or suggested changes? • Map and road segments: Was the map easy to navigate? Were the colors and symbols easy to see? Anything that could be improved or changed? Any additional information or functionality you would want included? • Road segment data table: Did you like it? Was the road segment data useful? Anything that could be improved or changed? • Field sensor data table: Did you like it? Was the field sensor data useful? Anything that could be improved or changed?	

Walk-Through Task 2: Observing Traffic Speed Forecasts (2-Hour and 8-Hour Predictions)

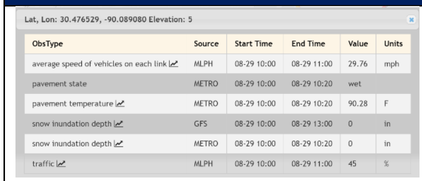
<table>
<tr><th>Screens</th><th>Activity</th></tr>
<tr><td>
</td><td>17. Left-click EB link over the Bogue Falaya River</td></tr>
<tr><td>
Lat, Lon: 30.476529, -90.089080 Elevation: 5
<table>
<tr><th>ObsType</th><th>Source</th><th>Start Time</th><th>End Time</th><th>Value</th><th>Units</th></tr>
<tr><td>average speed of vehicles on each link</td><td>MLPH</td><td>08-29 08:00</td><td>08-29 09:00</td><td>29.75</td><td>mph</td></tr>
<tr><td>average speed of vehicles on each link</td><td>LADOTD</td><td>08-29 07:56</td><td>08-29 08:01</td><td>31.69</td><td>mph</td></tr>
<tr><td>pavement state</td><td>METRO</td><td>08-29 08:00</td><td>08-29 08:02</td><td>wet</td><td></td></tr>
<tr><td>pavement temperature</td><td>METRO</td><td>08-29 08:00</td><td>08-29 08:02</td><td>77.28</td><td>F</td></tr>
<tr><td>snow inundation depth</td><td>GFS</td><td>08-29 07:00</td><td>08-29 10:00</td><td>0</td><td>in</td></tr>
<tr><td>snow inundation depth</td><td>METRO</td><td>08-29 08:00</td><td>08-29 08:02</td><td>0</td><td>in</td></tr>
<tr><td>traffic</td><td>MLPH</td><td>08-29 08:00</td><td>08-29 09:00</td><td>45</td><td>%</td></tr>
</table></td><td>18. Observe pop-up table
18a. Observe LaDOTD traffic speeds (31.69 mph)
18b. Left-click to close table</td></tr>
<tr><td>


</td><td>19. Using the time scale at the bottom of screen, move the time slider from 08:00 to 10:00
19a. Left-click 08:00 and drag to 10:00
19b. If needed, use the arrow keys to change the minutes
19c. Observe road segment color change from orange to red

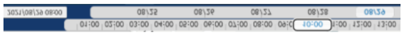
20. Left-click EB link over the Bogue Falaya River
20a. Observe pop-up table</td></tr>
</table>

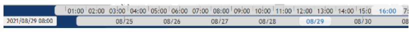
Screens	Activity

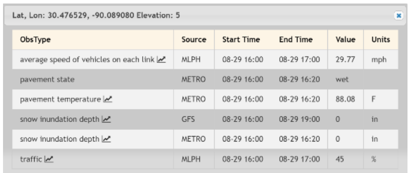


Lat, Lon: 30.476529, -90.089080 Elevation: 5

ObsType	Source	Start Time	End Time	Value	Units
average speed of vehicles on each link	MLPH	08-29 10:00	08-29 11:00	29.76	mph
pavement state	METRO	08-29 10:00	08-29 10:20	wet	
pavement temperature	METRO	08-29 10:00	08-29 10:20	90.28	F
snow inundation depth	GFS	08-29 10:00	08-29 13:00	0	in
snow inundation depth	METRO	08-29 10:00	08-29 10:20	0	in
traffic	MLPH	08-29 10:00	08-29 11:00	45	%







Lat, Lon: 30.476529, -90.089080 Elevation: 5

ObsType	Source	Start Time	End Time	Value	Units
average speed of vehicles on each link	MLPH	08-29 16:00	08-29 17:00	29.77	mph
pavement state	METRO	08-29 16:00	08-29 16:20	wet	
pavement temperature	METRO	08-29 16:00	08-29 16:20	88.08	F
snow inundation depth	GFS	08-29 16:00	08-29 19:00	0	in
snow inundation depth	METRO	08-29 16:00	08-29 16:20	0	in
traffic	MLPH	08-29 16:00	08-29 17:00	45	%

20b. Observe MLPH average speed (2-hour forecast) is 29.76 mph from 10:00 to 11:00

20c. Left-click to close table

21. Using the time scale at the bottom of screen, move the time slider from 10:00 to 16:00

22. Left-click EB link over the Bogue Falaya River

23. Observe pop-up table

23a. Observe MLPH average speed (8-hour forecast) is 29.77 mph from 16:00 to 17:00

23b. Left-click to close table

23c. <Provide ratings for observing traffic speed forecasts (2- and 8-hour forecasts)>

Question	Rating
Easy to Use?	
Easy to Understand?	
Useful to support Decision-making?	
Could be Improved?	

Rating: 1 to 5 where 1= Strongly Disagree, 2 = Disagree, 3 = Neither Agree or Disagree, 4 = Agree, 5 = Strongly Agree

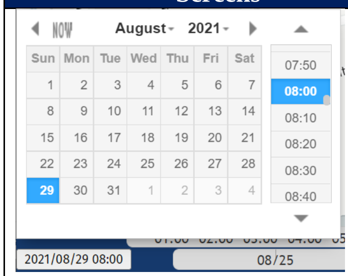
23d. <Answer Questions>

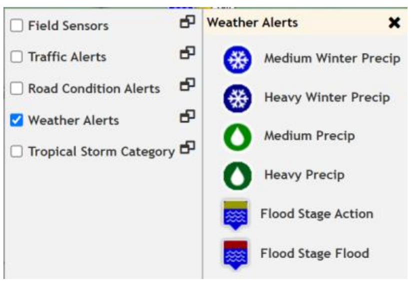
Topics covered: reference time, zoomed in to a specific map location, pulled up road segment data table to examine current average traffic speed, set time scale to 2 and 8 hours later than the reference time, observed MLPH average speed forecasts.

- Reference time: Any new comments or suggested changes or improvements?
- Map and road segments: Any new comments or suggested changes or improvements?
- Setting the time scale to examine forecast data: Did you like the method used to set times? Was it easy to keep track of your settings? Any comments or suggested improvements?
- Observing 2- and 8-hour forecasts: Was it easy to set up and get? Was the information useful? When would you want to use this information? Is the data entry process too cumbersome to view several locations? Would you want the functionality to view more

Screens	Activity
than one road segment at a time? Any suggested improvements?	

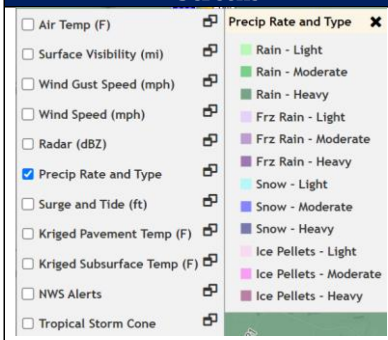
Walk-Through Task 3: Observing Weather Alerts & Forecasts (2- and 8-hr)

<table>
<tr><th>Screens</th><th>Activity</th></tr>
<tr><td>


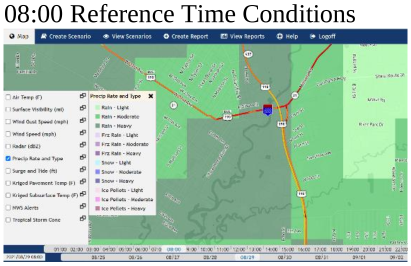


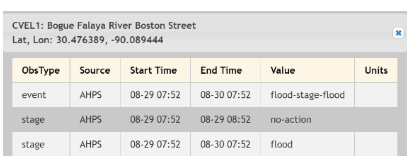
</td><td>
24. Set Reference Time to 8/29/2021, 08:00, using the Date/Time display in bottom-left corner
25. Left-click Points tab
25a. Select Weather Alerts
26. Left-click Legend icon
26c. Observe legend symbols and weather types
26d. <Provide ratings for weather alerts>
<table>
<tr><th>Question</th><th>Rating</th></tr>
<tr><td>Easy to Use?</td><td></td></tr>
<tr><td>Easy to Understand?</td><td></td></tr>
<tr><td>Useful to support Decision-making?</td><td></td></tr>
<tr><td>Could be Improved?</td><td></td></tr>
</table>
Rating: 1 to 5 where 1= Strongly Disagree, 2 = Disagree, 3 = Neither Agree or Disagree, 4 = Agree, 5 = Strongly Agree
27. Close legend
28. Left-click Area tab
</td></tr>
</table>

Screens	Activity



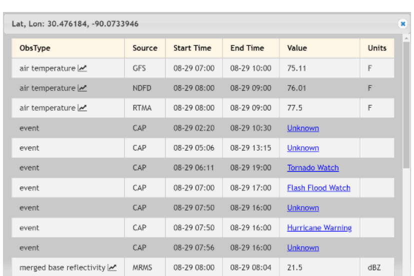
08:00 Reference Time Conditions





CVEL1: Bogue Falaya River Boston Street
Lat, Lon: 30.476389, -90.089444

ObsType	Source	Start Time	End Time	Value	Units
event	AHPS	08-29 07:52	08-30 07:52	flood-stage-flood	
stage	AHPS	08-29 07:52	08-29 08:52	no-action	
stage	AHPS	08-29 07:52	08-30 07:52	flood	



Lat, Lon: 30.476184, -90.0733946

ObsType	Source	Start Time	End Time	Value	Units
air temperature	GFS	08-29 07:00	08-29 10:00	75.11	F
air temperature	NDFD	08-29 08:00	08-29 09:00	76.01	F
air temperature	RTMA	08-29 08:00	08-29 09:00	77.5	F
event	CAP	08-29 02:20	08-29 10:30	Unknown	
event	CAP	08-29 05:06	08-29 13:15	Unknown	
event	CAP	08-29 06:11	08-29 19:00	Tornado Watch	
event	CAP	08-29 07:00	08-29 17:00	Flash Flood Watch	
event	CAP	08-29 07:50	08-29 16:00	Unknown	
event	CAP	08-29 07:50	08-29 16:00	Hurricane Warning	
event	CAP	08-29 07:56	08-29 16:00	Unknown	
merged base reflectivity	MRMS	08-29 08:00	08-29 08:04	21.5	dBZ

29. Select Precip Rate and Type

30. Left-click Legend icon
30a. Observe map overlay of Precip Rate and Type

30b. <Provide ratings for setting up Precip Rate and Type>

Question	Rating
Easy to Use?	
Easy to Understand?	
Useful to support Decision-Making?	
Could be Improved?	

Rating: 1 to 5 where 1= Strongly Disagree, 2 = Disagree, 3 = Neither Agree or Disagree, 4 = Agree, 5 = Strongly Agree

31. Close legend

32. Zoom out using scroll wheel to see precipitation variations around highways 190 & 21.

32a. Notice 08:00 Conditions: Light/Moderate/Heavy Rain

33. Left-click Weather Alert icon near Bus 190 and the Bogue Falaya River

33a. Observe pop-up table
33b. Observe Flood Stage data
34. Left-click to close table

35. Left-click Light Rain area of the map
35a. Observe pop-up table
35b. Observe the types of weather conditions/events, the sources, times, and values

36. Scroll down the table
36a. Observe the additional types of weather conditions/events, the sources, times, and values
37. <Provide ratings for observing current weather

Screens	Activity

Lat, Lon: 30.476184, -90.0733946

merged base reflectivity	MRMS	08-29 08:00	08-29 08:04	21.5	dBZ
precipitation category	RAP	08-29 08:00	08-29 09:00	moderate-rain	
precipitation category	IMRCP	08-29 08:00	08-29 08:04	light-rain	
surface visibility	GFS	08-29 07:00	08-29 10:00	14.25	mi
surface visibility	RAP	08-29 08:00	08-29 09:00	3.29	mi
surface visibility	RTMA	08-29 08:00	08-29 09:00	9.94	mi
wind speed	GFS	08-29 07:00	08-29 10:00	12.07	mph
wind speed	RAP	08-29 08:00	08-29 09:00	18.22	mph
wind speed	NDFD	08-29 08:00	08-29 09:00	16.11	mph
wind speed	RTMA	08-29 08:00	08-29 09:00	13.49	mph
wind speed gust	GFS	08-29 07:00	08-29 10:00	27.14	mph
wind speed gust	RTMA	08-29 08:00	08-29 09:00	29.64	mph

data>

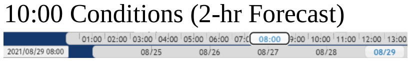
Question	Rating
Easy to Use?	
Easy to Understand?	
Useful to support Decision-making?	
Could be Improved?	

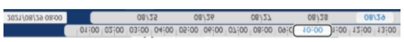
Rating: 1 to 5 where 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree or Disagree, 4 = Agree, 5 = Strongly Agree

38. <Questions> Too much information? Takes too long to comprehend?

39. Left-click to close table

10:00 Conditions (2-hr Forecast)





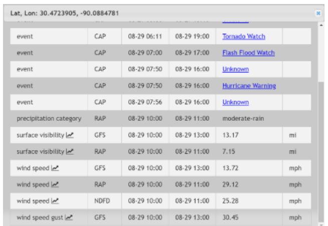
40. Using the time scale at the bottom of screen, move the time slider from 08:00 to 10:00

41. Observe Precip Rate color change on map

Lat, Lon: 30.4723905, -90.0884781

ObsType	Source	Start Time	End Time	Value	Units
air temperature	GFS	08-29 10:00	08-29 13:00	74.57	F
air temperature	NDFD	08-29 10:00	08-29 11:00	79.97	F
event	CAP	08-29 02:20	08-29 10:30	Unknown	
event	CAP	08-29 05:06	08-29 13:15	Unknown	
event	CAP	08-29 06:11	08-29 19:00	Tornado Watch	
event	CAP	08-29 07:00	08-29 17:00	Flash Flood Watch	
event	CAP	08-29 07:50	08-29 16:00	Unknown	
event	CAP	08-29 07:50	08-29 16:00	Hurricane Warning	
event	CAP	08-29 07:56	08-29 16:00	Unknown	
precipitation category	RAP	08-29 10:00	08-29 11:00	moderate-rain	
surface visibility	GFS	08-29 10:00	08-29 13:00	13.17	mi

42. Left-click Moderate Rain area of the map
 42a. Observe pop-up table for 2-hour forecasts
 42b. Observe the types of weather conditions/events, the sources, times, and values



Lat, Lon: 30.4723905, -90.0884781

event	CAP	08-29 06:11	08-29 19:00	Tornado Watch	
event	CAP	08-29 07:00	08-29 17:00	Flash Flood Watch	
event	CAP	08-29 07:50	08-29 16:00	Unknown	
event	CAP	08-29 07:50	08-29 16:00	Hurricane Warning	
event	CAP	08-29 07:56	08-29 16:00	Unknown	
precipitation category	RAP	08-29 10:00	08-29 11:00	moderate-rain	
surface visibility	GFS	08-29 10:00	08-29 13:00	13.17	mi
surface visibility	RAP	08-29 10:00	08-29 11:00	7.15	mi
wind speed	GFS	08-29 10:00	08-29 13:00	13.72	mph
wind speed	RAP	08-29 10:00	08-29 11:00	29.12	mph
wind speed	NDFD	08-29 10:00	08-29 11:00	25.28	mph
wind speed gust	GFS	08-29 10:00	08-29 13:00	30.45	mph

43. Scroll down the table
 43a. Observe the additional types of weather conditions/events, the sources, times, and values

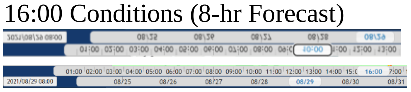
44. Left-click to close table

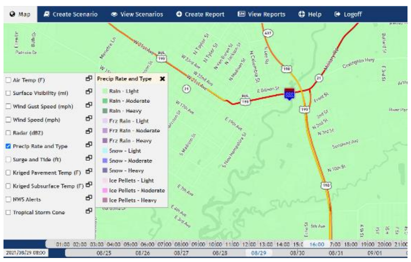
45. Using the time scale at the bottom of screen,

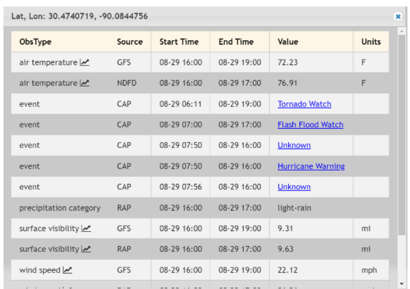
Screens	**Activity**

Screens

16:00 Conditions (8-hr Forecast)

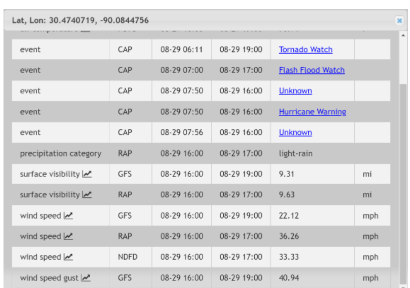






Lat, Lon: 30.4740719, -90.0844756

ObsType	Source	Start Time	End Time	Value	Units
air temperature	GFS	08-29 16:00	08-29 19:00	72.23	F
air temperature	NDFD	08-29 16:00	08-29 17:00	76.91	F
event	CAP	08-29 06:11	08-29 19:00	Tornado Watch	
event	CAP	08-29 07:00	08-29 17:00	Flash Flood Watch	
event	CAP	08-29 07:50	08-29 16:00	Unknown	
event	CAP	08-29 07:50	08-29 16:00	Hurricane Warning	
event	CAP	08-29 07:56	08-29 16:00	Unknown	
precipitation category	RAP	08-29 16:00	08-29 17:00	light-rain	
surface visibility	GFS	08-29 16:00	08-29 19:00	9.31	mi
surface visibility	RAP	08-29 16:00	08-29 17:00	9.63	mi
wind speed	GFS	08-29 16:00	08-29 19:00	22.12	mph



Lat, Lon: 30.4740719, -90.0844756

event	CAP	08-29 06:11	08-29 19:00	Tornado Watch	
event	CAP	08-29 07:00	08-29 17:00	Flash Flood Watch	
event	CAP	08-29 07:50	08-29 16:00	Unknown	
event	CAP	08-29 07:50	08-29 16:00	Hurricane Warning	
event	CAP	08-29 07:56	08-29 16:00	Unknown	
precipitation category	RAP	08-29 16:00	08-29 17:00	light-rain	
surface visibility	GFS	08-29 16:00	08-29 19:00	9.31	mi
surface visibility	RAP	08-29 16:00	08-29 17:00	9.63	mi
wind speed	GFS	08-29 16:00	08-29 19:00	22.12	mph
wind speed	RAP	08-29 16:00	08-29 17:00	36.26	mph
wind speed	NDFD	08-29 16:00	08-29 17:00	33.33	mph
wind speed gust	GFS	08-29 16:00	08-29 19:00	40.94	mph

Activity

move the time slider from 10:00 to 16:00

45a. Observe Precip Rate color change on map

46. Left-click Light Rain area of the map

46a. Observe pop-up table for 8-hour forecasts
46b. Observe the types of weather conditions/events, the sources, times, and values

47. Scroll down the table

47a. Observe the additional types of weather conditions/events, the sources, times, and values

48. <Provide ratings for observing 2- and 8-hour forecasts>

Question	Rating
Easy to Use?	
Easy to Understand?	
Useful to support Decision-Making?	
Could be Improved?	

Rating: 1 to 5 where 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree or Disagree, 4 = Agree, 5 = Strongly Agree

49. <Answer Questions> Too much information? Takes too long to comprehend?

<table>
<tr><th>Screens</th><th>Activity</th></tr>
<tr><td colspan="2">Topics: weather alerts, weather data tables, map with precipitation rates and types, precip 2- and 8-hour forecasts.

Weather Alerts: Was the legend useful? Could the legend be improved? Were the alert icons on the map easy to understand and use? Any suggested changes or improvements?
Weather Data Tables: Was the data table easy to understand? Were the weather data useful? When would you use this information? Anything that could be improved or changed?
Map with Precipitation Rates and Types: Was the organization of the layers meaningful and easy to use? Do you like the categories and colors in the legend? Any improvements or suggested changes?
Precip 2- and 8-hour Forecasts: After left-clicking the map to see weather data, were the forecasts useful? When would you want to use this information? Were the forecast data easy to understand? Was the amount of information too much or little? Was the organization of information easy to understand? Any additional information or functionality you would want included? Any suggestions for things that could be improved or changed?
</td></tr>
</table>

U.S. Department of Transportation
Federal Highway Administration
Office of Operations
1200 New Jersey Avenue, SE
Washington, DC 20590