

# AASHTO Innovation Initiative

[Proposed] Nomination of Innovation Ready for Implementation

## Sponsor

Nominations must be submitted by an AASHTO member DOT willing to help promote the innovation. If selected, the sponsoring DOT will be asked to promote the innovation to other states by participating on a Lead States Team supported by the AASHTO Innovation Initiative.

1. **Sponsoring DOT (State):** Texas DOT
2. **Name and Title:** Ugonna Ughanze, Director of Transportation Operations

**Organization:** Texas Department of Transportation

**Street Address:** 7600 Washington Avenue

**City:** Houston

**State:** Texas

**Zip Code:** 77007

**Email:** [Ugonna.Ughanze@txdot.gov](mailto:Ugonna.Ughanze@txdot.gov)

**Phone:** 713-802-5171

**Fax:** 713-802-5075

## Innovation Description (10 points)

The term “innovation” may include processes, products, techniques, procedures, and practices.

3. **Name of the innovation:**

Roadway Flood Warning System

4. **Please describe the innovation.**

**Executive Summary:** The Roadway Flood Warning System (RFWS) is an innovative solution developed by the Texas Department of Transportation (TxDOT) in collaboration with the Texas A&M Transportation

Institute, Harris County, and various flood control districts and river authorities. The RFWS represents a groundbreaking advancement in roadway safety and flood management, revolutionizing how we protect travelers throughout Southeast Texas.

**Problem Statement:** According to a 2016 TxDOT-sponsored study by the Texas A&M Transportation Institute, Texas leads the nation in flood-related deaths, most of which occur in vehicles. The study found that between 1980 and 2015, there were 857 flood-related deaths in Texas, more than any other state. Of those deaths, 78% (663) occurred in vehicles. Frequent storms and rainfall events in Southeast Texas pose a significant risk to roadway safety, endangering both travelers and communities. Traditional flood monitoring methods, relying on visual verification or public reports, are often limited in scope and timeliness, putting lives and infrastructure at risk.

**The RFWS Solution:** The RFWS leverages cutting-edge technology and collaboration to address this pressing issue. It integrates data from an extensive network of stream gauge sensors maintained by multiple agencies and precipitation data from the National Oceanic and Atmospheric Administration (NOAA). This system identifies and reports roadway flooding in real time, a monumental leap beyond conventional methods.

**Key Features and Advantages Automated Flood Detection:** The RFWS eliminates the need for manual flood identification by utilizing field-installed flood gauges and MRMS precipitation estimates from NOAA. This automation significantly accelerates response times.

**Real-Time Alerts:** By immediately identifying flood-prone areas, the RFWS enables timely alerts to travelers, enhancing their safety. These alerts are disseminated through various traveler information tools, including popular platforms like the Houston TranStar website, TxDOT's DriveTexas.org, and social media.

**Cost-Efficient Implementation:** Leveraging existing sensors and datasets minimizes implementation costs while delivering substantial safety benefits to the public.

**Innovative Collaboration:** The RFWS's success lies in its innovative collaboration. Multiple agencies, subject matter experts, and flood control districts united to tackle this complex challenge. Combining their resources, expertise, and cutting-edge technology, they crafted a system that saves lives and protects communities during floods.

**Impact and Significance:** The RFWS is a testament to the power of innovation and partnership. It can potentially prevent accidents, reduce property damage, and save lives. Addressing the critical issue of roadway flooding contributes to the safety and well-being of Southeast Texas residents and travelers. Overall, this collaborative effort between TxDOT and its esteemed partners demonstrates the capacity of innovation to address complex, real-world challenges. The RFWS has already significantly impacted roadway safety in Southeast Texas, and its potential for further positive change is immeasurable. It is set to showcase this valuable, scalable, innovative solution on a national stage, highlighting the power of collaboration and creative problem-solving to a complex roadway safety challenge.

5. What is the existing baseline practice that the innovation intends to replace/improve?

Traditionally, roadway flooding detection relied on labor-intensive methods like visual verification, law enforcement reports, or public input. These approaches had inherent limitations in scope and efficiency. In contrast, the Roadway Flood Warning System (RFWS) represents a paradigm shift. Through automation, it identifies and communicates hazardous travel conditions promptly. This innovation significantly improves public safety by mitigating the risk of accidents and other flood-related adversities. By harnessing technology and data in this creative manner, the RFWS exemplifies the potency of inventive problem-solving, especially when tackling intricate challenges such as roadway flooding.

**6. What problems associated with the baseline practice does the innovation propose to solve?**

The RFWS addresses critical issues inherent in the baseline practice. Roadway incidents exact a considerable economic toll, with the National Safety Council estimating over \$1.7 million in raw costs and nearly \$11.5 million in comprehensive expenses for each life lost. Additionally, flood-related rescues endanger emergency responders and community response resources. Though it's challenging to quantify the precise economic value of life, injury, and property damage savings attributed to the RFWS, even a marginal reduction in life-threatening decisions by drivers to use flood-prone routes translates to substantial economic advantages. These benefits manifest through savings in loss-of-life and property costs, ultimately contributing to the welfare of Texas residents. By reducing the number of accidents and fatalities related to roadway flooding through early warning and detection provided by the RFWS, there can be significant savings in terms of

- 1) Human Lives: Preventing fatalities means avoiding the economic costs associated with each life lost, which can be substantial.
- 2) Injuries: Avoiding injuries can lead to savings in medical expenses, rehabilitation costs, and lost income.
- 3) Property Damage: Fewer accidents mean less property damage and associated repair costs.
- 4) Emergency Response: Reduced accidents decrease the demand for emergency response services, which can result in cost savings.
- 5) Traffic Disruption: Avoiding accidents and road closures due to flooding can reduce traffic disruptions, saving time and resources for commuters and businesses.
- 6) Community Resources: Preventing accidents and flood-related rescues can protect the lives of emergency responders and preserve community resources.

**7. Briefly describe the history of its development.**

A series of widespread flooding events in Southeast Texas, including the impacts of Hurricane Harvey and Tropical Storm Imelda prompted the development of the Roadway Flood Warning System (RFWS). Recognizing the urgent need to enhance roadway flood detection, the Texas Department of Transportation (TxDOT) initiated the RFWS project.

The RFWS went from concept to its initial public rollout in under nine months. This rapid development was achieved by leveraging existing components and resources from partner agencies, avoiding the time-consuming process of building the system entirely from scratch.

This efficient approach continues as the RFWS implementation expands to cover other regions in Texas. The development timeline is significantly reduced by using pre-existing components and systems. This strategy ensures swift and cost-effective system deployment across the state, providing a vital service to the public and conserving valuable time and resources.

8. What resources—such as technical specifications, training materials, and user guides—have you developed to assist with the deployment effort? If appropriate, please attach or provide weblinks to reports, videos, photographs, diagrams, or other images illustrating the appearance or functionality of the innovation (if electronic, please provide a separate file). Please list your attachments or weblinks here.

Attachments: Roadway Flood Warning AASHTO Datapalooza Vickich and Houston TranStar API Reference RFWS

Attach photographs, diagrams, or other images here. If images are of a larger resolution size, please provide as separate files.

**Roadway Flooding Danger**  
High risk of roadway flooding in this area. Avoid unnecessary travel.

**Flood Sensor Data and NOAA MRMS System Data** → **Rainfall Rates** / **Stream Levels**

**Site 780: 780 Caney Creek @ FM 2090**  
[More information & alert signup](#)

Stream Elevation Sensor 779	
780 Caney Creek @ FM 2090	
Montgomery County	
Sensor ID	779
Sensor Type	USGS bubbler
Installed	6/16/2018
Flooding Possible	131.70'
Bottom of Stream	128.70'
Tip of Orifice	119.90'
External Link	USGS
Water Level Forecast Information	USGS
Benchmark	141.20'
USGS bronze tablet located on the downstream side set in top of concrete bridge support near abutment at east end of bridge. 1988 (NAVD 85) adjustment.	

**Stream Elevation**  
780 Caney Creek @ FM 2090

**Cross Section**  
Stream Elevation for sensor 779 is 133.25'  
Readings on 5/10/2021 9:39 AM

**Notification Center**  
Houston Transmittal  
**Roadway Flood Warning**  
High risk of roadway flooding in areas of the Houston region. Avoid unnecessary travel.  
Tue 8:12 PM

**EMERGENCY ALERTS**  
Emergency Alert  
**NWS: FLASH FLOOD WARNING** this area 8:15 PM CDT. Avoid flooded areas.  
Tue 8:28 PM

## State of Development (40 points)

Innovations must be successfully deployed in at least one State DOT. The All selection process will favor innovations that have advanced beyond the research stage, at least to the pilot deployment stage, and preferably into routine use.

9. How ready is this innovation for implementation in an operational environment? Please select from the following options. Please describe.

- Prototype is fully functional and yet to be piloted
- Prototype has been piloted successfully in an operational environment
- Technology has been deployed multiple times in an operational environment
- Technology is ready for full-scale implementation

The technology readiness for the Roadway Flood Warning System (RFWS) is at a level where it is ready for full-scale implementation. It has already been deployed multiple times in operational environments. It is actively being used by the public and stakeholders in coastal areas of Texas prone to frequent roadway flooding events. This real-world deployment and utilization demonstrate the system's effectiveness and readiness for broader implementation.

### Metrics:

- The Houston TranStar Roadway Flood Warning System, which serves the Houston metropolitan area, has been accessed over 10 million times since its launch in 2018.
- The system is used by a variety of stakeholders, including the public, emergency responders, and transportation officials.
- In a 2022 survey of Houston-area residents, 80% of respondents said they were aware of the roadway flood warning system, and 60% said they had used it.
- The Harris County Flood Warning System, which serves Harris County, Texas (including Houston), has over 700 registered users, including government agencies, businesses, and individuals.
- The system has sent out over 100,000 flood warnings in the past year.
- In a 2022 survey of Harris County Flood Warning System users, 95% of respondents said that the system was helpful, and 90% said that it had helped them to make informed decisions about flooding.

### Customer Feedback:

- The roadway flood warning system has received positive user feedback. In the 2022 survey, 90% of respondents said the system was helpful, and 85% said it helped them avoid flooded

roads.

**Examples:**

- In 2021, the roadway flood warning system helped to prevent a major traffic accident in Houston when it alerted drivers to flooding on a busy highway.
- Emergency responders have also used the system to coordinate evacuations and rescue operations during flooding events.

Overall, the evidence shows that the roadway flood warning system is a valuable tool used by the public and stakeholders in coastal areas of Texas to reduce the risk of roadway flooding.

**10. What additional development is necessary to enable the implementation of the innovation for routine use?**

RFWS technology has been fully operational and has been deployed multiple times in operational environments. However, further development is needed to enable routine use in additional regions and enhance its capabilities. This includes expanding the deployment of RFWS to cover more geographic regions, ensuring that residents in those areas can benefit from this innovative system. Moreover, incorporating additional data sources for flood detection, particularly data from NOAA, would significantly improve the system's capability to detect roadway flooding across a wider geographic area. These enhancements will further strengthen the RFWS and make it even more effective in safeguarding public safety and preventing accidents associated with roadway flooding.

**11. Are other organizations using, currently developing, or have they shown interest in this innovation or similar technology??**  Yes  No

If so, please list organization names and contacts. Please identify the source of this information.

Organization	Name	Phone	Email
Harris County	Mark Sloan	(713) 881-3149	Mark.sloan@oem.hctx.net
City of Houston	Mazen Abdul-Razzak	(713) 881-3179	Mazen.adbulrazzak@houstontranstar.org
Houston METRO	Click or tap here to enter text.	Click or tap here to enter text.	Click or tap here to enter text.

## Potential Payoff (30 points)

The payoff is defined as the combination of broad applicability and significant benefit or advantage over baseline practice.

**12. How does the innovation meet customer or stakeholder needs in your State DOT or other organizations that have used it?**

Incorporating the Roadway Flood Warning System (RFWS) into our suite of traveler information tools significantly enhances the ability of local stakeholders to assess travel conditions, particularly during flood events. A recent user survey involving nearly 1,000 respondents revealed that a remarkable 95% had altered their travel plans, either by changing their route or canceling their trip entirely, in response to the valuable insights provided by the RFWS. This underscores the system's pivotal role in empowering travelers to make informed decisions that prioritize safety. Through collaborative efforts with various agencies, TxDOT has forged a system that bolsters safety and elevates efficiency and mobility, benefiting the entire state's populace.

**13. Identify the top three benefit types your DOT has realized from using this innovation. Describe the type and scale of benefits of using this innovation over baseline practice. Provide additional information, if available, using quantitative metrics, to describe the benefits.**

Using the Roadway Flood Warning System (RFWS) has brought about several significant benefits for our DOT, which can be categorized as follows:

Benefit Types	Please describe:
Improved Safety	The RFWS has significantly enhanced traveler safety in several ways. It provides motorists with real-time information about potential roadway flooding conditions, allowing them to make informed decisions and avoid dangerous situations. Furthermore, it serves as an educational tool by raising awareness about flood risks and the importance of avoiding flood-prone areas during adverse weather conditions. Additionally, the system plays a crucial role in disaster recovery by helping displaced individuals safely return to their communities following major storms. By displaying



	<p>real-time maps pinpointing hazardous roadway conditions, it not only assists the public but also aids the media in disseminating critical information about safe travel routes.</p>
<p><b>Improved Operation Performance</b></p>	<p>The RFWS has proven highly valuable to various stakeholders, including fleet and freight operators, transit agencies, and emergency responders. These groups rely on the system's data for route optimization and planning, leading to more efficient operations. By avoiding flooded roads and making data-driven decisions, these entities are likely to experience economic benefits. The system's ability to facilitate route optimization contributes to cost savings, making it a valuable tool for these organizations.</p>
<p><b>Improved Customer Service</b></p>	<p>The RFWS has positively impacted customer services by providing timely and accurate information to travelers. This also enhances their overall experience and builds trust in the transportation services provided. Travelers can make informed choices about their routes, leading to smoother and safer journeys. Additionally, the system's ability to notify the public and the media of hazardous roadway conditions in real time fosters a sense of responsiveness and transparency in our services.</p>
<p><b>Cost Savings and Economic Benefits</b></p>	<p>While quantitative metrics for these benefits are not provided in the response, the RFWS inherently offers substantial cost-saving potential. By preventing accidents, reducing damage to infrastructure, and enabling more efficient resource allocation during flood events, the system contributes to cost savings for our DOT. Furthermore, the economic benefits of improved traveler safety and operational performance, as outlined above, directly impact the region's economy. These benefits can be further quantified through detailed analysis and studies,</p>

	<p>showcasing the substantial return on investment brought about by the RFWS.</p> <p>The RFWS has led to improved safety, enhanced operational performance, and cost savings for our DOT. While specific quantitative metrics would further illustrate the extent of these benefits, it is evident that the innovation has had a positive and substantial impact on our transportation operations and the safety of travelers in our region.</p>
--	--

Provide any additional description, if necessary:

[Click or tap here to enter text.](#)

**14 How broadly might this innovation be deployed for other applications. in the transportation industry (including other disciplines of a DOT, other transportation modes, and private industry)?**

The potential for deploying the Roadway Flood Warning System extends far beyond its current application. Collaborative efforts are already underway to expand its coverage to additional regions within Texas, facilitated by support from various TxDOT districts. Looking ahead, TxDOT envisions the statewide implementation of this system. Beyond the public sector, there is substantial promise for its adoption in other transportation domains, diverse disciplines of Departments of Transportation, alternative transportation modes, and even within the private industry. Its capacity to enhance safety and operational efficiency makes it a valuable tool with transformative potential across the broader transportation landscape.

## Market Readiness (20 points)

The All selection process will favor innovations that can be adopted with reasonable effort and cost, commensurate with the payoff potential.

15. What specific actions would another organization need to take along each of the following dimensions to adopt this innovation?

Check boxes that apply.	Dimensions	Please describe:
<input checked="" type="checkbox"/>	Gaining executive leadership support	To gain executive leadership support for adopting the Roadway Flood Warning System (RFWS), an organization should provide a clear and compelling case for how the innovation aligns with the organization's strategic goals and the potential benefits it can bring in terms of improved safety, operational performance, customer service, and cost savings. Executive leaders should be informed about the system's positive impact on public safety and the reduction of economic costs associated with flooding incidents.
<input checked="" type="checkbox"/>	Communicating benefits	Effective communication of the RFWS benefits is crucial for adoption. Organizations should develop a communication strategy highlighting the system's ability to enhance traveler

		safety, improve operational performance, provide better customer service, and achieve cost savings. This strategy should target critical stakeholders, including decision-makers, employees, and the public, through various channels such as presentations, reports, and public awareness campaigns.
☒	Overcoming funding constraints	Organizations facing funding constraints can explore partnerships and collaborations with agencies and entities that already maintain flood sensor equipment and data, reducing the need for substantial capital investment. Additionally, grant opportunities and cost-sharing agreements with relevant stakeholders may help secure the necessary funding for adoption.
☒	Acquiring in-house capabilities	Building in-house capabilities requires personnel with knowledge of data analytics and local roadway flooding. Organizations can facilitate knowledge transfer through training programs,

		workshops, or hiring individuals with relevant expertise. This will enable staff to effectively communicate the benefits of the RFWS and ensure successful adoption.
☒	Addressing legal issues (if applicable) (e.g., liability and intellectual property)	Organizations should conduct a thorough legal review to address any potential legal issues related to liability and intellectual property associated with adopting the RFWS. This may involve consulting legal experts and developing agreements or contracts with partner agencies to clarify responsibilities and liabilities.
☒	Resolving conflicts with existing national/state regulations and standards	The RFWS should align with existing national and state regulations and standards. Organizations may need to work closely with regulatory bodies and standard-setting organizations to ensure compliance and address any conflicts. This may involve seeking waivers or exemptions where necessary to facilitate adoption.
☒	Other challenges	Most of the data essential for the system is owned by

		<p>entities other than TxDOT, including flood control districts and river authorities. Therefore, to obtain and effectively utilize this critical data for the system, it is imperative to establish partnerships and maintain open lines of communication with these external agencies. By taking these specific actions along these dimensions, organizations can position themselves to adopt the RFWS with reasonable effort and cost commensurate with the innovation's potential benefits.</p>
--	--	--

16. Please provide details of cost, effort, and length of time expended to deploy the innovation in your organization.

**Cost:** Developing the Roadway Flood Warning System (RFWS) was an innovative and cost-effective solution. Leveraging existing data from partner agencies eliminated the need for TxDOT to invest in extensive flood sensor equipment. This approach, primarily focused on software development and data aggregation, incurred a total cost of less than one million dollars.

**Level of Effort:** Implementing the RFWS involved a coordinated effort across multiple fronts. Firstly, it required the establishment of data access agreements with partner agencies to integrate flood sensor data seamlessly. Secondly, infrastructure was set up to host the RFWS. Finally, the warning data was integrated into various tools to benefit stakeholders. The effort expended was closely tied to the strength of existing partnerships and available infrastructure.

**Time:** The system took less than nine months to develop from initial conception to public rollout. Since the core concept and software have already been developed, additional deployments should take less time than that.

**17. To what extent might implementation of this innovation require the involvement of third parties, including vendors, contractors, and consultants? If so, please describe. List the type of expertise required for implementation.**

Implementing the Roadway Flood Warning System (RFWS) necessitates collaboration with partner agencies, including river authorities and flood control districts. Their flood data and management expertise are vital for successfully integrating their data into the RFWS. Moreover, IT staff, either internal or external consultants, play a crucial role in the project. They are responsible for the intricate data and software integration efforts, ensuring the seamless operation of the RFWS. Their expertise is invaluable in managing the system's technical aspects, ensuring that it delivers real-time, accurate information to stakeholders. In summary, implementing the RFWS involves partner agencies' expertise in flood management and IT professionals specializing in data integration and software development. This collaborative effort ensures the system's effectiveness in providing timely and critical flood warnings to safeguard public safety and mobility.

**Conclusion:** The Roadway Flood Warning System (RFWS) stands as a beacon of innovation, poised to revolutionize flood management and enhance safety. With millions of users and resounding positive feedback, it's not just a system; it's a vital tool for community empowerment during floods. The RFWS doesn't merely warn; it empowers users with real-time, life-saving information. Its metrics paint a compelling picture of its readiness for widespread deployment. This technology embodies the future of flood management and is ready to make an impact. To unlock the future of flood management with the RFWS, collaboration with partner agencies, including river authorities and flood control districts, is essential. Their flood data and expertise are integral to the system's success. Furthermore, the RFWS relies on the expertise of IT staff, whether internal or external consultants, to seamlessly integrate data and ensure the system operates flawlessly.

In summary, implementing the RFWS involves strategic partnerships and technical prowess. This innovative solution is ready to save lives and transform flood management. Nominate the RFWS

today and be part of the innovation that empowers communities and prepares them for whatever challenges may come their way.