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Driving Through Extreme Weather (DEW) Mobile App: Improving Risk Communication from NWS to Vehicle Drivers

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16. Abstract

The Driving through Extreme Weather (DEW) project addresses the critical need for effective risk communication between the National Weather Service (NWS) and vehicle drivers during severe weather events, particularly tornadoes. Many travelers either fail to receive timely weather warnings or lack actionable guidance on how to respond while on the road. To close this gap, this project developed and demonstrated a prototype mobile application integrated with a backend decision-support system. The app provides real-time visualization of severe weather alerts—including storm origin, path direction, and affected zones—using a user-friendly map interface. Built on a Django REST backend and an Android-based frontend, the DEW system dynamically renders tornado alerts as geospatial polygons and warns drivers if their planned route intersects hazardous areas. The app leverages data from the NWS and Google Maps APIs to guide user decisions during active weather threats. While the full route optimization algorithm is reserved for future work, the current system successfully enables timely and location-specific risk awareness for drivers. This prototype offers a scalable framework for enhancing public safety on roadways and lays the foundation for broader deployment and integration with commercial navigation platforms.

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Abstract

The Driving through Extreme Weather (DEW) project addresses the critical need for effective risk communication between the National Weather Service (NWS) and vehicle drivers during severe weather events, particularly tornadoes. Many travelers either fail to receive timely weather warnings or lack actionable guidance on how to respond while on the road. To close this gap, this project developed and demonstrated a prototype mobile application integrated with a backend decision-support system. The app provides real-time visualization of severe weather alerts—including storm origin, path direction, and affected zones—using a user-friendly map interface. Built on a Django REST backend and an Android-based frontend, the DEW system dynamically renders tornado alerts as geospatial polygons and warns drivers if their planned route intersects hazardous areas. The app leverages data from the NWS and Google Maps APIs to guide user decisions during active weather threats. While the full route optimization algorithm is reserved for future work, the current system successfully enables timely and location-specific risk awareness for drivers. This prototype offers a scalable framework for enhancing public safety on roadways and lays the foundation for broader deployment and integration with commercial navigation platforms.

Chapter 1 Background and Problem Statement

1.1 Severe Weather Risks for Drivers

Severe thunderstorms—particularly tornadoes—represent a significant and growing risk to drivers and transportation personnel across the central United States. While many drivers routinely rely on mobile navigation tools such as Google Maps and Apple Maps, these applications are not designed to incorporate real-time hazard information or provide safety-based routing under extreme weather conditions.

A major concern lies in the inability of drivers to receive or interpret localized severe weather warnings. Many travelers are unfamiliar with the counties they traverse and are therefore unable to respond meaningfully to alerts issued by county name. Moreover, satellite radio services, which are commonly used during long-distance travel, are not geographically targeted. Consequently, many drivers either do not receive relevant alerts or receive them too late to act.

Even when alerts are received, the lack of actionable guidance—such as where to seek shelter, which exit to take, or whether to continue traveling—results in confusion or inaction. This communication gap contributes to unnecessary exposure to severe weather threats and highlights the need for a more intelligent, location-aware warning system tailored to the realities of road travel.

1.2 Project Motivation and Objectives

The Driving through Extreme Weather (DEW) project was initiated to address this gap. It aims to bridge the divide between severe weather alert systems and protective decision-making for road users. Specifically, the project seeks to improve real-time risk communication from the National Weather Service (NWS) to vehicle drivers by integrating weather alerts with actionable routing information through a mobile platform.

Missouri was selected as the pilot location due to its high tornado frequency, and tornadoes were chosen as the initial hazard type for system development. The project partners included the Springfield, MO NWS office and the Missouri Department of Transportation (MODOT)—both active members of Missouri's Integrated Warning Team.

The primary goals of the project were to:

- Develop a backend decision-support framework that incorporates real-time tornado alert data and geospatial mapping.
- Build an Android mobile application (the DEW App) to visualize alerts, routes, and risk zones.
- Create logic to detect when a user's selected route intersects any hazard polygon and notify them accordingly.
- Lay the foundation for broader application to other weather events (e.g., flash floods) and for future integration with commercial navigation systems.

1.3 Comparative Analysis of Existing Weather Websites

To inform the DEW mobile app design, a detailed comparative analysis was conducted on three prominent weather information websites:

- National Weather Service Radar (radar.weather.gov)
- Storm Prediction Center Convective Outlooks (spc.noaa.gov/products/outlook)
- Local NWS Severe Weather Information (weather.gov/gsp/severe)

1.3.1 National Weather Service Radar (radar.weather.gov)

The NWS Radar website provides users with real-time radar images and animations to visualize precipitation intensity and storm movements, as shown in Figure 1.1. Its interface includes interactive maps, overlays of county lines, and simple controls for zooming and looping radar imagery.

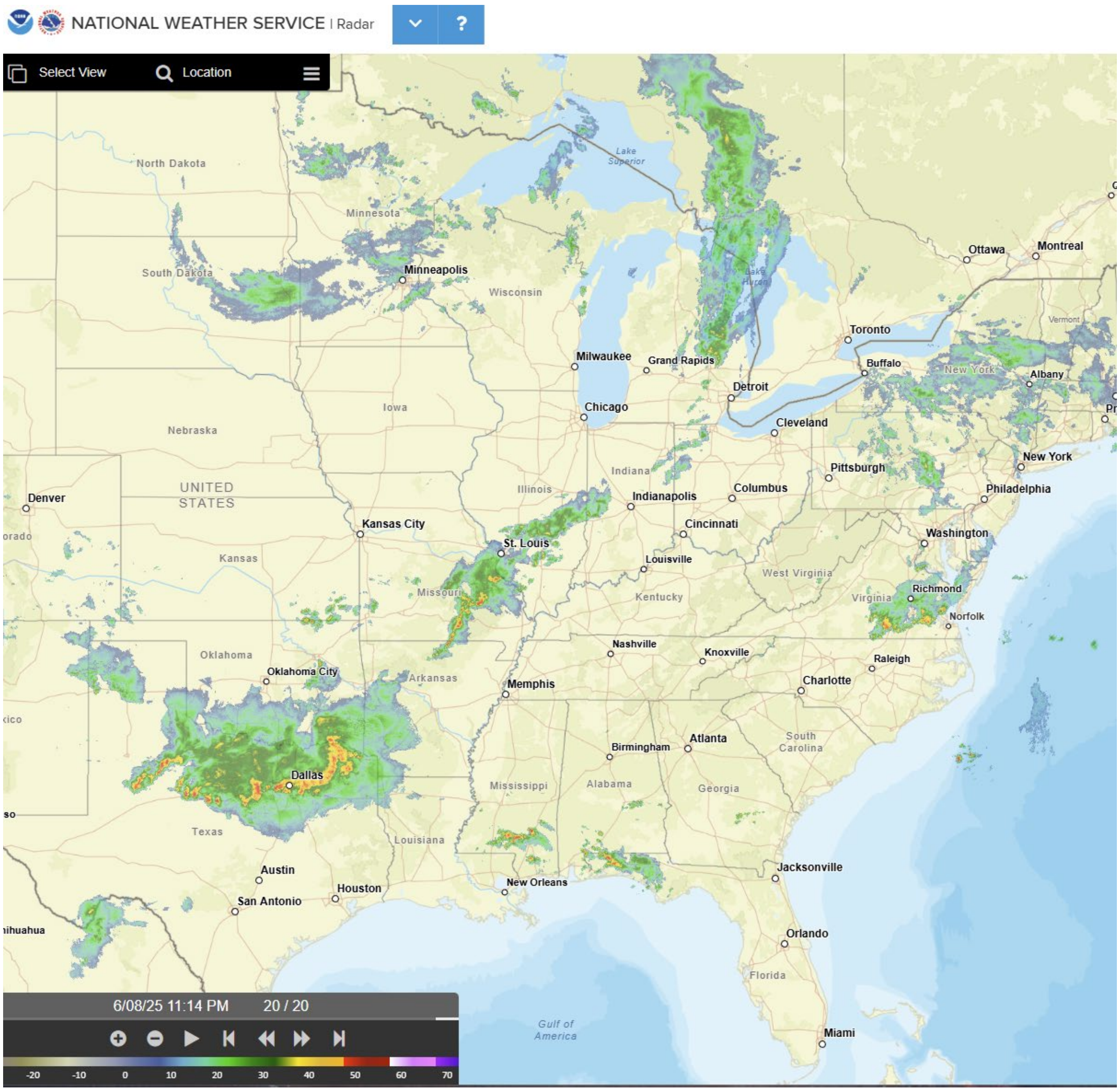


Figure 1.1 NWS Radar interface

- User Interface: Clean, simple, and intuitive, with minimal text clutter. Interactive tools for zooming and looping radar animations.

- Data Presentation: Highly visual, color-coded radar imagery clearly illustrates storm intensity and location but lacks explicit directional arrows or movement predictions.
- Effectiveness in Risk Communication: Effective for users familiar with radar interpretation, but it assumes significant user meteorological literacy. It lacks explicit guidance on protective actions or route-specific alerts for drivers.

1.3.2 Storm Prediction Center Convective Outlooks (spc.noaa.gov/products/outlook)

The SPC website focuses on providing national-level outlooks on severe weather potential, categorized into risk levels (e.g., marginal, slight, enhanced, moderate, high), as shown in Figure 1.2. Maps show generalized risk areas accompanied by detailed meteorological text discussions.

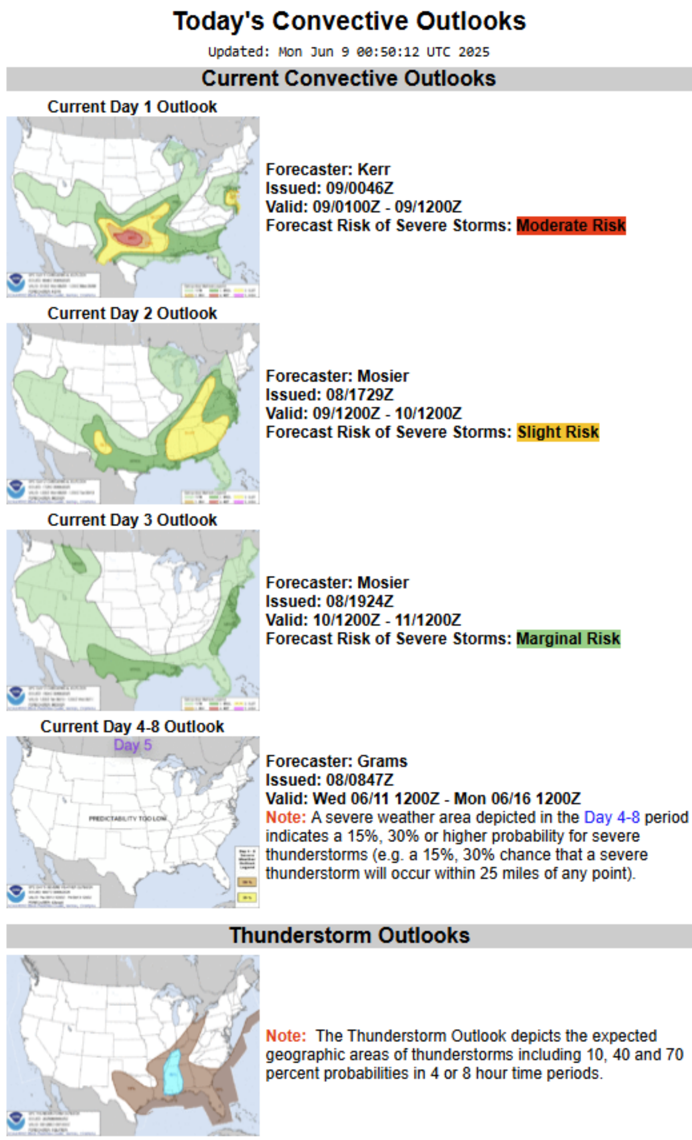


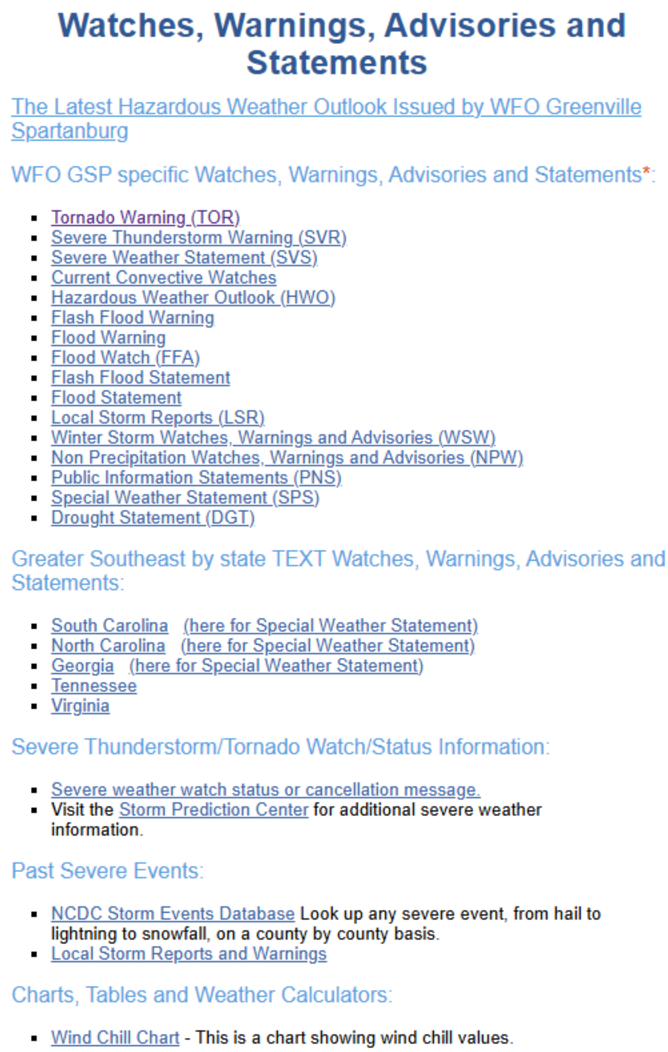
Figure 1.2 Storm Prediction Center Convective Outlooks

- User Interface: Dense with technical meteorological terminology; requires users to interpret textual forecasts in combination with generalized map visualizations.
- Data Presentation: Maps display broad areas of risk, color-coded by severity, with supplemental textual information detailing risk rationale and forecast confidence.

- Effectiveness in Risk Communication: Highly effective for meteorologists, emergency managers, or weather enthusiasts. However, its complexity and use of technical jargon significantly limit accessibility and usability for the general driving public seeking immediate actionable guidance.

1.3.3 Local NWS Severe Weather Information (weather.gov/gsp/severe)

Local NWS severe weather pages provide county-specific severe weather warnings and statements, often displayed in text-based formats with detailed bulletins and static county-level maps, as shown in Figure 1.3.



Watches, Warnings, Advisories and Statements

The Latest Hazardous Weather Outlook Issued by WFO Greenville Spartanburg

WFO GSP specific Watches, Warnings, Advisories and Statements*:

- Tornado Warning (TOR)
- Severe Thunderstorm Warning (SVR)
- Severe Weather Statement (SVS)
- Current Convective Watches
- Hazardous Weather Outlook (HWO)
- Flash Flood Warning
- Flood Warning
- Flood Watch (FFA)
- Flash Flood Statement
- Flood Statement
- Local Storm Reports (LSR)
- Winter Storm Watches, Warnings and Advisories (WSW)
- Non Precipitation Watches, Warnings and Advisories (NPW)
- Public Information Statements (PNS)
- Special Weather Statement (SPS)
- Drought Statement (DGT)

Greater Southeast by state TEXT Watches, Warnings, Advisories and Statements:

- South Carolina (here for Special Weather Statement)
- North Carolina (here for Special Weather Statement)
- Georgia (here for Special Weather Statement)
- Tennessee
- Virginia

Severe Thunderstorm/Tornado Watch/Status Information:

- Severe weather watch status or cancellation message.
- Visit the Storm Prediction Center for additional severe weather information.

Past Severe Events:

- NCDC Storm Events Database Look up any severe event, from hail to lightning to snowfall, on a county by county basis.
- Local Storm Reports and Warnings

Charts, Tables and Weather Calculators:

- Wind Chill Chart - This is a chart showing wind chill values.

Figure 1.3 Local NWS Severe Weather Information

- User Interface: Primarily text-based, organized into bulletins, and supplemented by static, non-interactive images or maps.
- Data Presentation: County-specific, text-heavy alerts with detailed timestamps and expiration notices. Visual information is minimal, typically static and lacks dynamic elements or interactivity.

- Effectiveness in Risk Communication: Provides clear localized textual information but lacks intuitive visual context needed for drivers unfamiliar with the region. The absence of dynamic or interactive elements limits situational awareness and quick decision-making for travelers on the move.

1.3.4 Insights Gained for DEW Mobile App Development

This comparative analysis yielded important insights for the DEW application design:

- Balance between visualization and textual detail: A balance is necessary to ensure that drivers quickly interpret risk without becoming overwhelmed by meteorological complexity. Highly visual, dynamic interfaces are essential, supplemented with concise, clear text instructions.
- Intuitive and accessible data visualization: Clearly labeled directional indicators (e.g., arrows showing storm movement), alert polygons with distinctive color coding, and simple interactive features (e.g., tapping for detailed text alerts) significantly enhance risk comprehension.
- Actionable, route-specific guidance: Unlike general weather websites, the DEW app must deliver immediate actionable instructions based on user-selected travel routes. This includes explicit warnings when a selected route intersects severe weather polygons.
- Reduced cognitive load: Minimizing technical jargon and complex meteorological explanations is crucial to allow rapid comprehension and decision-making under stress.

1.4 Identified Needs and Technological Gaps

Existing systems fail to provide the following:

- Spatially specific alert awareness: Drivers do not always know their location in county terms or how it relates to an alert polygon.

- Visual representation of threats: Standard alerts offer no visual feedback on where a storm is, how it is moving, or whether it intersects a driver's route.
- Protective action recommendations: Even when a threat is known, drivers rarely have clear instructions on the best response or alternative routing.

To meet these unmet needs, the DEW system integrates:

- A Django-based REST API that delivers geospatial alert data (including tornado polygon boundaries, severity, and movement direction).
- An Android mobile frontend using Google Maps SDK, allowing users to enter their origin and destination, view their route, and receive visualized warnings.
- A risk logic system that checks for route–alert zone intersections using geometric methods and issues immediate user alerts.

<u>1.5 Societal and Transportation Safety Implications</u>

The broader implication of this project lies in its contribution to the U.S. Department of Transportation's strategic goal of Safety: reducing serious injuries and fatalities in transportation systems. The DEW system supports this mission by transforming static warning systems into dynamic, route-aware, and driver-specific tools.

Furthermore, the mobile application enhances equity in hazard communication by ensuring that travelers without prior regional knowledge (e.g., tourists, truck drivers, interstate travelers) can access the same level of protective guidance as local residents.

This project's initial success in building a functional, scalable framework for tornado-aware navigation opens the door for future extensions, including:

- Expansion to iOS platform.
- Application to other hazard types (e.g., blizzards, flash floods).

- Integration with autonomous vehicle routing system.
- Coordination with shelter databases and real-time traffic feeds.

Through a combination of technological innovation and strategic collaboration with NWS and MODOT, the DEW project demonstrates how mobile risk communication can be transformed into a protective tool—not merely an informational one—for drivers navigating extreme weather events.

Chapter 2 System Architecture and Methodology

2.1 Overview of System Architecture

The DEW system architecture consists of two core components: a robust backend service developed using Django REST framework, and a user-friendly Android frontend application leveraging the Google Maps software development kit (SDK). These elements collaboratively provide real-time severe weather information tailored specifically for vehicle drivers.

Key considerations include scalability, interoperability, real-time responsiveness, and intuitive visual representation of severe weather alerts.

2.2 Backend Development (Django REST API)

The backend of the DEW system was developed using Django, enhanced by Django REST Framework to deliver structured, scalable RESTful APIs.

2.2.1 WeatherAlert Data Model

The backend system utilizes the WeatherAlert model, carefully engineered to store complex meteorological data efficiently. This model includes:

- Temporal Fields: capturing alert onset and expiration times.
- Alert Characteristics: specifying the event type (TOR—Tornado Warning or TOA—Tornado Watch), severity, urgency, and certainty.
- Geospatial Polygon Data: stored as JSON coordinates outlining affected geographic areas.
- Directional Movement Data: storing origin locations and directional bearings, essential for tornado warnings (TOR alerts).

2.2.2 Integration with National Weather Service API

A central innovation in the DEW system involves the integration of real-time meteorological data from the National Weather Service API Web Service. This API provides regularly updated severe weather alerts—including tornado warnings and watches—refreshed at five-minute intervals.

Key advantages of using the NWS API include:

- Real-Time Accuracy: Ensuring data freshness by automatically polling the API every five minutes.
- Structured Data: Direct access to alert metadata such as severity, urgency, certainty, polygon coordinates, and directional information.
- Reliability and Official Validation: Utilizing official U.S. government-maintained weather information ensures high reliability, credibility, and consistency.

The backend system continuously polls the NWS API, parses incoming data, and updates the WeatherAlert model accordingly. The processed information is immediately available to the frontend through the Django REST API. Figure 2.1 presents an example of obtained alert information from NWS API.

```
Pretty print
{
  "alerts": [
    {
      "event": "Flood Warning",
      "coordinates": [
        [
          [-86.9, 37.09],
          [-86.93, 37.14],
          [-86.9, 37.21],
          [-86.81, 37.29],
          [-86.8199999, 37.33],
          [-86.76, 37.3],
          [-86.61, 37.4],
          [-86.53, 37.37],
          [-86.45, 37.32],
          [-86.28, 37.08],
          [-85.75, 37.03],
          [-85.45, 36.94],
          [-85.51, 36.87],
          [-85.6, 36.87],
          [-85.59, 36.78],
          [-85.47, 36.7299999],
          [-85.5, 36.69],
          [-85.44, 36.62],
          [-87.06, 36.64],
          [-87.05, 37.06],
          [-86.9, 37.09]
        ]
      ]
    },
    {
      "event": "Flood Warning",
      "coordinates": [
        [
          [-83.99, 41.86],
          [-83.77, 41.9099999],
          [-83.77, 41.84],
          [-83.93, 41.79],
          [-83.99, 41.86]
        ]
      ]
    },
    {
      "event": "Flood Warning",
      "coordinates": [
        [
          [-95.67, 33.37],
          [-95.56, 33.4099999],
          [-95.49, 33.4099999],
          [-95.48, 33.3],
          [-95.5699999, 33.29],
          [-95.67, 33.37]
        ]
```


Figure 2.1 An example of obtained alert information from NWS API

2.2.3 RESTful API Endpoint

Structured JSON responses containing alert metadata are delivered via the endpoint /api/alerts/. The API includes:

- event (TOR or TOA)

- coordinates (polygon boundaries)
- origin_location (storm origin point when available)
- direction (movement direction when available)

This schema allows flexible and comprehensive visualization on mobile devices.

2.2.4 Technical Implementation and Testing

The backend was thoroughly tested using Django's built-in testing frameworks. Unit tests verified proper integration with the NWS API, data serialization, and API endpoint responsiveness. Integration tests simulated frontend queries to confirm seamless backend-to-frontend communication.

2.3 Frontend Development (Android Mobile Application)

The DEW Android app was developed in Kotlin, incorporating Google Maps SDK for visual representation of weather alerts and routing options. Frontend integration also utilized Google's Places Autocomplete and Directions APIs.

2.3.1 User Interaction and Route Selection

Upon launch, users are presented with a Google Map centered on their current location. Clear input fields ("From" and "To") enable easy route selection, facilitated by Google Places Autocomplete for intuitive location entry.

2.3.2 Visualization of Severe Weather Alerts

The frontend dynamically renders alerts received from the backend using:

- Red polygons: Indicating geographic alert extents.
- Green markers: Origin locations of severe weather events, if provided.
- Magenta arrows: Showing storm movement direction, enhancing user understanding of threats.

These visual elements adapt based on metadata availability, distinguishing between tornado warnings (TOR) and watches (TOA).

2.3.3 Route-Alert Intersection Logic

To enhance safety, the app uses geometric logic (PolyUtil.containsLocation() method) to detect if the user's planned route intersects active alert polygons. Upon detection, an immediate warning dialog is displayed:

"Your route passes through an alert area!"

2.4 Functional Flow of the DEW Mobile Application

As shown in Figure 2.2, the full user-interaction workflow involves:

- App Launch: Map centers on user's location.
- Route Selection: User selects travel origin and destination.
- Route Calculation: Directions fetched via Google Directions API.
- Alert Retrieval: Real-time alert data fetched from the backend, updated every five minutes from the NWS API.
- Map Rendering: Route and alerts visualized dynamically.
- Intersection Check and Warning: Immediate warnings triggered upon route-alert intersection.

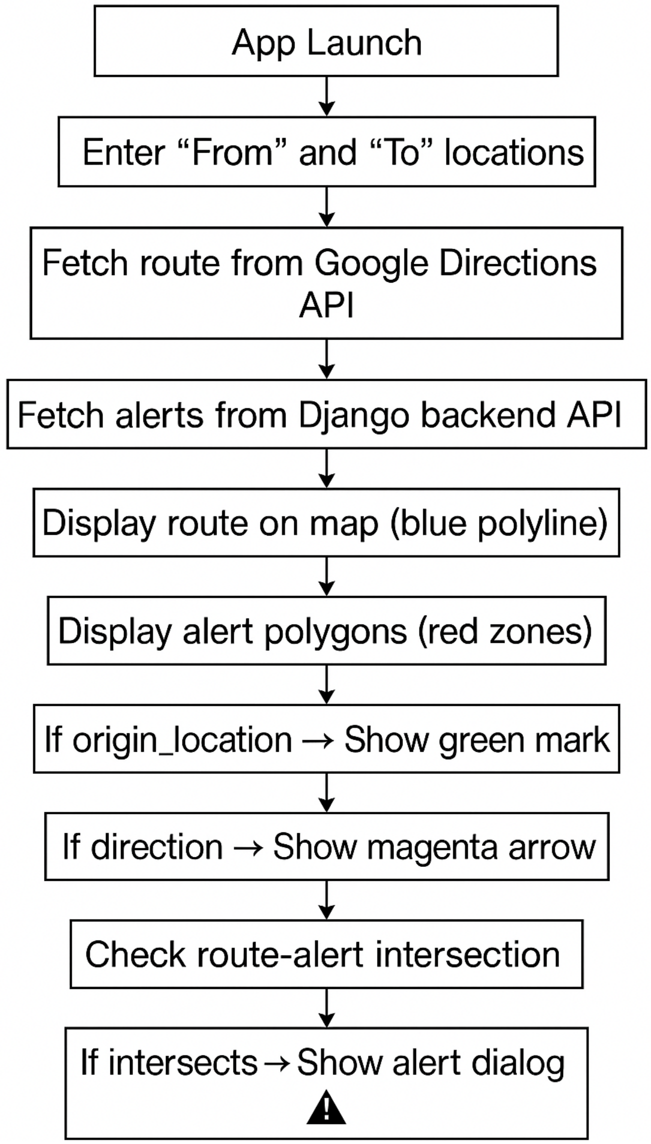


Figure 2.2 Functional Flow of the DEW Mobile Application

2.5 Technical Contributions and Innovations

The DEW system introduces several technical innovations:

- Real-Time NWS API Integration: Leveraging official, continually updated meteorological data.

- Dynamic Alert Visualization: Enhancing user comprehension through directional and polygon-based visualizations.
- Route-specific Risk Logic: Proactively communicating route-specific threats through real-time geometric containment logic.

2.6 Summary of Methodology and System Development

The DEW development process included iterative design, implementation, testing, and refinement stages. Initial stakeholder engagement and a detailed comparative analysis of existing weather websites informed system architecture. Continuous collaboration with the Springfield NWS office and MODOT ensured practical alignment with real-world needs.

The comprehensive integration of the National Weather Service API proved particularly critical, providing timely and official data updates every five minutes. This integration allows the DEW app to consistently deliver accurate, actionable warnings, thereby significantly enhancing transportation safety during severe weather.

Chapter 3 Results and System Demonstration

3.1 Overview of System Outcomes

The DEW system was successfully developed and rigorously demonstrated to verify its intended functionalities, performance, and practical usability. This chapter provides detailed descriptions of demonstration outcomes, illustrating backend reliability, effective frontend visualizations, and real-time route safety logic. The demonstrations confirmed the system's capability to provide precise, actionable severe weather risk communication to vehicle drivers.

3.2 Backend System Functionality

3.2.1 Data Acquisition from NWS API

The backend system robustly integrated real-time meteorological data from the National Weather Service (NWS) API Web Service, providing updates on tornado warnings and tornado watches every five minutes. This ensured high accuracy and timely delivery of alert information. Throughout extensive tests, the backend reliably ingested, processed, and stored critical weather alert information, demonstrating:

- Reliable periodic retrieval of alert data.
- High accuracy in alert metadata extraction, including:
  - Event types (TOR, TOA),
  - Polygon coordinates defining alert boundaries,
  - Storm origin points and movement directions (for TOR alerts), and
  - Temporal validity (onset and expiration timestamps).

3.2.2 REST API Endpoint Testing

Backend API endpoints were rigorously tested for reliability and consistency. Unit tests and simulated frontend queries confirmed that the API endpoint /api/alerts/ consistently returned structured JSON data, verified across multiple active alert scenarios, as shown in Figure 3.1. The response accuracy and speed significantly contributed to seamless frontend integration and reliable real-time user notifications.

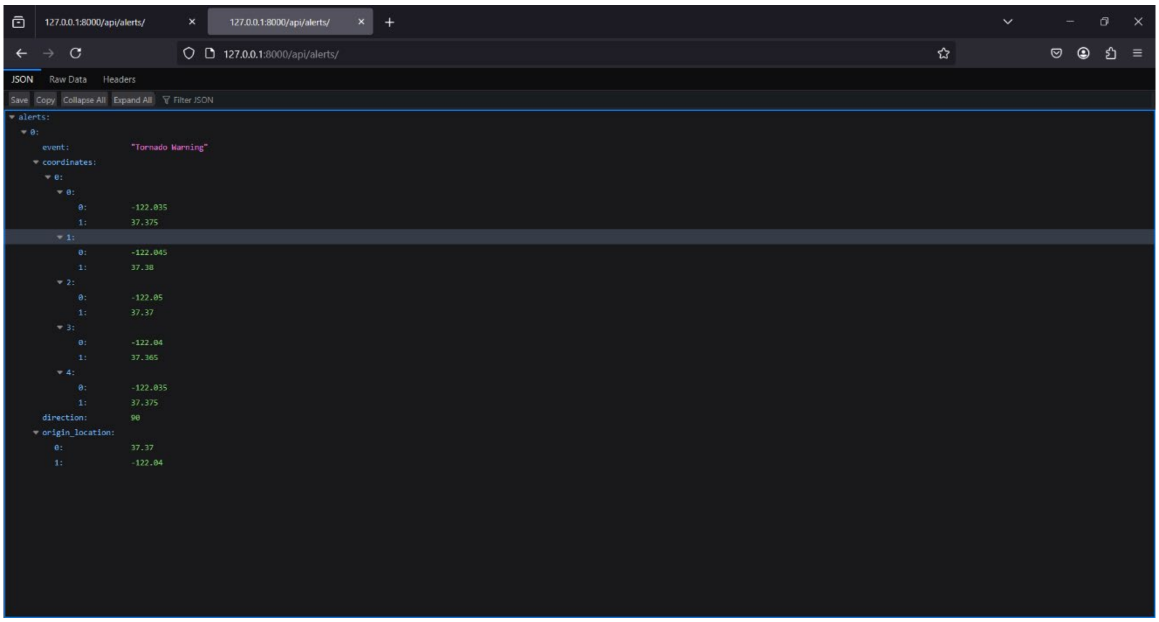


Figure 3.1 JSON response of Backend

3.3 Android Frontend Demonstration

The Android application underwent detailed demonstrations to illustrate how effectively severe weather alerts are visualized and communicated. The following sections describe frontend demonstrations using annotated screenshots and practical examples:

3.3.1 User Interface and Route Selection

Upon launching the DEW app, users were presented with a clear, intuitive landing page displaying their current GPS location centered on Google Maps. Users interacted seamlessly with the two input fields ("From" and "To"), as shown in Figure 3.2.

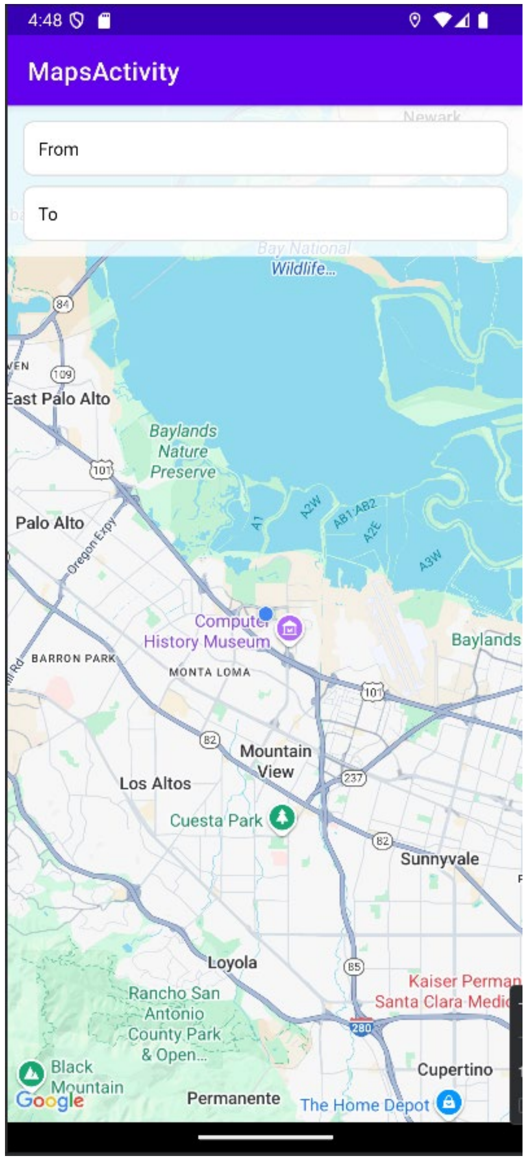


Figure 3.2 Landing Page with Search Bar and Autocomplete

Meanwhile, the Google Places Autocomplete provided precise suggestions, ensuring quick and intuitive route selection.

- Example Demonstration:

  As the user begins typing (e.g., “san”), a list of location suggestions is dynamically displayed, as shown in Figure 3.3. This feature enhances usability by allowing users to quickly find and select precise locations for both the "From" and "To" fields. The suggestions include cities, landmarks, and airports based on the input keyword.

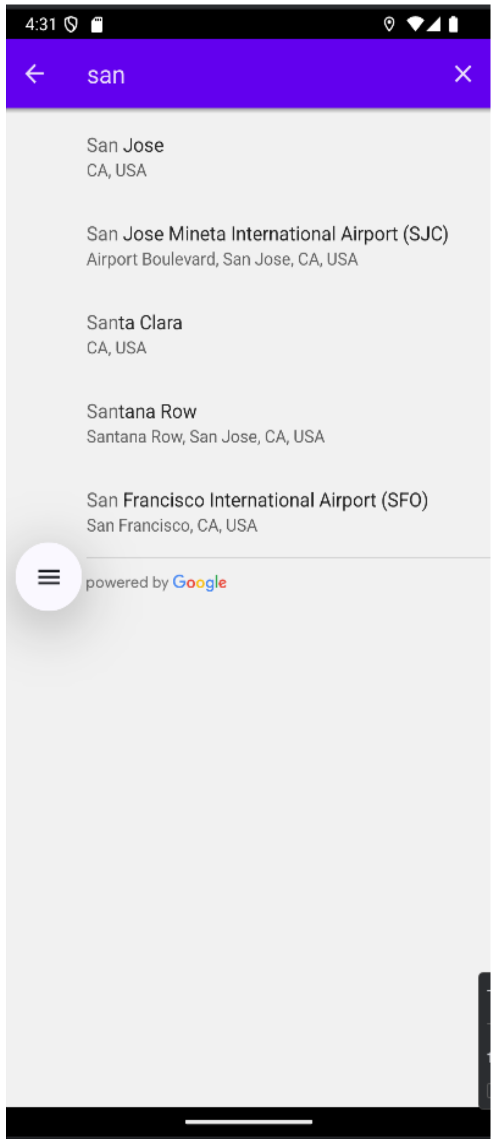


Figure 3.3 Google Places Autocomplete Interface

3.3.2 Visualization of Weather Alerts

Demonstrations focused on visually distinguishing between Tornado Warnings (TOR) and Tornado Watches (TOA), providing intuitive and actionable insights to drivers:

- Red Polygons: Clearly depicted active hazard zones. Users immediately understood regions to avoid or approach cautiously.
- Green Origin Markers: Displayed at the starting location of the tornado, helping users visualize storm initiation points when available.
- Magenta Directional Arrows: Provided critical directional indicators for TOR alerts, effectively illustrating storm trajectory.
- Example Demonstration: In a demonstrated scenario involving an active Tornado Warning near Sunnyvale, CA. As shown in Figure 3.4, the app visualized a red polygon clearly delineating the affected area. A green marker indicated the tornado's origin location, while a magenta arrow accurately indicated the storm's northeast movement, greatly enhancing driver's situational awareness.

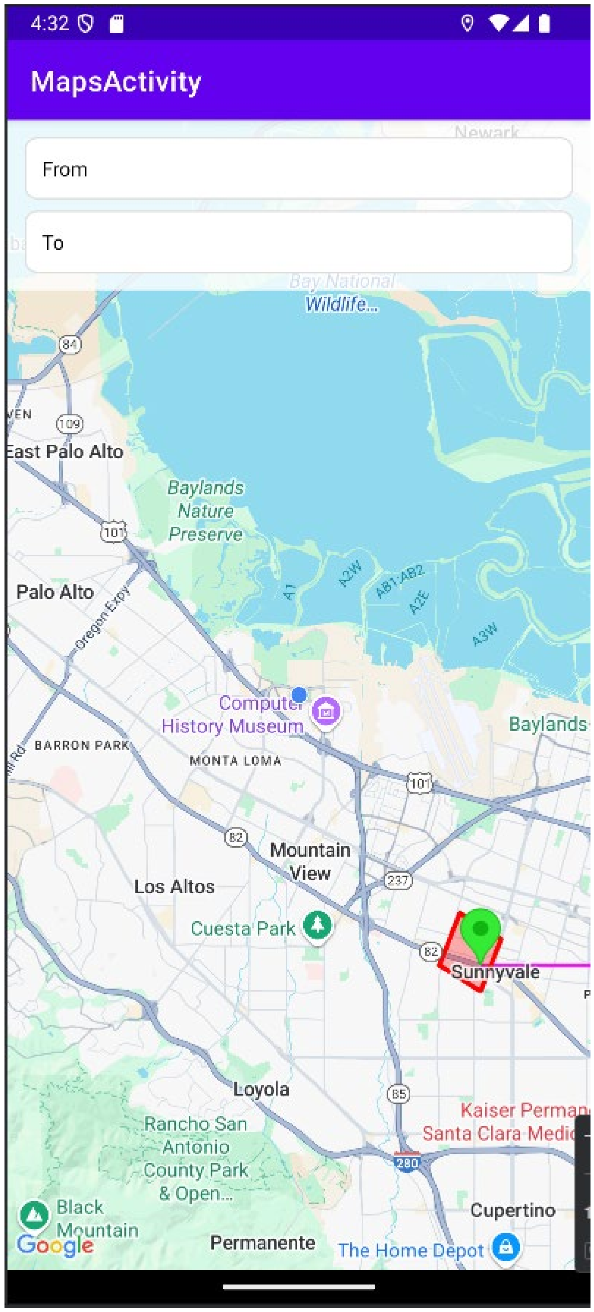


Figure 3.4 Map View Showing Alert Polygon and Direction Arrow

3.3.3 Route Intersection Logic and User Warnings

The app's core safety feature—route intersection logic—was thoroughly demonstrated. The geometric logic (PolyUtil.containsLocation() method) accurately identified when selected routes intersected active weather alert polygons, promptly triggering clear, immediate visual and textual notifications:

- A prominent dialog message explicitly warned users:

  "Your route passes through an alert area!"

- Example Demonstration:

  As indicated in Figure 3.5, when the user selects a route (e.g., from Mountain View to Sunnyvale), the system uses geometric logic (PolyUtil.containsLocation()) to check whether the route intersects any alert zone. If an intersection is detected, an alert dialog pops up with the message: *"Your route passes through an alert area!"*, helping the user make informed decisions about their travel.

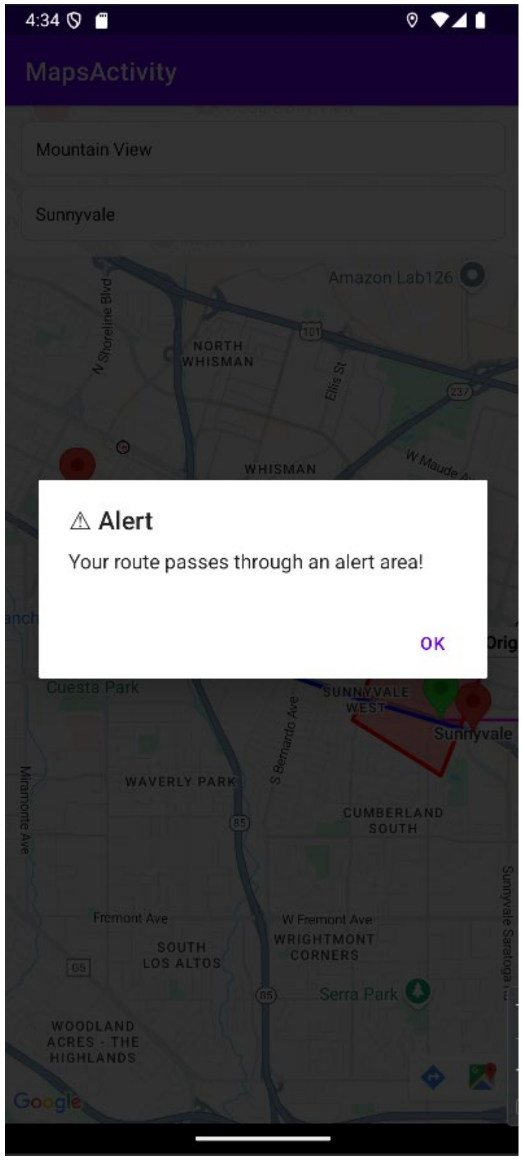


Figure 3.5 Alert Dialog Triggered by Route Intersection

3.4 Detailed Demonstration Scenario

Figure 3.6 shows a realistic demonstration scenario, which effectively validated the system’s reliability:

Scenario: Intersection with Tornado Warning (TOR)

- Test Route: Mountain View, CA → Sunnyvale, CA

- Alert Status: Active Tornado Warning
- Outcome:
    - Visualization: Red polygon, green marker (storm origin), magenta directional arrow
    - Warning: Immediate, clear warning dialog displayed to the user, highlighting the urgent risk of intersecting the active tornado path

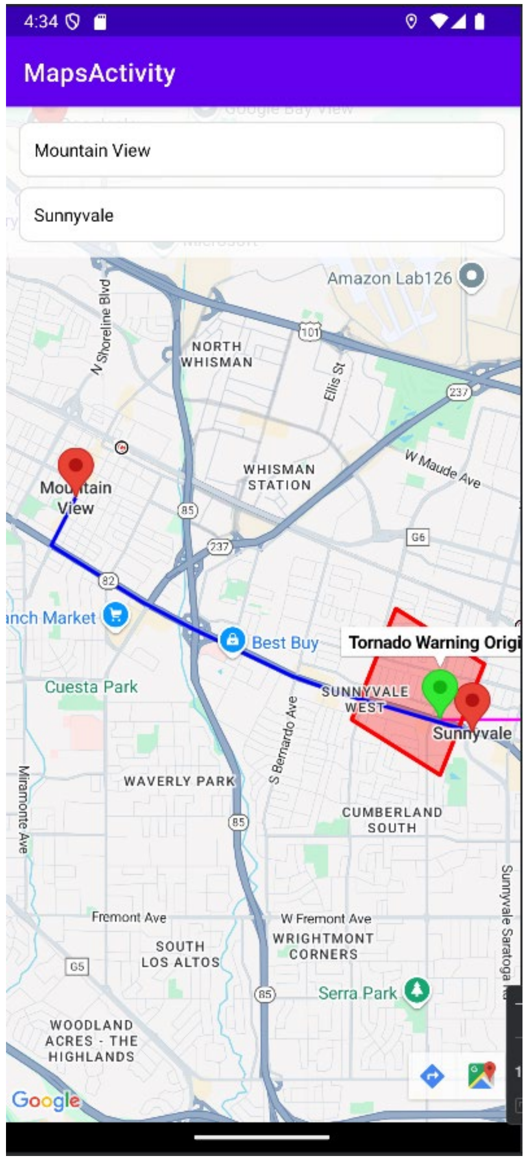


Figure 3.6 Full Route Display with Alert Overlay and Safety Indicators

3.5 Technical Performance and Reliability

The DEW system demonstrated outstanding reliability throughout extensive scenario testing:

- Stable Real-Time Integration: Backend-to-frontend communication was consistently fast, with negligible latency, allowing near-instantaneous app updates.

- Periodic Data Refresh: The five-minute refresh rate from the NWS API consistently maintained alert accuracy and timeliness.
- Robust Frontend Performance: The app maintained stable, responsive performance during complex scenario demonstrations, indicating readiness for real-world implementation and scale-up.

3.6 Broader Implications and Future Development

Demonstrations confirmed the DEW system's potential for significant positive impacts on transportation safety:

- Enhanced Safety: Demonstrations clearly showed the potential for significant improvement in real-time safety communication for drivers encountering severe weather.
- Scalability Potential: Demonstrations validated the framework's adaptability to other extreme weather scenarios, including flooding and winter storms, and to expanded geographical regions.
- Integration Opportunities: Positive demonstrations suggested future integration possibilities with commercial navigation applications and autonomous vehicle safety frameworks.

Future work includes conducting comprehensive field tests, broader public evaluations, refining based on user feedback, and expanding features and integrations.

Chapter 4 Conclusions and Recommendations

4.1 Summary of Key Findings

The Driving through Extreme Weather (DEW) project successfully designed and developed a mobile application that bridges a critical gap in severe weather communication for vehicle drivers. By combining real-time National Weather Service (NWS) data with route-aware risk logic and intuitive visualizations, the DEW system provides drivers with actionable, location-specific alerts that existing systems fail to offer.

Key project accomplishments include:

- Integration of NWS API Web Service: Enabled real-time tornado alert retrieval every five minutes, providing high-resolution hazard data.
- Backend System Implementation: A Django REST API delivered structured, geospatially detailed alerts to the frontend in a scalable and reliable format.
- Mobile App Development: An Android application was built using Google Maps SDK and successfully visualized alert polygons, storm movement, and origin data alongside user-defined travel routes.
- Route Intersection Logic: The system proactively alerted users when their selected route passed through a hazardous zone, offering immediate and actionable feedback.
- User Interface Design: The app provided an intuitive, visually-driven experience that effectively reduced cognitive overload and enhanced comprehension, particularly for non-expert users and out-of-town drivers.

Demonstrations validated the full system pipeline—from data ingestion and processing to real-time visualization and user notification—confirming technical feasibility and practical usability.

4.2 Contributions to Transportation Safety

This project contributes to the U.S. Department of Transportation's mission of improving road safety by transforming static warning systems into dynamic, user-specific guidance tools. In doing so, DEW addresses three fundamental weaknesses in existing weather communication tools for drivers:

- Geographic Relevance: Traditional county-based alerts do not align with how drivers navigate; DEW uses polygon-based, GPS-aware risk communication.
- Visualization Clarity: General weather websites often present complex, static maps or verbose text. DEW provides dynamic, map-based alerts with clear visual indicators.
- Actionability: While traditional systems inform, DEW empowers—providing route-specific notifications that support real-time decision-making.

These contributions have direct implications for reducing weather-related roadway incidents, enhancing public trust in weather communication systems, and improving accessibility for non-local or unfamiliar drivers.

4.3 Limitations and Challenges

Despite the system's success, several limitations were identified:

- Platform Scope: The mobile app was developed for Android only. iOS users currently do not have access to the system.

- Hazard Type Limitation: The system was designed and tested for tornado events only. Other threats like flash floods, snowstorms, or hail are not yet incorporated.
- Backend Data Source Reliance: The DEW system depends entirely on the NWS API. While reliable, it may not capture hyperlocal hazards or incorporate unofficial crowdsourced data sources.
- No Live Field Deployment: While simulated demonstrations were successful, no large-scale field deployment has yet been conducted with live users on the road under real-time severe weather conditions.

4.4 Recommendations for Future Work

To maximize the system's impact and practical value, the following recommendations are proposed:

4.4.1 Expand Platform Accessibility

- Develop an iOS version of the app to broaden access across all mobile user segments.
- Consider a web-based dashboard version for use by emergency managers and fleet operators.

4.4.2 Broaden Hazard Types

- Extend backend logic and visualization layers to include additional hazard types such as:
    - Flash Floods
    - Winter Storms
    - High Wind and Hail Events

4.4.3 Integrate Traffic and Shelter Data

- Incorporate real-time traffic overlays and shelter location databases.
- Enable rerouting features that not only avoid hazards but also suggest nearby shelters.

4.4.4 Real-World Pilot Testing

- Conduct structured field pilots with real drivers (e.g., delivery drivers, truckers, emergency responders) during active weather seasons.
- Collect behavioral and safety outcome data to evaluate real-world effectiveness.

4.4.5 Collaborate with Commercial Navigation Systems

- Explore partnerships with major navigation and logistics platforms (e.g., Google Maps, Waze, or UPS routing systems) to integrate DEW's alert logic at scale.
- Consider API licensing of the backend system to extend DEW capabilities into broader ecosystems.

4.5 Concluding Remarks

The DEW project demonstrates that mobile-based, real-time, driver-specific severe weather alerting is both technically feasible and socially necessary. By combining official meteorological data with geospatial route awareness and intuitive user design, the system elevates weather alerts from static messages to protective action tools. As severe weather events become more frequent and widespread due to climate variability, systems like DEW offer a critical path forward in enhancing transportation safety, empowering informed decisions, and ultimately saving lives.

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