Enhancing the Safety and Reliability of Railroad Corridors Prone to Geohazards Using a Decision Support System

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Introduction

Decision Support Systems (DSSs) are computer-based tools that assist decision-makers in efficient generation of solutions for semi-structured and unstructured problems through analytics modeling, data integration, information visualization, and interface design. Nowadays, DSSs have evolved from simple model-based systems into sophisticated platforms that incorporate artificial intelligence (AI) and collaborative features as well. These systems support decision-making across operational, tactical, and strategic levels.

The Ground Hazards DSS shows how advanced analytics and AI techniques can be integrated with geospatial data to support operational and strategic decisions. By combining diverse sources such as orthophotos, uncrewed aerial vehicle (UAV) imagery, ground penetrating radar (GPR) analyses, real-time meteorological feeds, and expert field observations, the DSS provides actionable insights through a unified interface to support risk prioritization, maintenance planning, and real-time alerts.

Decision Support System

The Ground Hazards DSS uses a web-based system to monitor areas of interest (AOIs) along railroad tracks. Information in the DSS includes remotely sensed data, such as orthophotos, ground penetrating radar data, analysis results, traditional condition monitoring data, and machine learning models for ground hazards characterization. The implemented system can help mitigate ground hazards along rail-road tracks by combining remotely sensed data and traditional condition monitoring data. The DSS development was divided into three main components: integrating datasets into the DSS from a geospatial database, developing a user-friendly web interface, and making reporting tools and metrics available.

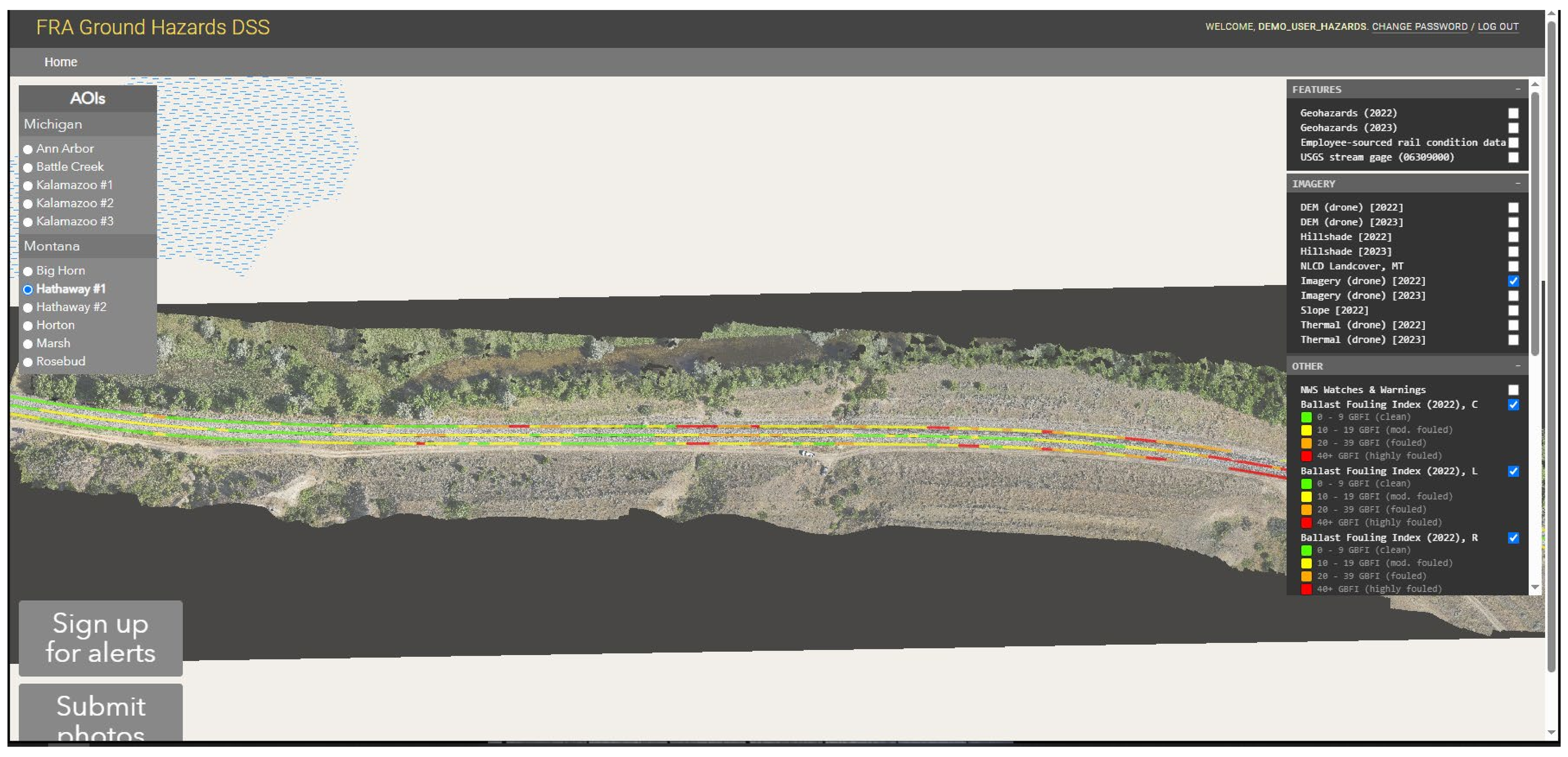

Figure 1. Real-time geospatial visualizations and implemented features of the DSSv1.1 for proactive railroad safety assessment

DSS Features

The DSS was developed using well-vetted and secure software packages (Django, PostGreSQL, Leaflet, MapServer) and secure protocols (Hypertext Transfer Protocol Secure (HTTPS), Web Map Service(WMS)). DSS access is restricted to a limited number of users, and account creation at this point can only be done by the DSS lead developer. State-specific users are restricted from viewing data from AOIs outside their state. The software is housed in a Mercurial repository stored on a secure Michigan Tech network drive. The PostgreSQL database is backed up weekly. Current features of the DSS are given in the Table 1.

Table 1: DSS features currently implemented

Category	Details
Data Security	Data is served via HTTPS, ensuring encrypted bidirectional communication for secure data transmission
Web Mapping	Uses Leaflet.js
Raster, Vector, and External Data	- Raster datasets and models - Vector files and related models - Continuously updated dataset (external sources)- 'Rail-Eye' input
Geospatial Raster Layers Display	- Digital Elevation Model (DEM) from project drone photogrammetry - Hillshade from DEM - Slope from DEM - Orthoimagery - National Land Cover Data (NLCD) - Flood prediction - Basemaps (OpenStreetMap, ESRI, CartoDB) - Employee-sourced data (Rail-Eye)
Vector Data Layers Display	- Geohazards - Moisture layers - Inundation layers - Rail roughness index
Other Data Formats (Live & Batch Feeds)	- National Weather Service (NWS) watches and warnings - Cumulative rainfall (next 72 hours) - The United States Geological Survey (USGS) alerts and stream gauge updates - Model inferences (e.g., integrated track risk index, change detection, anomaly detection) - Ballast fouling index - Railroad track roughness - Inundation contours

Conclusions

- Represents a substantial advancement in the proactive management of railway infrastructure safety
- Uses a diverse array of data sources including field observations, high-resolution drone imagery, GPR analyses, and real-time meteorological information
- Provides a comprehensive, multi-layered geospatial visualization
- Significantly enhances situational awareness and facilitates the early detection of potential geohazards.

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