NEITS Annual Interchange (2025)

Highway of the Future

Building the Next Generation of Highways

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Mission, Goals, and Objectives

Mission Statement: Provide a safe, reliable, efficient, secure, and adaptable system that will future-proof highways to accommodate next generation transportation needs.

Goals and Objectives:

SAFETY
Vision Zero: Eliminate fatal & serious injury crashes

RELIABILITY
Strive for TTI approaching 1.00 for all hours of the day

EFFICIENCY
Apply AI to optimize all aspects of roadway management

ASSET MAINTENANCE
Apply automation to improve safety in work zones

FREIGHT MANAGEMENT
Optimize the reliability of supply-chain logistics

AUTOMATED VEHICLES
Accommodate/leverage AVs approaching SAE Level 5

CONNECTIVITY
Integrate modes with efficient and reliable connections

USER EXPERIENCE
Enhance the highway traveler's user experience

FUNDING
Generate revenue streams to offset lifecycle costs

SUSTAINABILITY / SECURITY
Develop a resilient and secure highway infrastructure

Highway of the Future

- Dynamic, intelligent transportation network with smart sensors will communicate with vehicles in real time, optimizing safety and traffic flow
- Dynamic lane markings will change based on traffic conditions, ensuring smoother travel and fewer bottlenecks
- Vehicles will use dedicated lanes for AVs, while AI-driven traffic systems will manage unsafe travel behavior and rerouting to prevent crashes
- Augmented reality displays will provide instant navigation updates directly on windshields
- Multistate Connected Freight Corridor technology will be complemented by Advanced Air Mobility

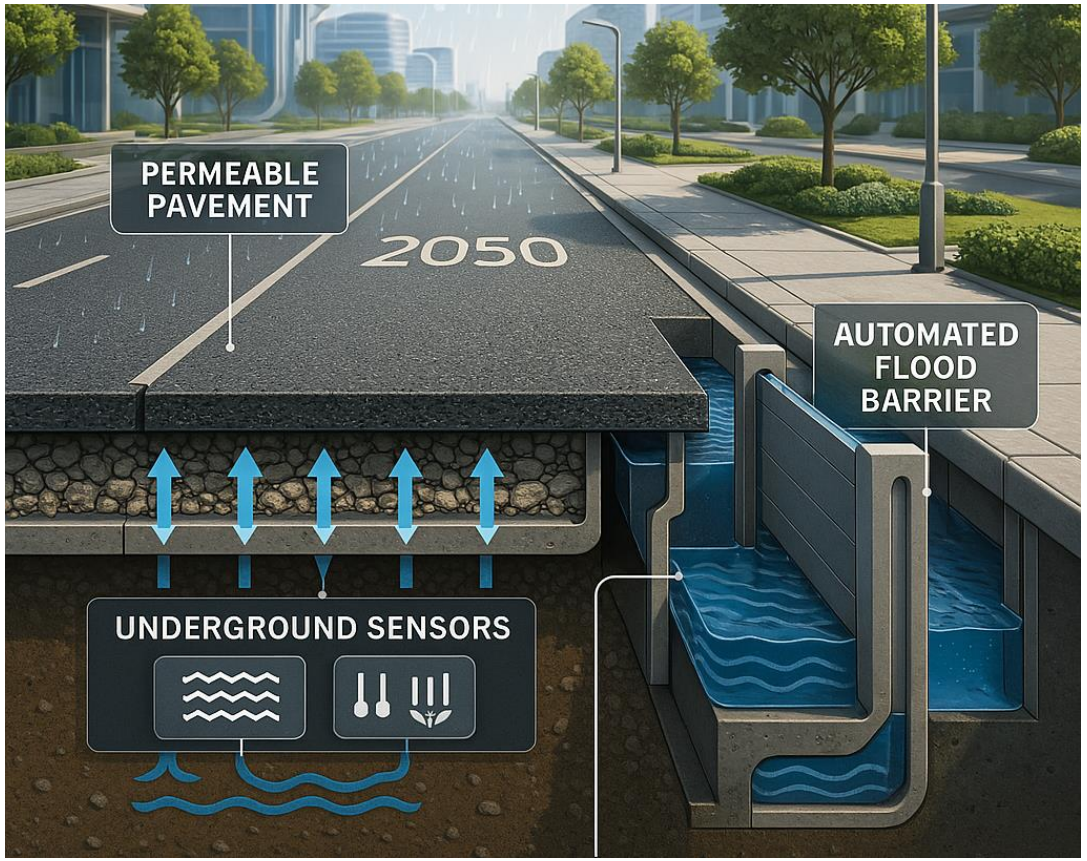
Roadway

- Sensors and IoT devices will monitor conditions and generate data for planning and research applications
- Smart Interchanges (i.e., Dynamic Lane Assignment, WWD, Ramp Metering, Vulnerable Road User safety)
- Variable Speed Limits for speed harmonization and automated enforcement to improve safety & traffic flow
- Solar panels within non-ridable surfaces within the ROW (e.g., medians, shoulders, clear recovery zones) to generate clean energy

Pavement

- Smart Powered Lanes with wireless power transfer technology
- Surfaces constructed from self-healing materials to repair cracks automatically and improve ride quality
- Replacement of pavement strips aligning with AV wheel tracks versus resurfacing or replacing all roadway pavement
- Embedded sensors to track vehicle movements, temperature changes, and pavement wear-and-tear

Drainage



- High performance permeable pavement to reduce runoff, minimize hydroplaning risks, and absorb sound for noise reduction
- Sensors and automated filtration systems to prevent debris and pollutants from clogging storm drains
- AI drainage systems to dynamically adapt to rainfall intensity and potential flooding
- Vegetated retention ponds along highways to filter and naturally absorb excess water
- Real-Time Water Monitoring to alert drivers of potential hazards before they encounter them; may be linked to VSL system

Bridges

- Sensors to continuously monitor structural integrity, traffic loads, wind speeds, environmental conditions, and deterioration
- Self-healing concrete automatically releasing healing agents when cracks appear
- Carbon fiber-reinforced composites to replace steel, making bridges lighter, stronger, and corrosion proof
- Modular construction, allowing for sections to be replaced or expanded with minimal disruption
- Increase vertical clearance to accommodate Connected Freight Corridors thru bridge jacking

Signing and Striping

- Less Static Signs and DMSs, more in-vehicle signage
- High resolution signing and pavement markings to support AVs
- AR windshield displays providing real-time navigation updates, hazard warnings, and lane guidance
- Smart Color DMSs at strategic locations powered by AI to adjust messages based on traffic conditions
- Smart LED-embedded pavement markings that change configurations based on traffic flow

Lighting

- AI-powered high intensity lighting at high crash locations, incident scenes, and work zones
- Smart LED automatically adjusting brightness based on traffic levels and weather conditions
- Motion-activated lighting detecting Vulnerable Road Users, brightening the roadway segment
- Integrated solar panels to store energy during the day to power highway lights at night

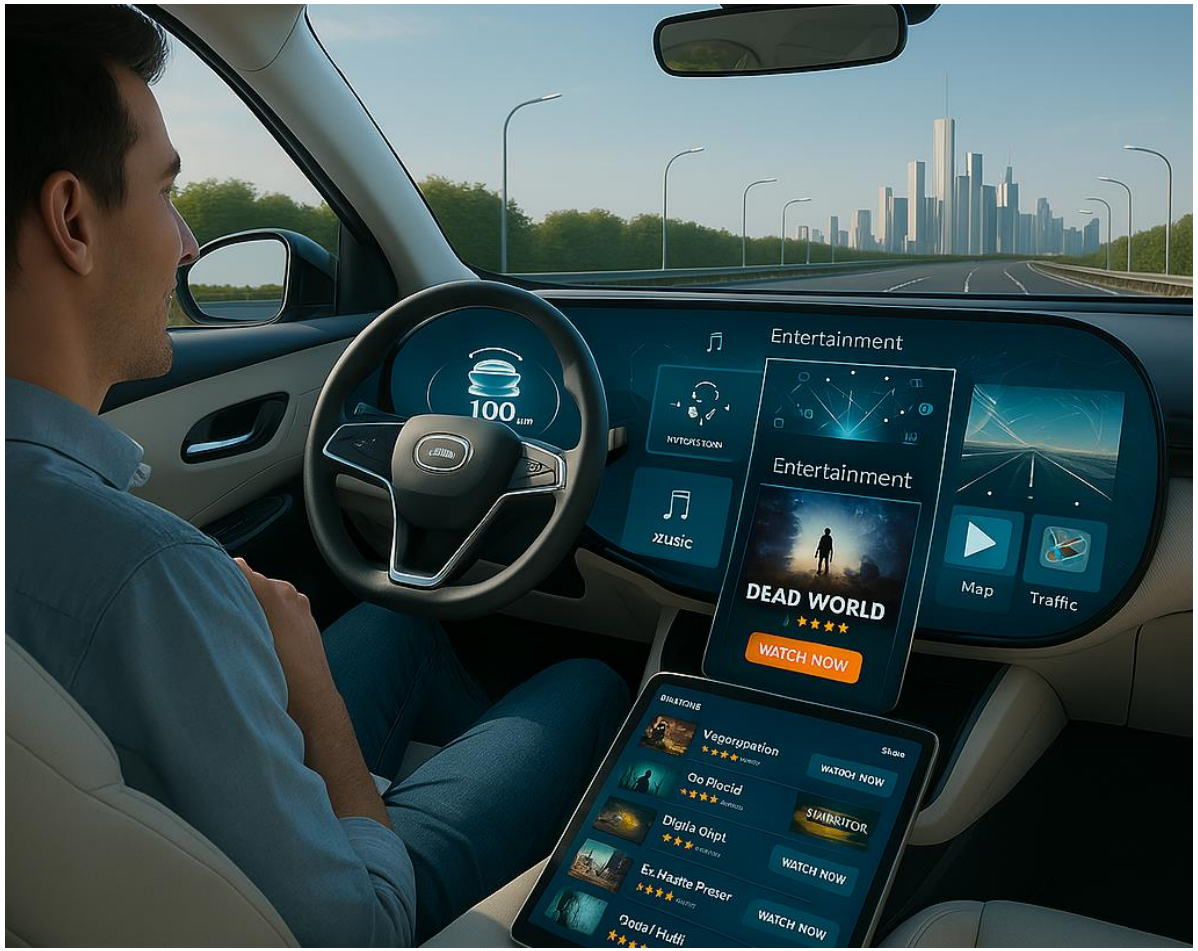
Transportation Management Centers

- Apply AI to forecast traffic patterns, allowing dynamic adjustments to routes, signals, transit modes
- Apply decision support systems to automate low-level functions, freeing operators for more complex tasks
- Provide seamless integration of connecting modes in a reliable manner at a system scale
- Monitor roadway assets in real-time to minimize disruptions and maintenance costs
- AV fleet management ensuring smooth interaction between human drivers and AVs
- Consider Virtual TMCs as a complement or substitute for other future needs (e.g., special events, demonstrations)

Modal Integration

- Dynamically designated lanes for Automated Vehicles, Flex Lanes, Bus Rapid Transit, Trucks
- Advanced Air Mobility coordination with municipalities
- Reservation-based truck parking at rest areas and intermodal freight transfer facilities
- Smart intermodal hubs to allow passengers to transfer between modes with minimal wait times (connection protection)
- AI-driven management systems to track all modes of transportation, optimizing connectivity
- V2X to ensure vehicles, transit, VRUs operate in synch, avoiding conflicts while maximizing efficiency

User Experience



- Provide opportunities to be more productive and less boring during travel, particularly for long stretches of highways in rural areas
- AR car windows to double as interactive screens, displaying local points of interest, historical facts
- Gamification (e.g., safe or eco-driving incentives accumulating points)
- Seamless internet access to enable entertainment, remote work, and enhanced communication
- Smart rest areas to feature EV charging, automated refueling, AI services, and immersive VR

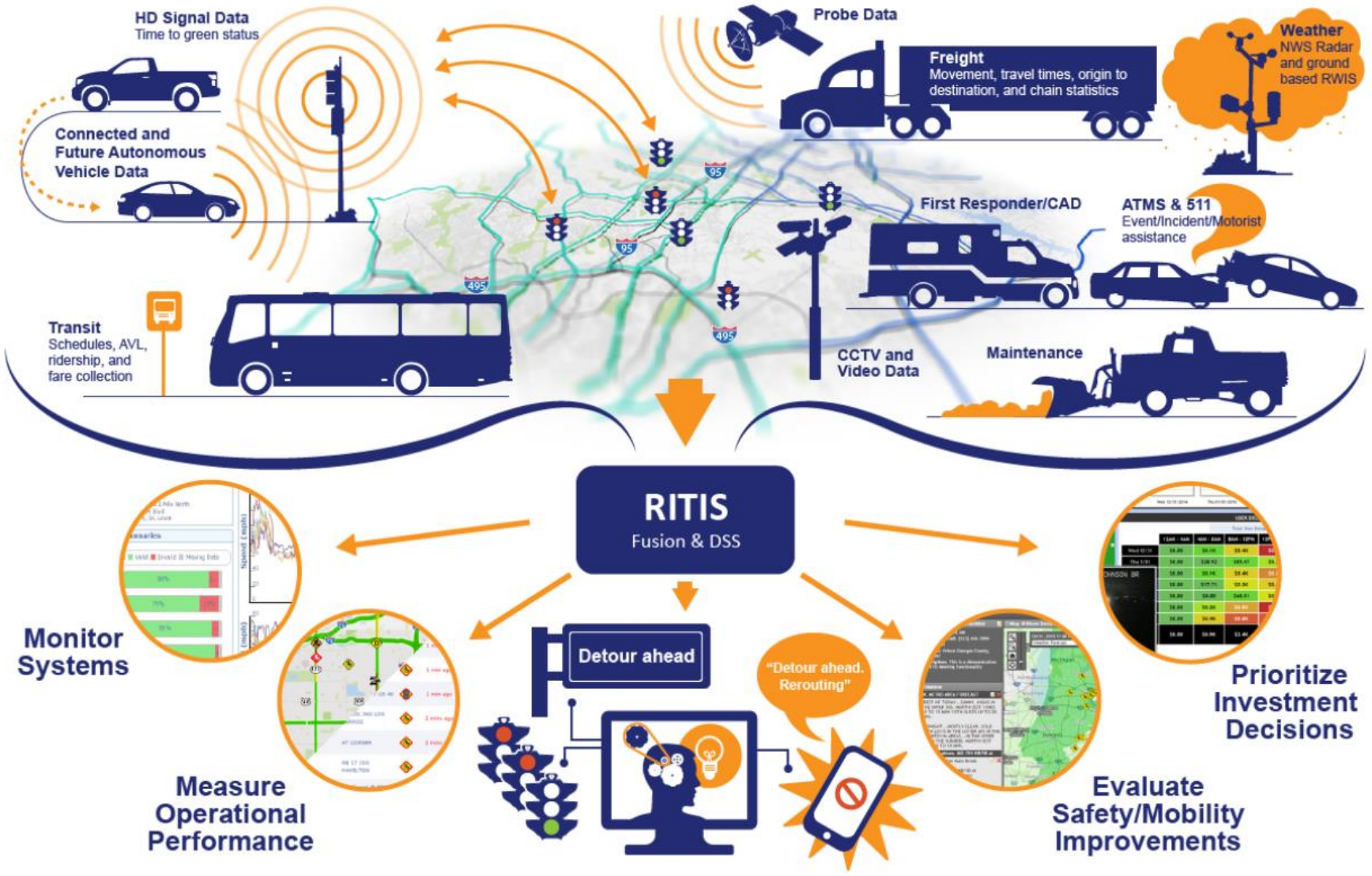
Asset Maintenance

- Robotic Safety Service Patrols to eliminate risk of operators in harms way
- AI-guided drones and robotic systems to inspect roads for damage, perform repairs, and maintenance of traffic
- Real-time monitoring systems to track pavement conditions, weather impacts, and traffic loads
- Robotic repair crews to make repairs on the fly, patching potholes and repainting lane markings
- Replaceable road segments to allow quick swaps without extensive construction

Revenue Generation

- Road User Charging dynamically adjusting rates based on real-time incentives and disincentives
- V2X Tolling and enforcement
- Solar-powered pavement to generate electricity, selling surplus energy to the grid
- Smart Powered Lanes to operate on a user fee subscription model
- Automated freight corridors funded by freight carriers generating revenue for maintenance

Data Management



Artificial Intelligence

TMC Operations

AI in automating SOPs and developing Decision Support Systems.

Incident Management

AI and drones to detect incidents faster and proactively dispatch optimum resources.

Speed Management

AI-driven adaptive speed limits in optimizing traffic flow, capacity, and safety.

Work Zone Management

AI to improve worker safety and manage congestion and queueing more effectively.

Special Event Management

AI in predicting and managing traffic fluctuations during special events/holidays.

Weather Event Management

AI to analyze weather data and optimize response during adverse conditions.

Dynamic Pricing

AI in predicting and managing traffic congestion using dynamic pricing.

Performance Management

AI in posting real-time and predictive metrics on video wall and workstations.

Driver Behavior

AI near-miss algorithms to be proactive in avoiding primary & secondary crashes.

Emerging Technologies

Connected Vehicles

AI/Digital Twins

TMC of the Future

Automated Vehicles

Advanced Air Mobility

Smart Signals

Mobility on Demand

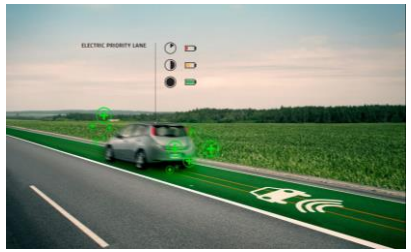
Robotics

Truck Platooning

Smart Mobility Hubs

Integrated Corridor Management

Road User Charging



Smart Powered Lanes

Part-Time Shoulder Use

Smart Cities

Business Plan

Short-Range (0-2 Years)
▪ **Prioritize strategic corridors** for implementation of “Highway of the Future” systems
▪ Prioritize “Highway of the Future” **systems** to include in high-priority strategic corridors
▪ Develop **Concepts of Operations** to identify roles during planning, design, construction, integration, O&M
▪ Develop **standards, specifications, and special provisions** for each “Highway of the Future” system to be deployed
▪ **Pilot test** selected “Highway of the Future” systems on a designated corridor
Medium-Range (2-5 Years)
▪ Assign **System Manager** to implement “Highway of the Future” corridors
▪ Build initial phase of “Highway of the Future” on three corridors (i.e., **metro, urban, rural**)
▪ Collect and analyze **before & after data** based on performance measures identified in the ConOps
▪ Collect **lessons learned** on initial corridors to consider adjustments for future deployments
▪ Update **ITS Design Manual** to include “Highway of the Future” systems
Long-Range (5-10 Years)
▪ **Program funding** to retrofit existing corridors or build new “Highway of the Future” corridors
▪ Continue to **add more** “Highway of the Future” systems to selected **corridors**
▪ **Revamp TMCs** to use AI to monitor “Highway of the Future” systems in real-time and a predictive mode
▪ Begin to implement **revenue generating systems** to offset “Highway of the Future” lifecycle costs
▪ Expand “Highway of the Future” scope to **integrate connecting arterials and other modes**

Thank you.

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