MACHINE LEARNING AT STATE DEPARTMENTS OF TRANSPORTATION

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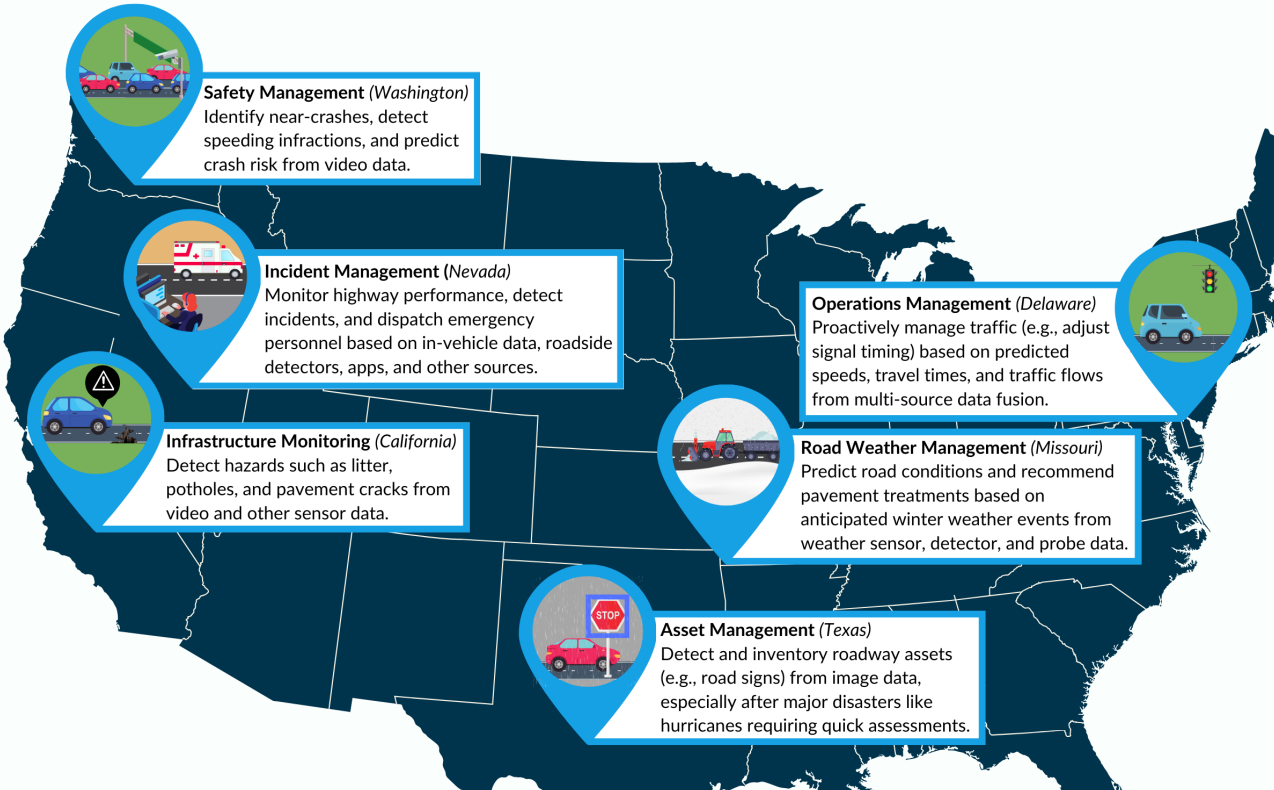
What is ML? Machine Learning (ML), a subset of Artificial Intelligence (AI), involves algorithms learning patterns from data. ML models improve by retraining on new data and can make predictions, find correlations, and optimize decision-making. Techniques range from simple linear regression to complex deep neural networks, which have advanced in image, video, sound, and language processing, even surpassing human performance in some tasks.

How is ML different from other methods? ML models help in automating repetitive tasks, and they prioritize accurate predictions over understanding relationships between variables. They adapt well to nonlinear data patterns, adjust to new information, offer new insights, and handle large and complex data types effectively. This sets them apart from traditional statistical models that rely on predefined structures and assumptions.

ML Value	Transportation Example
Respond to changing conditions	An ML adaptive signal control system can improve traffic flows by responding to dynamic conditions.
Make faster and better decisions	An ML traffic monitoring and incident management system can identify highway collisions in real-time and recommend strategies for first responders.
Identify new strategies	An ML system that supports transportation planning can craft a novel solution that would not have been previously considered by planners.
Maximize limited staff resources	ML can streamline agency operations through automation of repetitive tasks, such as permit processing, by extracting relevant information from applications, assessing them against predefined criteria, and even recommending approval or denial.
Encode agency expertise	ML can capture knowledge of highly trained maintenance personnel to detect and diagnose structural failings of equipment. Encoding agency expertise could become increasingly valuable amidst retirements.

Why use ML models? ML models have revolutionized industries like banking, healthcare, and marketing, offering new applications in chatbots and image processing. While crucial, ML requires quality data, faces explainability challenges, and demands resources. In transportation, ML solutions are popular in asset management, operations, and road safety, with high user satisfaction.

What are State DOTs doing with ML? Despite the potential benefits of ML in transportation agencies, it is not widely used currently. A 2022 survey revealed that most agencies do not have ML applications deployed or in development, and many are not familiar with ML methods and tools. However, the map at right shows six example agency implementations of ML.



Asset management and operations are low-hanging fruit areas for ML in transportation.

Common ML types include supervised learning, such as object detection.

Utilizing existing data sources can save on cost.

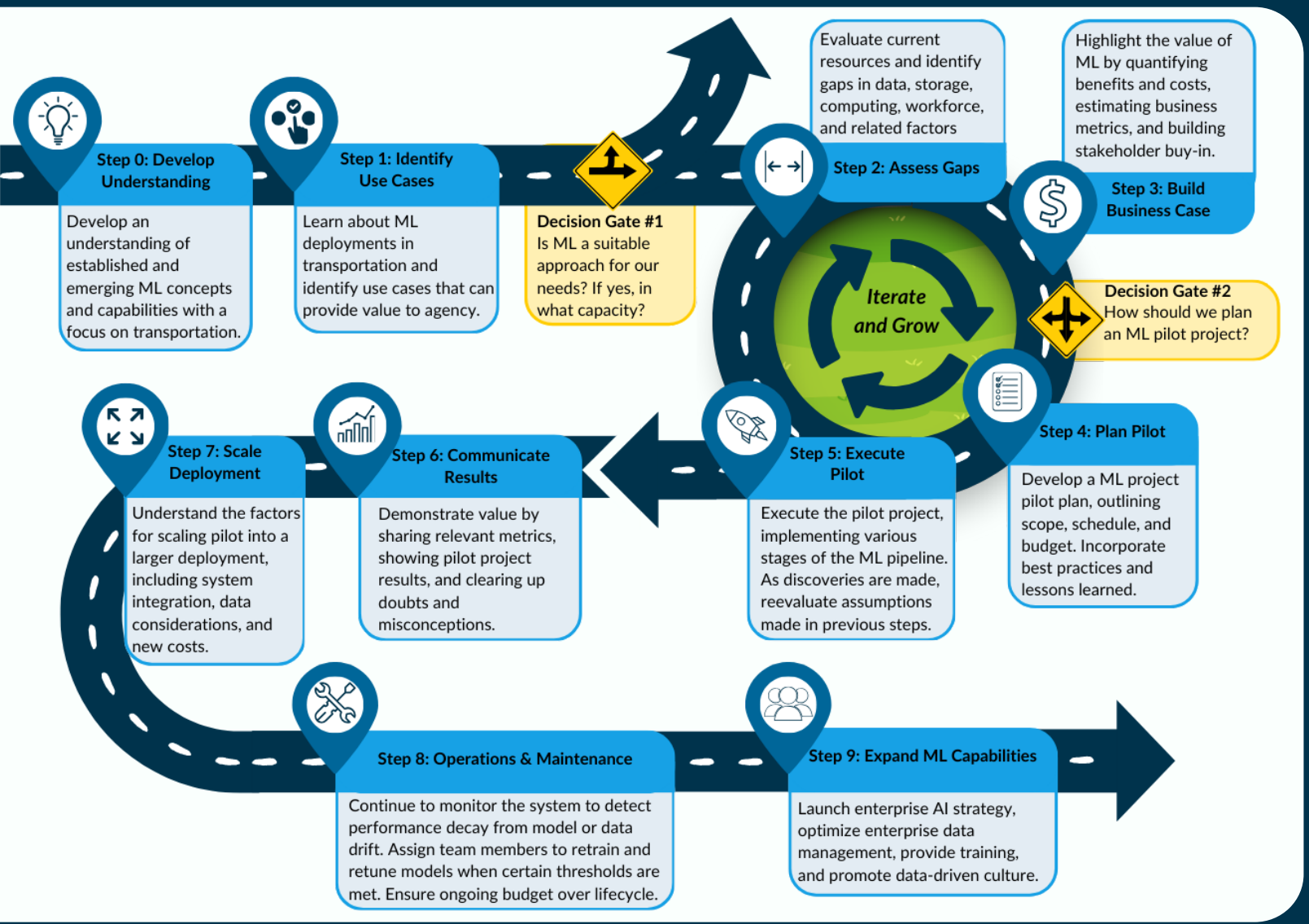
Building on pre-trained models and open-source tools is common practice.

Data storage, computational, and software resources are vital for ML applications.

ML as a service is becoming more common.

Federal grant funding could help kickstart ML programs.

How to implement ML successfully? Some insights from agencies pursuing ML are summarized above. ML has a promising future but may not be suitable for all problems. Agencies should understand ML's benefits, challenges, and risks to make informed decisions. A 10-step roadmap tailored to state DOTs has been developed to help transportation agencies build their ML capabilities. The roadmap is part of a broader ML guidebook based on best practices and lessons learned from research, surveys, and case studies with state DOTs.



What's next for ML in transportation? The ML landscape is rapidly evolving in transportation, with a rise in deep learning and generative AI models like ChatGPT. While these models offer tremendous capabilities, they also present challenges such as ethical concerns, potential inaccuracies, lack of explainability, and the need for domain expertise. As ML implementation processes in transportation advance, trends like the use of pre-trained models are expected to impact how ML solutions are acquired and utilized by transportation agencies.

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