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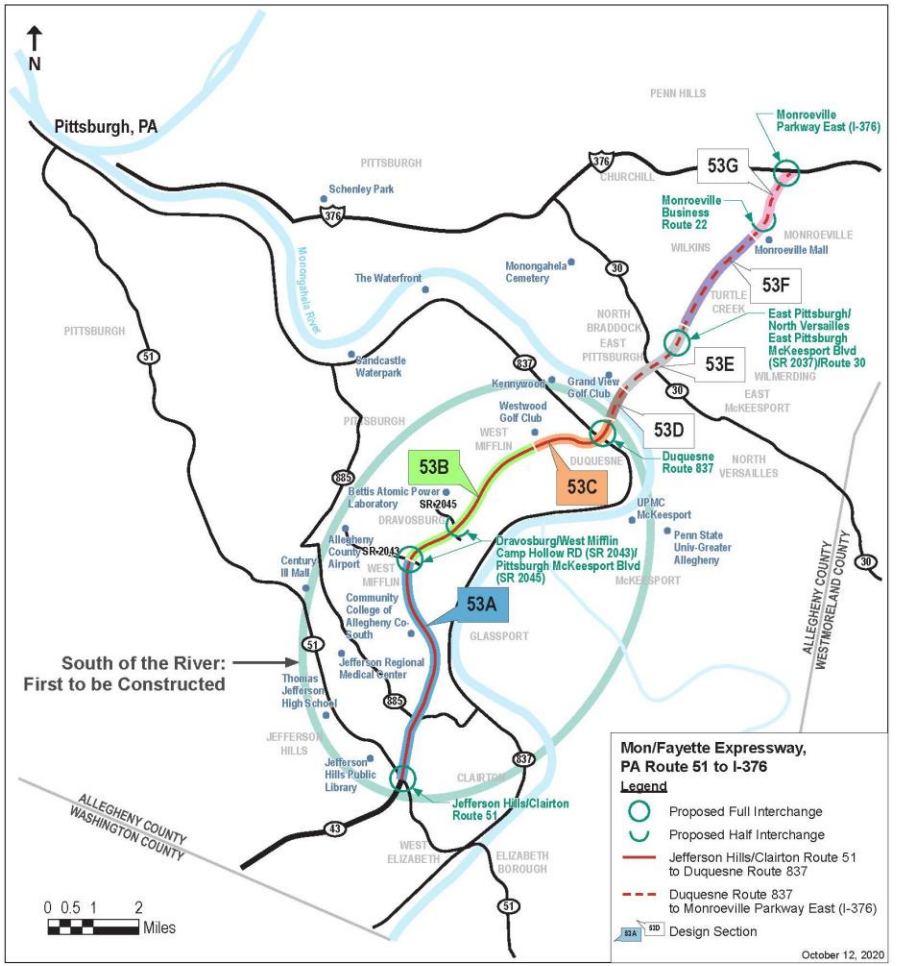
Pennsylvania Turnpike Climate Resistant Corridor

The Mon-Fayette Expressway: A Sustainable Corridor

- Digital Twin
- Absorptive Sound Barrier Walls
- Energy Harvesting Geogrids
- Electrified Roadways Strategic Plan



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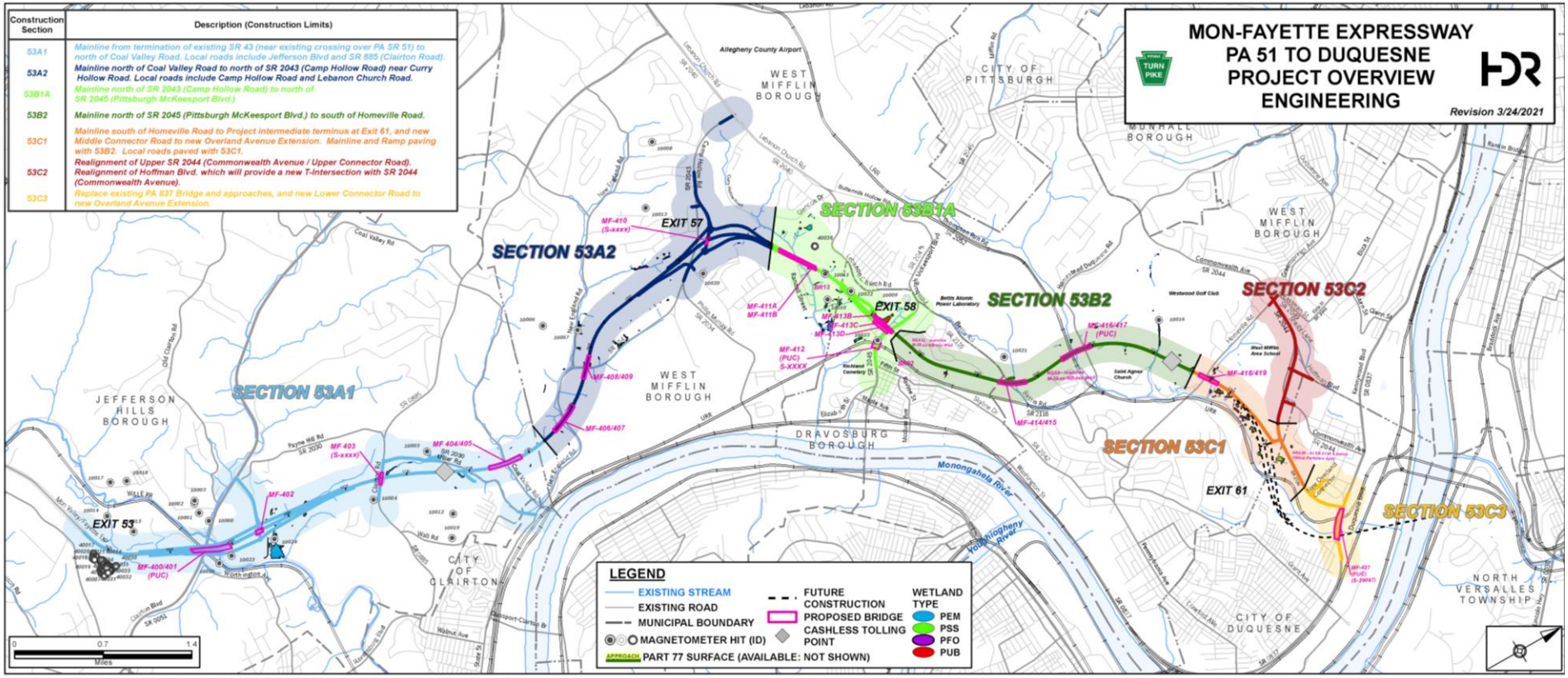

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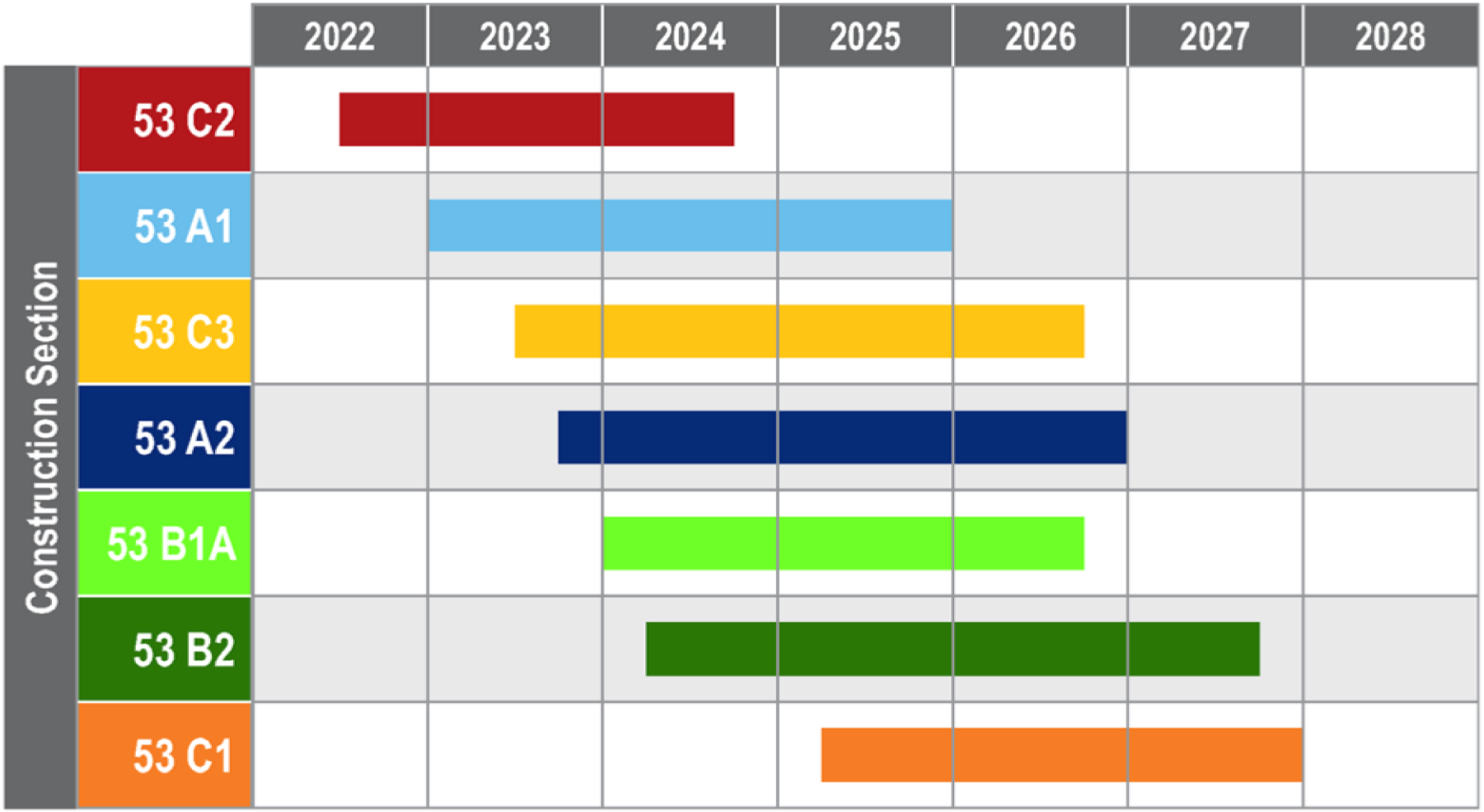
Mon Fayette Expressway Construction Schedule

PA Route 51 in Jefferson Hills to PA Route 837 in Duquesne



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DIGITAL TWIN

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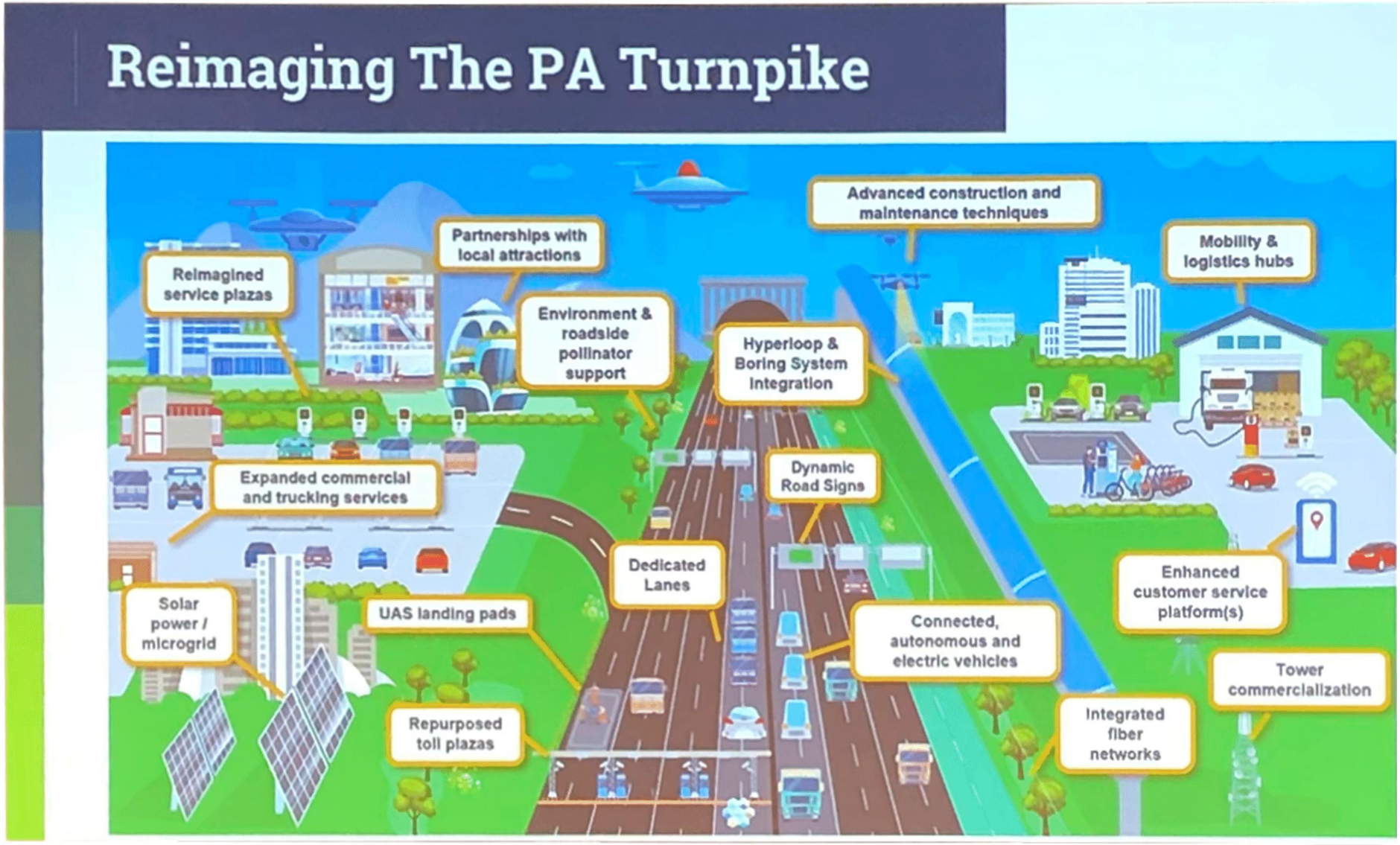
MOTIVATION



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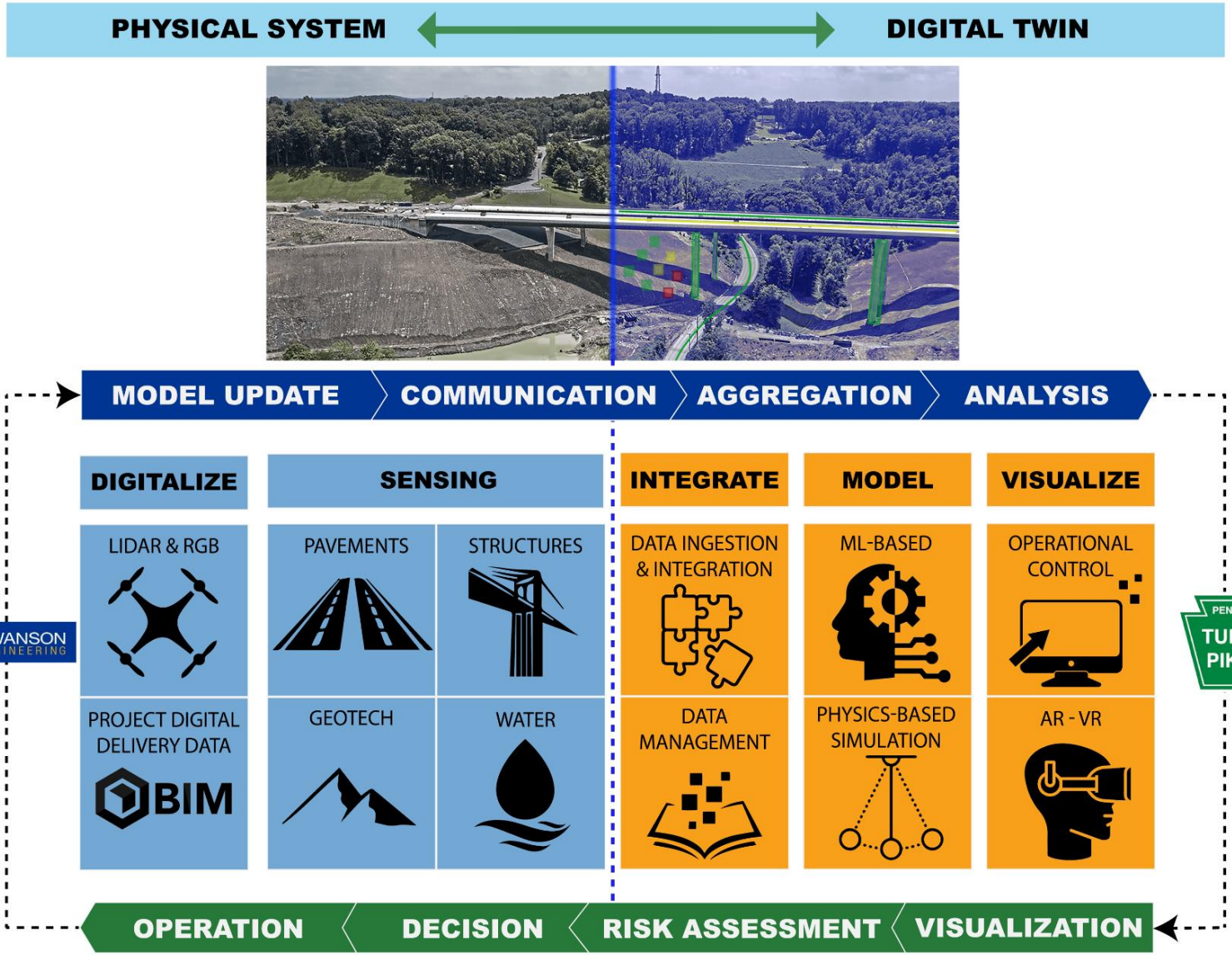
Capabilities



Overview of Research

- Digital Twin Model Creation and Development
- Sensor Installation
  - Pavement/Geotechnical
  - Structure
  - Stormwater Management
- Data Analysis and Validation
- Long Term Maintenance

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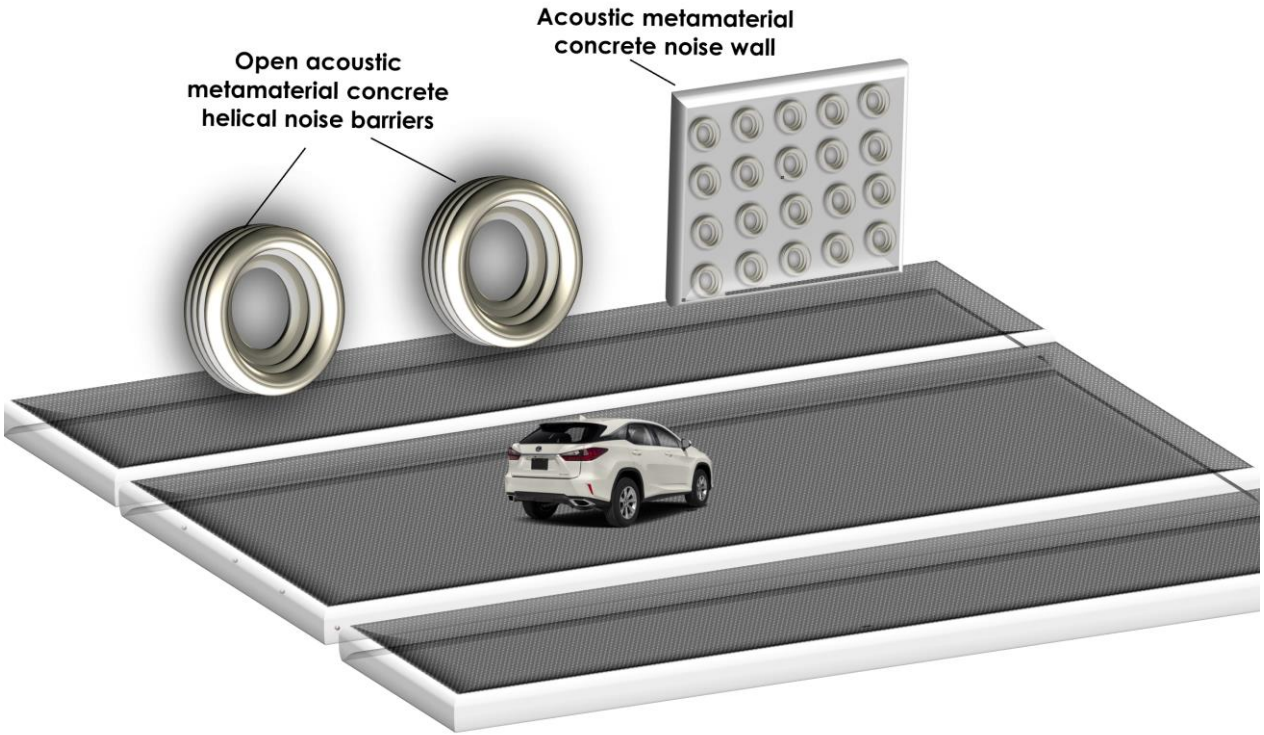
ABSORPTIVE SOUND BARRIER WALLS



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Motivation

Nitrogen oxide (NO) and nitrogen dioxide (NO2), even in small amounts, can be dangerous to human health

Vehicles are not only a major source of emissions but also the main contributors to noise pollution

Can we counter both NOx and noise pollution in urban areas?

Our solution: A multifunctional sustainable sound barrier with both noise cancellation and NOx reducing functionalities

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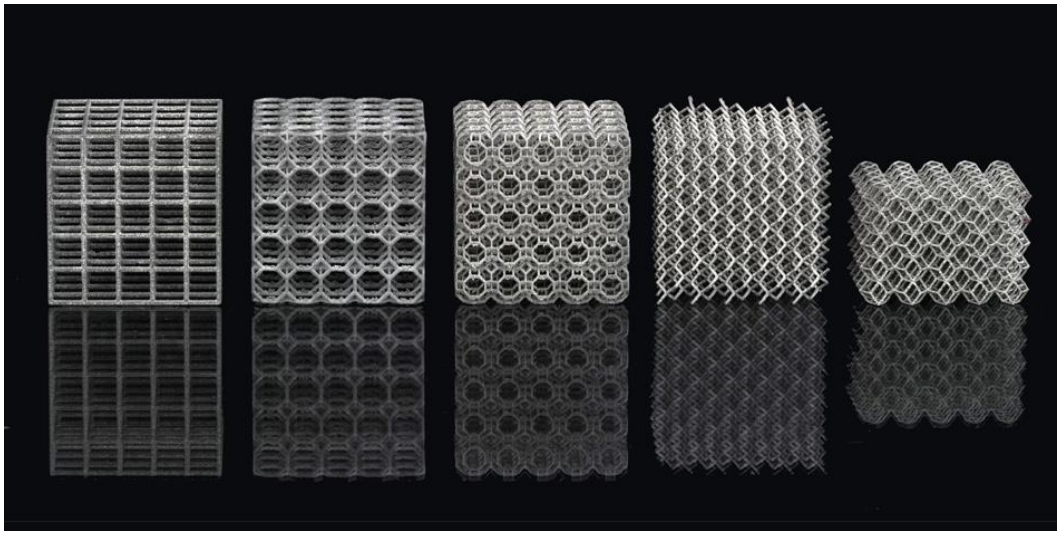
Components of the Sound Barrier

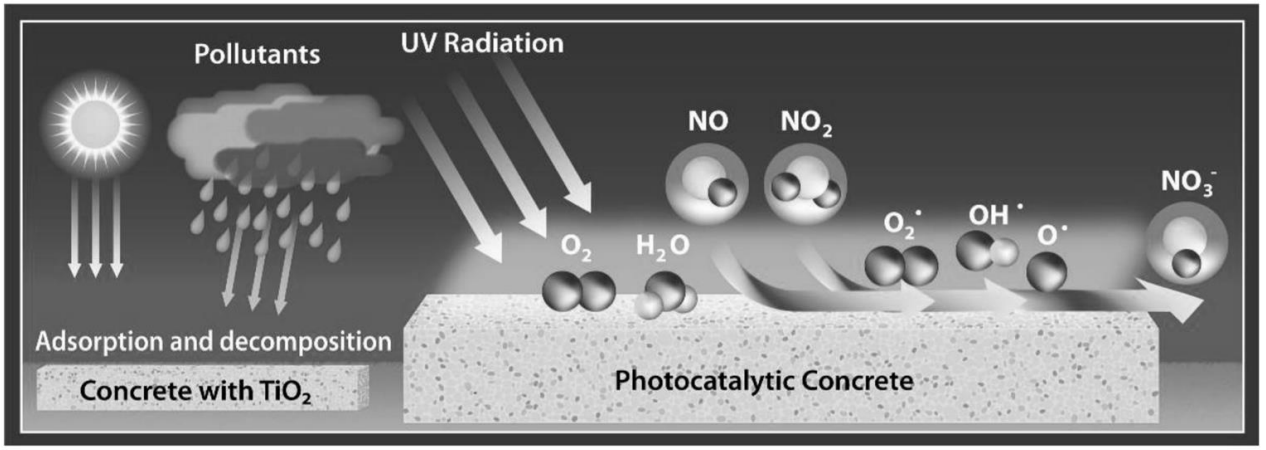
Acoustic Metamaterial

Acoustic metamaterials are artificial structures that can manipulate the propagation of acoustic waves



Photocatalysis

TiO_2 coatings on top of mortar or concrete results in a very high reduction in NOx concentration



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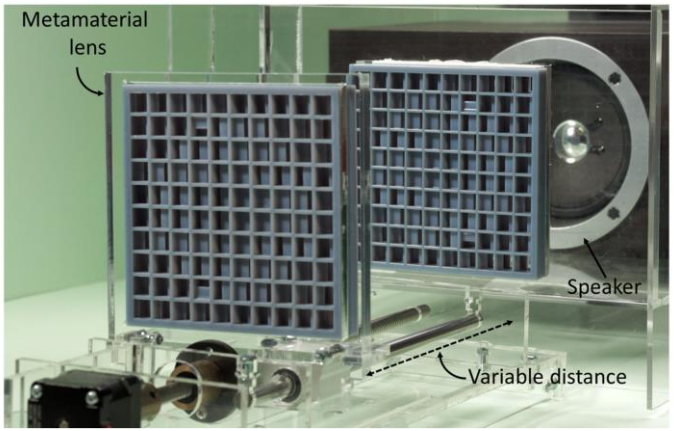
Overview of Research

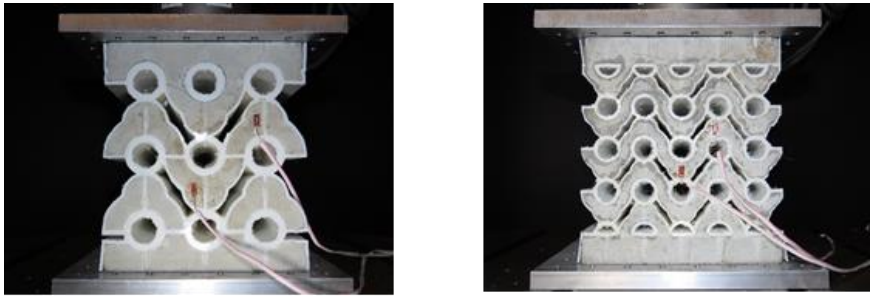
Phase 1: Investigating various potential designs for the acoustic concrete-based metamaterial wall

Phase 2: Fabricating large-scale prototypes of the optimal design identified at Phase 1

A final design to be deployed for road demonstrations on a designated section of the Southern Beltway in an upcoming Phase 3.



Modular acoustic metamaterial panel



Metamaterial concrete

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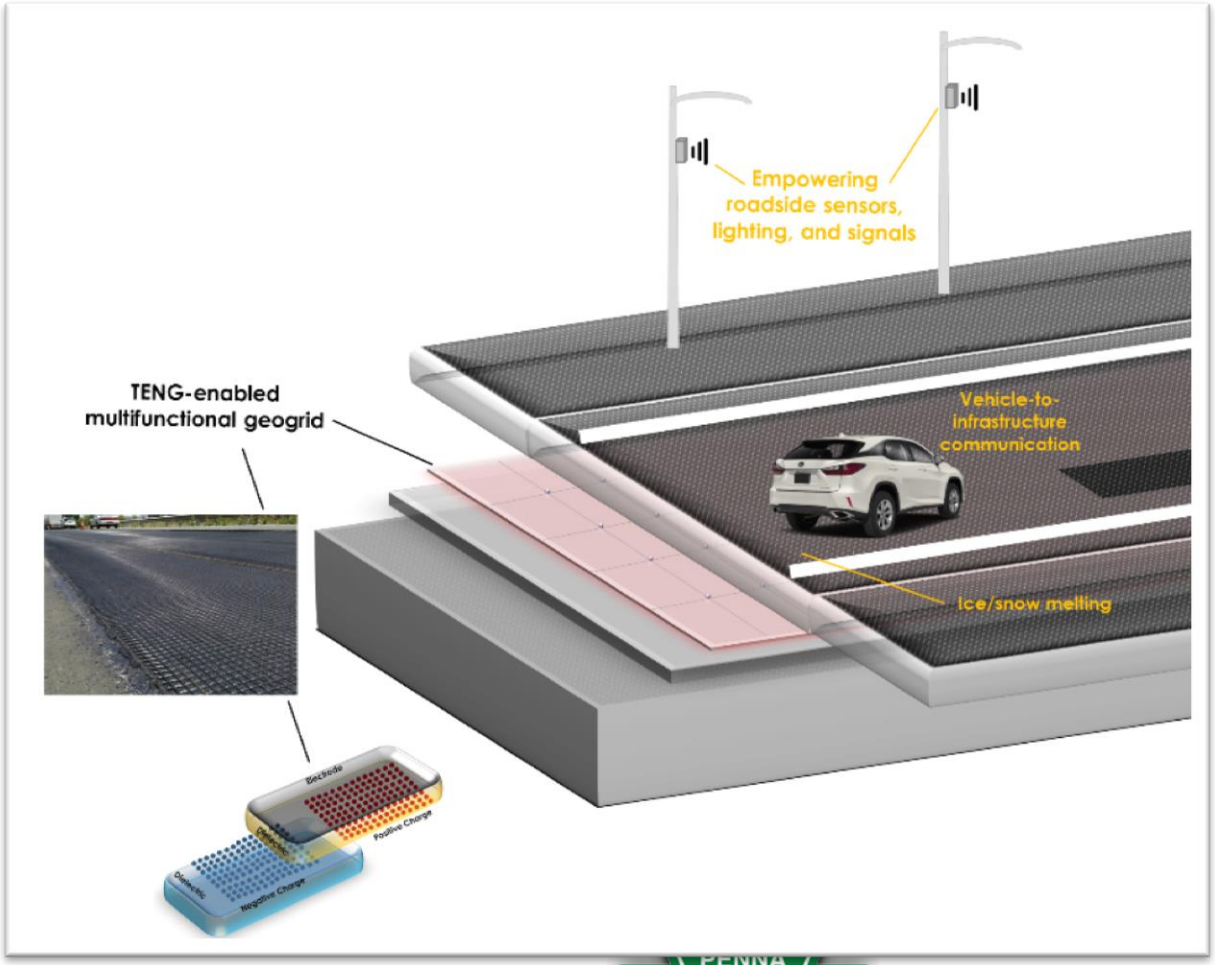
ENERGY HARVESTING GEOGRID



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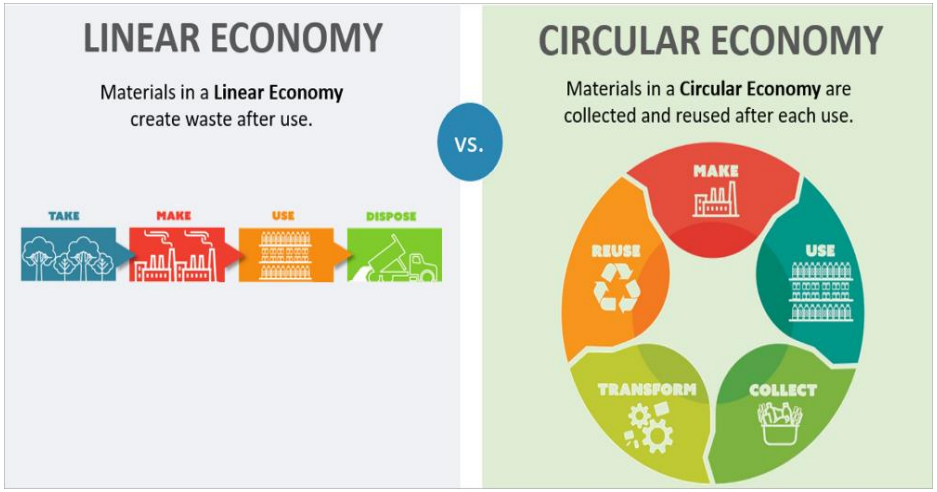
Motivation

Sustainable resources are one of the main pillars of circular economy

Using renewable energy sources and biodegradable, recyclable or renewable materials

In the last 70 years, an estimated 6.3 billion tons of plastic has been produced worldwide



Energy from finite sources

Energy from renewable sources

Our solution: Incorporating innovative, renewable and clean energy harvesting technologies with recyclable materials to improve the sustainability of civil infrastructure systems

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Energy Harvesting Geogrids

An alternative scalable solution is to use plastic wastes for manufacturing in form of geogrids

Huesker Group has introduced the world's first asphalt reinforcement geogrid - ecoLine - made from 100% recycled polyethylene terephthalate (PET) yarns

World's first asphalt reinforcement geogrid made from 100% recycled PET by Huesker Group, Germany

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Potential Benefits

1. Energy harvesting for roadside devices with different energy demands (~500 W/m^2)
2. Battery-free weigh-in-motion (WIN) system
3. A multifunctional digital pavement system
4. Enhancing pavement performance (high-tensile strength) against damages

Device	Typical Energy Demand
Wireless Sensor Networks	0. 1µW to 200 mW
LED Traffic Signal Bulbs	8-12 W/unit
LED Blinker Traffic Warning Signs (e.g. Tapco BlinkerSign)	77 mW
Passive Infrared Sensor	0.85 mW
Radar Sensor	912 mW

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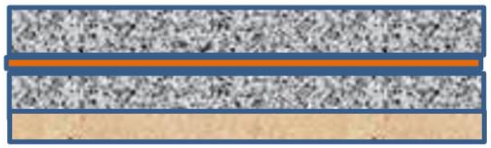
Overview of Research

Phase 1:

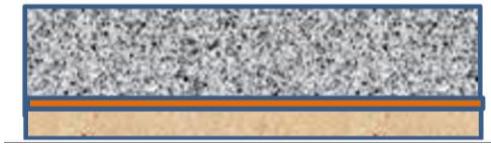
1. Numerical study and deflection analysis of pavement systems with different pavement designs
2. Creating a suite of designs for the smart TENG geogrids using various types of polyethylene-based materials
3. Experimental study using concrete beams with embedded smart geogrids

Phase 2:

1. Testing the optimized designed from Phase 1 in a large-scale slab specimen



PCC overlay
Nonwoven geotech fabric
Distressed PCC pavement



PCC pavement
Geogrid

Mill and fill
Geogrid
Distressed AC pavement

AC pavement
Geogrid

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ELECTRIFIED ROADWAYS

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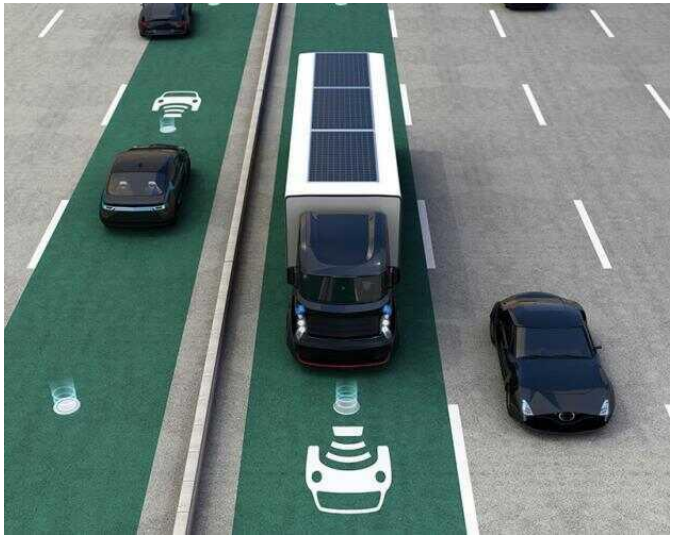
Motivation

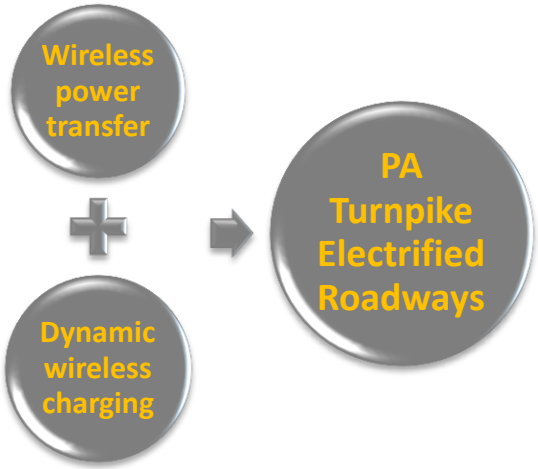
There is a huge interest in environmentally friendly modes of transportation

Electric vehicles (EVs) are viable solutions to environmental problems

Required infrastructure and long charging times at charging stations are major concerns



Our solution:



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Developing a Strategic Plan

Focus areas:

1. Capital Investment.
2. Research and Development.
3. Partnerships
4. Regulation and Policy
5. Operations and Maintenance
6. Strategic Staffing
7. Multimodal
8. Communications

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Questions?

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