

# Transportation Asset Management Webinar Series

Webinar 76

## Recent Research Roundtable

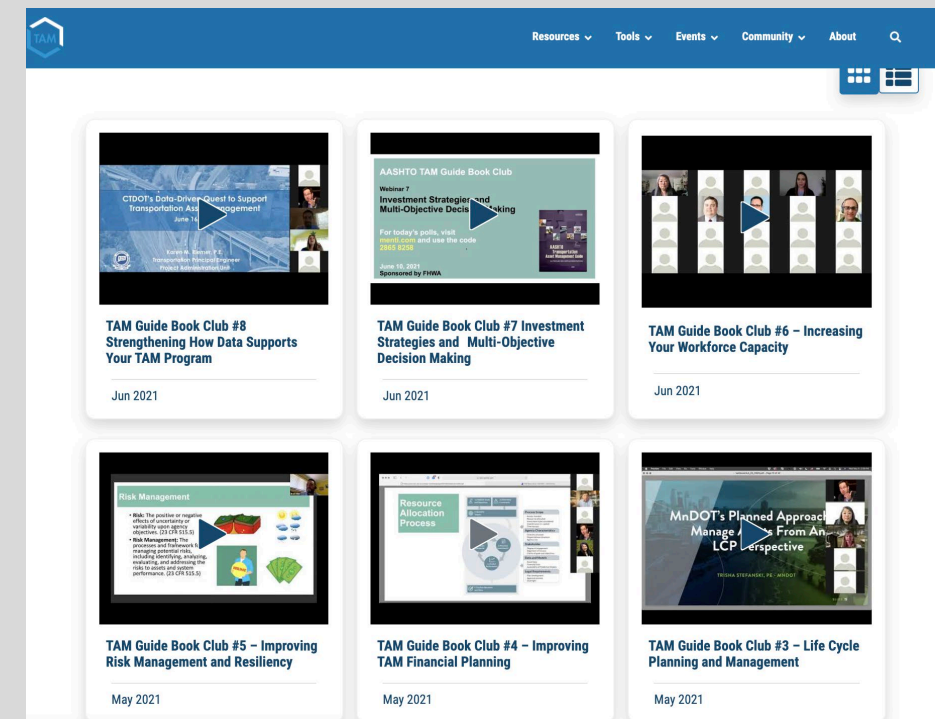
Sponsored by FHWA and AASHTO



August 20, 2025

# FHWA/AASHTO Asset Management Webinar Series

- This is the **76th** in a webinar series that has been running since 2012
- Webinars are held every two months, on topics such as off-system assets, asset management plans, asset and risk management, and more
  - Usually, the 3rd Wednesday of the month, 2PM Eastern
- We welcome ideas for future webinar topics and presentations
- Submit your questions using Zoom's chat feature



# Welcome!

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FHWA and the AASHTO Subcommittee on Asset Management are pleased to sponsor this webinar series

- Sharing knowledge is a critical component of advancing asset management practice
- FHWA Asset Management Hub:  
<https://www.fhwa.dot.gov/asset/pubs.cfm>

# Webinar Objectives

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- Promote key findings from recently completed projects and syntheses
- Highlight noteworthy research activities in ongoing projects
- Build awareness of developments in ancillary asset management, AI integration with TAM, and risk management coordination
- And as always, **share lessons-learned, ideas, and knowledge!!!**

# Webinar Agenda

- 2:00**     **Welcome, Overview, and Agenda**  
Anna McLaughlin, AASHTO; Tashia Clemons, FHWA; Hyun-A Park, Spy Pond Partners
- 2:15**     **Topic Introduction**  
Alma Mujkanovic, Georgia Department of Transportation, and Edgardo Block, Connecticut Department of Transportation
- 2:20**     **NCHRP 23-12, “Artificial Intelligence Opportunities for State and Local DOTs – A Research Roadmap”**  
Dr. Abhijit Sarkar, Virginia Tech Transportation Institute
- 2:35**     **NCHRP Synthesis 20-05/Topic 54-06, “Ancillary Asset Data Stewardship and Data Models”**  
Dr. Hala Nassereddine, University of Kentucky
- 2:55**     **NCHRP 23-32, “Transportation Asset Risk and Resilience”**  
Dr. Aimee Flannery, Jacobs
- 3:15**     **Q&A Discussion and Wrap Up**  
Hyun-A Park, Spy Pond Partners

# NCHRP 23-12

# Artificial Intelligence Opportunities for State and Local DOTs – A Research Roadmap

Abhijit Sarkar, PhD

# PROJECT TEAM



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Surendrabikram Thapa  
Research

# BACKGROUND

- State and local departments of transportation (DOTs) are being asked to solve ever more complex transportation problems and issues
- Artificial intelligence (AI) is being proposed and implemented to help address a number of these issues, such as
  - Improving safety, alleviating traffic congestion, assisting in real-time systems management, accommodating connected/automated vehicles, preserving the infrastructure, improving organizational efficiency, and improving customer service, among others
- There is no strategic guidance that state and local DOTs can use
  - to develop guidance, policies, and standards, and ensure a knowledgeable workforce that will enable them to effectively understand, develop, and apply AI solutions to improve their operations and to solve transportation problems

# OBJECTIVE

- To develop a research roadmap that identifies and prioritizes research needs to provide state and local DOTs
  - Better understanding of AI
  - What activities are suited for AI
  - Potential ways AI could be applied
- The roadmap will build upon existing research and be informed by outreach to the transportation community
- The focus of this research is
  - AI applications for state and local DOTs,
  - Being relevant to a wide variety of research organizations beyond NCHRP
  - To generate additional research ideas and encourage coordination among research agencies

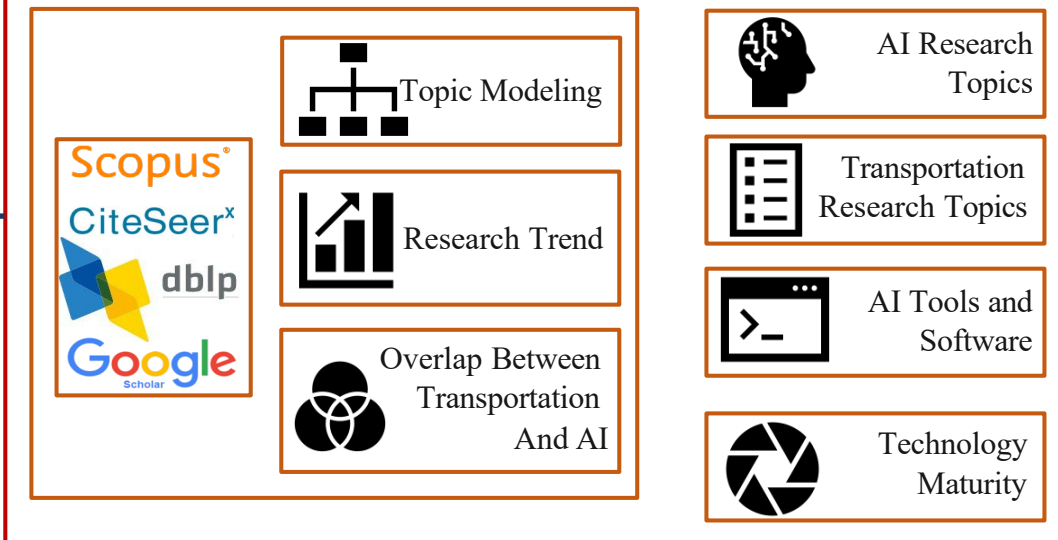
# OBJECTIVE

- Understand the current state of practice for the use of AI by state and local DOTs (Task 3)
- Highlight AI developments (tools, methods, technologies, platforms, etc.) in the larger transportation universe and in other fields that can be adapted to transportation applications for state and local DOTs (Task 2)
- Identify transportation-related problems that could be solved with AI, the benefits of incorporating AI to solve those problems, and how those benefits can be communicated (Task 3)
- Determine how state and local DOTs can evaluate proposed AI solutions, how they would know they are ready to use AI, and the prerequisites of using AI solutions (Tasks 2 and 4)

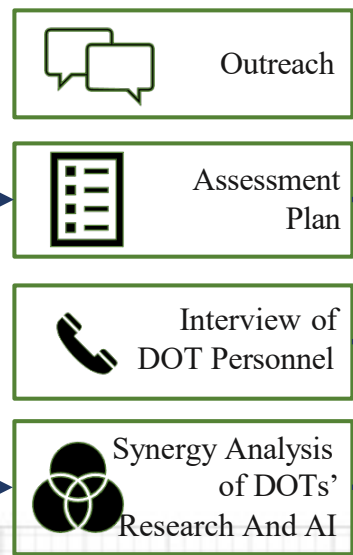
# OBJECTIVE

- Identify guidance, policies, and/or standards that are needed to assist transportation agencies in successfully applying AI
- Identify potential risks, limitations, and challenges of AI for transportation and transportation agencies, transportation modes, and transportation systems (Tasks 4 and 5)
  - Identify ethical, data security, and privacy challenges of AI and how they can be addressed and overcome (Tasks 2 and 5)
  - Reveal the diversity, fairness, and equity implications of AI (Tasks 2 and 5)
- Identify the workforce development implications of AI, including preparing and training the workforce (Task 5)

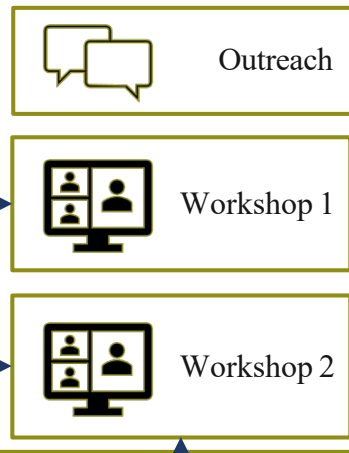
## Task 2: Literature Review to Assess The Scope of AI in Transportation Research and Development



## Task 3: State Of Practice And Readiness Assessment Of State DOTs



## Task 4: Collaborative Workshop for Knowledge Transfer



## Task 5: Development of Research Roadmap



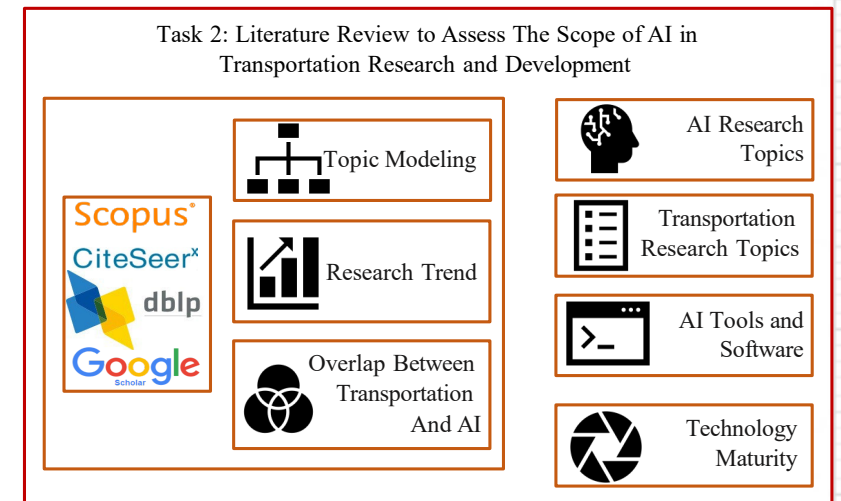
## Current state of AI in Transportation (Task 2)

- Topic Modeling Lit review report

# PROBLEM: UNDERSTANDING INTERACTION BETWEEN AI AND TRANSPORTATION

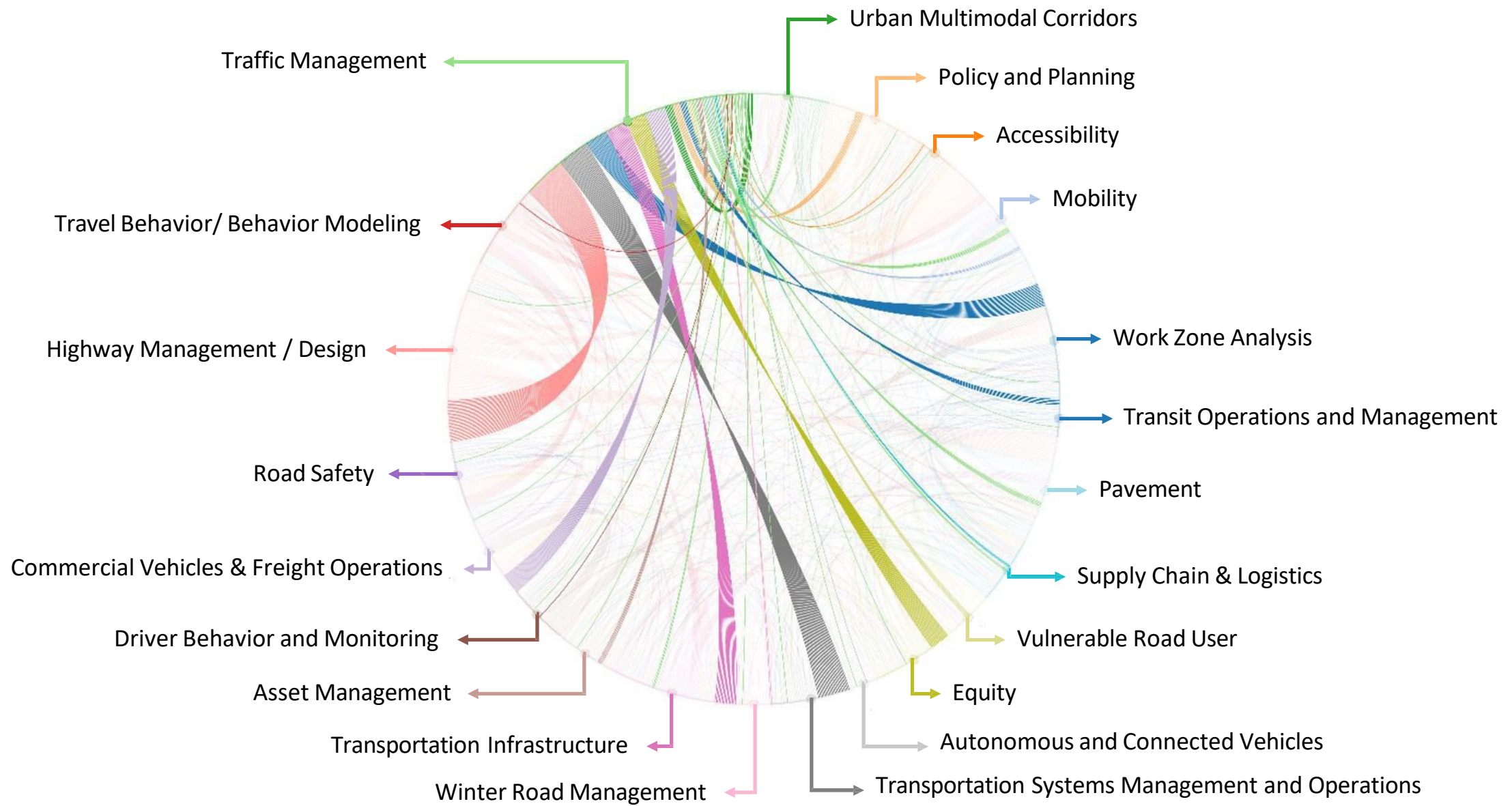
## HOW DO WE SOLVE THIS?

- Title: When Vehicles See Pedestrians with Phones: A Multicue Framework for Recognizing Phone-Based Activities of Pedestrians
  - Keywords: Articulated pose tracking; **computer vision**; **deep learning**; exemplar **support vector machines (SVMs)**; **highly autonomous vehicles**; panoramic surround behavior analysis; **pedestrian activity recognition**
- Title: Driver gaze zone estimation using convolutional neural networks: A general framework and ablative analysis
  - Keywords: **Advanced driver assistance systems**; **Automobile drivers**; Behavioral research; Classification (of information); **Computer vision**; Convolution; Image classification; Intelligent systems; Large dataset; **Neural networks**; **Pattern recognition**; Pattern recognition systems; **Statistical tests**; Driver assistance system; **Driver distractions**; Driver information systems; Facial feature extraction; Gaze estimation; **Gaze tracking**; On-road studies; Visual Attention; Eye tracking



11 years (2010 – 2021)

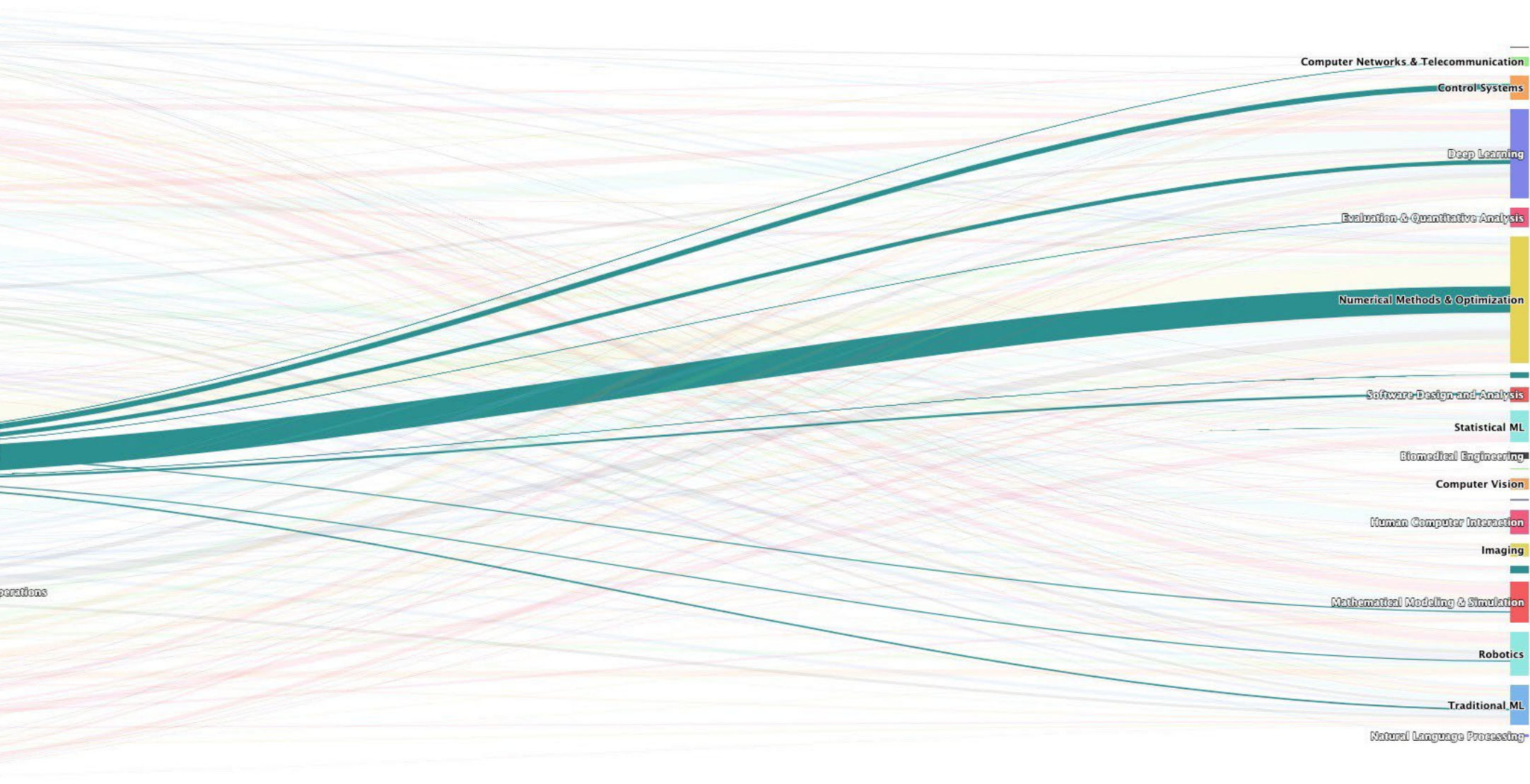
65000 publications





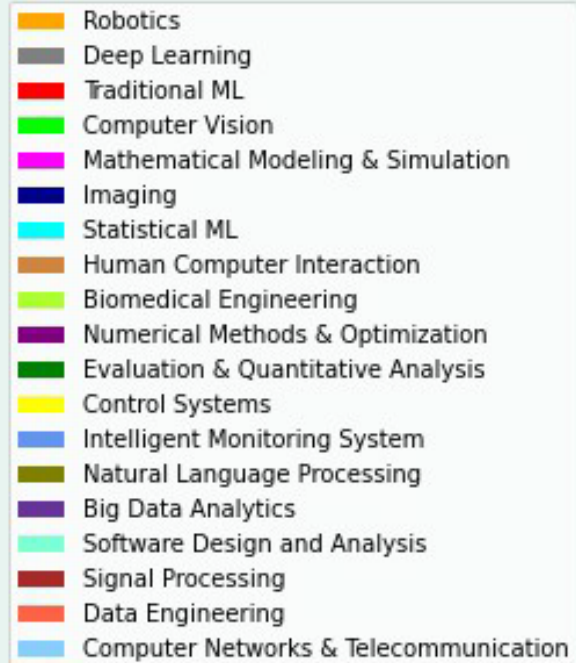
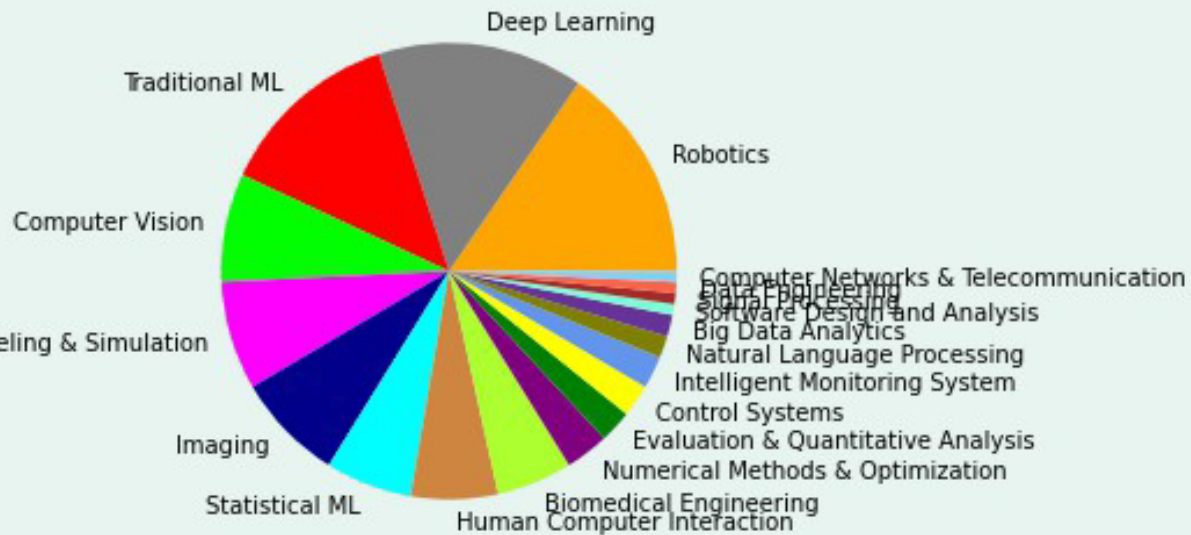
- Asset Management
- Driver Behavior
- Driver Monitoring
- Highway Management or Design
- Mobility
- Non-Motorized Mobility
- Pavement
- Pedestrian
- Policy and Planning
- Road Safety
- Sustainability
- Transit Operations and Management
- Transportation Equity
- Transportation Infrastructure
- Transportation Systems Management and Operations
- Travel Behavior or Behavior Modelling
- Urban Arterial Network
- Urban Multimodal Corridors
- Urban Planning
- Vulnerable road user
- Work-Zone Analysis

Relationship of AI topics with transportation topics  
Traffic Management: 4604

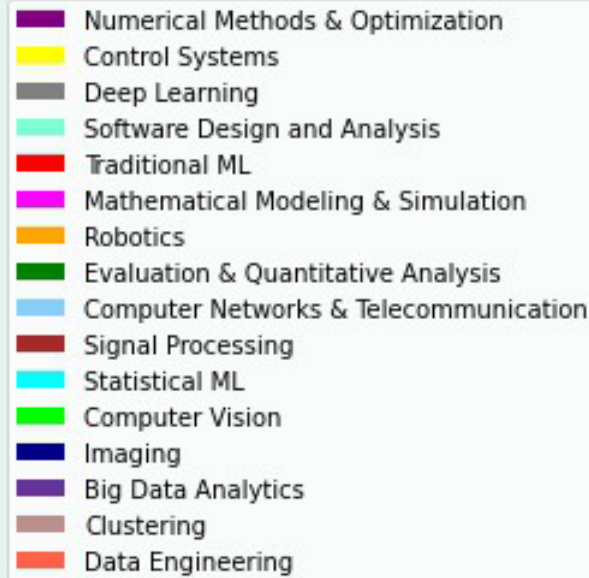
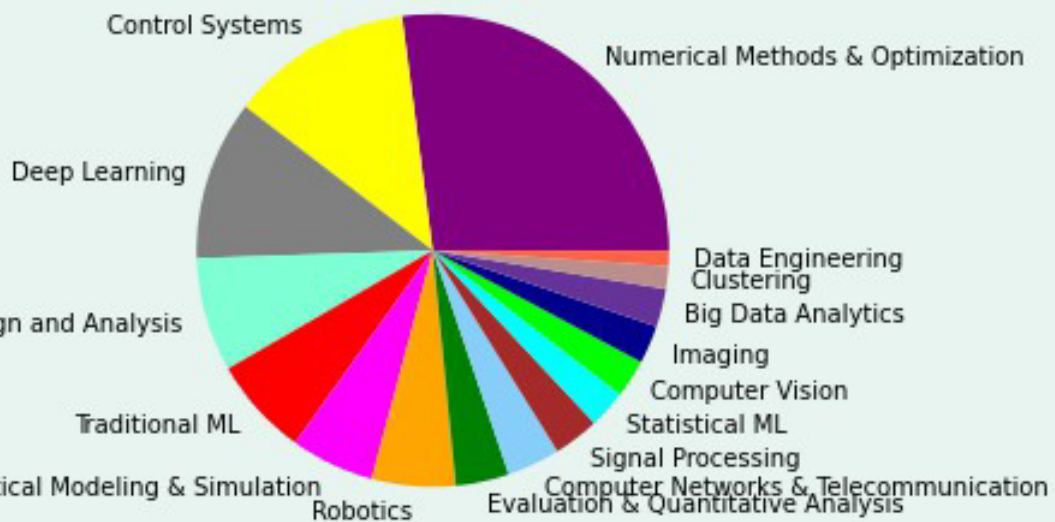


- Computer Networks & Telecommunication
- Control Systems
- Deep Learning
- Evaluation & Quantitative Analysis
- Numerical Methods & Optimization
- Software Design and Analysis
- Statistical ML
- Biomedical Engineering
- Computer Vision
- Human Computer Interaction
- Imaging
- Mathematical Modeling & Simulation
- Robotics
- Traditional ML
- Natural Language Processing

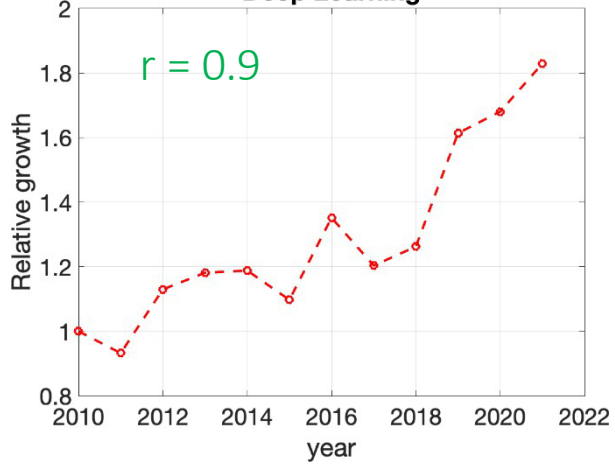
ML Topics used for Pedestrian



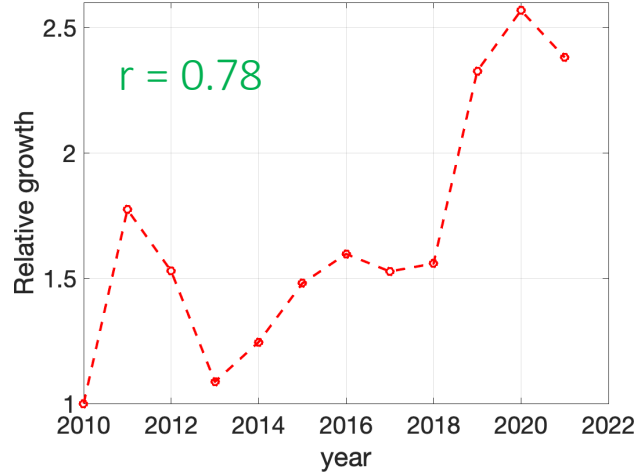
ML Topics used for Traffic Management



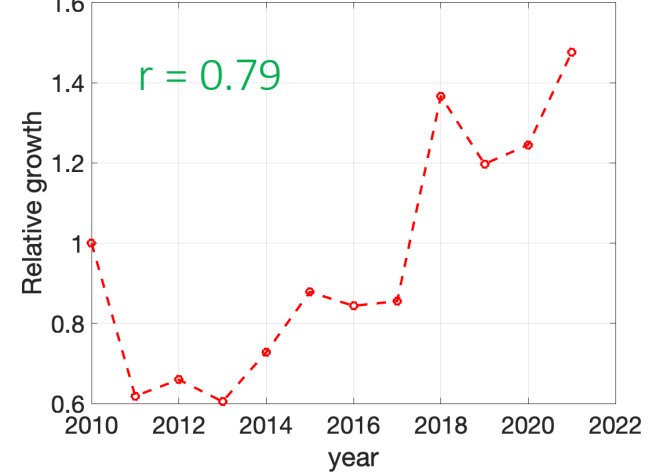
**Deep Learning**



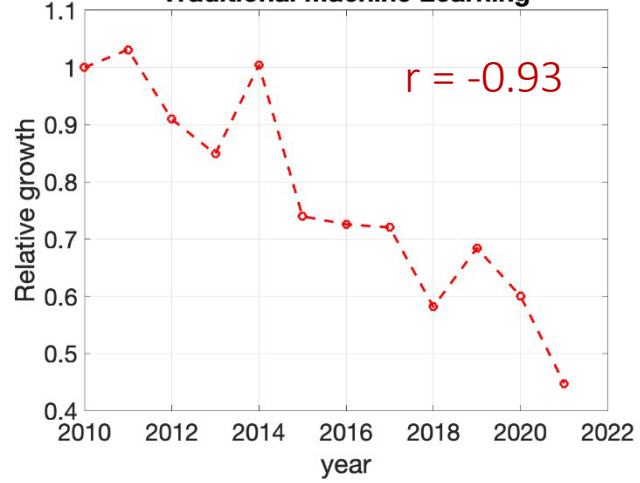
**Big Data Analysis**



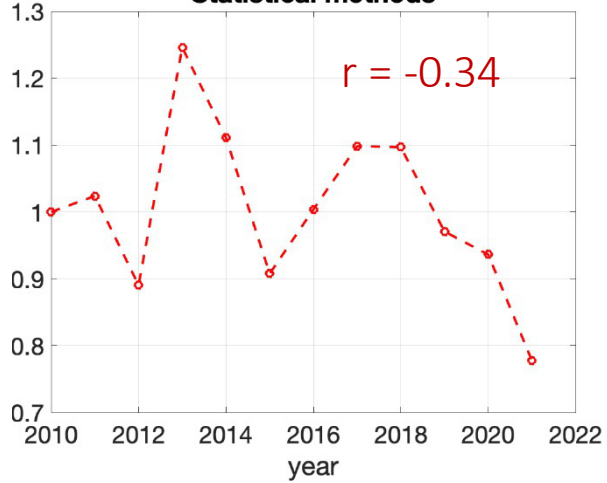
**Computer network and telecommunication**



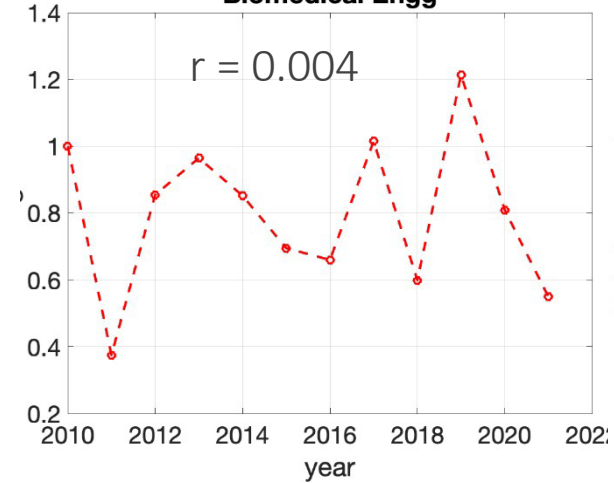
**Traditional Machine Learning**



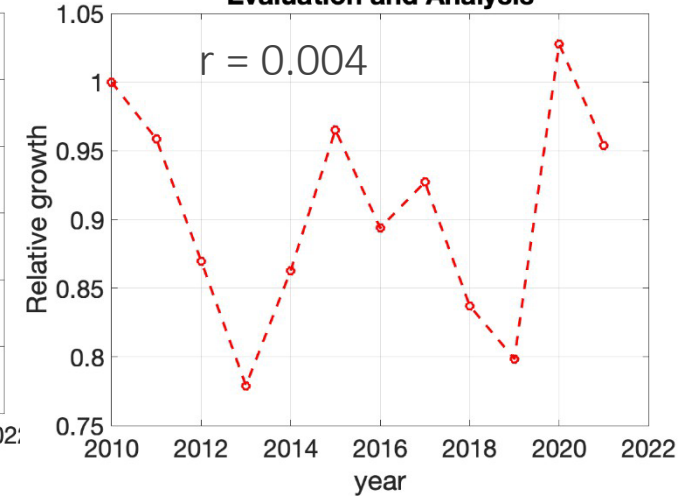
**Statistical methods**



**Biomedical Engg**



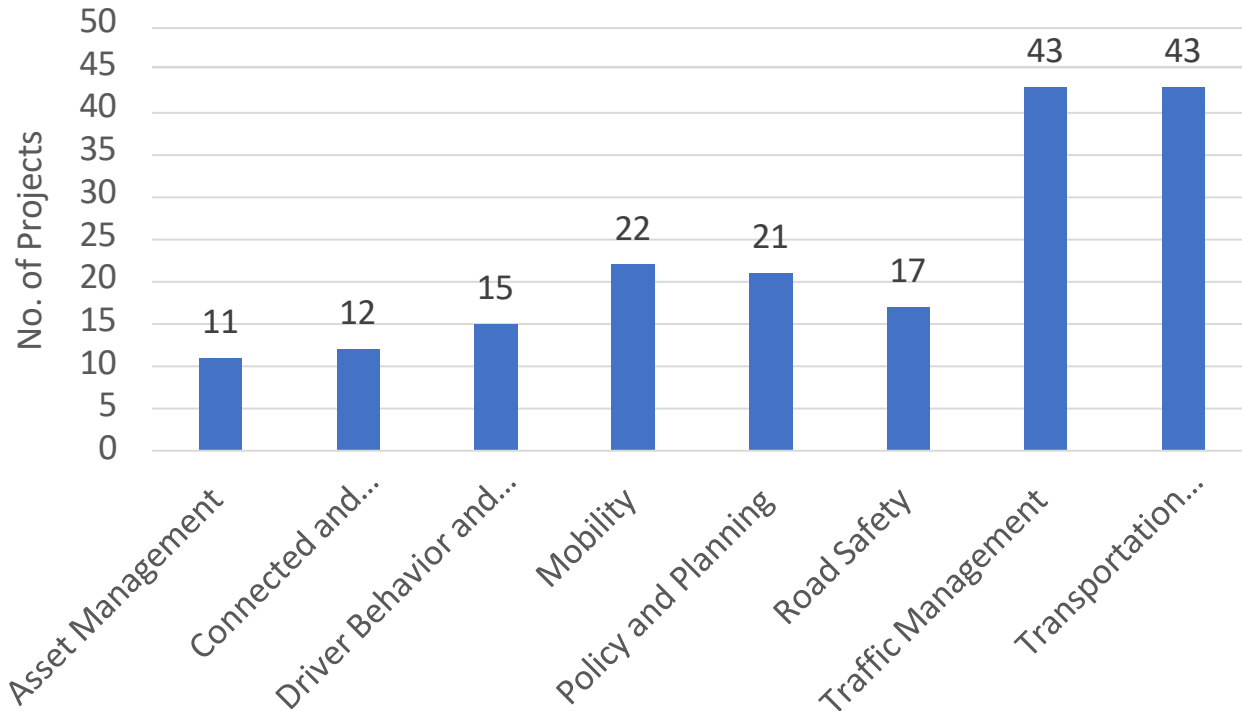
**Evaluation and Analysis**



## KEY FINDINGS (LIT REVIEW)

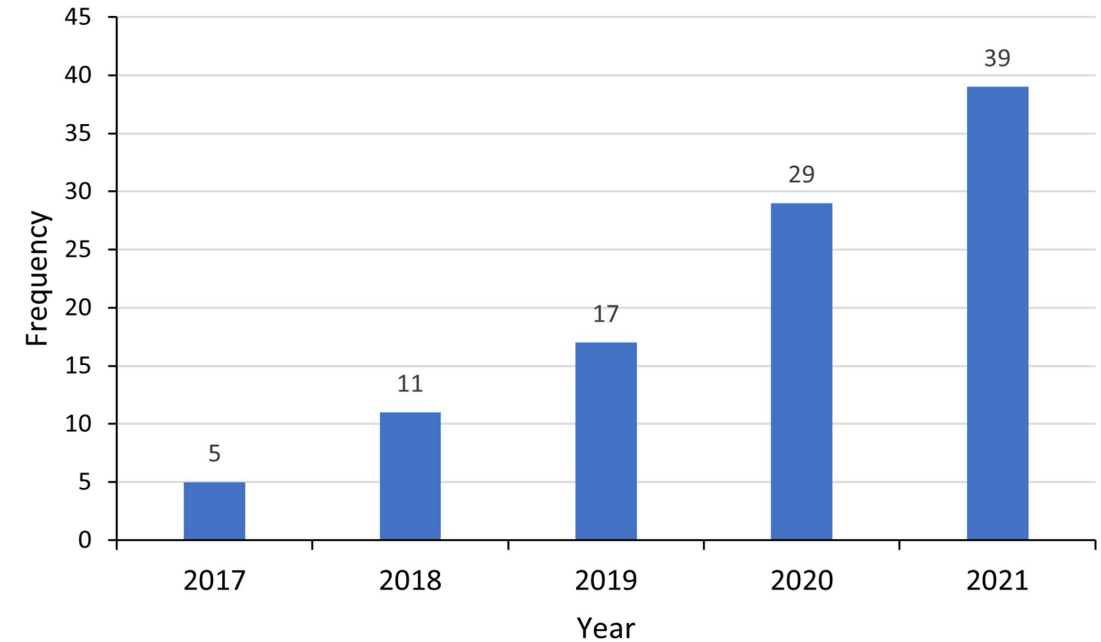
- Transportation topics are interdependent with each other
- A series of AI methods are used to solve a given transportation problem but there is more reliance on one AI topic than the other
- We see varying impacts of different AI fields on transportation research

## TRANSPORTATION AREAS ACROSS THE SELECTED PROJECTS



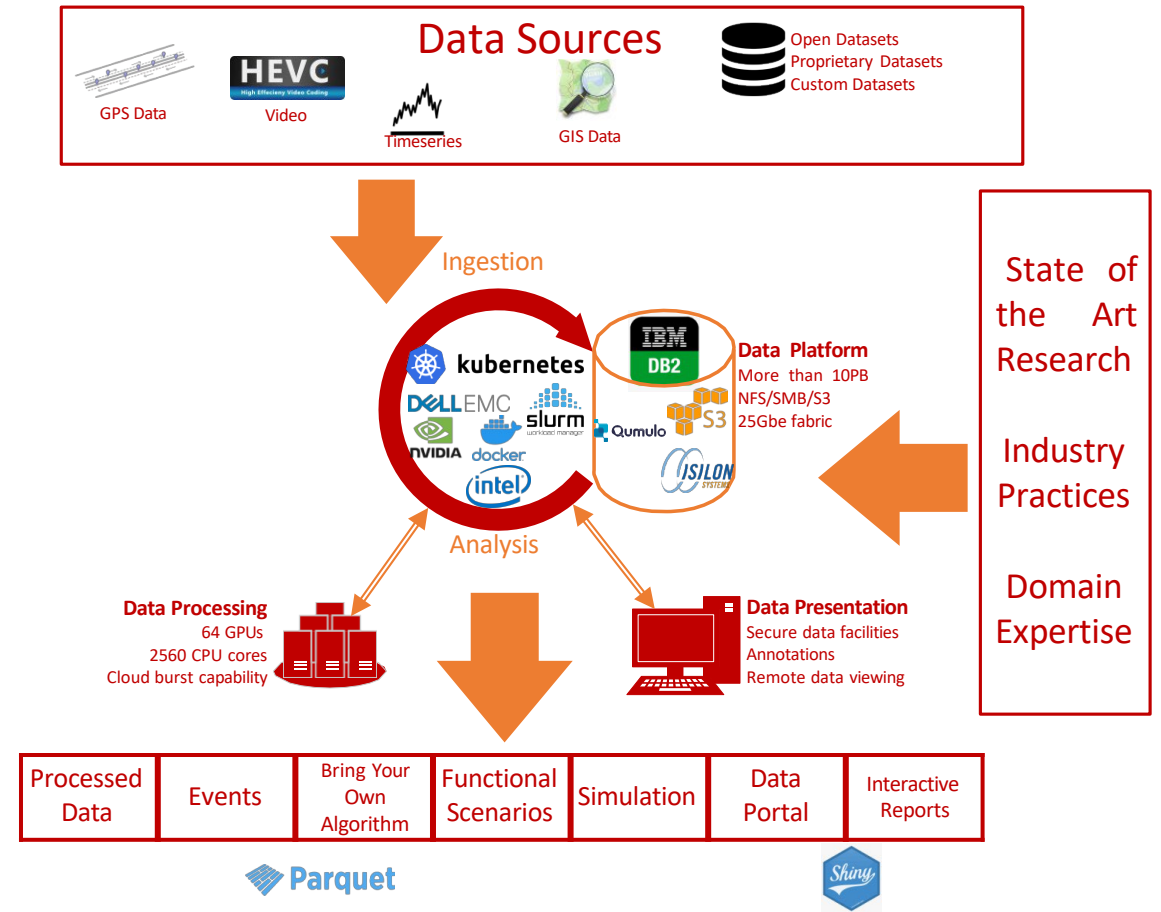
- Traffic management and transportation infrastructure were the areas with high prevalence of AI tools
- Use of Transportation Research Board database: 106 projects selected between 2017 and 2021
- Research into AI trends for mobility, policy and planning, and safety was prevalent
- There has been an increase in the number of funded projects for AI applications in transportation research over the last 5 years

## Trend in AI Projects by Year

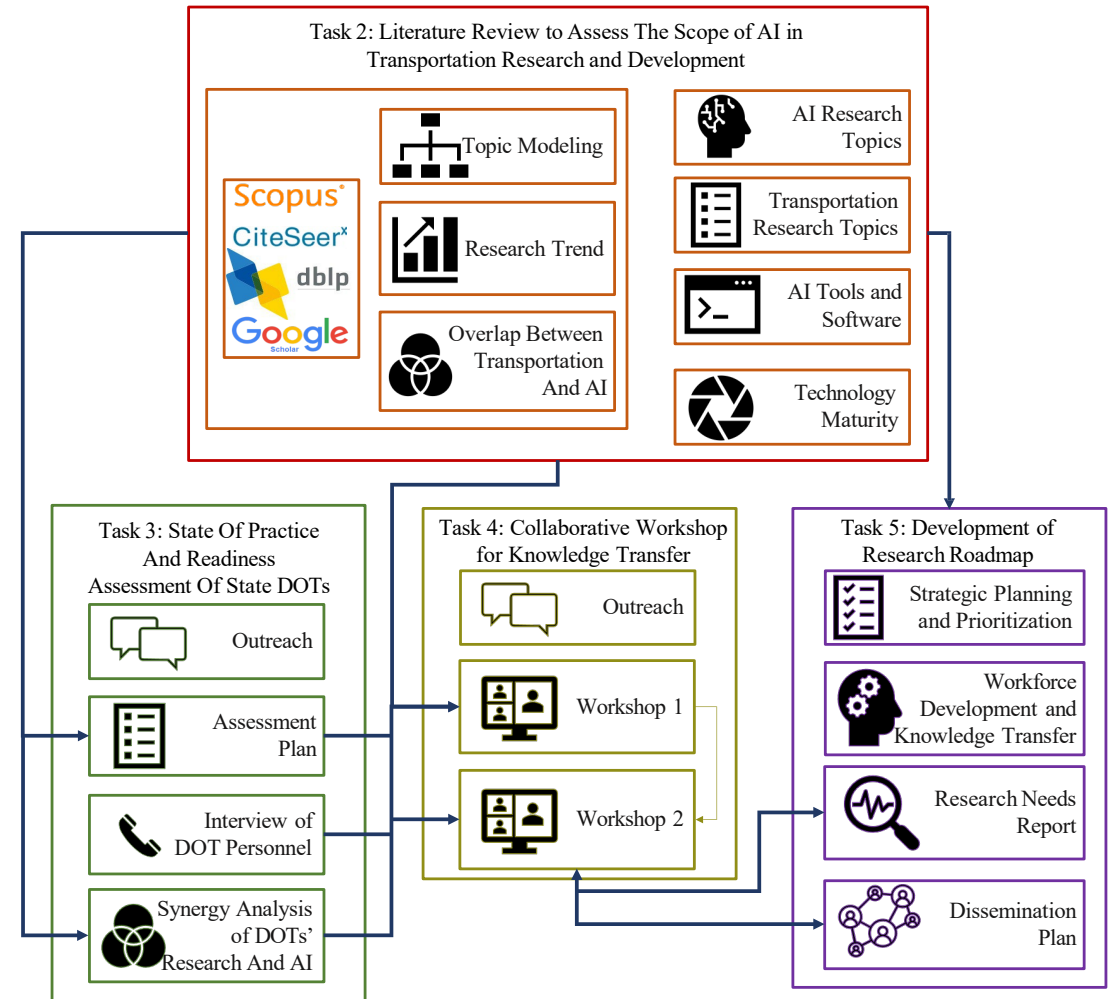


# THE AI ECOSYSTEM

- AI software platforms: We looked at all the software platforms and frameworks used in development, testing, and deployment of AI systems.
- Big data management: We mainly looked at data management tools, data collection sensors, data storage mechanisms, and security. We further investigated these management tools' operation modality, security, and limitations.
- Big data processing: We investigated handling data and algorithms efficiently, and computational needs.
- Cost and benefit: We investigated costs to develop maintain, and operate AI-based solutions, available platforms and solution providers.



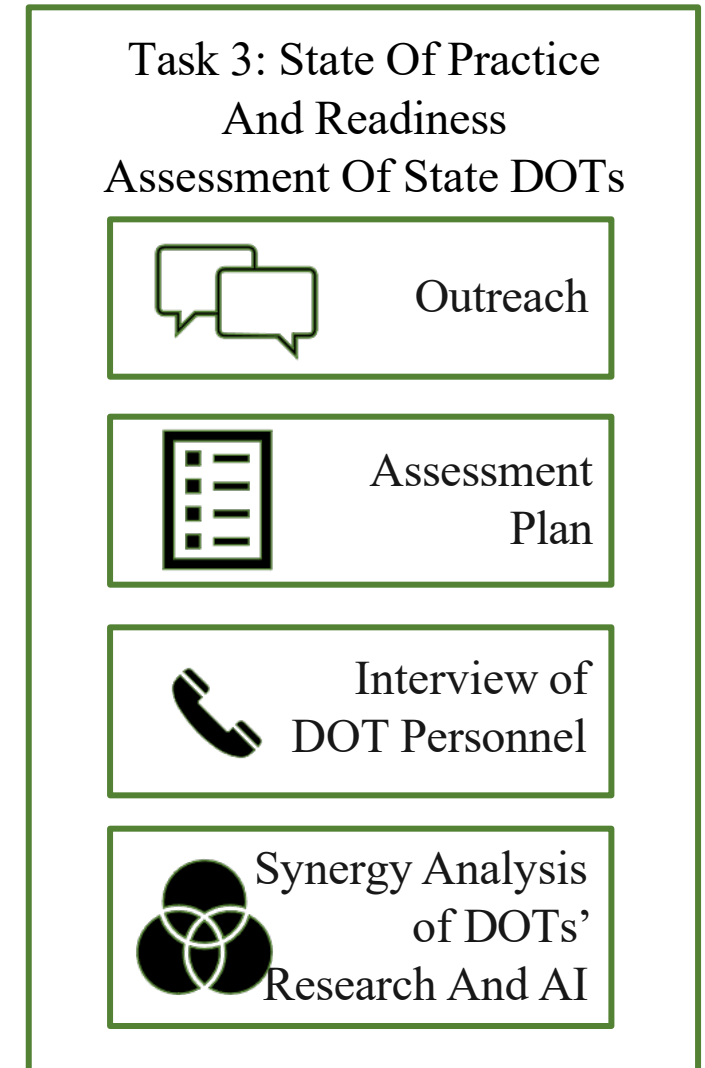
# Current state of AI in DOT



# STATE OF PRACTICE AND READINESS ASSESSMENT OF STATE DOTs

## OUTREACH GOALS

- Goal: Understand the current state of practice at state DOTs
- Assessment Plan
  - Current practices and research initiatives
  - Previous initiatives
  - Technical knowledge and expertise in AI
  - Deployment and evaluation of AI tools
  - Partnership with other agencies
  - Future direction and long-term focus



# SUMMARY OF FEEDBACK FROM WORKSHOP 1

- Areas suggested for inclusion in roadmap
  - Document management, plan review under highway maintenance, project management/ resource allocation, cybersecurity
- Lack of standardized AI-based solutions
- Challenges: Data availability, quality, funding, communication with leadership
- Workforce/ collaboration: Difficult to hire – beneficial to collaborate with universities and industries
- AI practice: Difficulty in understanding readiness of AI – properly communicate AI problem, build stronger internal collaborations

# RESEARCH ROADMAP

## PLANNING AND PRIORITIZATION

- Developed from the knowledge and feedback from Task 2, 3, and 4
- Developed from the NITRD\* strategic plan for AI R&D
  - Strategy 1: Make long-term investments in AI research
  - Strategy 2: Develop effective methods for human-AI collaboration
  - Strategy 3: Understand and address the ethical, legal, and societal implications of AI
  - Strategy 4: Ensure the safety and security of AI systems
  - Strategy 5: Develop shared public datasets and environments for AI training and testing
  - Strategy 6: Measure and evaluate AI technologies through standards and benchmarks
  - Strategy 7: Better understand the national AI R&D workforce needs
  - Strategy 8: Expand public-private partnerships to accelerate advances in AI
- University collaboration: UTC program and NSF AI institute program

specific



generic

# Research Statement

Problem Statement Title	Research Areas					
	RA 1	RA 2	RA 3	RA 4	RA 5	RA 6
Case Studies of Successful Implementation of AI Programs in State and Local DOTs		.	.	.	.	.
Toolbox to Guide the Selection and Deployment of AI Technologies in State and Local Transportation Agencies	.	.	.	.		
Workforce Needs and Development to Prepare Transportation Agencies for the Application of Existing and Emerging AI Approaches	.	.		.		
Implementable Funding Strategies for AI Opportunity Applications for State and Local DOTs		.	.	.		.
Develop a Guidebook to Understand the Vulnerability and Security Concerns for AI-based Transportation Solutions		.	.			.
Exploring the Integration of AI-based Methods in Multimodal Transportation Planning	.	.		.		.
Validation of AI Applications for Automated Pavement Condition Evaluation	.	.		.		
Explore Natural Language Processing-based Methods for Document Management and Public Interaction at DOTs		.		.		.
Develop a Roadmap for Successful Collaboration with Industry Partners that Provides AI-based Solutions		.	.	.	.	
Roadmap to Create Sharable, Reliable Sources of Data Sets	.	.		.	.	.
Creating a framework to process and manage data collected by DOTs	.	.		.	.	

RA 1 Workforce & Infrastructure Development, RA 2 Readiness and Evaluation of AI, RA 3 Challenges in Adopting AI, RA 4 Current Practices and Prioritization, RA 5 External Collaboration, RA 6 Policy & Planning

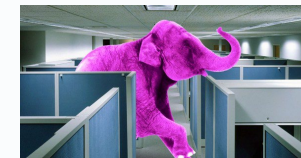
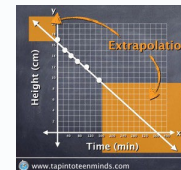
<b>Research Problem Statement</b>	<b>Estimated Budget</b>	<b>Duration</b>
Case studies of successful implementation of AI programs in state and local DOTs	\$ 250,000	18
Toolbox to guide the selection and deployment of artificial AI intelligence technologies in state and local transportation agencies	\$ 300,000	24
Workforce needs and development to prepare transportation agencies for the application of existing and emerging artificial AI intelligence approaches	\$ 250,000	24
Implementable funding strategies for AI opportunity applications for state and local DOTs	\$ 150,000	12
Develop a guidebook to understand the vulnerability and security concerns for AI-based transportation solutions	\$ 300,000	24
Exploring the integration of AI-based methods in multimodal transportation planning	\$ 200,000	24
Validation of AI applications for automated pavement condition evaluation	\$ 500,000	36
Explore Natural Language Processing-based methods for document management and public interaction at DOTs	\$ 550,000	30
Develop a roadmap for successful collaboration with industry partners that provides AI-based solutions	\$ 400,000	24
Develop a roadmap to create sharable, reliable sources of data sets	\$ 350,000	24
Createing a framework to process and manage data collected by DOTs	\$ 150,000	18



# DISSEMINATION AND IMPLEMENTATION

# CHALLENGES FOR IMPLEMENTATION

- Trust in AI
- Capabilities of integrating AI in existing systems
- High quality data availability
- Supporting funding and technology needs
- Potential bias
- Lack of workforce expertise
- Model extrapolation (hallucination)



# WORKFORCE CHALLENGES

## EXISTING AND FUTURE APPLICATIONS

- ❑ Scarcity of a skilled workforce,
- ❑ Uncertainty of the positions that need to be filled to implement AI strategies
- ❑ Lack of job descriptions and qualifications needed to fill those positions,
- ❑ Lack of the contextual understanding required for transportation applications, even by those individuals equipped with a strong AI background
- ❑ Navigating competition from private industry for top-tier talent
- ❑ High expectations from upper management
- ❑ Lack of established training mechanisms
- ❑ Lack of incentives and retention programs
- ❑ Difficulty in establishing meaningful partnerships

# CONCLUSION

- We presented 11 research statements for developing a roadmap to efficient integration of AI in DOTs
- We reviewed current practices, maturity of field
- We discussed challenges and scope at DOTs
- We developed a dissemination plan
- How to update the roadmap ideas?

Title

*Thank You!*

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**Hala Nassereddine, Ph.D.**

Associate Professor

Construction Engineering and Project  
Management

University of Kentucky

# **NCHRP** Synthesis 54-06 Ancillary Asset Data Stewardship and Data Models



# Document state DOT practices related to data stewardship and data models of **ancillary assets**

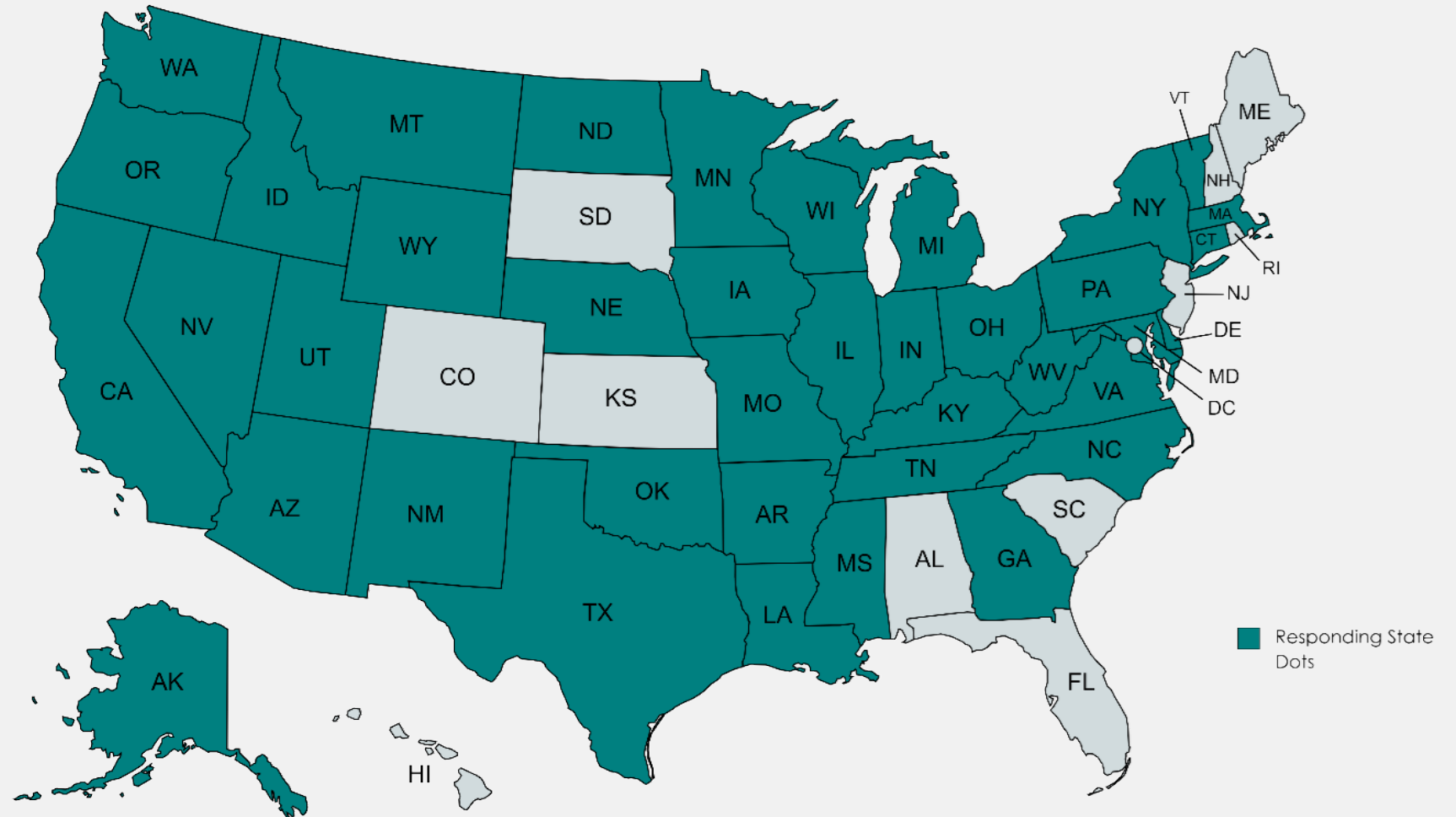
# Permanent Ancillary Assets

- 1) Access control limits
- 2) Barriers: noise
- 3) Bike paths
- 4) Drainage: culvert pipes/transverse/cross drains
- 5) Drainage: curb & gutter
- 6) Drainage: ditches
- 7) Drainage: inlets and outlets
- 8) Drainage: longitudinal drain (e.g., underdrain; pipes)
- 9) Drainage: small structure (culverts <20 ft. total span)
- 10) Drainage: storm water retention basins/ponds
- 11) Erosion control: permanent structure
- 12) Geotechnical boring
- 13) Guardrail: end treatments
- 14) Guardrail: impact attenuator
- 15) Guardrail: other barrier systems (e.g., cable barrier system)
- 16) Guardrail: w beam
- 17) Landscaping
- 18) Lighting: high- mast
- 19) Lighting: roadway other (e.g., luminaire; flashers)
- 20) parking lots/park and ride lots
- 21) Pavement markings /striping
- 22) Pedestrian access ramps
- 23) Retaining walls (earth retaining structures)
- 24) Right of way fence
- 25) Rockfall
- 26) Sidewalks
- 27) Signals: cabinets
- 28) Signals: heads and electrical equipment
- 29) Signals: signal supports, pole bases, and mast arms
- 30) Signs: ground-mounted roadside signs
- 31) Signs: overhead panel signs only
- 32) Signs: overhead sign support structure
- 33) Survey monuments or control points
- 34) Traffic management: its equipment only
- 35) Traffic management: its equipment support structure
- 36) Traffic management: network backbone (e.g., gigabit network backbone for large volumes of video data)
- 37) Utilities: overhead
- 38) Utilities: underground

# Data Collection

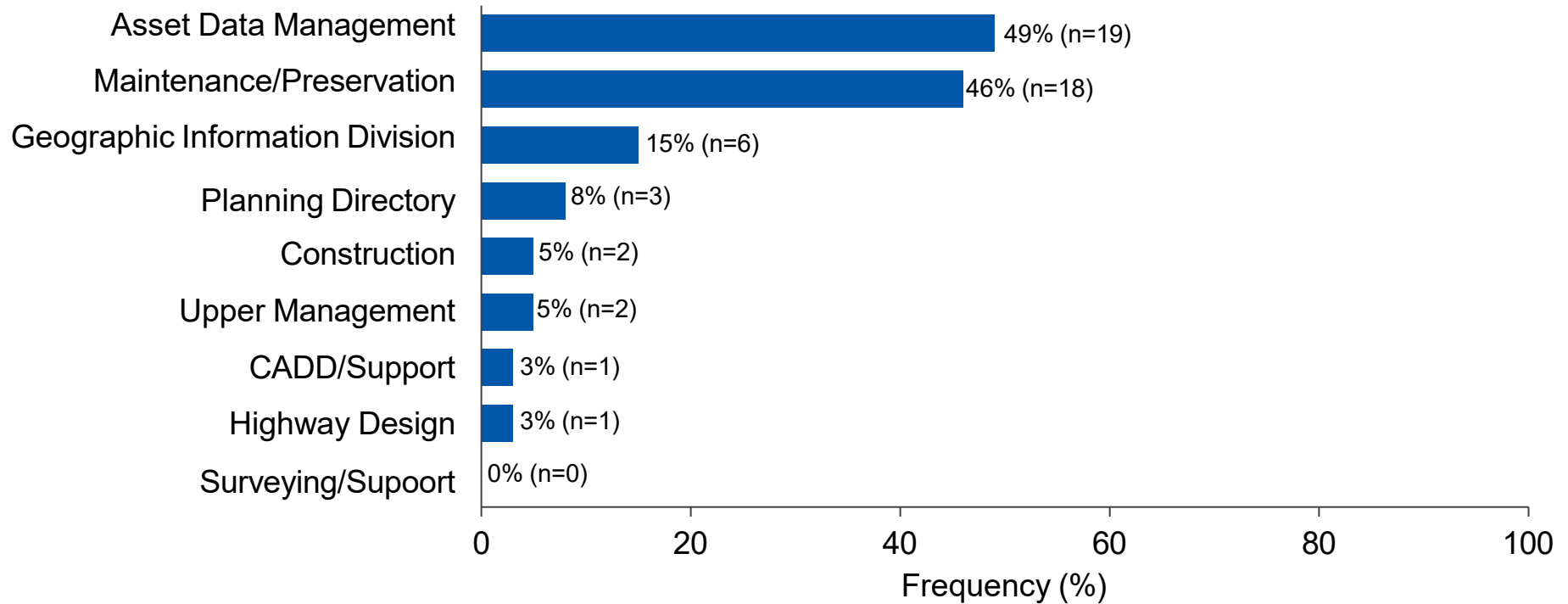
- Survey
  - Ancillary Asset Practices – What
  - Ancillary Asset Practices – How
  - Ancillary Asset Practices – When
  - Ancillary Asset Practices – Who
  - Ancillary Asset Challenges
  - Ancillary Asset Opportunities
- Audience – AASHTO Committee on Maintenance
- Total of 39 responses

# Geographical Distribution



Created with mapchart.net

# Respondent Divisions



# Asset Data Collection Status

Asset Data is *Important* and is *Being Collected*:

- Traffic Management: ITS Equipment Only

	Asset data is important, but will be collected in the near future	Asset data is important and is being collected	Asset data is important, but will not be collected	Asset data is not important and is being collected	Asset data is not important and will not be collected	Unknown/Unsure
Access Control Limits (n=35)	2	12	7	0	2	12
Barriers; Noise (n=38)	3	17	7	1	4	6
Bike Paths (n=37)	2	16	8	1	6	4
Drainage; Culvert Pipes/ Transverse/Cross Drains (n=37)	4	26	4	0	0	3
Drainage; Curb & Gutter (n=38)	2	15	12	0	5	4
Drainage; Ditches (n=37)	1	14	12	0	5	5
Drainage; Inlets and Outlets (n=37)	4	21	8	0	0	3
Drainage; Longitudinal Drain (e.g., Underdrain; pipes) (n=38)	5	18	8	1	1	5
Drainage; Small Structure (culverts <20 ft. total span) (n=37)	5	26	4	0	1	1
Drainage; Storm Water Retention Basins/Ponds (n=36)	0	19	8	0	3	6
Erosion Control; Permanent Structure (n=38)	1	10	10	0	1	16
Geotechnical boring (n=38)	2	11	9	0	1	15
Guardrail; End Treatments (n=37)	9	24	1	0	0	3
Guardrail; Impact Attenuator (n=36)	11	22	1	0	0	2
Guardrail; Other Barrier Systems (n=37)	8	25	2	0	0	2
Guardrail; W Beam (n=37)	9	25	2	0	0	1
Landscaping (n=37)	0	6	8	4	15	4
Lighting; High-Mast (n=37)	2	27	3	0	1	4
Lighting; Roadway Other (e.g., luminaire; flashers) (n=38)	6	16	9	0	1	6
Parking lots/Park and Ride lots (n=38)	1	14	5	1	9	8
Pavement Markings /Striping (n=38)	11	19	5	0	1	2
Pedestrian Access Ramps (n=37)	1	27	5	0	1	3
Retaining Walls (Earth Retaining Structures) (n=38)	3	21	7	0	2	5
Right of Way Fence (n=38)	3	6	11	4	8	6
Rockfall (n=38)	5	12	6	0	6	9
Sidewalks (n=36)	4	14	8	0	4	6
Signals ; heads and electrical equipment (n=38)	2	25	4	0	1	6
Signals; cabinets (n=37)	4	21	4	0	2	6
Signals; signal supports, pole bases, and mast arms (n=38)	4	28	5	0	0	1
Signs; ground mounted roadside signs (n=38)	6	26	5	0	1	0
Signs; Overhead panel signs only (n=37)	5	24	4	0	0	4
Signs; Overhead sign Support Structure (n=38)	6	27	3	0	0	2
Survey Monuments or Control Points (n=37)	1	13	6	0	6	11
Traffic Management; ITS Equipment Only (n=38)	4	30	2	0	0	2
Traffic Management; ITS Equipment support structure (n=38)	7	22	1	0	1	7
Traffic Management; Network Backbone (n=38)	3	14	2	0	1	18
Utilities; Overhead (n=37)	4	4	11	0	7	11
Utilities; Underground (n=36)	6	7	10	0	3	10
		0-25% of most frequent response				
		25-50% of most frequent response				
		50-75% of most frequent response				
		75-100% of most frequent response				

# Asset Data Collection Status

## Asset Data is *Important* and *Will Be Collected*:

- Guardrail
  - Impact Attenuator
  - W Beam
  - End Treatment
  - Other Barrier System
- Pavement Markings/Striping

	Asset data is important, but will be collected in the near future	Asset data is important and is being collected	Asset data is important, but will not be collected	Asset data is not important and is being collected	Asset data is not important and will not be collected	Unknown/Unsure
Access Control Limits (n=35)	2	12	7	0	2	12
Barriers; Noise (n=38)	3	17	7	1	4	6
Bike Paths (n=37)	2	16	8	1	6	4
Drainage; Culvert Pipes/ Transverse/Cross Drains (n=37)	4	26	4	0	0	3
Drainage; Curb & Gutter (n=38)	2	15	12	0	5	4
Drainage; Ditches (n=37)	1	14	12	0	5	5
Drainage; Inlets and Outlets (n=37)	4	21	8	0	0	3
Drainage; Longitudinal Drain (e.g., Underdrain; pipes) (n=38)	5	18	8	1	1	5
Drainage; Small Structure (culverts <20 ft. total span) (n=37)	5	26	4	0	1	1
Drainage; Storm Water Retention Basins/Ponds (n=36)	0	19	8	0	3	6
Erosion Control; Permanent Structure (n=38)	1	10	10	0	1	16
Geotechnical boring (n=38)	2	11	9	0	1	15
Guardrail; End Treatments (n=37)	9	24	1	0	0	3
Guardrail; Impact Attenuator (n=36)	11	22	1	0	0	2
Guardrail; Other Barrier Systems (n=37)	8	25	2	0	0	2
Guardrail; W Beam (n=37)	9	25	2	0	0	1
Landscaping (n=37)	0	6	8	4	15	4
Lighting; High-Mast (n=37)	2	27	3	0	1	4
Lighting; Roadway Other (e.g., luminaire; flashers) (n=38)	6	16	9	0	1	6
Parking lots/Park and Ride lots (n=38)	1	14	5	1	9	8
Pavement Markings /Striping (n=38)	11	19	5	0	1	2
Pedestrian Access Ramps (n=37)	1	27	5	0	1	3
Retaining Walls (Earth Retaining Structures) (n=38)	3	21	7	0	2	5
Right of Way Fence (n=38)	3	6	11	4	8	6
Rockfall (n=38)	5	12	6	0	6	9
Sidewalks (n=36)	4	14	8	0	4	6
Signals ; heads and electrical equipment (n=38)	2	25	4	0	1	6
Signals; cabinets (n=37)	4	21	4	0	2	6
Signals; signal supports, pole bases, and mast arms (n=38)	4	28	5	0	0	1
Signs; ground mounted roadside signs (n=38)	6	26	5	0	1	0
Signs; Overhead panel signs only (n=37)	5	24	4	0	0	4
Signs; Overhead sign Support Structure (n=38)	6	27	3	0	0	2
Survey Monuments or Control Points (n=37)	1	13	6	0	6	11
Traffic Management; ITS Equipment Only (n=38)	4	30	2	0	0	2
Traffic Management; ITS Equipment support structure (n=38)	7	22	1	0	1	7
Traffic Management; Network Backbone (n=38)	3	14	2	0	1	18
Utilities; Overhead (n=37)	4	4	11	0	7	11
Utilities; Underground (n=36)	6	7	10	0	3	10
		0-25% of most frequent response				
		25-50% of most frequent response				
		50-75% of most frequent response				
		75-100% of most frequent response				

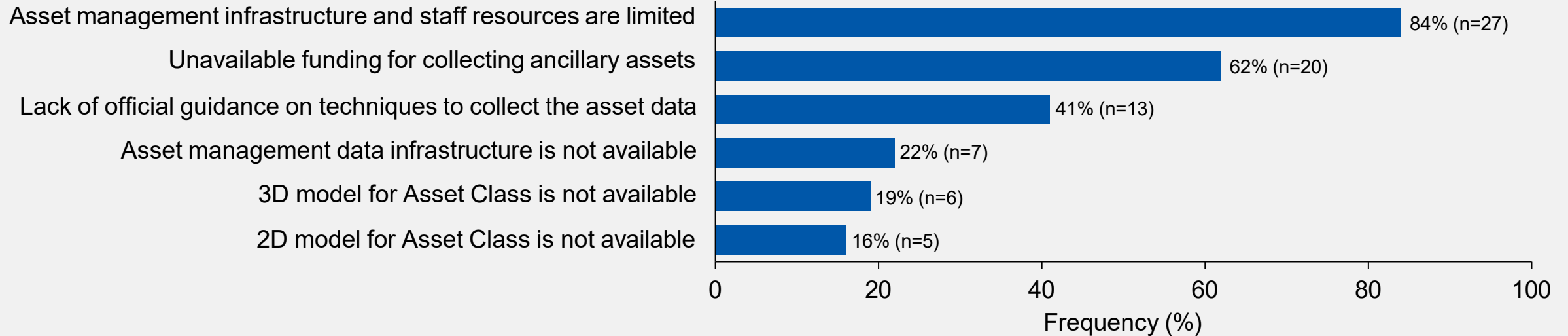
# Asset Data Collection Status

Asset Data is *Not Important* and *Will Not Be Collected*:

➤ Landscaping

	Asset data is important, but will be collected in the near future	Asset data is important and is being collected	Asset data is important, but will not be collected	Asset data is not important and is being collected	Asset data is not important and will not be collected	Unknown/Unsure
Access Control Limits (n=35)	2	12	7	0	2	12
Barriers; Noise (n=38)	3	17	7	1	4	6
Bike Paths (n=37)	2	16	8	1	6	4
Drainage; Culvert Pipes/ Transverse/Cross Drains (n=37)	4	26	4	0	0	3
Drainage; Curb & Gutter (n=38)	2	15	12	0	5	4
Drainage; Ditches (n=37)	1	14	12	0	5	5
Drainage; Inlets and Outlets (n=37)	4	21	8	0	0	3
Drainage; Longitudinal Drain (e.g., Underdrain; pipes) (n=38)	5	18	8	1	1	5
Drainage; Small Structure (culverts <20 ft. total span) (n=37)	5	26	4	0	1	1
Drainage; Storm Water Retention Basins/Ponds (n=36)	0	19	8	0	3	6
Erosion Control; Permanent Structure (n=38)	1	10	10	0	1	16
Geotechnical boring (n=38)	2	11	9	0	1	15
Guardrail; End Treatments (n=37)	9	24	1	0	0	3
Guardrail; Impact Attenuator (n=36)	11	22	1	0	0	2
Guardrail; Other Barrier Systems (n=37)	8	25	2	0	0	2
Guardrail; W Beam (n=37)	9	25	2	0	0	1
Landscaping (n=37)	0	6	8	4	15	4
Lighting; High-Mast (n=37)	2	27	3	0	1	4
Lighting; Roadway Other (e.g., luminaire; flashers) (n=38)	6	16	9	0	1	6
Parking lots/Park and Ride lots (n=38)	1	14	5	1	9	8
Pavement Markings /Striping (n=38)	11	19	5	0	1	2
Pedestrian Access Ramps (n=37)	1	27	5	0	1	3
Retaining Walls (Earth Retaining Structures) (n=38)	3	21	7	0	2	5
Right of Way Fence (n=38)	3	6	11	4	8	6
Rockfall (n=38)	5	12	6	0	6	9
Sidewalks (n=36)	4	14	8	0	4	6
Signals ; heads and electrical equipment (n=38)	2	25	4	0	1	6
Signals; cabinets (n=37)	4	21	4	0	2	6
Signals; signal supports, pole bases, and mast arms (n=38)	4	28	5	0	0	1
Signs; ground mounted roadside signs (n=38)	6	26	5	0	1	0
Signs; Overhead panel signs only (n=37)	5	24	4	0	0	4
Signs; Overhead sign Support Structure (n=38)	6	27	3	0	0	2
Survey Monuments or Control Points (n=37)	1	13	6	0	6	11
Traffic Management; ITS Equipment Only (n=38)	4	30	2	0	0	2
Traffic Management; ITS Equipment support structure (n=38)	7	22	1	0	1	7
Traffic Management; Network Backbone (n=38)	3	14	2	0	1	18
Utilities; Overhead (n=37)	4	4	11	0	7	11
Utilities; Underground (n=36)	6	7	10	0	3	10
		0-25% of most frequent response				
		25-50% of most frequent response				
		50-75% of most frequent response				
		75-100% of most frequent response				

# Reasons for not Collecting Asset Data



# Asset Data Content

- Geospatial data is collected the most.

	An asset design model is generated	An asset as-built model is generated	Remote inventory data (such as via aerial imagery)	Field or Site Inventory data	Measurements (such as quantities)	Geospatial and/or linear-referencing component	Others
Access Control Limits (n=11)	1	0	1	3	2	7	0
Barriers; Noise (n=17)	3	4	3	12	11	14	0
Bike Paths (n=13)	2	2	3	6	7	12	0
Drainage; Culvert Pipes/ Transverse/Cross Drains (n=24)	5	2	3	22	17	23	0
Drainage; Curb & Gutter (n=15)	1	0	3	11	6	10	0
Drainage; Ditches (n=13)	1	0	4	10	7	10	0
Drainage; Inlets and Outlets (n=20)	4	2	3	16	11	18	0
Drainage; Longitudinal Drain (e.g., Underdrain; pipes) (n=17)	2	1	4	13	9	13	0
Drainage; Small Structure (culverts <20 ft. total span) (n=24)	5	5	4	21	16	23	0
Drainage; Storm Water Retention Basins/Ponds (n=18)	4	3	3	16	9	13	0
Erosion Control; Permanent Structure (n=11)	2	1	0	9	6	8	0
Geotechnical boring (n=9)	2	1	0	5	4	5	0
Guardrail; End Treatments (n=22)	2	2	7	14	12	19	0
Guardrail; Impact Attenuator (n=22)	2	3	6	15	11	19	0
Guardrail; Other Barrier Systems (n=23)	2	3	7	16	13	21	0
Guardrail; W Beam (n=22)	2	3	8	12	12	19	0
Landscaping (n=6)	1	0	0	5	4	5	0
Lighting; High-Mast (n=26)	4	4	1	20	12	19	0
Lighting; Roadway Other (e.g., luminaire; flashers) (n=14)	4	2	1	12	8	12	0
Parking lots/Park and Ride lots (n=11)	2	1	0	9	6	8	0
Pavement Markings /Striping (n=15)	4	4	3	10	11	11	0
Pedestrian Access Ramps (n=24)	5	4	4	15	10	16	0
Retaining Walls (Earth Retaining Structures) (n=17)	4	3	3	15	11	13	0
Right of Way Fence (n=7)	0	1	1	5	4	4	0
Rockfall (n=9)	0	0	1	7	4	8	0
Sidewalks (n=14)	2	1	4	8	7	10	0
Signals ; heads and electrical equipment (n=21)	4	3	1	18	12	14	0
Signals; cabinets (n=21)	5	2	2	14	10	17	0
Signals; signal supports, pole bases, and mast arms (n=24)	4	3	4	19	11	18	0
Signs; ground mounted roadside signs (n=25)	6	3	6	18	16	20	0
Signs; Overhead panel signs only (n=22)	4	3	4	16	13	18	0
Signs; Overhead sign Support Structure (n=23)	4	5	5	17	12	21	0
Survey Monuments or Control Points (n=13)	2	2	0	10	3	8	0
Traffic Management; ITS Equipment Only (n=25)	3	4	3	21	12	19	0
Traffic Management; ITS Equipment support structure (n=18)	4	3	0	16	11	16	0
Traffic Management; Network Backbone (n=11)	4	2	1	9	7	7	0
Utilities; Overhead (n=3)	1	1	1	1	1	0	1
Utilities; Underground (n=5)	2	2	0	4	2	2	1
					0-25% of most frequent response		
					25-50% of most frequent response		
					50-75% of most frequent response		
					75-100% of most frequent response		

# Asset Data Content

- Geospatial data is collected the most.
- State DOTs rarely collect remote inventory data or generate an asset design model or an asset as-built model.

	An asset design model is generated	An asset as-built model is generated	Remote inventory data (such as via aerial imagery)	Field or Site Inventory data	Measurements (such as quantities)	Geospatial and/or linear-referencing component	Others
Access Control Limits (n=11)	1	0	1	3	2	7	0
Barriers; Noise (n=17)	3	4	3	12	11	14	0
Bike Paths (n=13)	2	2	3	6	7	12	0
Drainage; Culvert Pipes/ Transverse/Cross Drains (n=24)	5	2	3	22	17	23	0
Drainage; Curb & Gutter (n=15)	1	0	3	11	6	10	0
Drainage; Ditches (n=13)	1	0	4	10	7	10	0
Drainage; Inlets and Outlets (n=20)	4	2	3	16	11	18	0
Drainage; Longitudinal Drain (e.g., Underdrain; pipes) (n=17)	2	1	4	13	9	13	0
Drainage; Small Structure (culverts <20 ft. total span) (n=24)	5	5	4	21	16	23	0
Drainage; Storm Water Retention Basins/Ponds (n=18)	4	3	3	16	9	13	0
Erosion Control; Permanent Structure (n=11)	2	1	0	9	6	8	0
Geotechnical boring (n=9)	2	1	0	5	4	5	0
Guardrail; End Treatments (n=22)	2	2	7	14	12	19	0
Guardrail; Impact Attenuator (n=22)	2	3	6	15	11	19	0
Guardrail; Other Barrier Systems (n=23)	2	3	7	16	13	21	0
Guardrail; W Beam (n=22)	2	3	8	12	12	19	0
Landscaping (n=6)	1	0	0	5	4	5	0
Lighting; High-Mast (n=26)	4	4	1	20	12	19	0
Lighting; Roadway Other (e.g., luminaire; flashers) (n=14)	4	2	1	12	8	12	0
Parking lots/Park and Ride lots (n=11)	2	1	0	9	6	8	0
Pavement Markings /Striping (n=15)	4	4	3	10	11	11	0
Pedestrian Access Ramps (n=24)	5	4	4	15	10	16	0
Retaining Walls (Earth Retaining Structures) (n=17)	4	3	3	15	11	13	0
Right of Way Fence (n=7)	0	1	1	5	4	4	0
Rockfall (n=9)	0	0	1	7	4	8	0
Sidewalks (n=14)	2	1	4	8	7	10	0
Signals ; heads and electrical equipment (n=21)	4	3	1	18	12	14	0
Signals; cabinets (n=21)	5	2	2	14	10	17	0
Signals; signal supports, pole bases, and mast arms (n=24)	4	3	4	19	11	18	0
Signs; ground mounted roadside signs (n=25)	6	3	6	18	16	20	0
Signs; Overhead panel signs only (n=22)	4	3	4	16	13	18	0
Signs; Overhead sign Support Structure (n=23)	4	5	5	17	12	21	0
Survey Monuments or Control Points (n=13)	2	2	0	10	3	8	0
Traffic Management; ITS Equipment Only (n=25)	3	4	3	21	12	19	0
Traffic Management; ITS Equipment support structure (n=18)	4	3	0	16	11	16	0
Traffic Management; Network Backbone (n=11)	4	2	1	9	7	7	0
Utilities; Overhead (n=3)	1	1	1	1	1	0	1
Utilities; Underground (n=5)	2	2	0	4	2	2	1
					0-25% of most frequent response		
					25-50% of most frequent response		
					50-75% of most frequent response		
					75-100% of most frequent response		

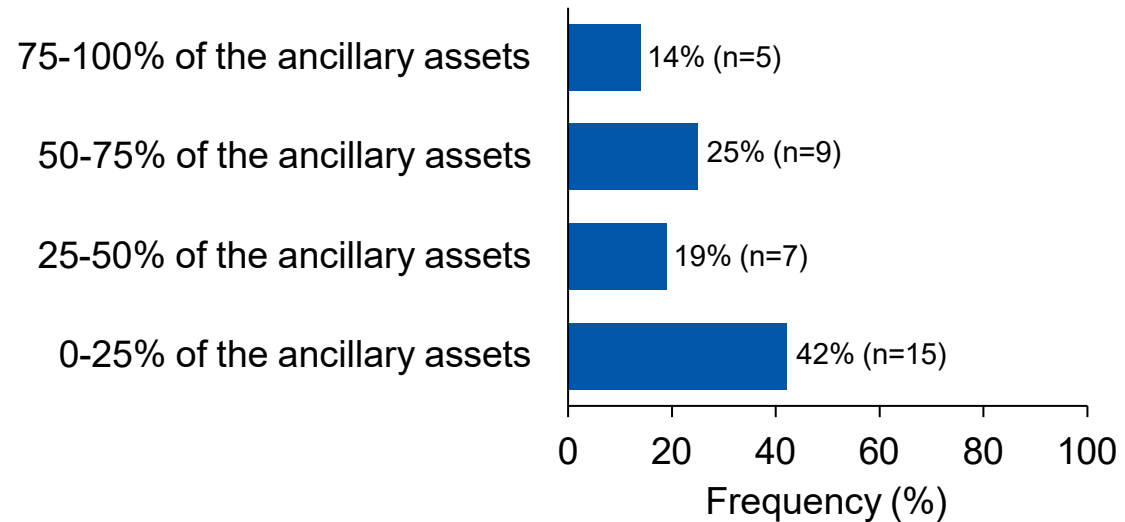
# Asset Data Format

- Most of the data is in a GIS geodatabase or in a database or unique software or program.
- Excel spreadsheet format is used less frequently.
- Paper-based or PDF format is rarely used.

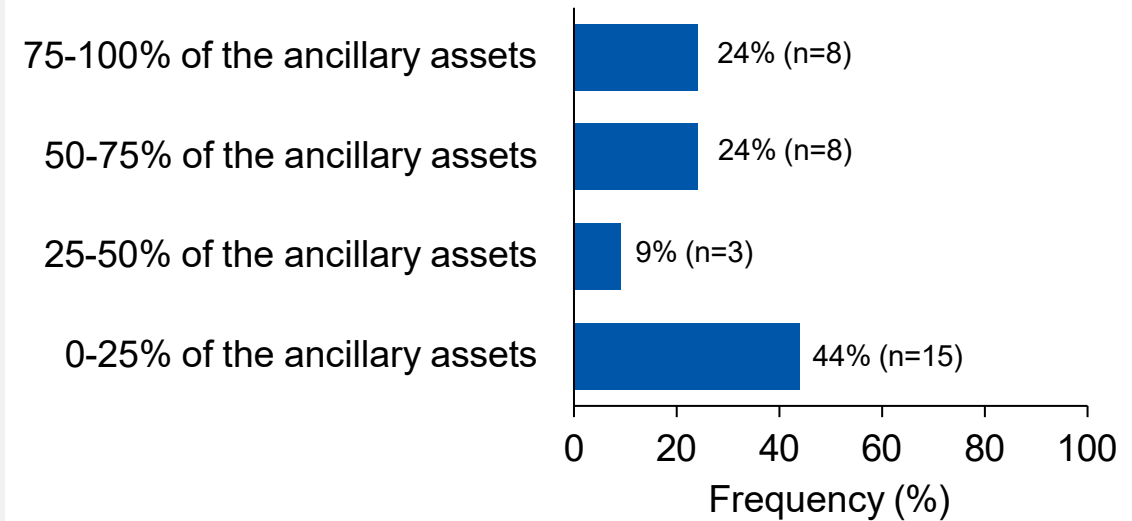
	Paper-based	Electronic documents (PDF/images)	Excel spreadsheets/ CSV with asset information	GIS Geodatabase	Database or Unique Software or Program
Access Control Limits (n=11)	1	1	2	6	3
Barriers; Noise (n=17)	0	5	4	14	5
Bike Paths (n=13)	0	1	1	11	2
Drainage; Culvert Pipes/ Transverse/Cross Drains (n=23)	1	6	6	20	10
Drainage; Curb & Gutter (n=13)	0	2	2	9	8
Drainage; Ditches (n=11)	0	1	2	9	6
Drainage; Inlets and Outlets (n=20)	0	4	4	16	9
Drainage; Longitudinal Drain (e.g., Underdrain; pipes) (n=17)	1	7	3	11	7
Drainage; Small Structure (culverts <20 ft. total span) (n=24)	1	9	5	20	11
Drainage; Storm Water Retention Basins/Ponds (n=18)	1	4	6	14	8
Erosion Control; Permanent Structure (n=11)	1	4	1	7	5
Geotechnical boring (n=10)	3	4	2	5	3
Guardrail; End Treatments (n=22)	1	2	6	17	8
Guardrail; Impact Attenuator (n=21)	0	1	6	16	8
Guardrail; Other Barrier Systems (n=24)	0	3	5	18	11
Guardrail; W Beam (n=22)	1	3	3	17	10
Landscaping (n=6)	1	1	2	4	2
Lighting; High-Mast (n=26)	4	9	10	14	12
Lighting; Roadway Other (e.g., luminaire; flashers) (n=15)	3	3	6	10	9
Parking lots/Park and Ride lots (n=11)	1	4	4	8	4
Pavement Markings /Striping (n=15)	1	3	6	10	8
Pedestrian Access Ramps (n=24)	3	5	5	15	5
Retaining Walls (Earth Retaining Structures) (n=17)	2	5	4	11	5
Right of Way Fence (n=6)	0	1	0	3	4
Rockfall (n=9)	1	1	2	5	4
Sidewalks (n=14)	1	1	1	11	6
Signals ; heads and electrical equipment (n=21)	4	5	6	11	11
Signals; cabinets (n=21)	3	5	9	13	10
Signals; signal supports, pole bases, and mast arms (n=24)	4	8	6	12	14
Signs; ground mounted roadside signs (n=25)	3	2	7	18	12
Signs; Overhead panel signs only (n=22)	3	4	7	14	11
Signs; Overhead sign Support Structure (n=22)	3	6	5	16	12
Survey Monuments or Control Points (n=14)	3	6	4	10	1
Traffic Management; ITS Equipment Only (n=25)	2	4	10	14	14
Traffic Management; ITS Equipment support structure (n=18)	1	4	9	11	10
Traffic Management; Network Backbone (n=11)	1	2	3	5	5
Utilities; Overhead (n=3)	1	2	0	1	1
Utilities; Underground (n=5)	2	3	1	1	1
		0-25% of most frequent response			
		25-50% of most frequent response			
		50-75% of most frequent response			
		75-100% of most frequent response			

# Data Dictionaries

- Data Dictionary Already Developed



- Data Dictionary Being Developed



# Software to Manage Asset Data



**Design**



**Construction**



**Asset Management**



**Maintenance**

# Asset Data Collection Methods

## Inventory and Condition

- Data is collected manually using handheld devices, GPS units, or pen and paper-based records.

	Manual	Automated	Remote	As-built documents from construction	Unknown/Unsure
Access Control Limits (n=11)	5	2	3	2	1
Barriers; Noise (n=14)	9	2	2	4	1
Bike Paths (n=15)	7	2	4	3	2
Drainage; Culvert Pipes/ Transverse/Cross Drains (n=23)	20	0	4	5	1
Drainage; Curb & Gutter (n=12)	9	1	2	1	0
Drainage; Ditches (n=13)	10	1	2	1	0
Drainage; Inlets and Outlets (n=18)	15	0	4	4	1
Drainage; Longitudinal Drain (e.g., Underdrain; pipes) (n=16)	14	0	2	5	0
Drainage; Small Structure (culverts <20 ft. total span) (n=22)	20	0	3	7	1
Drainage; Storm Water Retention Basins/Ponds (n=17)	13	0	4	4	2
Erosion Control; Permanent Structure (n=11)	9	0	1	5	0
Geotechnical boring (n=9)	5	0	0	4	1
Guardrail; End Treatments (n=22)	11	6	3	2	2
Guardrail; Impact Attenuator (n=19)	12	5	2	1	0
Guardrail; Other Barrier Systems (n=21)	15	6	4	3	0
Guardrail; W Beam (n=22)	14	6	4	3	1
Landscaping (n=7)	5	0	0	1	1
Lighting; High-Mast (n=24)	18	0	4	10	1
Lighting; Roadway Other (e.g., luminaire; flashers) (n=13)	12	0	1	4	0
Parking lots/Park and Ride lots (n=12)	8	1	4	1	2
Pavement Markings /Striping (n=14)	8	9	2	2	0
Pedestrian Access Ramps (n=24)	18	4	4	9	1
Retaining Walls (Earth Retaining Structures) (n=15)	14	3	2	5	0
Right of Way Fence (n=7)	4	2	1	1	0
Rockfall (n=10)	6	0	1	0	2
Sidewalks (n=13)	9	2	3	1	0
Signals ; heads and electrical equipment (n=21)	14	1	2	5	4
Signals; cabinets (n=18)	14	1	1	5	1
Signals; signal supports, pole bases, and mast arms (n=22)	16	0	5	8	2
Signs; ground mounted roadside signs (n=22)	15	7	5	4	0
Signs; Overhead panel signs only (n=20)	17	5	5	4	0
Signs; Overhead sign Support Structure (n=20)	18	3	4	6	2
Survey Monuments or Control Points (n=13)	9	0	0	2	4
Traffic Management; ITS Equipment Only (n=24)	18	1	3	7	4
Traffic Management; ITS Equipment support structure (n=19)	15	1	4	6	2
Traffic Management; Network Backbone (n=11)	8	2	1	3	2
Utilities; Overhead (n=4)	1	2	0	1	2
Utilities; Underground (n=6)	2	1	0	2	3
m construction		0-25% of most frequent response			
		25-50% of most frequent response			
		50-75% of most frequent response			
		75-100% of most frequent response			

# Asset Data Update Methods

- Data is updated manually using handheld devices, GPS units, or pen and paper-based records.

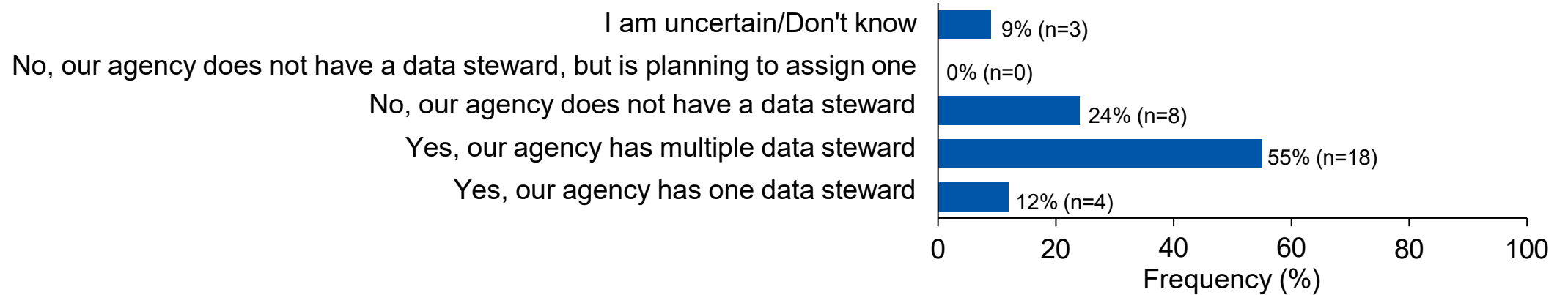
	Manual	Automated	Remote	Other
Access Control Limits (n=11)	9	1	0	0
Barriers; Noise (n=15)	11	4	0	0
Bike Paths (n=11)	8	4	1	0
Drainage; Culvert Pipes/ Transverse/Cross Drains (n=20)	17	2	2	1
Drainage; Curb & Gutter (n=13)	8	4	1	0
Drainage; Ditches (n=12)	8	4	1	0
Drainage; Inlets and Outlets (n=18)	15	2	2	0
Drainage; Longitudinal Drain (e.g., Underdrain; pipes) (n=13)	11	0	2	1
Drainage; Small Structure (culverts <20 ft. total span) (n=19)	17	3	2	0
Drainage; Storm Water Retention Basins/Ponds (n=16)	13	2	2	0
Erosion Control; Permanent Structure (n=9)	6	2	0	0
Geotechnical boring (n=7)	5	0	0	1
Guardrail; End Treatments (n=21)	12	8	1	1
Guardrail; Impact Attenuator (n=19)	12	6	1	0
Guardrail; Other Barrier Systems (n=21)	14	8	1	0
Guardrail; W Beam (n=22)	12	8	1	1
Landscaping (n=7)	6	0	0	0
Lighting; High-Mast (n=22)	20	2	2	0
Lighting; Roadway Other (e.g., luminaire; flashers) (n=12)	11	1	1	0
Parking lots/Park and Ride lots (n=11)	10	0	0	0
Pavement Markings /Striping (n=14)	9	6	0	0
Pedestrian Access Ramps (n=21)	18	3	1	1
Retaining Walls (Earth Retaining Structures) (n=14)	12	6	1	0
Right of Way Fence (n=7)	5	1	0	0
Rockfall (n=8)	7	0	0	0
Sidewalks (n=14)	12	3	2	0
Signals ; heads and electrical equipment (n=20)	19	0	0	1
Signals; cabinets (n=17)	16	1	1	0
Signals; signal supports, pole bases, and mast arms (n=21)	18	1	0	2
Signs; ground mounted roadside signs (n=21)	15	7	2	0
Signs; Overhead panel signs only (n=19)	13	6	2	0
Signs; Overhead sign Support Structure (n=20)	15	6	1	1
Survey Monuments or Control Points (n=10)	9	0	0	1
Traffic Management; ITS Equipment Only (n=23)	20	3	1	1
Traffic Management; ITS Equipment support structure (n=16)	14	2	0	1
Traffic Management; Network Backbone (n=11)	9	2	2	0
Utilities; Overhead (n=3)	2	1	0	0
Utilities; Underground (n=3)	2	1	0	0
		0-25% of most frequent response		
		25-50% of most frequent response		
		50-75% of most frequent response		
		75-100% of most frequent response		

# Asset Data Collection Time

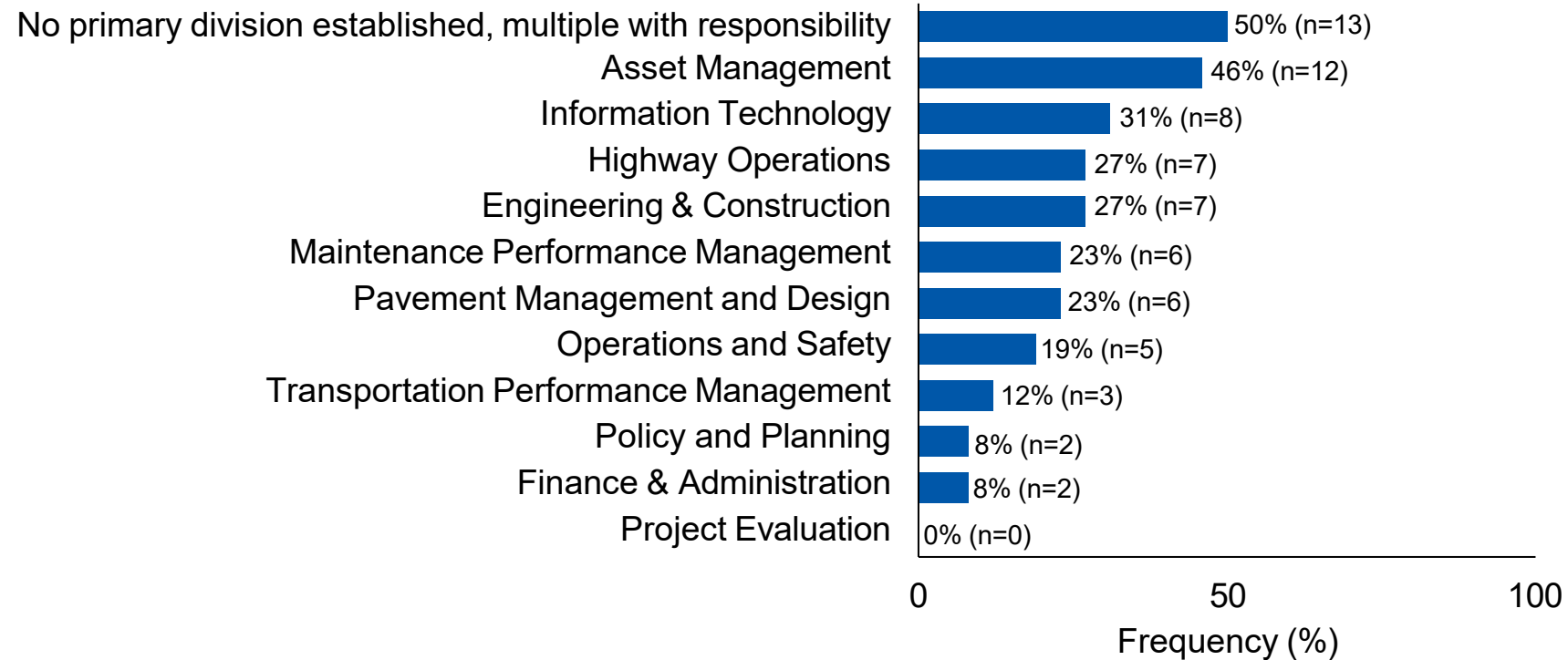
- Asset data is collected during the asset maintenance phase.
- Asset data is less frequently collected during the construction phase or as-built asset condition.
- Asset data is rarely collected during the design phase.

	During Design Phase	During Construction Phase or as-built asset condition	During asset maintenance
Access Control Limits (n=10)	1	4	6
Barriers; Noise (n=12)	1	6	7
Bike Paths (n=12)	0	4	9
Drainage; Culvert Pipes/ Transverse/Cross Drains (n=19)	1	9	17
Drainage; Curb & Gutter (n=12)	0	3	11
Drainage; Ditches (n=12)	0	2	11
Drainage; Inlets and Outlets (n=17)	1	7	15
Drainage; Longitudinal Drain (e.g., Underdrain; pipes) (n=14)	1	5	13
Drainage; Small Structure (culverts <20 ft. total span) (n=19)	1	11	15
Drainage; Storm Water Retention Basins/Ponds (n=15)	0	8	12
Erosion Control; Permanent Structure (n=10)	1	6	5
Geotechnical boring (n=7)	4	2	1
Guardrail; End Treatments (n=18)	0	4	17
Guardrail; Impact Attenuator (n=16)	0	3	15
Guardrail; Other Barrier Systems (n=18)	0	4	17
Guardrail; W Beam (n=19)	0	4	18
Landscaping (n=6)	0	2	5
Lighting; High-Mast (n=20)	2	11	12
Lighting; Roadway Other (e.g., luminaire; flashers) (n=13)	0	7	8
Parking lots/Park and Ride lots (n=10)	1	3	7
Pavement Markings /Striping (n=15)	0	5	13
Pedestrian Access Ramps (n=20)	3	8	14
Retaining Walls (Earth Retaining Structures) (n=11)	1	7	9
Right of Way Fence (n=7)	0	1	6
Rockfall (n=8)	0	1	6
Sidewalks (n=13)	0	5	10
Signals ; heads and electrical equipment (n=18)	1	9	13
Signals; cabinets (n=15)	2	6	11
Signals; signal supports, pole bases, and mast arms (n=19)	2	10	13
Signs; ground mounted roadside signs (n=19)	3	5	16
Signs; Overhead panel signs only (n=19)	2	6	16
Signs; Overhead sign Support Structure (n=17)	0	10	14
Survey Monuments or Control Points (n=10)	1	3	6
Traffic Management; ITS Equipment Only (n=24)	3	14	13
Traffic Management; ITS Equipment support structure (n=17)	0	10	10
Traffic Management; Network Backbone (n=11)	1	9	5
Utilities; Overhead (n=3)	0	1	1
Utilities; Underground (n=4)	0	1	2

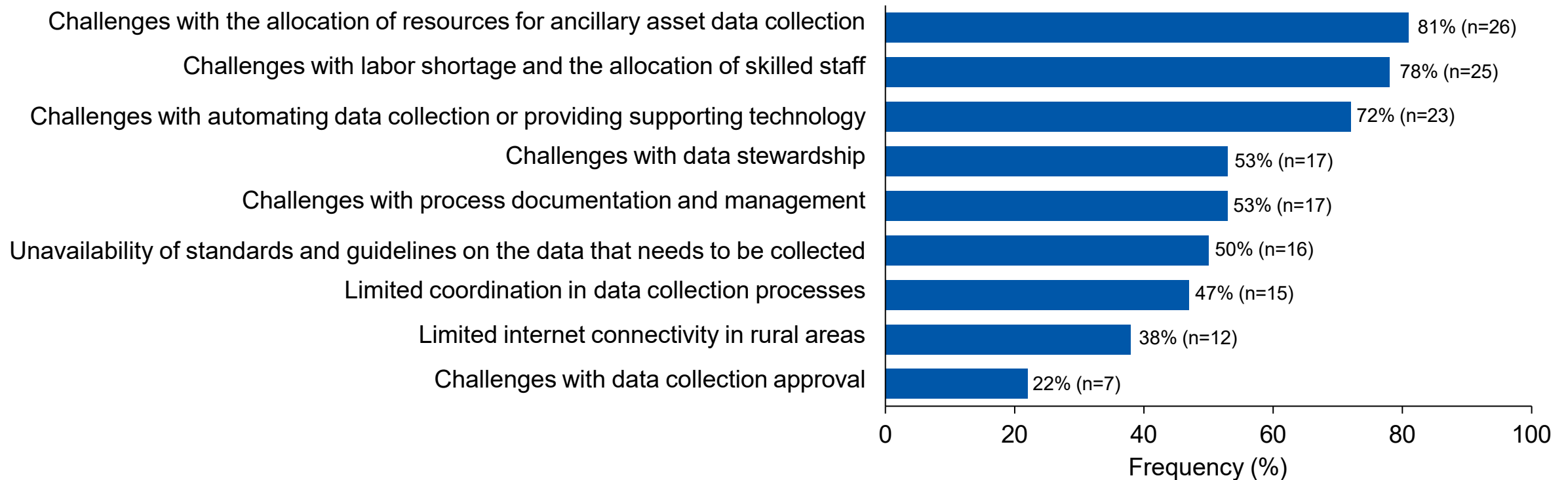
# Asset Data Stewards



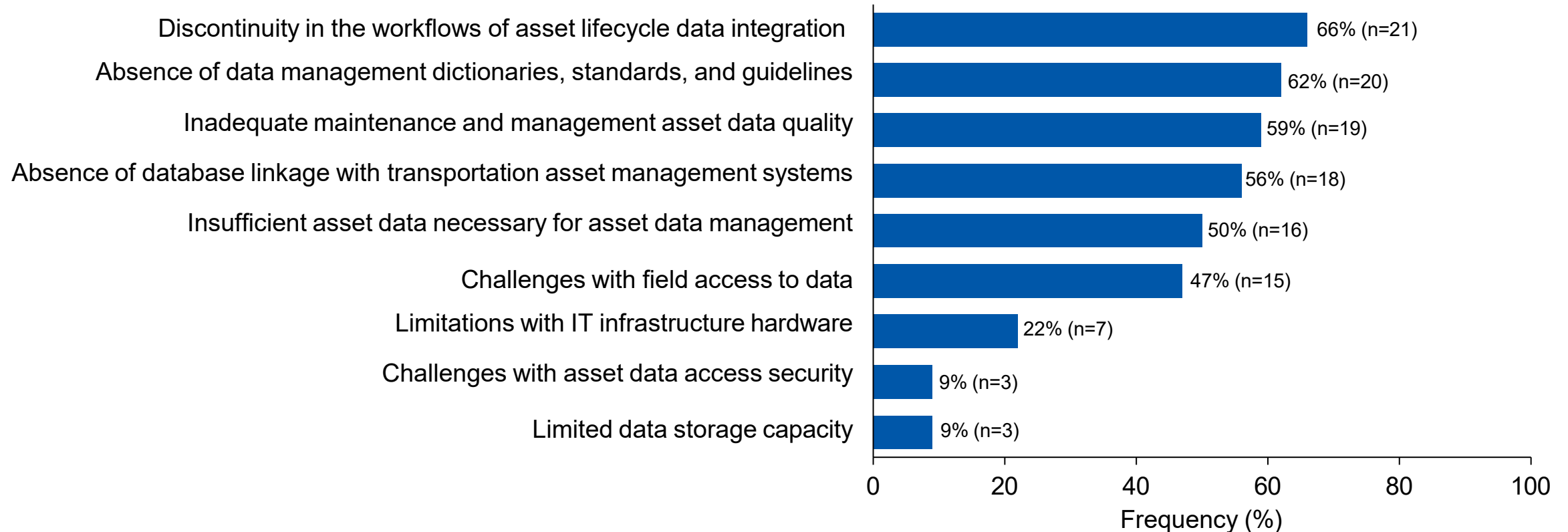
# Asset Data Stewards



# Data Collection Challenges

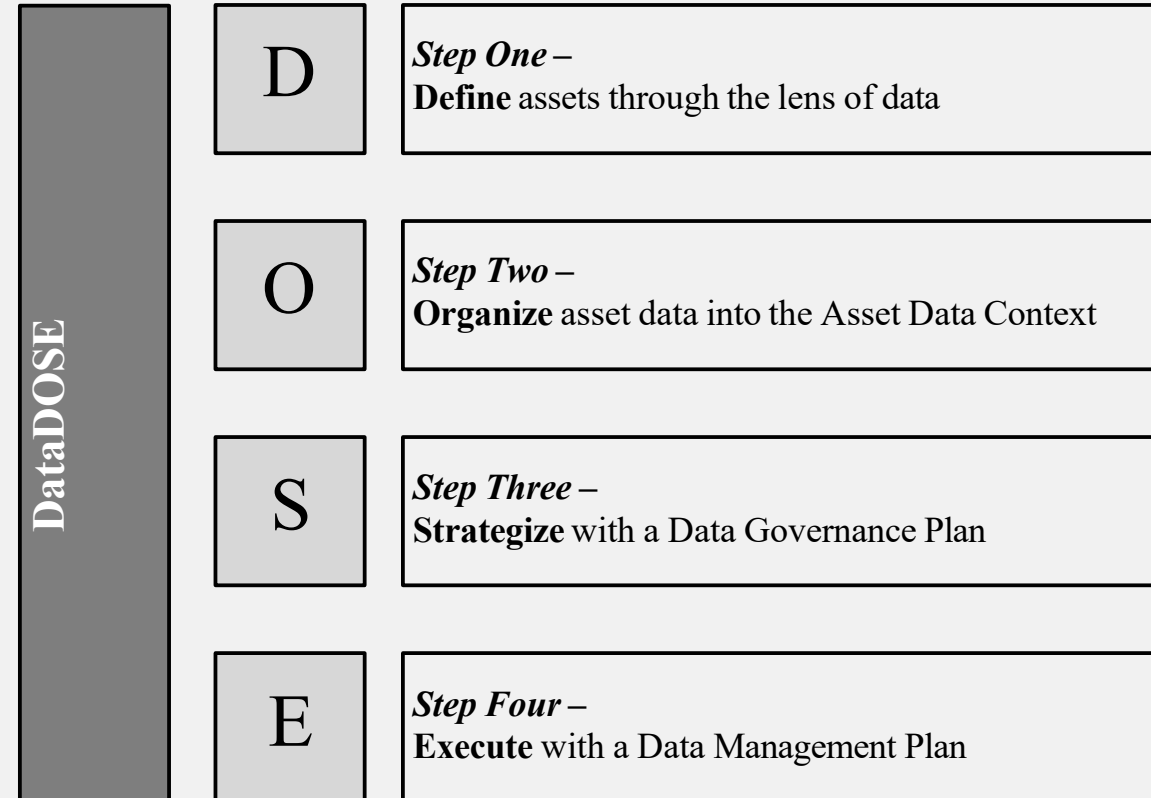


# Data Management Challenges



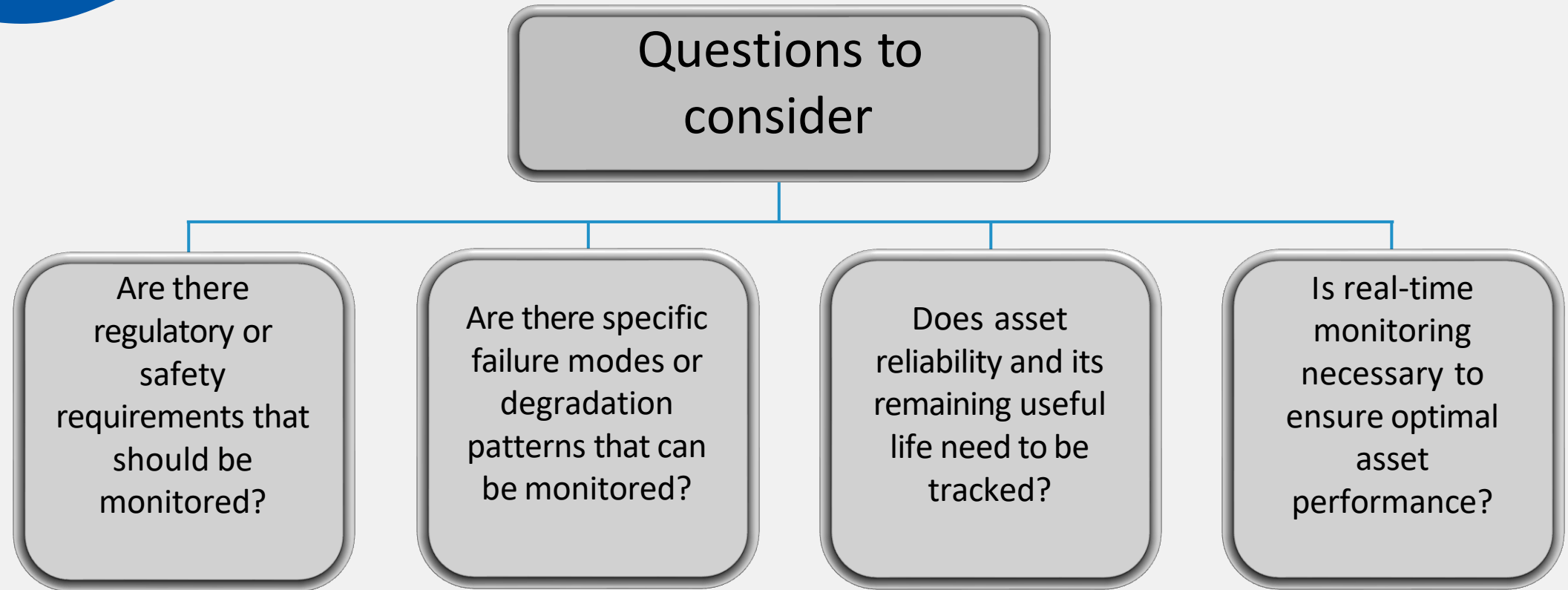
# Beyond NCHRP 54-06

# DataDOSE Framework

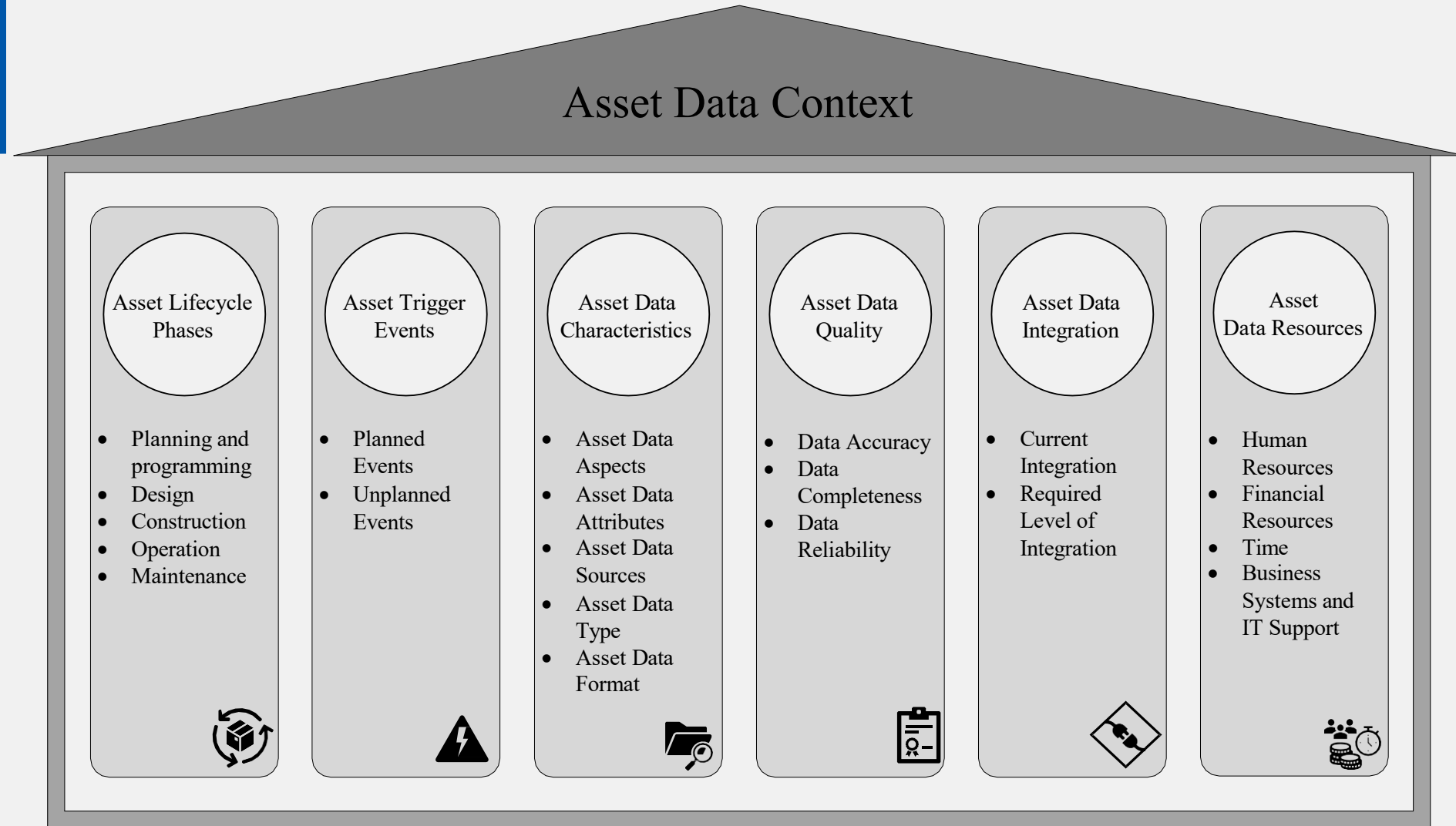


## Step 1 Define

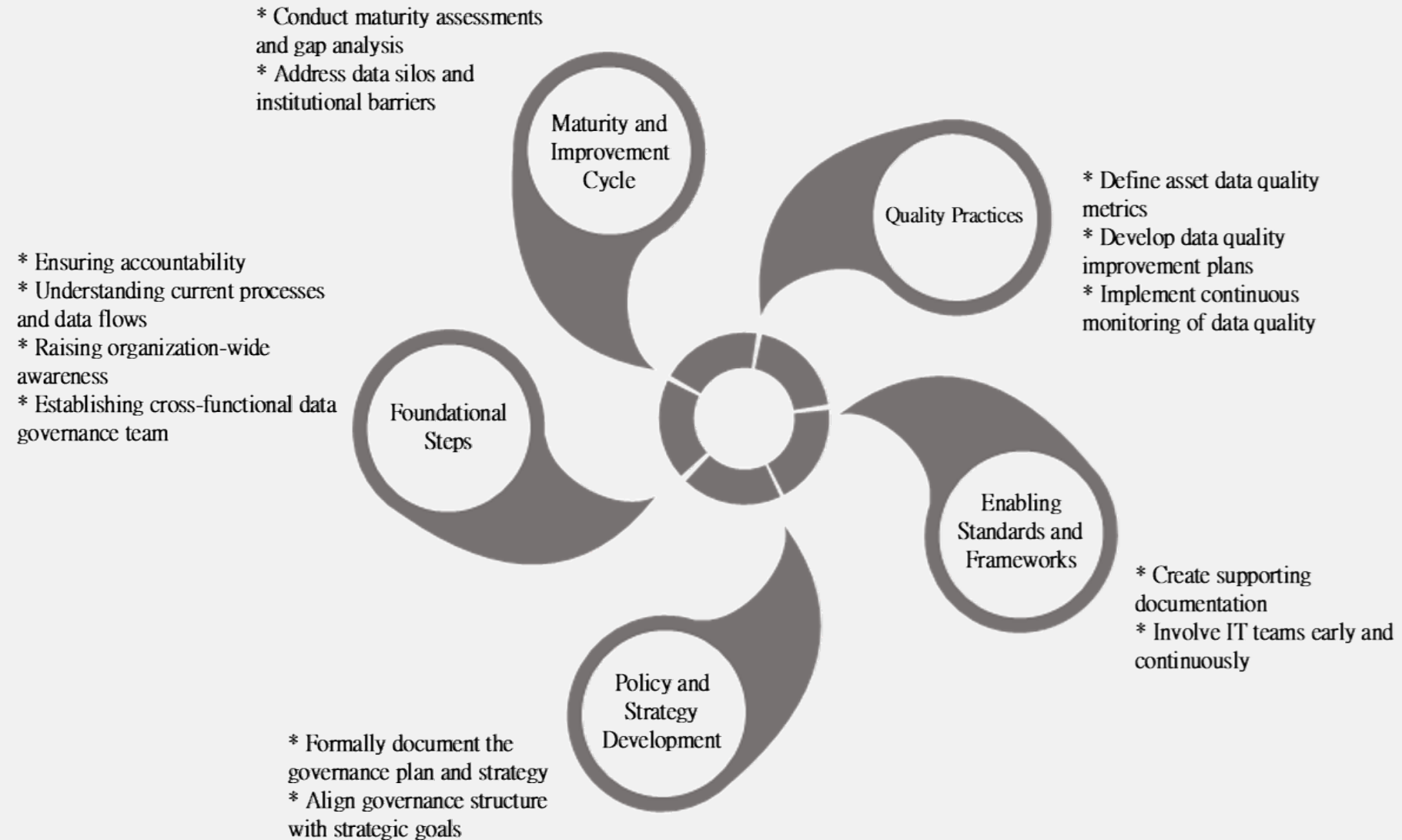
# Begin with the end in mind!



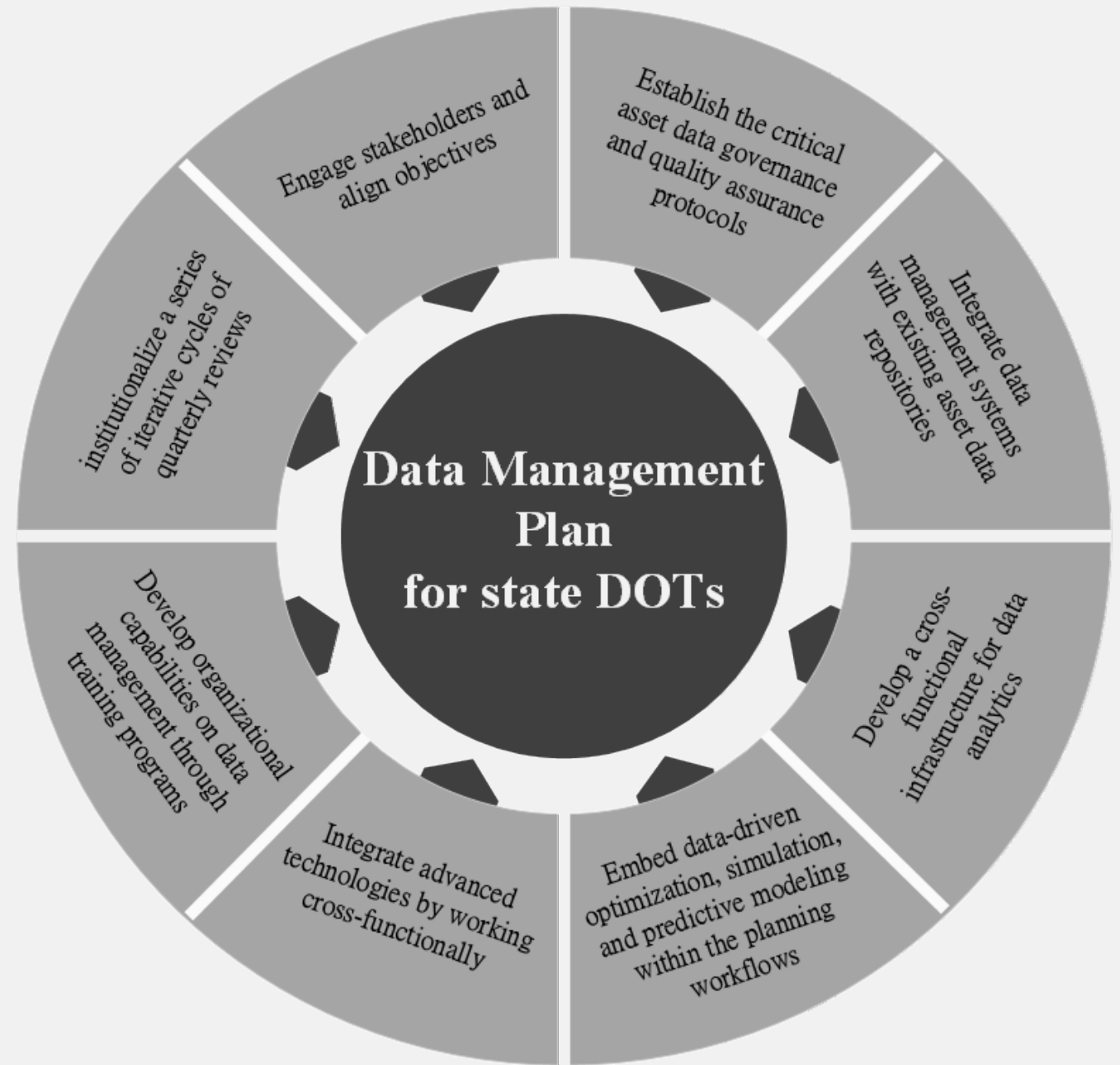
## Step 2 Organize



# Step 3 Strategize



## Step 4 Execute





**Hala Nassereddine, Ph.D.**

Associate Professor

Construction Engineering and Project  
Management

[hala.nassereddine@uky.edu](mailto:hala.nassereddine@uky.edu)

# Thank you!

Let's connect!

LinkedIn





# NCHRP: The States' Highway Research Program



- ✓ Started in 1962 by the State DOT CEOs working through the American Association of State Highway & Transportation Officials to address complex issues faces facing state DOTs nationwide.
- ✓ Program administered by the Transportation Research Board.
- ✓ Research needs statements can be submitted annually by three bodies:
  - ✓ A State DOT
  - ✓ An AASHTO Committee or Council
  - ✓ Federal Highway Administration
- ✓ Program funds ~\$30-35M in research annually



# NCHRP 23-32 Project Purpose

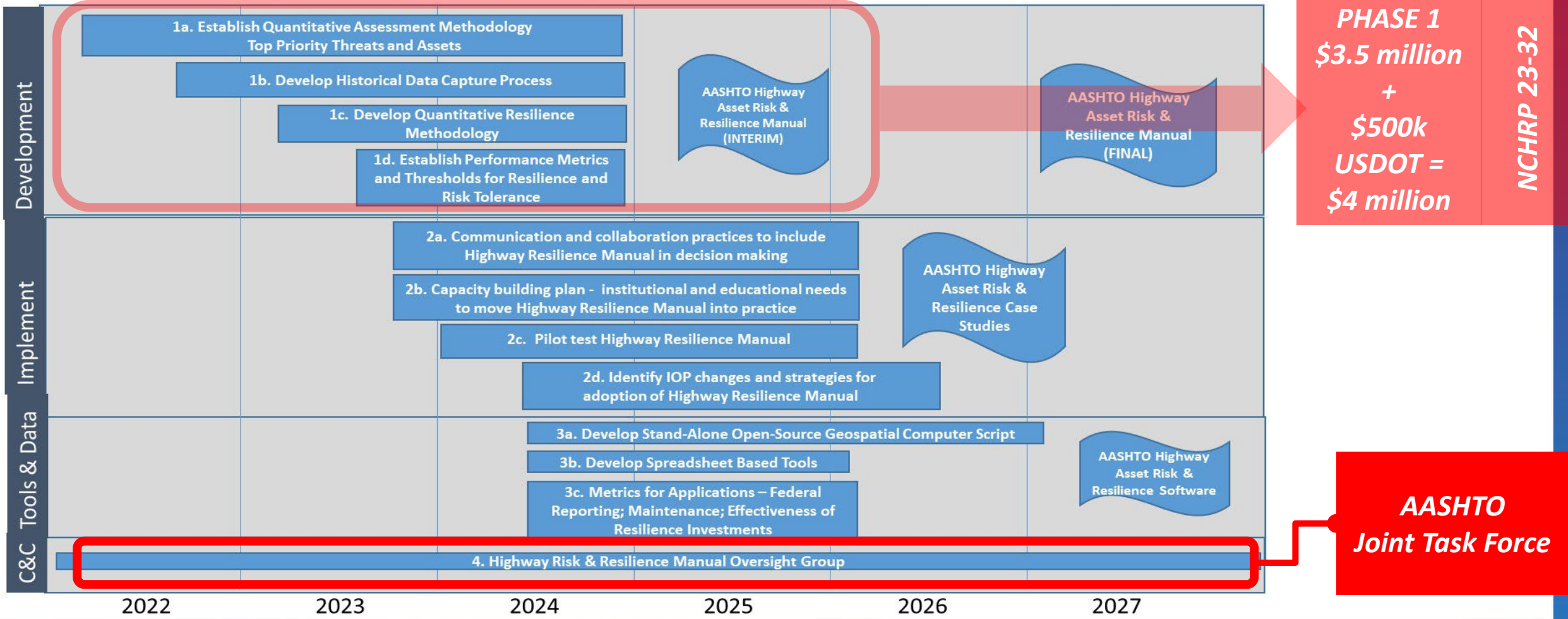
**Project Objective: Provide a science-based technical resource to assess risk and resilience in transportation planning, design, construction, operation, and maintenance decisions, including:**

- ✓ Quantitative, repeatable methods for conducting risk assessments on top priority threats/hazards for transportation assets
- ✓ A historical data-capture process and system to support risk and resilience modeling and assessments
- ✓ Quantitative resilience assessment methods and metrics for transportation assets
- ✓ Standardized methods to help state DOTs and other transportation agencies identify the most appropriate risk mitigation or resilience improvement strategies

# Transportation Asset Risk & Resilience Manual: AASHTO Timeline



Research Roadmap: Development and Adoption – 3 Phased Approach



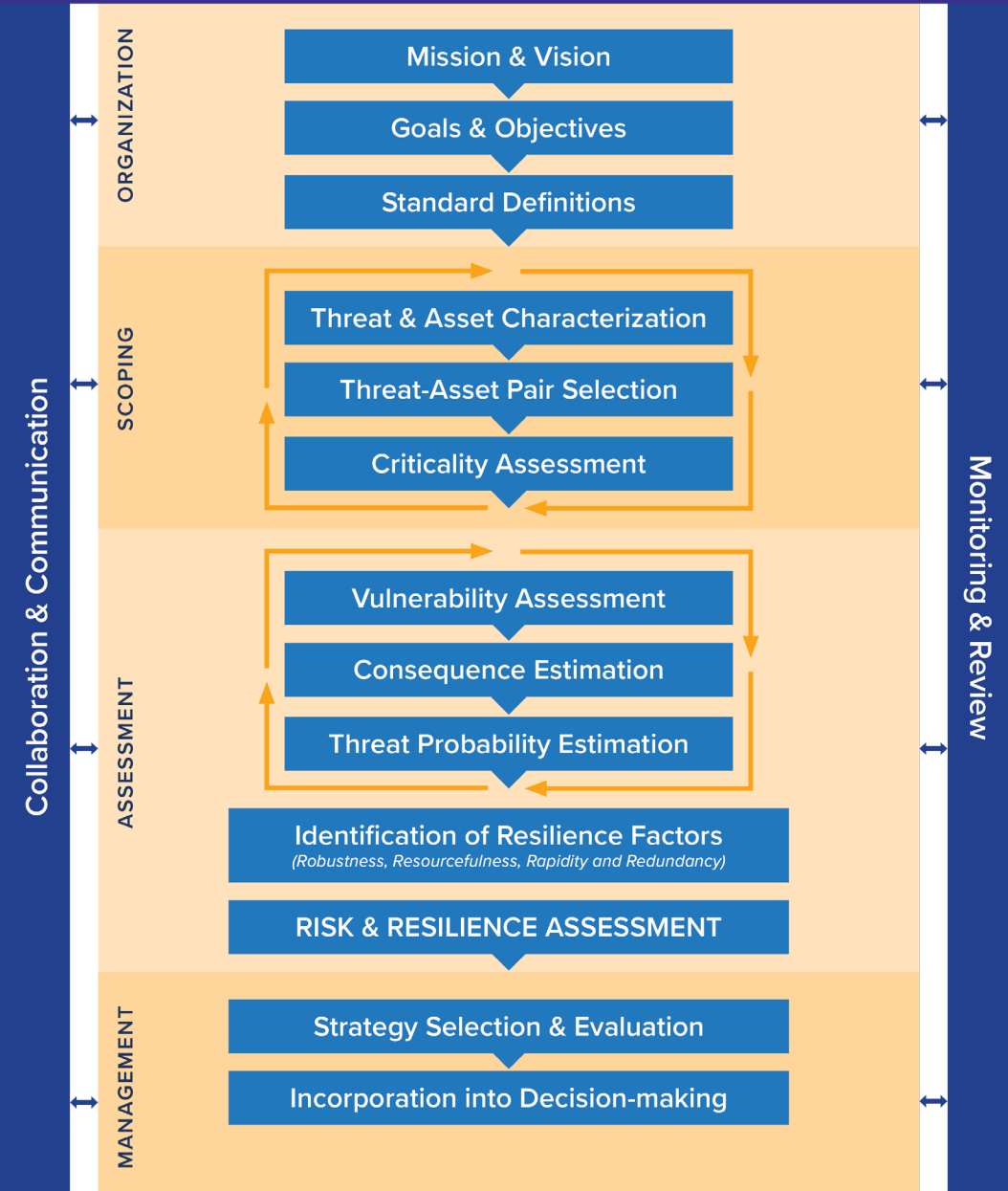
**PHASE 1**  
 \$3.5 million  
 +  
 \$500k  
 USDOT =  
 \$4 million

**NCHRP 23-32**

**AASHTO  
 Joint Task Force**

# Framework for Risk and Resilience Assessment in Transportation

## Project Scope



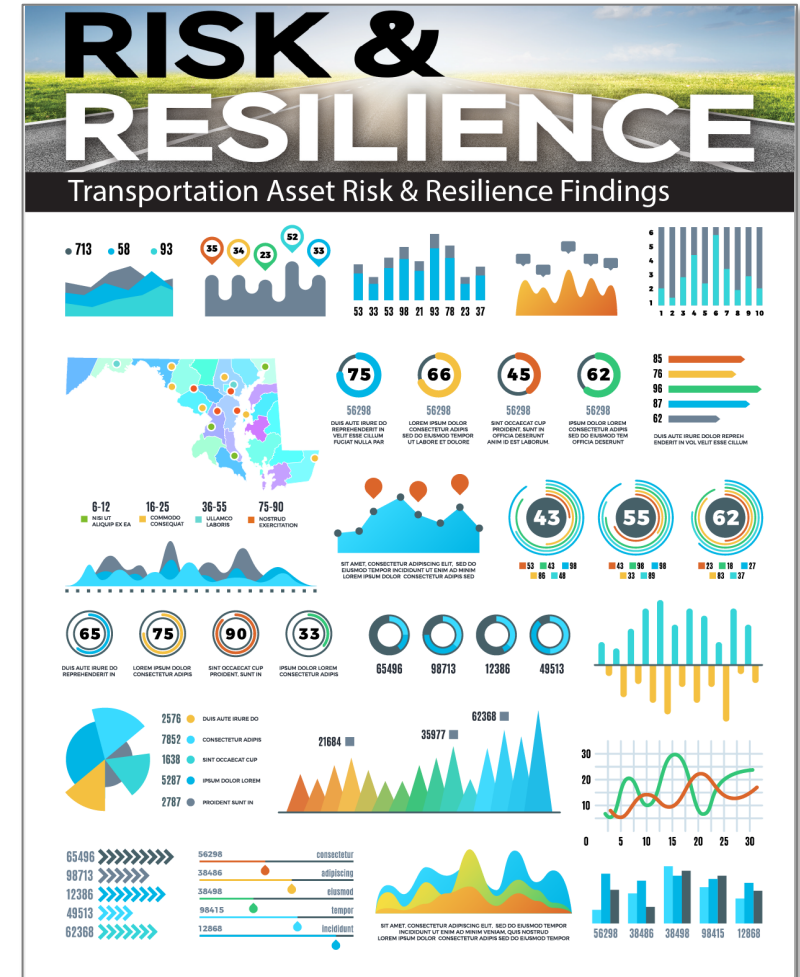
- Develop a *Transportation Asset Risk and Resilience Manual* based on NCHRP 23-09 Scoping Study to Develop the Basis for a Highway Standard to Conduct an All-Hazards Risk & Resilience Analysis framework & study findings.
- Review current practices to shape the Manual's quantitative risk and resilience assessment methods
- Scope Manual to reflect agency resources
- Engage stakeholders for technical input and AASHTO publication support
- Identify future research needs

# Project Timeline



# Project Final Deliverables

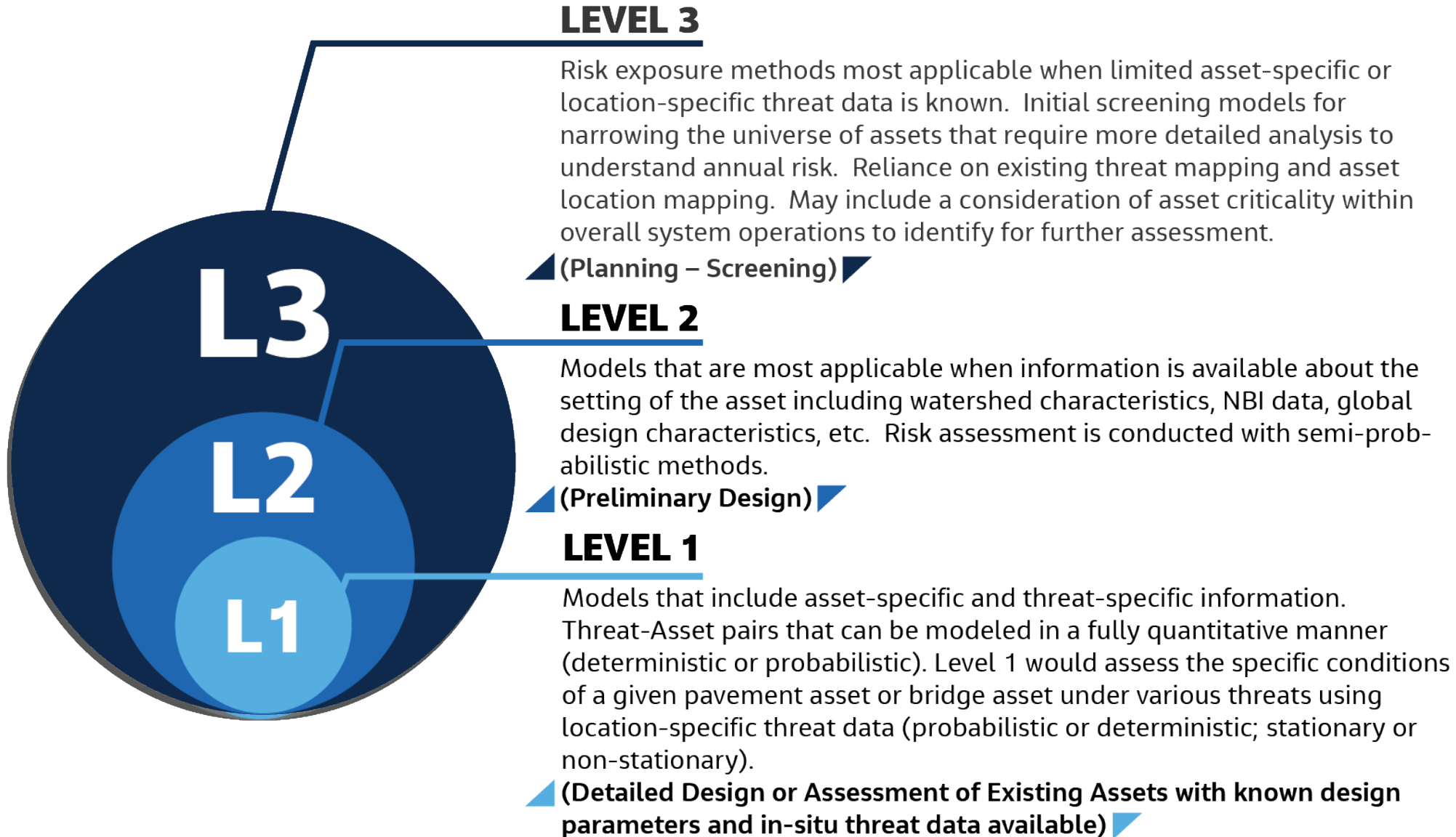
1. Transportation Asset Risk & Resilience Manual
  - The **first-of-its kind** manual for surface transportation to be considered for adoption by AASHTO
2. Final report documenting research effort and key findings
3. Recommendations for future research, including research problem statements
4. Stand-alone memorandum that identifies implementation needs and pathways



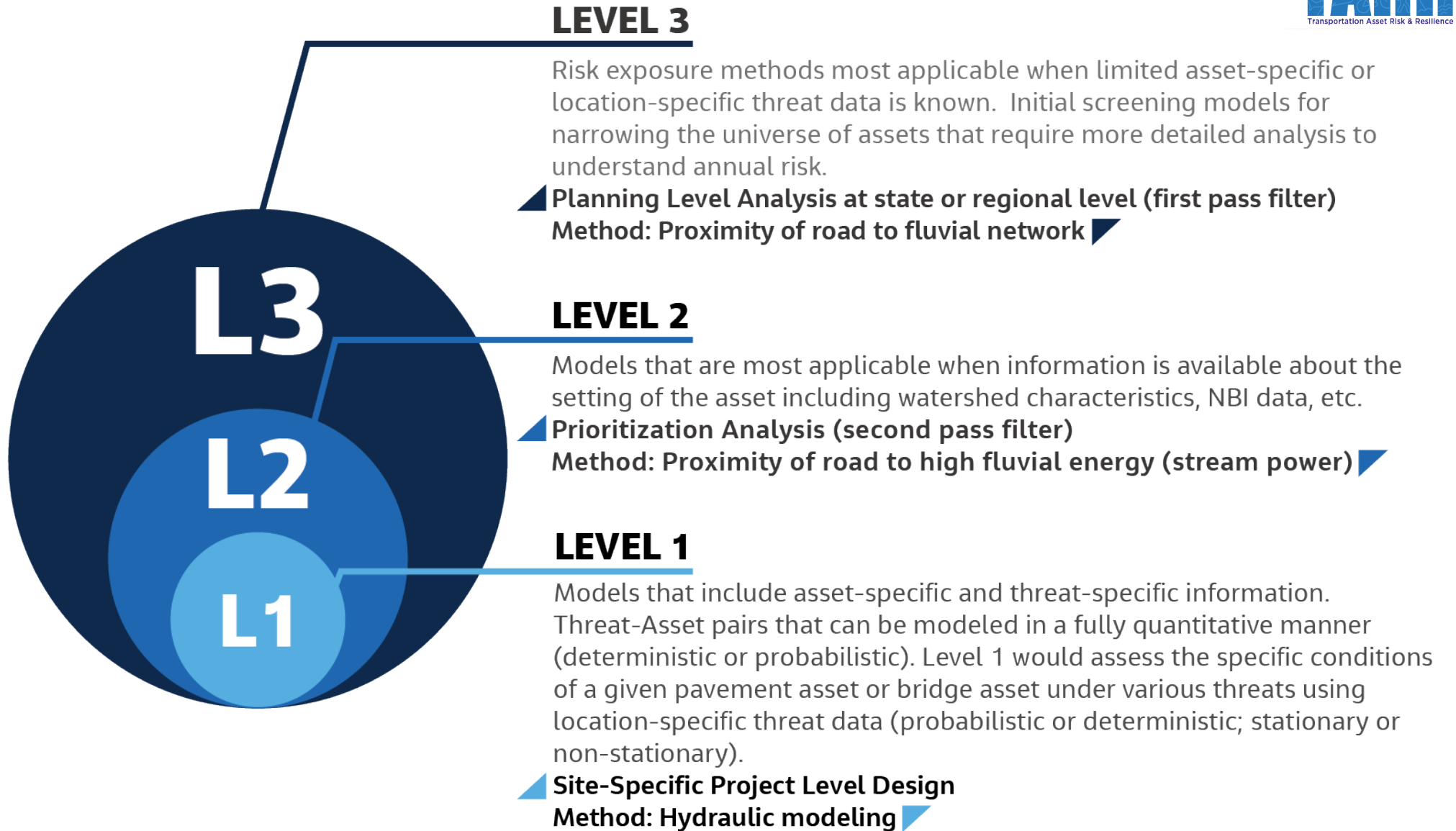
# Data Throughout Planning & Project Development Phases

- Asset-specific and threat-location-specific data improves throughout the planning and project development process
- Risk & Resilience Models or Methods needed to support **planning, preliminary engineering, detailed design or assessment of existing assets.**
  - Models need to reflect available information or data at the time of analysis

# Modeling Levels



E  
X  
A  
M  
P  
L  
E



# Erosion- Road Embankment

## Model Overview

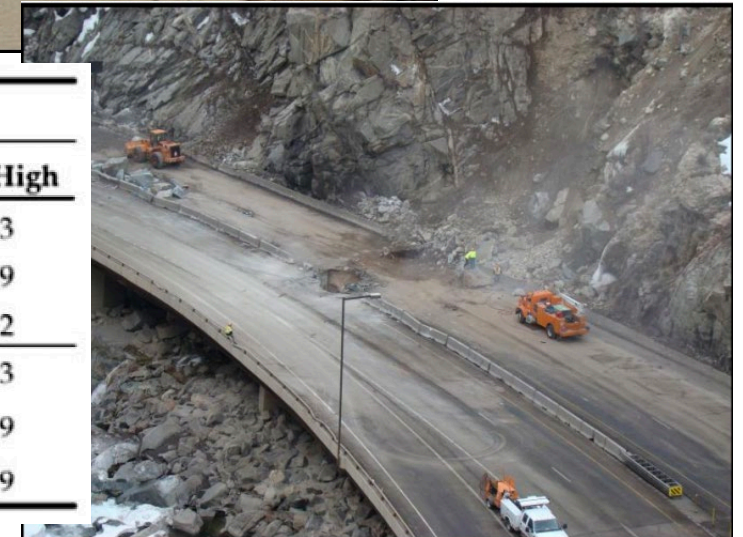
<u>Model Steps</u>	<u>Data Sources</u>	<u>Methodologies</u>	<u>Resources needed</u>	<u>Output</u>
<b>Step 1 : Asset Data Collection</b>	HPMS database Agency's asset management databases As built Plans**		Agency's HPMS or roadway geospatial data	<b>Asset Data</b>
<b>Step 2 : Threat Data Collection</b>	National hydrology and hydraulics tool-sets** Agency's H&H tool-sets Detailed H&H Assessments Expert Knowledge		National Elevation Dataset National Hydrography Dataset SME - H&H	<b>Threat Probability &amp; Magnitude (T)</b>
<b>Step 3 : Consequence Assessment</b>	Estimated Unit Costs for Impacted Roadway** Agency's Maintenance Records Expert Knowledge		SME - Pavement / Roadway Planning for Pricing	<b>Consequences (C)</b>
<b>Step 4 : Vulnerability Assessment</b>	<b>4.1 Stream Power Assessment</b> Percent Max Stream Power  <b>4.2 : Stream Proximity Assessment</b> Range banding statistics		SME - GIS Analyst SME - H&H	<b>Vulnerability (V)</b>
<b>Step 5 : Risk Assessment</b>	<b>Risk = C * V * T</b>			<b>Risk in \$ value</b>

\*\* Data sources and Methodology used

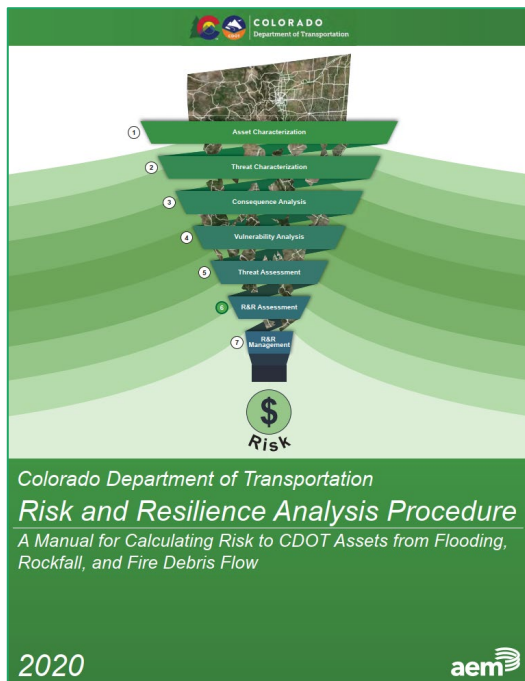
# Example Level 3 Vulnerability Assessment

## Colorado Department of Transportation Tool

CDOT developed vulnerability scores (from 0–1) to estimate highways to assess the vulnerability of roadways (highways) based on flood magnitude, terrain, and potential embankment erodibility. These values were developed based on research, stakeholder input, and engineering judgment and represent the probability the overtopped roadway segment experiences failure or the Worst Reasonable Consequence (CDOT 2020).



Flood Event Magnitude	Terrain	Embankment Erodibility Potential				
		Very Low	Low	Moderate	High	Very High
100-yr	Level	0.22	0.23	0.25	0.31	0.33
	Rolling	0.26	0.28	0.30	0.36	0.39
	Mountainous	0.35	0.37	0.40	0.48	0.52
500-yr	Level	0.55	0.59	0.63	0.77	0.83
	Rolling	0.66	0.70	0.75	0.91	0.99
	Mountainous	0.88	0.93	0.99	0.99	0.99



source: Flannery et al., (2017)

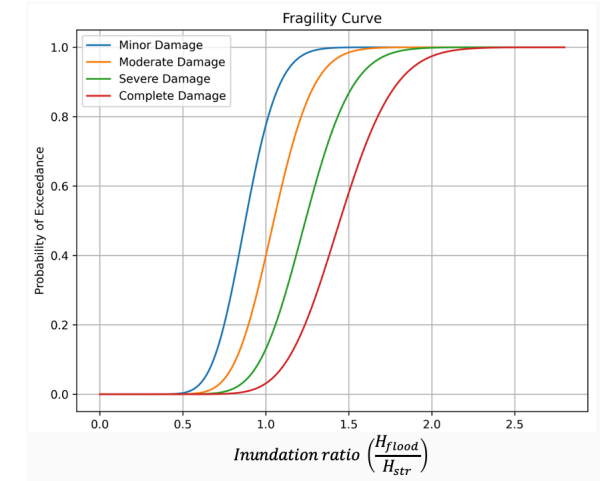
# Level 1 Example: Vulnerability Modelling in NCHRP 23-32

Fragility Curves – Bridge - Flooding TA Pair

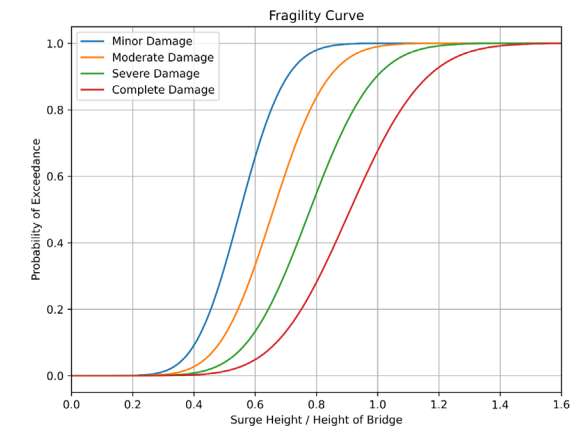
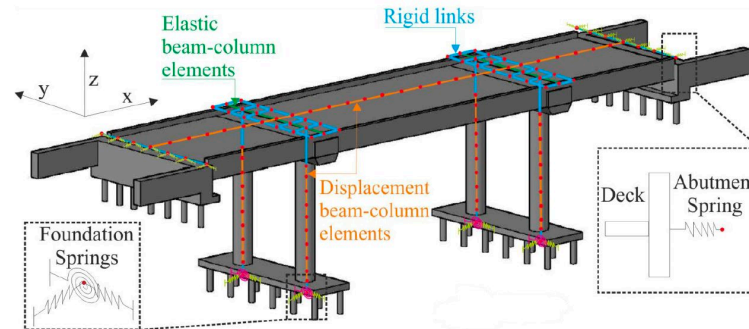
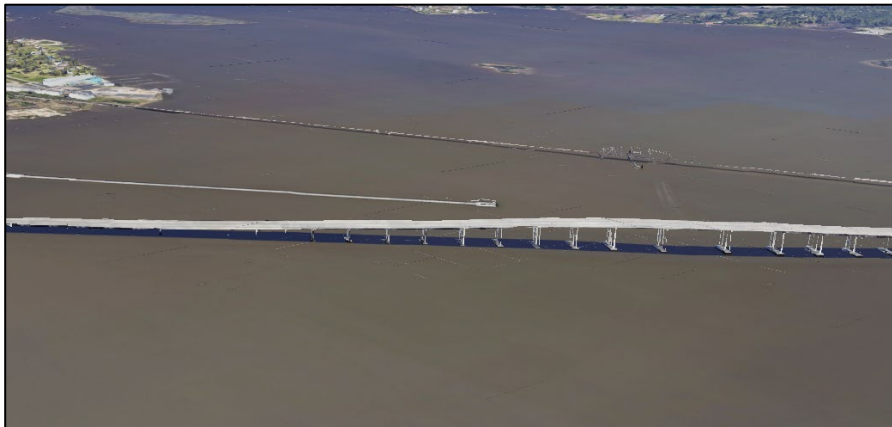
Define Limit State → FEA Modelling → Simulation → Develop Fragility Curves



Limit State	EDP (Lateral displacement)
Minor damage	0.25 inches
Moderate damage	0.75 inches
Severe damage	1.5 inches
Complete damage	2 inches



Fragility Curves – Bridge - Storm Surge TA Pair



# Risk Assessment

- **Risk Equation:**  $\text{Risk} = C * V * T$ 
  - **T:** Threat probability
  - **C:** Consequence value
  - **V:** Vulnerability factor
  
- Annual Risk for i-th damage state =  $(\text{Owner Consequences})_i \times V_i \times \text{Threat probability}$

# Example

Determine the probability of exceeding each damage state using Fragility curve

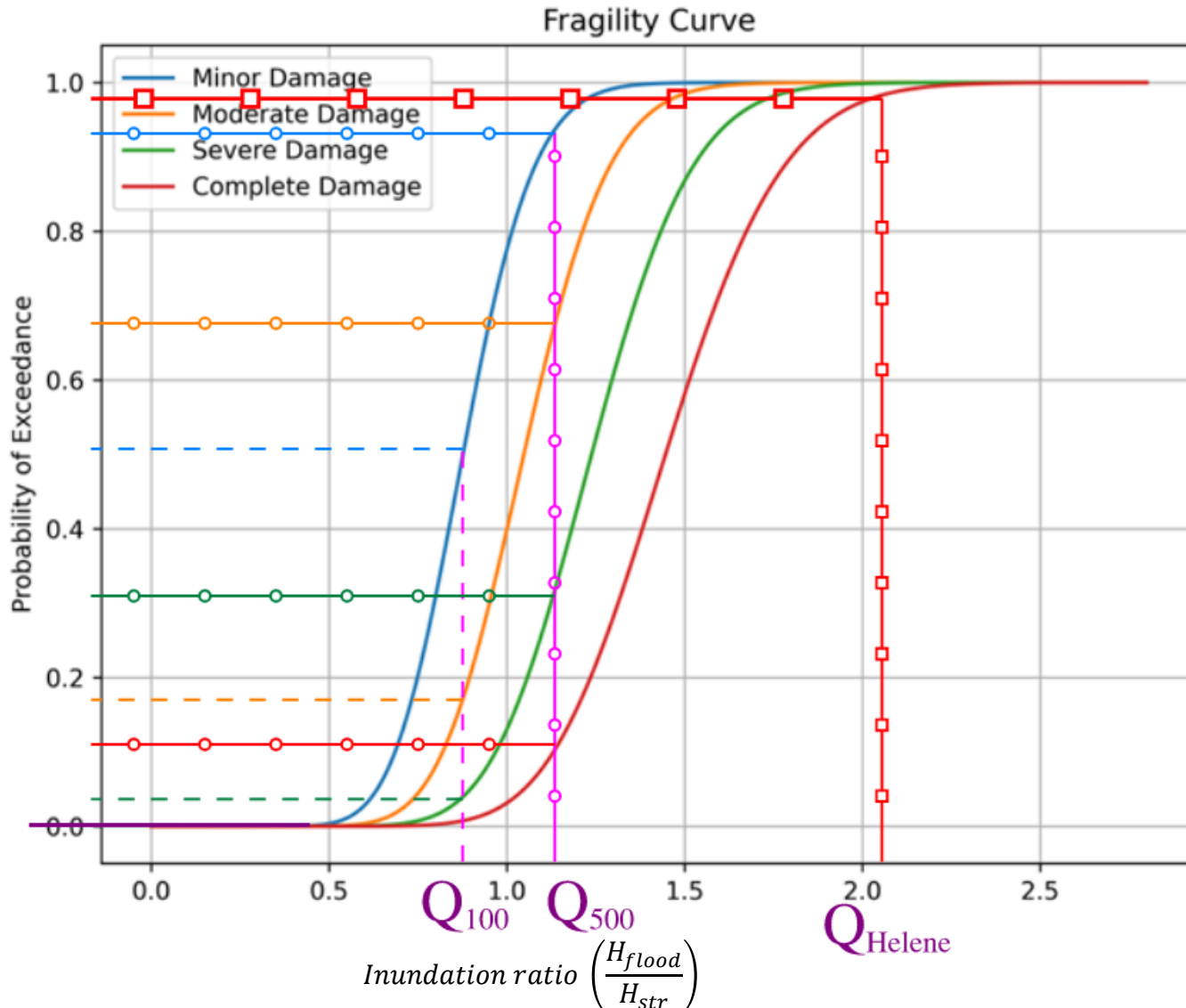


Table 7: Probability of exceedance of Damage States for 500-year flood

Damage State (DS)	Probability of Exceeding a given DS	Probability of being only in a given DS
Minor	0.94	0.26
Moderate	0.68	0.38
Severe	0.3	0.16
Complete	0.14	0.14

# Example

## Annual Risk for Example Bridge

	Consequence	Vulnerability	Threat Probability for 500-year flood	Annual Risk
Minor Damage	\$1,055,000	0.26	0.2%	~\$550
Moderate Damage	\$2,109,000	0.38	0.2%	~\$1,600
Severe Damage	\$3,164,000	0.16	0.2%	~\$1,000
Complete Damage	\$4,219,000	0.14	0.2%	~\$1,200

**Total Annual Risk = ~\$4,350**

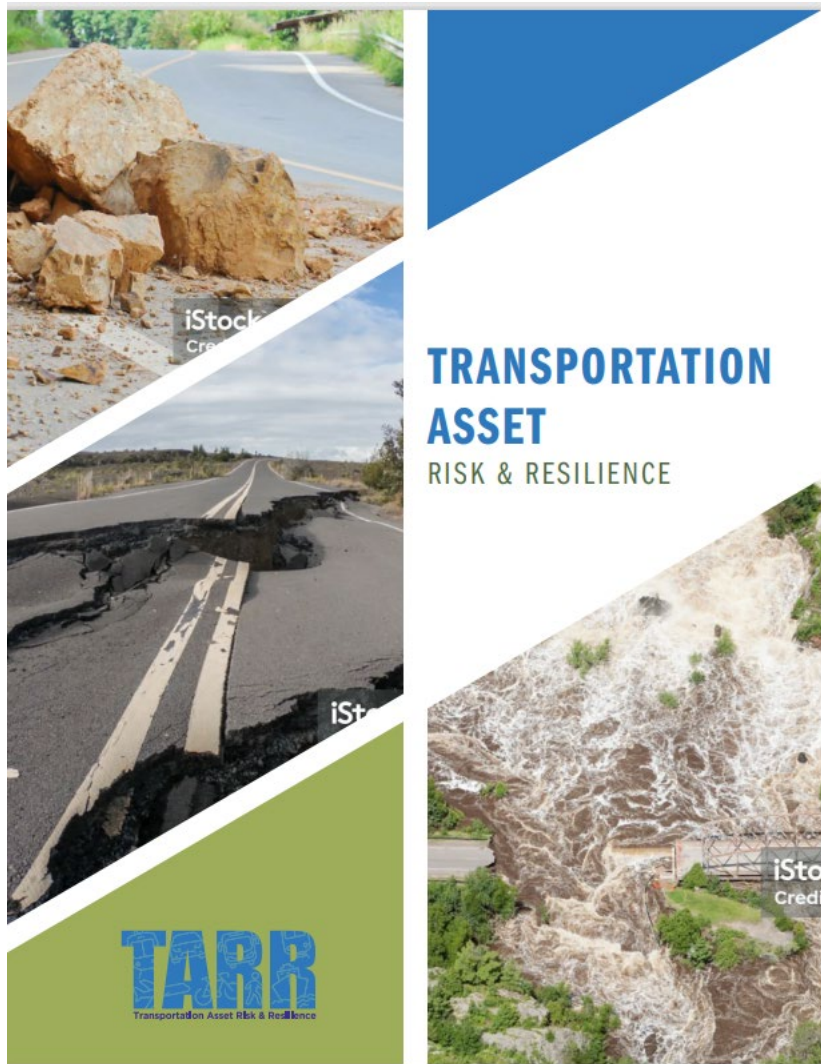
# Colorado DOT – Culvert Prioritization Use Case

## Prioritizing At Risk Culverts

- Step 1: Complete an inspection of identified high-risk culverts
- Step 2: Identify and document specific proposed mitigation action for each culvert based on inspection
  - Capital Improvement (e.g., replace culvert, slip line, etc.)
  - Operational Fix (e.g., increased cleanout frequency, install technology to monitor flows, etc.)
- Step 3: Run risk calculation for both base condition (as is) and mitigated condition – to determine potential risk reduction. Calculate Benefit / Cost.



Source: CDOT, Culvert Risk Mitigation Planning, 2020



\*Example Cover\*

## Next Steps:

Models refined and completed

Manual drafted, vetted by AASHTO Committees

Project complete November 2026

AASHTO consider for adoption

## Questions:

Aimee Flannery, Ph.D., PE

Global Principal Jacobs

Principal Investigator NCHRP 23-32

[Aimee.Flannery@jacobs.com](mailto:Aimee.Flannery@jacobs.com)

# Q&A and Discussion

Submit your questions using the Zoom's chat feature or raise your hand!

# All webinars available online:

<https://www.tam-portal.com/event-directory/tam-webinars/>

## Save the Dates!

A bimonthly webinar series, Wednesdays at 2:00 PM EST

### Next Webinar

**Wednesday, October 15, 2025 – 2:00 PM EST**

Topic: Advanced Technologies for TAM and TPM

**More to follow!**



For more information or to register:

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