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HYBRID AI–LCMS PAVEMENT DISTRESS A ALYSIS

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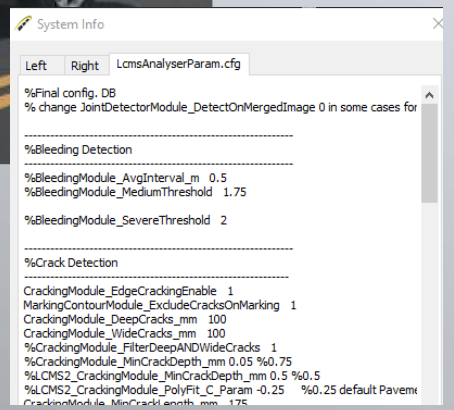
ICC-IMS

OUTLINE

- Problem Statement
- Development of a Dynamic LCMS Processing Framework
- AI-Assisted Configuration Selection
- Generalization Across Networks
- Conclusions

PROBLEM STATEMENT – LCMS AND 3D SYSTEMS



LCMS / 3D PAVEMENT IMAGING SYSTEMS PROVIDE:

- LIGHT INDEPENDENT SURFACE MEASUREMENTS
- HIGH RESOLUTION PAVEMENT GEOMETRY
- AUTOMATED DISTRESS DETECTION BASED ON PREDEFINED PROCESSING SETTINGS

LIMITATION:

- PROCESSING SETTINGS MUST BE SELECTED BEFORE DETECTION

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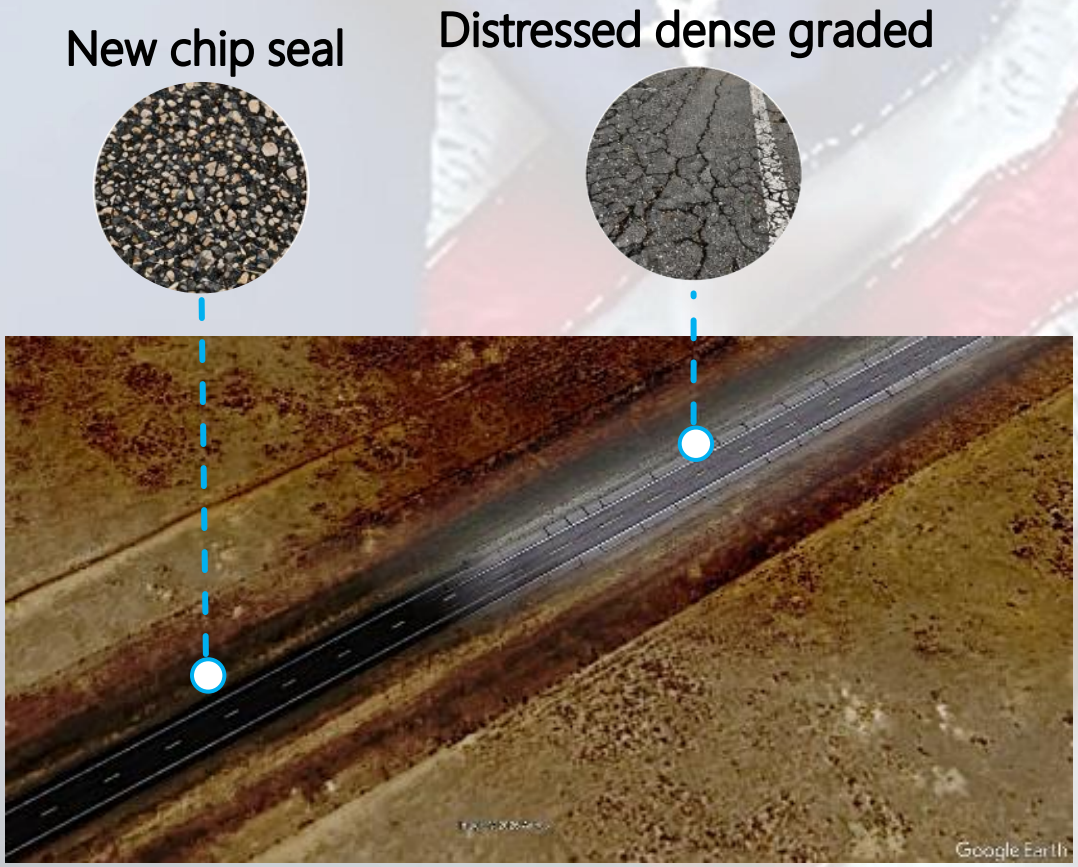
NETWORK LEVEL VS PROJECT LEVEL SETTINGS

Network level settings

- Applied to the entire network
- Designed to work well on most surface types
- Suboptimal on certain pavement types
- Efficient and repeatable

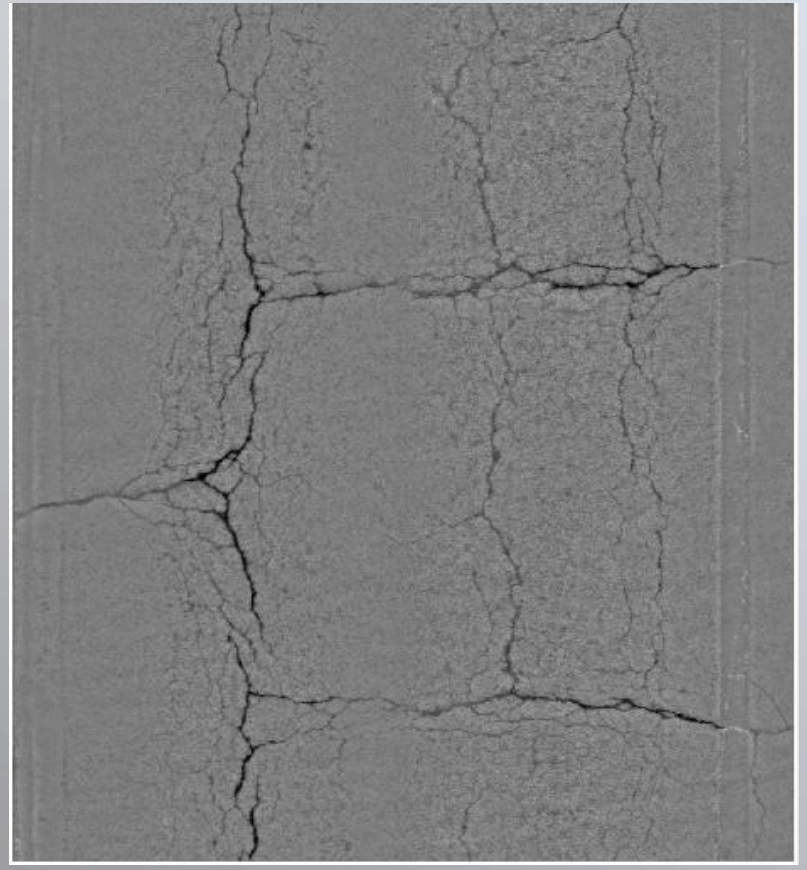
Project level settings

- Optimized for a specific project or pavement type
- Require manual review and iterations
- More accurate for difficult surfaces

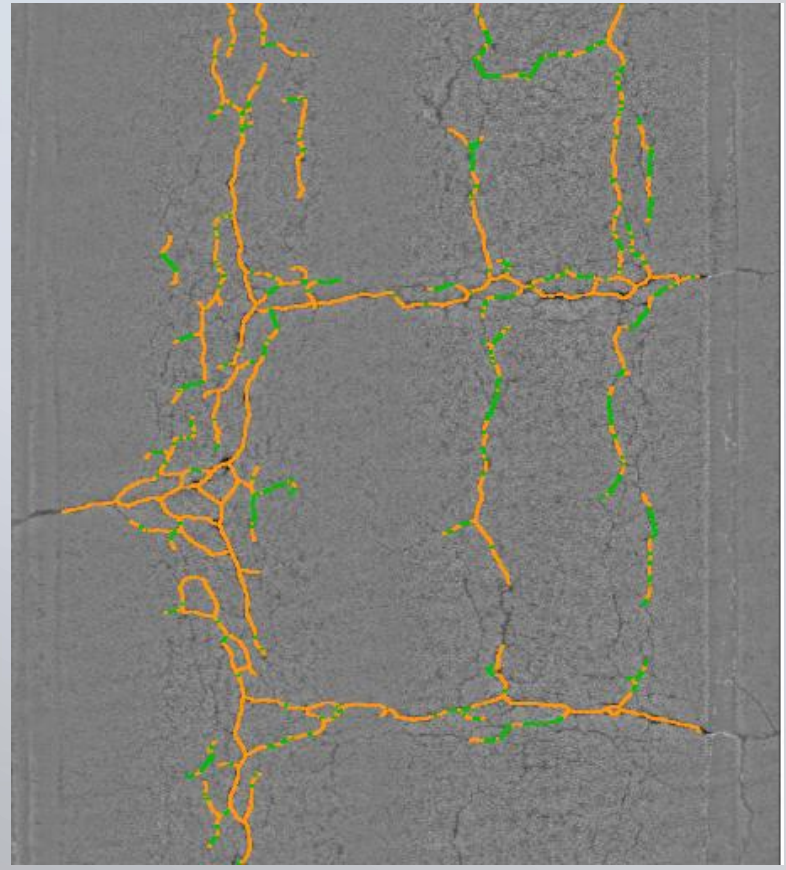


SETTING OPTIMIZATION – UNDERDETECTION EXAMPLE

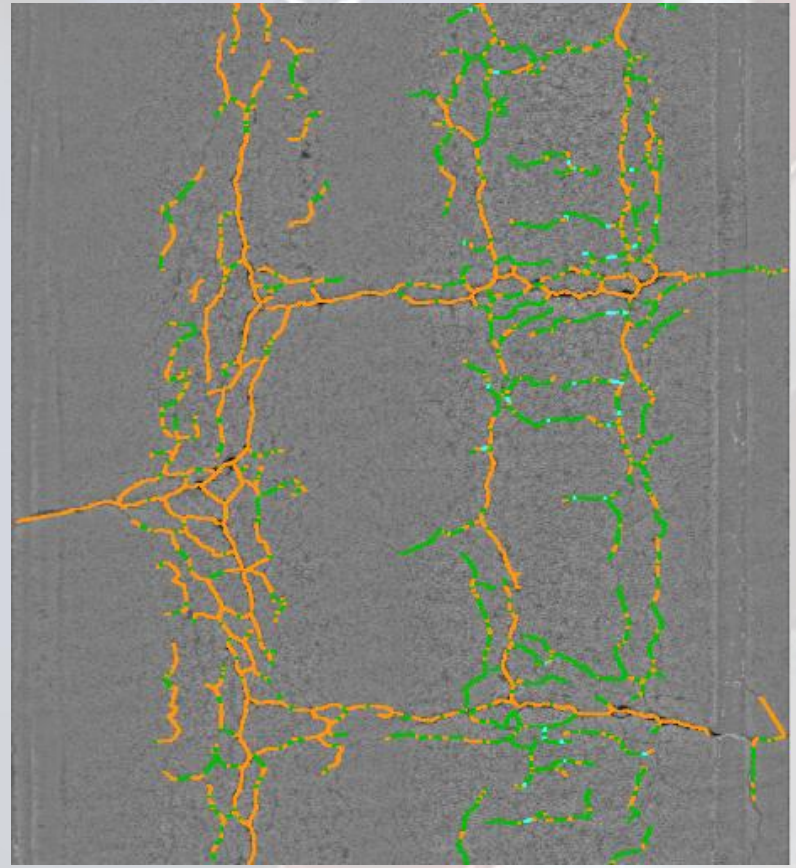
Range Image



Default

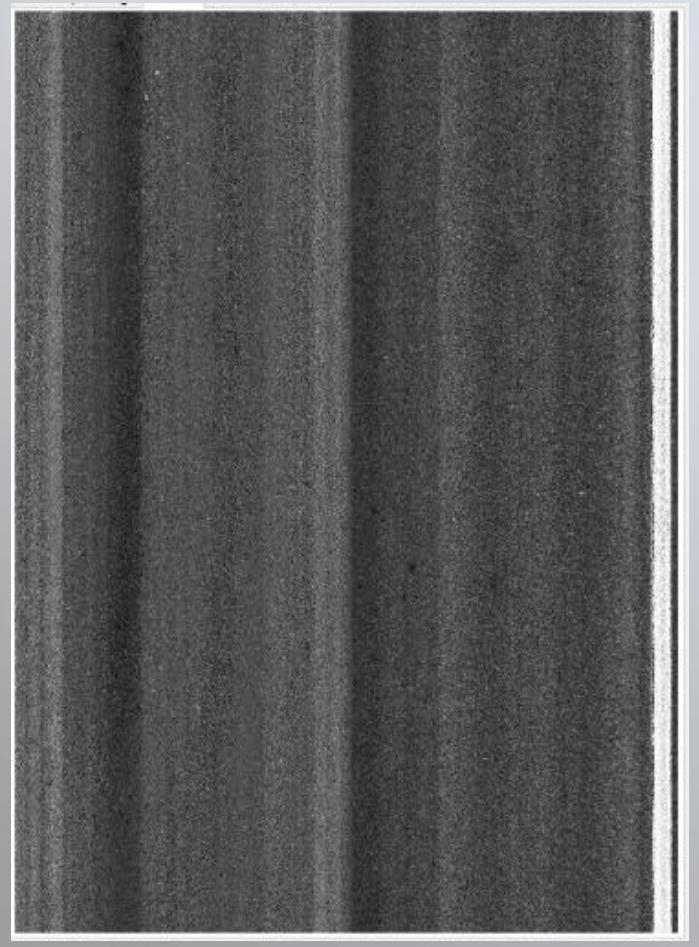


Optimized

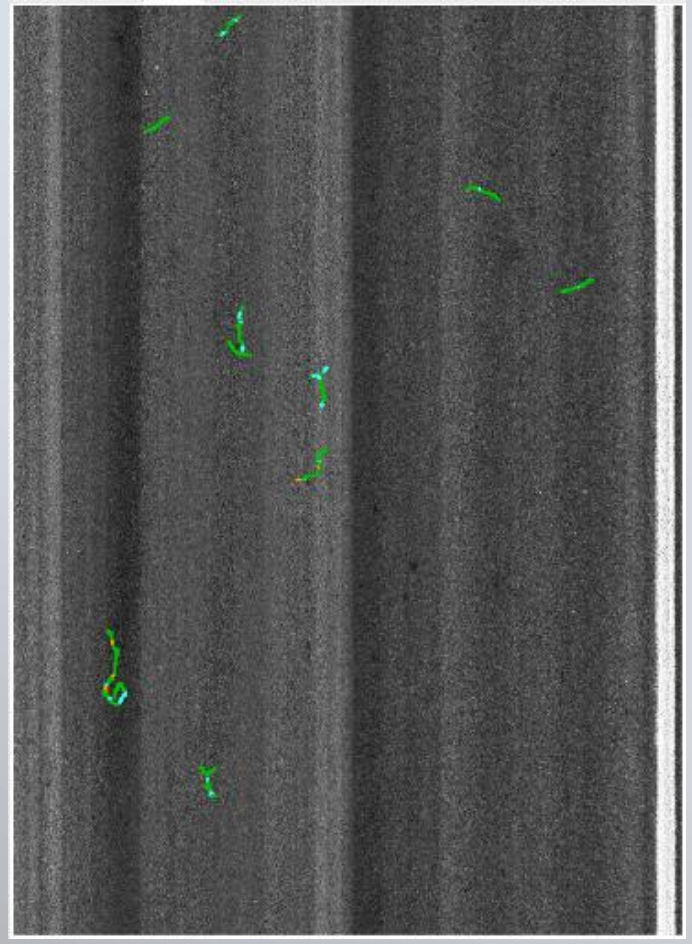


SETTING OPTIMIZATION – OVERDETECTION EXAMPLE

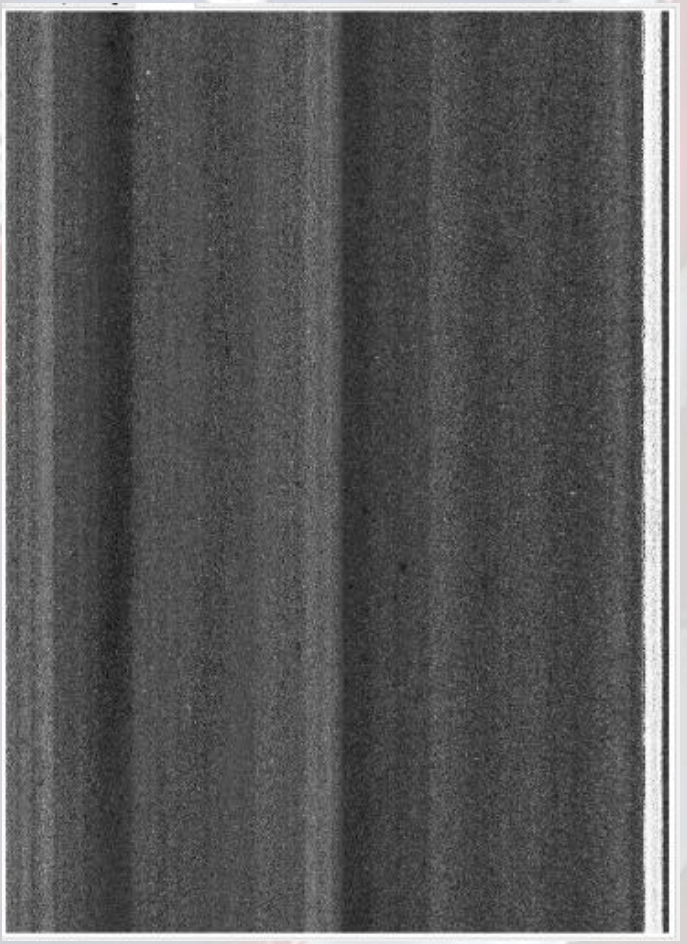
3D Image



Default



Optimized



SETTING OPTIMIZATION VS MANUAL RATING

Optimized settings

- Automated – repeatable and consistent
- Only works for known pavement types
- Can be tied to network layer for consistency over multiple years

Manual rating

- Subjective and less repeatable
- Required in cases where no optimized settings are found

Both are still needed !

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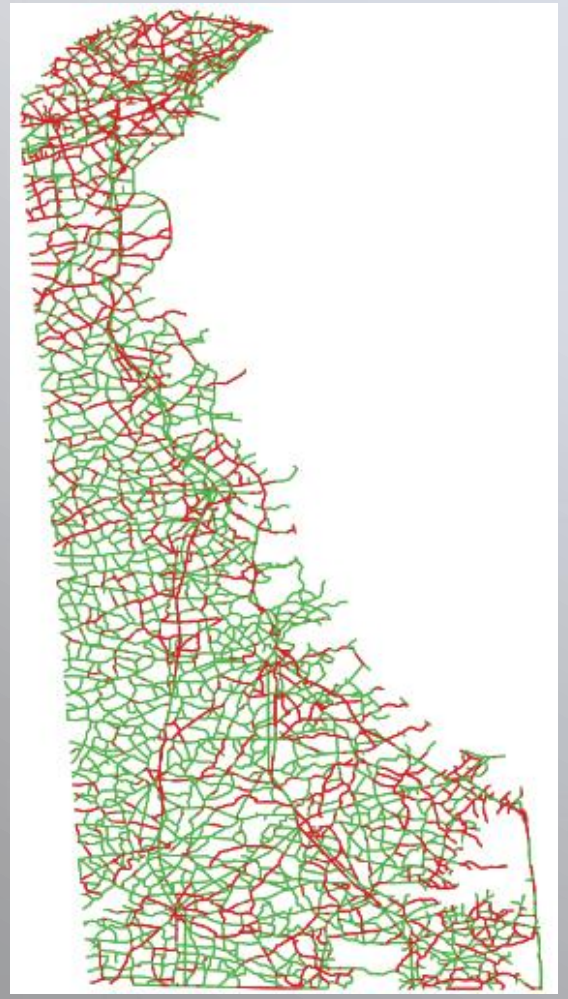
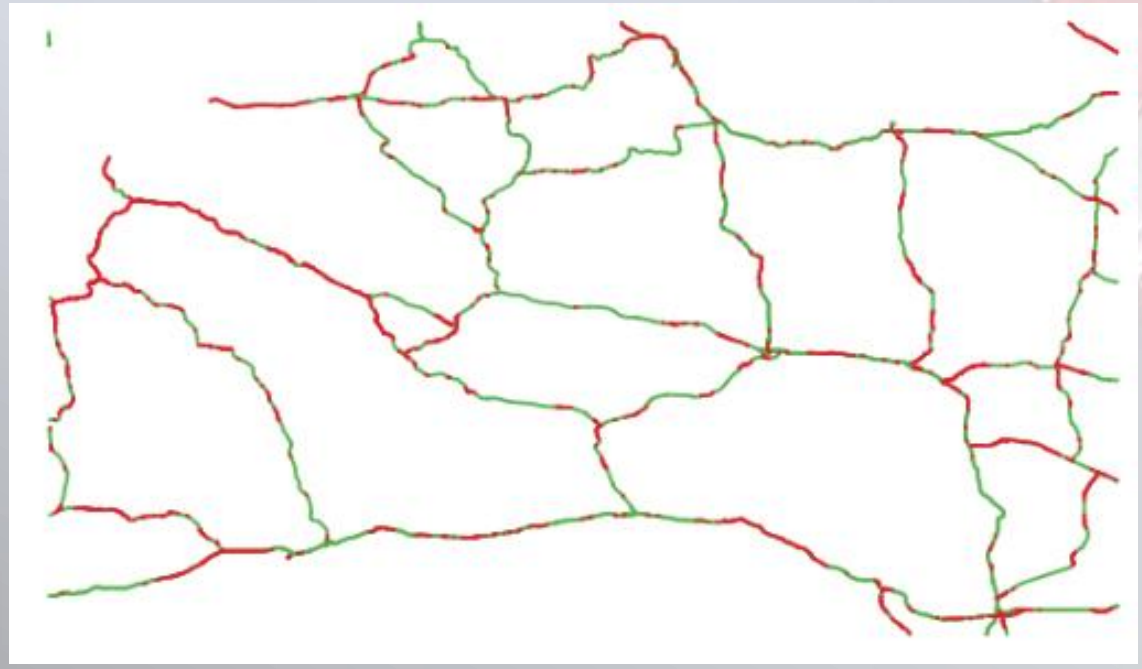
WHY IT MATTERS



LARGE NETWORKS (~43,000MILES) APPLICATION:

~25% required the use of non-default settings



LEGEND

- DEFAULT NETWORK SETTINGS
- OPTIMIZED SETTINGS

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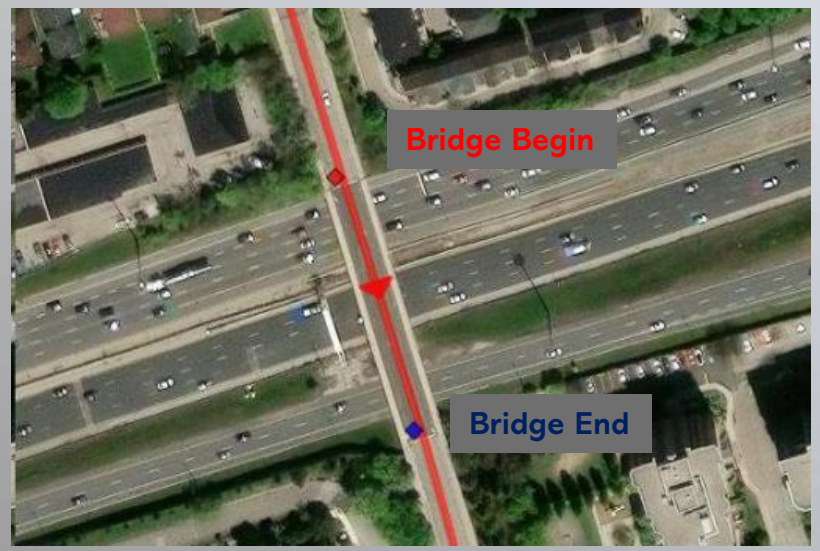
FRAMEWORK DEVELOPMENT

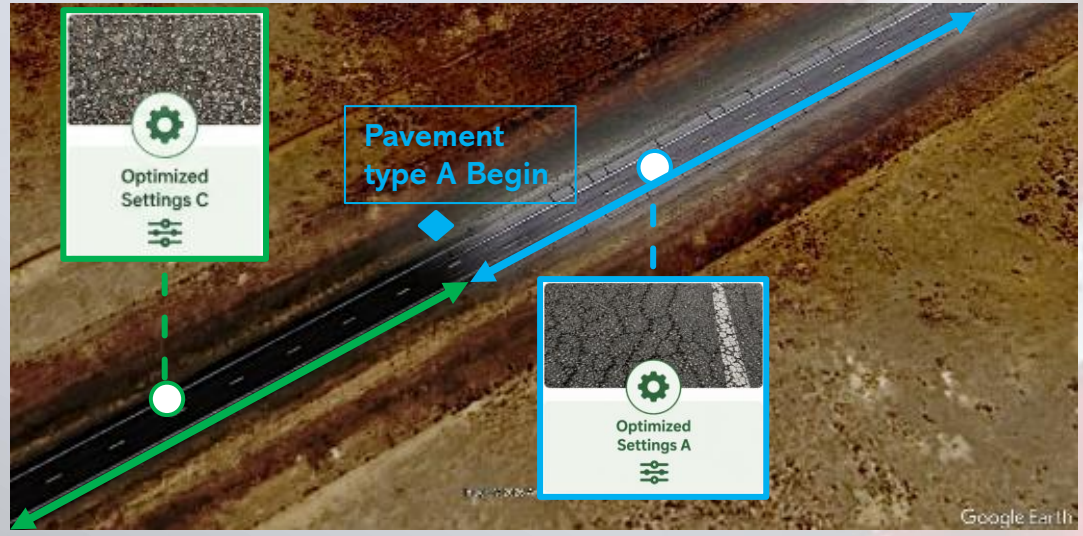
1) DEVELOP THE ABILITY TO RE-ASSIGN PROCESSING SETTINGS DURING DATA QUALITY CONTROL (QC)

Events are normally used to identify intervals to be treated with special rules, i.e. Bridges

→

Develop ability to associate processing settings to events





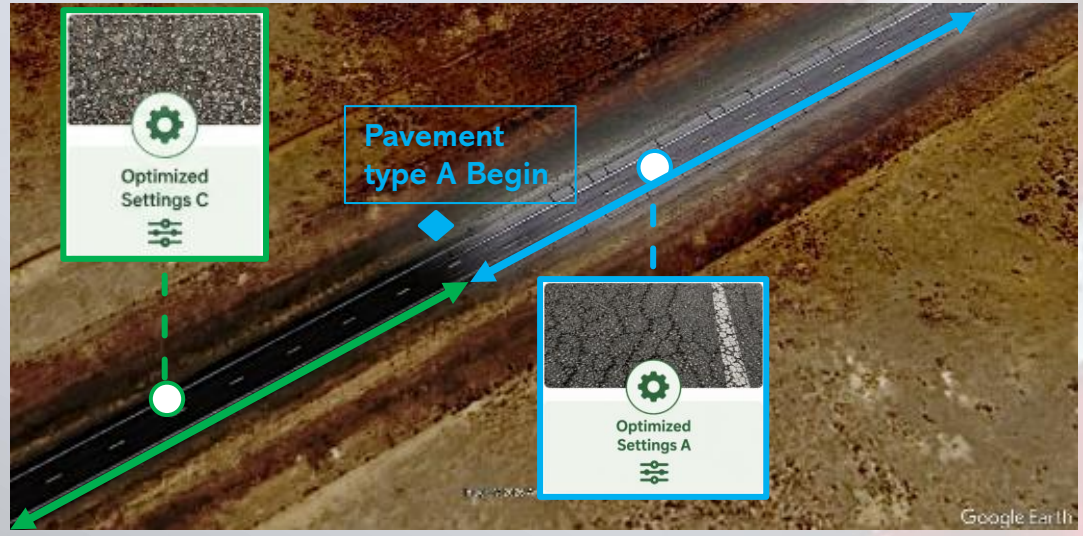
FRAMEWORK DEVELOPMENT

1) DEVELOP THE ABILITY TO RE-ASSIGN PROCESSING SETTINGS DURING DATA QUALITY CONTROL (QC)

PRO
- Better distress accuracy
- Processing settings can be tied to the network

LIMITATIONS
- Manual process
- Time consuming
- Reprocessing with new settings takes a long time and new results can't be immediately visualized

Develop ability to associate processing settings to events

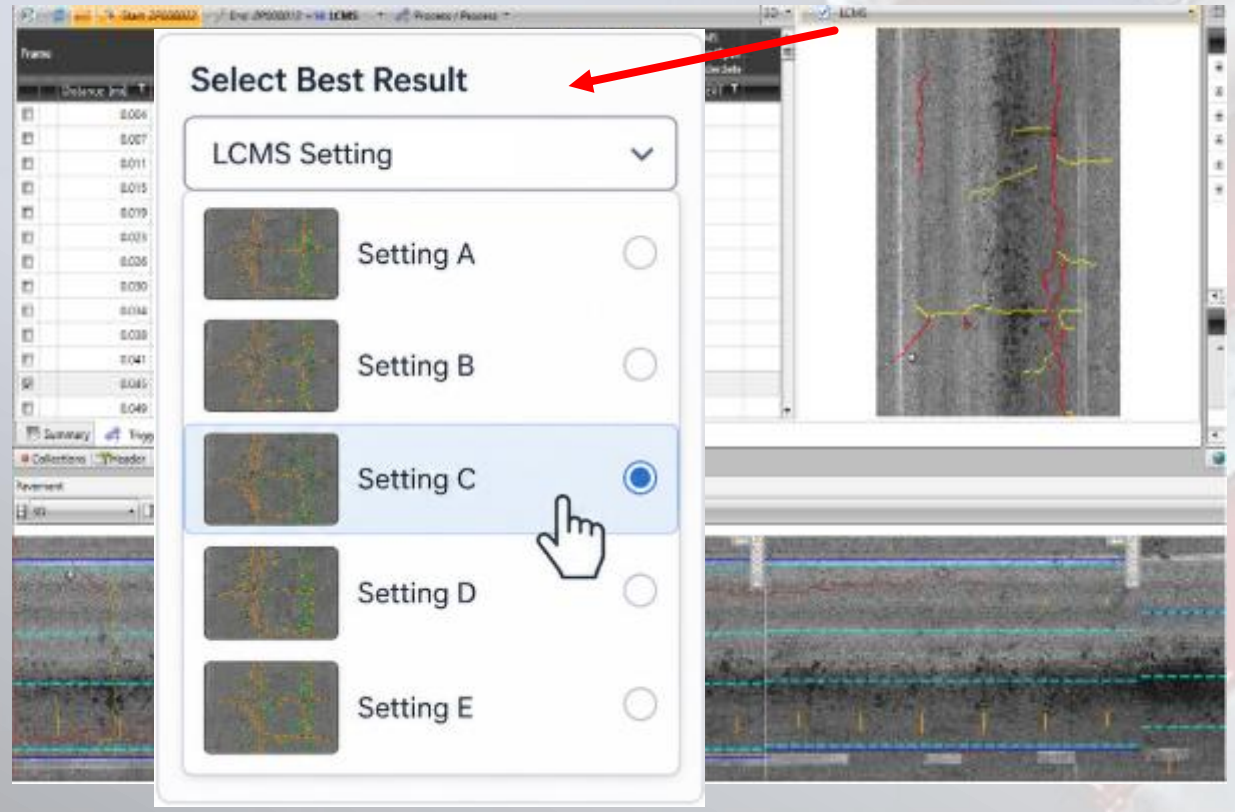


FRAMEWORK DEVELOPMENT

2) DEVELOP THE ABILITY TO PROCESS AND STORE THE SAME DATASET WITH MULTIPLE SETTINGS

PRO
- Allows preprocessing of all the data with multiple pre-determined setting groups
- All results visible during QC
- Reduces the labor time

LIMITATIONS
- Computationally expensive
- Data storage needs increase
- More time upfront pre-processing
- Applicable if dealing with a small amount of settings groups

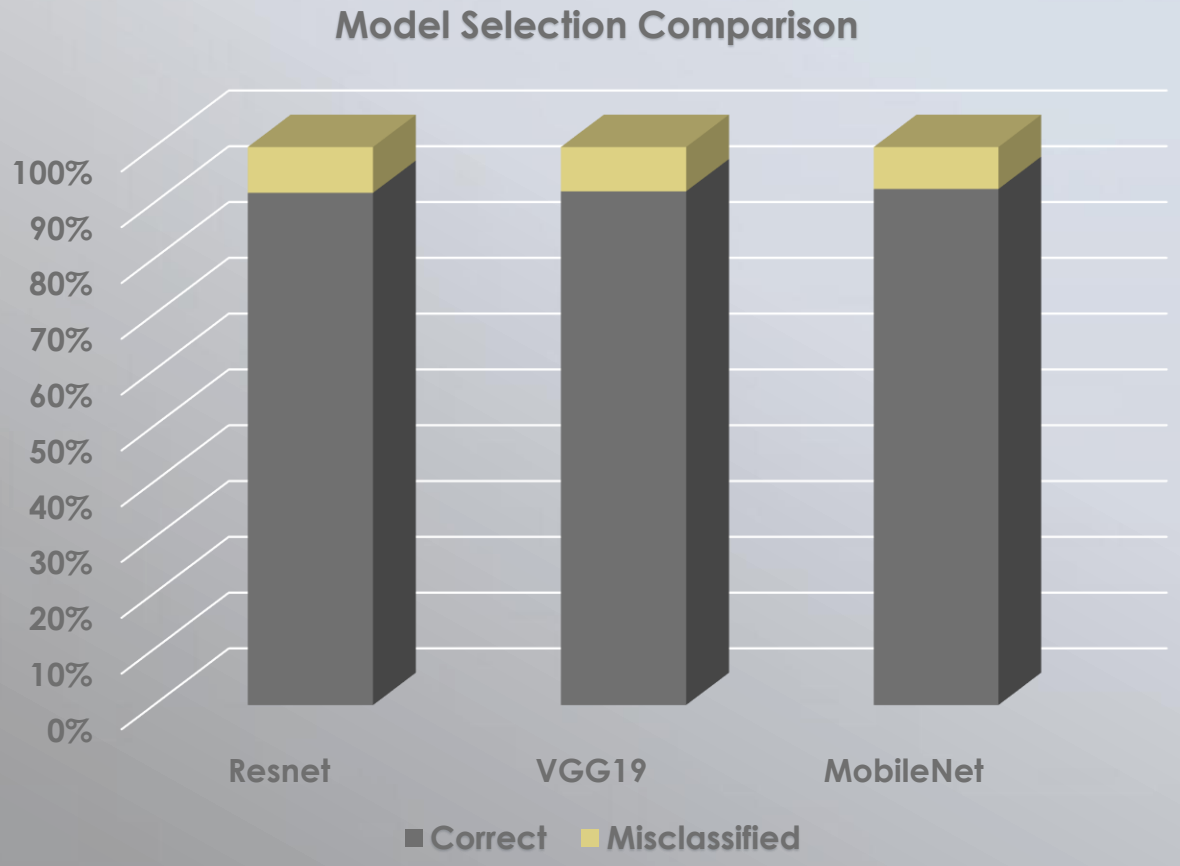


AI – HYBRID APPROACH

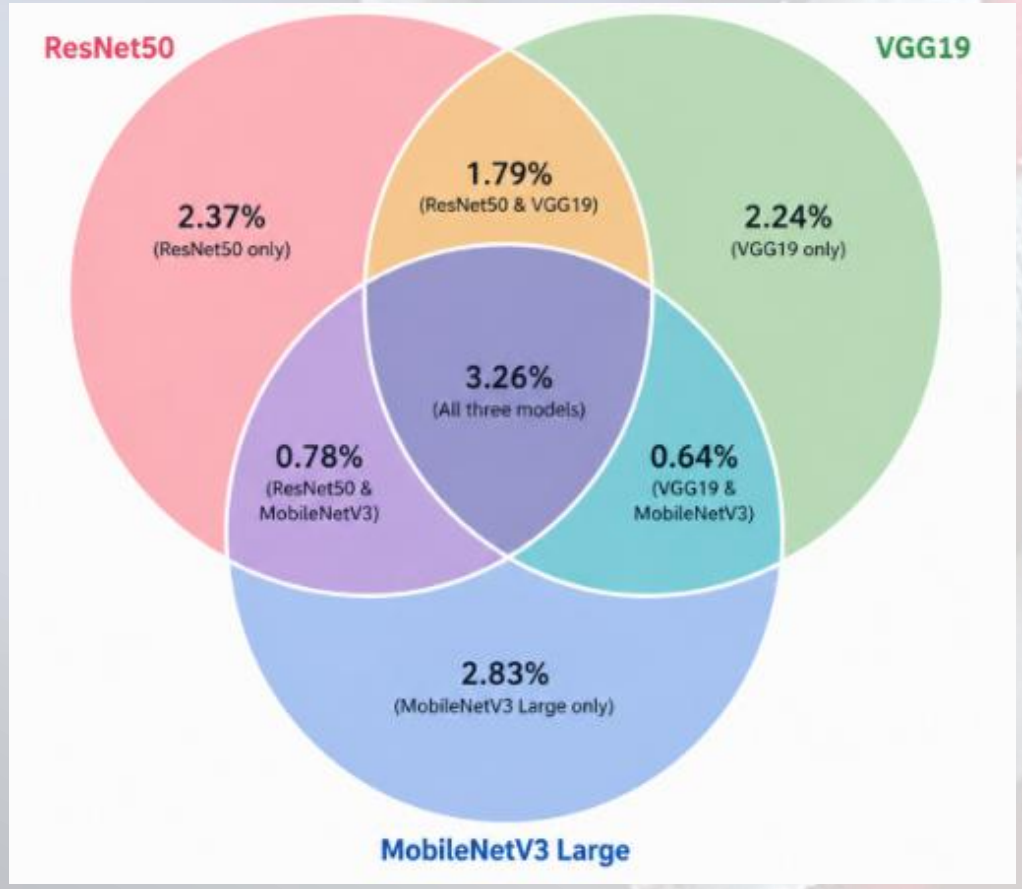
CONCEPT: TRAIN A MODEL TO IDENTIFY THE OPTIMAL GROUP OF SETTINGS DIRECTLY FROM THE IMAGES

	Complete / Brute Force	AI-Assisted / Balanced	AI-Reliant / Confident
KEY IDEA	Process everything everywhere	AI-guided processing	Minimum processing, only based on AI
HOW IT WORKS	• Apply all group of settings to all frames • Generate all alternatives • Pick the best	• Starts with default settings to all frames • AI identifies frames needing optimized settings • Keep default results as fallback	• Same as assisted, but no fallback results kept
PROS	• Most complete • No reprocessing • Easy review	• Balances efficiency and accuracy • Default data remains available • Can be automated and tied to the network	• Fastest and most efficient
CONS	• Highest processing time • Full manual review needed	• Might need reprocessing • Manual review of the AI results vs default still required	• Fully relies on automation
WHEN OPTIMAL	Project level – max accuracy	Moderate and large networks – balanced approach	Speed and efficiency are top priority

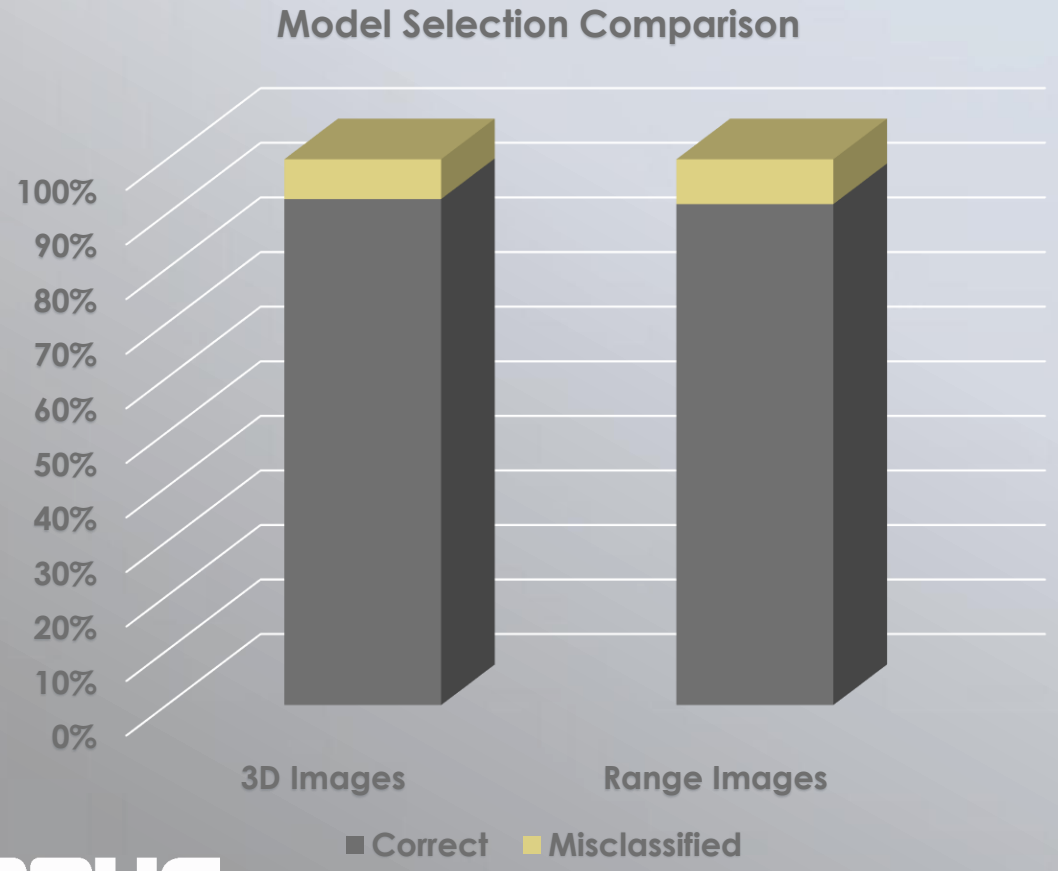
ARCHITECTURE SELECTION



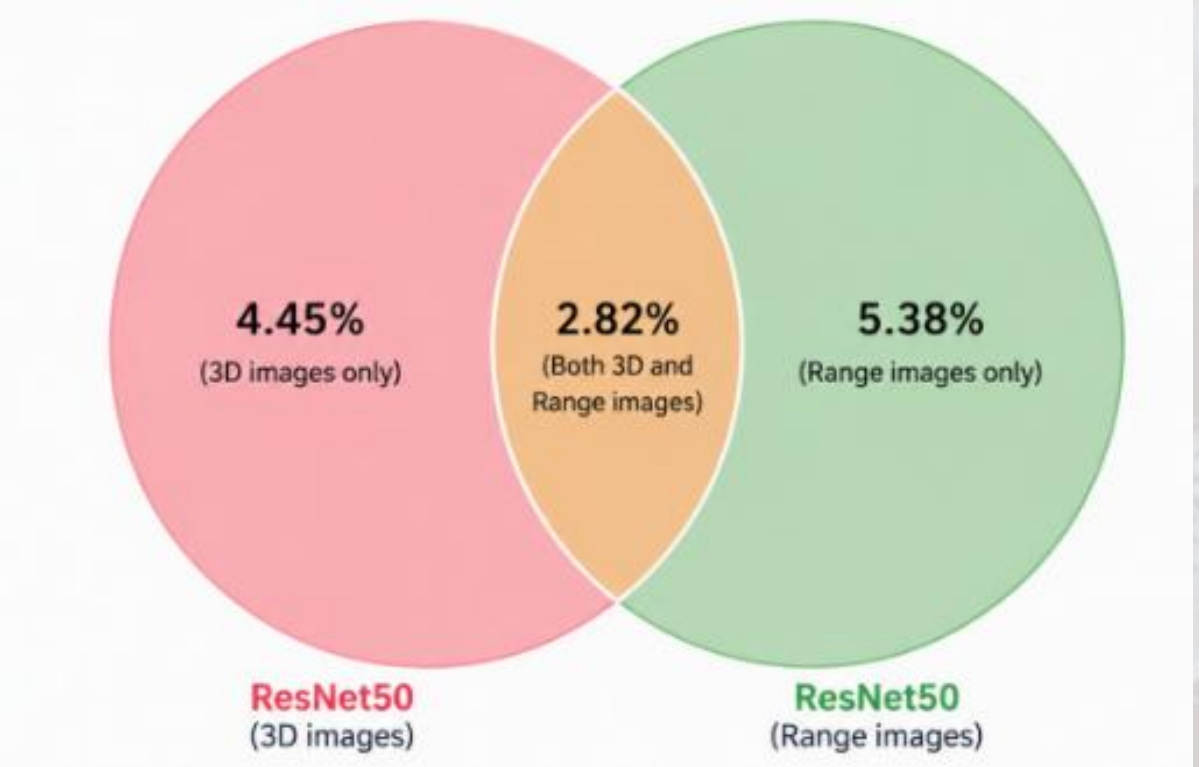
Comparison of misclassification



DATA SOURCE SELECTION



Comparison of misclassification



APPLICATION FOR DOTS VS MUNICIPAL PROJECTS

DOT COLLECTION

- Geographically concentrated
- Relatively few pavement types

MUNICIPAL COLLECTION

- Geographically dispersed
- Many pavement types
- Unique local challenges

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HONORING THE PAST. PAVING THE FUTURE.

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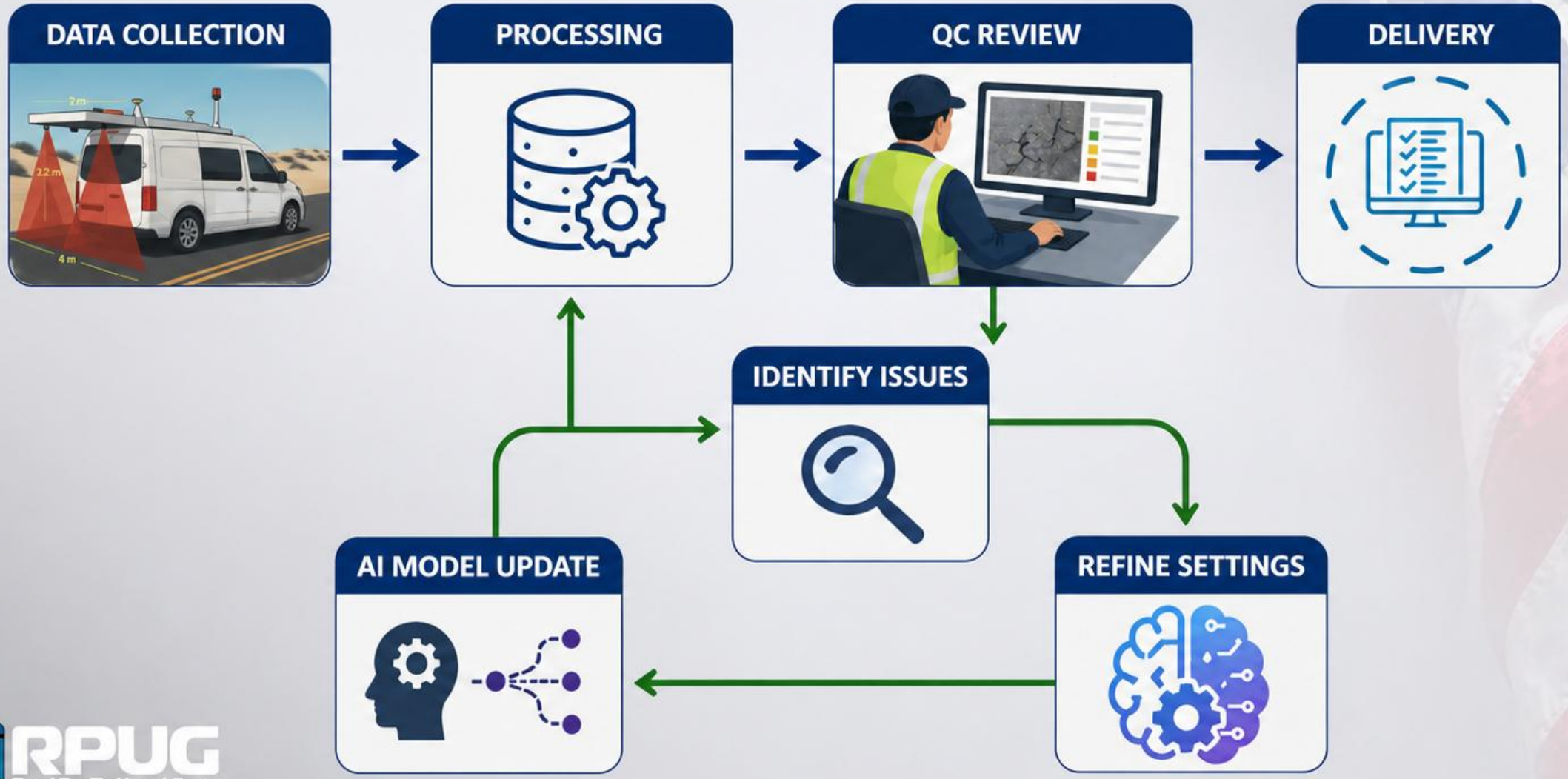
CONTINUOUS LEARNING

QC feedback drives continuous improvement of settings and AI



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NEXT STEPS – GENERAL APPROACH

WHAT IS NEEDED FOR A GENERALIZATION ACROSS NETWORKS

- Build a larger, more diverse training dataset across multiple projects
- Include pavement type, age, surface treatment from construction history logs
- Identify pavement clusters that respond to similar LCMS setting groups
- Use multiple inputs beyond imagery

CONCLUSIONS

- A **dynamic LCMS processing framework** was developed to apply optimized settings at network scale.
- Optimized settings improved distress detection on challenging pavement types and were required on approximately **25% of reviewed large-network routes**.
- Tying settings to the **GIS network** can improve consistency across production cycles.
- The framework enables a hybrid AI–LCMS approach, where **AI supports configuration routing rather than replacing LCMS detection**.
- Current AI models showed **limited generalization** across diverse municipal networks.
- Broader training data and **continuous QC feedback** are required to support generalized deployment.

THANK YOU!

CONTACT INFO

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