National Road Research Alliance

2019 Pavement Workshop
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+ 57 Associate Members

Research Project Geotechnical Team : Mechanistic Load Restriction Decision Platform for Pavement Systems Prone to Moisture Variations

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Develop ➪ Collaborate ➪ Research ➪ Implement ➪ Sustain.

Motivation

- A large portion of transportation agencies manage pavement systems with substantial subgrade moisture variations (both seasonal and post-storm)
- A large number of pavement subgrade moisture related Load/Traffic Restriction decisions are based on empirical approaches:
  - Fixed dates
  - Use of ground freeze data from select locations
  - **Subjective opinion post-flooding**
- Above approaches do not integrate **climate forecasting**, **soil-moisture state**, **pavement mechanics** and **traffic spectrum**

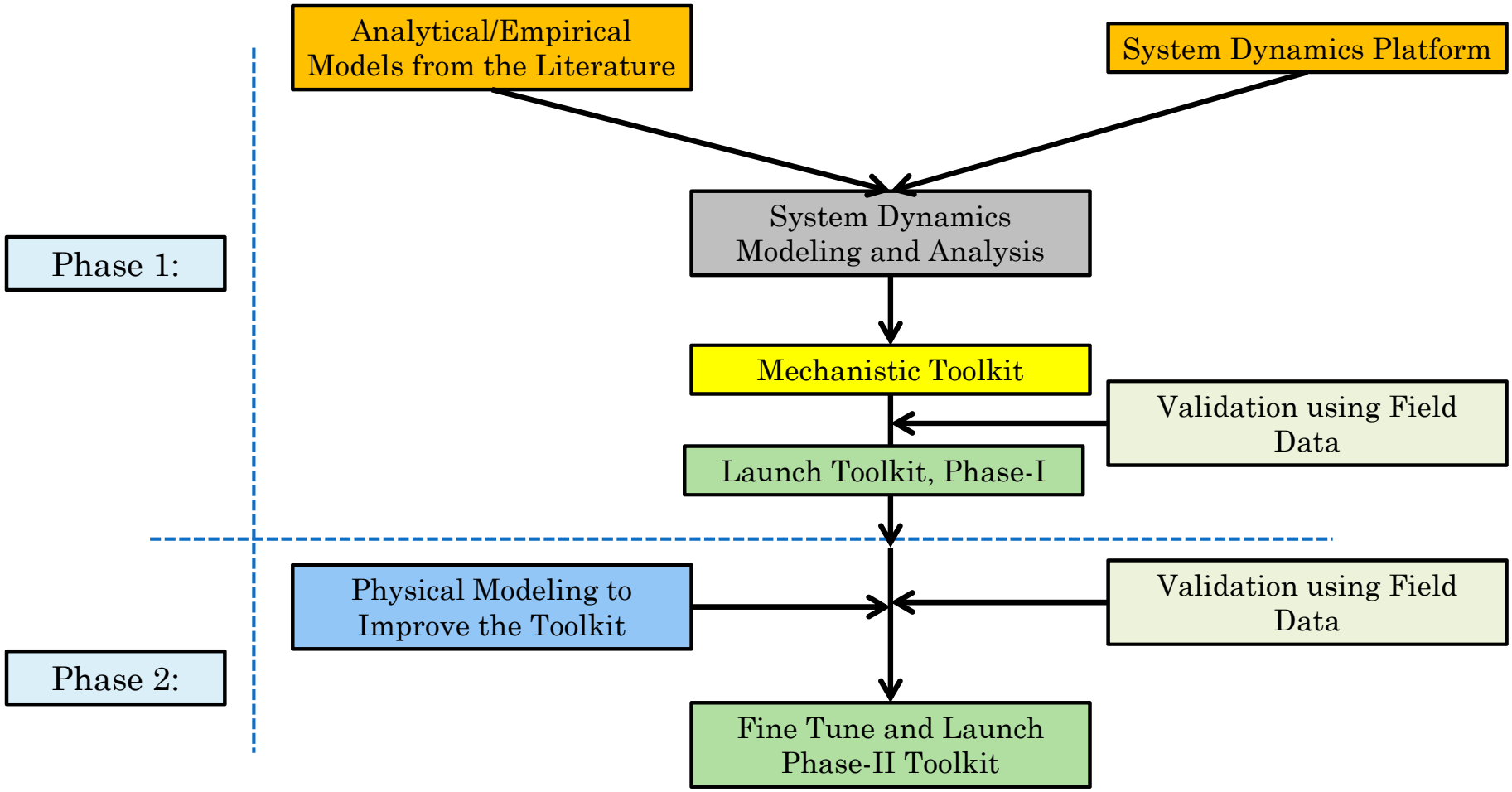
Motivation (cont.)

- Post-flooding traffic allowance and assessment
  - FHWA Flooded Pavement Assessment Study (Sias et al. 2018)
- Reliable pavement bearing capacity and performance assessment system for current and forecasted moisture conditions
- A mechanistic (real-time and forecasting) load restriction decision-platform for:
  - Damage vulnerability determination
  - Access to emergency responders
  - Traffic decisions during and after periods of excessive moisture → especially post-flooding
  - Maintenance and repair planning

Expected Benefits

- Develop a mechanistic framework to improve robustness of the load restriction decision process.
- Improve post-flooding and seasonal pavement capacity assessment.
- Implement a flexible platform that incorporates multi-variant effects with forecasting capability
  - This will be achieved through system dynamics modeling and analysis
- Develop a toolkit validated using field data for load restriction decision, specially for post-flooding load closures and openings.

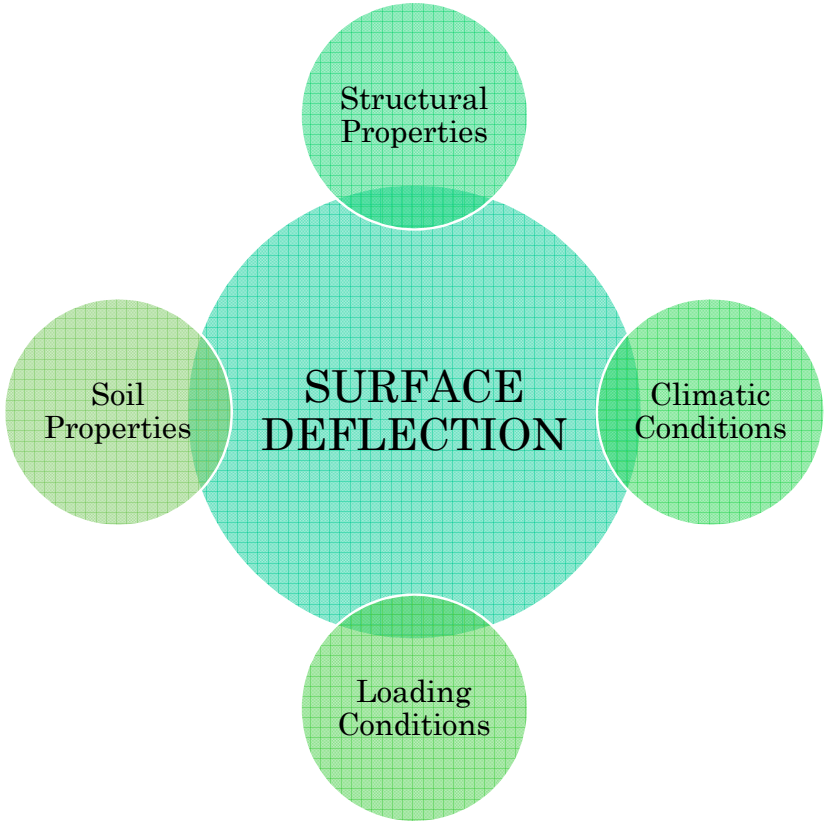
Implementation Steps



Research Approach

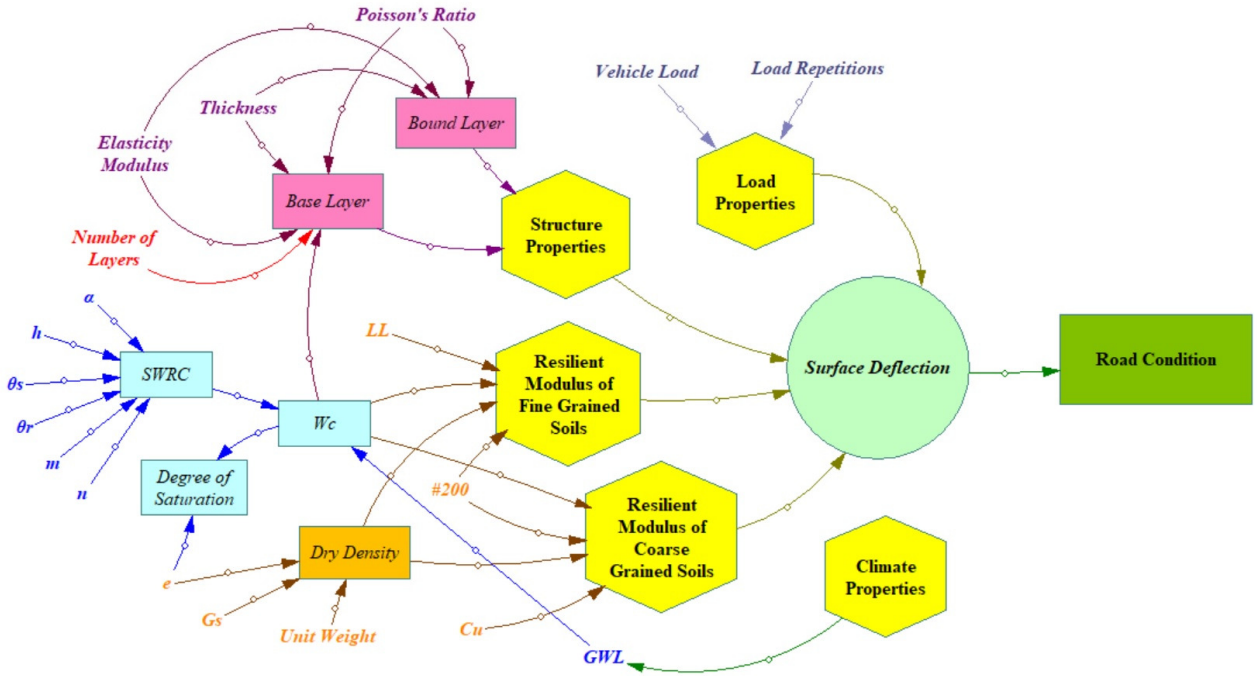
A comprehensive surface deflection platform incorporating components with major effects on pavement systems:

1. *Structural Properties*
   - Pavement layer types, Modulus, Poisson's Ratio, Thickness, etc.
2. *Climatic Conditions*
   - Evaporation, Infiltration, Runoff, etc.
3. *Soil Properties*
   - Soil Type, Density, PI, etc.
4. *Loading Conditions*
   - Vehicle Type, Load Repetitions, etc.



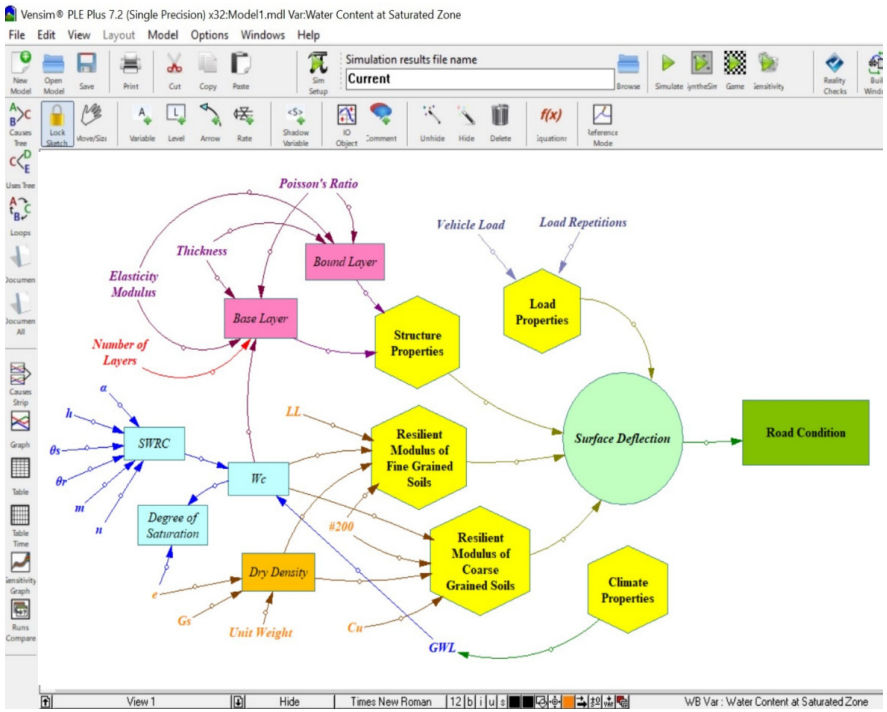
Research Approach

1. *System Dynamics for sensitivity assessment and to refine implementation*
   - Vensim



System Dynamics Approach

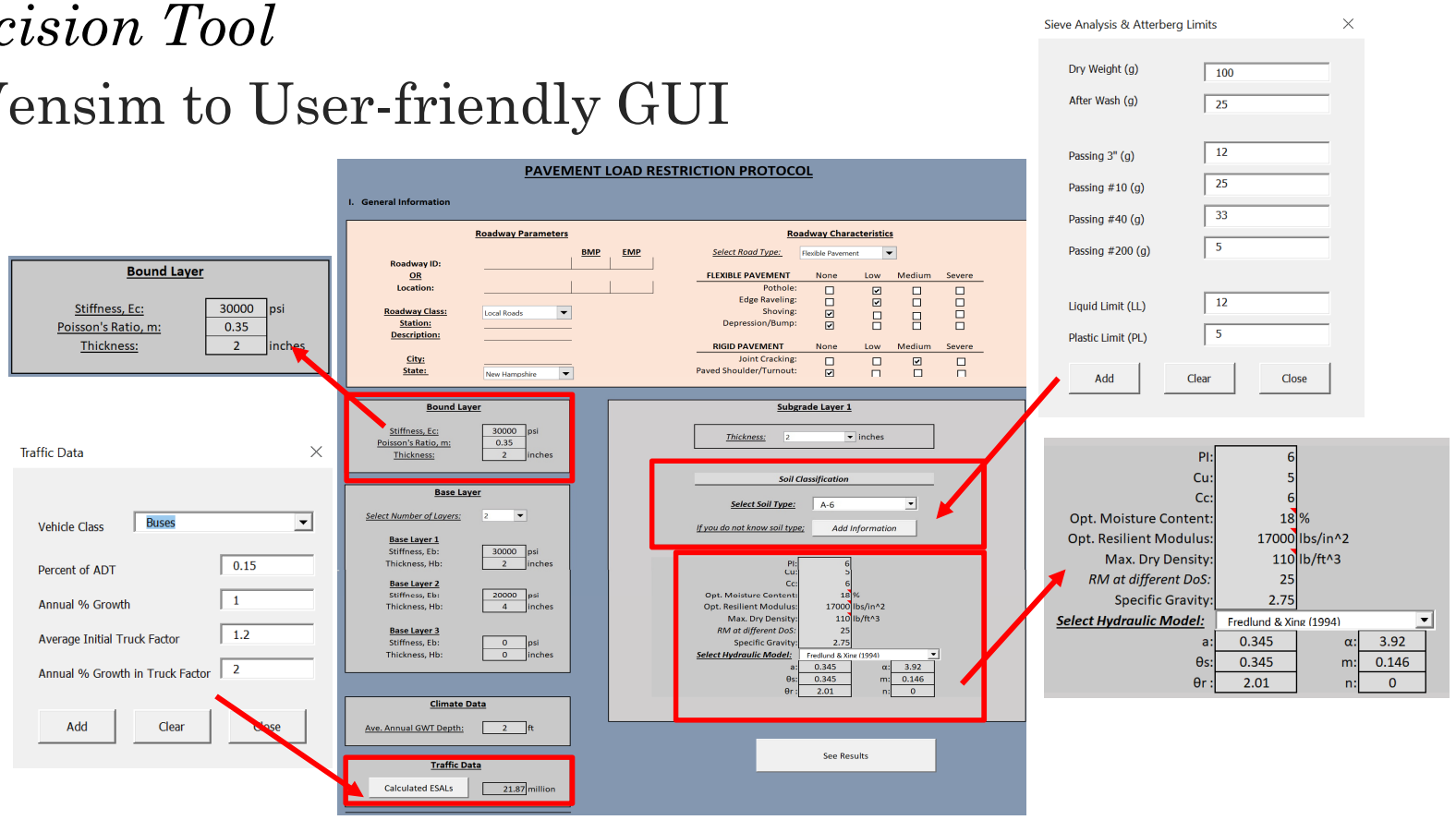
- Vensim is industrial-strength simulation software for improving the performance of real systems.
- Capable of conducting
  - *Sensitivity Analysis*
  - *Reality Checks*
  - *Instant output with continuous simulation*
- Different Models adopted from literature are related with each other using mathematical relationship among them.



Research Approach

2. *Decision Tool*

- Vensim to User-friendly GUI



Research Approach

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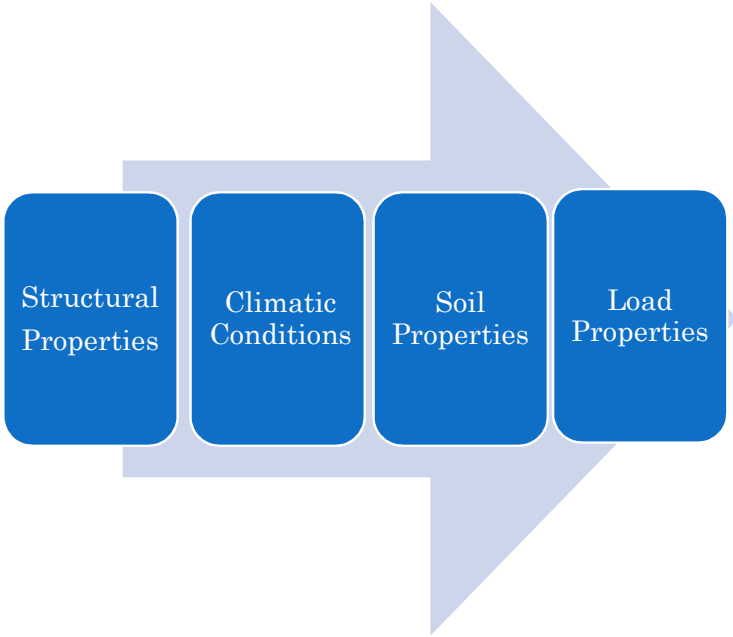

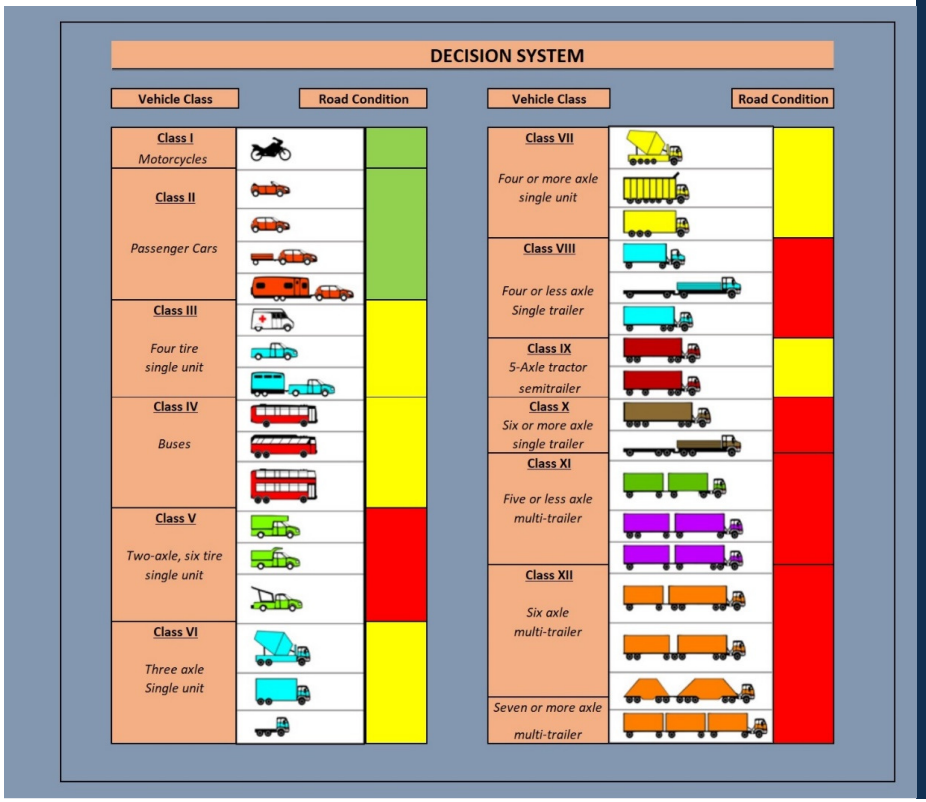

Research Approach

3. *Calibration and Preliminary Validation*

   - MnROAD data for preliminary validation

NRRA Study Research Tasks (24 months)

- Task 1: Initial Memorandum (due 10/31/2019)
- Task 2: Literature Review (due 10/31/2019)
- Task 3: System Dynamics Framework Development (due 3/31/2020)
- Task 4: Sensitivity Analysis and Framework Refinement (due 8/31/2020)
- Task 5: Toolkit Development (09/30/2020)
- Task 6: Calibration and Preliminary Validation of the Toolkit using MnROAD Data (11/30/2020)
- Tasks 7-10: Final Reporting

Thank You!

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