Motivation
There is a need for effective test strategies for autonomous ground vehicle systems. Limited research has investigated general quantitative effects of sources of variability on system and sub-system performance and procedures for quantifying algorithm performance have been developed largely on an ad-hoc case-by-case basis. The current work seeks to understand how error propagates through a system to inform the selection and design of system- and sub-system tests. The results of the work are expected to contribute directly to testing strategies for military AGV and to provide models for understanding error in AGVs.

Fundamental Research Questions
• How does error propagate through subsystems of autonomous navigation software?
• What is the relationship between subsystem performance and system level performance?
• Can system level performance be predicted through decomposition of autonomy software into task-level algorithms and assessment of error on task-level algorithms?

Objectives
• Measure AGV system and major sub-system performance propagation under different sources of variability from raw sensor readings to control outputs
• Develop and test model(s) that correlate subsystem and system level metrics of AGV performance

Approach
AGV detection and avoidance of a jersey barrier (1 m tall x 2 m wide) was simulated on a 90 m test course with a 100 m approach to reach test speed (10 m/s).

Mississippi State University Autonomous Vehicle Simulator with Chrono modeled direct effects of levels of 1 lidar range error, 2 stereo vision quality, 3 RTK pose error, 4 rainfall, and 5 dust on sensors.

Results
8,900 simulations were performed to test the 3 algorithms in ideal conditions and multiple levels of error conditions. Trials ended with one of four outcomes: Collision, Rollover, Timeout, or Success.
• System performance varies by error source and by algorithm.
  • Current system-level testing has proven to be highly discriminative.
  • Error source affects propagation of error through sub-systems.
• Current sub-system metrics do not fully characterize the effects of the error sources. Additional work is needed to identify effective general metrics for sub-systems.

Future Work
• Implement path planning (e.g., A*, D*, Potential Field) and control algorithms (e.g., pure pursuit) in the autonomous architecture.
• Add Bekker-Wong vehicle-terrain interaction models to simulate effects of variation in soil types and tire slippage.
• Identify other sources of variability (e.g., obstacle size and shape) that can be tested in real-world conditions.
• Implement algorithms on available AGV hardware and update vehicle models to match.
• Collect real-world data to validate simulation results.