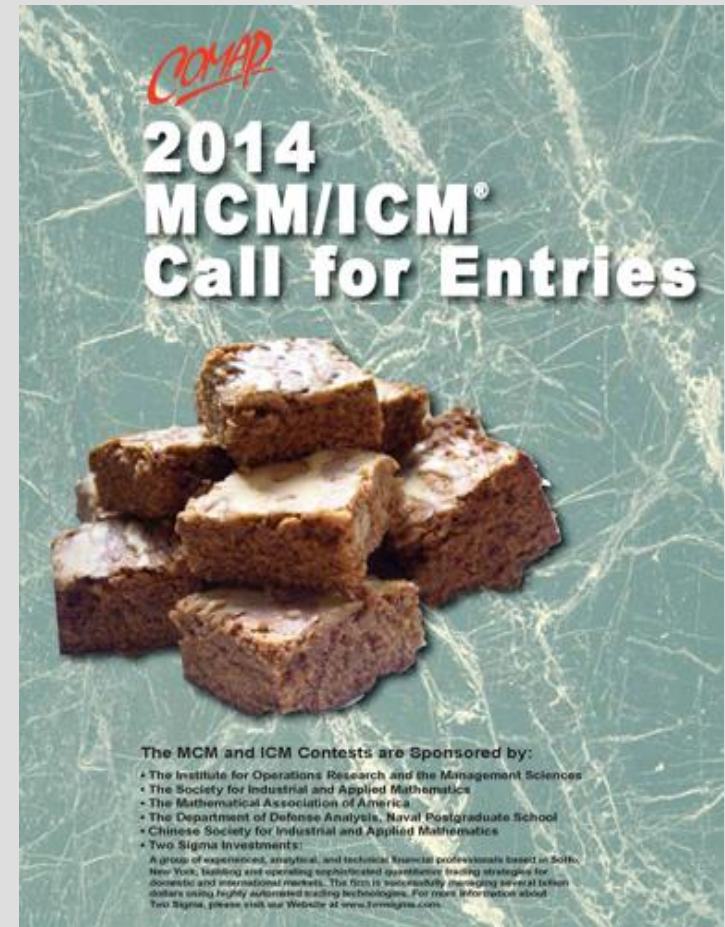


Mathematical Modeling of Highway Traffic Policies

Ben Squire, Nate Minor, John-Paul Mann

Mathematical Competition in Modeling

- 96-hour International Math Competition organized by COMAP
- Prompt:
 - Model and analyze the efficiency and safety of the Stay-Right-Except-to-Pass highway traffic policy
- Over 8000 teams
- Awarded 'Meritorious' (top 10%)



The poster features a green background with a white, fibrous, web-like pattern. In the top left, the COMAP logo is written in red. The main title '2014 MCM/ICM® Call for Entries' is in large, bold, white letters. Below the title is a stack of several brownies. At the bottom, there is a list of sponsors and a paragraph of text.

COMAP

2014 MCM/ICM® Call for Entries

The MCM and ICM Contests are Sponsored by:

- The Institute for Operations Research and the Management Sciences
- The Society for Industrial and Applied Mathematics
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Approach

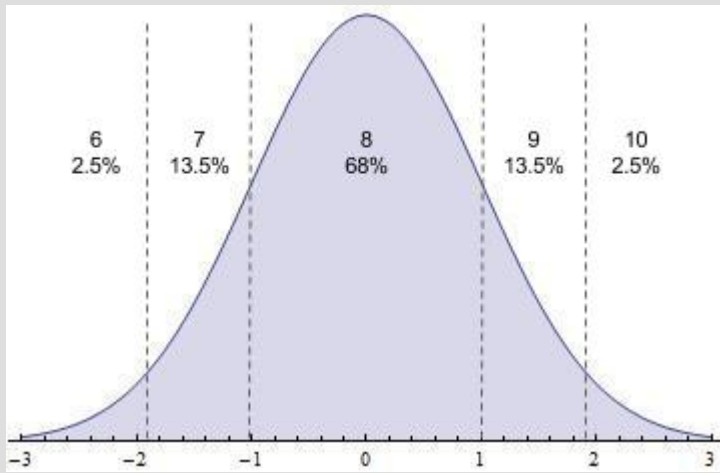


- **Macroscopic Model: Differential Equations**
 - Fluid Dynamics: Convection-Diffusion Equation
 - Lighthill-Whitman-Richards Model
- **Microscopic Model: Agent-Based**
 - Proto-Model

Assumptions & Definitions

- No Exit or Entry Ramps (Conservation of Cars)
- Identical Vehicles (length, driving ability, braking ability)
- Lane width, road curvature, shoulder width, and weather are *not* considered in our analysis
- Only Side-Swipe and Rear-End Accidents
- Accidents are only counted, they do not actually happen during the computer simulation
- Normal distribution of initial velocities
- Uniform random initial positions of vehicles

Simulation Scaling

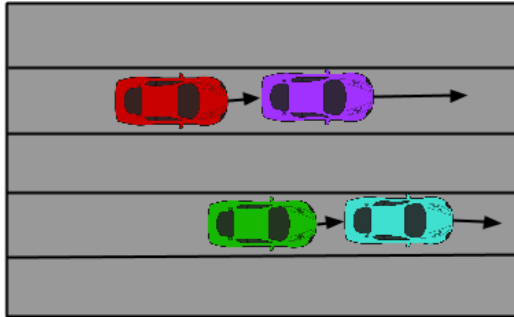


- Road Length: 10,000 tiles
- High Density: 75% tiles occupied by vehicles
- Low Density: 25% tiles occupied by vehicles
- 500 iterations per simulation (approx. 8 minutes)

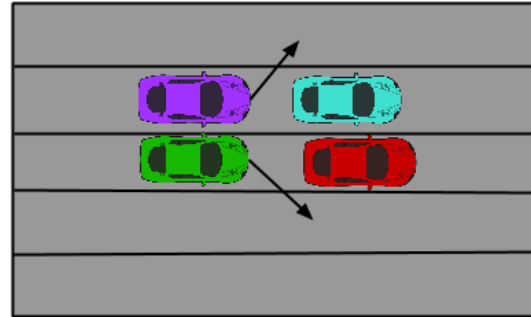
Simulation Speed	Real Speed	
	(MPH)	(KPH)
Tiles/Iteration		
6	54	86
7	63	101
8	70	115
9	80	130
10	90	144

Road Rules

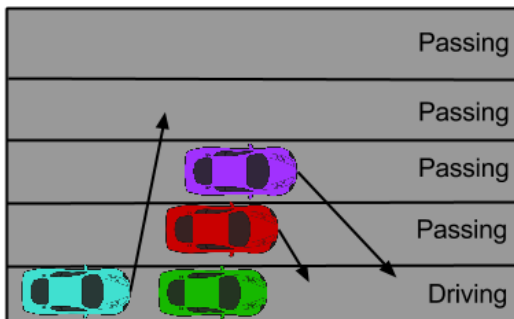
No Passing



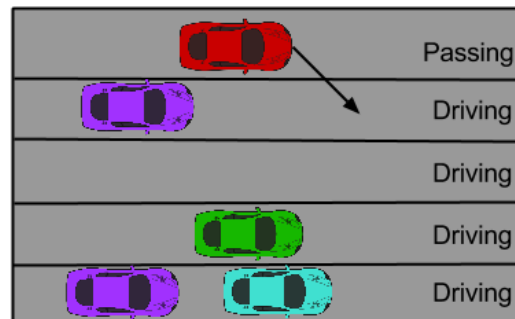
Free Passing



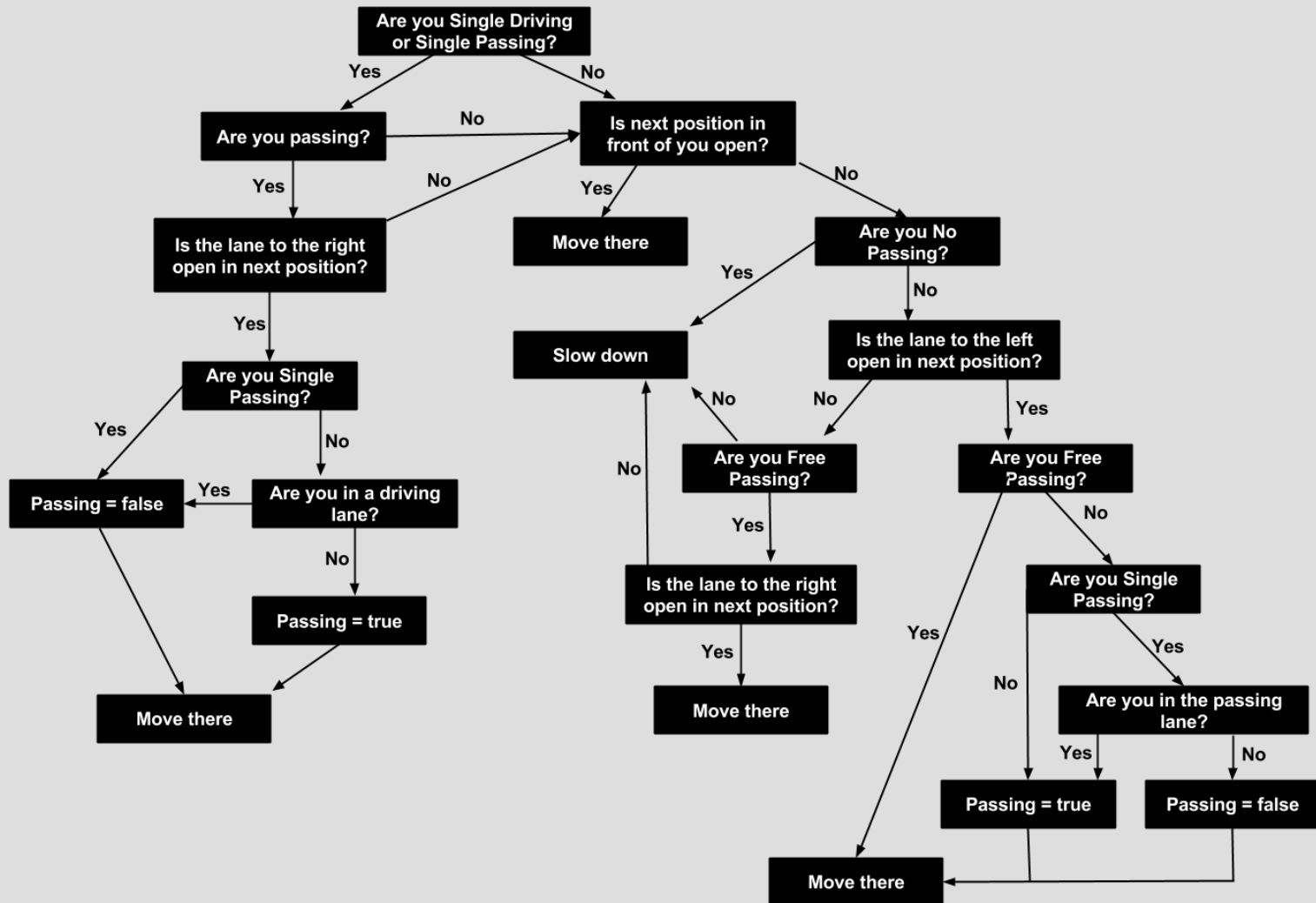
Single Driving



Single Passing

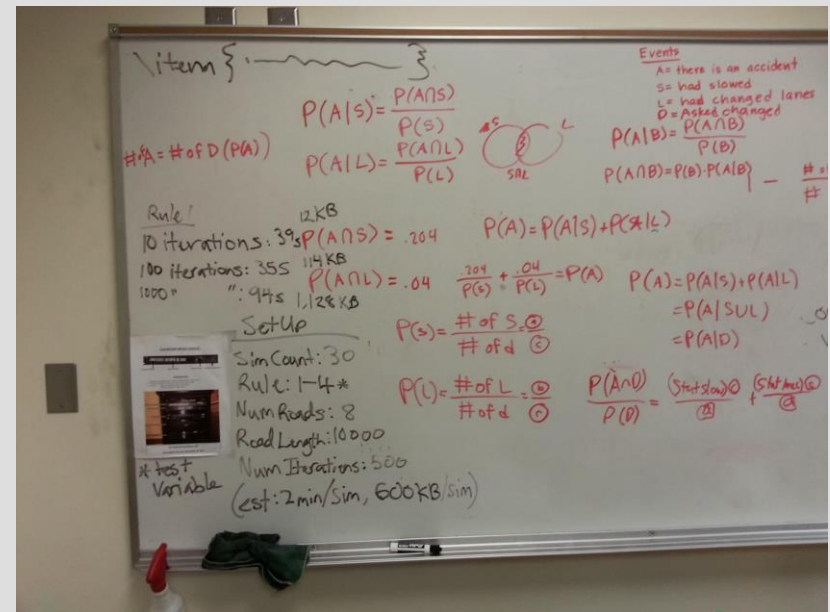


Vehicle Interaction Decision Tree

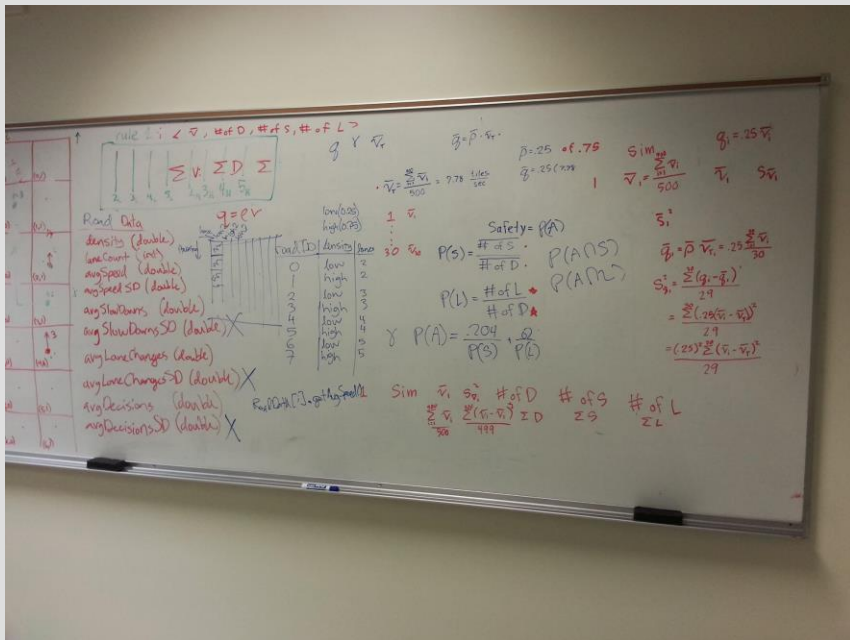


Experimental Methods

- Test 4 passing rules on 8 different road types (high/low density, 2-5 lanes)
- Run 30 computer simulations per passing rule
- Compare the average vehicle speed, average traffic flow, and average safety rating for each rule paired with a road type (i.e., compare free passing to single driving for a high-density 3-lane road)



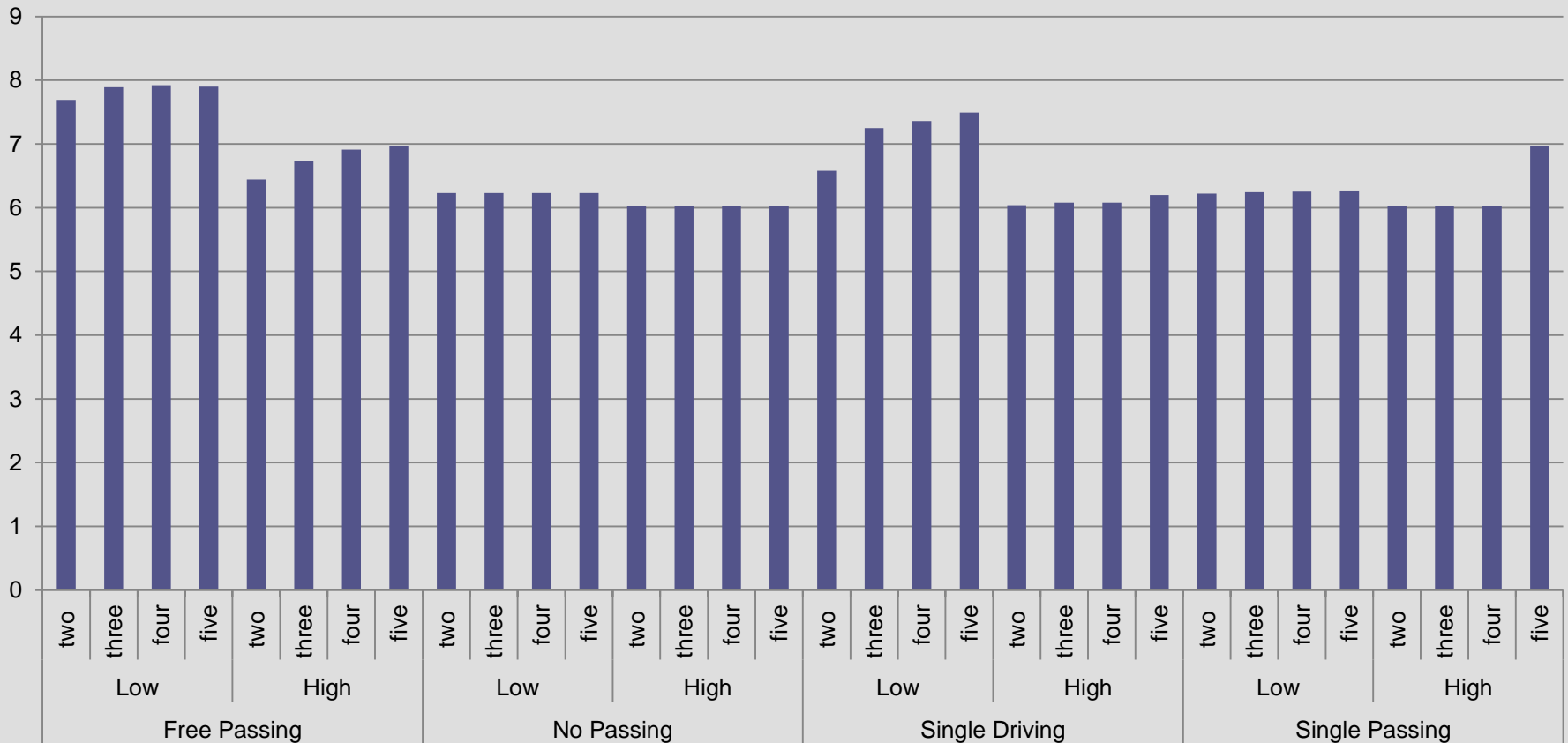
Simulation Data



- Collected per Iteration:
 - Average vehicle speed
 - Number of decisions
 - Number of lane change
 - Number of slow downs
- Calculated at the end of each Simulation:
 - Average vehicle speed
 - Average number of decisions
 - Average number of lane changes
 - Average number of slow downs

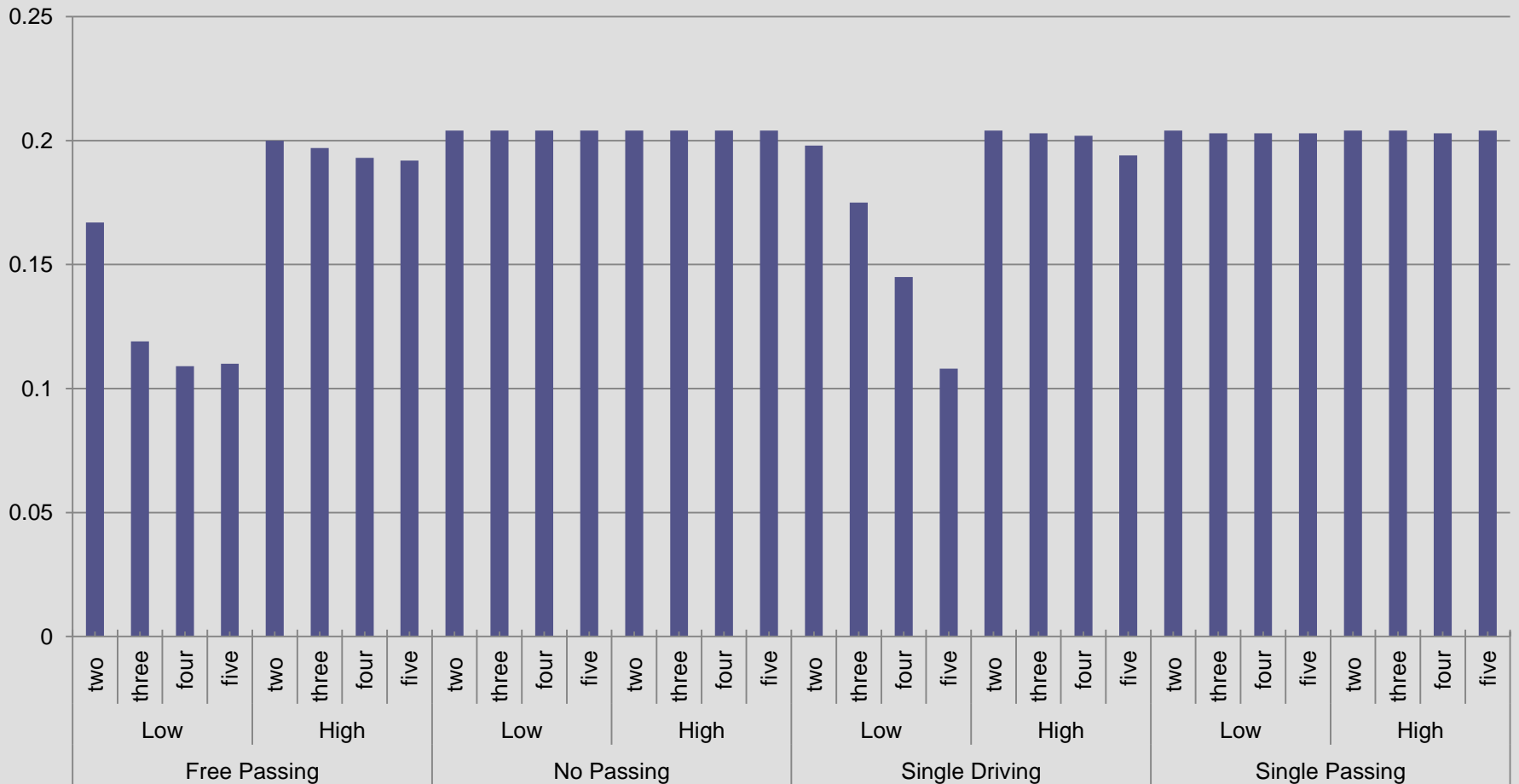
Simulation Results

**Average Vehicle Speed
(tiles per iteration)**



Simulation Results

Average Safety Rating



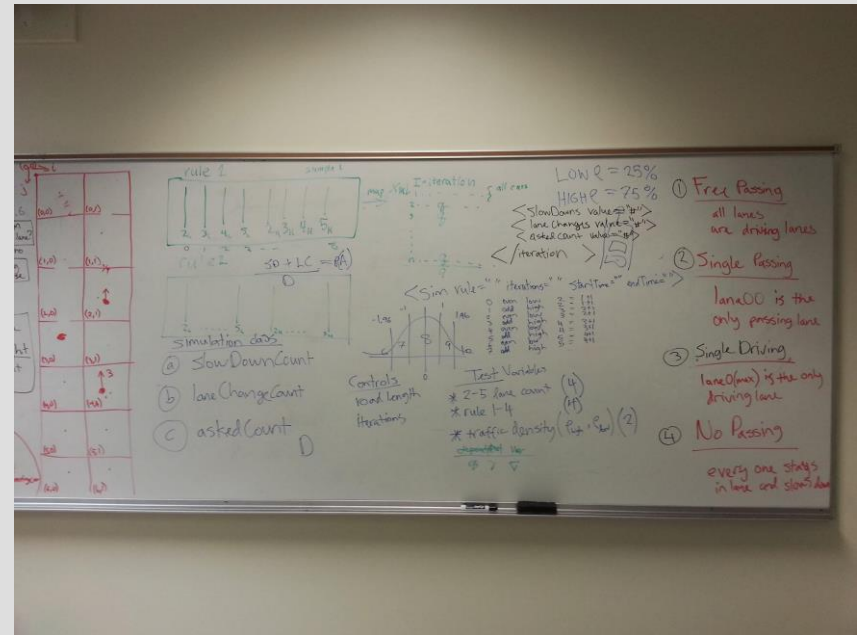
Conclusion

Free Passing: highest average traffic flow, highest average vehicle speed, & lowest average safety rating for all traffic densities and lanes counts.

Free Passing vs. Single Driving		
Lane Count : Density	Tests Flow (z-Score)	Tests Speed (z-Score)
2: Light	45.88	45.88
2: Heavy	26.74	26.74
3: Light	51.51	167.08
3: Heavy	43.04	108.69
4: Light	44.69	44.69
4: Heavy	87.26	87.26
5: Light	50.45	50.45
5: Heavy	22.45	121.39

Challenges & Solutions

- Challenges
 - Exporting XML to Excel without Macros
 - Interpreting results
- Solutions
 - Perform summary statistics in Java
 - Review statistical analysis step-by-step



Further Research

- Simulation data moved to a database
- Graphical User Interface (GUI) for 'playing-back' simulation data
- Individualized Vehicle Rules
- Variations in Driver Psychology
 - Oncoming Traffic
 - Condition of Road
 - Weather
 - Following Reaction Time

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