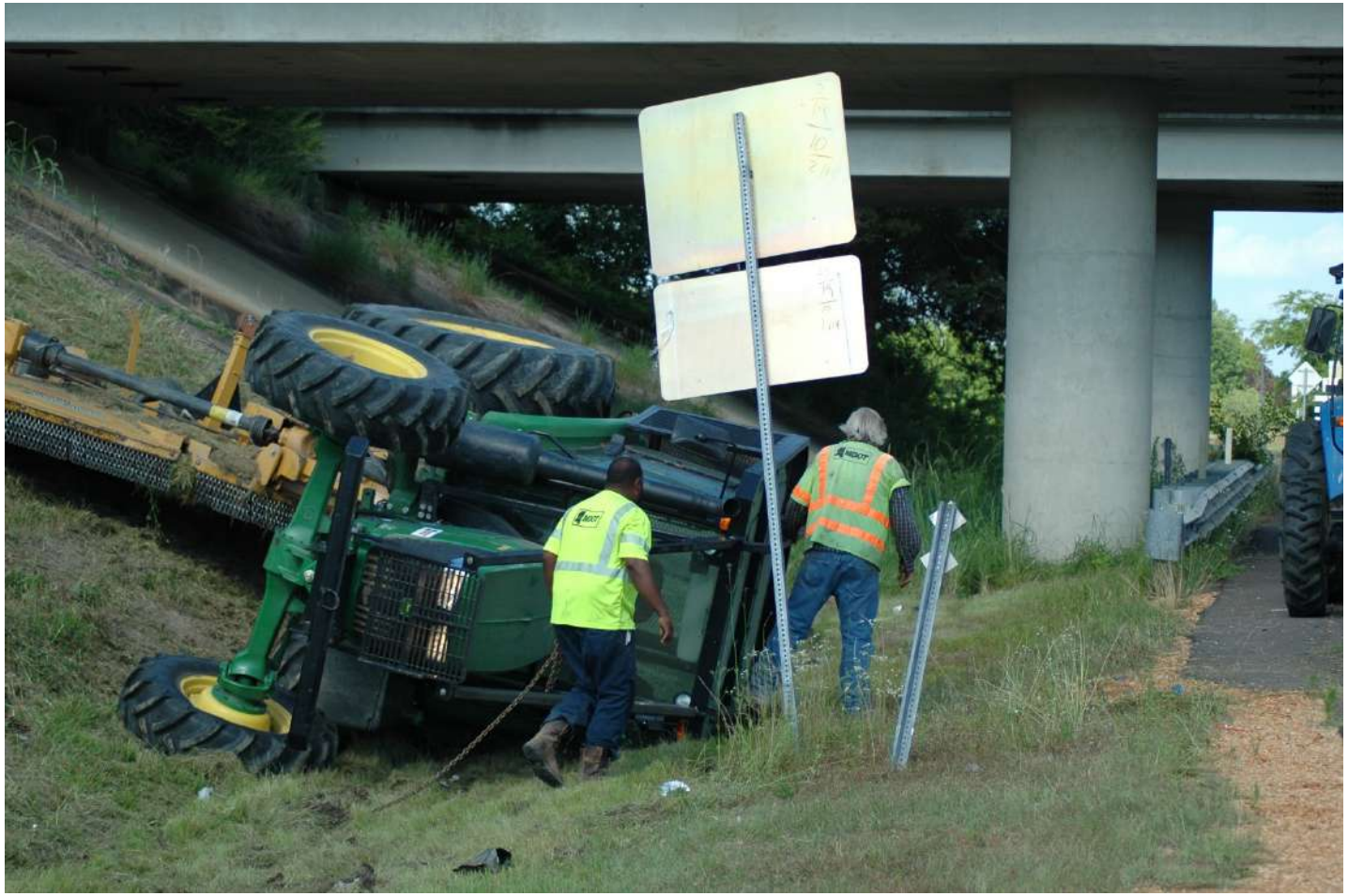
Exploring Simulator Options for MDOT Maintenance and Transit Operator Training

MSU CAVS: Daniel Carruth, John McGinley
MDOT: Cindy Smith, Rhea Vincent

A quick story…



MSU-CAVS / MDOT Project Objectives

- Task 1: Literature Review
- Task 2: Review of Simulation Use (DOTs)
- Task 3: Review of Simulation Use (Industry)
- Task 4: MDOT requirements
- Task 5: Vendor Discussions

Task 1: Literature Review

- Over 30 papers reviewed
- Information synthesized in a matrix of topic areas
  - Simulation fidelity, application areas, effectiveness in training, best practices, previously published reviews
- Findings
  - Performance metrics increased in simulation
  - Difficult to assess real world impact

- Transit Cooperative Research Program Report 72: Simulators and Bus Safety: **Guidelines for Acquiring and Using Transit Bus Operator Driving Simulators.** (2001)

Transit: Literature Review

- Some evidence for effectiveness
  - Reported effects
    - Operational costs <10% of training with real buses
    - Reduced length of training (by 2-5 days)
    - Potential revenue in providing training to other agencies
    - 10-60% reduction in collisions
    - 30-50% reduction in dropouts, course failures during training
  - Increases engagement
  - No evidence of negative effect
  - Mixed/limited evidence on transfer from simulation to real world
  - Useful for teaching ‘fundamentals of bus operation’

Tasks 2 & 3: Review of Simulation Use

- State DOTs
  - Email solicitation followed with phone and email interviews
  - 13 total completed surveys (additional contacts did not result in usable survey information)
  - Simulators:
    - Mostly snow plow
    - Several transit / bus
    - Some heavy equipment (front-end loader, grader)
    - Two reported no simulator use
    - Some actively use simulators for training
    - Some use simulators once per year
    - Some have simulators, but do not use them (old, out of date)
- Industry
  - Limited contacts
  - Vendors offered testimonials, potential contacts

Task 4: MDOT Requirements

- Initial meeting to discuss literature review, initial DOT and industry discussion
- Meetings and interview to discuss requirements
  - Discuss specific needs for maintenance and transit operations
  - Interviews with:
    - Maintenance managers
    - Transit managers
    - Safety
    - Research

Driving Simulator Requirements Documents

Mississippi Department of Transportation

High Quality Simulation for Maintenance and Transit Operator Training

System Requirements: Transit Simulator

Version 1.0 – 3/25/2019

Mississippi Department of Transportation

High Quality Simulation for Maintenance and Transit Operator Training

System Requirements: Tractor Simulator

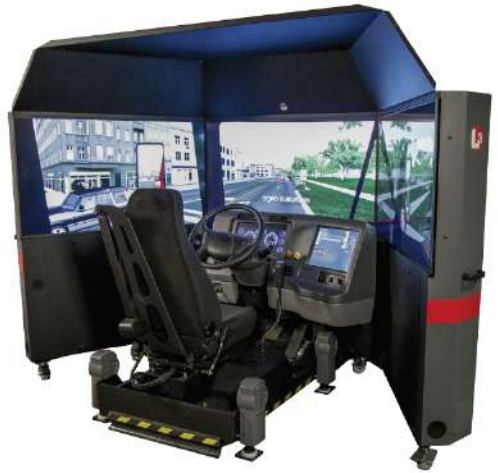
Version 1.0 – 3/25/2019

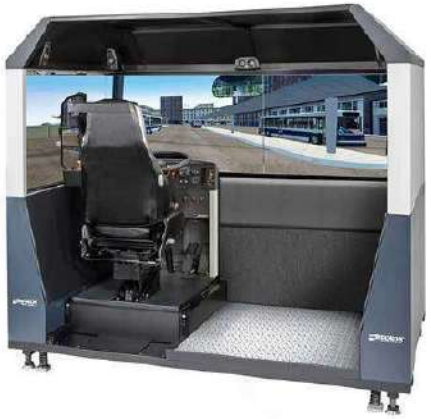
Task 5: Vendors discussions

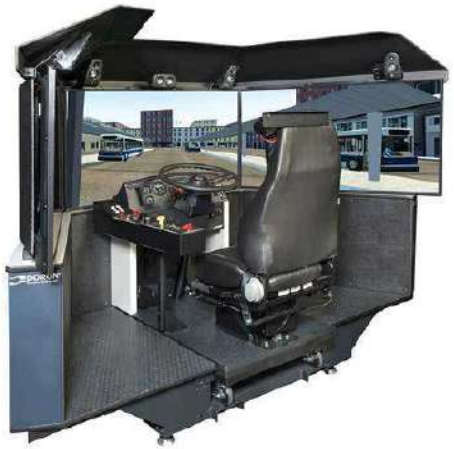
- Sorted into two types:
  - Transit
  - Maintenance

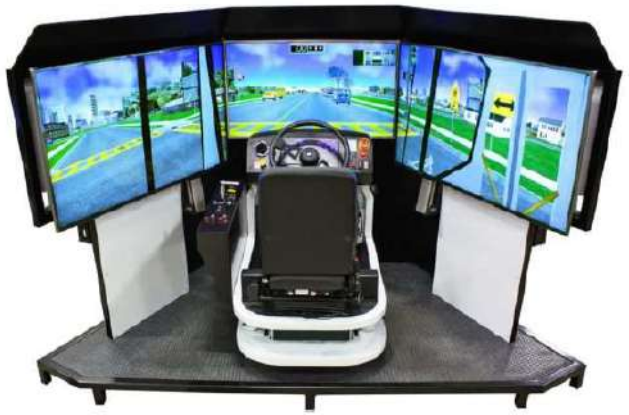
Transit Driving Simulators

- Most providers deliver standard curriculum, pre-loaded scenarios, maps, etc.
  - Providers can provide custom scenarios
- Complete solutions available from at least 3 driving simulation vendors
  - Customizable software and hardware
  - Widely used
  - Standard training materials









Transit Driving Simulator Recommendation

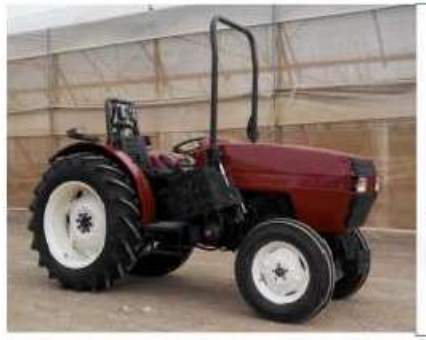
Pick one!

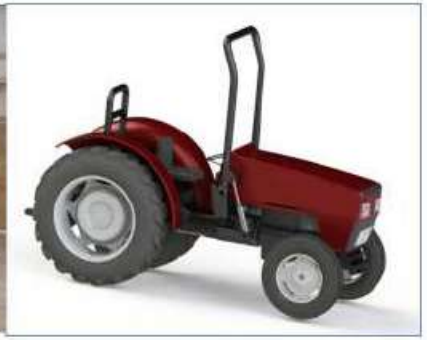
Literature Review: Maintenance Operator Simulation

- Limited or no commercial simulators for tractor operators
  - Even less evidence of commercial simulators for rollover prevention
- Range of Agricultural and Construction Simulation platforms
  - Earth movers, cranes, front-end loaders, etc.
  - **No farm tractors**
- Recent research on Tractor Roll Over Protection Systems and driving simulators
  - Kihl and Wolf – Snowplow simulators
  - Gonzalez et al
  - Llaras et al

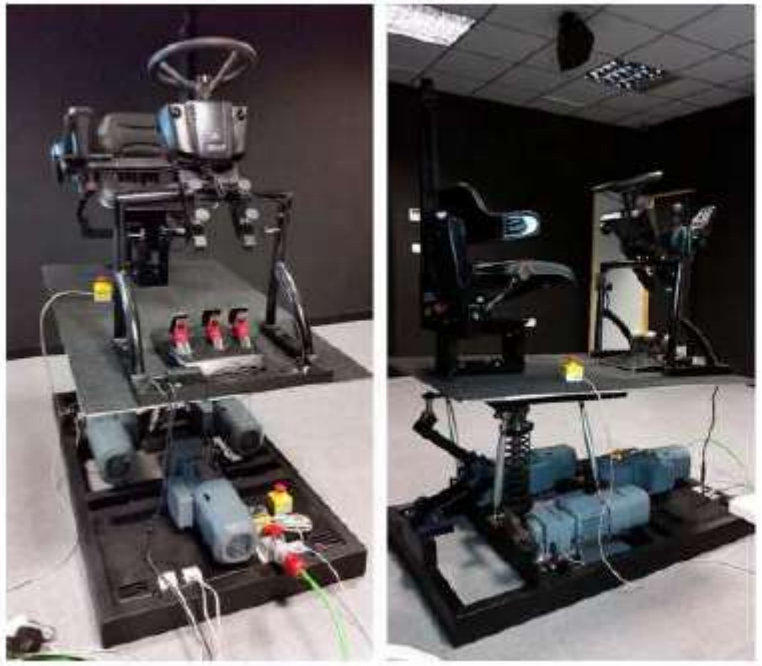
Gonzalez, et al, 2017 – Tractor Driving Simulator

- EU research project
- 40% of serious injuries and deaths in tractor rollover occurred when foldable ROPS was not deployed
- Project developed a VR HMD-based simulator to familiarize operators in use of ROPS
- Used Gaming Technologies
  - Built using Unity, NVIDIA PhysX, etc.
  - Custom motion base developed by University of Valencia
  - Modeled on CASE IH-2120 Tractor





Gonzalez Simulator



Gonzalez Simulator

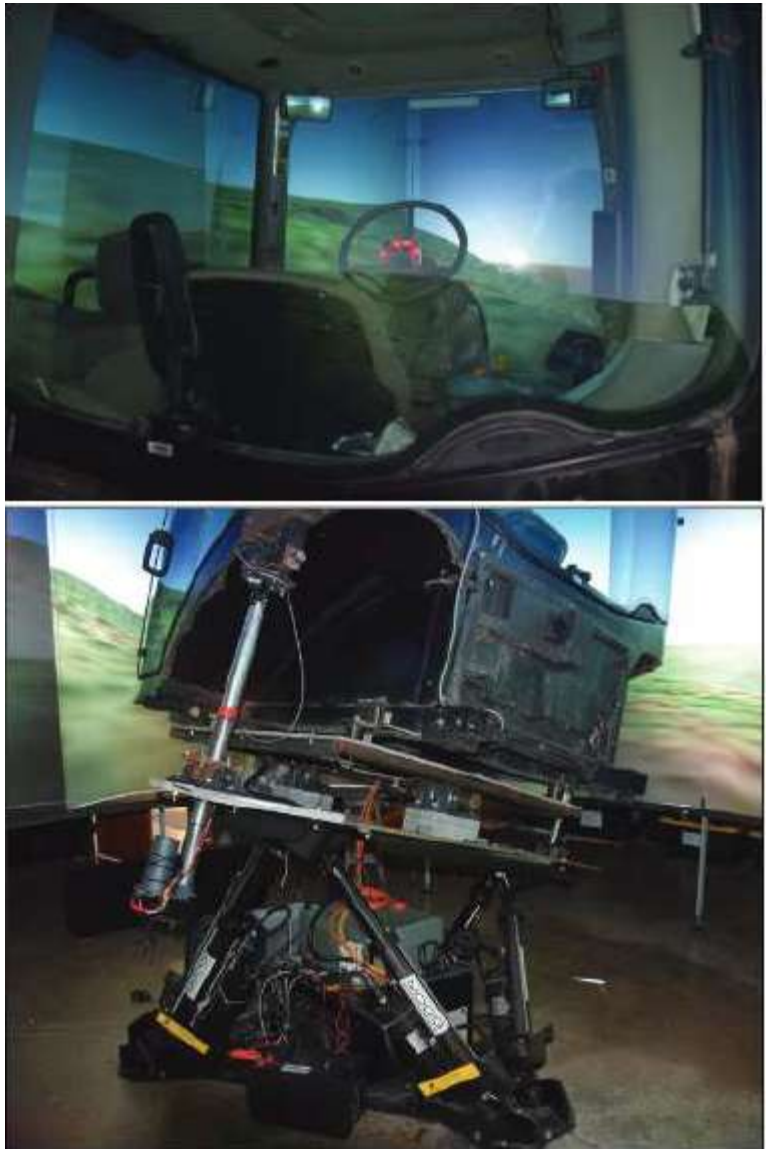
- Participant feedback
  - Students in training courses made fewer errors in deploying the ROPS
  - Perception of risk and safety increased after the simulator experience
  - Participants believe tractor driving simulator can help them drive more safely
  - All participants considered training to be a very positive experience

Lleras, et al, 2016 – Open source tractor driving simulator

- Penn State research project for Northeast Center for Occupational Health and Safety
- 43% of tractor deaths associated with overturn incidents
- Develop simulator for tractor stability tests
  - Reduce costs associated with driving simulation systems
- Viewing directions
  - Tractor drivers often look to side and rear of vehicle
  - Simulator must provide 360 degree FOV
- Slope – 12 to 15 degrees requires motion base

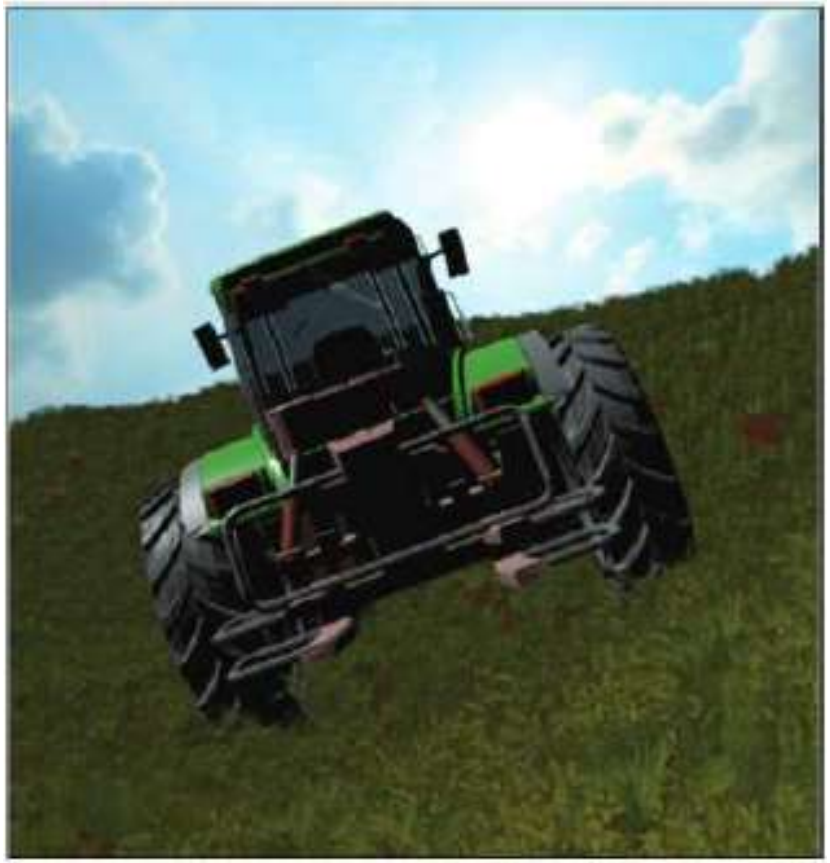
Lleras simulator

- 360 degree multi-panel screen display
- Custom motion base
  - Based on Moog industrial robot
  - Electric linear actuators, roll angle sensors
- Visuals
  - Built on robot control software (ROS) and associated simulation software (Gazebo)



Lleras simulator

- Developed custom hardware, software
- Expensive hardware
- Low upfront cost on software
- Limited or no support for software



Tractor operator simulator publications

- No further publications from these groups.
- Team spoke to both the Gonzalez team and the Lleras team
  - MARTÍN GÓRRIZ, BERNARDO
  - b.martin@upct.es

  - Brennan, Sean N
  - snb10@psu.edu

Tractor Driving Simulators Requirements Document

Mississippi Department of Transportation

High Quality Simulation for Maintenance and Transit Operator Training

System Requirements: Tractor Simulator

Version 1.0 – 3/25/2019

Vendor Discussions

- 11 vendors initially identified
- Phone/email interviews followed by detailed technical discussions
- Discussions at the 2019 Driving Assessment Conference
- 4 vendors not interested in pursuing further discussions
- 4 vendors identified as “willing and (potentially) able”

Tractor Driving Simulator Recommendation

General:

- Proven track record
- Willingness to take on this project
- Demonstrated understanding of the complexity / issues
- Ability to partner with HW/SW vendor as necessary

Candidates:

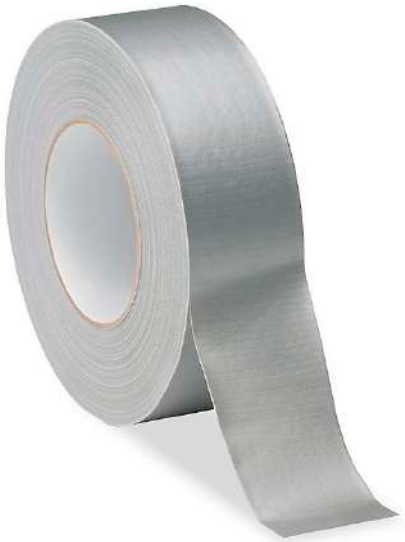
- 4 vendors selected for next round of discussions

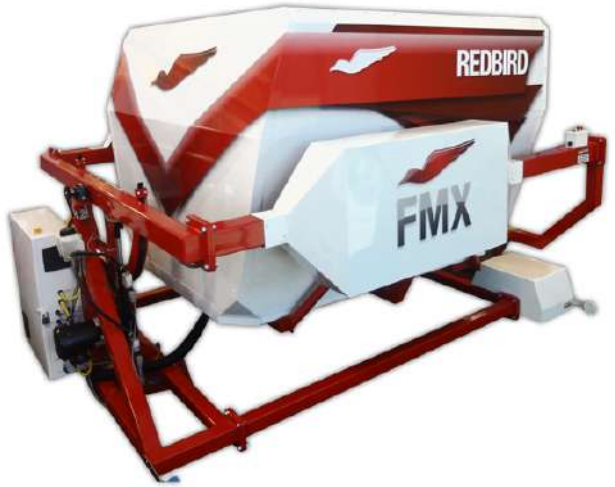
Challenges

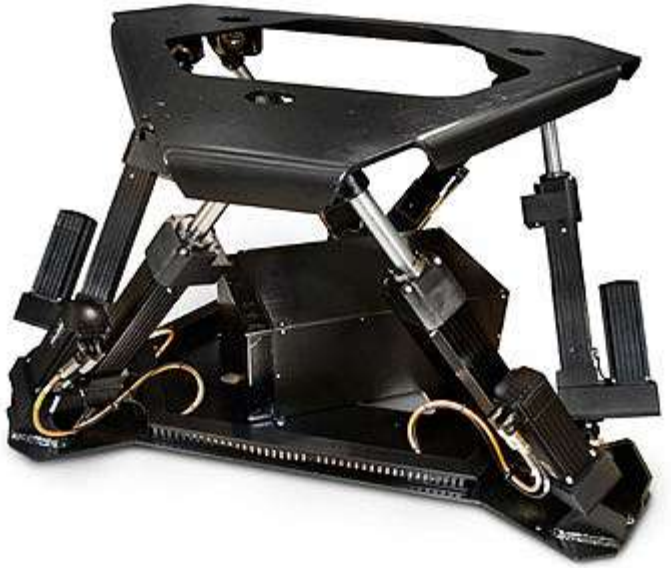
- No current simulator exists that meet these requirements
- Typical driving simulator motion platforms have limited roll angle
- Field of view requirements
- VR (if used)
  - Registration with physical world (hands, controls, etc.)
  - Simulator sickness
- Portability
- Cost

Next?

- Tip some tractors!
- Get creative!







Thanks to:

- Mississippi Department of Transportation
  - Cindy Smith
  - Rhea Vincent

- All the Women and Men who keep our highways maintained and beautiful

- All the Women and Men who keep our bus systems running

Thank YOU!