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Analysis of Small Unmanned Ground Vehicle Mobility Performance Algorithms

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Presented to Working Group 10 and 11

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Presentation Overview

- Project Overview
- ERDC SUGV testing data analysis
- Algorithm Analysis
- Terrain EDM Analysis
- Performance Comparisons
- Future Work
- Summary

Project Overview

Objectives

- Investigate small vehicle terrain interaction for on-road, off-road, and building material (curbs, stairs, carpet) surfaces and develop associated algorithms if required

- Enhance/verify use of the Standard Mobility API algorithms for estimating mobility performance of unmanned vehicles (10-5000 lbs)

Technical Approach and Goals

- Review of existing algorithms and available small vehicle data
- Identify terrain surfaces and conditions for which data is needed
- Identify and develop an approach for modeling electric powered vehicles in a trafficability/mobility model
- Develop approach for estimating effect of remote and autonomous operation on ground vehicle performance

Literature Review

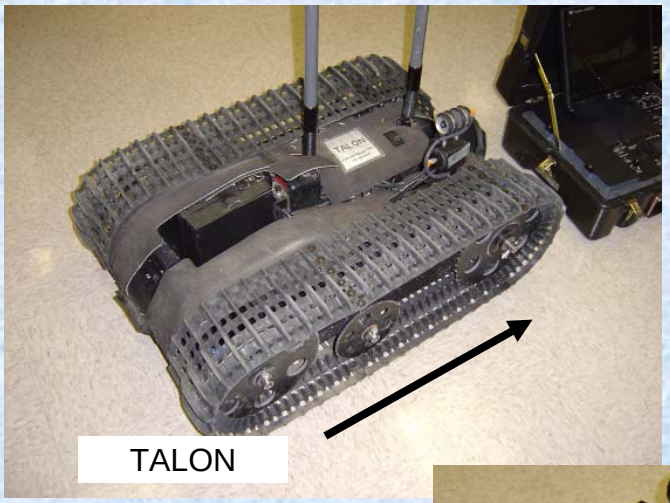
- Searched several databases with these key words:

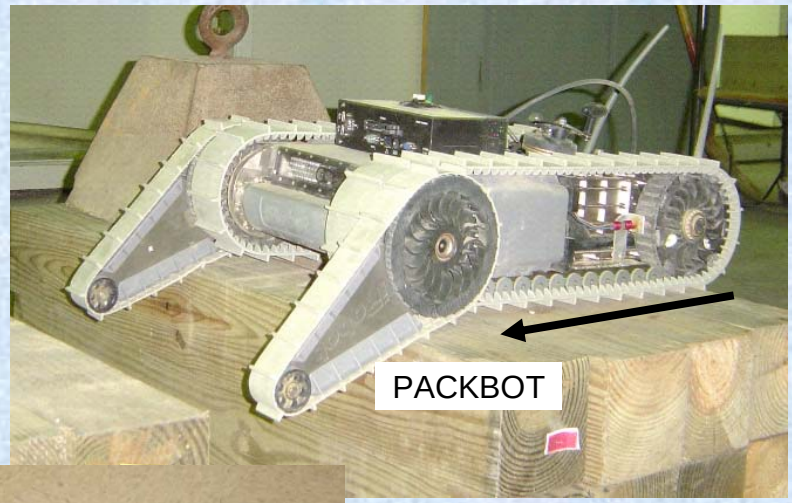
  unmanned ground vehicle, sugv, ugv, speed, mobility, robot, remote, autonomous, scale model
- Identified over 80 documents which contained data or other information which might be useful in the development of SUGV mobility performance algorithms
- However no comprehensive mobility performance study was found, principally found proof of concept, exploratory or reports of demonstrations

SUGV Test Data Analysis

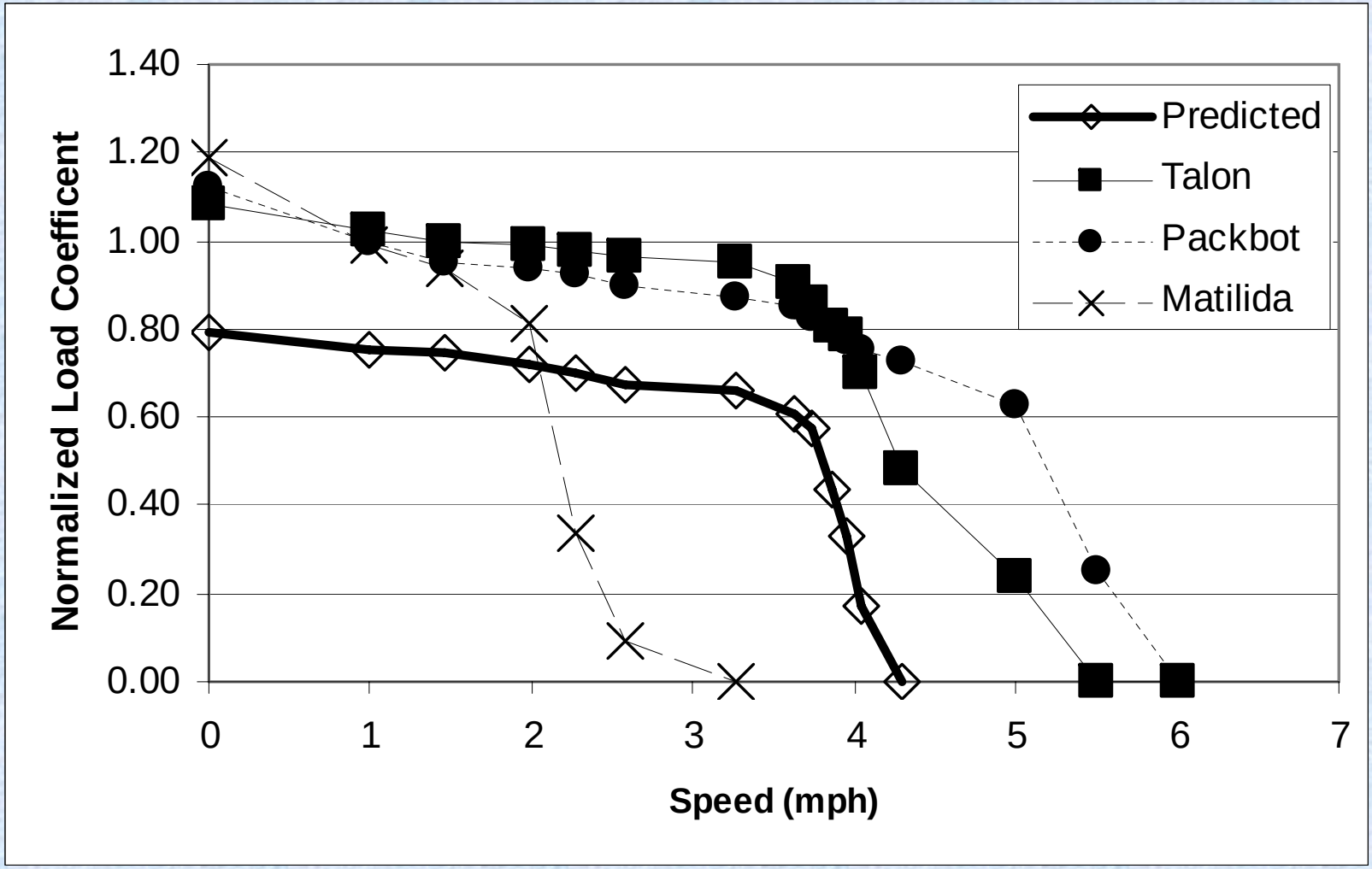
- ERDC had previously conducted limited mobility performance tests for 3 SUGV
- Analysis of data completed, developed NRMM and STNDMob data files based on these tests
- TO DO: compare model predictions with observed performance

SUGV'S Tested at ERDC





SUGV Test Data Analysis



SUGV Test Data Analysis

Stair Climbing

- The TALON was the only vehicle recorded as a no-go.
- Vertical step of 8 inches
- Horizontal step of 5.5 inches

Algorithm Analysis

Based on full sized manned vehicles:

- 19 vehicle performance algorithms identified
- 9 algorithms are based on driver behavior (e.g. ride comfort, reaction time)
- Most significant issue is scaling of obstacles (geometric and vegetation)

Levels of Autonomy

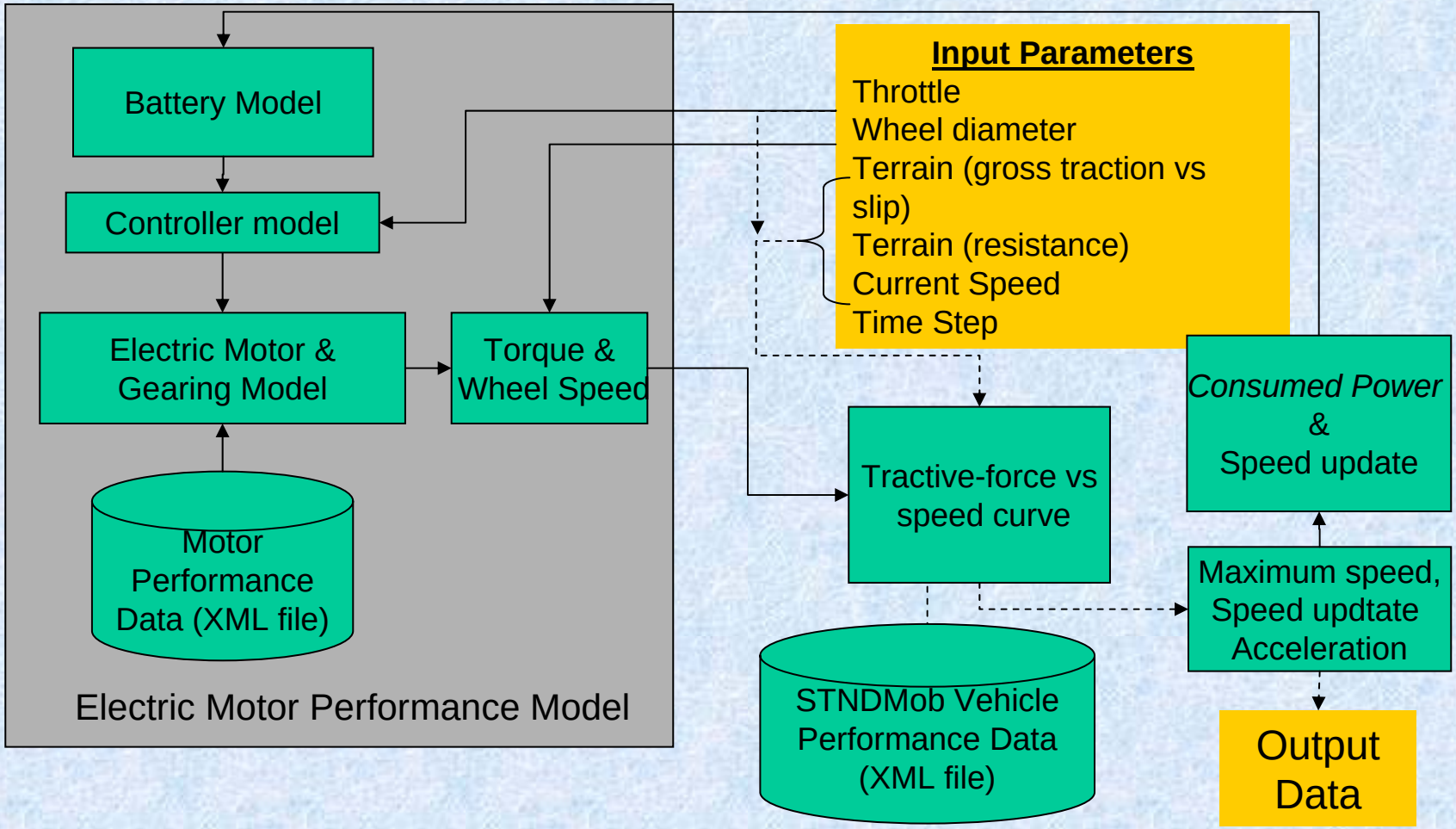
- 10 levels of autonomy defined by ALFUS working group[1]
- Most significant issue is characterizing ANS (Autonomous Navigation Systems) time delay

[1] http://www.isd.mel.nist.gov/projects/autonomy_levels/

Mobility Performance Algorithms:

- Tractive-force vs speed equation hyperbolic curve fit
- Dry and wet road surface friction coefficients for driving and braking
- Soil and road surface resistance (self-propelled or towed), Snow resistance
- Obstacle forces
- Slope effects (gravity)
- Vehicle cornering resistance (Wheeled/Tracked)
- Acceleration and deceleration
- Speed limited by sliding or tipping on curves
- Vegetation limited speed
- Visibility limited speed
- Ride (roughness, shock) limited speed
- Tire limited speed

Conceptual Electric Vehicle Trafficability Model



(dashed lines show current STNDMob API for full sized vehicles)

Terrain Environmental Data Model (EDM) Analysis

- STNDMOB based on OneSAF EDM (Terrain)
- SUGV also need to be able to move over building materials, as described by the OneSAF Ultra High Resolution Building EDM
- 4 building components identified:
  - Floor construction type
  - Stair construction type
  - Roof assembly type
  - Ventilation duct material type
- Modify STNDMob to recognize these materials, modify vehicle data file to contain performance data for these materials

Roofing Material Examples

Built-up roof with three different surfaces

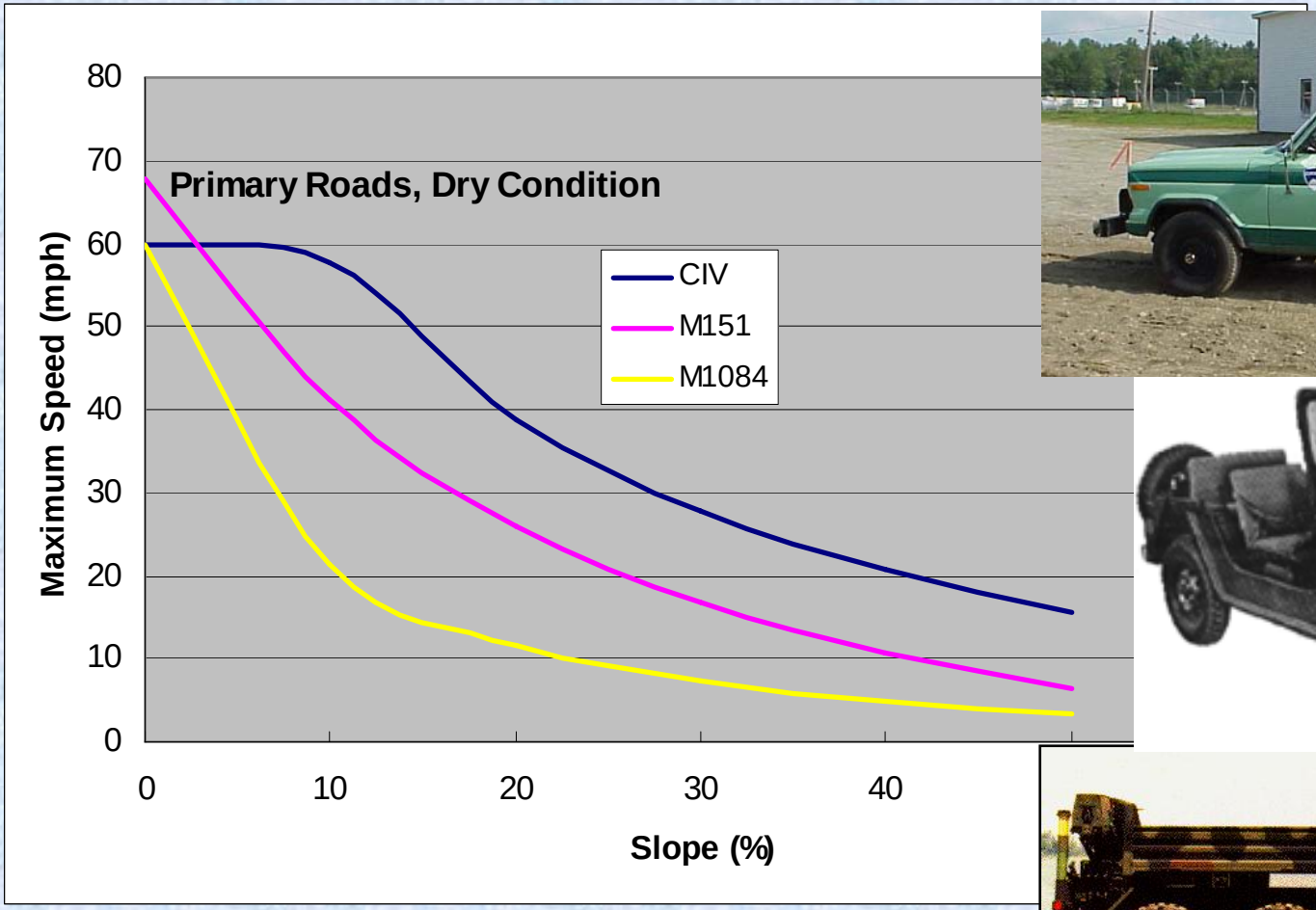
Tile roof with steep slope

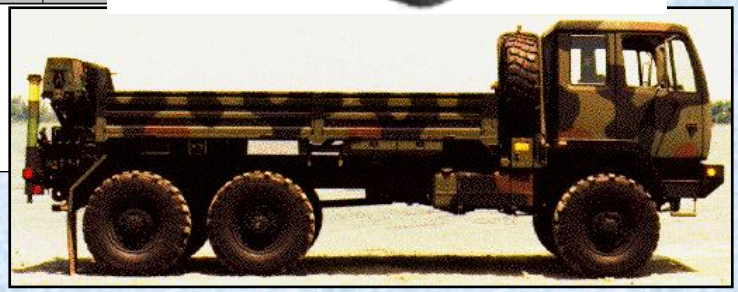
Performance Comparisons

Objectives:

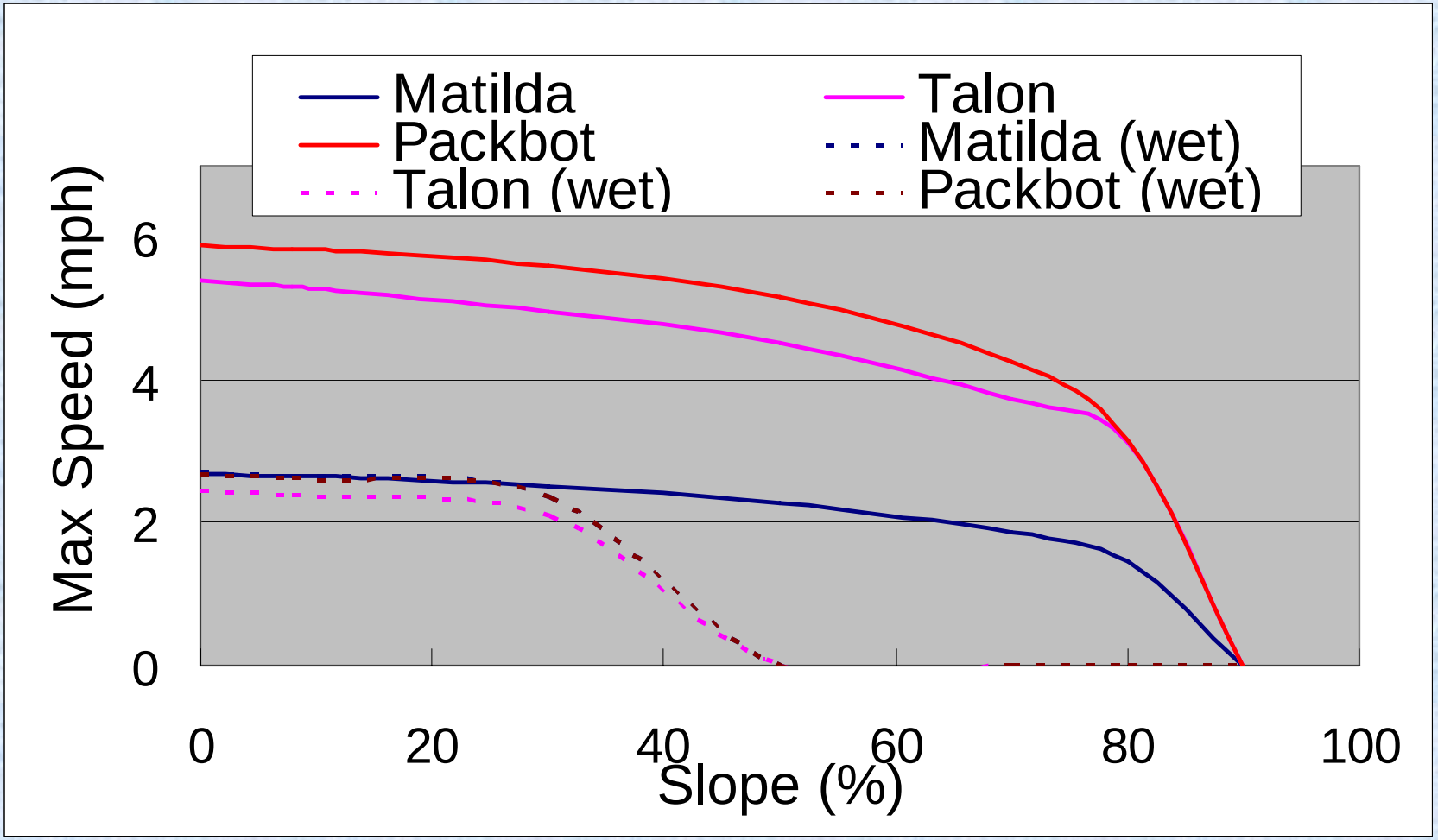
- Compare small vehicle test data to model performance
- Compare limited or qualitative data from literature to closest representative vehicle
- Determine if small vehicles can be categorized for force-on-force models

Performance Comparisons





Performance Comparisons



Future

- Continue analysis, and finalize/publish formal report of this work.
- Talon and Packbot will be tested on building material surfaces later this summer.

Summary

- No systematic SUGV mobility testing has been reported
- Small standard vehicles may need there own mobility class for use in STNDMob
- Identified 19 performance algorithms, 9 are related to the driver
- Quantifying time delays due to ANS or robotic control is problematic
- Future work is oriented towards building material surfaces

Questions??