June 20th, 2016 - August 19th, 2016

Improving the Mobility of a 3D Printed Robot for Search and Rescue Operations

Sarah Greisdorf[1], Austin Smith[2], Anish Thakker[3],
Lancelot Wathieu[4], Kamel Saidi[4], Adam Jacoff[4]

Office of Standards
Science and Technology Directorate
U.S. Department of Homeland Security

Intelligent Systems Division
Engineering Laboratory
National Institute of Standards and Technology

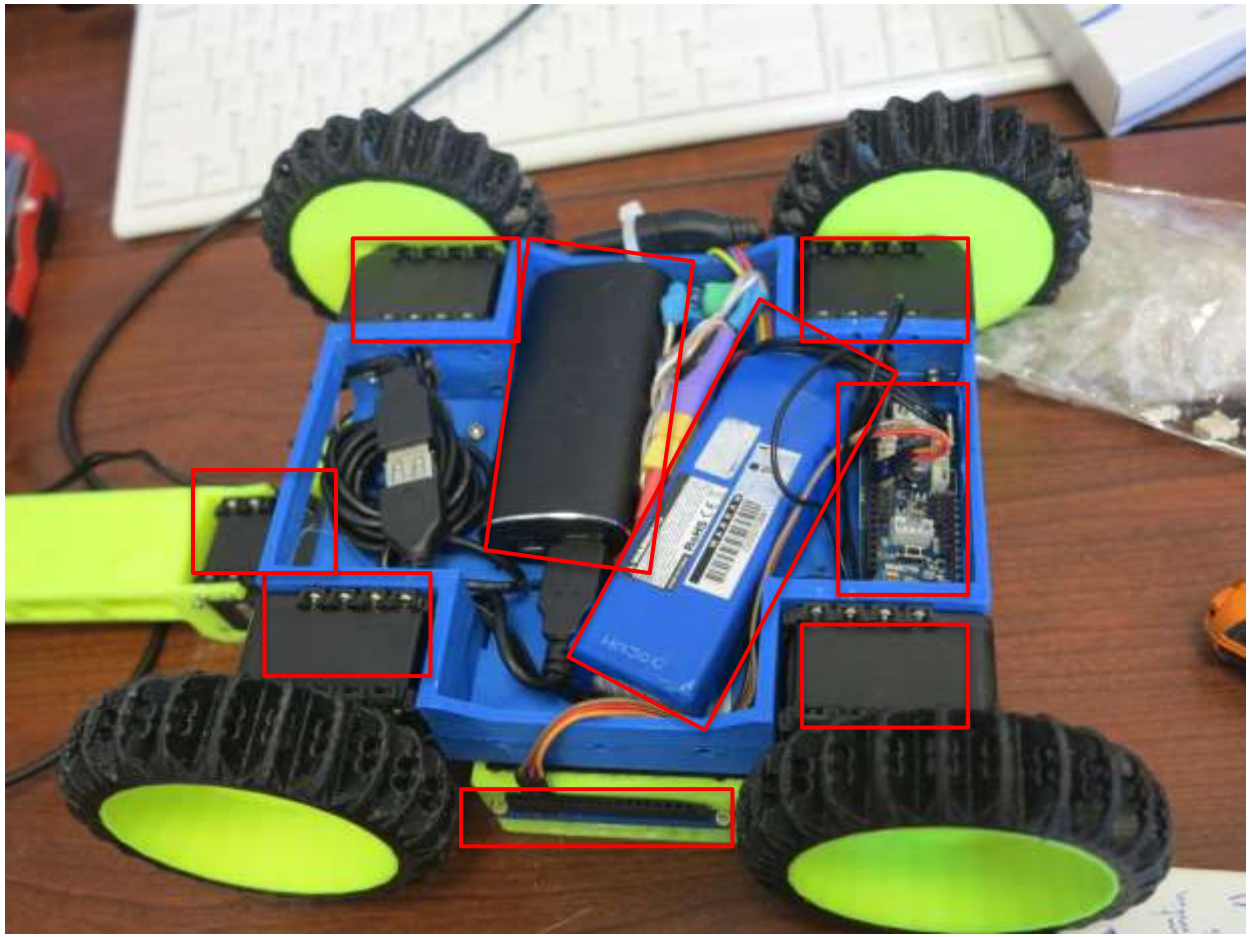
1. Holton-Arms
2. Governor Thomas Johnson
3. Wootton High School
4. National Institute of Standards and Technology

Emu Mini 2

Originally part of the Open Academic Robot Kit

Emu Mini 2

Originally part of the Open Academic Robot Kit



Parts:

Raspberry pi 2B

Open CM 9.04 Board

Lipo Battery

External Battery Pack

Dynamixel Servos

Wireless LAN Adaptor

Bluetooth Adaptor

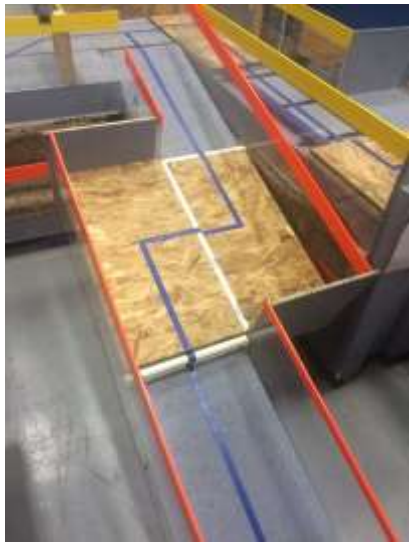
Standard Test Methods

Test methods measure performance of robot capabilities

Continuous Ramps

Gravel

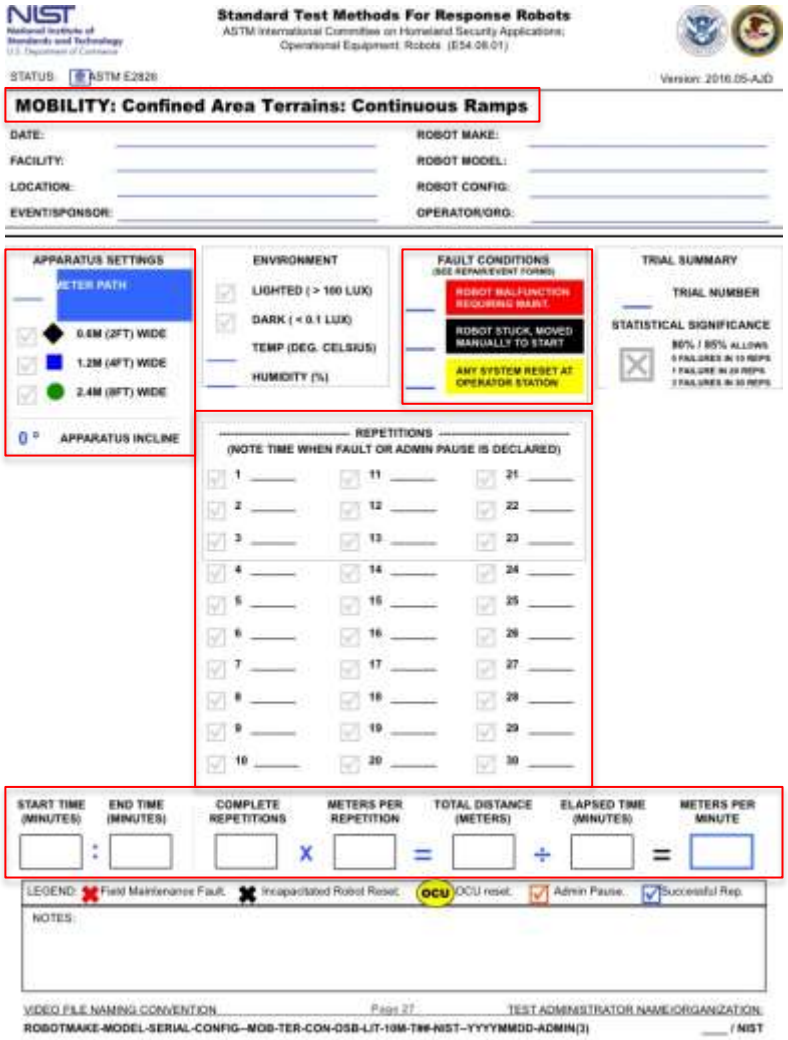
Crossing Ramps



Hurdles

Collecting Data Procedure

Test methods measure performance of robot capabilities



NIST

Standard Test Methods For Response Robots

ASTM International Committee on Homeland Security Applications; Operational Equipment: Robots (E54.08.01)

STATUS: ASTM E2826

Version: 2016.05-AJD

MOBILITY: Confined Area Terrains: Continuous Ramps

DATE:
FACILITY:
LOCATION:
EVENT/SPONSOR:
ROBOT MAKE:
ROBOT MODEL:
ROBOT CONFIG:
OPERATOR/ORG:

APPARATUS SETTINGS
METER PATH
0.6M (2FT) WIDE
1.2M (4FT) WIDE
2.4M (8FT) WIDE
0 ° APPARATUS INCLINE

ENVIRONMENT
LIGHTED (> 100 LUX)
DARK (< 0.1 LUX)
TEMP (DEG. CELSIUS)
HUMIDITY (%)

FAULT CONDITIONS
ROBOT MALFUNCTION REQUIRING MAINT.
ROBOT STUCK, MOVED MANUALLY TO START
ANY SYSTEM RESET AT OPERATOR STATION

TRIAL SUMMARY
TRIAL NUMBER
STATISTICAL SIGNIFICANCE
80% / 85% ALLOWS

REPETITIONS
(NOTE TIME WHEN FAULT OR ADMIN PAUSE IS DECLARED)

1	11	21
2	12	22
3	13	23
4	14	24
5	15	25
6	16	26
7	17	27
8	18	28
9	19	29
10	20	30

START TIME (MINUTES)		END TIME (MINUTES)		COMPLETE REPETITIONS		METERS PER REPETITION		TOTAL DISTANCE (METERS)		ELAPSED TIME (MINUTES)		METERS PER MINUTE
	:				X		=		÷		=	

LEGEND: Field Maintenance Fault; Incapacitated Robot Reset; OCU OCU reset; Admin Pause; Successful Rep.

NOTES:

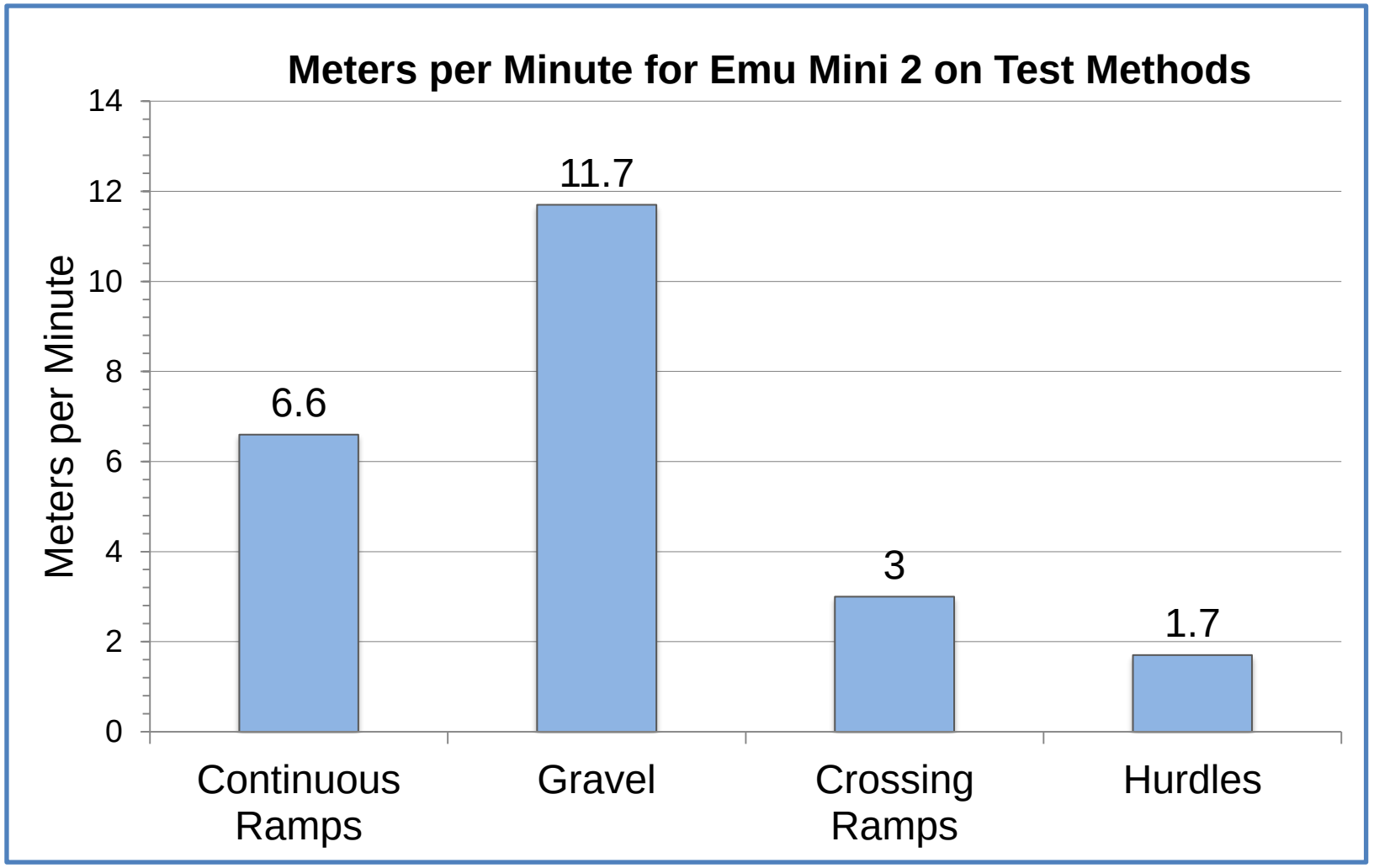
VIDEO FILE NAMING CONVENTION
ROBOTMAKE-MODEL-SERIAL-CONFIG--MOB-TER-CON-DSB-LIT-10M-T##-NIST--YYYYMMDD-ADMIN(3)

Page 27

TEST ADMINISTRATOR NAME/ORGANIZATION
___ / NIST

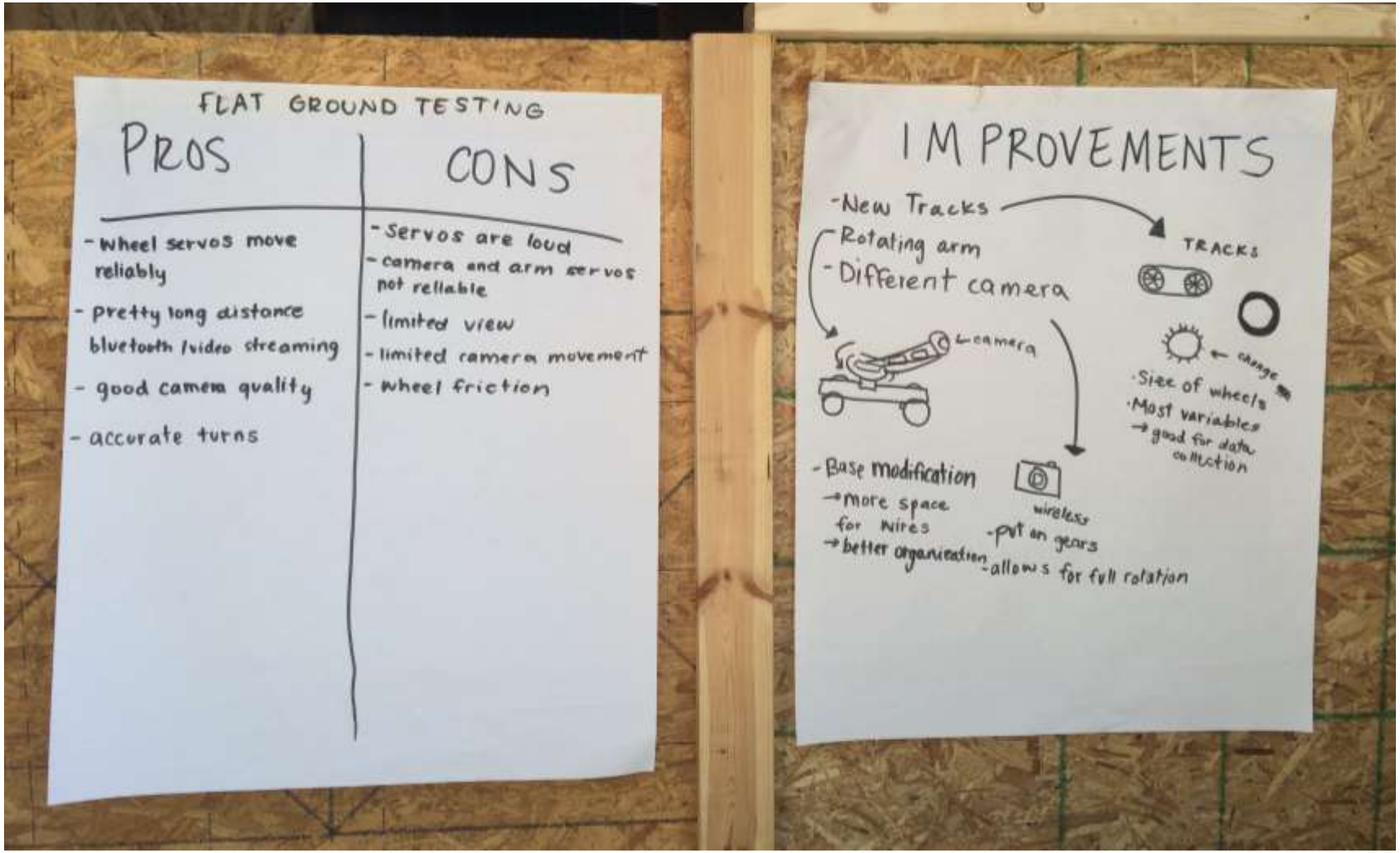
Initial Data Collection

Collected by running tests on the test methods



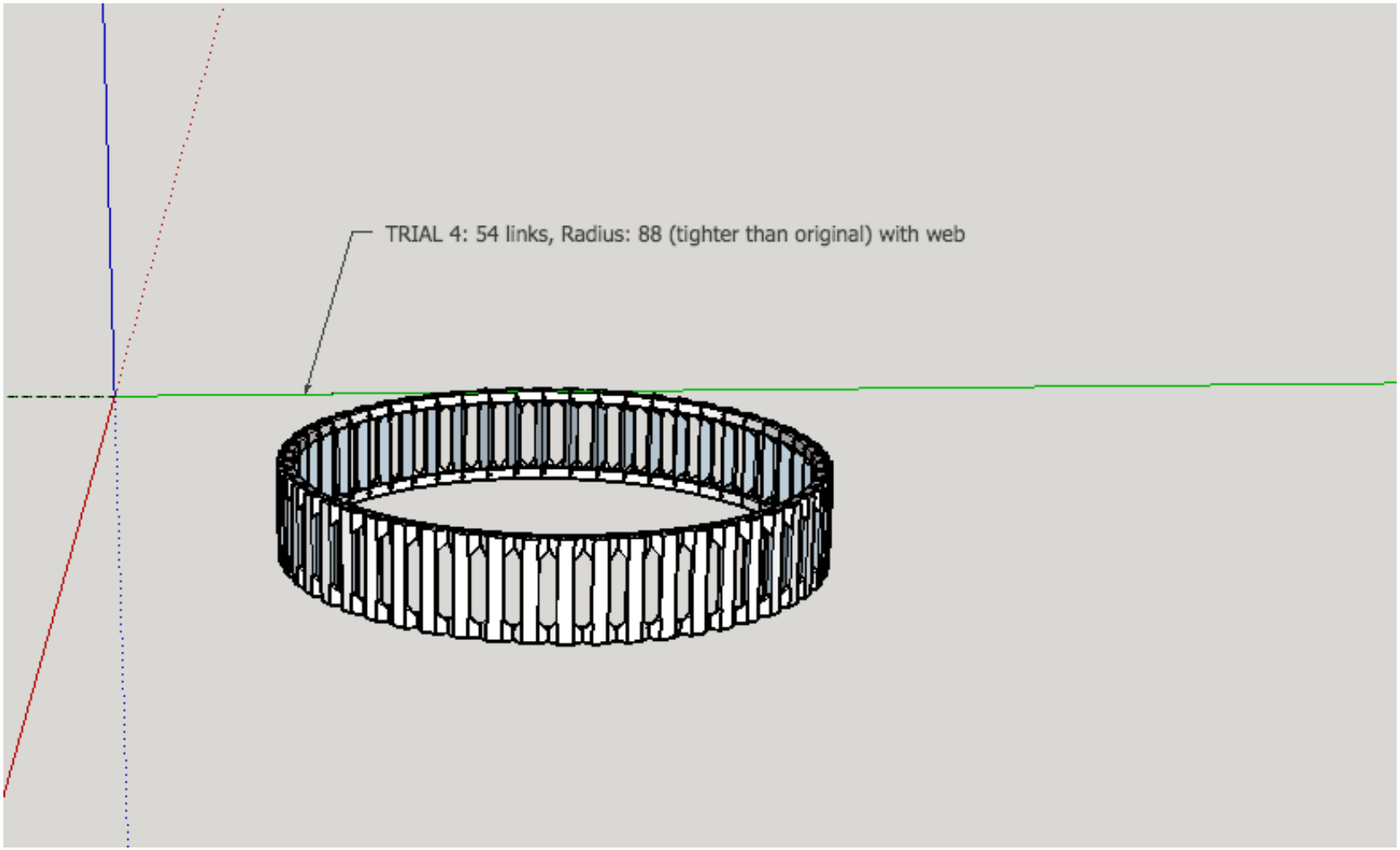
Modifications

Improving on the Emu Mini 2's original design



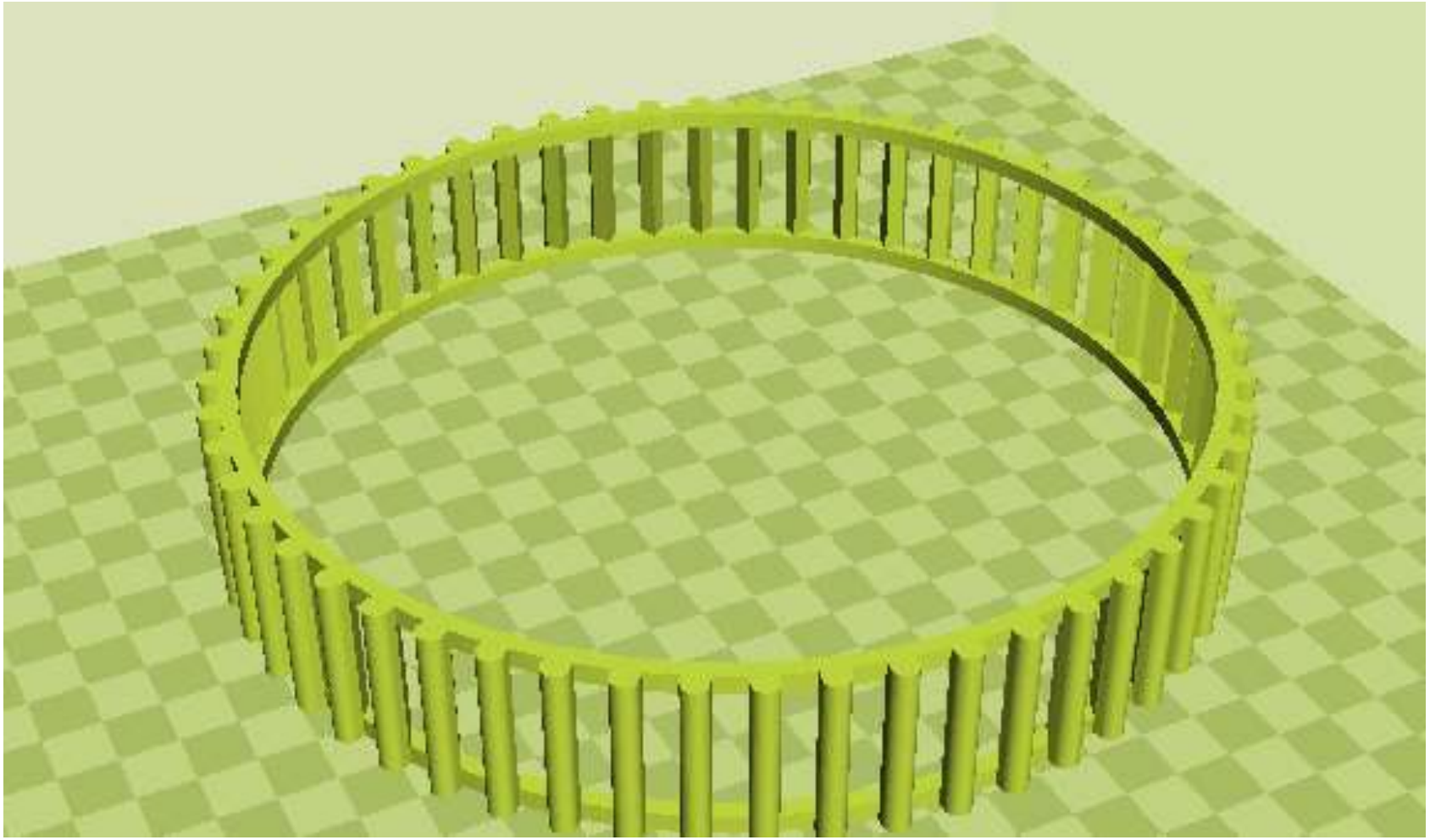
Re-Designs

Created new designs using SketchUp



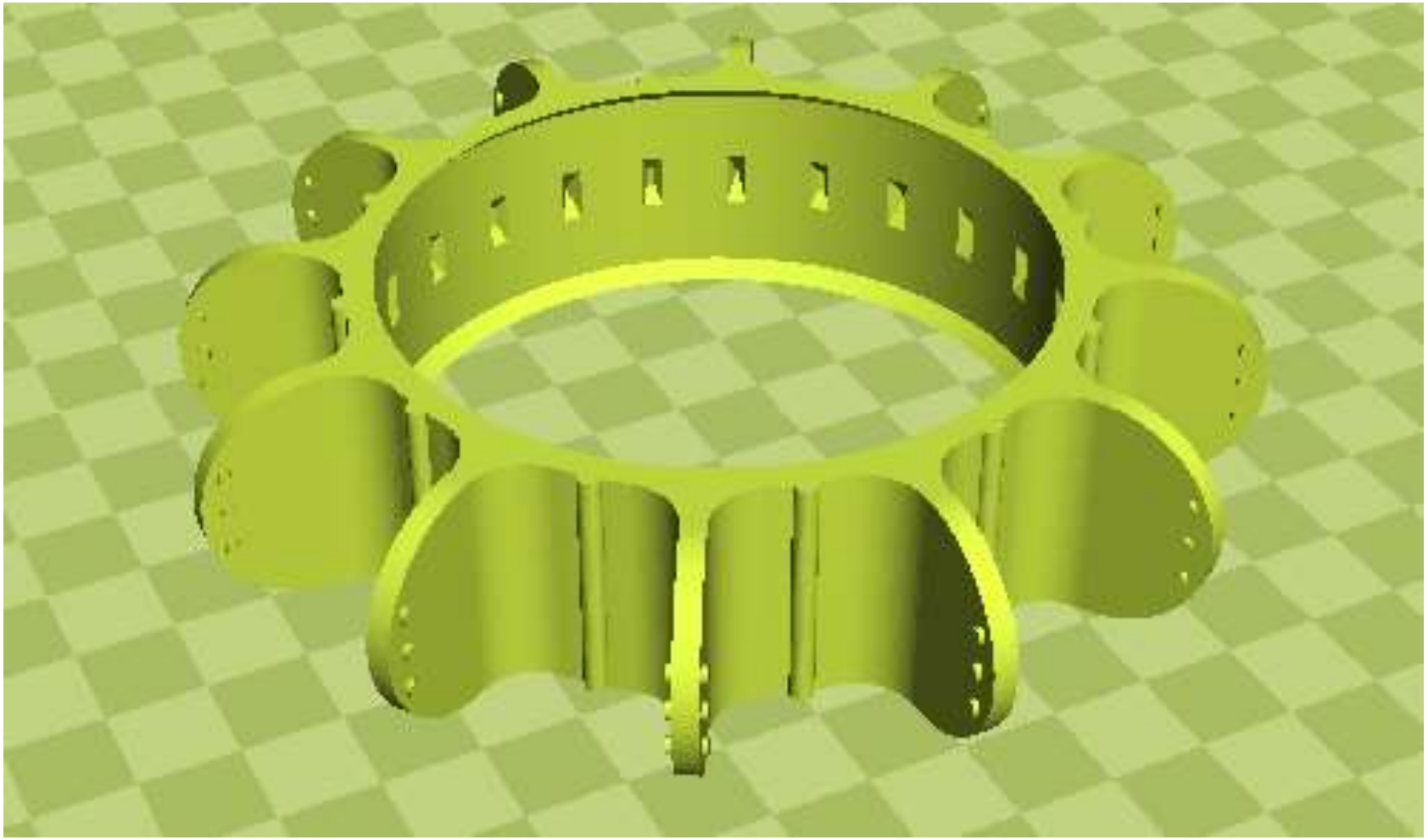
New Design: Tracks

New designs created from modifications



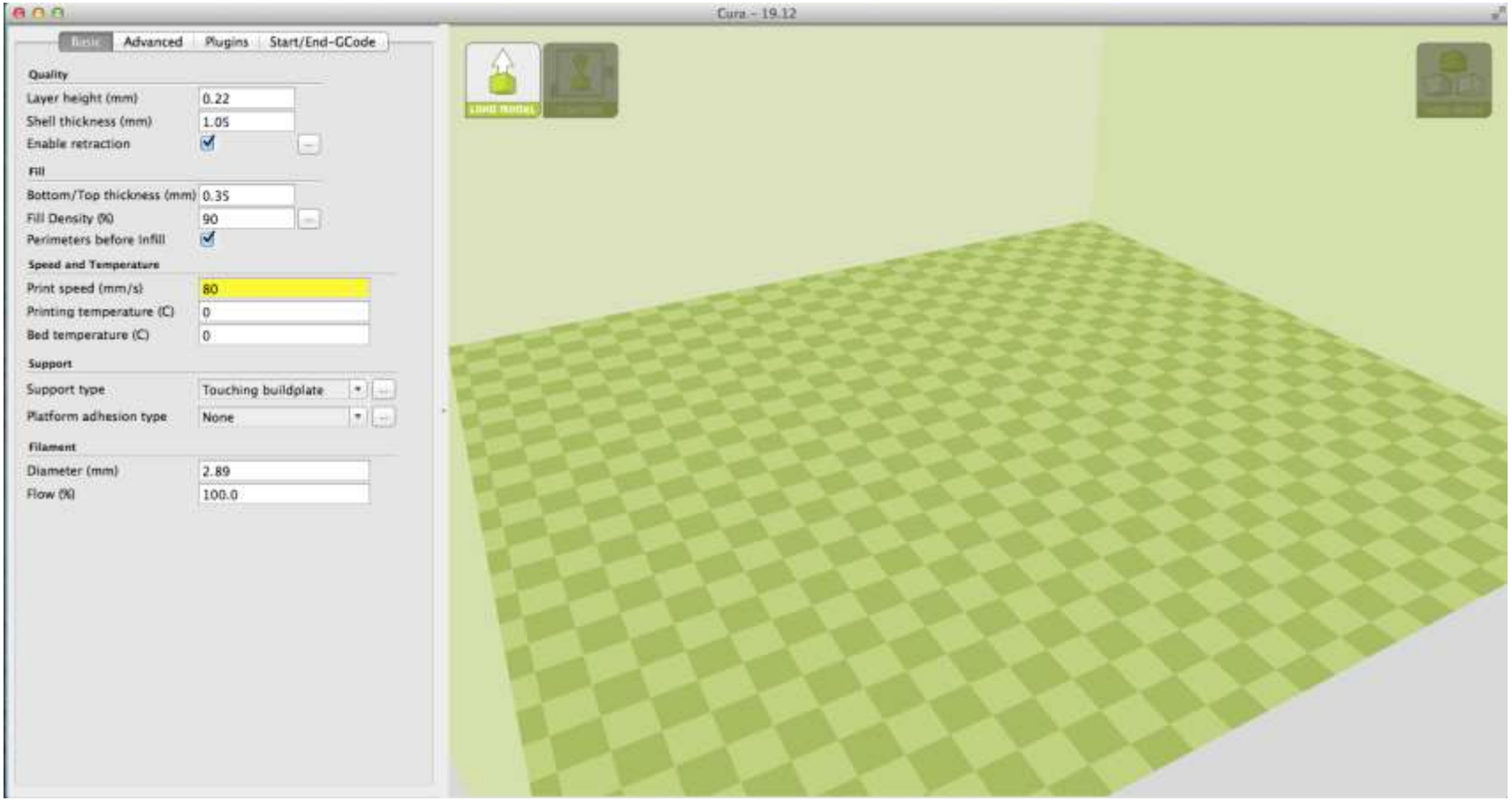
New Design: Wheels

New designs created from modifications



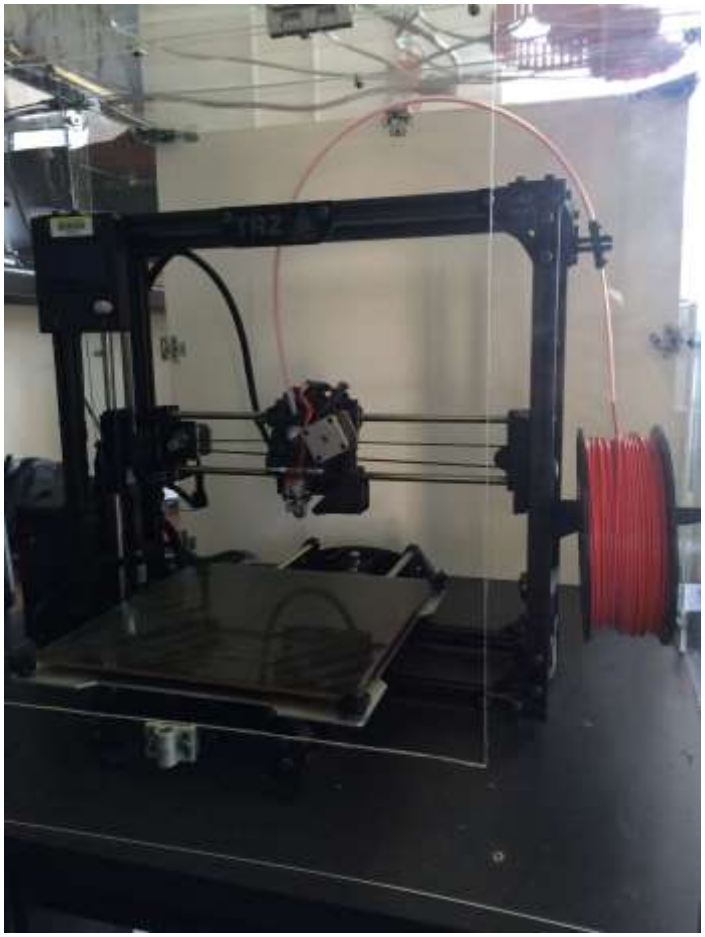
3D Printing: Setup

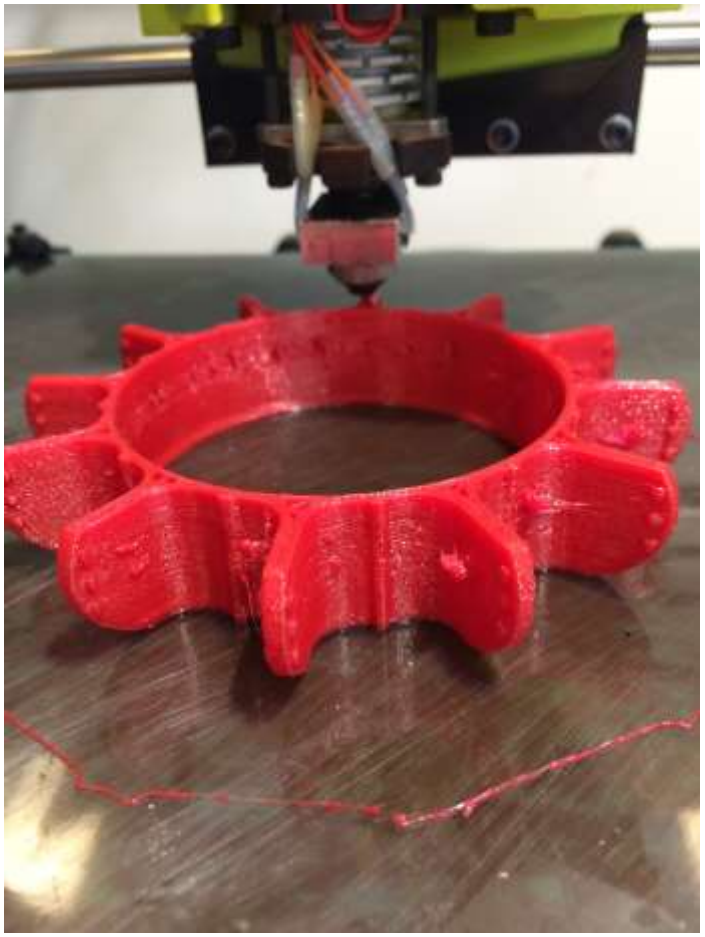
Prepared the new designs using cura



3D Printing: Moving to the Printer

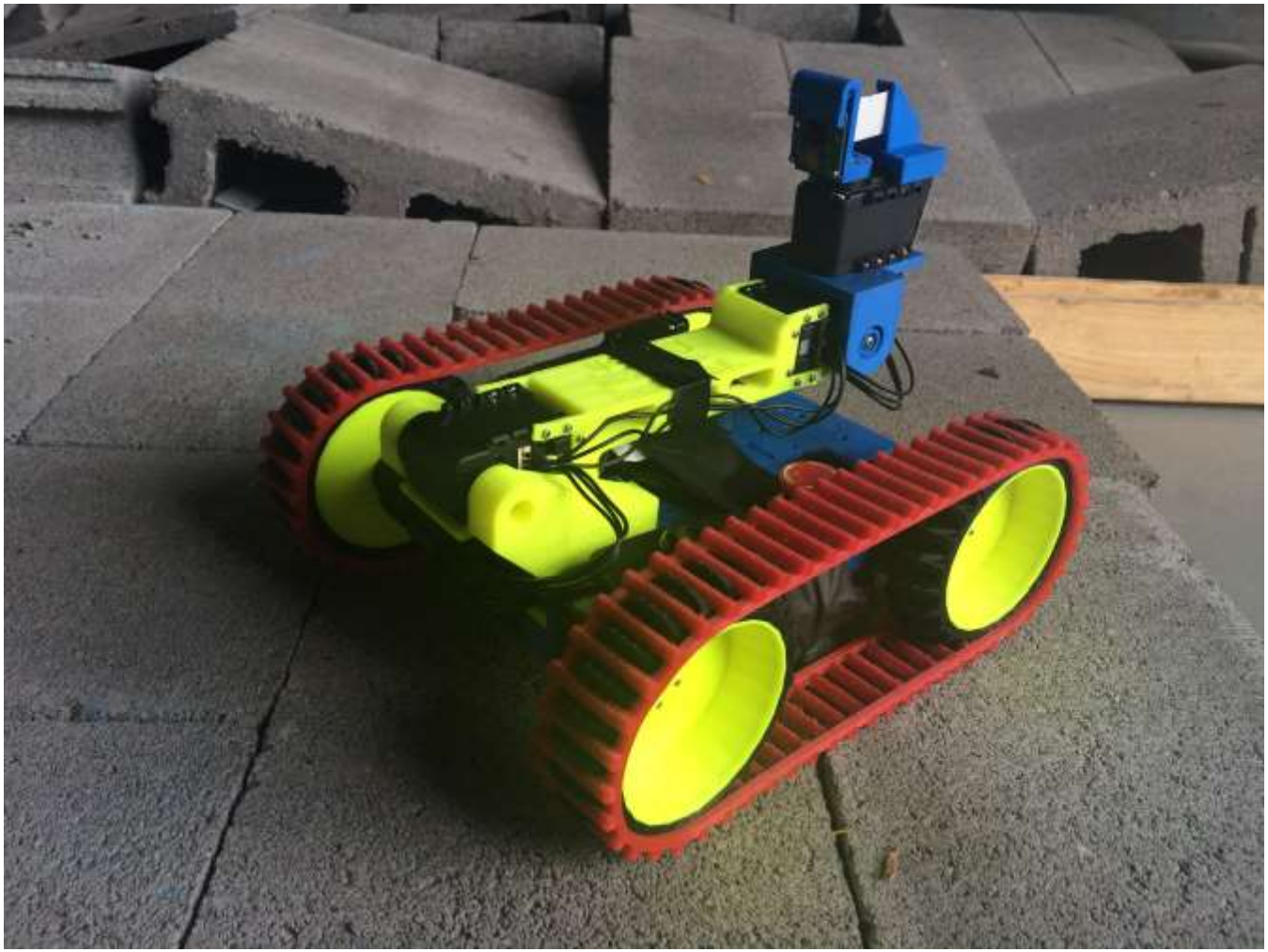
Printed the new designs using a Lulzbot Taz 4 printer





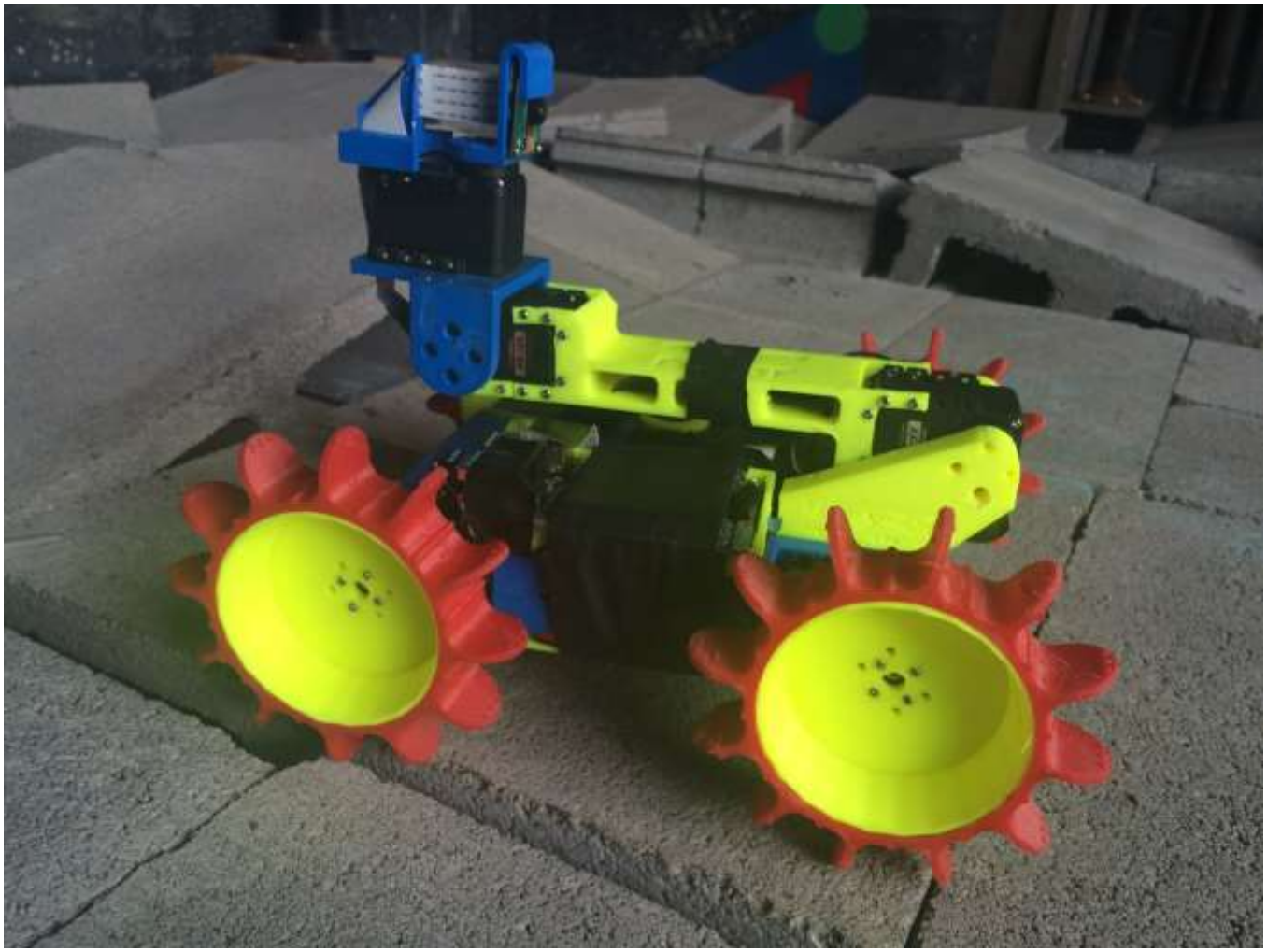
Tracks

Tracks designed to increase surface contact and traction



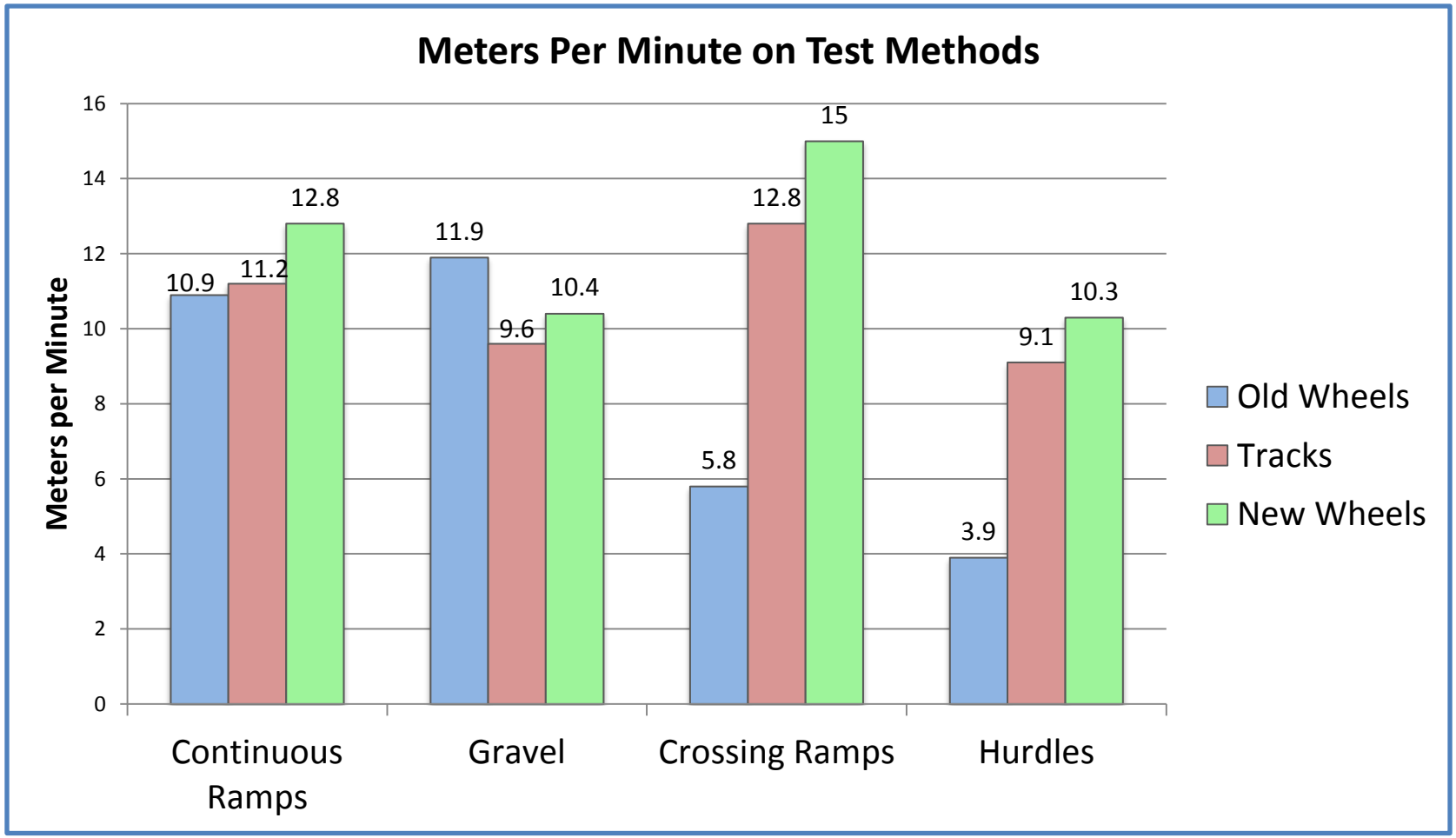
Wheels

Wheels designed to climb over hurdles and increase tread depth



Secondary Data Collection

Collected by running tests with the tracks and new wheels



Emu Mini 2: Meet Lauren

Second Emu Mini 2 (Robot 2) created for secondary testing

Differences Between Robots

Differences that may account for performance differences

Robot 1 (Ralph)

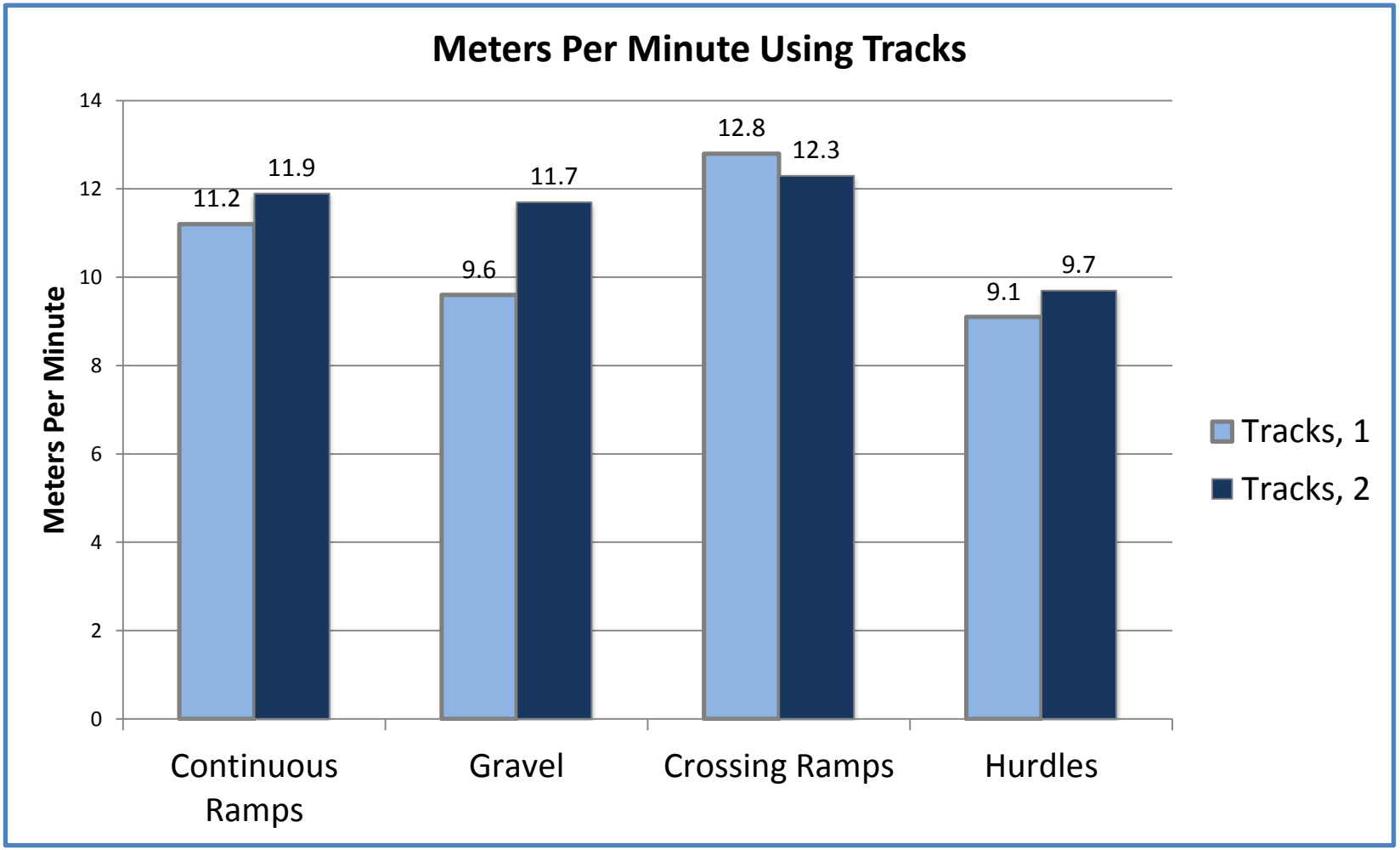
- Controlled by Raspberry Pi
- Raspberry Pi camera
- Needs backup battery
- Arm controlled by AX-12 servo
- Original arm, rest, shoulder design
- Average Speed: 15.7 m/min

Robot 2 (Lauren)

- Controlled by CM-530 board
- Mofek wifi camera
- Does not need backup battery
- Arm controlled by MX-64 servo
- Re-designed arm, rest, shoulder design
- Average Speed: 16.5 m/min

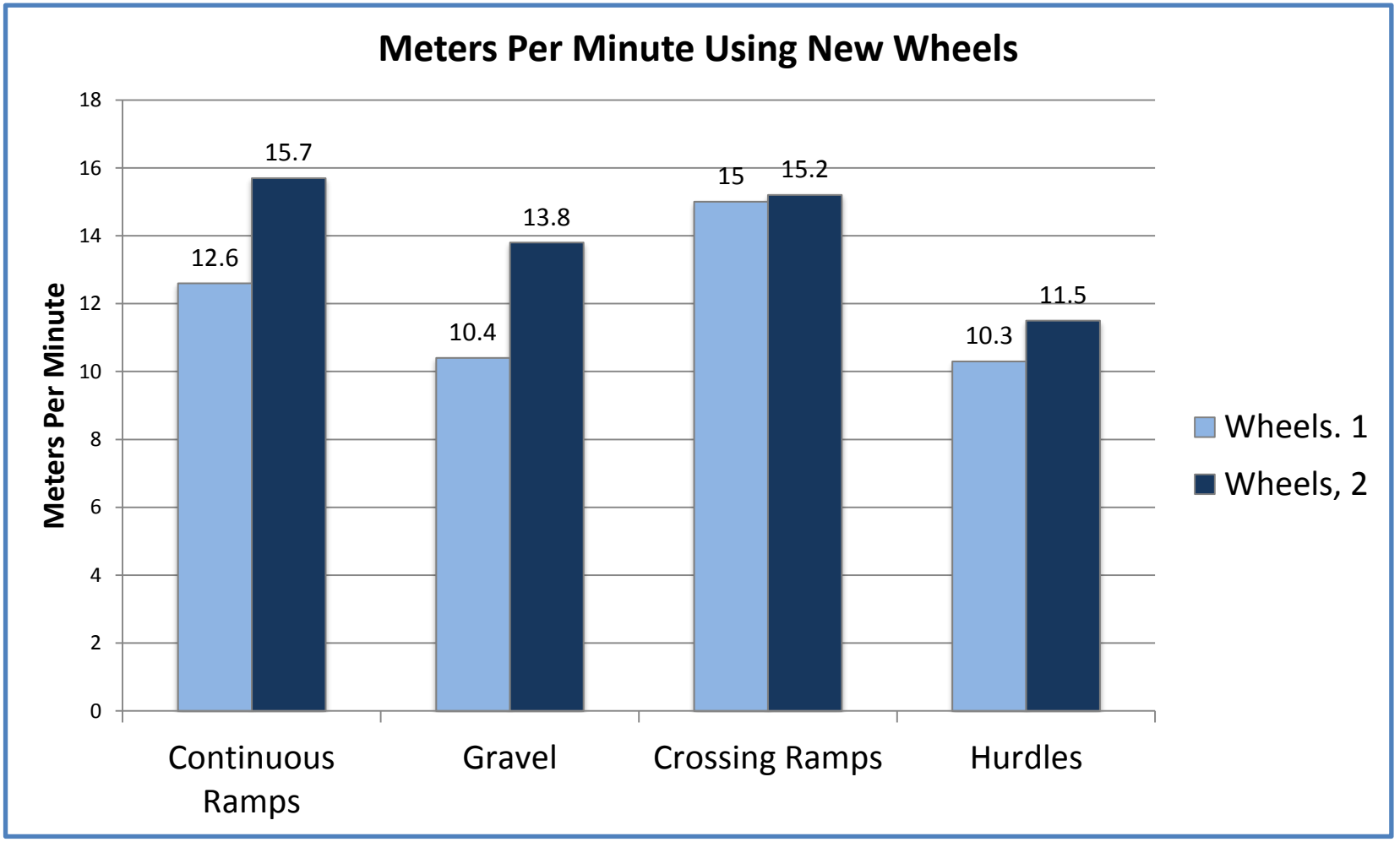
Track Data Collection

Collected by running tests with both Emu Mini 2 robots



Wheel Data Collection

Collected by running tests with both Emu Mini 2 robots



Conclusion

Discussion and next possible steps

- Best mobility combination: New Wheels + Robot 2 (Lauren)
- Second robot was better because of lower weight
- Actual tests are run via remote operations
- Next step: Run tests remotely and compare results between the different cameras and different robots