Mechanical Engineering
Carnegie Mellon University

Urban Landscape Traveling Investigation Mates (ULTIMates)

Senior Capstone Design Project

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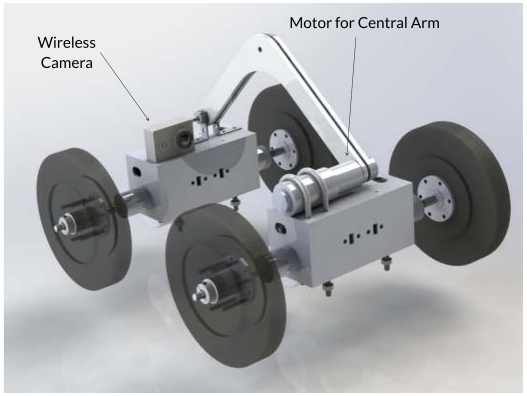
Opportunity:

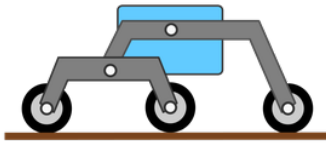
Police need an inconspicuous method to safely assess a high-stakes situation in a residential environment.

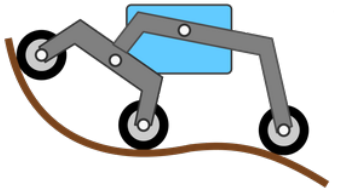
Design Solution:

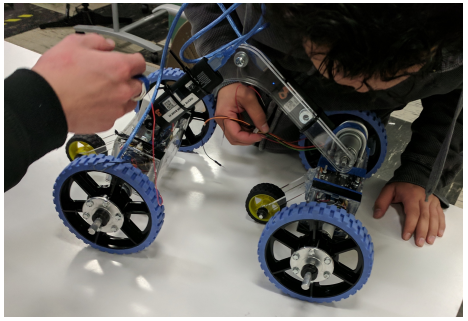
A pair of rovers that can attach to climb stairs and stream video.

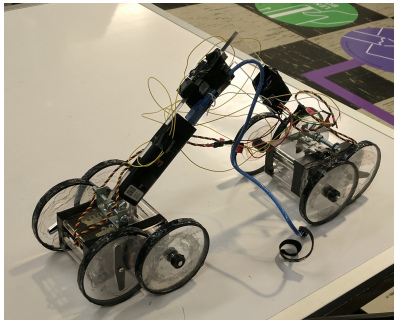
- The design draws mechanical inspiration from the Rocker-Bogie mechanism used in the Curiosity Rover (below, top right)
- Rocker-Bogie uses rear wheel horizontal force to generate the friction necessary to travel up obstacles (like steps)
- ULTIMates, when joined, provide one another with the proportional force to generate the friction necessary







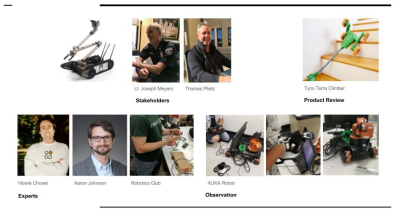




(Clockwise from top left)
Render of an iteration of the ULTIMates in formation, rocker bogie mechanism, early prototype, later prototype

Market Research:

By speaking with a firefighter, a police officer, and a **SWAT leader,** two robotics professors, and two robot makers – as well as by researching the market ourselves – we learned about emergency robotics. This included stair dimensions, existing mechanisms, and common police issues.



Market Research: User Research & Competitive Assessment

Benchmarking:

Our major competitors are **PackBot**, a large two-armed treaded tactical bot, and the **Recon Scout XT**, a small throwable recon robot.

From SWAT feedback, we determined that PackBot was **too large** for residential applications and the Recon Scout **couldn't overcome obstacles** (including stairs).

Recon Scout XT & PackBot

Engineering Analysis:

By leveraging the strength of the arm to generate more friction, the pair of rovers are able to climb up stairs in a much more mass-efficient way than other solutions.

Item and Function	Failure Mode	Effects of Failure	S	Causes of Failure	O	Design Controls	D	RPN	Recommended Actions
Wheels: allow the robot to move across ground	Not enough traction	Unable to pass obstacles	6	Low coefficient of friction	4	None	4	96	Analyze wide variety of surfaces and select wheel material accordingly
			6	Normal force too small	4	Linking arm motor can provide a varying normal force	4	96	Analyze motor and linking arm configurations and design accordingly
	Stuck	Unable to move freely	6	Wheels too big or small	4	None	4	96	Analyze various obstacle, stair, etc. dimensions and select wheel size accordingly
Motors: drive the wheels	Breaking	Unable to move entirely	8	Excessive stress	2	None	1	16	Select large enough motors based on the design
	Not enough torque	Unable to pass obstacles	6	Motor too weak	4	Motor torque can be controlled through control circuitry	4	96	Select motors with enough torque based on calculations
Aluminum housing: contains the motors, some circuitry, etc.	Bending, breaking	Decreased effectiveness	6	Excessive stress	3	None	2	36	Select strong enough material based on calculations
Linking arm: connects the two cars	Bending, breaking	Decreased effectiveness	6	Excessive stress	3	None	2	36	Select strong enough material based on calculations
Circuitry	Disconnection	Unable to move entirely	3	Loose wires	4	None	4	48	Inspect all circuit components before use
	Power failure	Unable to move entirely	3	Battery discharged	5	Battery level indicator	3	45	Select battery based on motor requirements
			6	Motors draw too much current	3	None	3	54	Select battery, control circuitry, etc. based on motor requirements

FMEA Table