Flat Belt Tire Tester Project Proposal

Authors: Duncan Wallace, Steven Paquette, Eli Henderson, Ben Klein, Marian Kleinow, Nathan Nguyen, Brad Kocher, Rachel Hillock, Nathan Dinh, Valeria Dillanes Gonzalez, and Meadow Loukmas

Mechanical Design

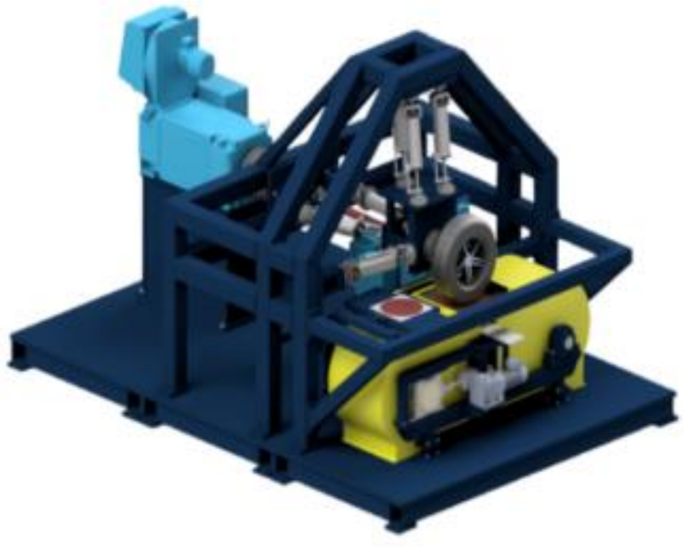
Authors: Duncan Wallace, Steven Paquette, Eli Henderson, Ben Klein, Marian Kleinow, Nathan Nguyen

Mission Statement:

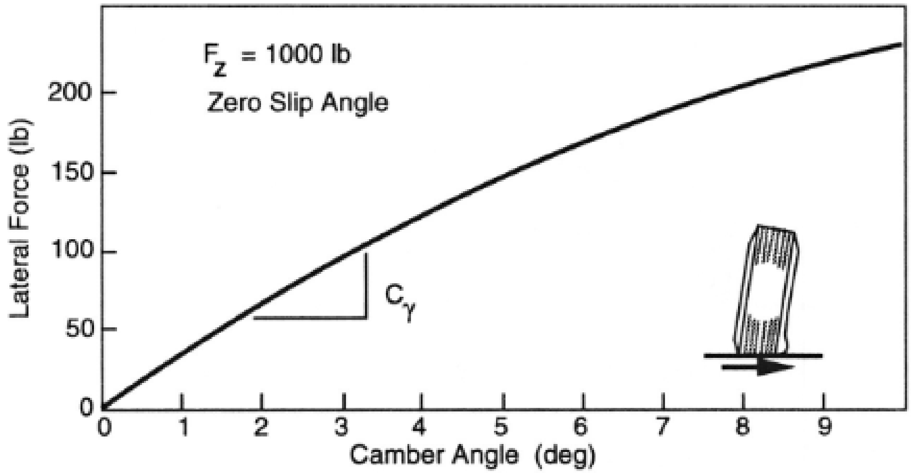
- Design, build, & validate a Flat Belt Tire Testing Machine
    - Design & select components used for the machine
    - Perform FEA analysis on the frame
    - Manufacturing & Fabrication
    - Testing & Validation
- The machine must
    - Analyze how tires behave in static & rotating conditions
    - Be accurate within 5% of rotation speed, within 20-30N for load

Background Research:

- Design of a flat-blet tire testing machine requires understanding of machine design principles, dynamic system behavior, safety, and constraints
- Incorporating cost effective design decisions to keep closer to budget while maintaining a safe design
- Designing with flexible constraints to accommodate for belt system integration
- Thomas Gillespie book to determine road loads and ride characteristics



321 Flat belt machine by LINK Engineering



Lateral force caused by camber angle of tire graph

Project Budget

Project:	Mechanical Design Flat Belt Tire Tester
Total Project Budget:	$1,500
Project Budget Allocated:	**$1,500**
Budget Remaining	**$0**
Item:	Total Cost:
3" Square Stock Tubing	$1,200
Hardware (Axel, Bolts, Nuts, etc.)	$200
Miscellaneous	$100

Customer Needs

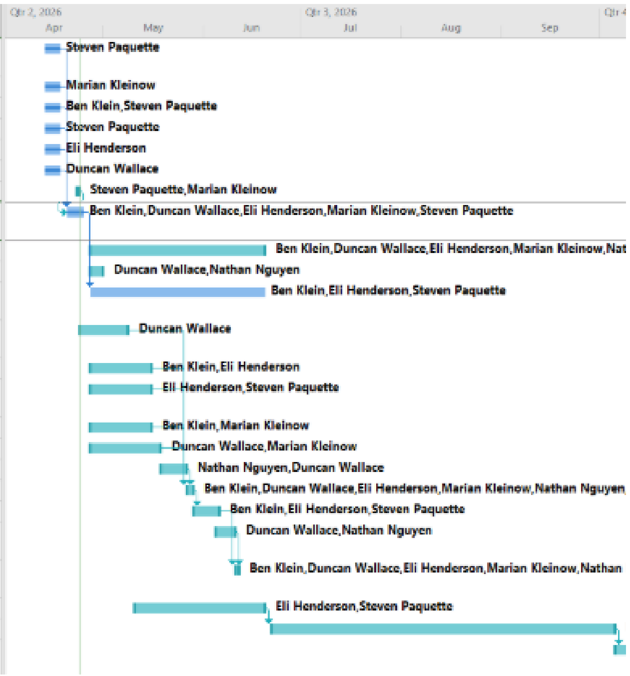
- Gain a better understanding of how tires behave in static and dynamic conditions.
  - Looking to move away from using SAE dyno – want to understand the tire itself, eliminate suspension and vehicle system variables.
- Testing to be completed on passenger vehicle-sized tires or smaller.
- Possibility to incorporate steering
- Met with Dr. Bastiaan to better understand customer requirements.

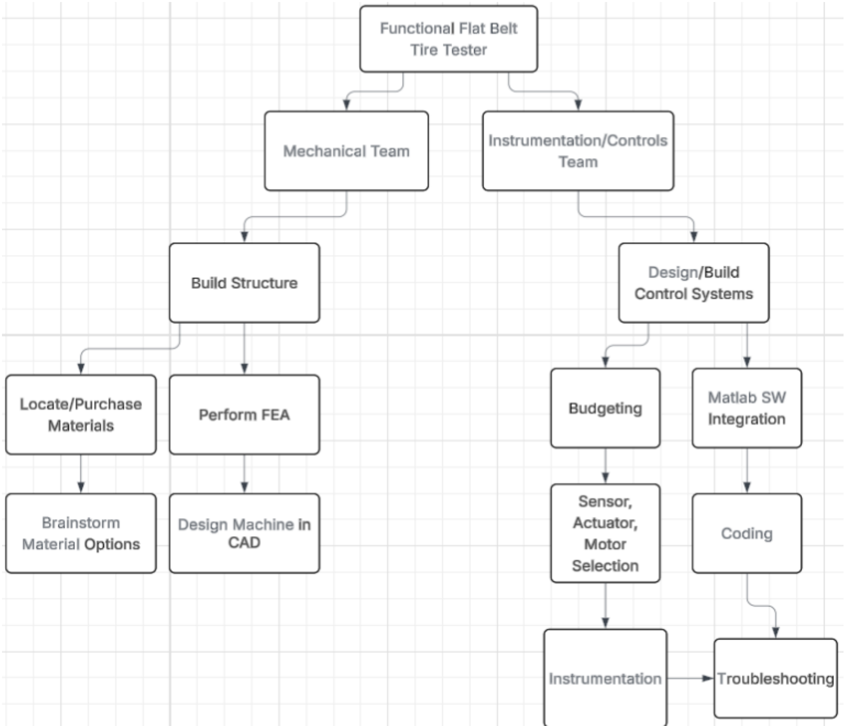
Organizational Need

- Microsoft Based
  - Use Teams/OneDrive for all file sharing
- Excel Gantt Chart
  - Clean/Easy to Use
  - Subdivide Tasks
- Flowcharts
  - Lucid Charts
    - Easy to use, shared through Teams
  - Breakdown Tasks into manageable portions

GANTT CHART

	Task Mode	Task Name	Duration	Start	Finish	Predecessors	Resource Names	% Work Complete
1		Scope of Work & Mission Statement	5 days	Mon 4/13/26	Fri 4/17/26		Steven Paquette	100%
2		Literature Review	5 days	Mon 4/13/26	Fri 4/17/26		Marian Kleinow	100%
3		WBS & Gantt Chart	5 days	Mon 4/13/26	Fri 4/17/26		Ben Klein,Steven Paquette	100%
4		Project Budget	5 days	Mon 4/13/26	Fri 4/17/26		Steven Paquette	100%
5		Customer Needs	5 days	Mon 4/13/26	Fri 4/17/26		Eli Henderson	100%
6		Risk Midigation	5 days	Mon 4/13/26	Fri 4/17/26		Duncan Wallace	100%
7		Customer Meeting	1 day	Thu 4/23/26	Thu 4/23/26		Steven Paquette,Marian Kle	100%
8		Initial Project Proposal	5 days	Mon 4/20/26	Fri 4/24/26	1,2,3,4,5,6,7	Ben Klein,Duncan Wallace, Eli Henderson,Marian	100%
9		Design of Test Stand	40 days	Mon 4/27/26	Fri 6/19/26		Ben Klein,Duncan Wallace,E	0%
10		Establish Load Cases	4 days	Mon 4/27/26	Thu 4/30/26		Duncan Wallace,Nathan Ngu	0%
11		Mechanical Design of Test Stand	40 days	Mon 4/27/26	Fri 6/19/26	8	Ben Klein,Eli Henderson, Steven Paquette	0%
12		Material And Component Slection	11 days	Fri 4/24/26	Fri 5/8/26		Duncan Wallace	0%
13		Frame Design	15 days	Mon 4/27/26	Fri 5/15/26		Ben Klein,Eli Henderson	0%
14		Tire Load Mechanism	15 days	Mon 4/27/26	Fri 5/15/26		Eli Henderson, Steven Paquette	0%
15		Tire Belt Design	15 days	Mon 4/27/26	Fri 5/15/26		Ben Klein,Marian Kleinow	0%
16		Safety Guard Design	16 days	Mon 4/27/26	Mon 5/18/26		Duncan Wallace,Marian Klei	0%
17		FEA Analysis	6 days	Tue 5/19/26	Tue 5/26/26		Nathan Nguyen,Duncan Wal	0%
18		Intial Design Review	2 days	Wed 5/27/26	Thu 5/28/26	12,13,14,15,16,1	Ben Klein,Duncan Wallace,E	0%
19		Design Changes	6 days	Fri 5/29/26	Fri 6/5/26	18	Ben Klein,Eli Henderson,Ste	0%
20		Design Change FEA Analysis	4 days	Fri 6/5/26	Wed 6/10/26		Duncan Wallace, Nathan Nguyen	0%
21		Critical Design Review	1 day	Thu 6/11/26	Thu 6/11/26	19,20	Ben Klein,Duncan Wallace, Eli Henderson,Marian	0%
22		Finalized BOM	30 days	Mon 5/11/26	Fri 6/19/26		Eli Henderson,Steven Paque	0%
23		Procurement	76 days	Mon 6/22/26	Mon 10/5/26	22	Ray Rust	0%
24		Test Stand Manufacturing	19 days	Tue 10/6/26	Fri 10/30/26	23	Ben Klein,Duncan Wallace, Eli Henderson,Ray Rust,Stev	0%





Risk Management Plan

Item	Risk Description	Cause	Probability	Impact	Severity	Risk Response Approach	Contingency Plan
1	Mechanical design is not aligned with instrument design	Poor communication with instrument design group	2	4	8	• Regroup with instrument design team to find a solution	• Keep constant communication within teams and class
2	Equipment not sufficient towards achieving design goals (not compatible or does not have the right specifications)	Insufficient design planning and specification research	3	4	12	• Identify issue and cheapest solution • Order compatible parts	• Research and confirm equipment compatibility before ordering parts through FEA and spec sheets • Work with Ray Rust to ensure design is compatible, and we have the proper materials
3	Absent group member	Personal circumstances	5	1	5	• Group members inform absent group members of project developments when they return	• Group members update any expected absences in advance.
4	Equipment is damaged due to overuse	• Equipment overheats	2	5	10	• Order new parts	• Set failure mode so that equipment does not run if equipment may overheat • Ensure factor of safety is incorporated into design
5	Safety risks posed to operator (projectiles, electrical hazards)	• No safety considerations included in machine instructions • Improper failure modes	4	5	20	• Emergency response plan	• Operation instructions require operator to leave the room during testing or for testing to be done behind a protective barrier • Casing around exposed electrical components • Cage over spinning parts

References:

- [1] Gillespie, T. D. (2020). *Fundamentals of vehicle dynamics* (Revised edition). Society of Automotive Engineers. https://doi.org/10.4271/9781468601770
- [2] Sabanovic, A., & Ohnishi, K. (2011). *Motion control systems*. IEEE Press ; John Wiley & Sons (Asia) Pte Ltd. http://site.ebrary.com/id/10510726
- [3] Langer, W. J., & Potts, G. R. (1980). Development of a Flat Surface Tire Testing Machine. *SAE Transactions*, *89*, 1111–1117.
- [4] Pieter van Gelder, Klaassen, P., Taebi, B., Walhout, B., Ruud van Ommen, Ibo van de Poel, Robaey, Z., Asveld, L., Balkenende, R., Hollmann, F., van Kampen, E. J., Khakzad, N., Krebbers, R., de Lange, J., Pieters, W., Terwel, K., Visser, E., Tiny van der Werff, & Jung, D. (2021). Safe-by-Design in Engineering: An Overview and Comparative Analysis of Engineering Disciplines. *International Journal of Environmental Research and Public Health*, *18*(12), 6329. https://doi.org/10.3390/ijerph18126329
- [5] Carlson, M. (2010). How to select a safety light screen for industrial machinery. *Control Engineering*, *57*(3), 23–24.
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- [7] Highway Tire Committee. (2020). *Force and Moment Test Method*. SAE International. https://doi.org/10.4271/J1987_202006
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Flat Belt Tire Testing: Instrumentation & Controls

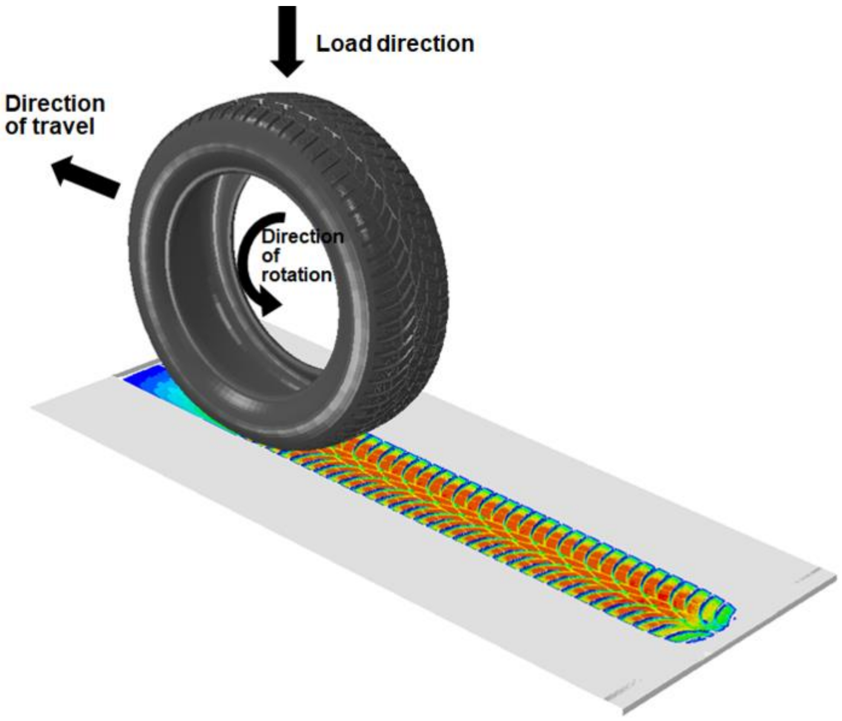
Authors: Brad Kocher, Rachel Hillock, Nathan Dinh, Valeria Dillanes Gonzalez, and Meadow Loukmas

Mission Statement

- Product Description: Electrical Components, controls, user interface, and data collection for a flat belt tire testing machine for testing passenger car tires for speed, RPM, and load/pressure on the tire.
- Key Goals: Gather accurate test data, with 5% margin of error for rotation speed and 20-30 N for load. Ensure testing is easy, repeatable, and reliable.

Background Research

- Tire testing is based on SAE standards (J1987, J1106) ensuring accuracy and repeatability
- Flat-belt systems improve realism by eliminating drum curvature effects and enabling better control of load, slip, and speed
- Conventional drum dynamometers are still used but require correction factors for geometric distortion
- Optical methods (DIC, stereophotogrammetry) enable full-field deformation and 3D tire behavior analysis
- Harmonic effects from tire rotation require filtering for accurate vibration and modal testing
- Tire–road interaction studies show limitations in drum and vehicle testing; tread-level sensing improves accuracy
- Overall design integrates standardized testing, precise measurement, and advanced control for realistic tire evaluation



References

[1] SAE International. (2020). Recommended Practice, Force and Moment Test Method, SAE Standard J1987_202006 https://doi.org/10.4271/J1987_202006.

[2] SAE International. (2012). Recommended Practice, Laboratory Testing Machines for Measuring the Steady State Force And Moment Properties of Passenger Car Tires, SAE Standard J1106_201208 https://doi.org/10.4271/J1106_201208.

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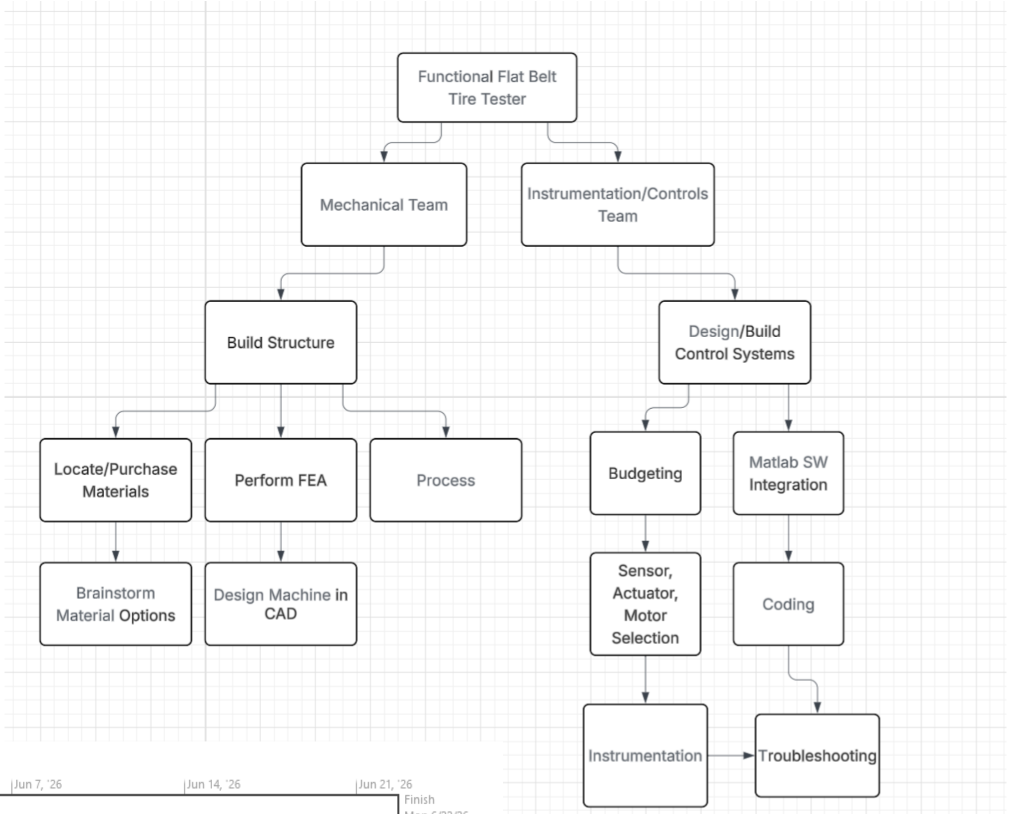
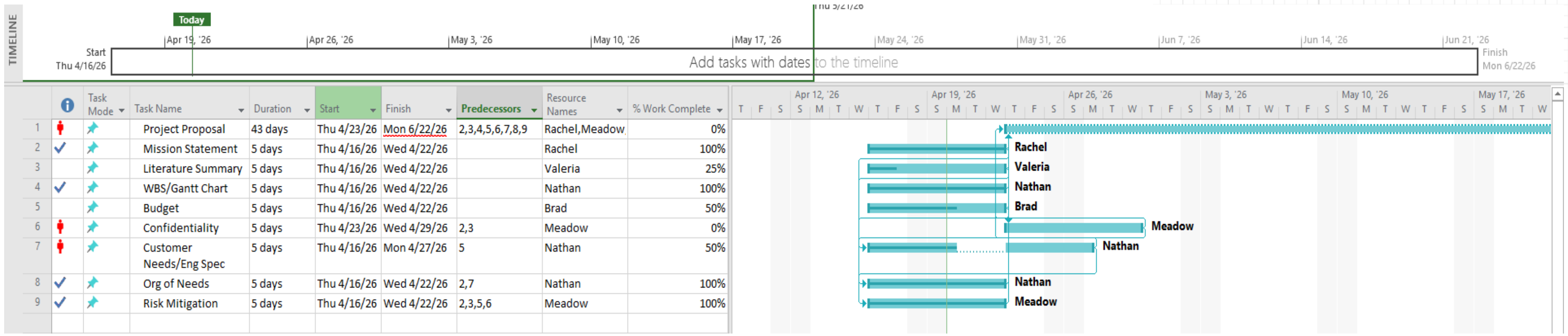
WBS/Gantt Chart

- Microsoft Based
  - Use Teams/OneDrive for all file sharing
- Projects Gantt Chart
  - Tasks are assigned to each member
- Flowcharts
  - Lucid Charts – In parallel with the mechanical team





	Task Mode	Task Name	Duration	Start	Finish	Predecessors	Resource Names	% Work Complete
1		Project Proposal	43 days	Thu 4/23/26	Mon 6/22/26	2,3,4,5,6,7,8,9	Rachel,Meadow	0%
2		Mission Statement	5 days	Thu 4/16/26	Wed 4/22/26		Rachel	100%
3		Literature Summary	5 days	Thu 4/16/26	Wed 4/22/26		Valeria	25%
4		WBS/Gantt Chart	5 days	Thu 4/16/26	Wed 4/22/26		Nathan	100%
5		Budget	5 days	Thu 4/16/26	Wed 4/22/26		Brad	50%
6		Confidentiality	5 days	Thu 4/23/26	Wed 4/29/26	2,3	Meadow	0%
7		Customer Needs/Eng Spec	5 days	Thu 4/16/26	Mon 4/27/26	5	Nathan	50%
8		Org of Needs	5 days	Thu 4/16/26	Wed 4/22/26	2,7	Nathan	100%
9		Risk Mitigation	5 days	Thu 4/16/26	Wed 4/22/26	2,3,5,6	Meadow	100%

Customer Needs/Engineering Characteristics

- Instrumentation system
  - Accurately & consistently capture deformation across multiple points using Digital image correlation on a Flat Belt Tester
  - Sensors and actuators to detect deformation and apply load

- Engineering Specs
  - Record Tire Speed (RPM) within 5% error
  - Record amount of load within 20-30N error
  - Capture the deformation at static and non-static conditions

Confidentiality & Intellectual Property Considerations

- Findings from background research remain the findings of the original owner
- There are no defined confidentiality requirements for this project for Kettering University
- Contributing students own the IP of this project

Change Management Plan

- Identify & report proposed change
  - Change is proposed through standard communication channels (group chat)
- Identify impact of change to project scope, time, and/or cost
  - Evaluate magnitude of change: major or minor
- Identify & meet with impacted stakeholders to acquire change approval
  - Major changes require approval from all stakeholders
  - Minor changes require approval from working group
- The change may be implemented following stakeholder approval
  - The Gantt chart and WBS must be updated accordingly
- All project changes will be documented in a central location

Project Priority Matrix

	Scope	Time	Cost
Constrain			**X**
Enhance		**X**	
Accept	**X**		

***Feasibility of project changes is dependent on the impacted area**

Risk Management Plan

Item	Risk Description	Cause	Probability	Impact	Severity	Risk Response Approach	Contingency Plan
1	Safety risks posed to operator (projectiles, electrical hazards)	• No safety considerations included in machine instructions • Improper failure modes	4	5	20	• Emergency response plan	• Operation instructions require operator to leave the room during testing or for testing to be done behind a protective barrier • Casing around exposed electrical components
2	Equipment not sufficient towards achieving design goals (not compatible or does not have the right specifications)	Insufficient design planning and specification research	3	4	12	• Identify issue and cheapest solution • Order compatible parts	• Research and confirm equipment compatibility before ordering parts.
3	Equipment is damaged due to overuse	Equipment overheats	2	5	10	• Order new, compatible parts	Set failure mode so that equipment does not run if equipment may overheat
4	Instrumentation is not aligned with mechanical design	Improper communication/ collaboration with mechanical design group	2	4	8	• Regroup with mechanical design team to find a solution	• Maintain consistent communication between teams (weekly)
5	Inconsistent or incorrect	• Electrical noise	4	2	8	• Identify root cause	• Follow calibration

Hierarchy of Needs

- Primary Needs
  - Sensors to record and interface with the DAQ
  - Motor & Actuator to rotate and induce a load on the tire
  - MATLAB Control SW
- Secondary Needs
  - PLC integration – Automation for repeatability
- Tertiary Needs
  - Steering System

Project Budget:

Item	Quantity	Price Per Unit	Total
Motors	2	200	400
Hardware	1	200	200
Instrumentation	1	300	300
Miscellaneous	1	300	300

Total: $1,200