



Model Based Systems Quadruped

Design Review 5



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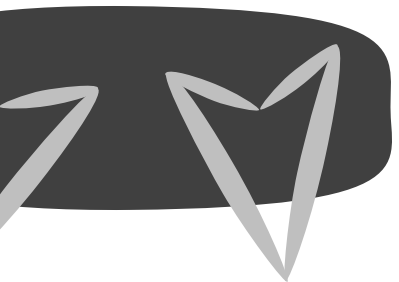
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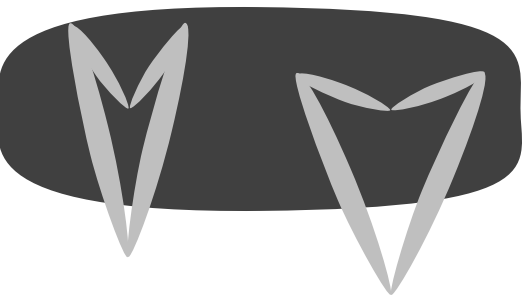
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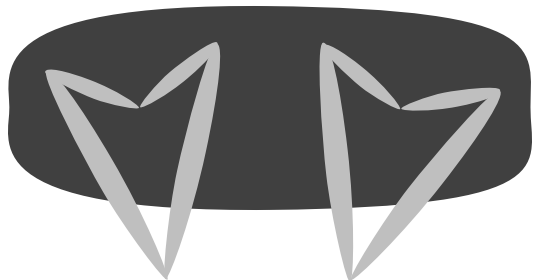
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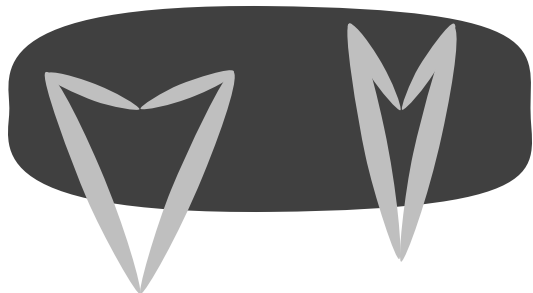
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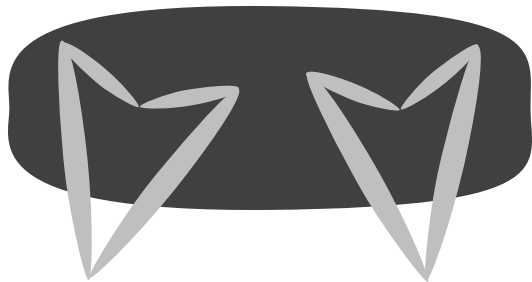
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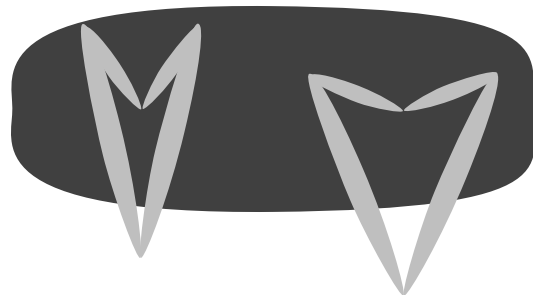
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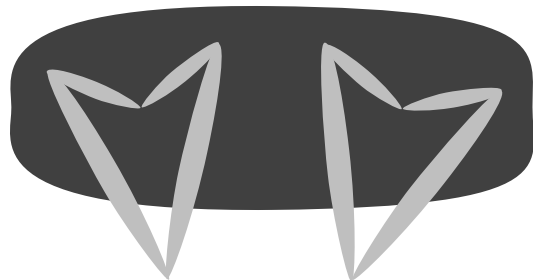
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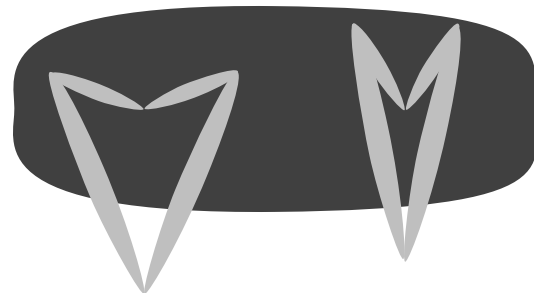
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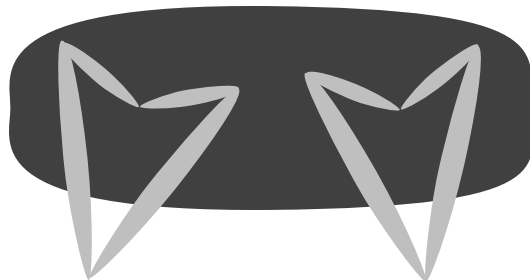
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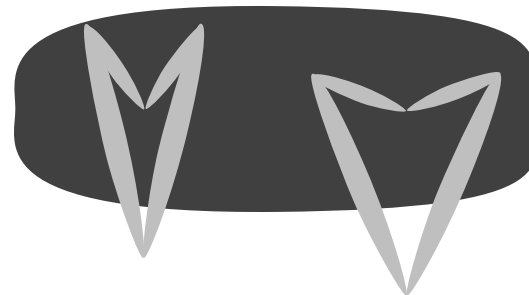
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Model Based Systems Quadruped

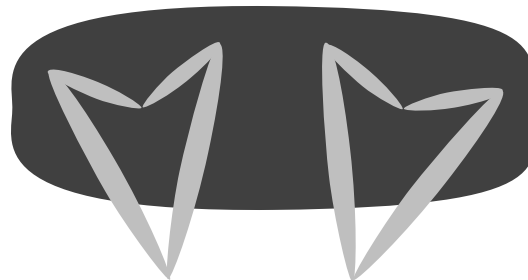
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Model Based Systems Quadruped

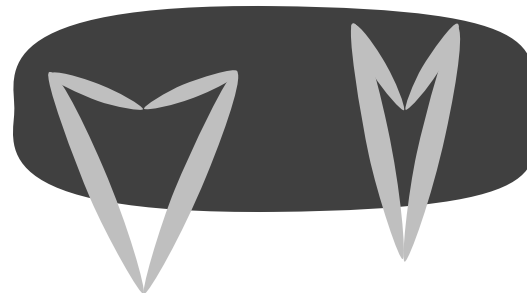
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Model Based Systems Quadruped

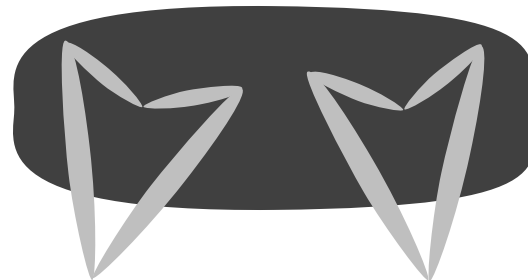
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Model Based Systems Quadruped

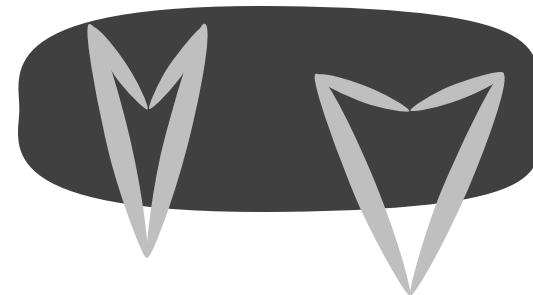
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Model Based Systems Quadruped

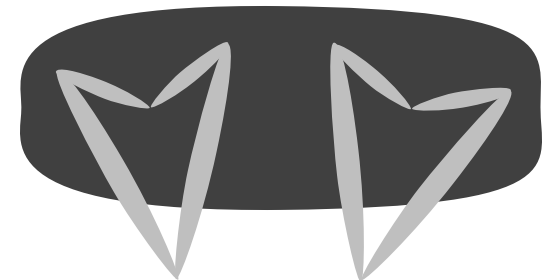
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Model Based Systems Quadruped

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Model Based Systems Quadruped

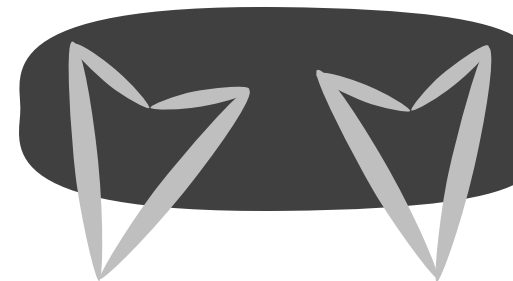
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Model Based Systems Quadruped

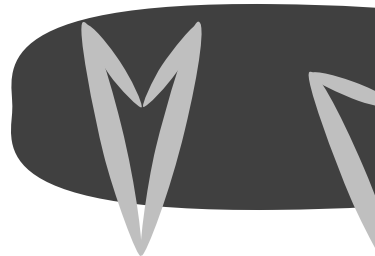
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Model Based Systems Quadruped

Design Review 5





Model Based Systems Quadruped

Design Review 5





Model Based Systems Quadruped

Design Review 5





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Design Review 5

Team Introductions



Milton Bouchard
Modeling Engineer



Michael Dina
Systems Engineer



Onoriode Onokpise
User Interface Engineer



Jackson Raines
Testing Engineer



Zachary Shapiro
Testing Engineer

Sponsors and Advisor



CENTER FOR INTELLIGENT SYSTEMS, CONTROL, AND ROBOTICS



Dr. Jonathon Clark
Sponsor



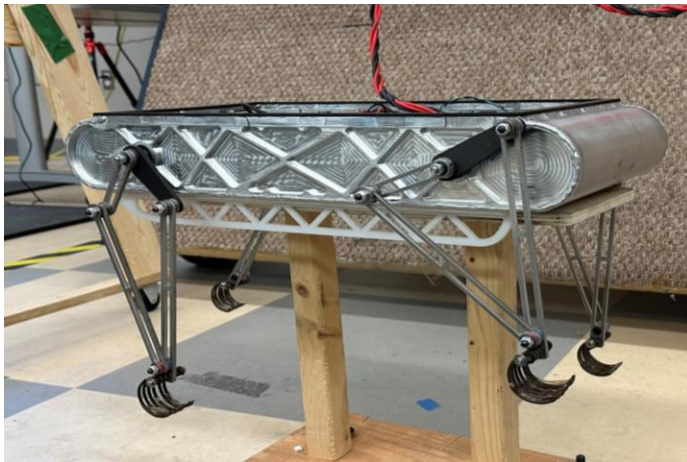
Dr. Patrick Hollis
Advisor



Dr. Shayne McConomy
Sponsor

Objective

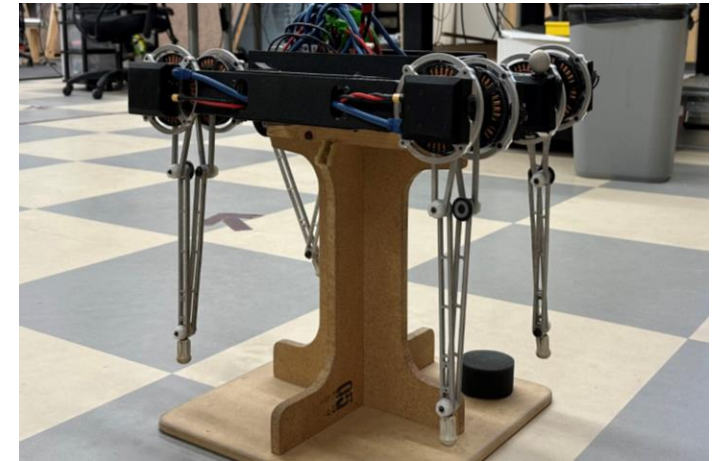
The objective of this project is to develop a software tool that expedites the design and construction of quadrupedal robots. The tool will use the knowledge gained from robots previously built at CISCOR.



ET-Quad



RHex

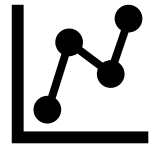


Minitaur

Key Goals



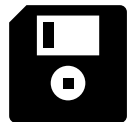
Develop a tool to assist new quadrupedal robot development



Return critical parameter values



Reduce development time

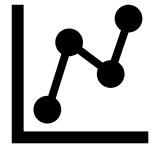


Act as a database of knowledge for robot development

Key Goals



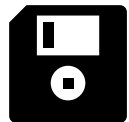
Develop a tool to assist new quadrupedal robot development



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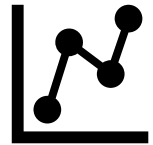


Act as a database of knowledge for robot development

Key Goals



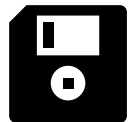
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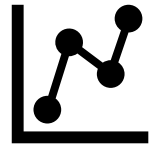


Act as a database of knowledge for robot development

Key Goals



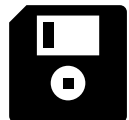
Develop a tool to assist new quadrupedal robot development



Return critical parameter values



Reduce development time

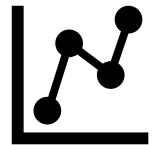


Act as a database of knowledge for robot development

Key Goals



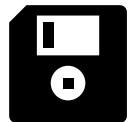
Develop a tool to assist new quadrupedal robot development



Return critical parameter values

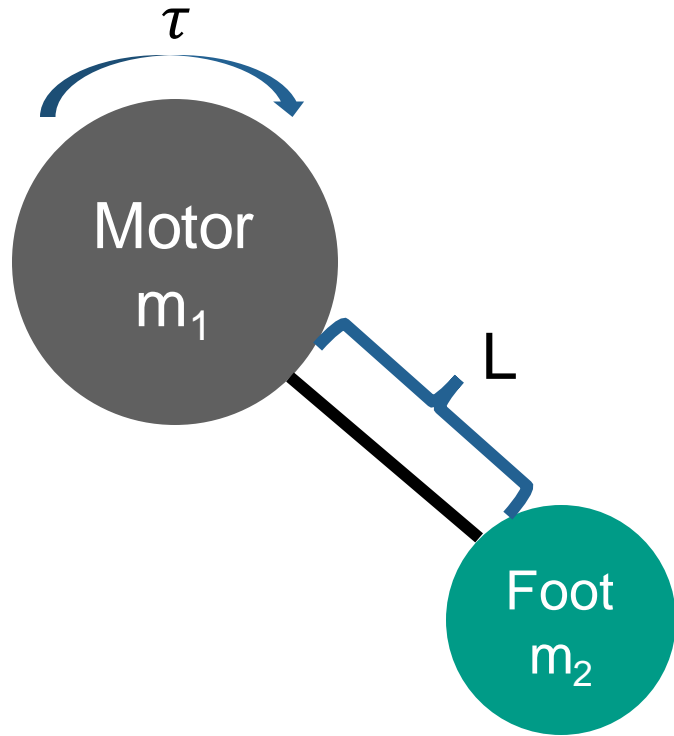


Reduce development time



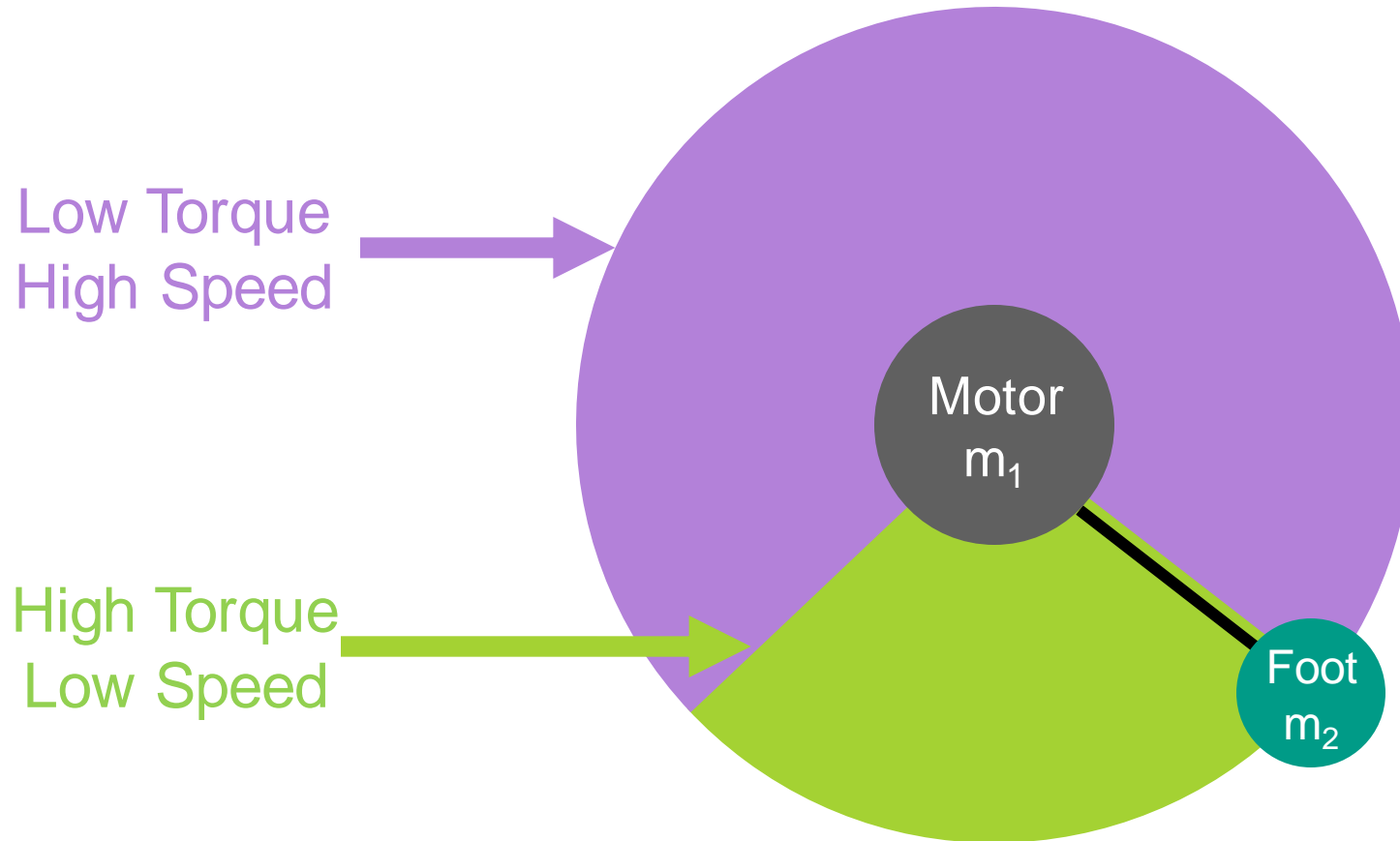
Act as a database of knowledge for robot development

Starting Motor Model - Simple

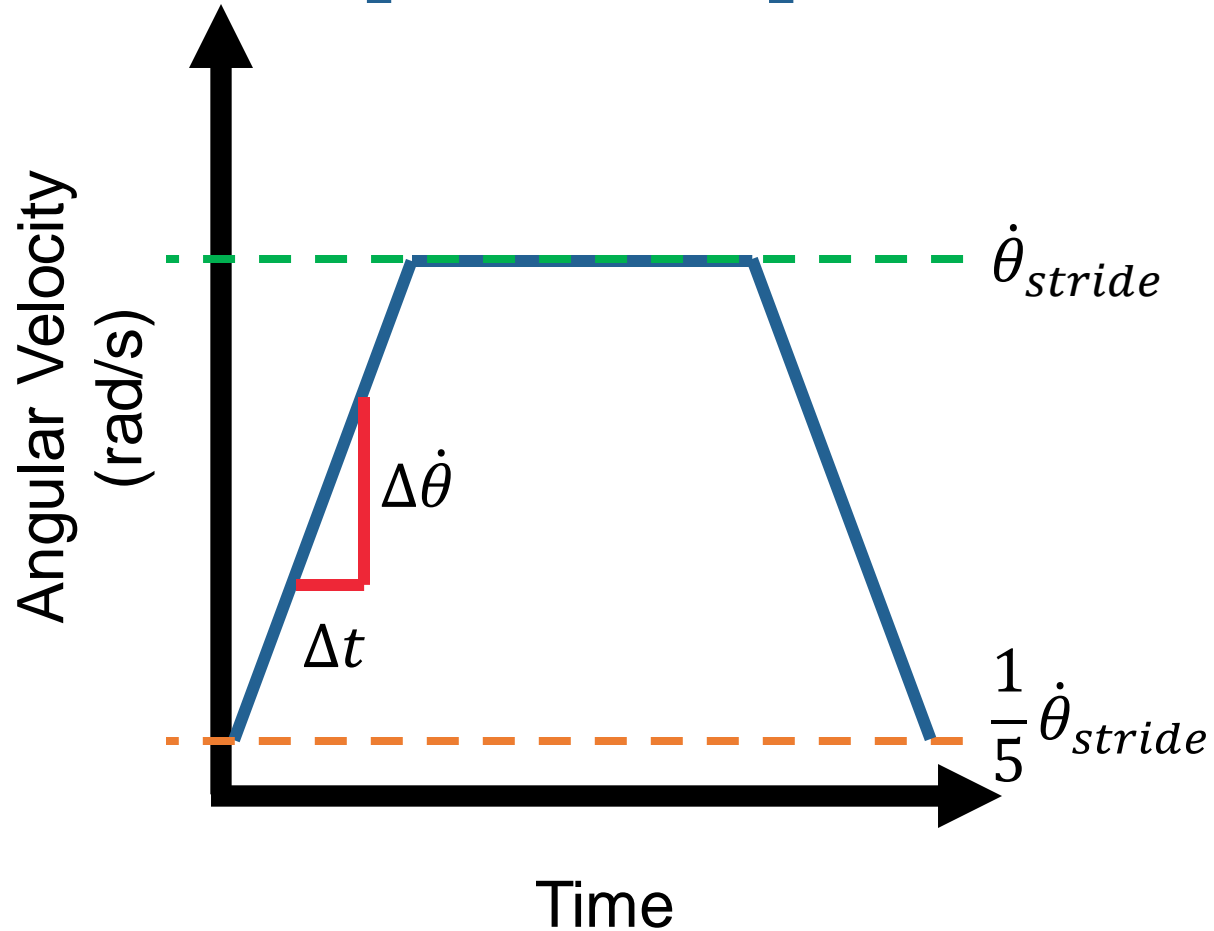


RHex

Two Phases - Slighte

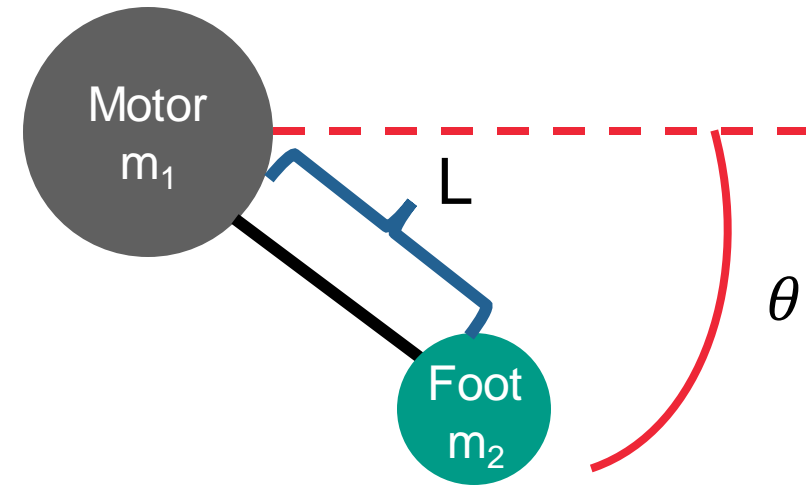


Torque Required

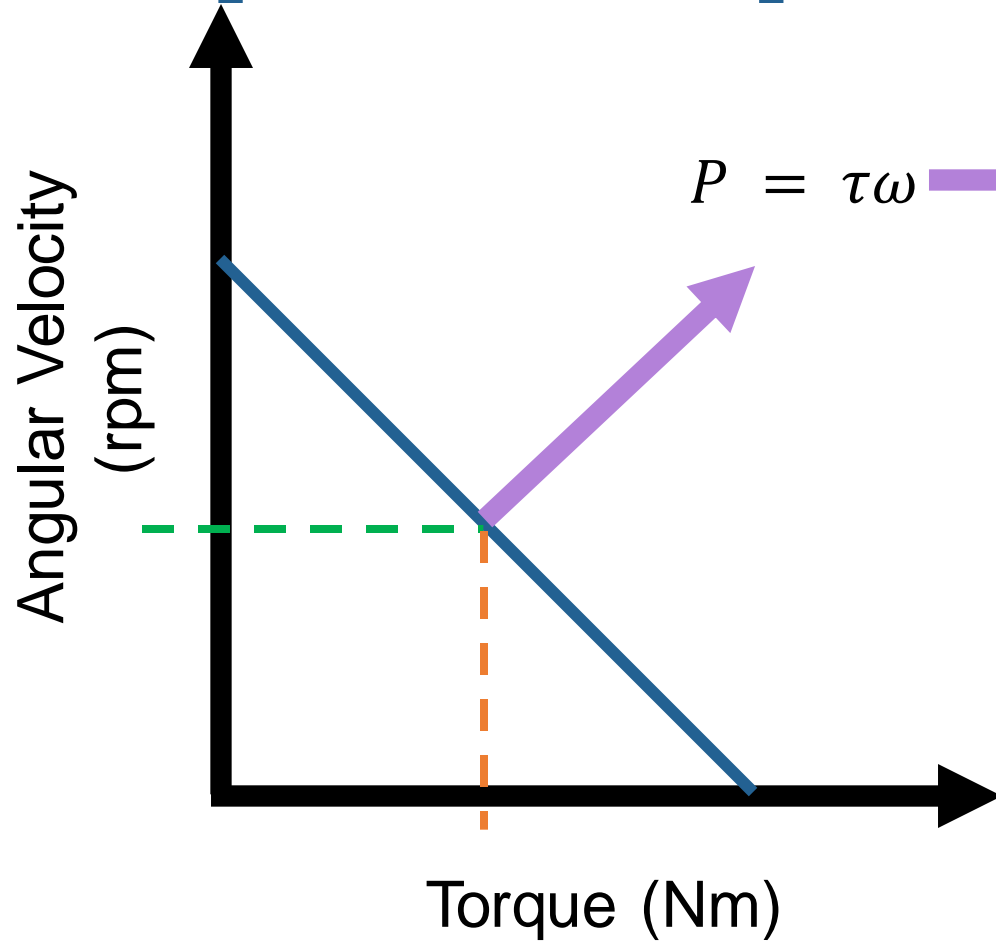


$$\tau_{stance} = m_1 L g \cos \theta$$

$$\tau_{stance} + \tau_{flight} = m_2 \left(\frac{8\pi f_{stride} L^2}{5\Delta t} + \frac{8\pi f_{stride} L^2}{5\Delta t} g \cos \theta \right)$$



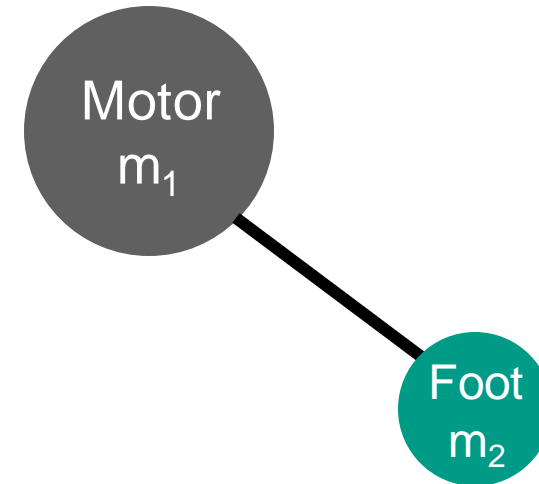
Speed-Torque Curve



$$P = \tau\omega$$

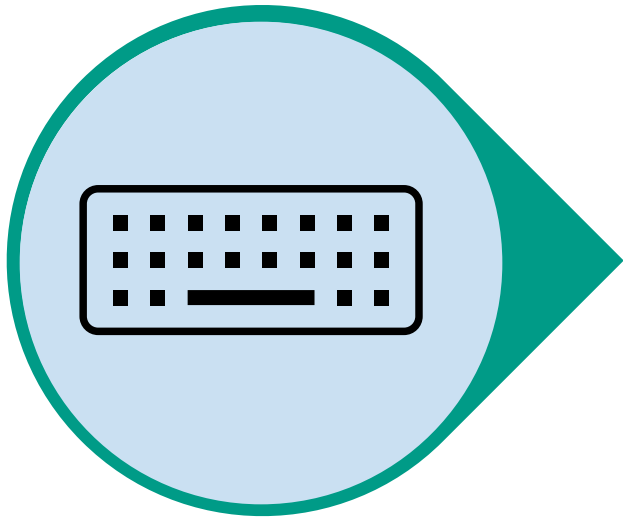
$$P \propto m$$

$$m_{motor} \cong 0.2m_{total}$$

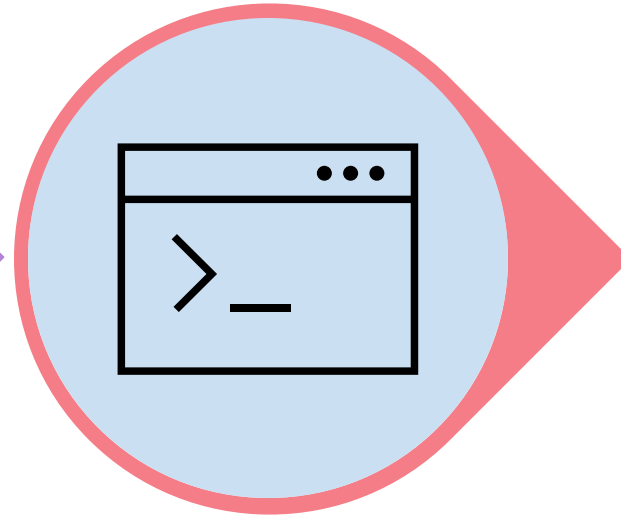


Targets and Metrics

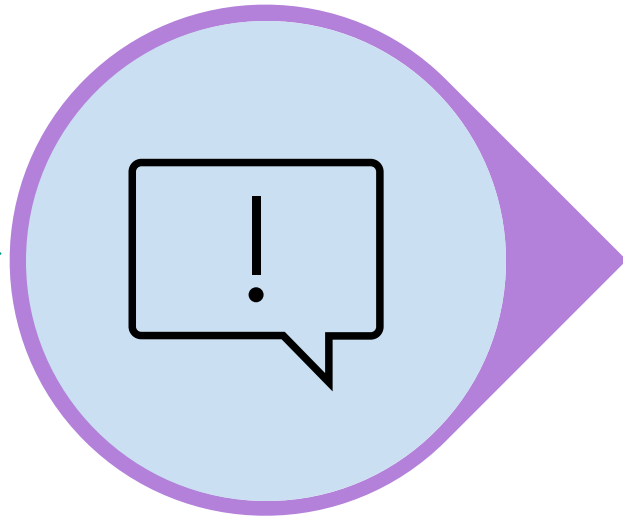
Inputs



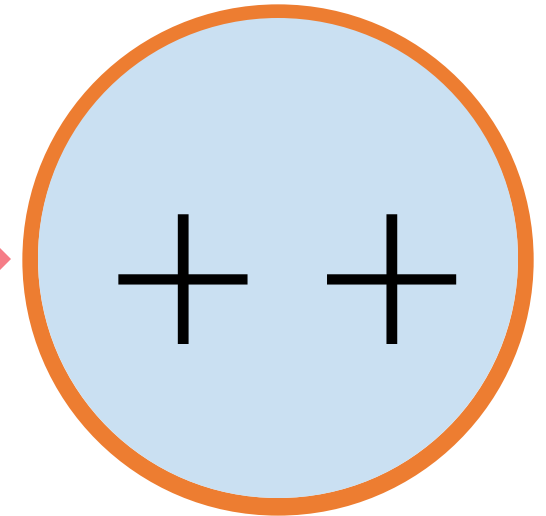
Modeling



Outputs



Additional



Concept Generation

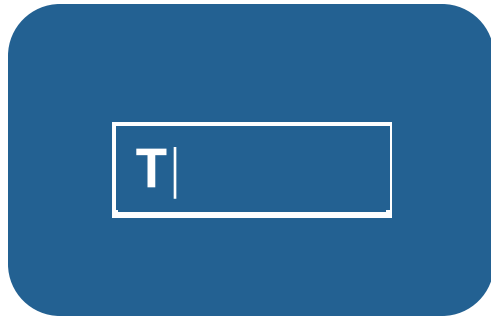


Brainstorming

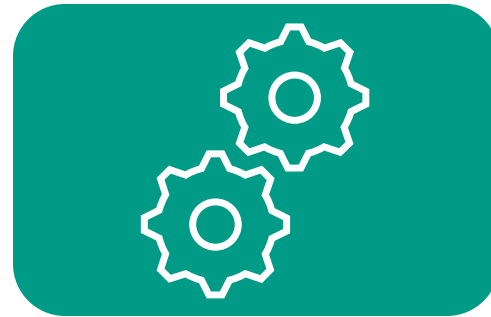


Forced Analogy

Medium Fidelity



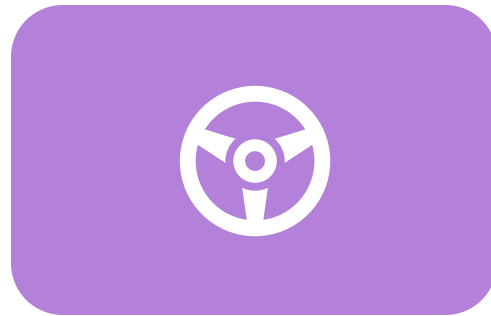
MATLAB Textbox



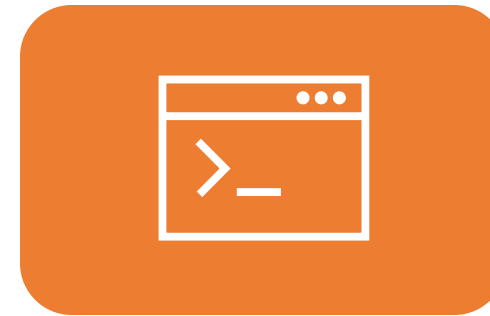
Simscape Model



MATLAB GUI with
information
Dashboard

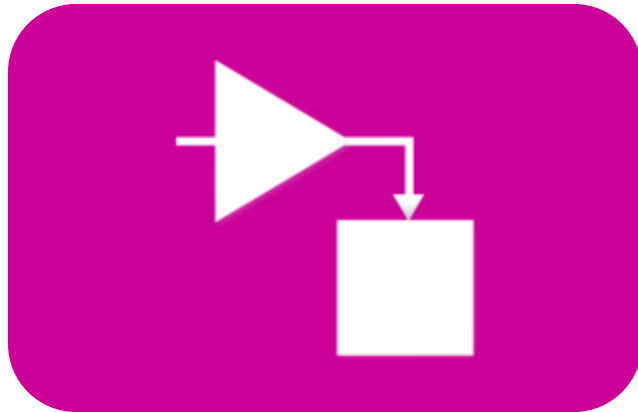


Racing Car
Game Selection

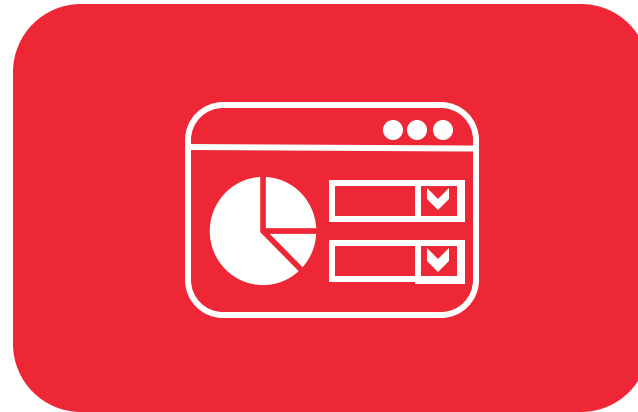


MATLAB command line

High Fidelity



MATLAB to
Simulink



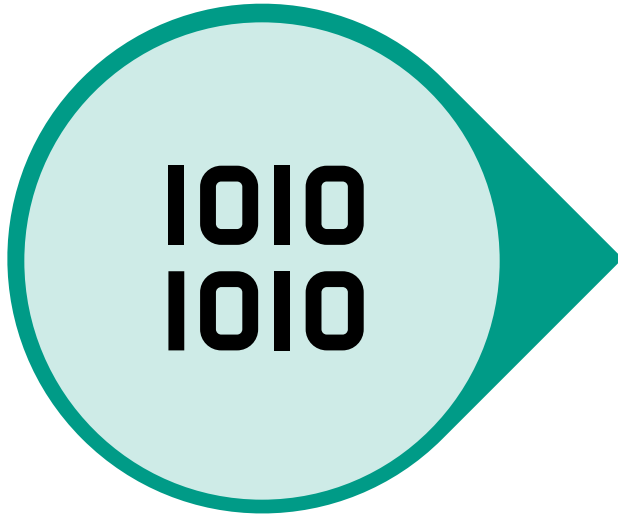
MATLAB GUI
with Dropdowns



System
Composer GUI

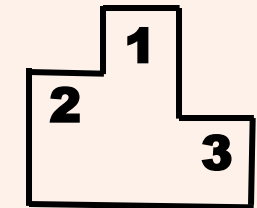
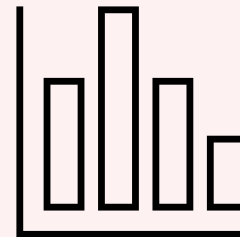
Concept Selection

Pairwise
Comparison



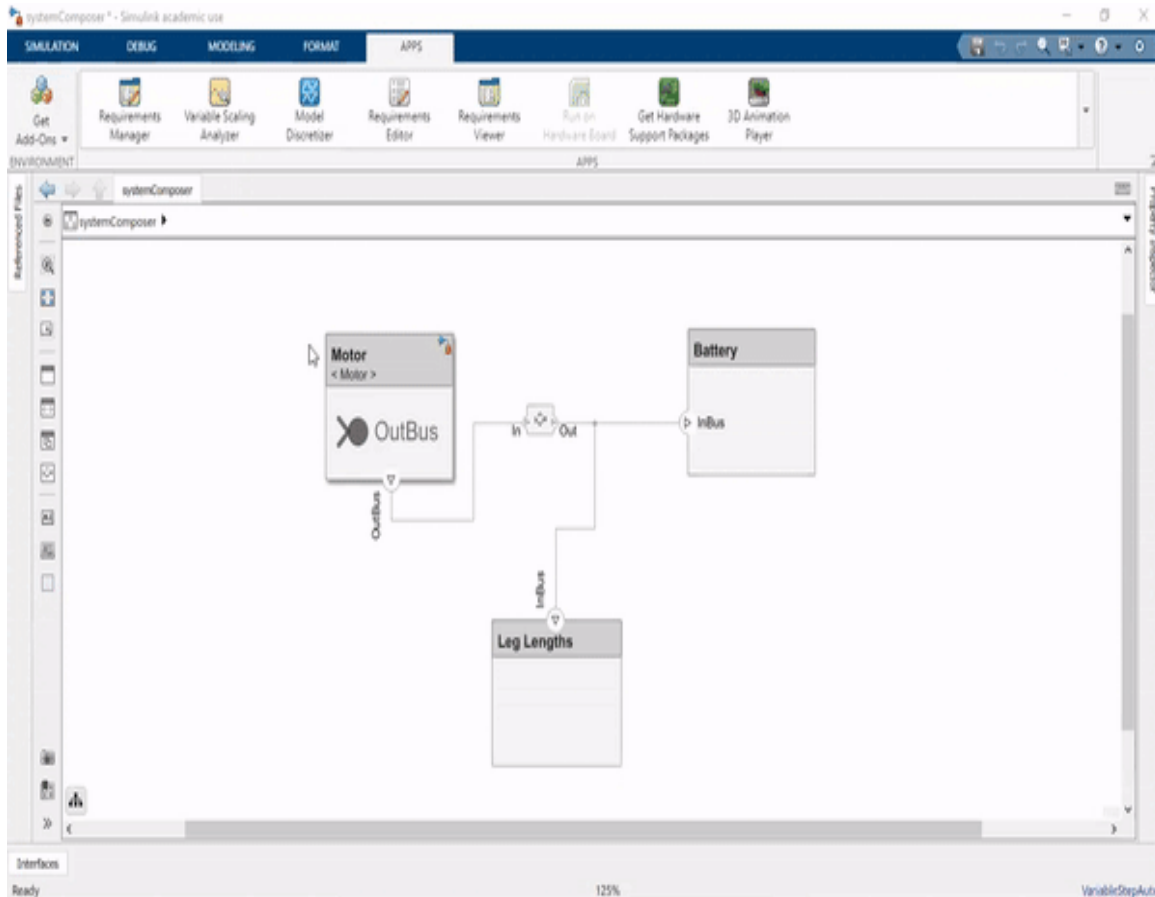
House
of Quality

Pugh
Chart



Analytical
Hierarchy

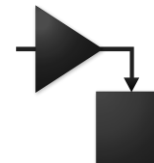
Final Selection



System Composer GUI

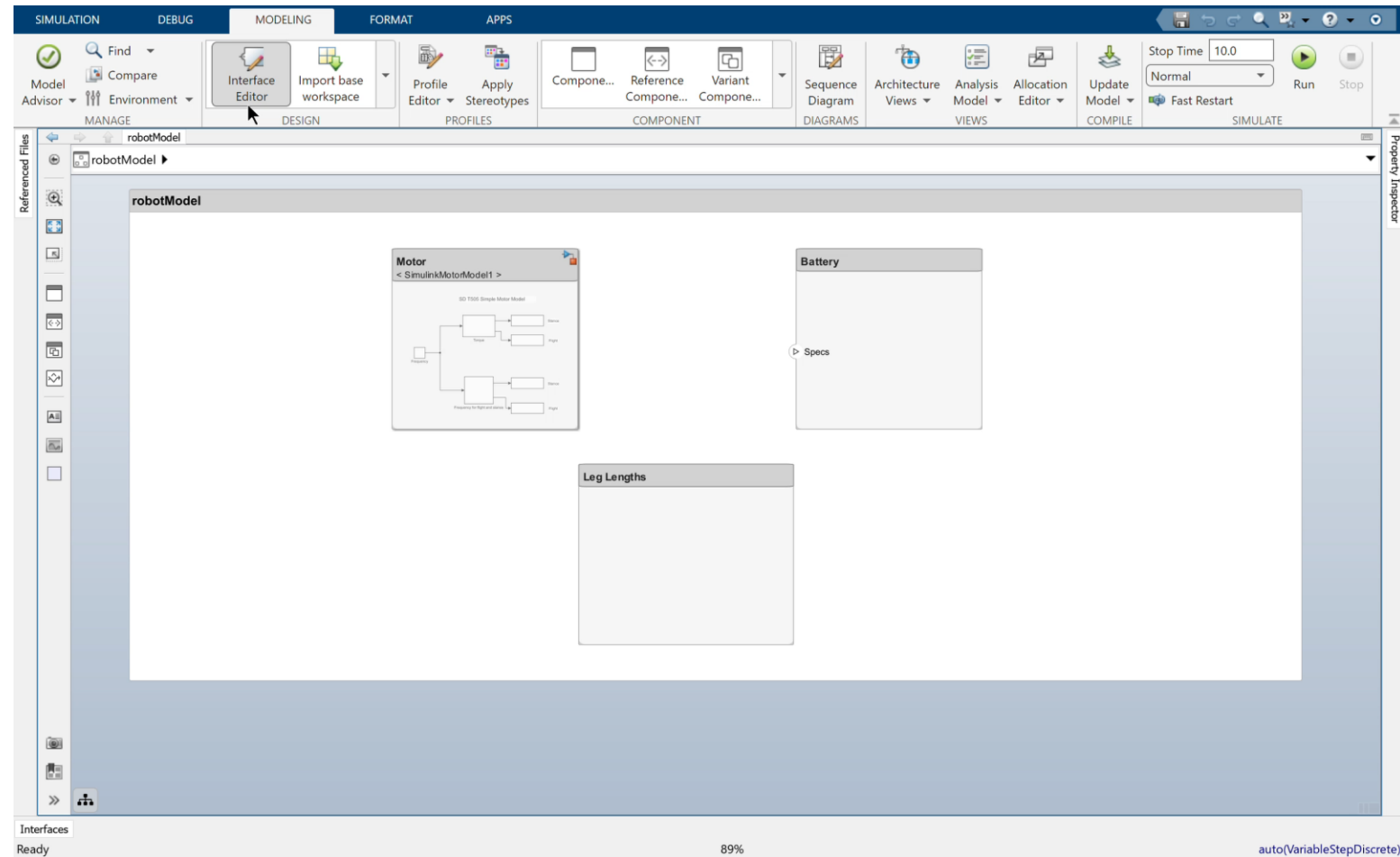


Accepts constraints from user in the form of performance characteristics



Attach Simulink models to specific functions

Modeling in System Composer



Software Architecture

Visible

GUI

Optional

Invisible

System
Composer

Variables
Run

Performance
Specifics
Compile
Send Updates

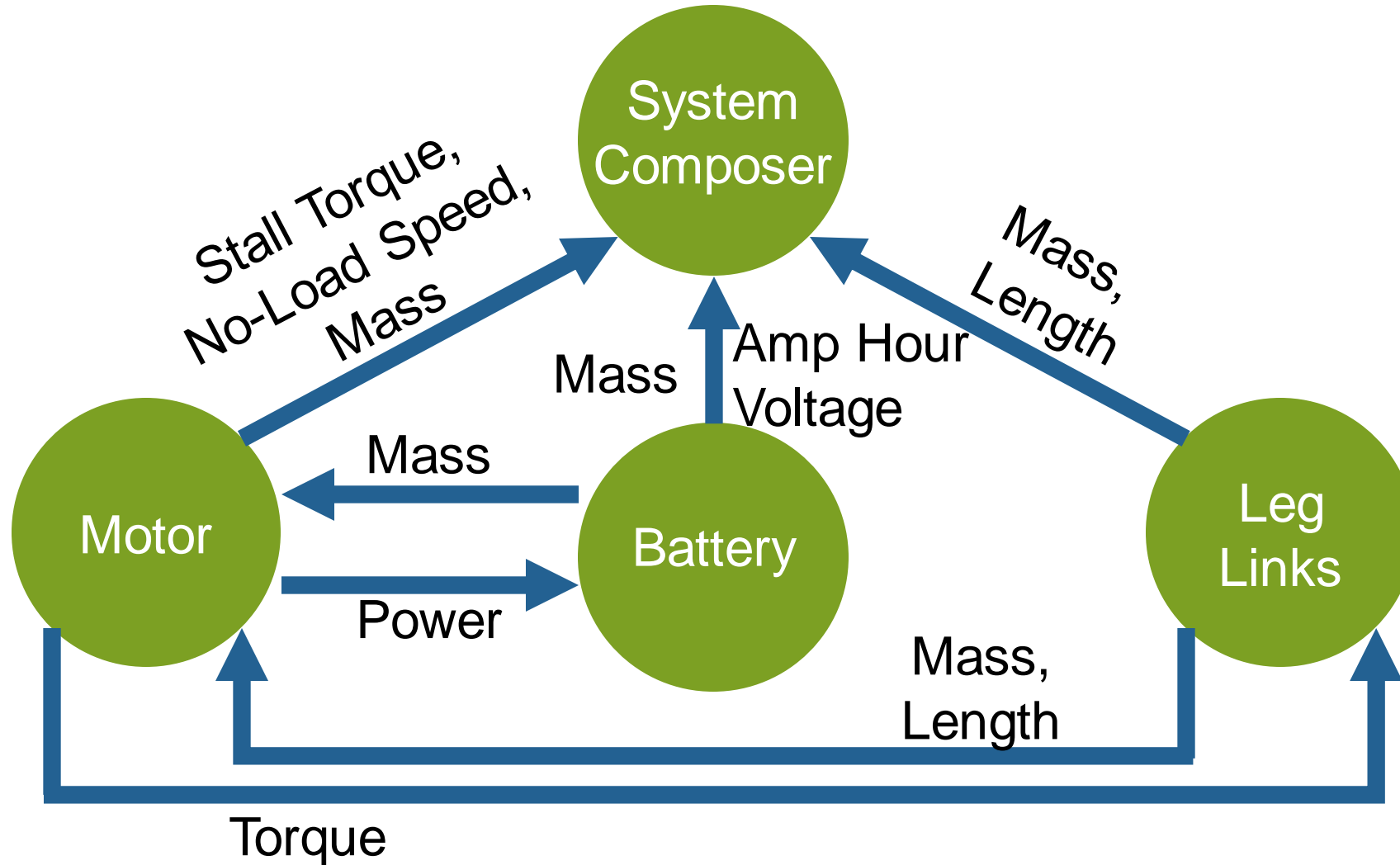
Show
Targets

Simulink

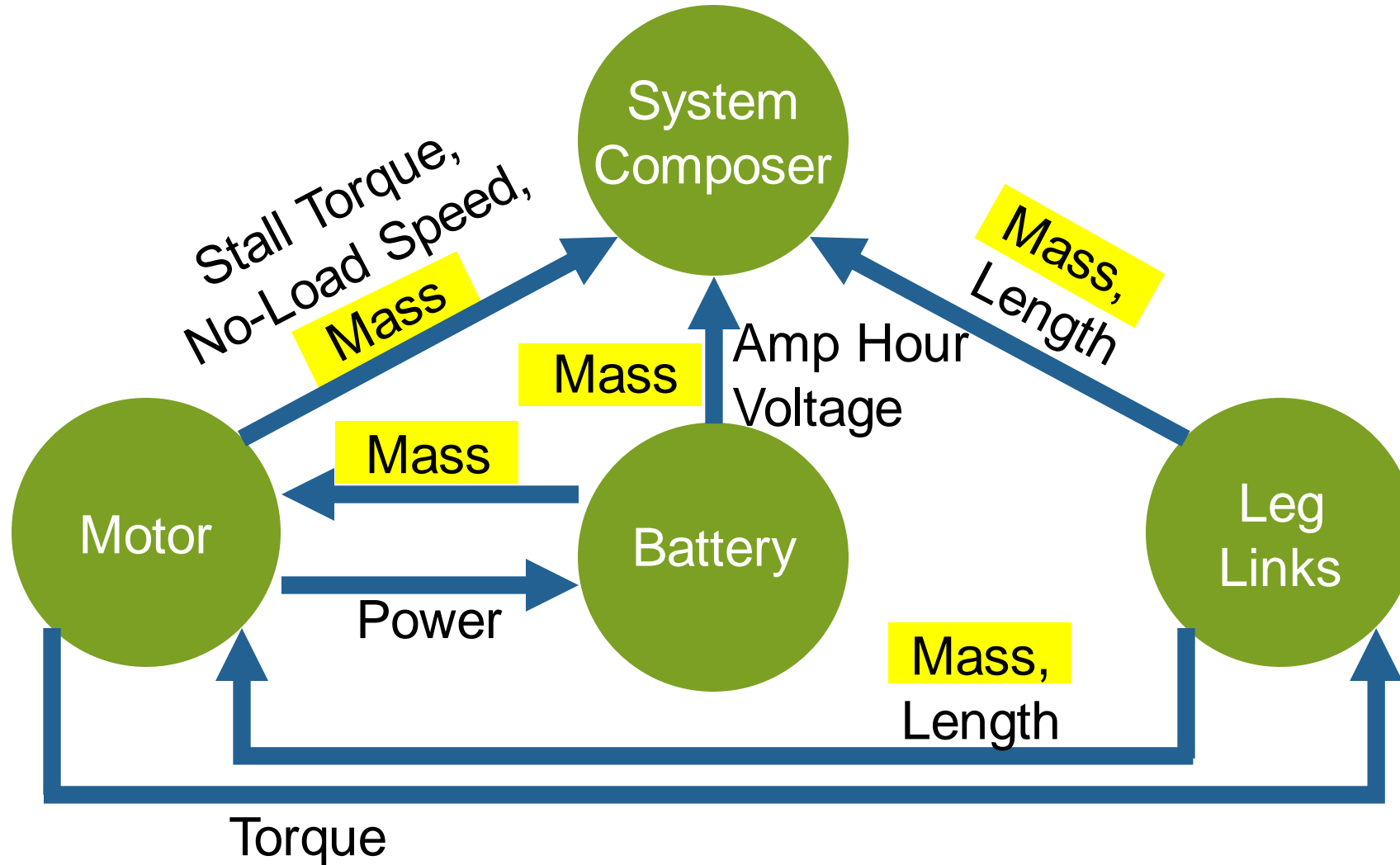
Results

Run Analysis

System Composer Architecture



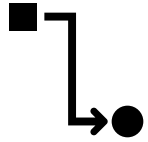
System Composer Architecture



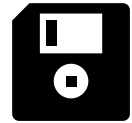
GUI Integration with Prototype

Visible Layer

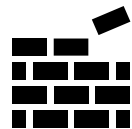
Shift in Focus



Complete process from the input to the output

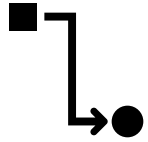


Focus on ET-Quad database

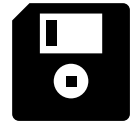


Set framework for improvement and future complexity

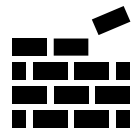
Shift in Focus



Complete process from the input to the output

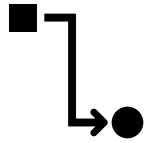


Focus on ET-Quad database

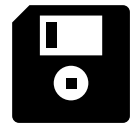


Set framework for improvement and future complexity

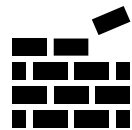
Shift in Focus



Complete process from the input to the output

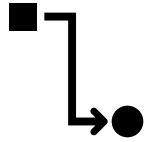


Focus on ET-Quad database

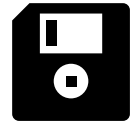


Set framework for improvement and future complexity

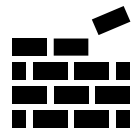
Shift in Focus



Complete process from the input to the output



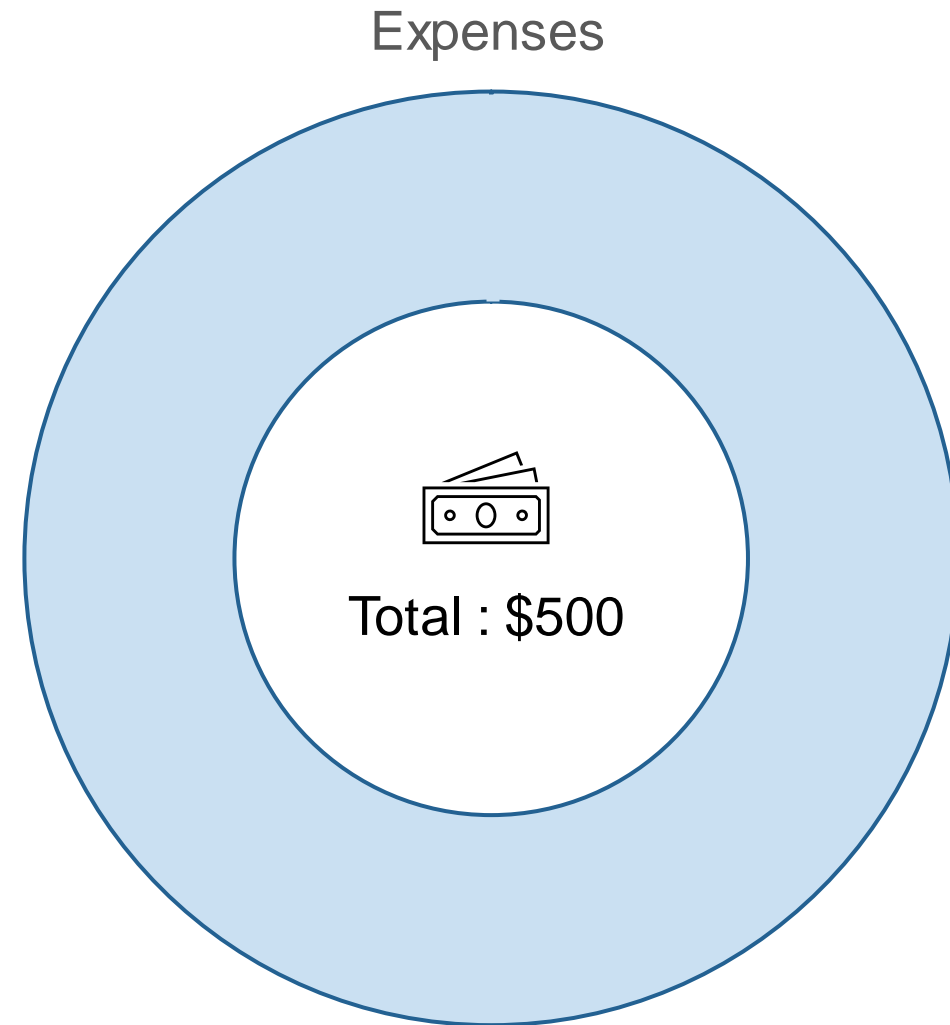
Focus on ET-Quad database



Set framework for improvement and future complexity

Budget Report

Project funding comes from \$500 provided by CISCOR

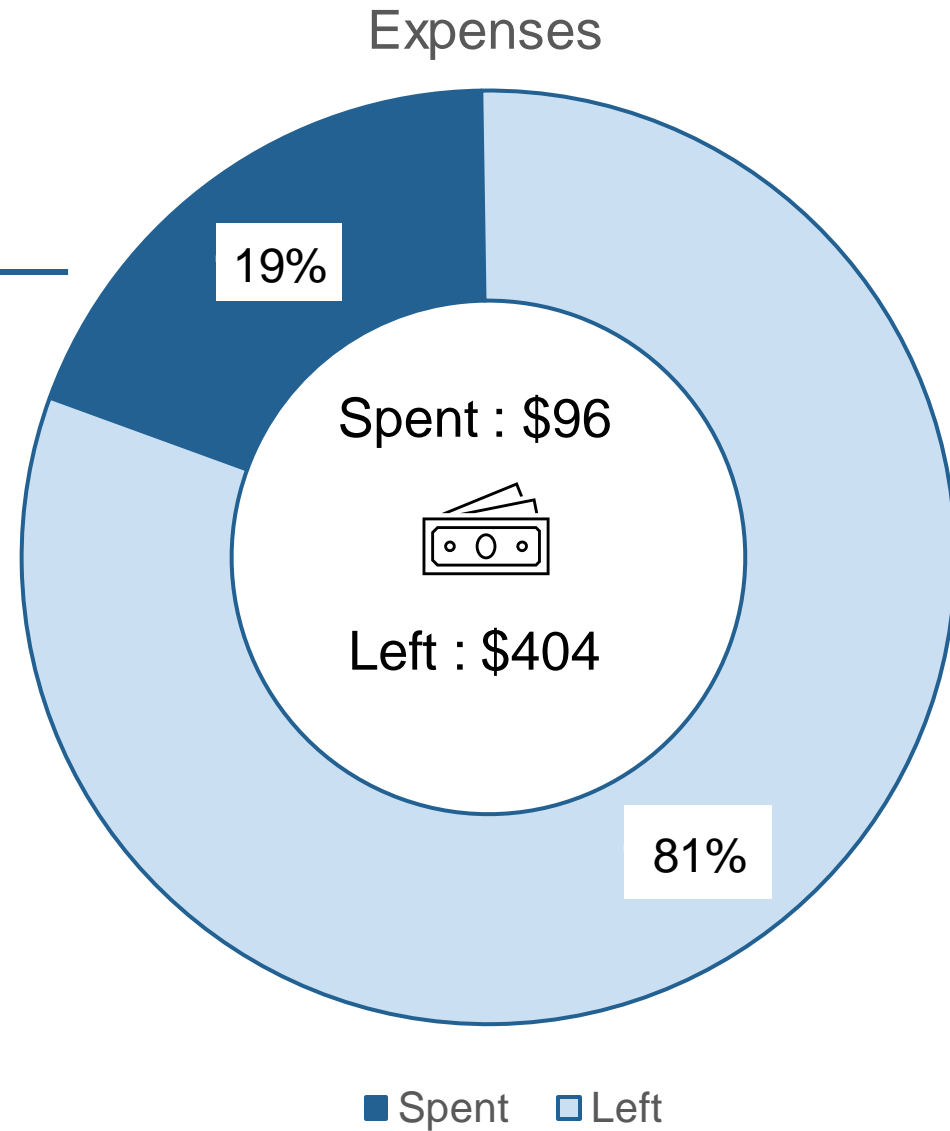


Budget Report

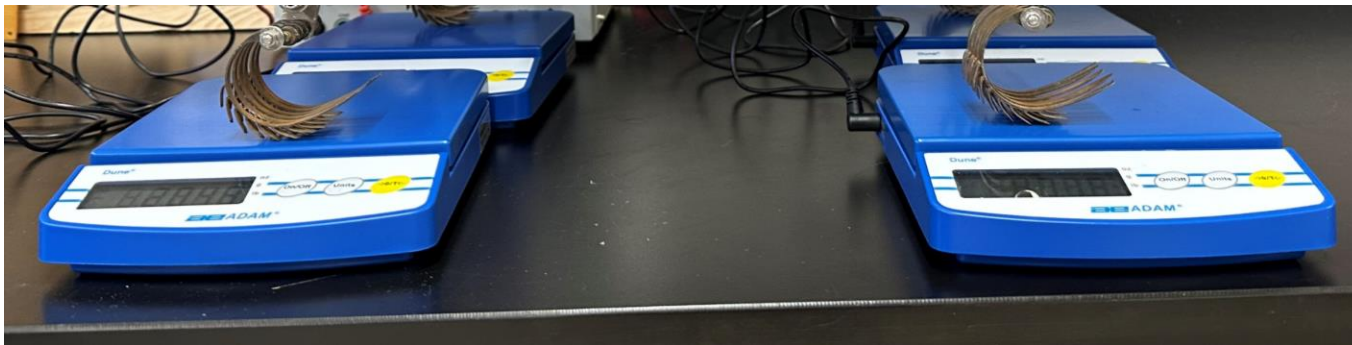


Compact Bench Scale

\$96 (19%) spent purchasing a scale to weigh robot parts

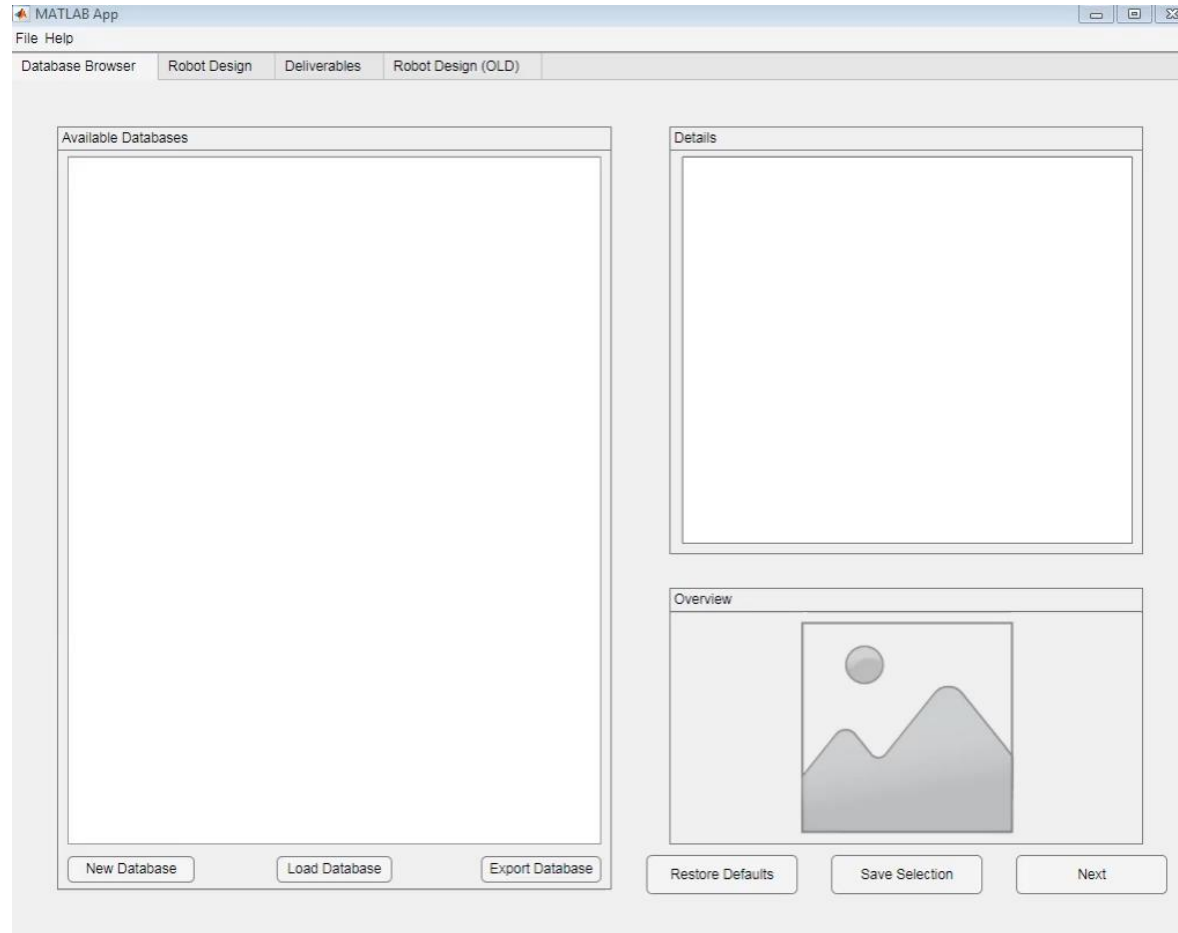


Database Creation



- 📍 Total robot mass
 - ✓ Used for verification
- 📍 Leg mass, battery mass, and sensor package mass
 - ✓ Help with mass budget
- 📍 Battery Mass
 - ✓ Used for linear approximations
- 📍 Motor mass
 - ✓ Used for verification

Current GUI Prototype



Future Work

Documenting Assumptions



```
graph TD; A[Documenting Assumptions] --> B[ ]; B --> C[ ]; C --> D[ ]
```

Future Work

Documenting Assumptions

Develop Operations Manual

Future Work

Documenting Assumptions

Develop Operations Manual

Application Deliverables Tab

Future Work

Documenting Assumptions

Develop Operations Manual

Application Deliverables Tab

Testing for Validation

Future Work : Testing



ET-Quad Peak Stance Torque



Model Validation



Margin of Error Validation



RHex

Future Work : Testing



ET-Quad Peak Stance Torque



Model Validation



Margin of Error Validation



RHex

Future Work : Testing



ET-Quad Peak Stance Torque



Model Validation



Margin of Error Validation



RHex

Future Work : Testing



ET-Quad Peak Stance Torque



Model Validation



Margin of Error Validation



RHex

LinkedIn Profiles



Milton Bouchard
Modeling Engineer



Michael Dina
Systems Engineer



Onoriode Onokpise
User Interface Engineer



Jackson Raines
Testing Engineer



Zachary Shapiro
Testing Engineer

