Salamander Robot Team (LM2) Proposal Presentation:

Salamander-Inspired Rescue Robot for Low-Traversability Environments

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Outline

Introduction

- Disaster scenarios can present extreme terrain and operating conditions
- Rescue robots allow stakeholders to “sense and act at a distance from the site of a disaster or extreme incident”[1]
- Unmanned ground vehicles (UGVs)
  - Search
  - Reconnaissance and mapping
  - Structural inspection
- A salamander-inspired UGV could provide mobility, stability, and portability

1. Robin R. Murphy. *Disaster Robotics*. 2014.

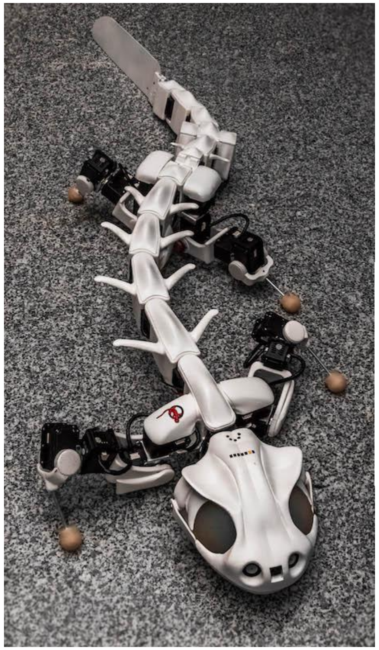
Qualitative Goals: Room for Improvement

- Currently used: ground & aerial robots, rescue dogs, microphones and cameras similar to endoscopic cameras
- Plan for improvement: Provide a system which can investigate faster, further, and more reliably than current systems
- Goal: Improve rescue response time and survival rate of disaster scenarios such as collapsed buildings
  - Build a **prototype** of salamander-inspired man-portable rescue robot
  - **Evaluate** potential of salamander-inspired unmanned ground vehicle (UGV) in a simulated disaster area

Prior Work

- Snakey (GT - IVALab, Dr. Vela)
- Hexapod (RHex project)
- Biomimetic salamander robot from EPFL

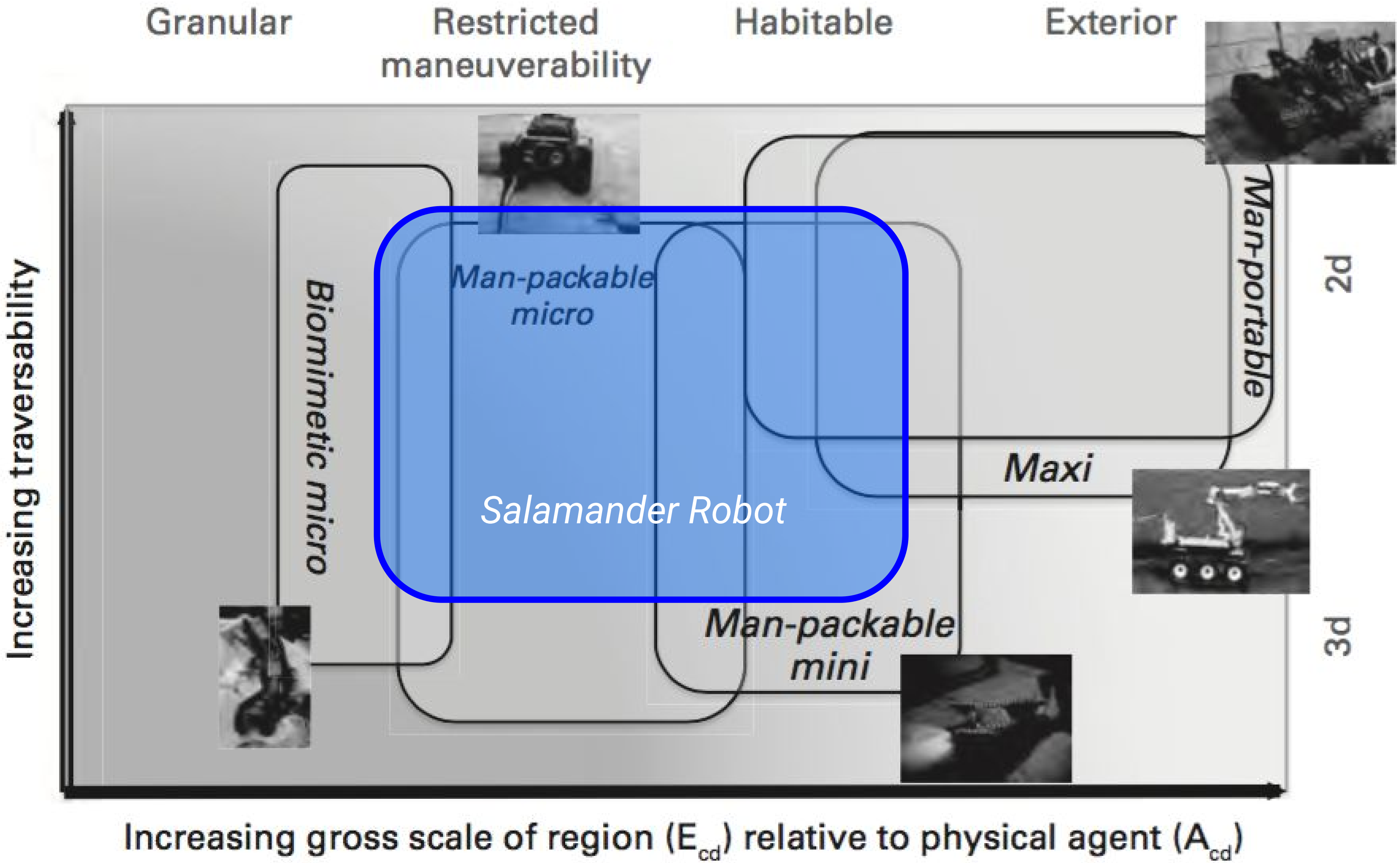
Snakey (GT - IVALab)



EPFL Pleurobot

IRS Soryu robot

Rescue UGV Product Space



1. Robin R. Murphy. *Disaster Robotics*. 2014.

Key Design Constraints & Limitations

- Small and agile enough to navigate under unknown rubble
- Light enough to be easily deployed to disaster environments
- Must be able to perform reliably in numerous disaster environments
- Must be an affordable addition to disaster response teams

Quantitative Robot Specifications

Minimum Viable Product

Item	Specification
Weight	< 25 kg
Bounding volume	< 2 m x 0.5 m x 0.5 m
Traversable terrain height deviation	> 5 cm
Traversable grade	> 3 %
Turn radius	< 2 m
Traversal speed	> 10m / minute
Man-portable	Yes
Tether length	> 3 m

Possible Future Functionality

Obstacle avoidance
Autonomous searching
Camera-enabled localization
Environment mapping
Localization

Design Approach: Fabrication

- This robot is inspired by EPFL's Pleurobot and used their approach to the bio-mimicry of a salamander

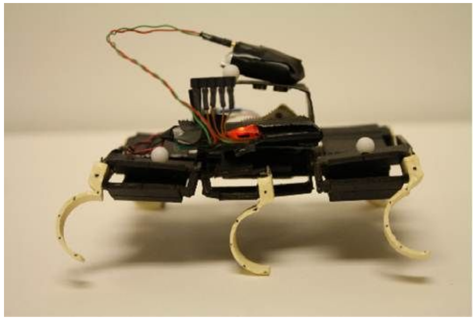
- The Mechanical Team will design the robot to function using a 'spine' of servos with attached legs and tail to mimic the gait of a salamander.

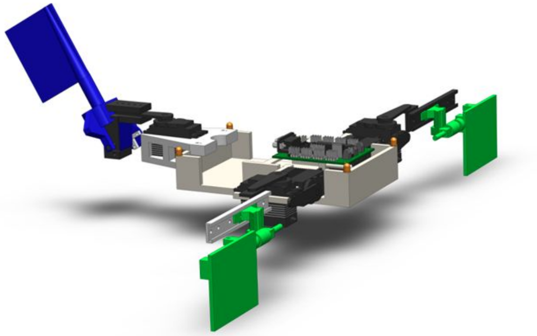
- Legs and Tail will be a combination of 3D printed parts and mechanical linkages to explore how to best traverse the terrain.

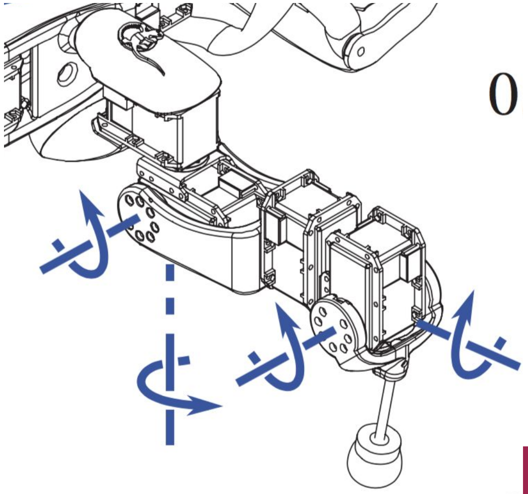
Design Approach: Foot Design

ME Team

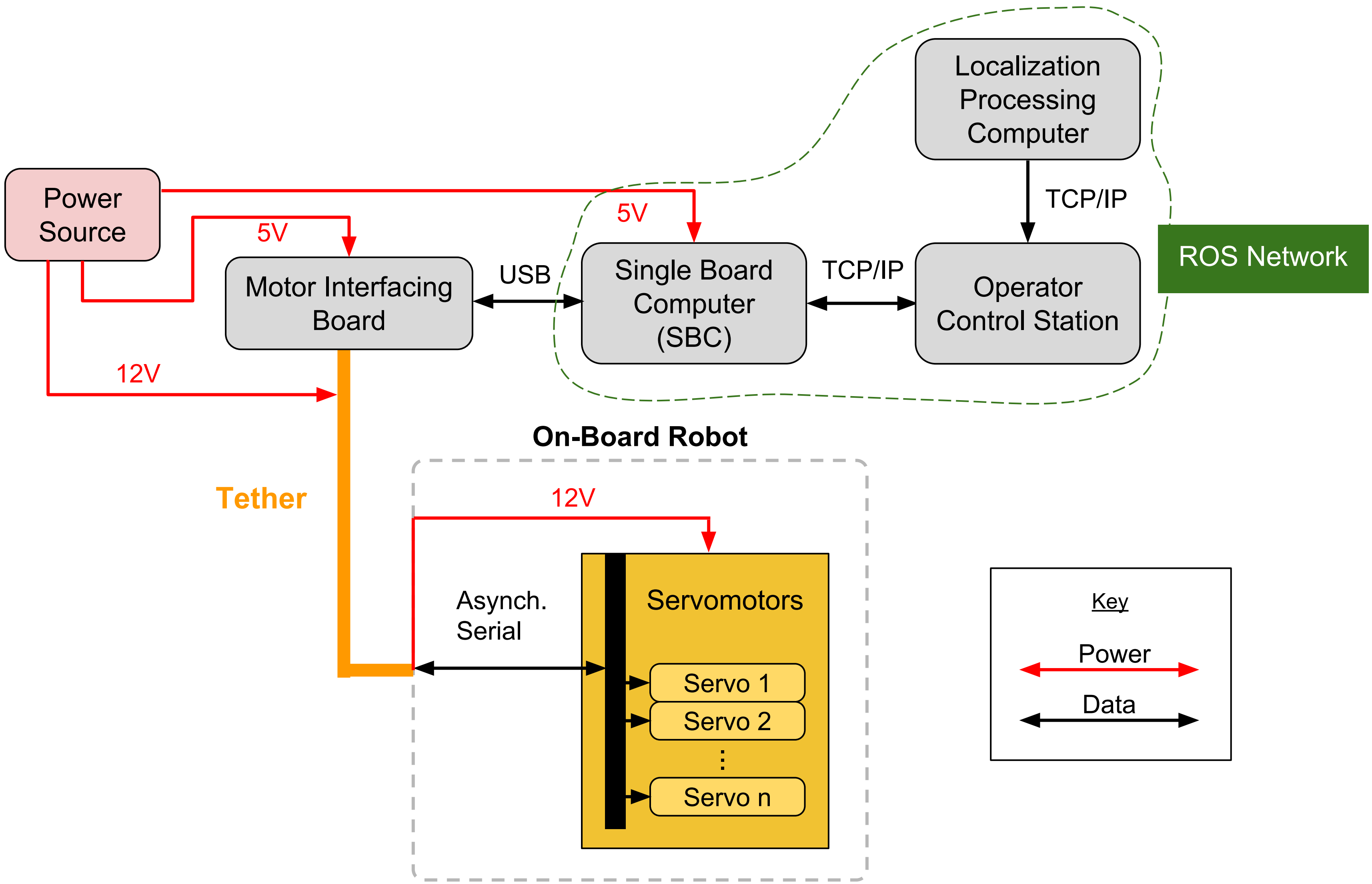
- A significant amount of testing and research will be necessary to find the best foot design to traverse rough terrain, and climb through rubble





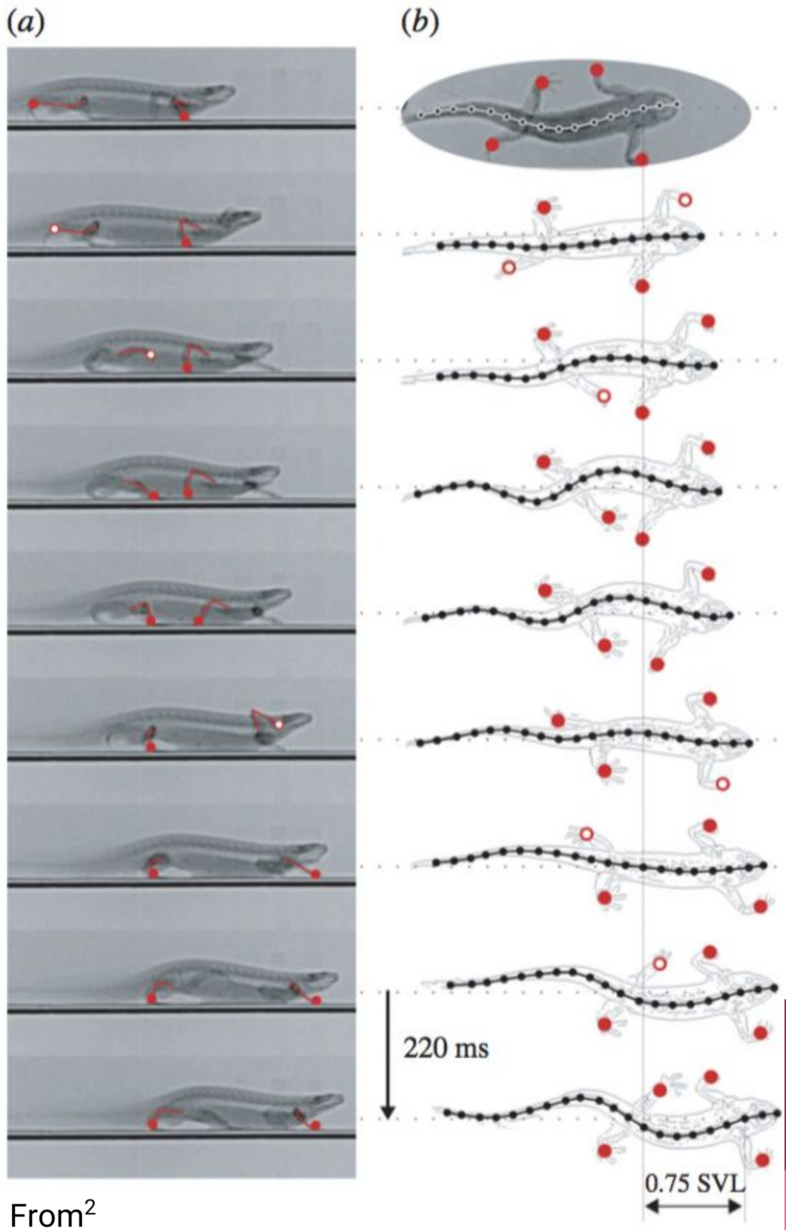


Images from Crablab @ Georgia Tech: crablab.gatech.edu


Power Source
5V
12V
Motor Interfacing Board
USB
5V
Single Board Computer (SBC)
TCP/IP
Localization Processing Computer
TCP/IP
Operator Control Station
ROS Network
Tether
On-Board Robot
12V
Asynch. Serial
Servomotors
Servo 1
Servo 2
⋮
Servo n
Key
Power
Data

Control Approaches: Salamander Gait

- Biomimetic walkcycle replication
  - Adapt data from Pleurobot for modified salamander
  - Servo position control (PID)
- Trajectory planning[1]
  - Inverse leg kinematics
  - Optimal control solver (Dr. Vela)
  - Discover gait pattern for walking over rubble

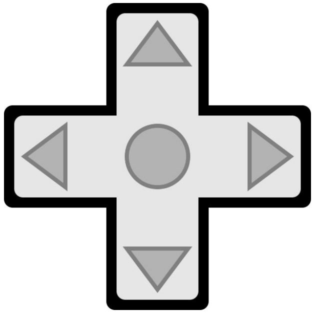


From[2]

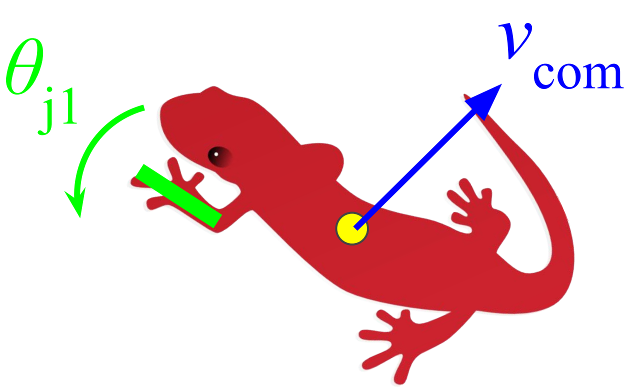
1. Manuel F. Silva et al. *Fractional Order PD Joint Control of Legged Robots.* 2006.
2. Karakasiliotis et al. *From cineradiography to biorobots: an approach for designing robots to emulate and study animal locomotion.* 2016.

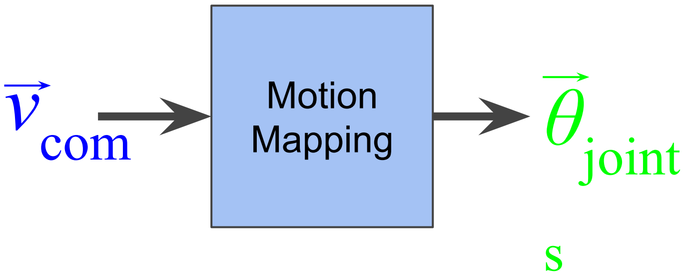
Motion Mapping & User Interface

- Map gait trajectory to simple motion commands for operator control
- Empirically determined
- Depends on control approach chosen

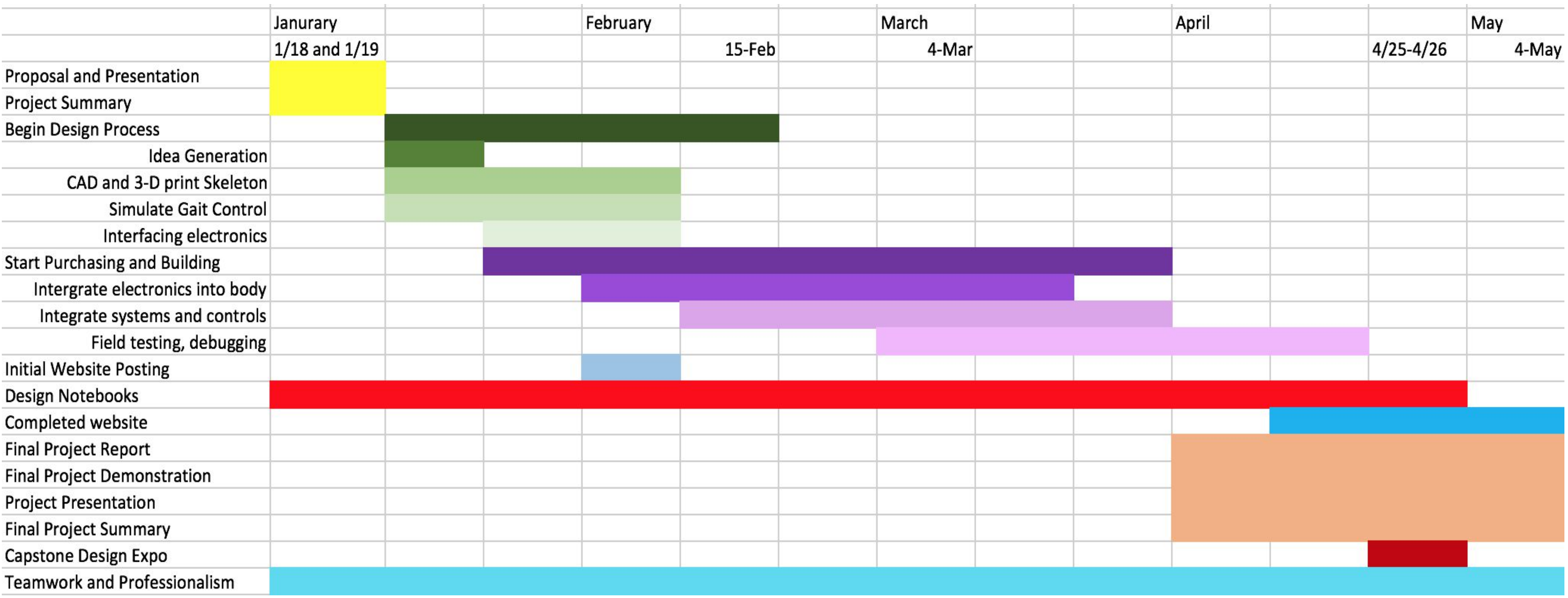


User interface



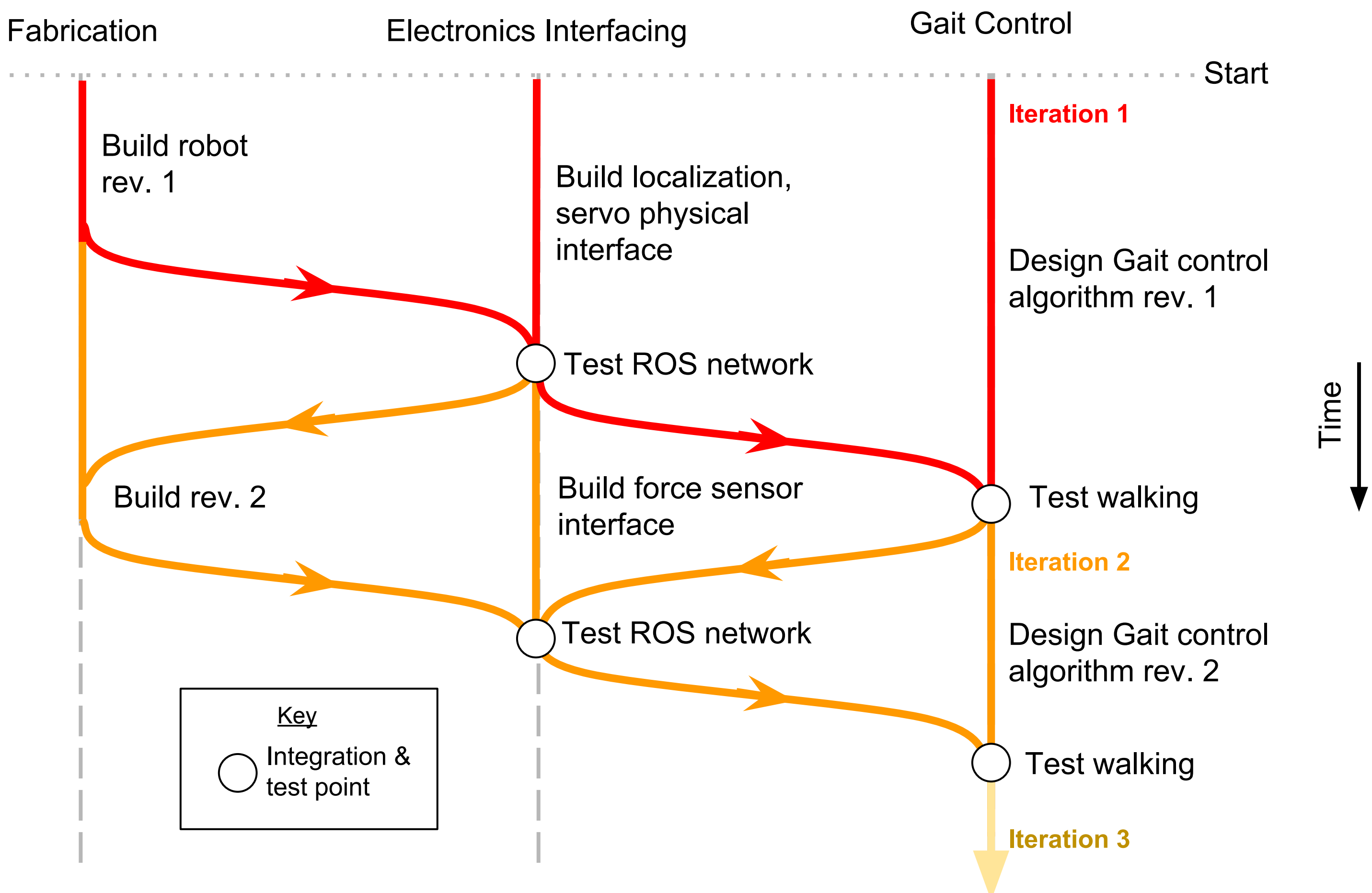


Schedule



Janurary
February
March
April
May
1/18 and 1/19
15-Feb
4-Mar
4/25-4/26
4-May
Proposal and Presentation
Project Summary
Begin Design Process
Idea Generation
CAD and 3-D print Skeleton
Simulate Gait Control
Interfacing electronics
Start Purchasing and Building
Intergrate electronics into body
Integrate systems and controls
Field testing, debugging
Initial Website Posting
Design Notebooks
Completed website
Final Project Report
Final Project Demonstration
Project Presentation
Final Project Summary
Capstone Design Expo
Teamwork and Professionalism

3-Thread Project Planning Approach

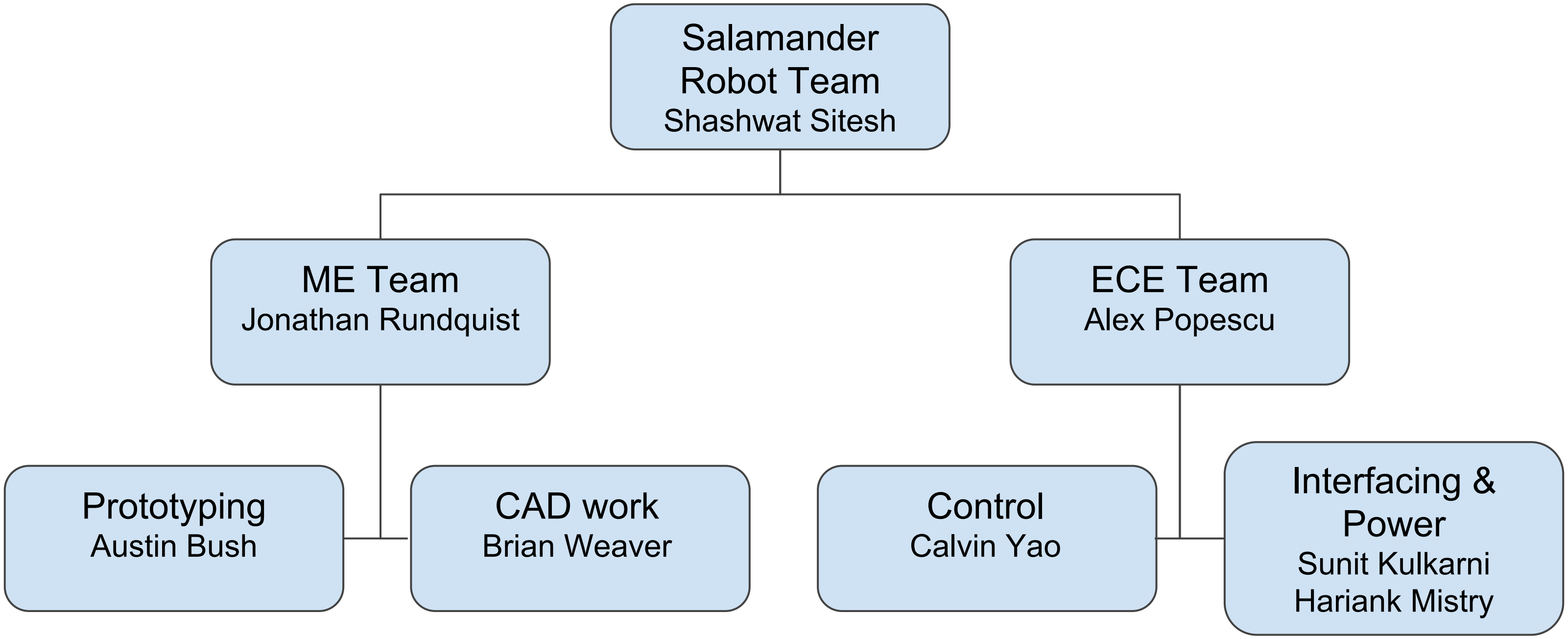


Funding & Budget

Funding Source	Amount
ECE Dept. (estimated)	$800.00
Total Funding	$800.00

Item	Unit Price	Quantity	Total Price
Dynamixel MX-28T Servomotor (Dr. Vela)	$0.00	12	$0.00
Dynamixel MX-64T Servomotor (Dr. Vela)	$0.00	6	$0.00
Raspberry Pi 3 Model B (senior design lab)	$0.00	1	$0.00
Dynamixel AX-12A Servomotor	$44.90	6 (est.)	$269.40
Tether materials (senior design lab)	$0.00	-	$0.00
3D printing material (ECE printer)	$0.00	-	$0.00
Total Cost			$269.40

Team Organization Chart



Current Status

- Welcoming 5 new team members:
  - Jon, Austin, Hariank, Brian, Sunit
- Ironing out deliverables for ECE, ME, MSE majors
- Researching mechanical foot design options
- In process of revising proposal
- Discussing with Dr. Vela and Alex Chang (grad student)

Thank you! Questions?