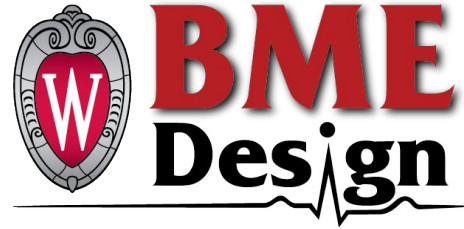


Adaptive Overhead Tether System



Porcine Innovation Group (P.I.G.)

Members: Katie Johnson (Leader), Alisha Schaeffer (Leader), Joshua Grauman (Communicator), Gabriela Medina Medina (BSAC) Evan Hoffman (BPAG), Catherine Sit (BWIG)

Client: Dr. Marco Failla Mulone

Advisor: Prof. Jonathan Soucy

BME 200/300

October 2nd, 2026



DEPARTMENT OF
Biomedical Engineering
UNIVERSITY OF WISCONSIN-MADISON

Overview:

- **Subject:**
 - Wisconsin Miniature Swine
- **Client:**
 - Dr. Marco Failla Mulone
 - Post-doc Research Associate
 - UW Madison Department of Neurological Surgery



Figure 1: “Wisconsin Miniature Swine”



**School of Medicine
and Public Health**



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Background and Motivation

- **Clinical Significance**

“More than 356,000 people have an out-of-hospital cardiac arrest in the United States every year” [1]

- **Neurological Impact**

“Among those who survive cardiac arrest, there is risk of neurologic dysfunction, brain injury, disorders of consciousness, neurocognitive deficits, changes in quality of life, as well as physical and psychological well being”. [2]

- **Research Motivation**

“Neurochemical monitoring can be used to measure molecular changes in brain tissue, and to assess the efficacy of treatments in preclinical stages”. [3]

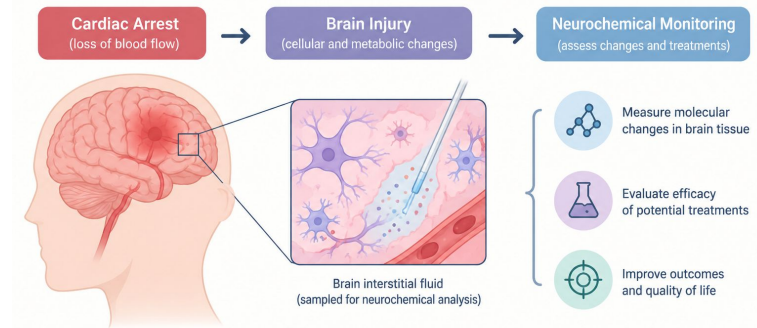


Figure 2: Neurological Effects of Cardiac Arrest and Brain Monitoring



Problem Statement

"The UW–Madison Department of Neurosurgery needs the development of an overhead tether management system that accommodates Wisconsin Miniature Swine movement within an enclosure while protecting intracranial tubing and cables during neuromonitoring studies"



Figure 3: "AI Generated Model of Client Design"



Competing Designs:

“Animal Cage with Motor Assisted Swivel” US20050076847A1 [4]

- **Limited Mobility Allowed**
 - Restricts the pigs movement to the length of the catheter
- **No Equipment Integration**
 - No room for integrating the catchers into the medical equipment
- **Limited Protection Features**
 - Does not protect catheters from animal behavior
 - Requires too much rotational force of catheters to reach the equipment

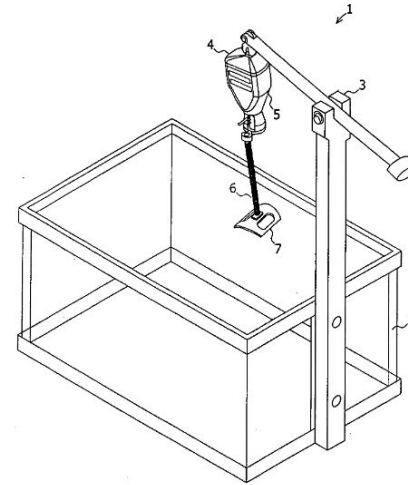


Figure 4: Motor-Assisted Swivel with Enclosure

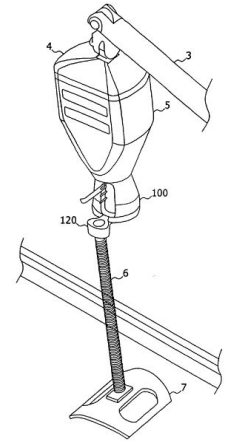


Figure 5: Motor-Assisted Swivel



Competing Designs:

“A tether system for cardiovascular studies with the behaving micropig” [5]



Figure 6: Pig in vest attached to assembly

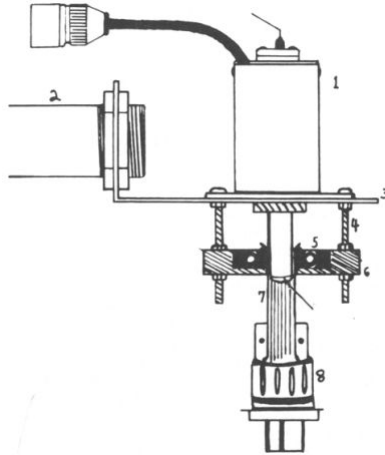


Figure 7 : Swivel Assembly

- **Unsuited for cerebrospinal catheters**
 - Requires very long catheters (~6ft) to reach equipment in adjacent room
 - Provides no protection to catheters
 - Designed for thick steel (0.365 in diameter) catheters
- **Limited mobility allowed**
 - Does not allow pig to roll
 - Designed for animals 35lbs+, vest is bulky on smaller animals



Product Design Specifications

Performance Specifications:

- Allow natural behaviors and movements of the swine
- Prevent damage to catheters
- Allow access to the swine and enclosure for maintenance
- Adjustable to swine growth and size variations
- Operational period: 2 weeks
- Cost: <\$3,000
- Size: Fits 12-15 kg Wisconsin Miniature swines

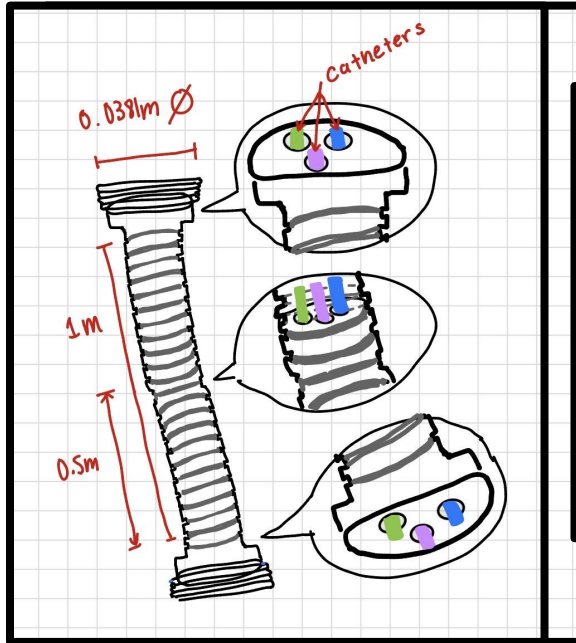


Figure 8: Our design needs to allow the swine subjects to engage in natural behaviors such as resting.

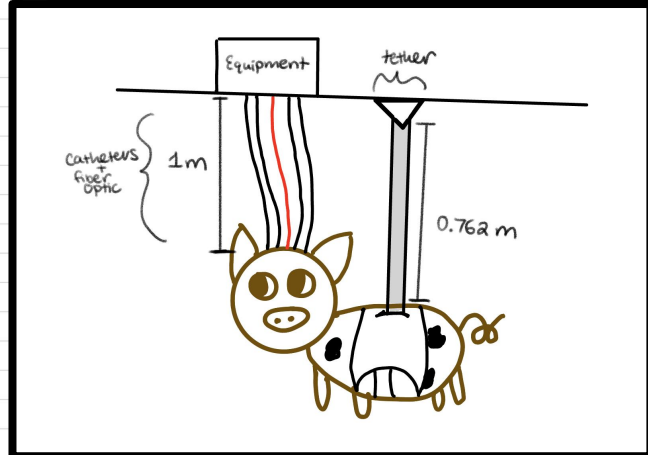


Design Matrix - Tether

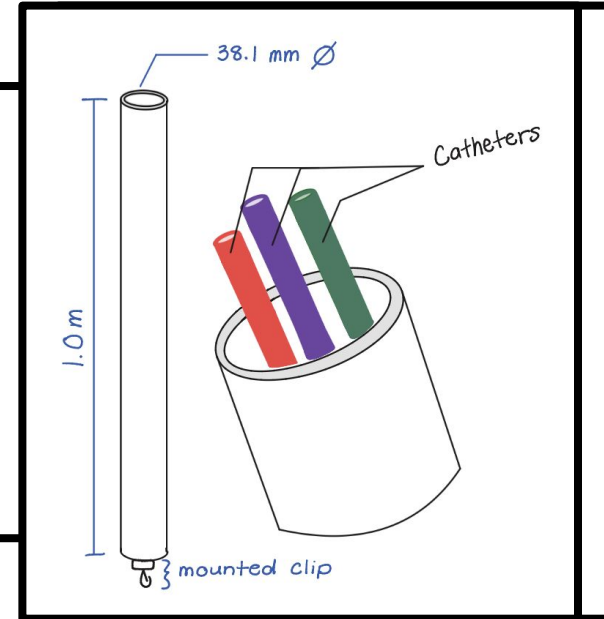
Design 1: Vacuum Hose Tether Cover



Design 2: Wireless Tether



Design 3: Rigid Hollow Rod Cover



Design Matrix - Tether

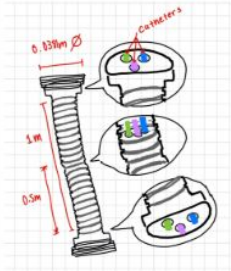
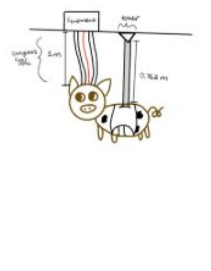
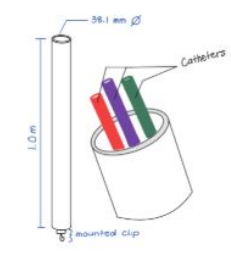
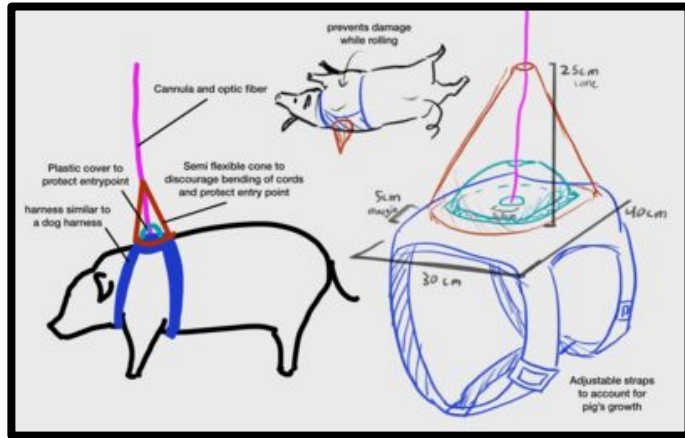
TETHER DESIGN MATRIX		Design 1: Vacuum Hose Tether Cover		Design 2: Wireless Tether		Design 3: Rigid Hollow Rod Cover	
							
Design Criteria		Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
Subject Safety and Comfort	30	3/5	18	2/5	12	3/5	18
Fiber Optic Catheter Protection	25	4/5	20	1/5	5	5/5	25
Catheter Entanglement Prevention	20	5/5	20	1/5	4	2/5	8
Ease of Use	10	1/5	2	5/5	10	4/5	8
Future Scalability	10	2/5	4	5/5	10	3/5	6
Cost	5	4/5	4	5/5	5	3/5	3
Total	100	68		46		68	

Table 1:
Tether Design Matrix

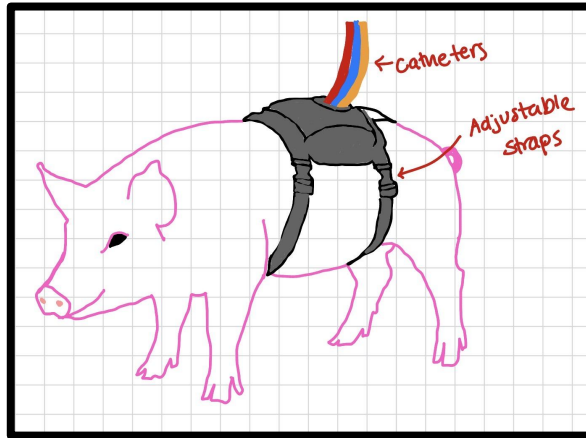


Design Matrix - Harness

Design 1: Traffic Cone



Design 2: PiggyBack



Design 3: Basket Harness



Design Matrix - Harness

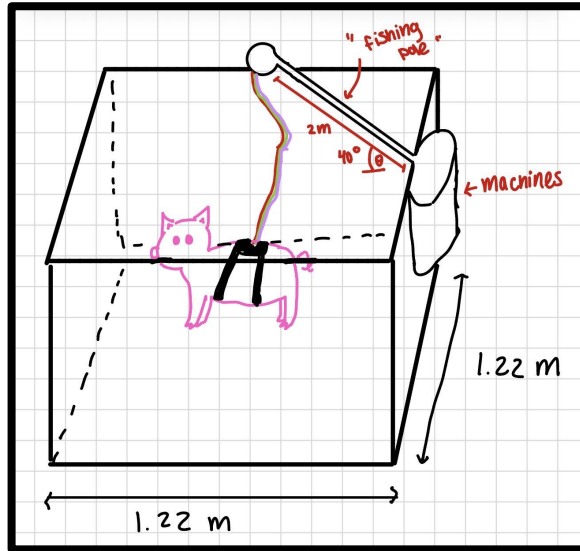
HARNESS DESIGN MATRIX		Design 1: Traffic Cone Harness		Design 2: PiggyBack		Design 3: Basket Harness	
		Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
Catheter Protection	25	4/5	20	3/5	15	2/5	10
Pig Safety	20	4/5	16	3/5	12	4/5	16
Size Scalability	20	5/5	20	4/5	16	4/5	16
Mobility	20	2/5	8	3/5	12	4/5	16
Cost	15	3/5	9	3/5	9	4/5	12
Total	100	73		64		70	

Table 2:
Harness
Design Matrix

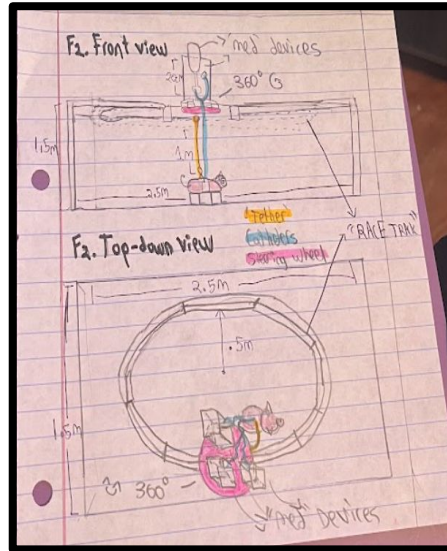


Design Matrix - Enclosure

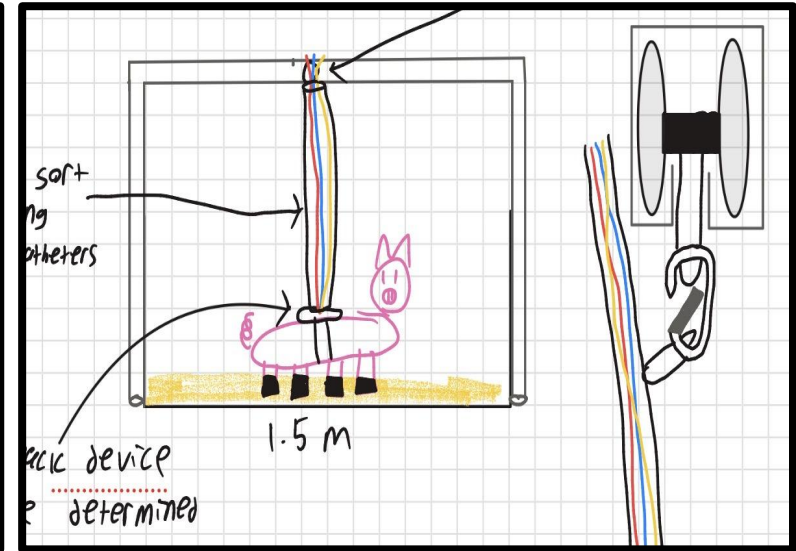
Design 1: Fixed-point Fishing Pole



Design 2: Steering Wheel Platform

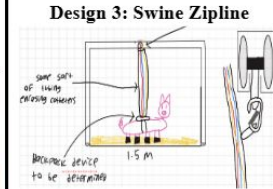
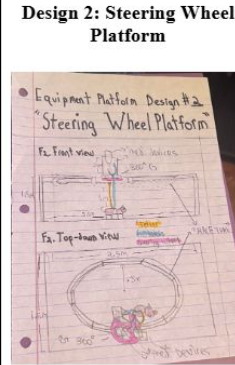
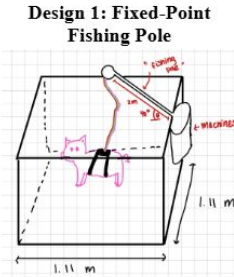


Design 3: Swine Zipline



Design Matrix - Enclosure

EQUIPMENT PLATFORM DESIGN MATRIX



Design Criteria		Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
Medical Equipment Integration	30	2/5	12	4/5	24	4/5	24
Mobility of pig	30	3/5	18	4/5	24	3/5	18
Catheter Integrity	20	1/5	4	5/5	20	4/5	16
Cost	10	5/5	10	3/5	6	3/5	6
Ease of Fabrication	10	5/5	10	1/5	2	2/5	4
Total	100	54		76		68	

Table 3:
Equipment Platform
Design Matrix

Final Design

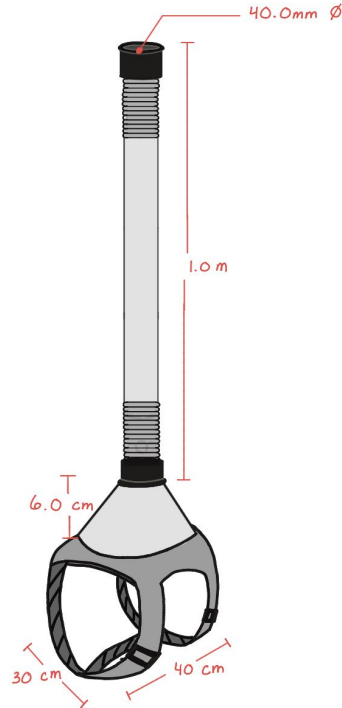


Figure 9: Tether & harness final design

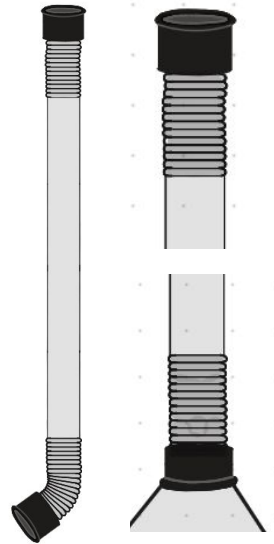


Figure 10: Tether system connection points

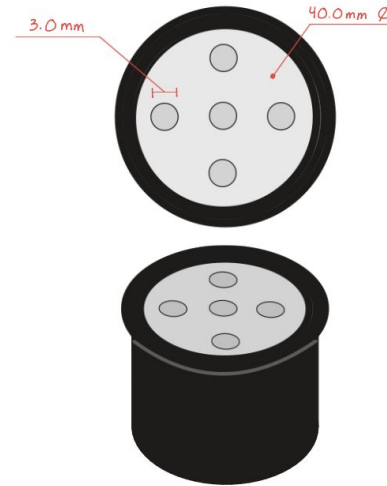


Figure 11: Catheter organization at ends of tether

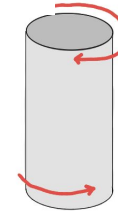
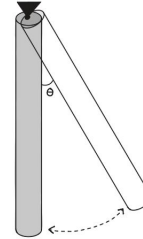


Figure 12: Traffic Cone Harness



Final Design Testing

- Stress & Strain of the tether.
- Range of motion of the fiber optic catheter.
- Twisting/kinking of catheters within the tether.



Future Work

- **Equipment Platform Fabrication**

- Design a swivel overhead system for the tether to attach to
- Must accommodate to the environment of the pig
- Motion sensor

- **Scalability**

- Incorporate different types of catheters/medical equipment for research on other physiological issues

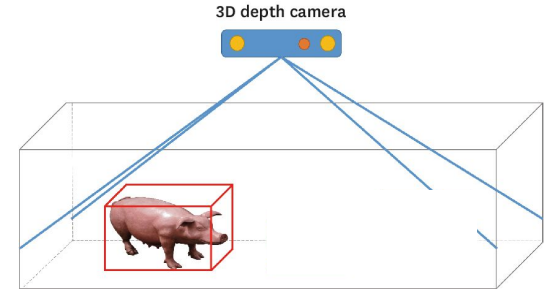


Figure 13: Pig motion tracker

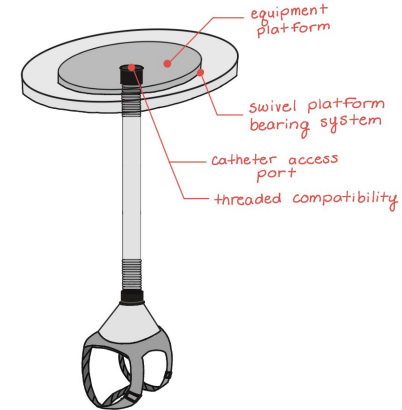


Figure 14: Swivel & equipment platform with final design



Acknowledgements



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Dr. Soucy



Client
Dr. Failla Mulone



PI
Dr. Siler



References

- [1] Benjamin EJ, Virani SS, Callaway CW, et al. Heart disease and stroke statistics—2018 update: A report from the American Heart Association. *Circulation*. 2018;137(12):e67–e492. Table 16-1.
- [2] NYU Grossman School of Medicine, “Consequences of Survival After Cardiac Arrest,” NYU Langone Health. Accessed: Oct. 02, 2026. [Online]. Available: <https://med.nyu.edu/research/parnia-lab/survivorship-psychological-wellbeing-cardiac-arrest/survival-cardiac-arrest>
- [3] C. Cicatiello et al., “The Neurochemical Signature of Cardiac Arrest: A Multianalyte Online Microdialysis Study,” *ACS Chem Neurosci*, vol. 16, no. 7, pp. 1323–1334, Apr. 2025, doi: 10.1021/acscchemneuro.4c00777.
- [4] A. Denietolis, J. Kauker, and J. Burke, “Motor Assisted Swivel,” Apr. 14, 2005 Accessed: Oct. 02, 2026. [Online]. Available: <https://patentimages.storage.googleapis.com/5b/99/ec/7568901d920904/US20050076847A1.pdf>
- [5] Anderson, D.E., Crowell, M.D. & French, A.W. A tether system for cardiovascular studies with the behaving micropig. *Behavior Research Methods, Instruments, & Computers* 24, 44–48 (1992). <https://doi.org/10.3758/BF03203468>



Thank You!
Questions?



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