

# BME Design: Fall Cushion

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## Introduction

### Background

- **300,000 elderly** Americans are hospitalized for **hip injuries from falls** every year<sup>2</sup>
- These injuries have extremely **high morbidity and mortality rates**<sup>3</sup>
- Fall injuries incur a **high cost** to the healthcare system, the individual, and their loved ones and caregivers<sup>1</sup>

### Problem

- Current solutions are
  - either **unable to prevent fall injuries**, such as a life alert system
  - or are bulky and stigmatizing, such as a walker or hip pads.



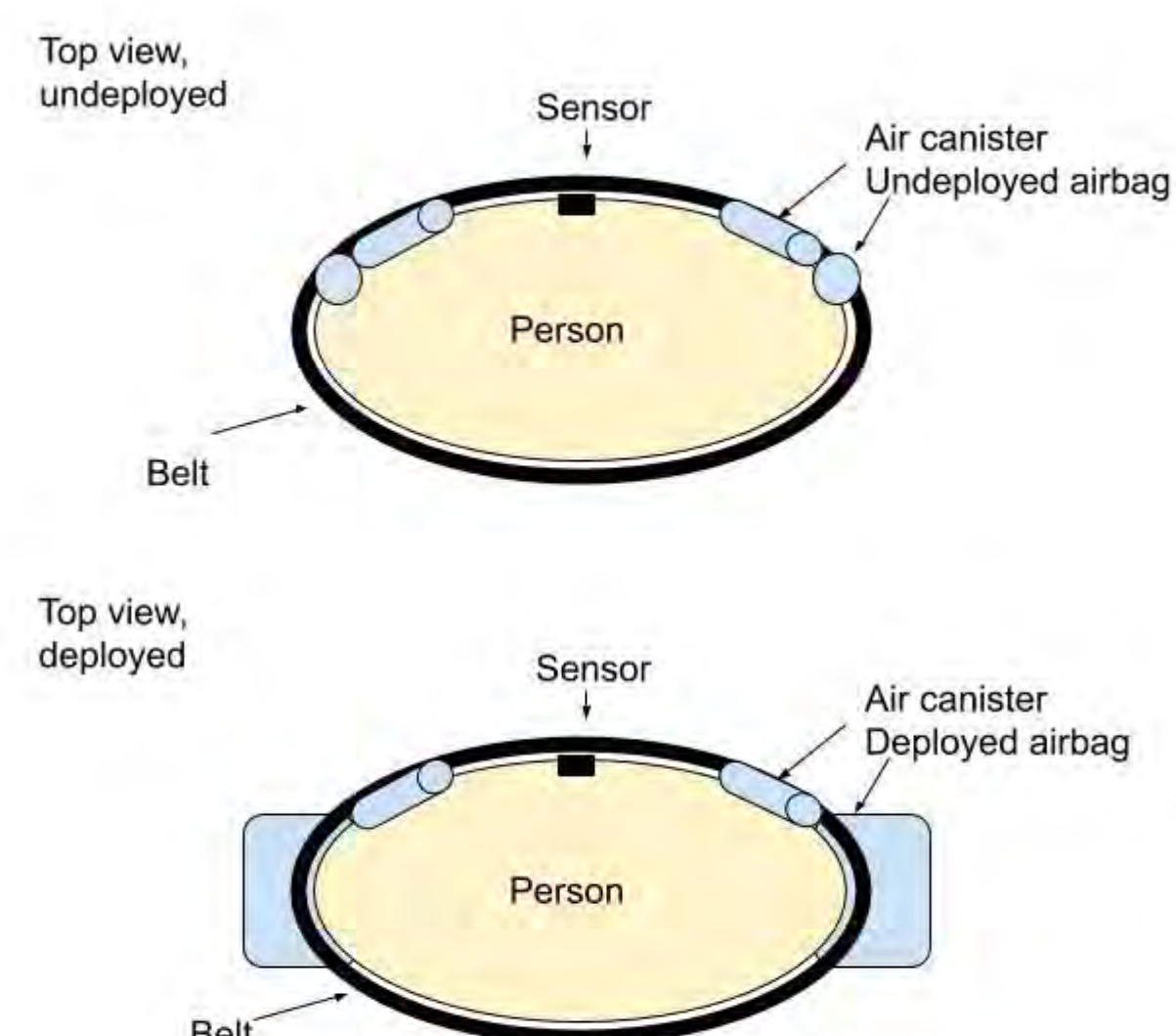
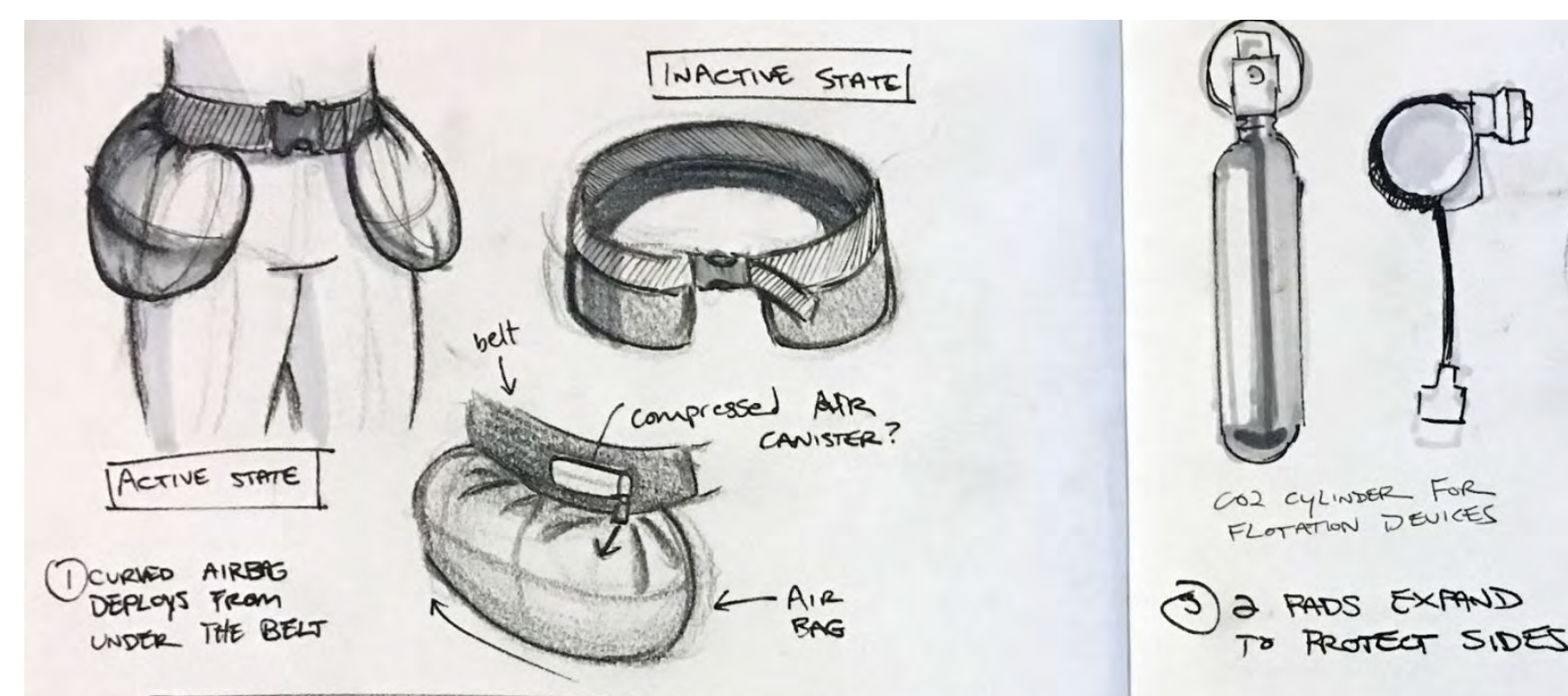
- This leads to seniors modifying their daily routines out of fear of hip injuries

### Need Statement

As such, a market exists for a device that is both **able to protect the hips during a fall**, but is **unobtrusive** or even **aesthetic**.

## Proposed Solution

- A belt mounted system
- The system is composed of a sensor, gas canisters and valves, and folded airbags
- When the sensor detects a fall state, the valves open, releasing compressed CO<sub>2</sub>, which will fill and expand the airbags.



- The airbag and canister are small and unobtrusive
- User can wear the belt during their daily routine without feeling self-conscious
- When a fall is detected, the airbags will deploy, protecting the hips

## Mechanical Design

### Airbag Design

- Ripstop nylon airbag
- Sized to cover the hip of an average sized adult male
- Coated with silicone to reduce permeability to air
- Shaped such that it will induce a roll rather than a bounce when a user falls on it



### Gas Canister & Deployment

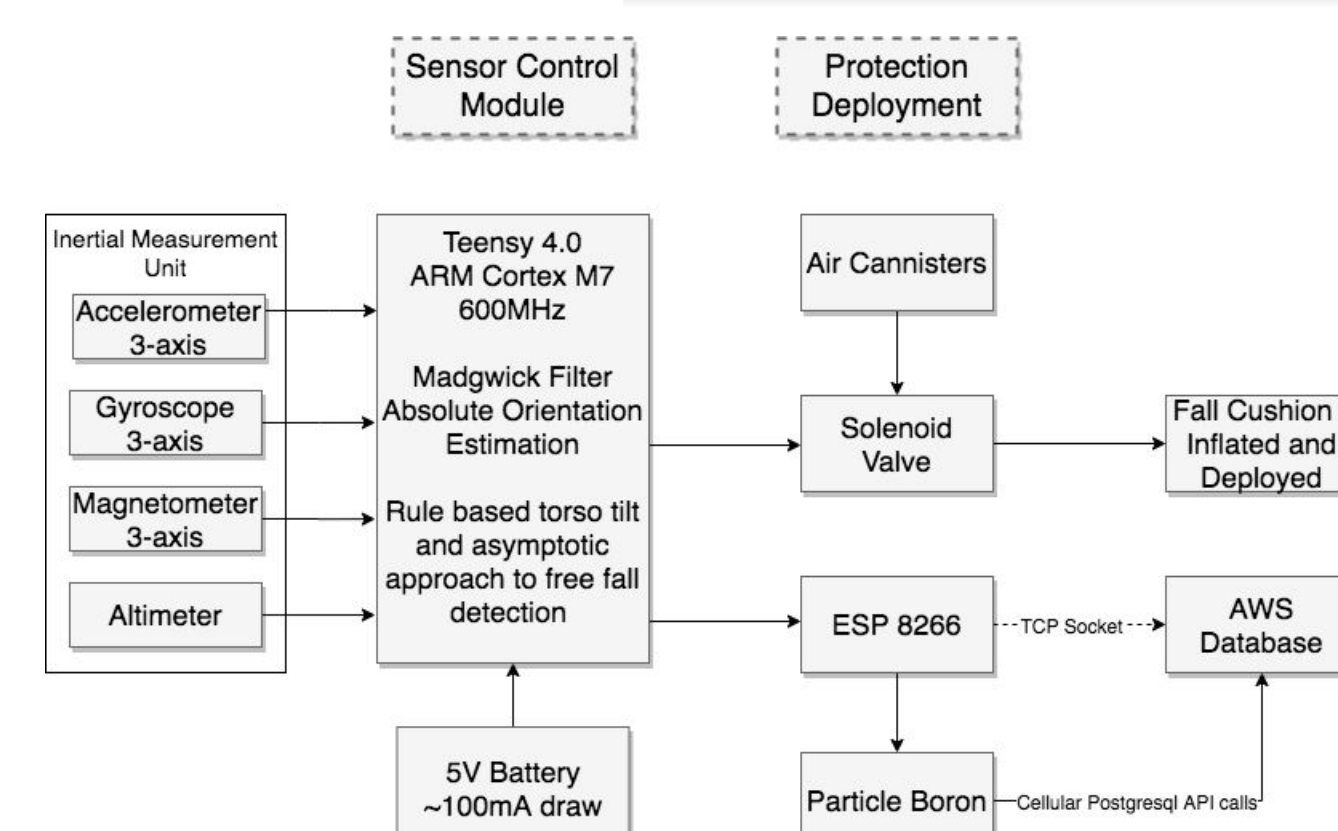
- Off-the-shelf CO<sub>2</sub> air canister with 60cc volume (expands to 0.1 m<sup>3</sup> at 25°C)
- Puncture and release mechanism



- Canister - tube fitting - solenoid valve - airtight tube - airbag

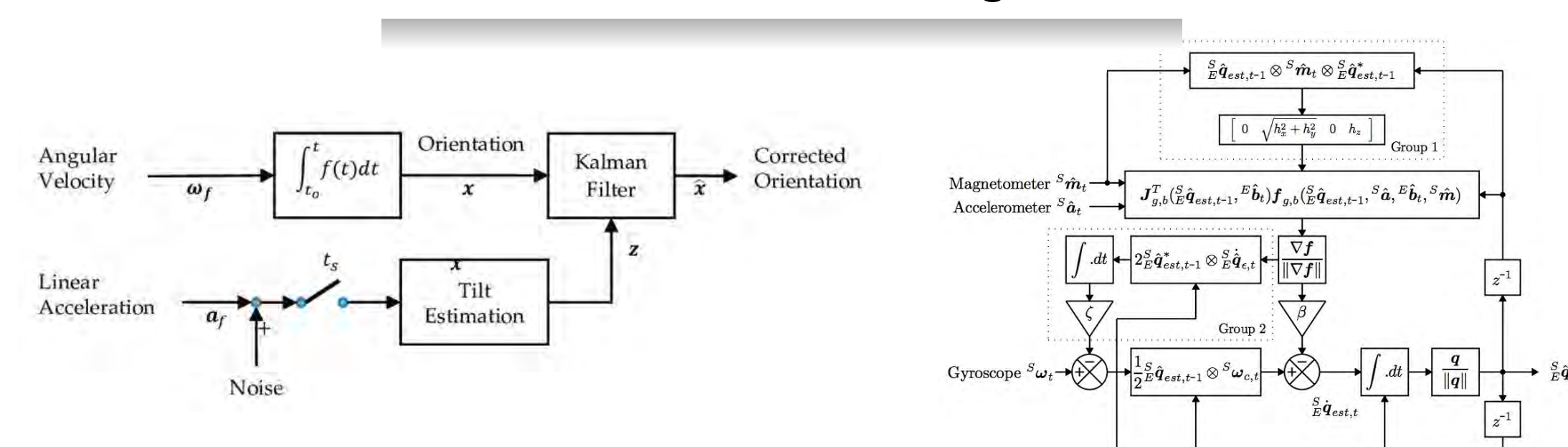
## Fall Detection Algorithm

### System Architecture Overview:



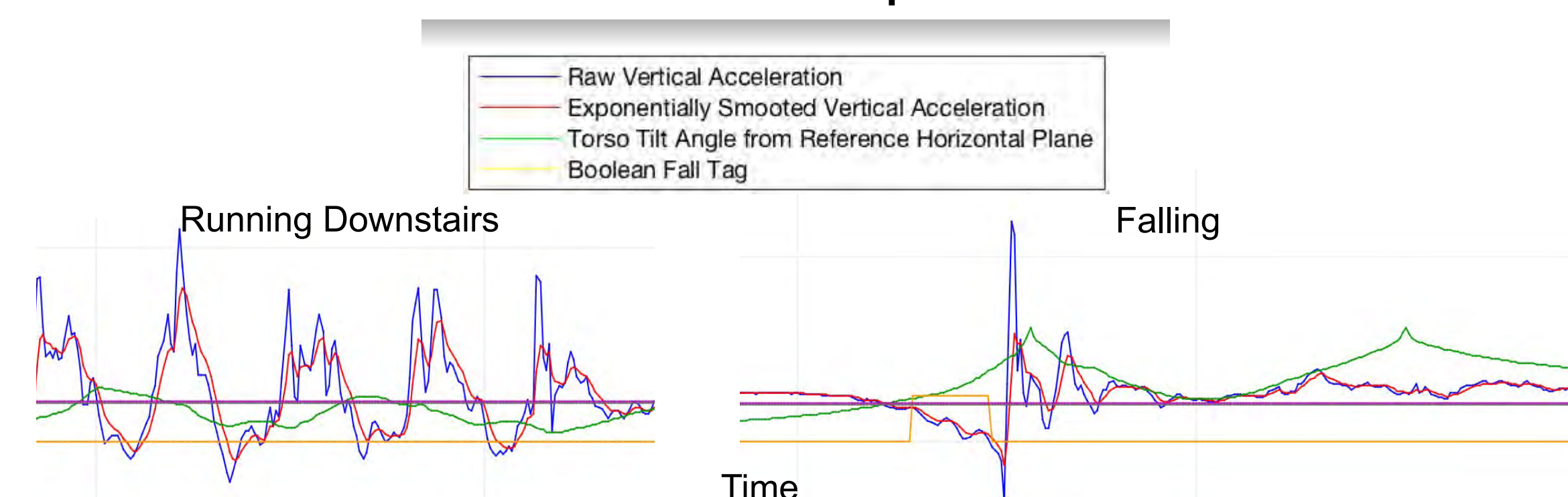
- The inertial measurement unit depicted is used for motion and orientation sensing
- The magnetometer is used as a compass to detect absolute orientation relative to geomagnetic poles

### Orientation Sensing:



- Complementary filtering techniques are used to estimate torso-tilts relative to the horizontal plane
  - This feature provides information about the balance and pose of the user
- Another primary feature used for detection is the asymptotic approach to 0g or free fall

### Sensor Outputs:



## Reimbursement, Patent, Cost

### Reimbursement

- Preventive services covered by Part B of Medicare: durable medical equipment (DME) category<sup>4</sup>
- Similar fall/fracture prevention devices: HCPCS code A4637 (Replacement, tip, cane, crutch, walker, each.) and A4636 (Replacement, handgrip, cane, crutch, or walker, each.)
- Device cost: ~ \$200; Medicare covers: \$160 (80%); Patient pays: \$40

### Patent Information

- ActiveProtective has filed patents on similar technology.
- Patents 7017195, 7150048, and 9107615 filed for as a "Method and apparatus for body impact protection."<sup>5</sup>
- These patents void most possibility of patenting this concept
- Potential improvement areas have still been identified in deployment speed and cost
- Further testing required to evaluate design improvements and differentiate it for justification of further development and licensing of the the design

### Manufacturing Cost

Item	Per Unit Cost	Unit-Device Cost	Volume Discount
Ripstop Nylon (60" x36")	\$30	\$7.5	\$5/400
Thread	\$0.01/yard	\$0.01	/
IMU+Teensy	\$55.07	\$55.07	\$23.85/100 +28.57
Belt	\$8	\$8	/
Canister (Point Two)	\$30	\$60	TBD
Solenoid Valve	\$27.99	\$27.99	/
Total	/	158.57	

## Conclusions

- This prototype proposed a possibly viable solution for a fall protection device.
- Our fall detection algorithm detects falls accurately. Running up and down stairs and jumping won't trigger false alarms.
- Future work should include
  - assembly of the entire system
  - testing of the device for its mechanical durability
  - testing for accuracy and robustness of algorithm

## References

- [1] Berry, Sarah D. and Ram R Miller. "Falls: Epidemiology, Pathophysiology, and Relationship to Fracture." Current Osteoporosis Reports, U.S. National Library of Medicine, Dec. 2008, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2793090>.
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