Engineering a Core Temperature Monitoring System to Support Patient Care at Risk of Exertional Heat Stress

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Introduction

Phoenix, Arizona experiences some of the most extreme temperatures reaching up to 120℉, specifically during the summer months, and leading to a high volume of heat-stress-related emergencies requiring rapid intervention by firefighters and EMS personnel. In severe cases, such as heat stroke, the core body temperature can rise quickly to life-threatening levels, making accurate and immediate core temperature a measurement a necessity in determining the type of treatment a patient shall receive, whether it is cold-water immersion (QR code above) or rapid IV treatments.

However, the temperature tools available; oral, tympanic, and skin thermometers are unreliable in high-heat environments and often produce inaccurate core temperatures due to ambient conditions such as sweat, airflow, and motion. Esophageal and nasal thermometers are considered the “gold standard” for rapidly and precisely measuring core temperature during heat emergencies, yet current probe designs are difficult to place safely and consistently during prehospital airway measurement.

Supporting Illustrations



Mission Statement

Our mission is to develop a field-deployable esophageal temperature monitoring system that empowers Phoenix Firefighters and EMS personnel to obtain fast, accurate, and reliable core temperature measurements, enabling earlier heat-stroke detection and guiding life-saving interventions during extreme heat emergencies.

Customer Needs and Metrics

Customer Needs:

1. Accurate Core Temperature Measurement (±0.2℃)
2. Fast Temperature Response for Critical Decision-Making
3. Reliable Performance in Extreme Heat and High-Motion Events
4. Ease of Placement During Prehospital Airway Management
5. Durable, EMS-Ready, Field-Safe Device
6. Affordable for PHOENIX FD and EMS budgets
7. Provides Continuous Monitoring and Alerts
8. Compatible with EMS Workflow and Data Capture Systems

Customer Metrics:

Temperature Accuracy	±0.2°C
Measurement Range	25°C-45°C
System Update Frequency	≤ 5 seconds
Placement-To-Read Time	≤ 30 seconds
Placement Success Rate	≥ 95% in simulated airway conditions
Water/Sweat Resistance	IP67
Operating Battery Life	≥ 12 hours
EMS data Integration	Compatible with standard run-report datasets
Disposable Probe Cost	≤ $2.50

Initial technical Models

Nasal Airflow Bias Correction System

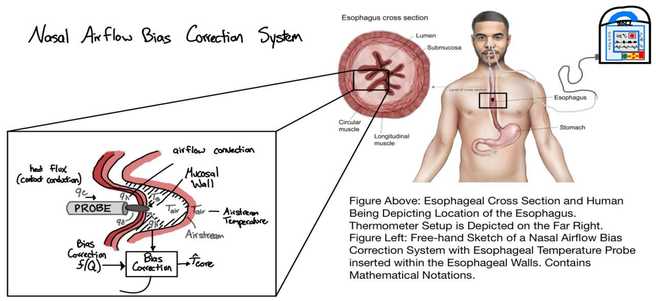
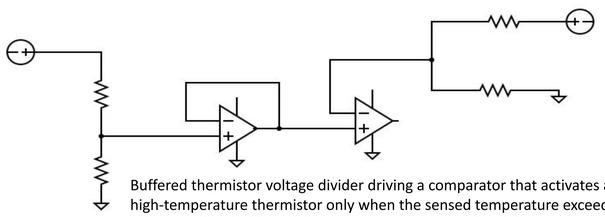
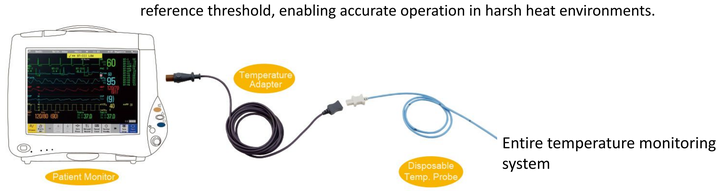


Figure Above: Esophageal Cross Section and Human Being Depicting Location of the Esophagus. Thermometer Setup is Depicted on the Far Right. Figure Left: Free-hand Sketch of a Nasal Airflow Bias Correction System with Esophageal Temperature Probe inserted within the Esophageal Walls. Contains Mathematical Notations.

Dynamic Thermal Model of Esophageal Temperature Probe



Buffered thermistor voltage divider driving a comparator that activates a high-temperature thermistor only when the sensed temperature exceeds the reference threshold, enabling accurate operation in harsh heat environments.



Entire temperature monitoring system

Project Timeline

Our project timeline follows the structured FDA Design Process.
Early stages included:

- Stakeholder interviews, Early concept exploration, Needs analysis, Competitive benchmarking, Initial technical modeling

Mid-cycle development tasks include:

- Advanced concept analysis, House of Quality development, Initial screening, Product architecture definition

Desert Chill is currently entering the virtual prototyping and simulation phase, which includes:

- Benchtop validation, Refined modeling, Manufacturability analysis

Summary, Conclusions and Future Directions

- Build benchtop prototype and validate shaping-wire placement
- Conduct EMS usability tests (placement speed, reliability)
- Enhance digital filtering for motion-heavy environments
- Test thermal response in simulated airway/torso phantom
- Integrate firmware with handheld monitor
- Perform environmental chamber tests at Phoenix-relevant temperatures
- Prepare for IRB pathway for future human-subject testing

References

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