WEARABLE ECG HOLSTER CHALLENGE

Design a Life-Saving Device for Space Medicine

A NASA-Inspired Engineering Design Challenge for High School Students

MARS MISSION

BIOMEDICAL ENGINEERING | SPACE MEDICINE | HUMAN-CENTERED DESIGN

THE SCENARIO

It's 2035.

A crew of six astronauts is on a 900-day Mars mission. 250 million miles from Earth, a crewmember becomes suddenly incapacitated — they cannot move on their own.

The onboard flight surgeon needs to run a 6-lead ECG to diagnose a potential cardiac event.

Problem:
The KardiaMobile ECG requires the patient to PRESS their thumbs on electrodes. An unconscious patient can't do this.

Earth → Space → Mars

900+ Mission Days	**250M** Miles from Earth
0 Hospitals Nearby	**6** Crew Members

MEET THE KARDIAMOBILE 6-LEAD

The KardiaMobile 6-Lead is a FDA-cleared, pocket-sized ECG device. It captures medical-grade heart rhythm data using three electrode contacts simultaneously.

6-Lead ECG

Clinical-grade cardiac data — same info as a hospital ECG machine

Wireless

Connects via Bluetooth to a smartphone or tablet — no cables

Thumb Electrodes

Top two electrodes require thumb contact — top of device

Leg Electrode

Bottom electrode must touch bare leg skin for a full 6-lead reading

30-Second Test

Captures a full rhythm strip in just 30 seconds

FDA Cleared

Medically approved for detecting Afib, bradycardia, tachycardia, and more

THE ENGINEERING PROBLEM

⚠ **CORE CHALLENGE:** How do you take an ECG reading on a patient who CANNOT MOVE their own thumbs or cooperate with the test?

No Muscle Tone

An unconscious patient's hands are limp. Thumbs won't stay on electrodes.

Time is Critical

Cardiac emergencies require fast diagnosis. Setup must be under 60 seconds.

Solo Caregiver

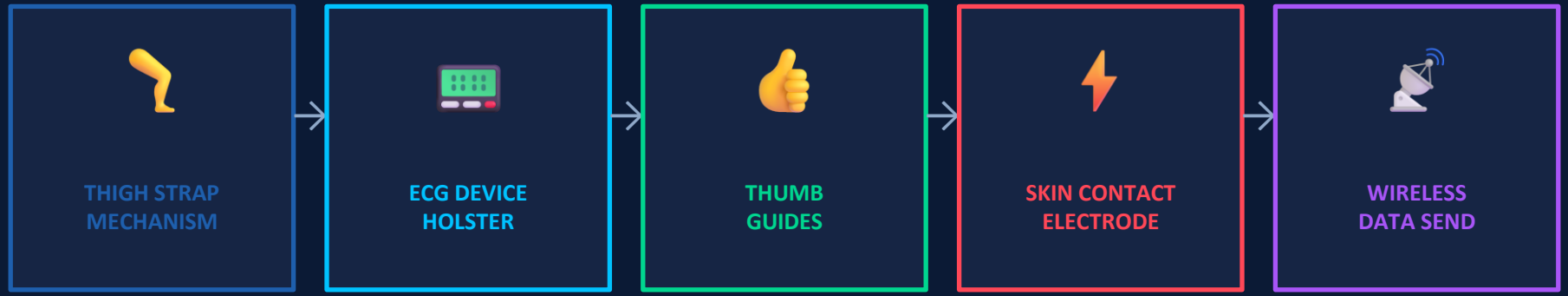
Only ONE caregiver may be available — the device must work with one person.

Space Constraints

Must not interfere with AED, blood pressure cuffs, or other emergency gear.

SYSTEM OVERVIEW

The proposed solution is a wearable thigh-mounted holster



HOW IT WORKS

1. Caregiver straps holster to patient's mid-to-lower thigh

2. KardiaMobile device slots into holster — rear electrode contacts bare skin through aperture

3. Patient's thumbs are placed into mechanical thumb guides (they hold thumbs in position even without muscle tone)

4. Caregiver presses start — 30-second ECG captures complete 6-lead rhythm data wirelessly

FUNCTIONAL REQUIREMENTS

3.1 Mechanical Design & Skin Interface

FR-3.1.1	Thigh-strap secures hardware to mid-to-lower thigh with a stable position during movement or medical procedures.	NASA-STD-3001 §9027
FR-3.1.2	Posterior aperture (opening) on the holster allows the KardiaMobile rear electrode continuous direct contact with bare skin for 6-lead acquisition.	
FR-3.1.3	Dedicated mechanical holders secure the patient's thumbs against the top electrodes, compensating for lack of muscle tone.	
FR-3.1.4	All materials shall be non-irritating to skin and compatible with medical-grade disinfection for multi-use cycles over a 900+ day mission.	NASA-STD-3001 §6110

FUNCTIONAL REQUIREMENTS

3.2 Operational & Assisted Donning

FR-3.2.1

60-SECO DEPLOY

60s

A single caregiver must be able to fully deploy the device AND position the patient's limbs in under 60 seconds during an emergency response — no instructions booklet allowed.

FR-3.2.2

VISUAL ALIGNMENT MARKERS

The design should include intuitive visual alignment markers so the caregiver can position the holster correctly on the thigh for optimal electrode contact — even under stress.

FUNCTIONAL REQUIREMENTS

3.3 & 4.0 Data Acquisition, Integration & Patient Safety

FR-3.3.1

No RF Interference

The holster materials shall NOT block or interfere with the Bluetooth wireless transmission of ECG data to the receiving device.

FR-3.3.2

Compatible with Emergency Gear

Device placement shall not block access for AED defibrillator pads, blood pressure cuffs, or other critical emergency hardware applied simultaneously.

FR-4.1

Safe Patient Transport

The design must allow the patient to be safely moved through the spacecraft habitat without the ECG device dislodging or causing pressure injuries.

DESIGN CONSTRAINTS

What your design MUST and MUST NOT do

✅ MUST HAVE	❌ MUST NOT
✓ Secure device on thigh without caregiver holding it	✕ Block Bluetooth transmmisson
✓ Allow rear electrode contact with bare skin	✕ Cause pressure sores during transport
✓ Hold thumbs in electrode contact passively	✕ Require patient cooperation
✓ Deployable in under 60 seconds	✕ Require more than one caregiver
✓ Skin-safe & disinfectable materials	✕ Allow device to dislodge during movement
✓ Allow AED pad access to the chest	✕ Degrade over 900+ day mission

YOUR DESIGN PROCESS

1 DEFINE

Re-read all requirements. Who is the user? What does success look like? Write a problem statement.

2 RESEARCH

Study medical holsters, orthopedic braces, rock climbing gear, prosthetics. What holds things securely?

3 IDEATE

Sketch 10+ ideas. No bad ideas! Think about velcro, buckles, hinges, foam, 3D printing.

4 PROTOTYPE

Build a low-cost model using cardboard, tape, straps, or clay. Test it on your own leg. You can use an AD8232 sensor as a cheap option to collect ECG signal.

5 TEST

Have a partner play 'unconscious patient.' Can you deploy in 60 seconds? Does it stay put?

6 ITERATE

What failed? What worked? Improve your design. Repeat until it meets all requirements.

MATERIALS TO CONSIDER

STRAPS & CLOSURE

Hook-and-loop (Velcro®) • Neoprene padding • Medical-grade elastic • Ratcheting buckle straps

STRUCTURAL FRAME

Thermoplastic (ABS, PLA) • Carbon fiber composite • Medical-grade aluminum • Flexible polymer (TPU)

ELECTRODE INTERFACE

Conductive fabric/mesh • Open-cell foam aperture • Silicone gasket seal • Hydrogel electrode pad

THUMB HOLDERS

Molded silicone cup • Padded finger cradle • Spring-loaded clamp • Adjustable loop strap

INSPIRATION FROM THE REAL WORLD

Engineers rarely start from scratch — they look at what already works

Weightlifting Belts

Wrap-around design, quick-release buckles, adjusts to body size

Prosthetic Limb Sockets

Custom-fitted hard shell with soft liner, holds securely without pressure sores

Climbing Harnesses

Distributes load, quick-don design, adjustable for different body sizes

Sports Holsters

GPS trackers worn during exercise — stays put during high activity

Medical Leg Cuffs

Blood pressure cuffs that self-position, EKG lead holders on hospital patients

Phone Mounts

Secure, vibration-resistant, removable — quick attach and detach mechanism

MEETING NASA STANDARDS

Your design must comply with NASA-STD-3001 — the Human Integration Design standard for space missions

NASA-STD-3001
§9027

Restraint Systems

Any device that restrains or positions a crewmember must be comfortable, adjustable for different body sizes, and must not restrict circulation or cause skin breakdown during movement and emergency situations.

NASA-STD-3001
§6110

Microbial Contamination

In a closed habitat like a spacecraft or Moon/Mars base, infections spread quickly. Medical equipment must be fully disinfectable between uses with standard medical-grade disinfectants without degrading material properties.

🦵 *Think Like an Engineer: Standards aren't bureaucracy — they exist because real people got hurt without them.*

YOUR DELIVERABLES

01

Annotated Sketches

At least 3 design concepts with labels identifying key components and materials.

02

Physical Prototype

A functional low-fidelity model (cardboard, tape, foam, straps) and inexpensive sensors that can be tested on a person.

03

Test Results

Document: How long did deployment take? Did thumbs stay in place? What failed? What worked?

04

Design Justification

One-page write-up explaining how your design meets each functional requirement (FR-3.1.1 through FR-4.1).

05

Presentation

5-minute pitch to the class — explain your design choices and what you would improve in version 2.