CardioTwin AI — Product Requirements Document

Version: 1.0 | **Date:** February 21, 2026 | **Status:** FINAL — Ready for 24-Hour Sprint

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1. Mission & Theme Alignment

Mission: Build a working prototype in 24 hours that demonstrates real-time cardiometabolic risk scoring from live sensor data, delivered through a web dashboard and WhatsApp notifications.

Hackathon Theme: "From Data to Prevention: AI as Your Health Partner"

Theme Word	Our Implementation
Data	Live biometric data from MAX30102 + NTC sensors
Prevention	Predictive risk scoring + what-if projections
AI	Adaptive risk engine + pattern detection
Health Partner	Real-time nudges via WhatsApp + dashboard

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2. Problem Statement

- **~11% of all deaths** in Nigeria are attributed to CVDs (WHO)
- **70% of cardiovascular deaths** occur in people who were **never screened**
- Nigeria has **~4 physicians per 10,000 people** — preventive cardiology is nearly non-existent

- No existing system makes the connection between **"what I just did"** and **"what my heart just felt"** immediate, tangible, and personal

> **Our Hypothesis:** If we give people a real-time, personalized score that visibly reacts to their physiological state, they will make better health decisions because consequences become immediate — not abstract.

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3. Solution Overview

CardioTwin AI is a station-based health screening system with three layers:

1. **Sense** — Captures HR, HRV, SpO_2, and skin temperature from a finger-placed sensor station
2. **Score** — AI risk engine processes raw biometrics into a **CardioTwin Score (0–100)**
3. **Nudge** — Delivers alerts via web dashboard, WhatsApp, and physical vibration buzz

Scope: IN □

- Working hardware station with finger sensor
- Real-time data streaming to Azure cloud
- CardioTwin Score algorithm (0–100, 4 zones)
- Live web dashboard with graphs and score gauge
- WhatsApp alert integration via Twilio
- What-if risk projection (static/pre-calculated)
- Before/after demo capability
- Vibration motor alert on station

Scope: OUT □

- Wearable device (pitched as v2 vision only)
- Facial expression analysis

- Mobile native app (web PWA only)
- User authentication / multi-user accounts
- Deep learning models
- Medical-grade diagnostic claims

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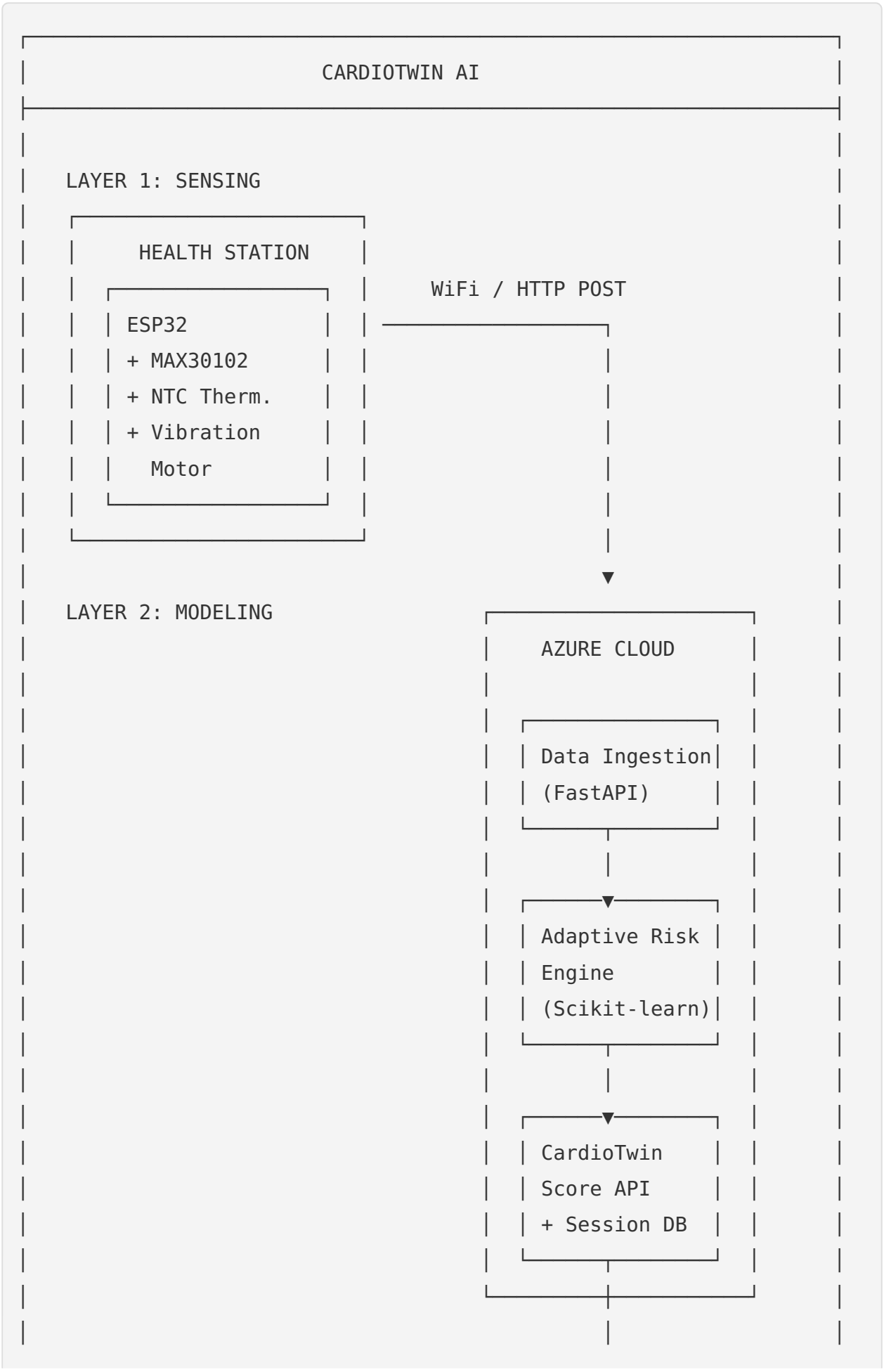
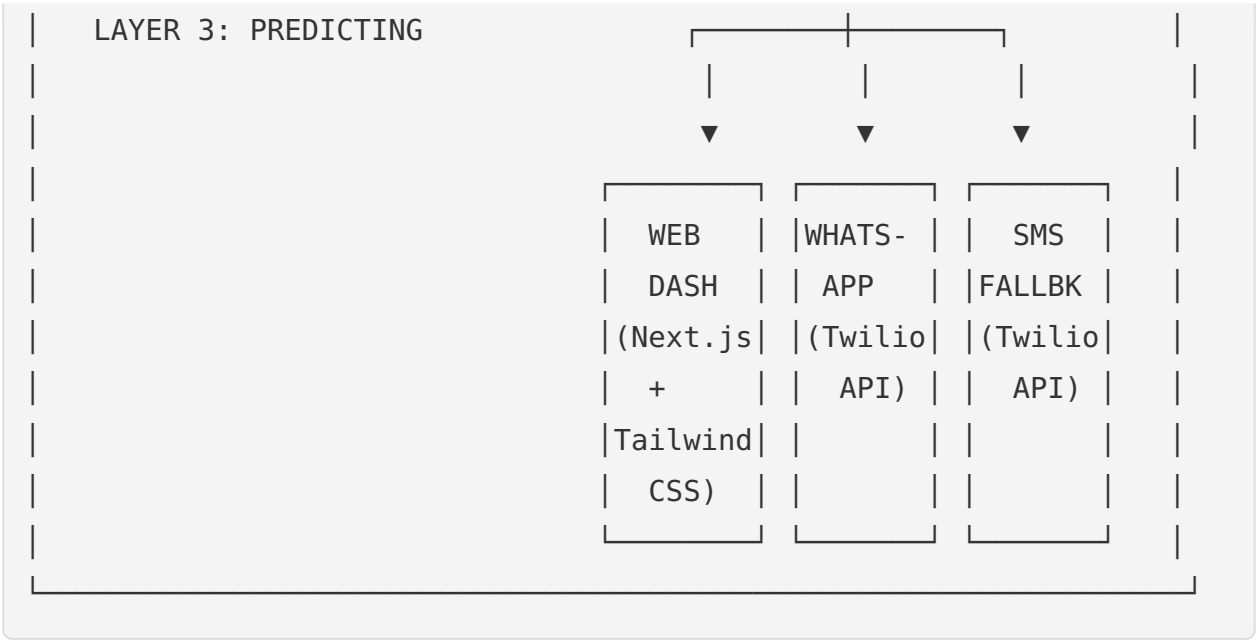
4. System Architecture


CARDIOTWIN AI
LAYER 1: SENSING
HEALTH STATION
ESP32
+ MAX30102
+ NTC Therm.
+ Vibration
Motor
WiFi / HTTP POST
LAYER 2: MODELING
AZURE CLOUD
Data Ingestion
(FastAPI)
Adaptive Risk
Engine
(Scikit-learn)
CardioTwin
Score API
+ Session DB



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5. The CardioTwin Score

The single most important feature — transforms complex multi-dimensional biometric data into one number anyone can understand.

Score Zones

Zone	Range	Label	Trigger
🟢 Green	80–100	Thriving	No alert
🟡 Yellow	55–79	Mild Strain	WhatsApp nudge
🟠 Orange	30–54	Elevated Risk	WhatsApp + vibration buzz
🔴 Red	0–29	Critical Strain	WhatsApp + vibration + urgent message

Scoring Weights

Component	Weight	Why
HRV (RMSSD)	**40%**	Strongest non-invasive predictor of cardiac autonomic health
Heart Rate	**25%**	Direct indicator of cardiovascular load
SpO_2	**20%**	Blood oxygenation — safety check for respiratory distress
Skin Temperature	**15%**	Correlates with stress response and inflammation

How It Works

1. **Baseline Calibration (first 30s):** Records resting HR, HRV, SpO_2, and temperature as personal reference
2. **Real-Time Scoring (every 2s):** Compares incoming data against baseline, calculates weighted composite
3. **Pattern Detection (over sessions):** Identifies personal risk patterns over time

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6. Hardware Specification

Station Design (Not a wearable — by design)

The MAX30102 requires firm, stable skin contact and minimal motion for accurate PPG readings. A station-based finger sensor gives **clinical-grade accuracy** every time, eliminates motion artifact risk, and avoids demo failures.

> During the pitch, frame the wearable as the v2 vision: "The algorithm is built. The form factor evolves."

Components

Component	Purpose	Est. Cost
ESP32-WROOM-32	Microcontroller + WiFi	~₦3,500
MAX30102	Heart Rate, HRV, SpO_2	~₦2,000
10kΩ NTC Thermistor	Skin Temperature	~₦300
10kΩ Resistor	Voltage divider for NTC	~₦50
Mini Vibration Motor (3V)	Tactile alert	~₦500
2N2222 NPN Transistor + 1kΩ Resistor	Motor driver	~₦100
Breadboard + Jumper Wires	Assembly	~₦800
Micro-USB Cable	Power + programming	~₦500
TOTAL		**~₦7,750 (~$10)**

Wiring Reference

```
ESP32 PIN           →    COMPONENT
──────────────────────────────────────────
3.3V                →    MAX30102 VIN
GND                 →    MAX30102 GND
GPIO 21 (SDA)       →    MAX30102 SDA
GPIO 22 (SCL)       →    MAX30102 SCL
3.3V                →    10kΩ Resistor ──┐
GPIO 34 (ADC)       →    Junction ───────┤
GND                 →    NTC Thermistor ─┘
GPIO 25             →    1kΩ → 2N2222 Base
                         Collector → Motor → 3.3V
                         Emitter → GND
```

Station Enclosure

Simple cardboard/foam box with a hole for the MAX30102 sensor on top. Labeled "Place Finger Here ☝". Sensor MUST be secured firmly (hot glue) to prevent wobble during demo.

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7. API Contract

All endpoints served from: `https://cardiotwin.azurewebsites.net`

`POST /api/session/start`

Starts a new measurement session.

Request:

```
{ "session_id": "demo", "user_phone": "+2348012345678" }
```

Response:

```
{ "status": "session_started", "session_id": "demo" }
```

`POST /api/reading`

Receives biometric reading from ESP32. Called every 2 seconds.

Request:

```
{
  "bpm": 72, "hrv": 42.3, "spo2": 98.1,
  "temperature": 36.4, "timestamp": 45000, "session_id": "demo"
}
```

Response (calibrating):

```
{
  "status": "calibrating", "readings_collected": 8,
  "readings_needed": 15, "alert": false
}
```

Response (scored):

```
{
  "status": "scored", "score": 86.2, "zone": "GREEN",
  "zone_label": "Thriving", "zone_emoji": "□",
  "alert": false, "nudge_sent": false,
  "components": {
    "heart_rate": { "value": 72, "score": 95.2 },
    "hrv": { "value": 42.3, "score": 88.1 },
    "spo2": { "value": 98.1, "score": 100.0 },
    "temperature": { "value": 36.4, "score": 93.5 }
  },
  "baseline": {
    "resting_bpm": 71.5, "resting_hrv": 43.1,
    "normal_spo2": 98.0, "normal_temp": 36.35
  }
}
```

`GET /api/score/{session_id}`

Returns latest score for frontend polling.

`GET /api/history/{session_id}`

Returns all scores for chart rendering. Array of score objects with timestamps.

`POST /api/predict`

What-if risk projection.

Request:

```
{ "session_id": "demo", "days": 90 }
```

Response:

```
{
  "current_score": 41.0, "projected_score": 35.2,
  "projected_resting_hr_increase_bpm": 6.8,
  "current_risk_category": "Elevated Risk",
  "projected_risk_category": "Critical Strain",
  "disclaimer": "Statistical projection only. Not a medical diagnosis."
}
```

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8. Tech Stack

Layer	Technology	Source
Microcontroller	ESP32	Off-the-shelf
Sensors	MAX30102 + NTC Thermistor	Off-the-shelf
Firmware	Arduino C++	Open source
Backend	Python FastAPI	Open source
AI/ML	Scikit-learn, NumPy	Open source
Cloud	Azure App Service + Cosmos DB	**GitHub Student Dev Pack**
Frontend	Next.js 14 + Tailwind CSS + Recharts	Open source
Notifications	Twilio WhatsApp + SMS	**GitHub Student Dev Pack**
Version Control	GitHub + GitHub Copilot	**GitHub Student Dev Pack**

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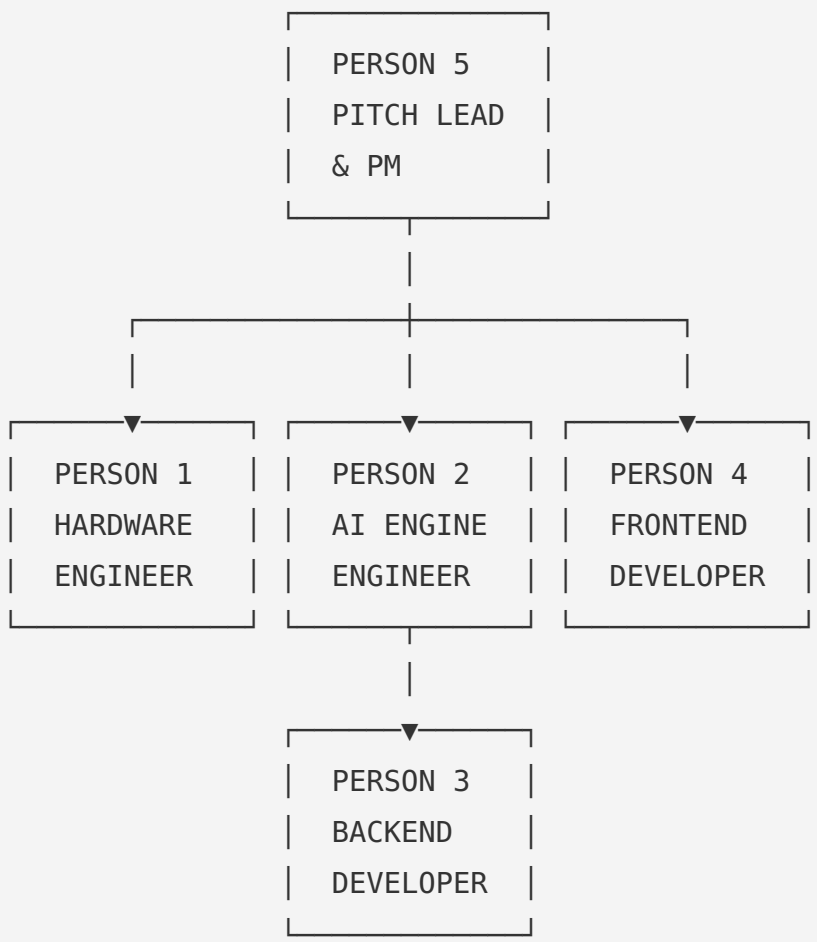
9. Team Roles & Responsibilities



Person 1 — Hardware Engineer

Deliverable	Priority
Wire ESP32 + MAX30102 + NTC + vibration motor	□ Critical
Write firmware: read HR, HRV, SpO_2, temperature	□ Critical
Implement WiFi + HTTP POST to backend every 2s	□ Critical
Vibration motor trigger on API alert response	□ Medium
Clean station enclosure with finger label	□ Medium
Calibrate sensor accuracy + integration test	□ Critical

Key Specs: - Send JSON via HTTP POST every 2 seconds - Finger detection: IR > 50,000 = finger present - Reject HR outside 30–220 BPM - HRV = RMSSD from beat-to-beat intervals - SpO_2 from RED/IR ratio (linear approximation) - Vibrate when API response contains `"alert": true`

Person 2 — AI Engineer

| Deliverable | Priority | |---|---|---| | Design CardioTwin Score algorithm (weighted composite) | 🔴 Critical | | Implement baseline calibration (first 15 readings) | 🔴 Critical | | Build zone classification (Green/Yellow/Orange/Red) | 🔴 Critical | | Build anomaly detection for real-time alerts | 🟡 Medium | | Build what-if projection engine (trend extrapolation) | 🟡 Medium | | Write nudge message templates per zone | 🔴 Critical | | Tune weights/thresholds during integration | 🟡 Medium |

Person 3 — Backend Developer (Python)

Deliverable	Priority
Scaffold FastAPI project, deploy to Azure	🔴 Critical
Implement `/api/reading` endpoint	🔴 Critical
Implement `/api/score` + `/api/history` endpoints	🔴 Critical
Implement `/api/session/start` endpoint	🔴 Critical
Integrate Person 2's scoring engine	🔴 Critical
Set up Twilio WhatsApp integration	🔴 Critical
Implement `/api/predict` endpoint	🟡 Medium
Set up CORS for frontend access	🔴 Critical

Person 4 — Frontend Developer

Deliverable	Priority
Scaffold Next.js + Tailwind CSS project	🔴 Critical
Build animated CardioTwin Score gauge (circular, color-coded)	🔴 Critical
Build real-time biometric cards (HR, HRV, SpO_2, Temp)	🔴 Critical
Build real-time score line chart (Recharts)	🔴 Critical
Implement 2-second polling from backend API	🔴 Critical
Build before/after comparison view	🟡 Medium
Build what-if simulator panel	🟡 Medium
Polish: animations, transitions, responsive design	🟡 Medium

Person 5 — Pitch Lead & PM

Deliverable	Priority
Write pitch script (3 minutes)	🔴 Critical
Build slide deck (8 slides max)	🔴 Critical
Coordinate integration between all members	🔴 Critical
Record backup demo video	🔴 Critical
Run 3+ dress rehearsals	🔴 Critical
Prepare Q&A answers for judges	🔴 Critical
Research Nigeria CVD stats for pitch	🟡 Medium

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10. 24-Hour Sprint Timeline

HOUR	TASK	OWNER
0-1	Kickoff: scope lock, repo setup, Azure provisioning, agree on API contracts	ALL
1-4	Hardware: wire + test raw sensor readings	Person 1
	AI: design + code score algorithm	Person 2
	Backend: scaffold FastAPI + deploy Azure	Person 3
	Frontend: scaffold Next.js + design UI	Person 4
	PM: draft pitch narrative + start deck	Person 5
4-8	Hardware: implement WiFi streaming	Person 1
	AI: baseline calibration + zone logic	Person 2
	Backend: /api/reading + /api/score live	Person 3
	Frontend: score gauge + biometric cards	Person 4
	PM: coordinate, write demo script	Person 5
8-12	Hardware: test continuous streaming	Person 1
	AI: what-if projection engine	Person 2
	Backend: Twilio WhatsApp + /api/predict	Person 3
	Frontend: live chart + what-if panel	Person 4
	PM: first end-to-end integration test	Person 5
12-14	□ MANDATORY REST — 2 HOURS	ALL
	(You WILL make worse decisions without rest)	
14-18	Full integration: hardware→backend→frontend	ALL
	Bug fixing + edge case handling	ALL
	PM: record backup demo video	Person 5
18-21	Polish: UI animations, loading states	Person 4
	Calibrate score thresholds with real data	Person 2
	Build clean station enclosure	Person 1
	Finalize pitch deck	Person 5
21-23	Full dress rehearsal (3 TIMES MINIMUM)	ALL
	Fix any demo-breaking bugs	ALL

```
23-24   Final prep: charge devices, test venue       ALL
        WiFi, load backup video, deep breaths
```

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11. Demo Script (3 Minutes)

Act 1 — The Hook (30s)

"Every 33 seconds, someone dies of cardiovascular disease. In Nigeria, 7 out of 10 of those people were never screened. What if your body could warn you — not your doctor, not a hospital — but your body, in real time, before it's too late?"

Act 2 — Live Demo (90s)

1. Volunteer places finger on CardioTwin Station
2. Dashboard shows data streaming live → Score: **86 — Thriving**
3. Volunteer does 30s of burpees (presenter narrates the AI engine)
4. Volunteer returns, places finger again
5. Score drops live: **41 — Elevated Risk**
6. Vibration motor buzzes on station
7. WhatsApp message arrives on volunteer's phone
8. Show What-If: "If this pattern continues 90 days → risk category shifts"

Act 3 — The Vision (45s)

"Today: one person, one station, one score. Tomorrow: community health workers across Nigeria, each with a ₦8,000 CardioTwin device, screening entire villages in hours. Population-level dashboards helping state health ministries allocate resources where risk is highest."

Act 4 — The Close (15s)

"From data, to prevention, to partnership. This is CardioTwin AI — your heart's early warning system."

BACKUP PLAN

Pre-record a full demo video the night before. If hardware fails, play the video. **Never demo without a backup.**

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12. Risk Register

Risk	Likelihood	Impact	Mitigation
WiFi fails at venue	High	Critical	Test venue WiFi early. Backup: mobile hotspot. Emergency: pre-recorded video
MAX30102 gives erratic readings	Medium	High	Station-based (not wearable) = stable contact. Calibrate before demo. Have backup recorded data
Azure deployment issues	Medium	High	Deploy by Hour 8. Test early. Fallback: run locally on laptop
Twilio WhatsApp fails	Medium	Medium	Pre-join Twilio sandbox. Test with real number. Fallback: show SMS or mock notification
Team member burns out	High	High	Mandatory 2-hour rest at Hour 12-14. No hero coding
Integration breaks at Hour 20	Medium	Critical	Integrate early (Hour 8 first test). API contracts agreed at Hour 0
Judges question "Digital Twin" claim	High	High	We DON'T call it a digital twin. It's an "Adaptive Risk Model" — honest and defensible

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13. Prepared Judge Q&A

Q: "Is this medically accurate?"

> "CardioTwin is a wellness screening tool, not a medical device. Our MAX30102 sensor provides research-grade PPG data, and our scoring algorithm is based on published clinical correlations between HRV and cardiovascular risk. We clearly disclaim this in the UI."

Q: "Why not a wearable?"

> "Clinical-grade PPG requires stable skin contact. Even Apple Watch uses motion compensation algorithms that took years to develop. Our station gives accurate data every time. The wearable is our v2 — the intelligence is built today."

Q: "How is this different from a Fitbit?"

> "Fitbit gives you data. We give you a decision. Our CardioTwin Score collapses complex biometrics into one actionable number, and our nudge system delivers guidance through WhatsApp — where 93 million Nigerians already live. No app download required."

Q: "Can this scale?"

> "The hardware costs ₦8,000. The backend runs on Azure free tier. Community health workers could screen a village of 500 in a single day. The data aggregates into population-level risk heatmaps for state health ministries."

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14. Data Privacy & Ethics

Principle	Implementation
Encryption	TLS 1.3 in transit, Azure managed keys at rest
Compliance	Follows NDPR (Nigeria Data Protection Regulation)
Consent	Explicit opt-in before data collection
No Diagnosis	Wellness tool — clearly disclaimed throughout
Data Ownership	Users can export or delete all data

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15. Business Model (For Pitch)

Stream	Model
B2C	Freemium — free basic score, paid insights (₦2,000/mo)
B2B	Corporate wellness dashboards, HMO partnerships (Leadway, AXA Mansard)
B2G	State health ministry screening tools, population CVD heatmaps

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16. What Makes This Win

Differentiator	Why It Matters
Working hardware prototype	90% of teams are software-only
CardioTwin Score (0-100)	One number anyone understands
WhatsApp delivery	Shows deep understanding of Nigerian users
$10 hardware cost	Proves accessibility at scale
Honest AI claims	"Adaptive Risk Model" builds trust with judges
Clear business model	Shows maturity beyond a hackathon
Backup demo video	Professional risk management

> **Remember: You're not building a product in 24 hours. You're building a story backed by a working prototype. The story wins. The prototype proves you can deliver.**

**Go build it. □□□