ZENPREXI
BIO-RISK™

# Technical Architecture

System Design & Published Research Foundation

January 2026 | CONFIDENTIAL

## Architecture Overview

Bio-Risk™ employs a three-tier architecture designed for enterprise deployment, privacy preservation, and carrier integration. The system implements published HRV-fatigue detection methodologies using validated clinical-grade sensors.

| Tier | Component | Function |
|---|---|---|
| Edge | Wearable Sensor | Continuous HRV capture, on-device preprocessing |
| Cloud | Bio-Risk™ Platform | CARI calculation, aggregation, carrier dashboards |
| Integration | Carrier API | RESTful endpoints for PolicyCenter/Guidewire |

## Sensor Validation (Published Research)

The platform is sensor-agnostic but validated with the Polar Verity Sense, which has extensive peer-reviewed validation against clinical ECG standards:

| Study | Finding | Citation |
|---|---|---|
| PLoS ONE (2019) | ICC = 0.99 vs ECG across exercise intensities | Gilgen-Ammann et al. |
| J Sports Sciences (2025) | r = 0.93 correlation; MAPE = 2.8% | Occupational validation |
| JMIR Cardio (2025) | "Highly accurate and reliable" | Wearable comparison |
| Scientific Reports (2023) | "Both valid and reliable for HR measurement" | Nature portfolio |

### Sensor Specifications

- Device: Polar Verity Sense (or equivalent validated optical HR sensor)
- Cost: ~$90/unit at scale
- Battery: 20+ hours operational
- Connectivity: Bluetooth LE 5.0
- Sampling: 1Hz continuous HRV (RR intervals)

## HRV-Fatigue Detection (Published Research)

The scientific basis for HRV-based fatigue detection is established in peer-reviewed literature. Bio-Risk™ implements these validated methodologies:

| Study | Method | Accuracy | Citation |
|---|---|---|---|
| Scientific Reports (2022) | SVM on HRV features | 84.3% AUC | Nature, Matuz et al. |
| PMC (2022) | LightGBM on HRV | 85.5% | Chen et al. |

| | | | |
|---|---|---|---|
| J Biomedical Informatics (2020) | Deep learning on 5-min HRV | 83% | Bent et al. |

Bio-Risk™ implements the 84-86% published baseline. Our federated learning architecture enables continuous model improvement as the platform scales, with accuracy gains compounding across carrier deployments without compromising worker privacy.

## System Performance Specifications

| Metric | Specification | Basis |
|---|---|---|
| Detection Accuracy | 84-86% (published baseline) | Peer-reviewed literature |
| False Positive Approach | Dual-threshold AND-gate validation | Designed to minimize |
| Latency | <500ms edge-to-dashboard | Architecture requirement |
| Uptime Target | 99.9% | AWS/Azure redundancy |
| Data Retention | Configurable per carrier policy | Compliance flexibility |

## Privacy-First Architecture

Bio-Risk™ is designed with privacy as a core architectural principle, addressing carrier concerns about biometric data liability:

- **Edge Processing: Raw biometric data processed on-device; only CARI scores transmitted**
- **De-Identification: Carriers receive Worker IDs only, no PII or raw biometrics**
- **Federated Learning: Model improvements without centralizing sensitive data—creates data network effect**
- **Compliance Path: Architecture designed for GDPR, CCPA, BIPA, HIPAA alignment**
- **Security Roadmap: SOC 2 Type II certification targeted 2026**

## Intellectual Property

Provisional Patent US 63/919,896 (November 2025) covers the integrated system architecture, CARI algorithm, privacy-preserving data flows, and PANT intervention protocols. PCT international filing planned within 12-month priority window.

## References


1. Matuz, A., et al. (2022). ML models for mental fatigue prediction from HRV. Scientific Reports (Nature). doi:10.1038/s41598-022-24415-y
2. Chen, S., et al. (2022). HRV-Based Physical Fatigue Assessment. PMC. doi:10.3390/s22093199
3. Gilgen-Ammann, R., et al. (2019). Validation of Polar OH1. PLoS ONE. doi:10.1371/journal.pone.0217547
4. Bent, B., et al. (2020). Deep learning with HRV for health prediction. J Biomedical Informatics.
5. JMIR Cardio (2025). Wrist-worn wearable HR sensor validation.
6. PMC (2024). Federated learning for privacy-preserving health data. doi:10.3390/s24154994