# The Technology Landscape for Visually Impaired Mobility

*A Critical Assessment Through the Lens of Independent Running*

A Companion Paper to:
*Breaking the Cognitive Barrier to Independent Running in Low Vision:*

*A Biomimetic Framework for Workload-Sensitive Assistive Training Systems*

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# Executive Summary

Our companion white paper, Breaking the Cognitive Barrier to Independent Running in Low Vision, introduced the Stress Wall—a theoretical threshold at which cumulative perceptual workload exceeds sustainable cognitive capacity during high-speed locomotion. That paper argued that the core challenge facing visually impaired runners is not obstacle detection alone, but the sustainability of cognitive load across an entire training session.

This companion paper surveys the current technology landscape for visually impaired mobility and evaluates each category against the demands of independent running. We assess more than twenty products, research prototypes, and service platforms across six functional categories: GPS navigation apps, smart mobility devices, computer vision guidance systems, haptic navigation wearables, remote human assistance services, and robotic guide devices.

Our central finding is that the vast majority of existing technologies were designed for walking-speed pedestrian navigation. They address the question “How do I get from point A to point B?” rather than “How do I sustain autonomous locomotion at running speed for thirty minutes without cognitive overload?” This distinction is critical. Walking-speed navigation tolerates latencies of several seconds, allows the user to stop and reorient, and accommodates high-bandwidth audio feedback. Running compresses time-to-contact windows, demands continuous perceptual mediation, and saturates auditory channels already needed for environmental monitoring.

Only a handful of systems—Google’s Project Guideline, Nordic Evolution’s precision GPS guidance, the Wayband’s haptic corridor model, and the University of Indonesia’s RunSight prototype—have been explicitly designed or tested at running speeds. Even among these, none yet implements the biomimetic principles of adaptive sampling, distributed gradient sensing, or workload-sensitive feedback modulation that our companion paper proposes as the architectural foundation for a sustainable assistive training system.

# 1. Analytical Framework: The Running Filter

To evaluate each technology, we apply five criteria derived from the Stress Wall model and the biomimetic design principles outlined in our companion paper:

- Velocity Tolerance: Can the system operate reliably at running speeds (8–15 km/h or faster), where time-to-contact windows compress and decision latency becomes safety-critical?
- Cognitive Load Profile: Does the system reduce net cognitive load, or does it introduce new attentional demands (audio interpretation, device management, verbal processing) that compound the perceptual workload of running with low vision?
- Feedback Modality Efficiency: Does the system deliver guidance through channels that preserve the user’s ambient environmental awareness? Continuous audio narration, for example, may occlude traffic sounds and social cues that runners rely on for safety.
- Environmental Dependency: Does the system require permanent infrastructure modification (painted lines, beacons, mapped routes), or can it operate in unprepared environments?

- Autonomy and Scalability: Can the system be used independently without a sighted companion, paid agent, or organizational support? Does it scale to daily training use?

These criteria are not arbitrary preferences. They map directly onto the variables of the cognitive load function $CL(v, E, \tau) = \alpha \cdot v^\gamma \cdot E^\delta \cdot (1/\tau)$ introduced in our companion paper. Velocity tolerance addresses $v$. Cognitive load profile addresses the net effect on CL. Feedback modality efficiency governs $\tau$ (sampling interval efficiency). Environmental dependency modulates E. Autonomy determines whether the system is practically deployable for routine training.

# 2. Technology Categories and Assessment

## 2.1 GPS Navigation Applications

This category includes smartphone applications that provide location awareness and turn-by-turn navigation using GPS, map databases, and voice output. Products surveyed include BlindSquare, Seeing Assistant Move, RunGo, Kapsys Kapten, and HumanWare Trekker Breeze.

### How They Work

These applications use GPS positioning cross-referenced with map databases (OpenStreetMap, Foursquare, Google Maps) to announce points of interest, street intersections, and turn-by-turn directions via synthesized speech or, in some cases, via connected Braille displays. BlindSquare, the most widely adopted, serves over 60,000 users in 186 countries. RunGo, while designed for sighted runners, offers turn-by-turn voice navigation with VoiceOver accessibility support and has been used by some visually impaired runners.

### Shortcomings for Independent Running

GPS accuracy at consumer grade (typically 3–10 meters) is insufficient for lane-level or path-centering guidance at running speed. A 5-meter lateral error on a 3-meter-wide bike path represents a safety-critical failure mode. These systems were designed for intersection-level wayfinding at walking speed, not for the continuous boundary-tracking that running requires.

More fundamentally, voice-based navigation competes directly with the auditory channel that low-vision runners depend on for environmental awareness—traffic, cyclists, dogs, other pedestrians. Continuous voice narration raises the cognitive load floor rather than lowering it. In the language of our model, these systems increase the effective sensory sampling interval ($\tau$) by occupying the auditory channel, precisely the opposite of what a biomimetic system would do.

None of these applications implement adaptive feedback cadence. They deliver the same density of information on a straight, obstacle-free path as they do approaching a complex intersection—violating the echolocation cadence principle of quiet when stable, active when necessary.

## 2.2 Smart Mobility Devices

This category includes technology-enhanced physical mobility aids: the WeWALK Smart Cane (ultrasonic obstacle detection with GPS navigation integrated into a white cane handle) and the Sunu Band (an ultrasonic sonar wristband providing haptic proximity feedback).

### How They Work

The WeWALK Smart Cane 2 attaches a sensor-equipped handle to a standard white cane, adding above-waist obstacle detection via ultrasonic sensors, turn-by-turn GPS navigation, and a GPT-powered voice assistant. The Sunu Band emits ultrasonic pulses from the wrist and translates reflected signals into vibration patterns that intensify as objects approach, providing upper-body collision avoidance at ranges up to 5 meters.

### Shortcomings for Independent Running

The white cane—smart or otherwise—is biomechanically incompatible with running. The sweeping gait required for effective cane technique conflicts with the arm swing biomechanics of running. No competitive or recreational visually impaired runner uses a cane while running. The WeWALK is an excellent walking aid; it is not a running technology.

The Sunu Band's ultrasonic proximity detection is theoretically hands-free and could be worn while running. However, its detection is directional and narrow-beam, requiring the user to actively point their wrist toward potential hazards—an attentional demand that adds to cognitive load rather than reducing it. Its 4-hour battery life under continuous sonar use is marginal for a runner who may train daily. The product has been discontinued by the American Printing House for the Blind, raising questions about long-term support.

Neither device implements gradient-based sensing, adaptive sampling, or any workload-modulating behavior. They are reactive obstacle detectors, not proactive spatial awareness systems.

## 2.3 Computer Vision Guidance Systems

This category represents the most direct attempts to address independent running: Google's Project Guideline, Biped AI's NOA vest, and the University of Indonesia's RunSight smart glasses.

### How They Work

Google's Project Guideline uses a smartphone camera worn at the waist to track a painted guideline on the ground via an on-device segmentation model (DeepLabV3+). Audio signals delivered through bone conduction headphones shift in pitch and pan to indicate lateral drift from the line. The system has been used to complete a 5K in Central Park and a half marathon in Stockholm.

Biped AI's NOA is a shoulder-worn vest with 170-degree infrared cameras, on-device AI processing, GPS navigation, and scene description capabilities. It provides 3D spatial audio obstacle alerts and was developed with over 250 beta testers across 20 countries.

RunSight, from the University of Indonesia, is an RGB camera-based smart glasses prototype that detects running lanes and obstacles in real time, communicating guidance through voice instructions. It won the Samsung Solve for Tomorrow global innovation award.

### Shortcomings for Independent Running

Project Guideline is the most promising system for structured-loop running, but it requires permanent physical infrastructure: a painted or taped guideline on the running surface. This creates a significant deployment barrier. Every new path requires physical preparation, weather can degrade line visibility, and the system cannot operate on unprepared surfaces. Its reliance on a single visual feature (the line) also means it has no fallback if the line becomes occluded by leaves, shadows, or other runners. The project has been open-sourced but appears to have limited ongoing development momentum.

Biped AI's NOA is designed for walking and explicitly does not yet support running. Its weight (under 900g but still substantial for running), continuous audio scene description, and GPS navigation are walking-speed features. The cognitive architecture of continuous verbal scene description ("In front of you is a busy coffee shop with three people in line") directly contradicts the biomimetic principle of gradient-based, non-verbal spatial encoding. For a runner, verbal scene description is not just unnecessary—it is actively harmful to cognitive sustainability.

RunSight is still an early-stage prototype focused on track running with a guide present. It has not been tested for fully independent outdoor running, and its reliance on voice instructions for course corrections faces the same auditory channel competition problems as GPS navigation apps.

## 2.4 Haptic Navigation Wearables

This category includes devices that communicate spatial information through vibrotactile feedback rather than audio: the Wayband by WearWorks, the feelSpace naviBelt, and a Stanford ME327 research prototype for haptic running guidance.

### How They Work

The Wayband is a wrist-worn device that uses GPS, magnetometer, and compass sensors paired with OpenStreetMap data to create a "virtual corridor." When the user is on course, the device is silent. When they veer off, vibrations intensify proportionally to deviation. In 2017, blind runner Simon Wheatcroft used a prototype to run 15 miles of the New York City Marathon without a guide.

The feelSpace naviBelt uses 16 vibration motors distributed around the abdomen to indicate cardinal direction or route guidance. Research from the University of Osnabrück demonstrates that users can develop an intuitive spatial sense from prolonged use, with reported improvements in orientation confidence and reductions in anxiety.

The Stanford ME327 course project explored haptic feedback for running guidance using vibrotactile wristbands to communicate directional corrections.

### Shortcomings for Independent Running

Haptic wearables are the most architecturally promising category for running because they preserve the auditory channel and communicate through gradient-like patterns rather than discrete verbal instructions. The Wayband's virtual corridor model is conceptually closest to the lateral line principle described in our companion paper: it provides centering feedback through differential intensity rather than object classification.

However, all current haptic systems are GPS-dependent, inheriting the same 3–10 meter accuracy limitations as voice GPS. At running speed, GPS drift can generate false correction signals, introducing spurious cognitive load rather than reducing it. The Wayband's GPS signal was lost at mile 16 of the NYC Marathon, forcing Wheatcroft to complete the race with human assistance—a vivid illustration of the scalability problem.

None of the current haptic systems implement adaptive feedback cadence (increasing resolution during curves, decreasing during straightaways) or dual-layer sensing (coarse macro-awareness with fine-grained micro-correction). They deliver constant-frequency feedback, which risks attentional saturation during long runs—exactly the problem that the echolocation cadence model is designed to avoid.

The feelSpace naviBelt's 16-motor distribution is the closest approximation to distributed flow sensing currently available, but it communicates compass direction rather than path-relative boundary gradients. It tells you which way is north, not whether you are drifting left relative to the path edge.

## 2.5 Remote Human Assistance Services

This category includes platforms that connect visually impaired users with sighted human agents via live video: Aira and Be My Eyes.

### How They Work

Aira connects users to professionally trained visual interpreters via smartphone camera. Agents describe the environment, read text, assist with navigation, and provide real-time visual information. The service operates 24/7 through a subscription model and a growing network of free-access partner locations (airports, universities, Starbucks stores). Be My Eyes operates similarly but relies on volunteer sighted helpers and has recently integrated AI-powered visual assistance.

### Shortcomings for Independent Running

Remote sighted assistance is fundamentally incompatible with the goal of independent running. A human agent watching a bouncing smartphone camera cannot provide the sub-second correction signals needed at running speed. The service was designed for deliberate, walking-speed tasks like reading labels, navigating airports, and identifying objects—tasks where latency of several seconds is acceptable.

More importantly, reliance on a remote human replaces one form of dependency (a co-located guide) with another (a remote agent). The entire premise of our research agenda is to expand autonomous training capacity—the ability to run without scheduling, coordinating, or depending on another person. Remote assistance services, while valuable for many aspects of daily living, do not address this goal.

Subscription costs also create a scalability barrier for daily training use. Aira's plans are designed for intermittent use, not for 30–60 minutes of continuous daily exercise.

## 2.6 Precision GPS Guidance and Robotic Guide Devices

This category includes systems that go beyond consumer GPS to provide high-precision path-following or physical guidance: Nordic Evolution's digital guide system and Glidance's Glide robotic guide.

### How They Work

Nordic Evolution uses a compact GPS module connected to multiple satellite systems and a proprietary sensor array to achieve average position accuracy of 10 cm (and up to 1 cm in optimal conditions). Users follow pre-recorded digital paths via audio signals in both ears; straying from the path causes one side to fall silent while the other intensifies. The system has been used for running, cross-country skiing, alpine skiing, kayaking, and track athletics. It weighs approximately 100 grams and is worn with a headband.

Glidance's Glide is a two-wheeled robotic guide device that the user pushes forward by its handle. On-board sensors, cameras, and AI guide the device's steering to avoid obstacles and navigate to waypoints. It provides haptic and audio feedback and has been described as an "electronic guide dog." The device is priced at $1,499 and is currently in beta testing, with commercial delivery planned for Spring 2026.

### Shortcomings for Independent Running

Nordic Evolution's 10 cm accuracy represents a genuine technical advance over consumer GPS and approaches the precision needed for path-centering at running speed. Its ear-based differential audio model is a rudimentary but functional implementation of gradient-based correction. However, the system is currently limited to Sweden's satellite network conditions, requires WiFi connectivity via a smartphone, and depends on pre-recorded paths—meaning every new route must be manually surveyed. For structured loops (tracks, established bike paths), this is viable. For spontaneous training route variation, it is restrictive.

More critically, Nordic Evolution's audio feedback does not implement adaptive cadence. The signal pattern is constant regardless of path complexity—the same density of feedback on a 400m straightaway as through a sharp curve. This represents a missed opportunity for workload optimization.

Glidance's Glide is a walking device. Its physical form factor (a handled wheeled robot) is incompatible with running biomechanics. The company has stated plans to support activities beyond walking in the future, but the current design requires the user to hold the handle and push the device forward. At running speed, this is impractical and potentially dangerous. The device's greatest contribution to our analysis is philosophical: its CEO, Amos Miller, explicitly describes the cognitive load advantage of the device over a white cane, noting that users can "listen to emails or talk on the phone while moving with Glide." This validates the cognitive load framework of our companion paper from a product design perspective, even though the product itself does not address running.

# 3. Emerging Research

Several academic and institutional research efforts address aspects of the independent running problem without yet producing commercially available systems.

The EU CORDIS-funded project for advanced guiding technology for visually impaired athletes explored sensor-based guidance systems for independent track running. Research published in BMC Sports Science, Medicine and Rehabilitation has examined the experiences and biomechanics of guide-runner partnerships, providing baseline data on the communication bandwidth and correction frequency required during guided running—data that informs the design requirements for any technological substitute.

The ACM CHI 2025 paper on RunSight explores augmented reality support for nighttime guided running for low-vision runners, demonstrating that AR headsets can enhance residual vision sufficiently to enable caller-style guided running (where the runner follows a guide visually without a tether) in darkness. While still guide-dependent, this work provides empirical evidence that visual augmentation can shift the cognitive load profile of running.

A Stanford ME327 course project explored haptic glove-based guidance for running, testing vibrotactile correction signals during locomotion. While preliminary, it provides design data on haptic perception thresholds during the rhythmic impact loading of running gait.

# 4. The Gap: What No Current System Provides

When the surveyed technologies are mapped against the five criteria of our running filter, a consistent pattern emerges:

| Technology | Velocity | CL Reduce | Modality | No Infra | Autonomy |
|---|---|---|---|---|---|
| **GPS Nav Apps** | ✗ | ✗ | ✗ | ✗ | ✓ |
| **Smart Cane/Band** | ✗ | Partial | Partial | ✓ | ✓ |
| **Project Guideline** | ✓ | ✓ | ✓ | ✗ | Partial |
| **Biped AI NOA** | ✗ | ✗ | ✗ | ✓ | ✓ |
| **RunSight** | Partial | Partial | ✗ | Partial | ✗ |
| **Wayband** | Partial | ✓ | ✓ | ✗ | ✓ |
| **feelSpace Belt** | ✗ | ✓ | ✓ | ✓ | ✓ |
| **Aira / Be My Eyes** | ✗ | ✗ | ✗ | ✓ | ✗ |
| **Nordic Evolution** | ✓ | Partial | ✓ | ✗ | Partial |
| **Glidance Glide** | ✗ | ✓ | Partial | ✓ | ✓ |

The table reveals that no existing system satisfies all five criteria simultaneously. More importantly, no current system implements any of the three biomimetic architectural principles proposed in our companion paper:

1. Distributed gradient sensing (lateral line principle): No system provides continuous boundary-proximity feedback through distributed sensor arrays. The closest approximations—the feelSpace belt's 16-motor compass and Nordic Evolution's ear-based differential audio—are proof-of-concept implementations that demonstrate the viability of the approach without yet targeting the specific needs of running.
2. Adaptive sampling cadence (echolocation model): No system modulates feedback density based on environmental complexity or uncertainty. All systems provide constant-frequency output regardless of context, violating the metabolic efficiency principle that biological navigation systems optimize for.
3. Motion-based gradient control (insect optic flow): No system uses motion-field asymmetry for path centering. All systems that provide centering feedback rely on absolute positioning (GPS or line detection) rather than relative motion gradients.

# 5. Implications for Phase II Research

The technology landscape analysis confirms that the Phase II empirical research agenda proposed in our companion paper is not redundant with existing commercial or academic efforts. Specifically:

- The structured outdoor loop environment proposed for Phase II testing is well-matched to the capabilities of precision GPS (Nordic Evolution-class) and haptic gradient systems (feelSpace/Wayband-class), but requires integration of adaptive feedback logic that neither currently provides.

- Bone conduction headphones, validated by Project Guideline and widely adopted in the visually impaired running community, are a proven feedback delivery mechanism that preserves environmental awareness. Phase II should adopt this as a baseline output channel while exploring haptic supplementation.
- The virtual corridor concept demonstrated by the Wayband provides a validated interaction model for gradient-based path following that aligns with the lateral line principle. Phase II should build on this conceptual foundation while replacing GPS positioning with higher-precision sensing modalities.
- The workload-sensitive feedback modulation that no current system provides represents the primary research contribution opportunity. Phase II should focus experimental design on measuring the cognitive load differential between constant-cadence feedback and adaptive-cadence feedback during running, using the behavioral and physiological metrics identified in our companion paper.

# 6. Conclusion

The assistive technology landscape for visual impairment has advanced significantly over the past decade. Individuals with low vision have more tools than ever for pedestrian navigation, obstacle detection, and environmental awareness during walking-speed mobility. Several of these technologies—particularly haptic wearables, precision GPS, and bone conduction audio systems—incorporate design elements that are relevant to the running problem.

However, independent running at training intensity remains an unsolved problem. The specific demands of sustained high-velocity locomotion—compressed decision windows, continuous perceptual mediation, cumulative cognitive load accumulation—are not addressed by any commercially available system. The biomimetic principles of distributed sensing, adaptive sampling, and gradient-based correction proposed in our companion paper are absent from the current technology landscape.

This gap represents both a research opportunity and a practical imperative. With an estimated 150–200 million working-age adults with low vision not meeting recommended physical activity guidelines, and with perceptual workload sustainability identified as a potentially modifiable barrier, the development of workload-sensitive assistive training systems is not merely a technology challenge. It is a public health priority.

Phase II research should build on the most promising elements of the existing landscape—haptic gradient feedback, bone conduction audio, precision positioning, virtual corridor models—while introducing the adaptive, biomimetic control logic that distinguishes a cognitive load management system from a navigation aid. The goal is not to help a runner find their way. It is to help a runner sustain the cognitive conditions under which running remains possible, sustainable, and joyful.

# References and Technologies Surveyed

The following technologies and sources were surveyed for this analysis:

## GPS Navigation Applications

- BlindSquare — MIPsoft Oy (blindsquare.com)
- RunGo — RunGo Inc. (rungoapp.com)
- Seeing Assistant Move — Transition Technologies S.A. (seeingassistant.tt.com.pl)
- Kapsys Kapten — Kapsys (kapsys.com)
- HumanWare Trekker Breeze — HumanWare (humanware.com)

## Smart Mobility Devices

- WeWALK Smart Cane 2 — WeWALK (wewalk.io)
- Sunu Band — Sunu Inc. (discontinued via APH)

## Computer Vision Guidance Systems

- Project Guideline — Google Research (research.google/blog/project-guideline)
- NOA by Biped AI — Biped AI (biped.ai)
- RunSight — University of Indonesia / Labmino team

## Haptic Navigation Wearables

- Wayband — WearWorks (haptic.works)
- feelSpace naviBelt — feelSpace GmbH (feelspace.de)
- Stanford ME327 Haptic Running Guidance — Stanford University course project

## Remote Human Assistance Services

- Aira — Aira Tech Corp. (aira.io)
- Be My Eyes — Be My Eyes (bemyeyes.com)

## Precision GPS and Robotic Guide Devices

- Nordic Evolution Digital Guide — Nordic Evolution (nordic-evolution.com)
- Glidance Glide — Glidance Inc. (glidance.io)

## Research and Academic Sources

- EU CORDIS Advanced Guiding Technology for VI Athletes (cordis.europa.eu/article/id/170254)
- RunSight: AR for Nighttime Guided Running — ACM CHI 2025 (dl.acm.org/doi/10.1145/3706598.3714284)
- Exploring Experiences of Runners with VI and Sighted Guides — PMC/NIH (pmc.ncbi.nlm.nih.gov/articles/PMC5336106)
- Sports Technology Blog: Assistive Tech for VI Runners (sportstechnologyblog.com)