Cosmic Motion

A clip-on sport performance tracker with a Lead II ECG

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Executive Summary

Cosmic Motion is the next-generation wearable for athletes and fitness enthusiasts that bridges the gap between the inaccuracy of wrist-based optical sensors and the discomfort of chest straps. This clip-on device provides high quality ECG accuracy in a lightweight, unobtrusive form factor that attaches to a waistband or belt. Paired with an app delivering professional analytics and coaching, Cosmic Motion targets a clear unmet need in the wearables market: accurate, comfortable, and actionable feedback during training.

Unlike existing platforms which rely heavily on photoplethysmography (PPG) and often become unreliable under heavy motion and sweat conditions, Cosmic Motion leverages a proven ECG front end for robust heart and health metrics. Combined with motion sensing, vibration feedback, and an intuitive app, this product can provide professional quality coaching and recovery tools that both improve performance and reduces injury risk.

Version History

9/29/2025 -- V1.0

- Proposal released.

10/1/2025 – V1.1

- MDBT50Q-P512K swapped in for cost and availability.
- Twin IMU changed to single BMI323 for cleaner analytics.
- Side clips changed to ECG only for size, comfort, and cable optimization.
- Added pcb renderings.
- Updated market analysis.
- Added BOM and cost analysis.
- Added reference list

10/2/2025 – V1.2

- Added 3D Aluminum Case Concept Image.
- Added detail to the prototype design plan.

Background

Modern devices such as the apple watch and Fitbit can provide reliable HR metrics at rest but struggle at high BPM and with heavy motion. Chest strap ECGs on the other hand are bulky and uncomfortable; however, they provide gold standard diagnostics.

Cosmic motion bridges this gap -- It delivers the accuracy of a chest strap in a flexible clip-on form factor. The device shifts the cost and complications of designing a custom strap by providing non disposable dry electrode clips that connect to a central information processing device. Electrodes will be swappable and can be changed to disposable adhesive electrodes for better signal integrity if the user desires. The user is able to provide their own belt, waistband, or simply attach the clips to their clothing. The end result is a comfortable, light, durable, and importantly accurate tool to help athletes train smarter and reach their goals faster.

Approach

To achieve the small form factor, the device is split into a string of three clips each with their own electrode facing the skin. The electrodes are stainless steel (316L) and pop into the clips with a possible upgrade to Ag/AgCl adhesive or plated stainless alternatives. The central electrode acts a bias to improve signal to noise ratio (SNR) for the Lead II equivalent ECG. A Bosch IMU provides accurate acceleration and gyroscopic to analyze motion and posture in real time. Data will be stored onboard in flash when away from a connection to the app and synched over BLE 5.0 once connection is established so a constant phone connection is not needed. A coin vibrator will be used to provide interval coaching and alerts as a complement to the app. The enclosure will be 3D printed initially but will eventually move to a full injection molded waterproof case to reduce cost in high volume orders.

Research

Market Research

“RunScribe” and “Lumo Run” are two examples of prominent clip-on wearables. Both targeted serious runners with clip-on IMUs that delivered detailed gait metrics like pronation, ground contact time, and pelvic rotation. RunScribe began via Kickstarter and gradually pivoted toward professional and clinical markets after validating its data in academic studies soon after it launched. They were able to sustaining themselves in niche segments but struggled to scale to consumer adoption. Their product featured open-source hardware and software but with a subscription tier to access the full data on their app.

Lumo Run, on the contrary, was backed by venture funding and evolved from “smart clothing” into a clip-on and tried licensing its motion-science platform. Consumers were not interested in obscure metrics such as hip sway and preferred devices with a clear step, distance, and calorie counter. Competition from other wearables led to its discontinuation. Both of these products illustrate that accuracy and unique metrics alone aren’t enough without building and catering to the needs of a long-term community.

In contrast, Garmin, Polar, Apple, Fitbit, and Whoop established themselves in the mass market by bundling heart rate, GPS, sleep, and lifestyle tracking into convenient wrist-worn devices, supported by large ecosystems and recurring revenue models. Garmin and Polar both used their leverage to produce ECG straps alongside their watches, targeting athletes with robust, proven data. Apple and Fitbit dominate general wellness markets with seamless phone integration, optical sensors, and app ecosystems that emphasize convenience over precision. Whoop distinguishes itself with continuous monitoring and a subscription model, monetizing data and coaching rather than hardware.

The market opportunity for this product lies between two extremes: delivering lab-grade accuracy and science backed coaching in a lightweight clip-on form that avoids the discomfort of chest straps and the inaccuracy of wrist optics. By focusing on actionable training guidance through haptic feedback and recovery alerts, and integrating with existing ecosystems rather than competing with dominant products, this device can carve a niche among serious runners who want reliable heart data without the bulk or compromises of current solutions.

Patent Research

The combination of clip-on ECG and IMU technology is well established, and current patents do not appear to restrict development of this product in its current state. For use as a fitness performance tracker, there is freedom to operate, but the product itself is not sufficiently unique to warrant patent protection.

Regulations

The device is positioned strictly as a sports performance aid and will not make any medical claims. An IP67 waterproof rating is a stretch target to guarantee protection against sweat and rain. Wireless compliance is covered by the pre-certified radio module, eliminating the need for additional certification at the system level. The integrated Li-ion battery must meet Japanese regulatory requirements and pass UN38.3 testing, with an on-cell NTC included for safety monitoring otherwise an external NTC will need to be board mounted.

Hardware

MCU

The MDBT50Q, a low power Bluetooth only system on module (SoM) with built in antenna was chosen. This module is cheap and includes an nRF52840 MCU which is pre certified under various wireless standards so there will be less paperwork to get a shipped product. The product has a 2.4GHz BLE 5.2 transceiver with very low power transmission rates. Its processor is an ARM M4 32-bit 64MHz with 1MB flash, 256 KB RAM, USB 2.0, 32MHz SPI, on-chip DC/DC, fast-wake and low idle current. An external 32.768MHz crystal will be used for accurate sleep timing and to reduce power consumption as much as possible. The BC805M is another cheap module which can be seamlessly swapped in depending on market price and availability changes.

Sensors

The ECG will be a single lead ambulatory ECG with (3) .5x26mm 316L stainless steel electrodes in a Lead II equivalent configuration with the central electrode as a common mode rejection (CMR) bias. Non disposable Ag/AgCl plated stainless electrodes would be preferrable for lower impedance and polarization if they could be sourced cheaply. There will be one central BMI323 IMU to capture gyroscopic and 3 axis acceleration data. Shielded cables in a silicone jacket will leave each clip and connect to the main MCU via a signal and ground. The ECG will use an ADS1291 serial peripheral interface (SPI) analog front end (AFE) which is a well-established ECG IC.

Power

The device will be powered by a EEMB 402030 200 mAh Li Ion pouch, connected by a 3 pin JST-GH-P1.0mm connector to the main clip encloser. The cell will be monitored by the BQ24075 charger IC and charged by a board mounted USB C receptacle with ESD protection. The power will be regulated to the MCU by a TPS7A0230 LDO with another TPS7A0230 for a quiet analog power source. Should the device use excessive power, a buck converter will take the place of the digital LDO. Battery cell voltage will be read periodically and combined in the radio packets. The device will not be usable while charging and will shut down during overheating.

Memory

The device will be able to store data during long recording sessions without constant connection to a phone by storing recent data in a W25Q32JVZPIQ 32MB SPI NOR flash IC which will store information even during power loss. The data will be able to be uploaded to the app or the cloud when connected for long term data storage and analytics. To save on read/write wear the device will store data initially in RAM and send data preferentially over BLE when a phone is nearby and connected. If more memory is needed in the future, a simple swap to an SD card could provide more space than a user would use in the lifetime of the product.

Haptics

A JYC1020 ERM coin vibrator will be used to provide the user haptics with different vibration profiles indicating different training strategies. This can be programmed or disabled in the app. The vibrator will be case mounted close to the interface between the bias electrode so it will be felt more clearly by the user.

Enclosure

Two designs for enclosures will be made, one for the center clip containing the main components and the other for the side clips containing just the electrode interface. Each clip will aim to be IP67 tested for sweat and rain resistance as needed. The designs will start out as 3D printed enclosures and switch to either anodized aluminum if quality is priority, or injection molding if cheap lightweight packaging is superior. Note that injection molding costs $1-10k to produce the initial tooling depending on complexity. The device will have a transparent window for an LED, if included, and a button pad to control power, connectivity, and mode. O-rings and gaskets will be used if to provide better water proofing along with epoxy coatings on the internals.

Software

ECG

The two side electrodes will have their voltage levels referenced using the central bias electrode to provide an accurate Lead II ECG reading alongside the AFE's internal reference bias. The AFE will compare the micro-volt analog voltages and send its data over SPI to the MCU where it will be filtered, processed, and stored for later upload. The data will be used to determine HR, HRV, and arrhythmias.

IMU

A central IMUs will communicate directly to the MCU via I2C and data will be filtered, processed, and stored for later upload. The data will be used to calculate steps, pace, cadence, motion irregularities, hip sway, calories and to filter out motion artifacts from the ECG sampling.

Data Management

Data will be stored on a 32MB flash chip when no Bluetooth connection is established so that performance data is never lost. The data will be timestamped and sent over Bluetooth in a series asynchronous bulk packets once connected to a device. Data encryption is possible to implement if needed in software in order to require a password to upload logged data for user security.

Power Management

The system will be designed for low power with an idle current of 10uA and an average active current of 1.5mA aiming for a battery life in excess of 5 hours of constant use. The device will turn off after ten minutes of not detecting a heart rate or motion to save power. There will be a power switch that also controls connectivity and mode control that can be used to manually cycle the power.

Phone App

The phone app will have a free data metrics tier and a performance subscription tier which grants access to the full data and the coaching platform along with other advanced features. The app will be the most important aspect of development as it is the primary user interface. The initial work will be done on producing the product but should it enter production focus will switch primarily towards the app. Alternatively, the product could integrate with an existing app such as Training Peaks with an established user base. This would allow development to focus on the product itself however it would limit future returns in terms of app revenue.

Budgeting

BOM

Part Number	Quantity	Bulk Price ($)
MDBT50Q-P512K	1	5.93
SMF5V0A D_SMD	5	0.019
ECG wires 20cm w/ Silicone Jacket	2	-
USB_C_Receptacle_USB2.0_14P	1	0.65
Coin vibrator	1	0.85
Li Ion 200mAh Cell	1	1.2
499k R_0603	1	0.003
1M R_0603	2	0.003
51k R_0603	2	0.003
10M R_0603	2	0.003
100k R_0603	1	0.003
1K R_0603	2	0.003
10k R_0603	2	0.003
4.7k R_0603	4	0.003
0 R_0603	1	0.003
TPS7A0230PDQNR	2	0.312
TPD2EUSB30	1	0.12
W25Q32JVZPIQ	1	0.294
BQ24074RGT	1	0.412
Push Button SPST SMD (KMR6 class)	1	0.47

0.1uF C_0603	12	0.0018
10uF C_0603	9	0.062
1uF C_0603	5	0.0025
1nF C_0603	2	0.0025
220pF C_0603	1	0.0014
4.7nF C_0603	2	0.003
12pF C_0603	2	0.0015
SMD Fuse 0603	1	0.084
BMI323	1	0.821
ADS1291IPBSR	1	3.82
JST_GH_3P1.5mm Male/Female	1	0.24
JST_GH_2P1.5mm Male/Female	3	0.2
1.18k R_0603	1	0.003
PZT2222A T	1	0.012
46.4k R_0603	1	0.003
1.13k R_0603	1	0.003
330k R_0603	1	0.003
Ag/AgCl Electrodes	3	-
LED (0603)	1	0.01
32.768kHz SMD 6.0×3.5mm	1	0.1
3D Case A	1	-
Clips	3	-
3D Case B	2	-
M2 Screws	9	-
Button Pad	1	-

Prototyping

The first prototype will carry a higher per-unit cost due to low volumes and setup fees. A five-board minimum order of 4-layer PCBs and optional 3D-printed enclosures will dominate costs. It’s estimated to cost $60 to manufacture in small batches not including labour. The price can be minimized initially by avoiding high density routing and replacing BGA components with QFN versions which would otherwise save money over time in large batch orders. This phase is designed to validate core functionality, expose the hardware, optimize firmware, and collect the initial user data, not to achieve cost efficiency.

Mass production

In 1k unit batches with injection molded cases this cost shift dramatically. Electronics cost drops to $20, assembly and testing to $10, enclosure to $3 with a total per unit cost of $33 depending on market prices. Production will ramp up gradually in stages depending on user adoption. Immediately on success of initial testing, the first 100 units will be ordered and shipped. As the product grows and receives a following, subsequent orders of 1000 units at a time will allow enough product to be in stock without over producing.

Pricing strategy

The wearable market supports a large range of product price points. A conservative break-even floor of $75 per unit covering production, fulfillment, distribution, and other fees is estimated. Two price points exist: $100 price point to target the mass market or a $200 premium market with higher quality components and an aluminum case to target luxury markets and clinics. Regardless of the price point, as is seen in many wearable products, the true long-term margins come from the software. The companion app will deliver professional analytics and adaptive coaching as a premium monthly subscription service. This would allow the product to make a ROI even at break even prices. It is also worth noting that the quality and adoption of the app by the community will determine the true success of this product as such development will shift focus towards the app should this product proceed past the prototyping stage.

Design

Prototype Design Guide

The initial 45x45mm pcb will be fabricated and assembled in house with a small test run of 5 units. The firmware will be uploaded, debugged, and optimized. The size of the pcb can be reduced in size to 25x25mm by using denser components which require automated manufacturing which is expensive in small batches and so were not chosen for the initial prototype.

Once assembled, the device will be fault tested, stress tested, and EMI/SNR tested and its ECG and IMU readings validated. Lead time and assembly will take a minimum of two weeks with testing and software development requiring an additional 2 weeks. Meanwhile, work will begin on development of the companion app which will provide support for a wide range of devices. A 3D enclosure will optionally be printed to test out the form factor and will be tested by a group of athletes to optimize user experience alongside the app. After testing, reviewing feedback, and iterating the design, a final cheaper injection molded case will be designed or optionally a high-quality aluminum case should the product cater to a higher price point. A conservative estimate puts the final product in a position to reach small batch production (>1000 units) within 6 months.

Schematics

Figure 1: 3D Model of $45mm^2$ Aluminum Clip-On Case

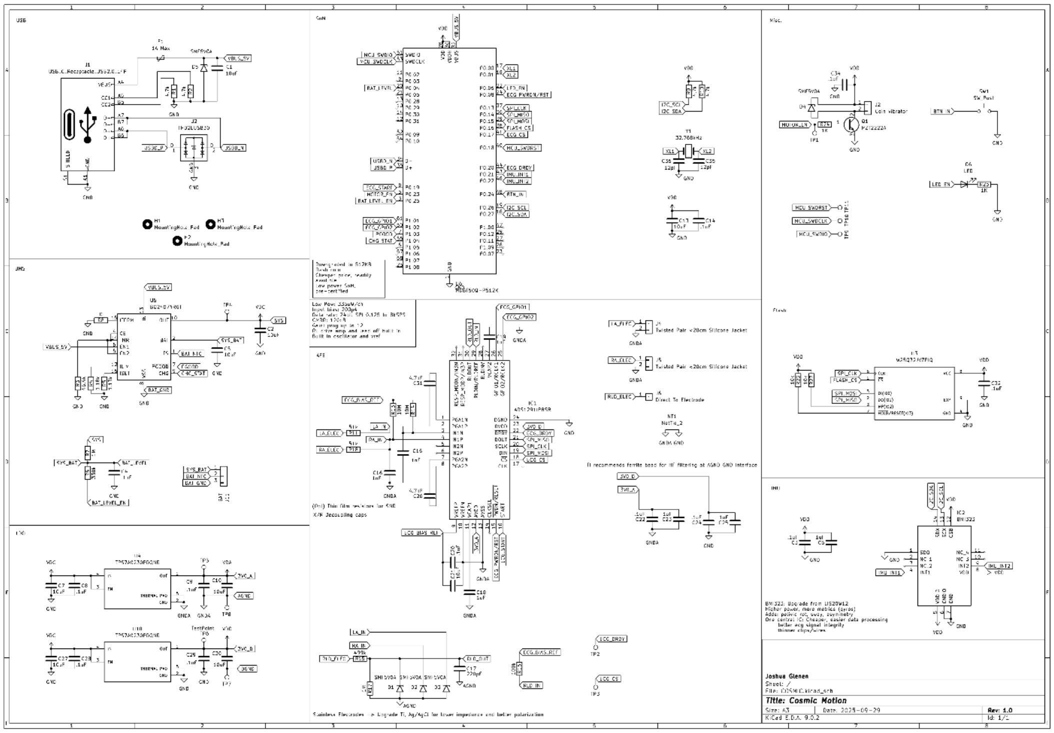

Figure 1: Central Clip Schematic

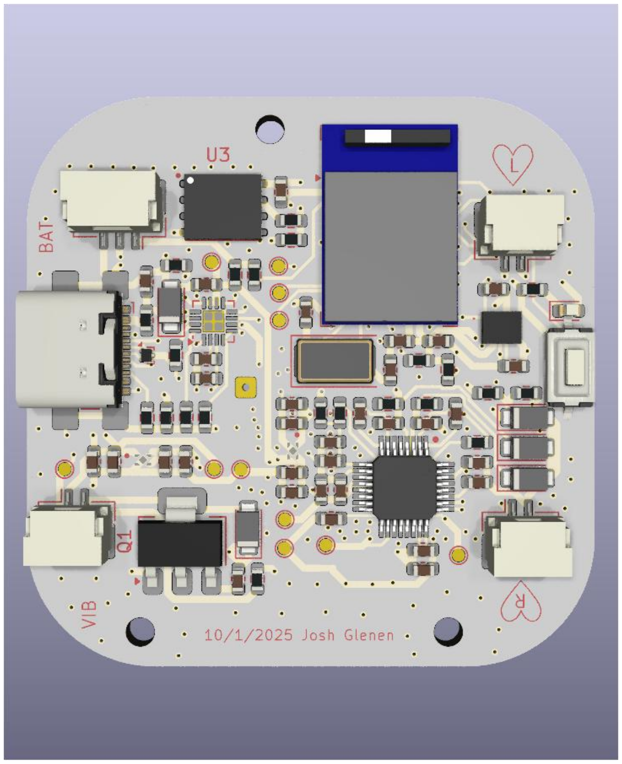

Figure 2: Central Clip PCB Front

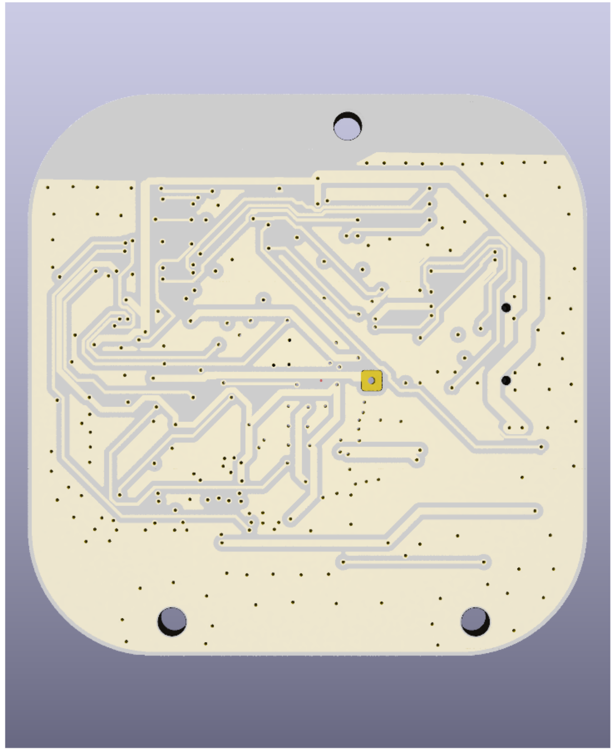

Figure 3: Central Clip PCB Front

Conclusion

This product is designed to deliver chest-strap-level ECG accuracy in a compact, lightweight clip-on form factor. By combining reliable ECG data with state-of-the-art motion tracking and real-time coaching, Cosmic Motion can earn its place within a crowded but evolving performance wearables market. The development plan is realistic, the components are widely available with low risk, and the application is both practical and valuable. With tight control over the manufacturing expenses, a tiered rollout strategy, and a well-designed companion app, this product has the potential to be a market contender.

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