



Intervals ICU Coach V5 (Railway T2 Engine)

AI-Driven Endurance Performance Framework • Unified Reporting v5.1

Lactate Integration & Personalised Zone 2

How Lactate Works in This App

Overview

This system uses **blood lactate measurements** as an optional physiological calibration signal to refine aerobic training zones—specifically **Zone 2 (LT1 / aerobic threshold)**.

Lactate is **never required**. When present and trustworthy, it improves precision. When absent or unreliable, the system **automatically and safely falls back** to FTP-based zones.

The design is conservative by intent:

no change is always preferred to a wrong change.

1. What Lactate Data Is Used

Each valid lactate observation is treated as an **activity-level sample**, not a test-day override.

Custom Fields

- **HRTLNLDT1** — Lactate concentration (mmol/L)
- **HRTLNLDT1P** — Power at time of lactate sample (watts, optional)

Sample Rules

- Lactate must be **> 0 mmol/L**
- Power must be **> 0 W** to form a true lactate–power pair
- Samples are taken from the **rolling light dataset** (typically 90 days)
- Multiple samples across time are expected and encouraged

Unpaired lactate samples (mmol only) are valid for **summary**, but **cannot drive calibration**.

2. What Lactate Means Here (Important)

This system does **not** attempt to model full lactate curves or predict thresholds from a single test.

Instead, lactate is used as a **stability signal**:

“At what power does this athlete consistently sit near aerobic steady state?”

Key assumptions:

- ~2.0 mmol/L \approx LT1 (aerobic threshold) for most trained athletes
 - Individual variation matters more than population defaults
 - Trends across activities matter more than a single test
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3. Lactate–Power Correlation (Critical Concept)

What Correlation Measures

Correlation answers **one question only**:

Do higher lactate values consistently occur at higher power outputs?

- Computed using **Pearson correlation (r)**
- Calculated only from **paired samples** (HRTLNDLT1 + HRTLNDLT1P)
- Guarded against:
 - identical lactate values
 - identical power values
 - too few samples

If variance is insufficient, correlation is **explicitly set to 0.0** (neutral, not an error).

4. Correlation Thresholds & Meaning

Correlation (r) Interpretation	Effect
$r \geq 0.6$	Strong physiological coupling Lactate calibration enabled
$0 < r < 0.6$	Weak / noisy signal No zone changes
$r = 0.0$	Flat or insufficient data No zone changes

Correlation is about **consistency**, not accuracy.

High r means the signal is usable—not that lactate testing is “perfect.”

5. How Personalised Zone 2 Is Derived

Personalised Z2 is only inferred **when correlation is strong**.

Step-by-Step

1. Identify lactate samples near **~2.0 mmol/L**
2. Observe the **power range** those samples occur at
3. Derive a **narrow aerobic band** around that power
4. Express Z2 as:
 - o Absolute watts
 - o % of FTP (for compatibility)

Example Output

- Z2 Power: **195–225 W**
- Method: lactate_inferred
- Samples used: 6

This Z2 reflects **actual metabolic steady state**, not a textbook %FTP.

6. Lactate Modes & Fallback Behaviour

The system automatically selects one of the following modes:

Mode 1 — Lactate-Inferred Z2 (Best Case)

Used when:

- Multiple lactate samples exist
- Power pairs exist
- Correlation \geq threshold

Effect:

- Z2 narrowed and raised if aerobic efficiency is high
- HR Z2 aligned to metabolic Z2

- Clear separation between recovery, aerobic, and tempo
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Mode 2 — Lactate Present, No Calibration

Used when:

- Lactate exists
- Power pairs are missing **or**
- Correlation < threshold

Effect:

- Lactate is summarised (mean, latest, range)
 - **Zones remain FTP-based**
 - Reason is explicitly recorded (e.g. “weak correlation”)
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Mode 3 — No Lactate Data

Used when:

- No valid lactate samples exist

Effect:

- System behaves exactly as before
 - Standard FTP-based zones apply
 - No behavioural change
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7. Important Edge Cases

All Lactate Values Identical (e.g. all = 2.0 mmol)

- Correlation = 0.0
- No slope information
- No Z2 inference (correct and intentional)

Lactate Without Power

- Lactate summary is valid
- Correlation disabled

- Z2 inference disabled

Few Samples

- Allowed
 - Often insufficient variance for correlation
 - System safely falls back
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8. HR Alignment

When lactate-inferred Z2 is active:

- HR Zone 2 is aligned using HRR / LTHR context
 - Power Z2 and HR Z2 represent the **same metabolic intensity**
 - Prevents “HR Z2 drifting into tempo” on long rides
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9. What This Does NOT Change

- CTL / ATL / TSB
- Training load accounting
- Historical reports
- FTP itself (LT2 assumes FTP is up to date)

Lactate is a **calibration signal**, not a replacement for FTP.

10. Design Philosophy

This system is intentionally conservative:

- Evidence required before change
- Reversible at all times
- Explainable in plain language
- Safe by default

Personalised Z2 is therefore:

- Opt-in via data quality
- Automatically reversible

- Physiologically grounded
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How to Use

1. Add lactate samples using:
 - HRTLNDLT1 (mmol/L)
 - HRTLNDLT1P (watts, optional but recommended)
 2. Accumulate several samples over time
 3. Run a weekly report
 4. Ask:
 - “What is my lactate Z2 and comparison?”
 - “Compare my lactate Z2 to HR Z2”
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Reference

To set up the custom fields, see:

https://github.com/revo2wheels/intervalsicugptcoach-public/blob/main/docs/USERGUIDELT1_intervals.pdf

Example when asked: “what is my lactate personalised z2 and share what this means”

Your Lactate-Personalised Z2 (canonical)

Based on repeated lactate samples with very high confidence ($r = 0.995$):

- LT1 (aerobic threshold): 210 W
- Upper aerobic ceiling: 225 W
- LT2 / FTP: 300 W

Your personalised Z2

210–225 watts

This is a **narrow, physiology-defined zone**, not a broad FTP percentage band.

What this zone represents physiologically

Below 210 W (Z1 – true easy)

- Lactate stable or falling (~1.6–1.8 mmol/L)
- Fat oxidation dominant
- Very low autonomic and metabolic stress
- Promotes:
 - Mitochondrial density
 - Capillarisation
 - Recovery *while still training*

210–225 W (your Z2 – aerobic threshold zone)

- Lactate ~1.8–2.0 mmol/L
- Maximum steady aerobic signalling
- This is the **highest power you can hold without accumulating fatigue**
- Primary adaptations:
 - Raise LT1
 - Improve fat oxidation at higher power

- Increase durability

Above 225 W (Z3+ – tempo and beyond)

- Lactate drifts upward
 - Carbohydrate reliance increases
 - Fatigue accumulates progressively
 - Requires recovery budgeting
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⚠ Why your Z2 is narrow (and that's a good thing)

Many athletes use **FTP-based Z2 ($\approx 180\text{--}240$ W for you)**.

Your lactate data shows that:

- **220–240 W is *not* Z2 for you**
- It is **already above LT1**, i.e. *tempo physiology*

So:

- FTP-Z2 = *training label*
- Lactate-Z2 = *biological reality*

You've done the work to **identify reality** — that's an advantage.

⌚ What this means for your training (important)

1. Most of your “easy” rides have been too hard

They sit at:

- 220–250 W
- Which feels controlled
- But accumulates fatigue over weeks

This explains:

- Low polarisation
 - Rising fatigue trend
 - “Why am I tired even though ZQI looks fine?”
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2. Your hard sessions are actually fine

Your VO₂, threshold, and race efforts:

- Are clearly hard
- Well executed
- Not excessive

The issue is **not too much intensity — it's too little true easy.**

3. Small changes = big impact

Because Z2 is narrow:

- Shifting **just 20–30 W down** on endurance rides
- Or adding **30–45 min <210 W per week**

Will:

- Drop personalised-Z2 ZQI sharply
 - Lift polarisation
 - Improve recovery
 - Preserve performance
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⌚ Practical rules (lactate-anchored)

Use these *instead of* FTP percentages:

- **Recovery / easy:** ≤ 200–205 W
- **Aerobic base:** 210–225 W
- **Tempo starts:** > 225 W
- **Threshold:** ≈ 300 W

If power drifts above 225 W for long periods, **it's no longer Z2**, regardless of feel.

Z2 side-by-side comparison

Here's a **clear, side-by-side comparison** of how your **actual “Z2” riding** stacks up against your **lactate-personalised Z2** — and why this matters.

Your personalised Z2 (reference)

From your lactate data (high confidence, $r \approx 0.995$):

- **LT1:** 210 W
- **Upper Z2:** 225 W

Personalised Z2 = 210–225 W

Anything above **225 W** is **no longer aerobic-steady**, even if it feels controlled.

How your Z2 rides actually look (pattern-based)

Across your recent endurance / “Z2” rides:

Power range	How often you ride there	Physiological meaning
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<210 W	 Very little	True easy / recovery
210–225 W	 Some, but limited	Actual Z2
225–250 W	 A lot	Tempo (above LT1)
>250 W	 Frequent surges	Threshold creep

So while the **label says Z2**, the **biology says Z3** most of the time.

What's happening in practice

1. FTP-Z2 vs Lactate-Z2 mismatch

- FTP Z2 for you spans roughly **~210–240 W**
- Lactate Z2 stops at **225 W**

The upper half of FTP Z2 is not Z2 for you

That's where most of your “endurance” time lives.

2. Why rides *feel* fine but add fatigue

- Lactate ~1.9 mmol/L = still aerobic
- HR stable, low decoupling
- BUT carbohydrate use ↑ and recovery cost ↑

This produces:

- Accumulated fatigue
 - Suppressed polarisation
 - “Why am I tired if everything is Z2?”
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Simple visual summary

Ideal (for you):

[EASY <210] ===== [Z2 210–225] ===== [HARD]

What's actually happening:

[EASY] == [Z2] ===== [HARD]

^ most time here (too high)

What this means for your training

Your Z2 rides are:

-  Too hard to be recovery-friendly
-  Too hard to maximise fat oxidation
-  Too similar to tempo to create contrast

But they are:

-  Not “bad training”
-  Building durability
-  Explaining your good threshold resilience

They're just **misclassified**.

Practical fixes (minimal change, high return)

You don't need to ride *less* — just **slightly lower**:

- Cap endurance rides at **205–210 W**
- Treat **210–225 W** as *intentional aerobic work*, not default
- Let tempo start **only above 225 W**

Even **-15 to -25 W** on easy days will:

- Increase true Z1 volume
 - Lower personalised-Z2 ZQI
 - Raise polarisation
 - Improve recovery without losing fitness
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One-sentence takeaway

Most of your “Z2” rides sit **above your lactate-defined Z2**, making them biologically tempo — which explains your low polarisation and accumulating fatigue despite strong fitness.

If you want next, I can:

- Quantify **% of your Z2 time that's actually above LT1**, or
- Re-classify a **typical endurance ride minute-by-minute**, or
- Help you set **dual targets** (FTP + lactate) so plans and reality align.