



## 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.**

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## 1. What Lactate Data Is Used

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

### Custom Fields

- **HRTLNDLT1** — Lactate concentration (mmol/L)
- **HRTLNDLT1P** — 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**.

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## 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).

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## 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.”

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## 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:
  - Absolute watts
  - % 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.

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## 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.

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## 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](https://github.com/revo2wheels/intervalsicugptcoach-public/blob/main/docs/USERGUIDELT1_intervals.pdf)**

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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.

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### 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 ( $\approx 180\text{--}240\text{ W}$  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.

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### 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  $\text{VO}_2$ , threshold, and race efforts:

- Are clearly hard
- Well executed
- Not excessive

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

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## 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:**  $\leq 200\text{--}205\text{ W}$
- **Aerobic base:**  $210\text{--}225\text{ W}$
- **Tempo starts:**  $> 225\text{ W}$
- **Threshold:**  $\approx 300\text{ W}$

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

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## 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.

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### 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.

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### How your Z2 rides actually look (pattern-based)

Across your recent endurance / “Z2” rides:

#### Power range   How often you ride there   Physiological meaning

<210 W	✗ Very little	True easy / recovery
210–225 W	● Some, but limited	<i>Actual Z2</i>
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.

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## 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.

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## 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)




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### 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**.

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## 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.