# eStela tracking data in protest hearings: response to the discussion paper on session 17792

Nov 14, 2026

## 1. Introduction

eStela tracking is designed to follow and replay a race, not to decide a protest. We answer the discussion paper in full, but we have never endorsed our tracking as a tool for settling disputes, and we do not do so here.

Protests are part of sailing and always will be. The Racing Rules of Sailing place the decision with the protest committee, which weighs all the evidence, including what witnesses saw from the water and from the shore. Under rule 63.5(a) the committee decides how much weight any evidence deserves, and tracking data is no exception.

We understand why technology is tempting in a hearing. A replay looks precise, it can be paused at any second, and it seems to settle questions that witnesses remember differently. That appearance of precision is exactly what calls for caution.

A fleet tracked with phones is not one measuring instrument. It is many independent devices, each with its own limits:

- **Operating systems.** iOS and Android estimate position with different algorithms and report accuracy in different ways.
- **Hardware.** GPS chipsets and antennas vary from one phone model to another, and so does their accuracy.
- **Placement on the boat.** Each phone sits somewhere different: in a pocket, in a dry bag, on deck or below. The GPS antenna is not where the hull's extremities are.
- **Battery state.** Power-saving modes can change how often a phone measures and sends its position.
- **GPS signal.** Sky view, sails, the crew's bodies, reflections off the water and the satellite geometry at that moment all change the error, and they change it differently for each boat.

Together these make it very hard to claim that a phone-based system is deterministic, or reliable enough on its own to establish a few metres of separation between two boats at one exact instant. eStela does not make that claim.

What we can do, and do below, is explain how our data is captured, processed and displayed. We are open about what we know, what we do not record, and where the replay is an approximation, so that the committee can decide for itself how much weight to give it.

This document refers to session 17792, *Wed. Twilight Race 6*, RMYC Port Hacking Sailing, 11 November 2026. It follows the order of the discussion paper dated 14 November 2026.

## 2. How eStela data flows from the phone to the replay

Each boat's track is built only from that boat's own phone. Positions pass through three stages: capture on the phone, checks on our ingest server, and display in the replay. No stage combines one boat's measurements with another's.

**On the phone.** The eStela app (version 3.x) reads the operating system's location service about once per second. It sends each reading unmodified: time, latitude, longitude, speed, course over ground, the phone's own accuracy estimate and battery level. The app does not smooth, average or move positions. It only discards readings: those that are clearly impossible, such as a jump implying more than 20 m/s (about 39 knots), some erratic readings while the boat is nearly stationary, and on Android an exact repeat of the previous reading. Readings are queued on the phone and sent every couple of seconds; if there is no signal, they are sent later with their original times.

**On our ingest server.** Readings are checked one by one, per boat:

- A reading whose accuracy estimate is 30 m or worse is rejected.
- A reading implying 100 knots or more is rejected.
- When the reported course is missing, unreliable or turns too fast, it is replaced by the bearing from the previous reading of the same boat. The turn is limited to 50 degrees per reading. When the course or speed is invalid, speed is recalculated from the distance between the two readings.
- Latitude and longitude are never adjusted, apart from being kept within valid ranges.
- Times are stored to the whole second, in UTC, as recorded by the phone. A reading delayed by poor coverage is stored at the time it was measured, not the time it arrived.

After the race ends, a second pass smooths course values recorded below 2 knots, where phone course readings swing widely. It changes only the course field, never the position, and keeps a backup of the original values.

**In the replay.** The player draws each boat at the replay time by linear interpolation between that boat's two neighbouring readings. Section 3 explains this in detail.

**Session 17792 at a glance.** Both boats used the current app and transmitted at one reading per second throughout the race.

| | L'attitude (AUS717) | Jazz Bar (AUS36) |
|---|---|---|
| Phone and system | Samsung SM-S921B, Android | iPhone 15, iOS 26.5 |
| eStela app version | 3.11.0 | 3.10.1 |
| Readings stored | 6,644 | 4,682 |
| Interval between readings | 1 s, with 22 gaps of 2 s | 1 s, with 1 gap of 2 s |
| Bow offset entered by the organiser | 6 m | 9 m |
| Course values smoothed after the race (below 2 kn) | 811 readings, none between 17:46 and 17:48 | 5 readings, none between 17:46 and 17:48 |

Times in this document are local (AEDT, UTC+11) unless marked UTC. The incident at 17:47:18 AEDT is 06:47:18 UTC.

## 3. Answers to the nine questions

In short: each position is the location of the phone's GPS antenna, stored to the second and never smoothed. The replay draws straight lines between consecutive readings, and per-reading accuracy is not kept. The answers follow the numbering of the discussion paper.

### 3.1 Device placement

The reported position is wherever the phone was on the boat, fore and aft and side to side. eStela does not know the phone's position on the boat. The only placement figure is the **bow offset**: the distance from the phone to the bow, entered by the organiser for each boat.

The bow offset is used in two places:

- **Results.** When a boat moves faster than 1 knot, our server projects the bow forward from the phone along the course over ground, by the bow offset. That projected point decides when the boat crosses the start, the finish and the rounding lines used for the results.

- **The committee player.** It scales the drawn hull outline (see 3.9).

There is no transverse offset: a phone kept to port or starboard is treated as if it were on the centreline. Orientation is taken from the **course over ground**, not from where the bow actually points. With leeway, current or a slow turn the two differ, and the projected bow differs with them.

## 3.2 Position and speed inputs

For every reading the phone sends:

- time, with milliseconds
- latitude and longitude
- speed
- course over ground, as reported by the operating system
- the operating system's accuracy estimates for position and course
- battery level and charging state

The app does not send a separate compass heading.

We retain:

- **time**, to the whole second, in UTC
- **latitude and longitude**
- **speed**, in knots to 0.1
- **course**, in whole degrees
- **wind**, only when a wind sensor is connected

Battery is kept only as each boat's latest value, not per reading. Accuracy is used for rejection and then discarded (see 3.3).

Latitude and longitude are stored as single-precision numbers, which limits their resolution. Near Port Hacking this means steps of about **0.42 m north–south and 1.4 m east–west**. The stored values in session 17792 show exactly these steps.

Displayed speed is the speed reported by the phone, which phones usually derive from the Doppler effect on satellite signals rather than from positions. When the phone reports zero speed, or an invalid course, our server replaces the speed with the distance between consecutive readings divided by the time between them.

## 3.3 Position accuracy

The phone sends its own accuracy estimate with each reading, but eStela does not store it. It cannot be exported.

The estimate is used only once, on arrival: readings estimated at 30 m or worse are rejected. A stored reading therefore carries a phone-reported accuracy better than 30 m, but we cannot say how much better for any particular reading.

On the confidence level: Android documents its figure as the radius within which the true position lies with 68% probability. Apple does not publish a confidence level for the iPhone's figure. In the two boats here, one phone was an Android and the other an iPhone, so even the two estimates would not have meant the same thing.

We have no published validation of relative accuracy, meaning the error in the distance between two nearby phones. Shared errors may partly cancel between nearby phones of the same type, but we cannot quantify that, least of all between an Android and an iPhone.

## 3.4 Sampling and reporting

- **Measurement.** About one reading per second. On Android the app requests exactly 1,000 ms. On iPhone the operating system delivers readings at its natural rate, normally once per second, because the app sets no distance filter.
- **Recording.** One reading per boat per second at most, because times are stored to the second.
- **Transmission.** Readings go to our server in small batches, normally every two readings. After a loss of signal, the backlog is sent with the original times.
- **Fixed or adaptive.** Fixed in the current app. A phone in power-saving mode may still deliver fewer readings; the app only warns the sailor when that mode is on.
- **Actual intervals.** These can be established for every race from the exported files. For session 17792 they are in the table in section 2.

## 3.5 Time alignment

The stored time is the time the phone's location service attached to the reading, not the time our server received it. The only exception is a reading timed in the future, which is set back to its arrival time.

We do not correct the phones' clocks. Times are **cut to the whole second**: a reading measured at 17:47:18.9 is stored as 17:47:18. Two boats' readings stored under the same second may therefore have been measured up to almost one second apart. At 5 knots a boat covers about 2.6 m in that time.

When comparing boats, the replay places each boat independently at the same replay instant, from its own readings. Late-arriving readings are stored at their measured time, so the record does not depend on when they arrived.

## 3.6 Connectivity and gaps

- **Without signal.** The phone keeps up to 24 hours' worth of readings and sends them when coverage returns, with their original times.
- **GPS interruption.** No readings are produced, and none are invented.
- **Duplicates.** Each boat has at most one reading per second; a later reading for the same second replaces the earlier one.
- **Rejected readings.** These are not stored and not marked anywhere.
- **How gaps are shown.**
  - Gaps shorter than 6 seconds are bridged by interpolation in the replay.
  - At 6 seconds or more, the boat stays at its last reading and then jumps to the next one.
  - After 30 seconds without readings, the boat is shown faded, with the time of its last reading.
  - Exported files contain only stored readings, so a gap appears as missing seconds; it is not otherwise flagged.

## 3.7 Interpolation and prediction

The replay **interpolates**: between two readings less than 6 seconds apart, the boat moves in a straight line at an even pace. Its course turns smoothly by the shorter way, and the speed shown is that of the earlier reading. A turn made between two readings is therefore drawn as a straight segment.

The replay **does not extrapolate**: after a boat's last reading it stays where that reading put it.

The committee player has one prediction feature, a translucent "ghost" that projects each boat ten seconds ahead. It works only during a live race, is drawn dashed, and does not appear when replaying a finished race.

Interpolated positions are drawn exactly like recorded readings, so a viewer cannot tell them apart. We recognise this as a limitation. Pausing on a whole second (17:47:18) shows the readings stored for that second. Between seconds it shows a blend of two readings.

## 3.8 Filtering and smoothing

Positions are never smoothed or moved anywhere in the system. The filtering that does exist removes readings or replaces course and speed values:

| Where | What it does | Original kept? |
|---|---|---|
| Phone | Discards readings implying more than 20 m/s and some erratic readings when nearly stationary; Android also discards exact repeats | No |
| Server, on arrival | Rejects readings with accuracy of 30 m or worse, or implying 100 knots or more | No |
| Server, on arrival | Replaces a missing or implausible course with the bearing from the previous reading, turning at most 50 degrees per reading; recalculates speed when course or speed is invalid | No |
| Server, after the race | Smooths course values recorded below 2 knots | Yes, a backup of the original values |
| Replay trail | Shows fewer trail points when zoomed out: every reading only at close zoom | Not applicable: display only |

Because positions are untouched, none of this shifts where or when a boat was recorded. Replaced course values change the drawn orientation of the boat and the direction of the projected bow.

## 3.9 Displayed boat symbols

Every boat symbol is anchored on the **phone's position**, rotated to the course over ground.

In the committee player, the hull outline is the boat's symbol scaled so that the bow tip lies the bow offset ahead of the phone. The stern and beam follow the symbol's proportions, not the real boat's measurements. For the standard monohull symbol, the drawn length is about 1.57 times the bow offset and the beam about 0.57 times. So the outline is only as accurate as the bow offset, and its aft and side edges are approximations.

The three-length zone circle drawn around each mark also uses the bow offset. It is based on a length of 1.1 times the bow offset of the boat nearest the mark, which is shorter than the drawn monohull outline. The circle should be read as indicative, not as the zone defined in the Racing Rules.

In session 17792 the organiser entered 6 m for L'attitude and 9 m for Jazz Bar. eStela does not know whether those values match where the phones were actually carried. 6 m is also the value used when none is entered.

# 4. The two reported visual differences

Both differences can arise without any fault in the data. The replay shows phone positions and a mark plotted on a chart, while witnesses see hulls and a floating buoy.

## 4.1 Separation between the tracks and the plotted mark

**How the marks were set for this session.** Every mark of session 17792 was entered in the eStela course editor rather than measured at the buoy. The marks were created on 8 November 2026. None was positioned with our buoy-laying app at the physical buoy, which would have recorded an anchoring time and a GPS accuracy. The plotted mark is therefore where it was entered, not a measurement of where the buoy floated.

**Mark movement.** Marks in eStela are fixed points. A buoy swinging on its mooring, dragging, or laid away from its charted position is not tracked.

**Changes after the race.** The course of session 17792 was saved again from an organiser account on 13 November 2026 at 04:00 UTC (15:00 AEDT), two days after the race. The results were recalculated at that moment. eStela does not keep a history of mark coordinates, so we cannot confirm whether the marks shown today are exactly those in place on race day. The organiser can confirm what was changed.

eStela also has an automatic post-race adjustment that can move a mark by up to 20 m to fit where the fleet rounded it. It only runs for races with a single start time for the whole fleet. Session 17792 was a pursuit race, in which each boat starts at its own time, so the adjustment never applies to it. Our records confirm that no mark of this session was moved by it.

**How to read a track-to-mark separation.** The distance on screen runs from a phone to a plotted point. To compare it with what witnesses saw, allow for:

1. the phone's distance from the centreline and from the hull side nearest the mark (not modelled; see 3.1)
2. the uncertainty of each phone position, which is typically a few metres and can be more
3. the resolution of stored coordinates, about 1.4 m east–west and 0.42 m north–south here
4. the error in placing the mark on the map
5. any movement of the physical buoy

These effects add up in ways we cannot quantify for a single moment, so a separation of a few metres on screen does not establish the separation on the water.

### 4.2 Longitudinal separation at the reported time of contact

**What the tracks represent.** Each track is the path of one phone, not of a hull. Contact happens between hull extremities, typically one boat's bow against another's stern or side. Two phones can be several metres apart while the hulls touch: the distance between phone points must be reduced by each phone's distance to the part of the hull that made contact.

**Same measurement time.** At a paused whole second, both boats are drawn at the readings stored for that second. Because times are cut to the second (see 3.5), the two readings may have been measured up to almost a second apart. At the speeds recorded near the mark, about 4 to 5 knots, that is up to about 2.5 m.

**Interpolation, prediction and filtering at that instant.**

- **Interpolation:** between whole seconds, positions are a straight-line blend of two readings.
- **Prediction:** the replay does not predict positions.
- **Filtering:** no filtering or smoothing has moved either boat's positions. The post-race course smoothing did not touch either boat's readings around 17:47.

Each phone's position error is independent and typically a few metres. Combined with the points above, this means the data cannot confirm or exclude contact between two boats a few metres apart. The witnesses' observations and the data address different things, and the committee must weigh them.

## 5. Suitability for evidentiary use

eStela cannot provide a defensible uncertainty estimate for the separation between two boats at a given second. We advise against treating its data as decisive wherever a conclusion turns on a few metres.

**What the platform is designed for:** following races live, replaying them, computing results, and helping sailors analyse their own performance. It has not been validated as a measuring instrument for protest hearings. eStela does not claim recognition under World Sailing's policy on augmented race management systems.

**Why no uncertainty estimate is possible:**

- Per-reading accuracy is not stored (see 3.3).
- The accuracy of the distance between two nearby phones has not been validated.
- In session 17792 the two boats carried different phones on different operating systems, whose errors need not be alike.

The data can reasonably support:

| Use | Suitability |
|---|---|
| The general sequence of a race: who led, where boats tacked or gybed | Good |
| Timing of events to within a few seconds | Good |
| Approach angles and courses over several seconds | Reasonable, when speed is above about 2 knots |
| Separation or closest approach of a few metres at one instant | Weak: within the uncertainty |
| Overlap, or a hull's position relative to a mark or line, at one instant | Weak without corroboration |

Conclusions about hull positions, overlap or crossing a mark or line need more than the tracks:

1. the measured position of each phone on its boat: distance to bow, to stern and to the centreline
2. the real length and beam of each boat
3. a mark position measured at the buoy, not placed on a map
4. a pattern that holds over several consecutive seconds, not a single frame
5. a difference clearly larger than the combined uncertainties described here
6. independent corroboration, such as witnesses, photographs or video with reliable times

Under rule 63.5(a) the protest committee decides what weight to give all this. We hope this document helps it do so.

## 6. Our recommendation: work from the raw files, not the replay

We recommend downloading the position files of both boats and the course file, and building any analysis from them. These files hold the stored readings themselves, with no interpolation and no drawn hulls. Anyone can reproduce and check an analysis built on them.

### Where to download them

The files are on the club's tracking portal. Downloading requires a free sign-in to the portal.

1. Open the session's datasets page: rmyc-port-hacking-sailing.estela.co → Wed. Twilight Race6 → Datasets.
2. Under **Fleet Data**, find **L'attitude** and **Jazz Bar** and choose **Download CSV** for each. Download GPX gives the same readings in GPX format, for mapping tools.
3. Under **Race course**, choose **Download CSV** or **Download GPX**. Both list every mark with its name and coordinates.

The course CSV has the columns name, lat, lon, waypoint, gated and updated_at. The updated_at column holds the time a mark was positioned at the buoy with our buoy-laying app; it is empty for every mark of this session (see 4.1).

## What the position CSV contains

| Column | Meaning |
|---|---|
| time | Time of the reading, ISO 8601 in UTC, to the second (17:47:18 AEDT appears as 2026-11-11T06:47:18+00:00) |
| lat, lon | Phone position in decimal degrees, as received, at the resolution described in 3.2 |
| sog | Speed over ground in knots, as described in 3.2 |
| cog | Course over ground in degrees true, as described in 3.8 |
| cog (mag) | The same course in degrees magnetic, using the session's declination of 12.9° |
| wind speed, wind dir, wind dir (mag) | Wind from an onboard sensor; empty for these two boats |

The files have **no accuracy column**, because accuracy is not stored (see 3.3). On request we can also supply the original course values for the readings smoothed after the race. None of them falls near 17:47 for either boat.

We are glad to answer further questions about how the data was produced. We will not comment on the facts of the protest itself, which are for the protest committee.

**Javier Vidal**
Founder and Technology Director, eStela