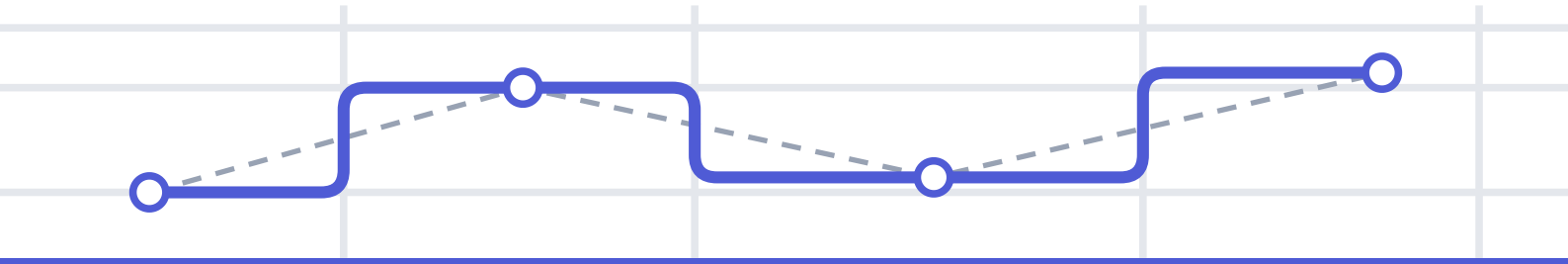
MALAYSIA TRANSIT + SG-JB TRANSIT

TECHNICAL WHITE PAPER · NOVEMBER 2026

Enhanced route lines from OpenStreetMap

How Malaysia Transit and SG-JB Transit draw every bus route along its roads and every train along its track: built ahead of time from OpenStreetMap with pfaedle and a track-following method of our own, in place of Google Directions.



1,337
route patterns drawn along roads and track, for 19 timetables in Malaysia, Singapore and southern Thailand

5.5 m
from Causeway Link's own route maps, on average: how closely pfaedle's lines follow them

20 min
to rebuild every line on our own server, with nothing to pay per line shown

AT A GLANCE

Enhanced route lines from OpenStreetMap

A route line is what the map draws for a route between its stops. Since 26 November 2026, Malaysia Transit and SG-JB Transit draw their Enhanced route lines from OpenStreetMap, the open map of the world, instead of Google Directions. Buses are matched to the roads with pfaedle, an open-source tool from the University of Freiburg made for exactly this job, and trains follow the railway track by a method of our own that also finds stations a timetable puts in the wrong place.

1,337
route patterns drawn: 1,210 bus patterns by pfaedle, 127 train patterns along the track

802
Singapore bus service directions, which LTA publishes with no lines at all

6–11 m
from the stops to the new lines, on average, across the eight BAS.MY timetables tested

23
KTM stations found off the railway or out of order in the timetable, reported back

In four points

- **Lines that follow the route's own roads.** pfaedle works out which roads a bus takes through all its stops, in order, preferring main roads and the bus routes mapped in OpenStreetMap, so a line no longer swerves onto another road to reach a stop set back from the kerb.
- **Ours to show, keep and share.** The lines are OpenStreetMap data, under the Open Database Licence: they may be shown on any map, kept for good and shared, with the credit "© OpenStreetMap contributors". Google's terms allowed none of that.
- **Checked line by line.** Every line passes a quality check before it is kept. One that fails falls back to the timetable's own line, so Enhanced is never worse than Basic.
- **Cheap to keep up.** All the lines are rebuilt in about 20 minutes on the server the apps already run on, into about 2 MB of files. Nothing is paid per line shown.

Contents

1 What a route line is
2 Where the lines came from
3 Why Google's lines had to go
4 The options
5 OpenStreetMap, the map underneath
6 pfaedle, in brief
7 How pfaedle matches a route
8 Our build, step by step
9 Trains, along the track
10 Routes no timetable draws
11 The trial
12 What is built today
13 Against Google's lines
14 What the build found
15 How the apps use the lines
16 Rebuilding
17 Licence and credit
18 Limits and next steps
19 Sources

BACKGROUND

Why route lines needed a new source

Riders read a route from its line. Most of the timetables we show don't draw one that follows the roads, and the service that used to draw them for us came with terms our maps can't meet.

1 What a route line is

A route line is the path the map draws for a bus or train route between its stops. Riders use it to see which roads a bus takes, where it turns and where to wait for it, and the apps draw each ride of a planned journey along it. Both products offer two styles, switched on the map under Route Style:

Basic

The stops joined by straight lines, or the operator's own line where its timetable has one. Always available, and honest about what the timetable says.

Enhanced

The route along the roads it really takes, and trains along their track. Labelled "✓ Enhanced along OpenStreetMap" where the line comes from this work.

Timetables in the GTFS format may carry each route's path (the optional `shapes.txt` file), but most of the ones we show don't carry one that follows the roads:

- **BAS.MY's feeds** on data.gov.my for Alor Setar, Ipoh, Kangar, Kota Bharu, Kuala Terengganu, Kuching and Seremban (two) have one point per stop, so their own line is just the stops joined up.
- **KTMB's live feed** has no lines at all.
- **LTA DataMall** gives Singapore's bus routes as lists of stops, with no lines.
- **Our own timetables** for Causeway Link, City Public Link S19, KLIA Ekspres and SRT's shuttle to Hat Yai had lines made with Google Directions (section 2).

Prasarana's feeds (Rapid KL's buses and trains, the MRT feeders and Rapid Penang), BAS.MY's for Johor Bahru and Melaka (5 to 20 points per stop) and Rapid Kuantan's already have good lines of their own, and keep them. The server uses an Enhanced line where a timetable's own is too sparse to follow the roads: fewer than 1.5 points per stop, no line at all, or a KTM train.

2 Where the lines came from

Until 26 November 2026, Enhanced lines came from Google Directions, in three ways:

- **On request.** Malaysia Transit's server asked Google for directions through a route's stops when a rider opened it, and kept the answer. KTM's lines came the same way.
- **Saved into our timetables.** Four build scripts had fetched Google's directions once and saved them as lines: Causeway Link's CW2 and parts of CW4S and CW6 (also copied into SG-JB Transit), City Public Link S19, KLIA Ekspres and SRT's shuttle. Some station positions had been copied from Google Maps too.
- **Kept for good.** SG-JB Transit's server kept its Google lines in a permanent cache file.

3 Why Google's lines had to go

Not allowed on our maps

Google's Service Specific Terms say Directions results "must not" be used "in conjunction with a non-Google map" (section 4.2). Our websites draw with Leaflet on an OpenStreetMap map, and the apps with MapLibre: neither is Google's.

Not allowed to keep

Only latitudes and longitudes may be cached, for up to 30 days (section 4.3), and the general terms forbid storing Google's content or making new content from it (section 3.2.3). Lines saved into timetables, or cached for good, did both.

Not the bus's roads

A directions service finds its own best way between each pair of stops: it doesn't know which roads the bus takes. Where a stop sat a little off the road, Google's line sometimes swerved onto another road to reach it.

A bill that grows

Every line asked for is a billed request (US$5.00 per 1,000 Directions calls after 10,000 free a month), and the risk was larger than the bill: breaking the terms lets Google suspend the account's Maps services, all at once.

4 The options

On 26 November 2026 the first plan was to fall back to Basic lines everywhere, until we asked whether Enhanced lines could come from somewhere other than Google. These were weighed:

OPTION	HOW IT WORKS	VERDICT
Basic lines only	The stops joined up, or the operator's line	Allowed and free, but gives up the road-following lines riders had
pfaedle	Matches whole timetables to OpenStreetMap's roads and railways ahead of time	**Chosen** Made for exactly this, open source, offline, about a minute per timetable
MOTIS's route shapes	The journey planner can work out lines for trips without one from its own street routing (its `route_shapes` setting)	Not yet running when the lines were needed, and it would tie the route views to the planner. The planner now draws its rides along pfaedle's lines instead
Valhalla	An open-source router with a bus profile, which can snap points to the roads when a line is asked for	One more service to run and call while riders wait, as Google was. Building lines ahead of time is simpler, and each can be checked before anyone sees it
Google Directions	Directions through the stops	Not allowed on our maps or to keep (section 3)

We trialled pfaedle on the server first (section 11). Its first lines looked better than Google's had, and they became the new Enhanced the same day.

METHOD

How the lines are made

Buses and trains are drawn by two methods, on the same OpenStreetMap data, into the same kind of file. Both run ahead of time, so riders never wait on them.

5 OpenStreetMap, the map underneath

OpenStreetMap is the free, editable map of the world, made by volunteers and published under the Open Database Licence. Besides drawing the base map of both products, it describes everything a route line needs:

WHAT	HOW OPENSTREETMAP RECORDS IT	USED FOR
Roads	`highway=*` ways, from motorways to service roads, with `oneway` and access tags	Bus lines
Turn rules	`type=restriction` relations (no right turn, only straight on…)	Bus lines
Railway track	`railway=rail` ways, with `service=siding`, `yard`, `crossover` or `spur` for side track	Train lines
Stops and stations	Bus stops, platforms, stop positions and stations, with their names	Placing stops; station positions

- **The extract:** Geofabrik's Malaysia–Singapore–Brunei file (about 250 MB, OpenStreetMap data until 17 November 2026 for today's lines).
- **Southern Thailand:** SRT's railway from Padang Besar to Hat Yai lies outside that extract, so a small extract of just that railway is taken from an Overpass API server (section 10).
- **The same roads as the map.** Both products' base maps are drawn from OpenStreetMap too, so a line follows exactly the roads the map shows under it. Google's lines were drawn from Google's own road geometry over our OpenStreetMap map.

6 pfaedle, in brief

pfaedle is a free, open-source tool that gives a GTFS timetable its route lines by matching every trip to OpenStreetMap. It comes from the Chair of Algorithms and Data Structures at the University of Freiburg in Germany (Professor Hannah Bast's group), where Patrick Brosi wrote it and still develops it. It first appeared in 2018, with the paper "Sparse Map-Matching in Public Transit Networks with Turn Restrictions" (Bast and Brosi, ACM SIGSPATIAL 2018), and its method is the first part of Brosi's doctoral thesis, *Automated Generation of Transit Maps* (2022). It is written in C++ and published under the GNU General Public Licence, version 3.

Made for timetables

It reads a whole GTFS feed and works from what a timetable already has: each trip's stops in order, their positions and names, and their times.

Each mode on its own ways

Its settings cover buses and coaches, trams and subways, trains, ferries, gondolas and funiculars, each matched only to the kind of way it runs on.

Run ahead of time

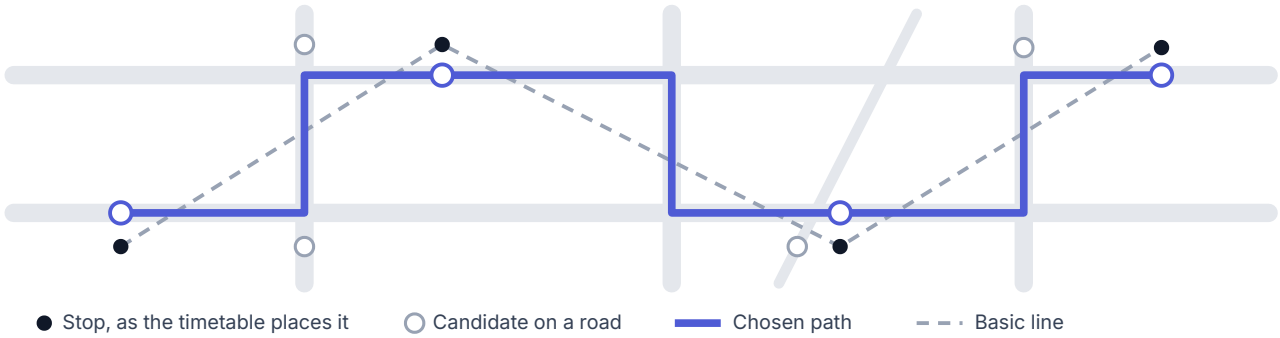
It writes the lines into the timetable's `shapes.txt`. Nothing is asked of any service while riders use the apps.

Fast, and tested

In the thesis it matched every trip in Germany in 8.5 minutes (not counting reading the map), and got 90% of trips right on at least nine hops in ten, against 84% for the usual distance-based method, with lines 6.9 m from the true path on average.

7 How pfaedle matches a route to the roads

Map matching usually starts from a GPS trace: a position every second or so, close together. A timetable gives far less: only the stops, often hundreds of metres apart. Between two stops many paths are possible, and the job is to pick the one the bus really takes. pfaedle treats this as a hidden Markov model, the standard tool for map matching: the stops are what is observed, and where each stop really sits on the network is hidden. With the settings it ships with, it works like this:



Each stop gets candidate positions on the roads nearby (two shown per stop here). pfaedle chooses one per stop, and the roads between them, so that the whole trip costs least; the Basic line just joins the stops.

1. **A network for each mode.** From the extract it builds a graph of the ways a mode may use, sorted into eight levels by their tags, each with an average speed. For buses, trunk and primary roads are level 1, secondary roads level 2, residential streets level 4 and service roads level 5, with speeds from 85 km/h on the fastest level down to 5 km/h on the slowest. OpenStreetMap's mapped bus routes are read too.
2. **Candidates for each stop.** For each stop it gathers the places where the stop could be: stops and stations mapped in OpenStreetMap within 200 m, scored by how alike their names are to the timetable's, weighed with distance; the nearest points on roads within 100 m, down to service roads; and, as a last resort, the stop's own position. A candidate costs a little more the further it is from the stop, and a little more again if it isn't a mapped stop, or its name doesn't match.
3. **Hops between candidates.** For each pair of candidates at consecutive stops, it finds the quickest path along the network, at each level's speed. Driving against a one-way street costs five times the time plus 5 minutes, and a banned turn 5 minutes: heavy penalties rather than outright bans. A U-turn costs 2 minutes, and stretches away from the line's own mapped bus route take a fifth longer.
4. **The timetable's times as a limit.** Each hop's search stops at three times the time the timetable allows for it (at least a minute), and is widened up to three times if nothing is found. If no path fits even then, pfaedle reports "No viable hop found" and draws that hop straight.
5. **The best path overall.** The candidates form one layer per stop, joined by the hops. The trip's line is the cheapest path through all the layers, one candidate per stop: a shortest-path search through the layers, which is how a hidden Markov model's most likely sequence (the Viterbi path) is found.

6. **Shared work.** Trips of the same line with the same stops are merged into a tree of stop sequences and matched once, so a timetable of thousands of trips takes about a second.

8 Our build, step by step

One script, `scripts/osm-lines/build.mjs`, builds every line. It runs on the server beside the live apps, so it is careful with memory.

STEP	WHAT HAPPENS
1. Pick the timetables	From the service areas the apps serve: every BAS.MY city but Kuantan, Bas Muafakat Johor, Causeway Link, City Public Link S19, the Singapore cross-border buses and, given LTA DataMall's routes, every Singapore bus service; for trains, KTMB, KLIA Ekspres and SRT's shuttle. A new BAS.MY city is picked up at the next build.
2. Find the trip patterns	A pattern is one distinct sequence of stops: a route, a direction, a variant. Every trip with that sequence shares its line, so 1,338 patterns stand for all the trips. The stops are the ones the server lists, after it merges a timetable's stops into places, so the line's stop ids are the ones the apps receive.
3. Write a small timetable	One trip per pattern, with its stops and times, as a GTFS folder for pfaedle.
4. Run pfaedle	In a container from an image pinned to one exact build, matching buses only and every trip afresh. Each run is capped at 3 GB of memory and 2 CPUs at low priority, one at a time; none starts with less than 3.5 GB free, and a run is stopped after 45 minutes.
5. Check each line	The quality gate below. A line that fails is not kept, and the server goes on showing the timetable's own line for that pattern.
6. Pin the stops	Each stop is pinned to its point on the line, in the stops' order. A stop's choices are its nearest points on up to 8 pieces of the line and the nearest point of every pass the line makes within 250 m of it: a loop that starts and ends at its terminal passes it twice, and the first stop belongs on the first pass even where the nearest pieces all lie on the last. A line that can't pass its stops in order isn't kept. The server can then cut the line between any two stops.
7. Simplify and store	Points closer than 2 m (buses) or 4 m (trains) to the simplified line are dropped, as the eye can't see them; stop points are always kept. Each line is stored as an encoded polyline (to about a metre), in one JSON file per timetable with its build time, the map data's date, the credit and the licence.
8. Report	Each timetable's patterns kept and not kept, and why; lines with a straight piece over 1.5 km (a road pfaedle couldn't follow there); and the stations left out of train lines.

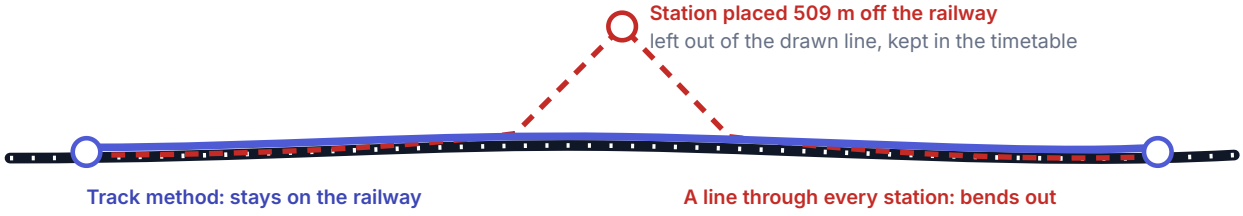
The quality gate for bus lines

A line is kept only if it **passes its stops in order**, **every stop is within 200 m of it**, and, for patterns longer than 300 m, it is **between 0.7 and 3 times as long as its stops joined up**. The trial's worst kept cases were a stop 115 m from its line (a pole recorded well off the road) and a two-stop route 2.5 times its straight length, because its road really goes round. A line that is too short has cut a corner; one that is far too long has wandered.

9 Trains, along the track

pfaedle draws a train's line through every station, as it should. But KTMB's timetable places some stations well away from the railway, and a station in the wrong place pulls the line off the track: out to Sedenak, 509 m from the railway between Layang-Layang and Kulai; out to Kalumpang, placed about 7 km from the real station; and zigzagging to East Coast halts several kilometres off the line. So trains are drawn by a method of our own (`scripts/osm-lines/railPaths.mjs`), on the railway track pfaedle extracts from the map:

1. **Track.** Only ways tagged `railway=rail`, the track KTM trains run on. Light rail, monorail, funicular, tram, disused and unbuilt track are left out. Sidings, yards, crossovers and spurs may be used but count three times their length, so the main line wins.
2. **Stations meet the track.** Each station is matched to the nearest point on up to 8 nearby tracks, measured to the track itself, not to its mapped points: straight track can have points kilometres apart. KL Sentral has six tracks within 40 m, and the KLIA Ekspres line must find its own among them.
3. **Off the railway.** A station with no track within 300 m is out of place, and left out of the line.
4. **The shortest way along the track.** The line joins the stations in order by the shortest route along the track. A hop may be up to 3 times the straight distance, or 5 km more; a station the line can't reach in order within that is left out too.
5. **Doubling back.** KTM trains don't reverse on the way, so a station that makes the line run past it and come back (by over 30% of the direct way, and over 1 km) is in the wrong place or the wrong order, and left out, the worst first. At most three stations in a row are left out.
6. **Close to the station.** Where a station has several tracks nearby, the line uses the one that keeps it closest to the station: each metre between station and track counts like 5 m of track.



What happened at Sedenak, between Layang-Layang and Kulai. The black and white line is the track.

Left-out stations stay in the timetable and on the map; only the drawn line doesn't bend to them, and the server lists them with the line (`skippedStops`). Where stations are placed correctly, this method and pfaedle give the same line: on Komuter Utara both sit on the railway, and the track method places stations a few metres closer (17 m and 28 m on average, against 22 to 32 m). Long hops are real track, not errors: Ipoh to Kuala Kangsar is 51.7 km by rail for 25.3 km in a straight line, and Dabong to Kuala Krai 55.0 km for 27.3 km. Two settings were tuned on such cases: at 2 times the straight distance the method wrongly dropped Ipoh and Kuala Krai, and without the 5-to-1 weight lines started 261 m from Dabong and 198 m from Gua Musang, joined through a short station siding.

10 Routes no timetable draws

- **Singapore's buses.** LTA DataMall lists each service's stops in order, with distances, but no line. Given a copy of the server's LTA data, the build turns all 802 service directions into patterns and matches them in about 3 minutes. SG-JB Transit uses the same file.

- **Causeway Link AA1**, the only bus to Senai Airport, is in no timetable feed. Its two lines are built the same way, by the Lot 10 stop as the bus goes.
- **SRT's shuttle to Hat Yai.** Its track is in Thailand, outside the main extract, so the build reads a small extract of the railway between Padang Besar and Hat Yai from an Overpass API server, and draws it by the track method. Its four stations' positions now come from the same data (KTM's stop positions at Padang Besar, averaged, and the Thai stations' nodes).
- **Kuching's Q11 to Q16.** data.gov.my's feed gives every stop on these routes the same time, so all 6,026 stop-to-stop hops last minus 10 seconds, and pfaedle, which uses the time between stops to limit each hop's search, reported "No viable hop found" and drew them straight. Stand-in times worked out from distance (20 km/h between stops, plus 15 seconds at each) are used for drawing only, never shown as a timetable. With them, all 22 Kuching patterns matched, stops 6.6 m from the line on average.
- **The border checkpoints.** At Woodlands, the stop "Woodland Checkpoint Out" sits on a one-way carriageway that OpenStreetMap doesn't let a bus reach from the south, so CW2 and CW5 towards Johor drew straight lines of 18.7 km and 17.0 km in the first round; a few shorter stretches at the Second Link did the same. Such a stretch is now drawn straight, as Basic draws it, and the report counts it. At JB Checkpoint, the 160, the 950 and the 170X go out to JB Sentral and back between the checkpoint's two bays, but pfaedle turned them round on the checkpoint's own bus lanes, so JB Sentral and the bay to Singapore shared one point, 158 m and 84 m off. They're now drawn through a point on each carriageway of Jalan Ismail Sultan, round the loop OpenStreetMap maps for the 170X, and both stops sit within 22 m of their lines.
- **Station positions.** Positions copied from Google Maps were replaced with OpenStreetMap's: KLIA Ekspres's and KLIA Transit's six stations (each station's stop positions in the two routes' relations, averaged) moved 15 to 60 m, and Tebedu's stop, now the immigration complex's bus station, about 70 m.

RESULTS

The lines in numbers

pfaedle was tried in three rounds on 26 November 2026 before anything went live, on the same server and with the same caps as the build uses today.

11 The trial

Round 1: four timetables

TIMETABLE	TIME	PEAK MEMORY	TRIPS MATCHED	STOP TO LINE
Singapore cross-border buses	73 s	437 MB	1,565 of 1,565	11.4 m
Causeway Link	73 s	446 MB	1,015 of 1,015	9.6 m
BAS.MY Kangar	48 s	353 MB	344 of 344	6.5 m
KTMB (rail)	36 s	131 MB	265 of 265	20.1 m

Stop to line: the median, over a timetable's patterns, of the average distance from each stop to the line. Most of each run (about 65 seconds) is spent reading the map file; the matching itself takes about a second per timetable.

- **Against the operator's own lines** (28 Causeway Link patterns): pfaedle's lines stay within **5.5 m** of them on average, with 95% of points within 15.8 m.
- **Against Google's old line** for CW2, from Larkin to Queen Street, along the expressway and across the Causeway: **2.5 m** on average, 6.2 m at the 95th percentile.
- **Most "stop off the line" flags were cosmetic:** single stops set back from the road or inside an interchange or terminal (Jurong Town Hall, Queen Street, Larkin, Woodlands), and some Kangar poles recorded 50 to 96 m off the road. The lines themselves followed the roads.

Round 2: six more BAS.MY cities, and Komuter Utara

TIMETABLE	TIME	PEAK MEMORY	PATTERNS	STOP TO LINE
Alor Setar	61 s	498 MB	26	6.7 m
Kota Bharu	55 s	397 MB	32	8.4 m
Kuala Terengganu	49 s	282 MB	17	8.1 m
Kuching (with stand-in times)	48 s	293 MB	22	6.6 m
Ipoh	55 s	328 MB	29	11.2 m
Seremban A	61 s	489 MB	19	8.0 m
Seremban B	73 s	562 MB	22	8.1 m

Ipoh's figure is the highest because its feed lists a separate pole for every route at shared stops. Komuter Utara's lines were good too: all 40 straight pieces over 2.5 km stay within 6 m of the real track, half within 1 m, because pfaedle draws straight track with few points.

Round 3: trains along the track

KTMB TIMETABLE	TIME	STATIONS	LINES	STATIONS LEFT OUT	STRAIGHT GAPS
Malaysia Transit's copy	17 s	184	45	23	0
data.gov.my's live feed	54 s	156	86	14	0

Every train line followed the railway with no straight gaps; each straight piece over 2.5 km is a single piece of mapped straight track (the longest, 5.8 km, crosses the Perlis and Kedah paddy belt). Kept stations sit within 150 m of their line, except two whose recorded positions are that far from the track.

12 What is built today

TIMETABLE	METHOD	PATTERNS KEPT	FILE
Singapore's buses (LTA DataMall)	pfaedle	802 of 802	943 KB
KTMB (every KTM service)	Track	121 of 121	417 KB
BAS.MY Melaka	pfaedle	66 of 66	113 KB
Bas Muafakat Johor	pfaedle	57 of 57	51 KB
BAS.MY Johor Bahru	pfaedle	45 of 45	66 KB
Causeway Link	pfaedle	36 of 36	38 KB
BAS.MY Kota Bharu	pfaedle	32 of 32	70 KB
BAS.MY Ipoh	pfaedle	30 of 30	50 KB
BAS.MY Alor Setar	pfaedle	27 of 27	33 KB
BAS.MY Kangar	pfaedle	23 of 23	40 KB
BAS.MY Kuching	pfaedle	23 of 23	31 KB
BAS.MY Seremban B	pfaedle	22 of 22	53 KB
BAS.MY Seremban A	pfaedle	18 of 19	33 KB
BAS.MY Kuala Terengganu	pfaedle	19 of 19	32 KB
Singapore cross-border buses	pfaedle	6 of 6	10 KB
KLIA Ekspres and KLIA Transit	Track	4 of 4	5 KB
Causeway Link AA1	pfaedle	2 of 2	2 KB
City Public Link S19	pfaedle	2 of 2	3 KB
SRT Padang Besar–Hat Yai	Track	2 of 2	2 KB
19 timetables	**1,211 pfaedle, 127 track**	**1,337 of 1,338**	**1.94 MB**

Built on 26 November 2026 from OpenStreetMap data until 17 November 2026 (SRT's railway: an extract of 28 July 2026); on 27 November the bus lines' stops were pinned again, as step 6 of section 8 describes, the cross-border buses' lines built again on LTA DataMall's stop positions, and those and Singapore's built again with the 160, the 950 and the 170X drawn out to JB Sentral and back (section 10). One line doesn't pass its stops in order and isn't kept: Seremban A's Desa Rhu loop. KTMB's file serves all 11 KTM services in the apps, from Komuter Klang Valley to Shuttle Tebrau and the Intercity trains to Kota Bharu. BAS.MY Johor Bahru's and Melaka's own lines already follow the roads, so their route views keep them.

13 Against Google's lines

	GOOGLE DIRECTIONS (BEFORE)	OPENSTREETMAP (NOW)
On our own maps	Not allowed (section 4.2)	Allowed, with the credit
Keeping them	Coordinates only, for 30 days	Ours to keep, and to share under the same licence
Which roads	Google's own best way between each pair of stops	The quickest way through all the stops in order, weighing each stop's distance, road class, turns and mapped bus routes
A stop set back from the road	Could swerve onto another road to reach it	Pinned to the road beside it; a line too far from any stop isn't kept
Trains	Through every station, even one placed off the line	Along the track, leaving out stations placed off it, and reporting them
Fit with the map	Google's road geometry over an OpenStreetMap map	The same roads the map draws
Cost	US$5.00 per 1,000 requests after 10,000 free a month	Nothing per line; about 20 minutes of our server per rebuild
Fresh roads	Google's current map	As fresh as the extract: rebuilt every month or two
If it fails	No line, or a line that bends wrong	The quality gate falls back to the timetable's own line

On ordinary roads the two are very close: CW2's new line is 2.5 m from Google's on average. The difference shows where it matters to riders: at stops set back from the road, at terminals and interchanges, and on trains whose timetable puts a station in the wrong place.

14 What the build found

Drawing lines carefully is also a close check of the timetables. These findings are worth sending to KTMB and data.gov.my, and are listed with every build:

KTM stations off the railway. More than 5 km off: Mela, Sg Mengkuang Baru, Kuala Gris, Kemubu, Sri Mahligai, Kalumpang (placed near Lembah Beringin), Tembeling and Padang Piol. Closer in: Sri Bintang 4.5 km, Pahi 4.4 km, To' Uban 2.9 km, Aur Gading 1.6 km, Sri Jaya 1.4 km, Kg Berkam 1.1 km, Bertam 666 m, Sedenak 509 m, Dura 412 m, Sungai Temau 341 m and Holiday Plaza 307 m.

In the wrong place or order. "Mengkuang" is timetabled between Triang and Kemayan in Pahang but placed south of Kuala Krai in Kelantan, about 330 km up the line. Kubang Rusa and Teluk Gunong are listed in swapped order, and so are Kg Telang and Pdg Tungku.

Other timetable issues. On Kuching's Q11 to Q16 every stop has the same time (section 10). KTMB's live feed has no route lines at all, and codes its five Komuter services, Shuttle Selatan among them, as trams. The KTMB copy used in the trial had 8 stop times pointing at a station (37200) missing from its stop list, and 39 Komuter trips with no stops. BAS.MY's feeds, all but Johor Bahru's and Melaka's, have one line point per stop, and some poles recorded 40 to 115 m off the road. (Hat Yai is left out of KTM's lines only because the main extract stops at the border: not a timetable error.)

IN USE

Serving, upkeep and licence

The lines are plain files in the server's code. The server reads them when it starts, and riders get them with no outside service in the way.

15 How the apps use the lines

- **Route views.** `GET /api/routes/:routeId/geometry/enhanced` gives a trip its OpenStreetMap line where the timetable's own is too sparse (section 1). The answer says `source: openstreetmap`, carries the credit, and lists the stations the line leaves out.
- **Trips that changed since the build.** A trip whose stops run in a row inside a longer pattern gets that stretch of its line; a trip unlike any pattern gets the timetable's own line until the next build.
- **Journey plans.** Each ride in a planned journey is drawn along the same line, cut between the stops where the rider boards and leaves, so a journey looks exactly like the route view. Where that piece of line ends a little off those stops, up to 400 m away (a terminal inside a building, say), it is joined to them with a short straight piece; a line that ends farther away isn't used for the ride.
- **Shared timetables.** A file serves every service that shares its timetable, including ones added after the build: KTM Shuttle Selatan, added to the Rest of Johor on 26 November 2026, had lines from KTMB's file at once.
- **SG-JB Transit** keeps its own copies of four files and serves them the same way: the Singapore buses' and AA1's, for its route views and journeys, and the cross-border buses' and KTMB's, for its journeys across the Causeway.

16 Rebuilding

Lines are rebuilt when a timetable's trips change a lot, and every month or two for newer map data. The whole build takes about 20 minutes on the server:

1. Download a fresh Geofabrik extract (about 250 MB).
2. In a scratch copy of the code, never the copy the live server runs from, run the builder with the extract, LTA DataMall's cached bus routes and SRT's railway extract.
3. Read the report: patterns kept and not kept, straight pieces, stations left out.
4. Look over each area's new lines against Basic on an internal review page.
5. Commit the files; the server reads them on its next start. Copy the Singapore, cross-border, AA1 and KTMB files to SG-JB Transit.

Per timetable a run takes about a minute and under 0.5 GB of memory; extracting the railway for the train method takes 43 seconds at a 139 MB peak, and the track method itself seconds.

17 Licence and credit

- **OpenStreetMap's data** is © OpenStreetMap contributors, under the Open Database Licence (ODbL) 1.0. The lines are built from it, so they are under the ODbL too.
- **Credit:** wherever a line shows, "© OpenStreetMap contributors". Both products' maps already credit OpenStreetMap, and every API answer with one of these lines carries the credit.

- **Sharing:** anyone may use the line files under the same licence, which makes them something we can offer partners and other developers, as Google's lines never were.
- **pfaedle** is free software under the GNU General Public Licence, version 3, run unchanged as a separate tool in a container. The lines it writes are OpenStreetMap data, and pfaedle's own documentation asks that a timetable carrying them credit OpenStreetMap under the ODbL when it is shared.

18 Limits and next steps

- **Only as good as the map.** A missing road, a wrong one-way or a missing link bends a line or leaves a straight piece. The fix is to correct OpenStreetMap itself, which helps everyone who uses it; the Woodlands checkpoint lanes are the first candidate.
- **Only as good as the stops.** A stop recorded far from its road, or a station in the wrong place, is reported rather than drawn to. Fixing the timetables at the source (section 14) fixes the lines too.
- **New routes wait for the next build.** Until then they show the timetable's own line. A scheduled monthly rebuild, like the journey planner's nightly refresh, is a natural next step.
- **One more region.** If the main extract gains southern Thailand, as the journey planner's street map already has, SRT's line can come from the main build.

19 Sources

pfaedle: github.com/ad-freiburg/pfaedle (code, default settings and README, read 27 November 2026); H. Bast and P. Brosi, "Sparse Map-Matching in Public Transit Networks with Turn Restrictions", Proceedings of ACM SIGSPATIAL 2018, pp. 480–483, doi:10.1145/3274895.3274957; P. Brosi, *Automated Generation of Transit Maps*, doctoral thesis, University of Freiburg, 2022, chapter 2, "Map-Matching Schedule Data", doi:10.6094/UNIFR/228990.

OpenStreetMap: openstreetmap.org/copyright (credit and licence); the Open Database Licence 1.0, opendatacommons.org/licenses/odbl/1-0; Geofabrik's Malaysia, Singapore and Brunei extract, download.geofabrik.de/asia/malaysia-singapore-brunei.html; the Overpass API, overpass-api.de.

Timetables: data.gov.my's GTFS feeds (CC BY 4.0); LTA DataMall's bus routes and stops (Singapore Open Data Licence); the GTFS reference for `shapes.txt`, gtfs.org.

Google Maps Platform: Service Specific Terms (version of 24 November 2026), cloud.google.com/maps-platform/terms/maps-service-terms; Terms of Service, cloud.google.com/maps-platform/terms; pricing, developers.google.com/maps/billing-and-pricing/pricing (read 27 November 2026).

Malaysia Transit's own records: how the lines are built (`docs/osm-route-lines.md`), the builder (`scripts/osm-lines/`), the line files (`data/osm-lines/`, built 26 November 2026, the bus lines' stops pinned again on 27 November), and the pfaedle trial report of 26 November 2026, with its three rounds.