Part III: Layout
Chapter 10: Historic Single-Track Lanes

Created 1/4/26

10.1 Justification

10.1.1 National design guidance does not explicitly or directly address the operation of historic single-track rural lanes with constrained geometry, particularly where access to new development relies on intermittent passing places rather than continuous carriageway width. This guidance therefore provides a safe, consistent and proportionate framework for assessing development proposals served by historic narrow, low-traffic lanes, reflecting their rural character and established operational function.

10.1.2 Where additional development places demands on lane capacity or safety, proposals should seek to retain the rural character and operational simplicity of the lane and avoid incremental or 'creeping suburbanisation'. The introduction of new signage, extensive road markings and kerbing should be limited to the minimum necessary to achieve a safe and legible layout, and designs should minimise future maintenance liabilities. The discouragement of extensive kerbing in this chapter does not preclude localised kerbed radii, strengthened edges or similar measures where required to accommodate agricultural or heavy vehicles safely, as provided for in Chapter 3.9.

10.1.3 This guidance focuses on the use, siting and design of passing places because, on historic single-track lanes, they are typically the only proportionate and practicable means of accommodating limited additional traffic without fundamentally altering the character and function of the route. Where development can be accommodated through well-designed and appropriately spaced passing places, this represents a pragmatic and established operational solution.

10.1.4 Where the scale or nature of development would, in effect, result in suburbanisation or exceed the practical limits of passing-place operation, the lane shall be fully upgraded to meet the relevant standards set out elsewhere in this guide, or alternative access arrangements shall be provided.

10.2 Relationship between Part III, Chapter 9 and Part III, Chapter 10

Part III, Chapter 9: Agricultural Access and Part III, 10: Historic Single-Track Lanes address different highway design considerations and may apply independently or together depending on site context.

Part III, Chapter 9 governs the design of individual agricultural, equestrian or rural accesses to the public highway, regardless of road type.

Part III, Chapter 10 governs the operational suitability and mitigation of historic single-track lanes where development traffic relies on passing places rather than continuous carriageway width.

Where a proposal involves a new or intensified access taken directly from a historic single-track lane, both chapters apply: Chapter 9 to the access itself, and Chapter 10 to the operation of the lane i.e., compliance with the operational principles of this chapter does not remove the need for access-specific design in accordance with Chapter 9 where development traffic enters or leaves the lane via an agricultural or rural access.

10.3 Carriageway Width

10.3.1 For new development to be supported requiring access via an existing single-track lane(s), the lane's width should normally be 3.2m to 3.5m measured kerb-to-kerb or carriageway edge-to-edge to minimise uncertainty regarding the ability of two vehicles to pass without designated passing places and to ensure verges and footways are not overrun. Widths toward the lower end of this range will only be appropriate where speeds are low, geometry is forgiving, and heavy vehicle use is minimal.

10.3.2 The need for localised widening at bends must be assessed on a case-by-case basis using appropriate vehicle (e.g., refuse truck, HGVs, or farm vehicle) swept path analysis tools to confirm adequate turning space without overrunning verges.

10.4 Passing Places in Relation to Forward Visibility

10.4.1 Passing places should not be located at, or immediately beyond, locations of materially constrained forward visibility (including sharp bends and crests) where drivers are unlikely to perceive an oncoming vehicle or the next passing opportunity in sufficient time to make a clear proceed / wait decision. Particular attention shall be given to visibility from access points and scheme entries to the first passing place, as lack of entry-to-bay intervisibility increases reversing and operational instability.

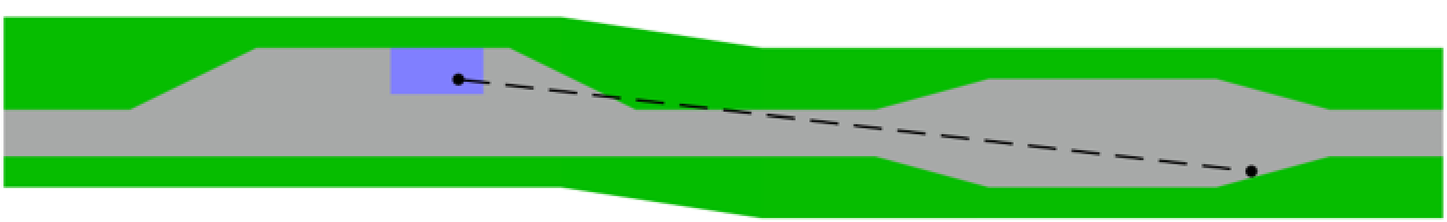
10.5 Passing Places in Relation to Stopping Sight Distance

10.5.1 A passing place should not normally be positioned within the Stopping Sight Distance (SSD) envelope to a junction or other defined conflict point, or where it would encourage stopping within the SSD envelope measured from the driver's eye position along the running lane to the conflict point using the applicable design speed.

10.6 Passing Places in Relation to Intervisibility

10.6.1 Intervisible passing places shall be provided at maximum intervals of 200m (or less where flows, directional imbalance, gradient or heavy vehicles increase encounter risk) where practicable within physical/environmental constraints and consistent with the operational assessment of the link. Passing places shall be clearly identifiable and safely accessible through consistent surfacing, geometry, and verge treatment, without reliance on excessive signage or road markings.

10.6.2 Passing places are intervisible where a driver positioned at one passing place can clearly see an oncoming vehicle occupying, or approaching, the next passing place. Intervisibility is an operational requirement and does not replace the need to protect SSD at defined conflict points.

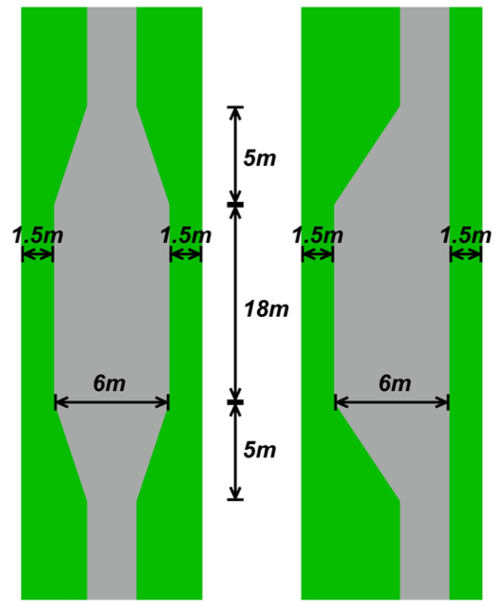


10.7 Mitigation Where Constraints Exist

10.7.1 Where physical or environmental constraints prevent full compliance, the preferred response is to relocate the passing place such that it lies wholly outside the Stopping Sight Distance (SSD) envelope to the relevant junction or conflict point.

10.7.2 Where wholesale relocation is not practicable, proportionate design measures may be applied to achieve the same outcome. These may include vegetation management, localised horizontal realignment, or limited longitudinal adjustment of the passing place (for example upslope or downslope), provided that the resulting layout ensures the SSD envelope to the conflict point remains fully unobstructed and does not encourage stopping within it.

10.8 Passing Place Dimensions



10.8.1 The total paved width, measured from carriageway edge to carriageway edge across the passing place, shall be 5.5m increasing to 6.0m if buses, agricultural, or HGVs are anticipated. The minimum length of the passing place shall be:

- 6.0m for general traffic,
- 18.0m where usage by buses, long agricultural vehicles or HGVs is anticipated.

Minimum taper lengths of 5.0m shall be provided at both ends of the passing place to facilitate smooth vehicle entry and exit. Widening on both sides is preferred to maintain visual continuity of the running lane and to avoid the passing place being perceived as a lay-by. These dimensions represent typical operationally effective layouts rather than absolute requirements and may be varied where equivalent safety and operational outcomes are demonstrated.

Note: For development accesses intended to operate routinely at higher peak flows or with pronounced tidal peaks, passing places should be sized to accommodate multiple vehicles (e.g. ‘three-car’ effective length) or provided at greater frequency.

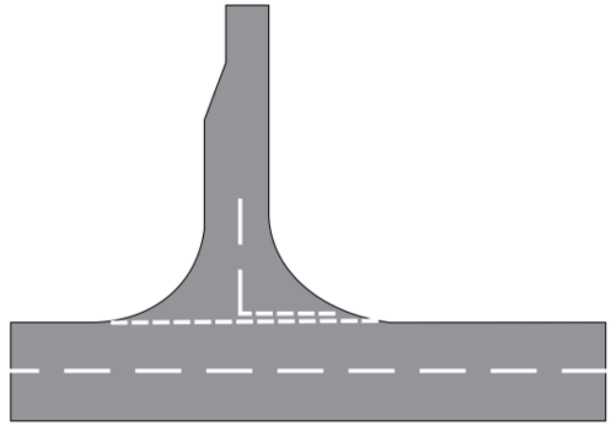
10.8.2 Rural road verge widths should generally match existing verges, but with minimums:

- ≥1.5m minimum verge width,
- ≥2.5m where a restraint system is required.

Where the full 1.5m verge cannot be achieved, the minimum must be a 1.0m clear refuge width for pedestrians, with additional engineering measures to prevent rutting, edge breakup, and verge collapse when vehicles overrun and where pedestrians are likely to step aside.

10.9 Structures (Overbridges and Underbridges)

10.9.1 Inter-visible passing places must be provided at each end of narrow structures that cannot accommodate two-way traffic.



10.10 Widening at Junctions

10.10.1 Provide local widening to at least 5.5m increasing to 6.0m if buses, agricultural vehicles or HGVs are anticipated for a minimum distance of 13m–20m (depending on the size of expected vehicles) from the junction to allow two vehicles to pass and avoid blocking the main road. The distance may require increasing if platooning is common or expected.

10.11 Non-motorised users

10.11.1 The needs of pedestrians, cyclists, and equestrians shall be considered on a site-by-site basis, including the implications of any carriageway widening for their safety and comfort.

10.11.2 Where widening is proposed, applicants must demonstrate that the design does not increase vehicle speeds or reduce perceived safety for non-motorised users, particularly where shared on-carriageway use is relied upon.

10.11.3 Where traffic flows and speeds are consistent with those typically associated with Quiet Lanes, shared use on-carriageway will often be appropriate. On lanes with higher operating speeds or regular non-motorised user activity, it may be necessary to provide suitable provision for pedestrians, and potentially cyclists and equestrians, where traffic volumes are proposed to increase. In such circumstances, proposals must be supported by a non-motorised user audit.

10.11.4 The presence, frequency, or reasonable expectation of non-motorised users also influences driver speed perception and expectancy on single-track lanes. Where drivers anticipate encountering pedestrians, cyclists, or equestrians, they are more likely to adopt cautious speeds, accept slower progress, and make earlier and more predictable decisions when approaching passing places or opposing traffic. Conversely, layouts that visually suggest higher speeds while accommodating non-motorised users can create a mismatch between driver expectancy and actual operating conditions, increasing the likelihood of abrupt braking, hesitation, or conflict.

10.11.5 Design proposals must therefore demonstrate that any carriageway widening, visibility improvement, or passing place provision does not create a road environment that appears inconsistent with the anticipated presence and behaviour of non-motorised users. This reflects the broader emphasis of this guidance on managing driver expectancy, operational predictability, and speed choice, rather than relying solely on geometric standards or theoretical capacity.

10.12 Drainage

10.12.1 Over-the-edge drainage should be used wherever gradients and contours permit, maintaining rural character and reducing the need for kerbing. Kerbs should only be introduced where a positive drainage system or footway continuity requires them. Where positive drainage is necessary, trapped gullies and catchpits are preferred to long kerb runs or conventional manholes.

10.13 Frontages

10.13.1 Where a single-track lane is proposed to be fronted by development, the carriageway shall be widened to a minimum of 5.5m along the frontage to accommodate stationary vehicles without obstructing through traffic. The widening should not be considered as a passing place unless there is sufficient length to accommodate the anticipated level of on-street parking and bidirectional traffic flow. The width should be increased to a minimum of 6.0m if required to accommodate buses, agricultural vehicles, or HGVs. A 2.0m minimum width verge shall front a single isolated dwelling or pair of dwellings with abutting driveways. Driveways shall be connected by a 2.0m kerbed footway if separated. A 2.0m kerbed footway shall be provided across the entire frontage where there are to be multiple dwellings or other proposed developments with multiple frontage access. Footway connections shall be provided where there are nearby footways or made-up footpaths in all instances.

10.14 Capacity of Single-Track Lanes

10.14.1 Single-track lanes that rely on passing places are generally only suitable to support additional development where predicted two-way flows in the busiest (design peak) hour remain within the range of approximately 100–150veh/h, subject to the site-specific criteria below. This range is a planning benchmark reflecting the period when operational stability, yielding behaviour and reversing risk are most critical, rather than a theoretical maximum capacity.

10.14.2 Earlier research indicates higher theoretical throughputs can be achieved on short, straight, well-sighted single-track sections with very frequent passing provision; however monitored schemes show that reversing, close following, platooning and driver behaviour can degrade service quality at substantially lower flows, supporting conservative planning benchmarks on historic lanes.

10.14.3 The operation of single-track lanes is governed by discretionary yielding and, where necessary, reversing to reach a passing place. These behaviours are inherently variable and sensitive to local conditions such as passing place visibility, geometry, gradients, heavy vehicle presence and non-motorised user activity. Accordingly, theoretical or modelled capacities derived under idealised assumptions should not be used in isolation to demonstrate suitability for development.

10.14.4 Directional imbalance increases the frequency and severity of opposing-flow encounters. Where directional splits materially depart from 50/50 (e.g. commuter peaks), delays, stop frequency and the likelihood of reversing typically increase disproportionately compared with balanced flows. Assessment should therefore consider directional flow profiles, not solely total two-way volume. Evidence from monitored schemes indicates that under tidal peaks the lower-flow direction may nevertheless experience disproportionate yielding and delay, particularly where gradient or visibility favours the dominant flow.

10.15 Platooning (vehicle bunching)

10.15.1 Analytical calculations and some model outputs assume broadly independent vehicle arrivals and do not explicitly represent platooning. In practice, platoons form where speeds are constrained, where there is a tidal peak, or where slow-moving vehicles (including agricultural traffic) are present. Platooning increases operational sensitivity because a single opposing meet can delay multiple vehicles and queueing can propagate upstream from passing places. Where predicted flows approach the upper end of the benchmark range, applicants should provide proportionate evidence that accounts for platooning effects and delay variability, rather than relying on mean values alone.

- Applicants should demonstrate that passing places provide adequate effective storage for plausible platoon sizes, or that the layout provides frequent recovery opportunities to prevent queue propagation and ‘bay over-saturation’.

10.16 Why the 100–150veh/h two-way range is used

10.16.1 Above the benchmark range, service quality and reliability may deteriorate non-linearly on single-track lanes with passing places, including:

- increased delays and intermittent queueing, especially during directional peaks,
- increased stop frequency and a higher likelihood of reversing to resolve meets,
- reduced driver expectancy and greater hesitation at constrained sections and passing places, and
- disproportionate disruption from heavy vehicles due to longer occupancy, greater space requirement and reduced manoeuvrability.

These effects reflect the inherently behaviour-led nature of single-track operation and the instability of operation near practical limits.

10.17 When 150veh/h two-way may be acceptable

10.17.1 Use of the upper end of the benchmark range (around 150veh/h two-way) should be limited to situations where all the following are demonstrated:

- passing places are frequent, intervisible and of consistent usable quality,
- heavy vehicle and agricultural shares are low,
- forward visibility and stopping sight distance are generally good,
- frontage access and non-motorised user activity are minimal,
- geometry is forgiving (adequate width, gentle bends, good verges), and
- observed operation (or robust evidence) indicates stable behaviour with minimal reversing and no recurring standoffs.

10.18 When 100veh/h two-way is more appropriate

10.18.1 Use the lower end of the benchmark range (around 100veh/h two-way) where any of the following apply:

- heavy vehicle proportion is elevated (as a guide ≥10–15%) or agricultural traffic is regular,
- passing place intervisibility is not consistently achieved,
- there is a strong directional imbalance (e.g. commuter peak conditions),
- constrained geometry exists (narrow, winding, steep gradients, poor verges),
- there is notable non-motorised user activity or frontage access, or
- reversing, recurring delays, queues or standoffs have already been observed.

In such circumstances, proposals relying on flows above ~100veh/h two-way will normally require additional mitigation or alternative access arrangements unless robust evidence demonstrates stable operation.

Note: This benchmark range is intended to support consistent and proportionate decision-making for historic single-track lanes. It is not a substitute for safety-critical requirements (including maintaining unobstructed stopping sight distance to defined conflict points) and should be applied alongside the siting and design principles elsewhere in the guidance.

10.19 Evidence Note — TRL monitoring and implications for passing-place operation

Purpose

10.19.1 This section summarises relevant evidence from TRL's DfT-commissioned monitoring of a single-track rural lane with passing places (Bird Lane, Brentwood, Essex) and earlier single-track research referenced within TRL597. It explains how these findings support the behavioural and planning assumptions used in this guidance, and how they inform the siting and design principles for passing places, (TRL Report 597, 2004).

Context of the TRL monitored scheme

10.19.2 The TRL monitoring related to Bird Lane, Brentwood, a rural lane approximately 900m in length that was converted to single-track operation with passing places as part of a traffic-calming scheme. Prior to implementation, two-way weekday flows were of the order of 2,000 vehicles per day, with pronounced tidal peak conditions associated with commuter traffic. The scheme provided passing places typically accommodating up to three cars, spaced at approximately 60–110m, with a signed 20mph limit. Post-implementation monitoring recorded reduced average speeds (typically in the mid-20mph range) and reduced overall flows, but also identified frequent give-way events, reversing, platooning and uneven delay under peak directional imbalance, particularly where visibility between entries and the next passing place was constrained. This is presented as an illustrative monitored case; the specific values should not be treated as a template for all rural lanes.

A. What TRL observed on a real single-track lane with passing places

1. **Operation is governed by behaviour, not theoretical "capacity".** TRL597 reports that driver experience and performance were heavily influenced by yielding behaviour, reluctance to give way, and poor visibility to the next passing place. Drivers reported "road rage", excessive speed between passing places and a frequent need to reverse, attributed to driver behaviour and/or limited visibility in places.
2. **Visibility to the next passing place is a dominant determinant of stability and reversing.** TRL identified the northern entry as a problem location because drivers entering could not see the first passing place, and this led to reversing and a marked reduction in 85th percentile speeds at that entry. The video survey found reversing occurred most frequently at the northernmost passing place and was linked to the entry/pass-place intervisibility constraint.
3. **Directional imbalance ("tidal" peaks) disproportionately affects who yields and the level of delay.** TRL's peak-period video surveys recorded materially higher northbound flows than southbound (approximately three-to-one) and found that southbound drivers gave way notably more often in the peak. Moving-camera runs during the peak similarly found the southbound direction experienced substantially more give-way events and longer running times than northbound.
4. **Platooning and close-following can defeat passing-place assumptions.** TRL reports driver complaints of northbound convoys of up to six vehicles, too many to fit within the passing places. Video analysis also captured "close-following" behaviour in which a following vehicle effectively takes priority through a give-way event, particularly where one direction dominates flow. These effects increase delay variability and reduce the reliability of operation compared with steady-arrival assumptions.
5. **Geometry and layout details matter, including passing-place length and spacing, but are not sufficient without visibility and behavioural robustness.** In Bird Lane, passing places were about 17m (≈ three cars) and spaced 60–110m. TRL noted that even with this comparatively frequent

provision, poor visibility at key locations and driver behaviour still generated reversing and negative perceptions.

B. What earlier single-track research (cited in TRL597) implies

TRL597 summarises earlier evidence that, at an average journey speed of 20mph, single-track road capacity ranged from around 100veh/h for poor alignment and limited sight distance to around 220veh/h for well-aligned roads (Walker et al., 1964, cited in TRL597). It also notes TRL work (1970s; referenced via Design Bulletin 32) indicating that short single-track sections with frequent passing places could accommodate higher two-way flows under controlled, straight and level conditions, but emphasises the need for drivers to see each other before a point where stopping to use a bay becomes infeasible. TRL597 further cautions that vehicle performance and aggressive driving have increased since those trials, and that the earlier work was aimed at housing estate contexts rather than rural lanes.

C. How TRL evidence supports the assumptions in this guidance

The TRL evidence supports the key planning assumptions already adopted in this guidance, namely that:

- **A conservative planning benchmark is appropriate** because operational stability deteriorates due to behavioural variance, reversing and platooning well before any theoretical maximum throughput is reached.
- **Intervisibility and forward-visibility siting principles are critical** and should be treated as core operational requirements, not optional enhancements, because poor entry-to-bay visibility materially increases reversing and instability.
- **Directional imbalance must be considered explicitly**, as it increases the frequency and severity of opposing-flow encounters and causes one direction to bear disproportionate yielding and delay.
- **Platooning should be assumed to occur** on constrained rural links under tidal peaks and behind slower vehicles, and can exceed the storage length of passing places, undermining “mean delay” arguments.

D. Planning interpretation (how to use TRL597 in decision-making)

TRL597 should be used to support behaviour-led design and assessment rather than to define universal numeric thresholds. In particular, the report reinforces that proposals should not rely solely on calculated capacities or average delays; instead, they should demonstrate robust operation under plausible behavioural and peak-direction scenarios, and prioritise intervisible, consistently usable passing places located so that drivers can perceive and commit to the next passing opportunity without creating reversing within constrained visibility envelopes.

10.20 Capacity Calculation Methodology

10.20.1 This methodology estimates capacity on a single-track lane using a conflict-based steady-state analytical calculation, which reflects how real traffic behaves when two-way movements share a narrow link with passing places. This method incorporates:

- vehicle dynamics (acceleration and braking),
- the achievable average speed between passing places,
- the probability of meeting an oncoming vehicle (“conflict”), and

- the additional delay associated with resolving each meeting.

However, it does not include several factors that degrade practical service quality on rural single-track lanes:

- driver decision-making variance,
- hesitation/stand-offs when two large vehicles meet,
- uneven passing-place quality and visibility,
- sight-line constraints and gradient effects on heavy vehicles,
- consequences of reversing manoeuvres (time + safety),
- platooning behind cautious drivers.

The calculation estimates the total two-way capacity for any given passing place spacing and predicted directional headways and is intended to establish whether two-way peak flows would remain within the range of approximately 100–150veh/h only. Outputs above this benchmark should be treated as an indication that operational robustness is likely to be poor unless supported by calibrated behavioural modelling and/or observed evidence. Calculated capacities exceeding the 100–150veh/h benchmark should be interpreted as indicating where instability is likely to occur, not as evidence that such flows are acceptable in planning terms.

10.21 Planning Interpretation

- Analytical or spreadsheet-based capacity outputs must not be used to demonstrate acceptable operational performance on single-track roads.
- Development proposals should normally be designed such that predicted two-way flows do not exceed 100–150veh/hr, depending on site-specific conditions.
- Where predicted flows approach or exceed these levels, mitigation or an alternative access solution will be required, unless robust, site-specific evidence demonstrates stable operation.
- Any departure from the indicative flow thresholds must be supported by explicit platoon modelling using a suitably calibrated microsimulation model, demonstrating stable operation across appropriate demand and behavioural scenarios.

10.22 Microsimulation models

10.22.1 Microscopic traffic simulation tools such as PARAMICS, Aimsun, and VISSIM model individual vehicles moving through a network over time, using car-following, gap-acceptance, and priority rules to represent driver behaviour. These tools explicitly simulate interactions at narrow sections and passing places, allowing platooning, queue formation, yielding behaviour, and delay propagation to emerge dynamically.

10.22.2 Evidence from such models typically indicates that single-track roads experience greater delay, variability, and operational instability at higher flows than is suggested by analytical capacity methods. This behaviour underpins the conservative flow thresholds adopted in this guidance, which implicitly account for these effects without the need for detailed modelling.

10.22.3 While microsimulation can be valuable in exceptional or contentious cases where flows exceed the indicative thresholds, such models require extensive calibration, are sensitive to behavioural assumptions, and produce a range of possible outcomes. They are therefore not considered proportionate for routine planning decisions. The conflict-based assessment method set out in this guidance provides a transparent and defensible planning-level approach, with microsimulation reserved solely for the purpose of testing genuinely exceptional circumstances.

Worked Example

Inputs

Geometry & speed

- Link length between passing places: $L = 75\text{m}$
- Target speed: $v = 40\text{km/h} = 11.111\text{m/s}$

Vehicle dynamics

- Cars: $a_{car} = 1.5\text{m/s}^2, b_{car} = 2.5\ \text{m/s}^2$
- HGVs: $a_{hgv} = 0.9\text{m/s}^2, b_{hgv} = 2.0\ \text{m/s}^2$

Meet delay parameter

- Mean meet-delay per conflict: $t_r = 6\text{s}$

Flows (veh/h) & directional splits

- Cars: $Q_1^{car} = 100,\ Q_2^{car} = 35\ \Rightarrow\ Q_{tot}^{car} = 135,\ p_{car} = \frac{100}{135} = 0.741$
- HGVs: $Q_1^{hgv} = 20,\ Q_2^{hgv} = 10\ \Rightarrow\ Q_{tot}^{hgv} = 30,\ p_{hgv} = \frac{20}{30} = 0.667$

Link kinematics and travel time

Minimum length to reach target speed

$$L_{\min} = \frac{v^2}{2a} + \frac{v^2}{2b}$$

- Cars: $L_{\min} = \frac{11.111^2}{2\cdot 1.5} + \frac{11.111^2}{2\cdot 2.5} = 65.844\text{m}$
  $L(75\text{ m}) \geq L_{\min} \Rightarrow$ **target speed reached**.
- HGVs: $L_{\min} = \frac{11.111^2}{2\cdot 0.9} + \frac{11.111^2}{2\cdot 2.0} = 99.451\text{m}$
  $L(75\text{ m}) < L_{\min} \Rightarrow$ **target speed not reached**.

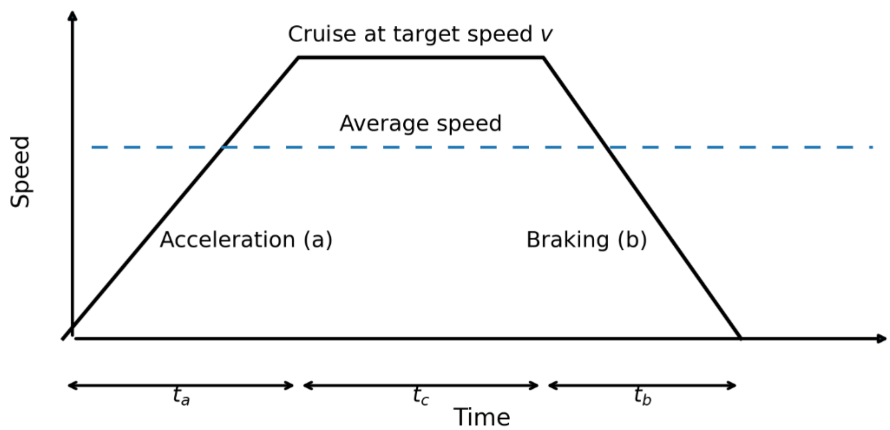
Cars: Average speed and travel time – target speed reached

Since $75m \geq 65.84m$ ($L \geq L_{min}$), the car reaches the target speed. The vehicle accelerates to v, cruises, then decelerates to stop (trapezoidal speed profile).

If $(L \geq L_{\min})$:

$$t_a = \frac{v}{a},\ t_b = \frac{v}{b},\ L_c = L - L_{\min},\ t_c = \frac{L_c}{v}$$

$$T = t_a + t_c + t_b, v_{avg} = \frac{L}{T}$$



Compute the three time components

Acceleration time:

$$t_a = \frac{v}{a} = \frac{11.111}{1.5} = 7.407\text{s}$$

Braking time:

$$t_b = \frac{v}{b} = \frac{11.111}{2.5} = 4.444\text{s}$$

Cruise distance:

$$L_c = L - L_{\min} = 75 - 65.8423045 = 9.158\text{m}$$

Cruise time:

$$t_c = \frac{L_c}{v} = \frac{9.158}{11.111} = 0.824\text{s (approx.)}$$

Total travel time and average speed

Total travel time:

$$T = t_a + t_c + t_b = 7.407 + 0.824 + 4.444 = 12.676\text{s}$$

Average speed:

$$v_{\text{avg}} = \frac{L}{T} = \frac{75}{12.6759} = 5.917\text{m/s}$$

Cars — results:

- $T_{\text{car}} = 12.676\text{s}$
- $v_{\text{avg,car}} = 5.917\text{m/s}$

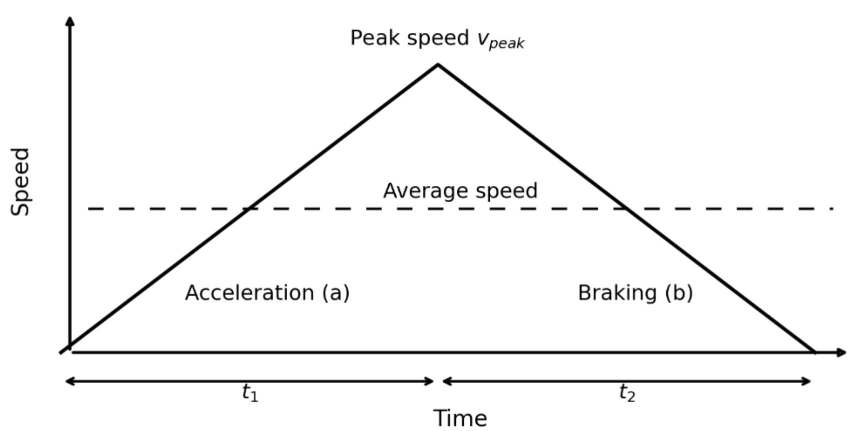
HGVs: Average speed and travel time – target speed not reached

Since $75m < 99.45m$ ($L < L_{\min}$), the vehicle accelerates from rest to a peak speed v_{peak} and then immediately decelerates back to rest, with no cruising section (triangular speed profile).

If $L < L_{\min}$:

$$v_{peak} = \sqrt{\frac{2abL}{a+b}},\ t_1 = \frac{v_{peak}}{a},\ t_2 = \frac{v_{peak}}{b}$$

$$T = t_1 + t_2, v_{avg} = \frac{L}{T}$$



Compute numerator:

$$2abL = 2 \times 0.9 \times 2.0 \times 75 = 270$$

Denominator:

$$a + b = 0.9 + 2.0 = 2.9$$

So:

$$v_{\text{peak}} = \sqrt{\frac{270}{2.9}} = \sqrt{93.103} = 9.649\text{m/s}$$

Acceleration and braking times

$$t_1 = \frac{v_{\text{peak}}}{a} = \frac{9.649}{0.9} = 10.721\text{s}$$

$$t_2 = \frac{v_{\text{peak}}}{b} = \frac{9.649}{2.0} = 4.825\text{s}$$

Total travel time

$$T = t_1 + t_2 = 10.721 + 4.824 = 15.546\text{s}$$

Average speed

$$v_{\text{avg}} = \frac{L}{T} = \frac{75}{15.5456} = 4.825\text{m/s}$$

HGV results:

- $v_{\text{peak,hgv}} \approx 9.649\text{m/s}$
- $T_{\text{hgv}} \approx 15.546\text{s}$
- $v_{\text{avg,hgv}} \approx 4.825\text{m/s}$

Meeting probability (Conflict) and delay

Conflict (expected meets per vehicle on the link)

$$\text{Conflict} = p(1-p)\, Q_{tot}\, \frac{T}{3600}$$

Cars — worked:

$$\begin{aligned} p(1-p) &= 0.7407 \times 0.259 = 0.191 \\ p(1-p)\,Q_{tot} &= 0.191 \times 135 = 25.833 \\ \text{Conflict}_{car} &= 25.833 \times \frac{12.676}{3600} = 0.0913 \end{aligned}$$

HGVs — worked:

$$\begin{aligned} p(1-p) &= 0.667 \times 0.333 = 0.222 \\ p(1-p)\,Q_{tot} &= 0.222 \times 30 = 6.667 \\ \text{Conflict}_{hgv} &= 6.667 \times \frac{15.546}{3600} = 0.029 \end{aligned}$$

Delay per vehicle from meets

$$\text{Delay} = \text{Conflict} \times t_r$$

- Cars: $0.091 \times 6 = 0.548$s
- HGVs: $0.029 \times 6 = 0.173$s

Although the per-vehicle delays look small, across many vehicles they inflate effective headways and thus limit throughput.

Directional headway and two-way capacity (homogeneous flows[1])

Directional headway

$$H_{dir} = T + \text{Delay}$$

Two-way capacity

$$C_{tot} = \frac{3600}{H_{dir}}$$

- **Cars:** $H_{dir}^{car} = 12.676 + 0.548 = 13.224$ s $\Rightarrow C_{tot}^{car} = \frac{3600}{13.224} = 272.239 \;\rightarrow\; 272\text{veh/h}$
- **HGVs:** $H_{dir}^{hgv} = 15.546 + 0.173 = 15.718$s $\Rightarrow C_{tot}^{hgv} = \frac{3600}{15.718} = 229.032 \rightarrow\; 229\text{veh/h}$

[1] Homogeneous traffic flow is a flow where:

- vehicles are similar in size and performance,
- drivers behave in broadly the same way,
- speeds, headways, and manoeuvres are relatively uniform over time.

In other words, traffic arrives and moves in a steady, even, predictable manner.

Mixed-traffic capacity

Flow shares

$$x_{car} = \frac{135}{135 + 30} = 0.818, x_{hgv} = 0.182$$

Flow-weighted directional headway

$$H_{mix} = x_{car}\, H_{dir}^{car} + x_{hgv}\, H_{dir}^{hgv} = 0.818 \times 13.224 + 0.182 \times 15.718 = 13.677\text{s}$$

Two-way capacity (mixed)

$$C_{tot}^{all} = \frac{3600}{H_{mix}} = \frac{3600}{14.176} = 253.955 \text{ veh/h} \rightarrow 254$$

Summary

- $C_{tot}^{car} = \mathbf{272}$ veh/h
- $C_{tot}^{hgv} = \mathbf{229}$ veh/h
- $C_{tot}^{all} = \mathbf{254}$ veh/h Practical operational limits exceeded (100–150veh/h two-way)

Interpreting the Capacity Outputs

The capacity model provides three results:

- Cars-only capacity (C_{tot}^{car}) — the theoretical two-way capacity if *all* traffic consisted of cars.
- HGV-only capacity (C_{tot}^{hgv}) — the theoretical two-way capacity if *all* traffic consisted of HGVs.
- Mixed-traffic capacity (C_{tot}^{all}) — the *actual* two-way capacity for the input proportions of cars and HGVs.

The mixed-traffic capacity will always lie between the two homogeneous capacities, weighted toward the dominant vehicle type. In this example, cars make up ~82% of the flow, so the mixed capacity (254veh/h two-way) is closer to the cars-only capacity (272veh/h two-way) than the HGV-only capacity (229veh/h two-way). All exceed practical operational limits (100–150veh/h two-way).

Summary — Why This Model Works Well

This methodology captures the real behaviour of single-track lanes because it includes:

- Directional imbalance
- Meeting probability
- Delay from resolving meetings
- Speed limitations due to short passing-place spacing
- Mixed-fleet behaviour (cars + HGVs)

It gives a physics-based capacity estimate that can be used to justify passing place spacing decisions.

Implications for Development Proposals

- Single-track lanes are a finite and fragile form of infrastructure.
- Incremental development can quickly push operation beyond acceptable service quality even where theoretical capacity exists.
- Proposals that rely on exceeding the 100–150veh/h two-way planning threshold will normally require:
    - NMU provisions,
    - carriageway widening, or
    - alternative access arrangements.

-End-