

When a Level Crossing Is Triggered at a Fixed Distance, It Stays Closed Longest for Slow Trains, Not Fast Ones

— with a fixed activation distance the crossing stays closed **154.000000** seconds at **30** km/h, **4.333333** times as long as at **130** km/h, while triggering by time until arrival needs only **54.000000** seconds — the separator is whether activation is set by distance or by time until arrival — [Paper 894]

Yuuki YAMAGISHI (山岸 勇輝)

Yamagishi Complexity Torus Lab, Japan

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YOI: <https://www.yamagishiyuuki.com/yoi/894>

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Abstract

It is easy to assume that one waits longest at a level crossing when a fast train is coming. This paper counts, for each train speed, how long the crossing stays closed when activation is at a fixed distance and when it is set by the time until arrival. No new theorem or law is claimed. First, the activation distance is set by the fastest train: for a 30-second warning at 130 km/h, the activation point is placed **1083.333333** m before the crossing (Section 1). Second, and this is the core. With fixed-distance activation, slower trains close the crossing longer: the crossing is closed **35.538462** seconds at 130 km/h, **46.200000** at 100 km/h, **77.000000** at 60 km/h and **154.000000** at 30 km/h (Section 2). Third, the ratio is the ratio of speeds itself: the ratio **4.333333** of closed times at 30 and 130 km/h equals the speed ratio 130/30 (Section 2). Fourth, triggering by time leaves only the train length as a difference: activating 30 seconds before arrival gives **54.000000** seconds at 30 km/h and **42.000000** at 60 km/h, and the ratio to 130 km/h shrinks to **1.519481** times (Section 3). Fifth, the formula matches stepping: advancing the train's head in 0.001-second steps from the activation point until its rear clears the crossing agreed with the formula within 0.01 seconds at all four speeds (Section 2). Sixth, the separator is whether activation is set by distance or by time until arrival: by distance, the warning length is inversely proportional to speed; by time, the warning is 30 seconds for every train, and only the time to pass the train's length remains (Section 4). **Keywords:** level crossing, activation point, closure time, warning time, train speed.

Scope of this paper (scope note): No new theorem or law is claimed: that crossing warnings start when a train passes a fixed point, that slower trains then keep the crossing closed longer, and that there are schemes adjusting the start of warning to train speed are all known in railways. No real crossing is claimed: the 30-second warning, top speed of 130 km/h and train length of 200 m are model values matching no crossing's settings. Trains run at constant speed: acceleration, braking, stopping on the way, and two trains in succession are not included. Those waiting are not discussed: the behaviour of people kept waiting and which scheme ought to be chosen are not discussed. Relation to earlier papers: Paper 893 showed that adding signal aspects cannot bring trains closer than the braking distance plus the train length. This paper stands beside it. There the block length was set by the braking distance at top speed. Here the activation distance is likewise set by top speed, and slower trains use that same distance, so they keep the crossing closed longer. What is added is laying out closed times at four speeds, measuring that their ratio equals the ratio of speeds, comparing with activation by time until arrival, and placing the separator on distance versus time until arrival.

1. Notation and the Question

Setting: a train runs at constant speed v and has length $L = 200$ m. In the fixed-distance scheme, the activation point is placed where a train at the top speed $v_{\max} = 130$ km/h gets a warning of exactly $T = 30$ seconds. The crossing is closed from when the train's head passes the activation point until its rear clears the crossing.

$$D = v_{\max}T, \quad t_{\text{dist}}(v) = \frac{D + L}{v}, \quad t_{\text{time}}(v) = T + \frac{L}{v}$$

t_{time} is the time when every train activates the crossing 30 seconds before arriving. Separately from the formula, the train's head was advanced in 0.001-second steps to track the closed time.

Question: does one wait longest at a crossing for a fast train or for a slow one?

2. Activation at a Fixed Distance

Computation 2.1: the activation point is $D = 1083.333333$ m before the crossing. Closed times were computed at four speeds.

train speed	closed time (formula, s)	stepped value (s)
130 km/h	35.538462	35.539000
100 km/h	46.200000	46.200000
60 km/h	77.000000	77.001000
30 km/h	154.000000	154.001000

Observation 2.2

this is the core. With fixed-distance activation, slower trains close the crossing longer. A 30 km/h train keeps it closed 154.000000 seconds, 4.333333 times the 35.538462 seconds at 130 km/h. This ratio equals the speed ratio 130/30. The distance to the activation point and the train length are the same for every train, so the closed time is inversely proportional to speed. The stepped values agreed with the formula within 0.01 seconds at all four speeds.

3. Activation by Time Until Arrival

Computation 3.1: with every train activating the crossing 30 seconds before arrival, closed times were computed at the same four speeds.

train speed	closed time (s)
130 km/h	35.538462
100 km/h	37.200000
60 km/h	42.000000
30 km/h	54.000000

Observation 3.2

with time-based activation slower trains still take longer, but the difference is only the time to pass the train's length. The ratio between 30 and 130 km/h shrinks to 1.519481 times, and the closed time at 30 km/h is 0.350649 times its fixed-distance value: at top speed both schemes return the same 35.538462 seconds, because the activation point was placed for that train.

4. The Separator

Observation 4.1

the separator is whether activation is set by distance or by time until arrival. By distance, the warning length D/v is inversely proportional to speed, and slow trains creep over a distance chosen for the fastest one: by time until arrival, the warning is 30 seconds for every train, and only the time L/v to pass the 200 m train changes with speed.

Observation 4.2

placed beside Paper 893.893 set the block length by the braking distance at top speed and showed that adding aspects cannot make the spacing shorter than braking distance. Here, too, a length is set by top speed, and slower trains use that same length. As a result, the waiting grows for the slower trains.

Observation 4.3

what is not said. Real crossing settings, acceleration and braking, trains in succession, the behaviour of those waiting, and which scheme ought to be chosen are not treated. What is shown is that, in this model, fixed-distance activation keeps the crossing closed longer for slower trains, with a ratio equal to the ratio of speeds.

5. Census and Closing

1. $t_{\text{dist}} = (D + L)/v$ (Section 1): fixed-distance activation.
2. activation point **1083.333333 m** (Computation 2.1): 30 seconds at 130 km/h.

3. **35.538462** seconds at **130 km/h** (Computation 2.1): **the shortest**.
4. **154.000000** seconds at **30 km/h** (Computation 2.1): **the core**.
5. **ratio 4.333333** (Observation 2.2): **the speed ratio 130/30**.
6. **stepping within 0.01 seconds** (Observation 2.2): **matches the formula**.
7. **54.000000** seconds at **30 km/h by time** (Computation 3.1): **0.350649 times**.
8. **ratio 1.519481** times (Observation 3.2): **only the train length**.
9. **same 35.538462 seconds at top speed** (Observation 3.2): **placed for that train**.
10. **distance, or time until arrival** (Observation 4.1): **the separator; Paper 893**.

Closing: When a level crossing is triggered at a fixed distance, it stays closed longest for slow trains, not fast ones. With the activation point 1083.333333 m before the crossing, giving a 30-second warning at 130 km/h, the crossing is closed 35.538462 seconds at 130 km/h and 154.000000 seconds at 30 km/h, and the ratio 4.333333 equals the ratio of speeds, because slow trains creep over a distance chosen for the fastest. Triggering by time until arrival gives 54.000000 seconds even at 30 km/h, and the ratio shrinks to 1.519481 times. What remains is only the time to pass the train's length. Placed among the earlier papers: beside the blocks of Paper 893, whose length is set by top speed, we placed a crossing whose distance is likewise set by top speed and used by slow trains. To be honest: warning length, top speed and train length are model values, and acceleration, braking and successive trains are not included.

References

1. Yamagishi, Y. (2026). *Adding Signal Aspects Cannot Bring Trains Closer Than the Braking Distance Plus the Train Length* [Paper 893]. YOI: <https://www.yamagishiyuuki.com/yoi/893>
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Yuuki YAMAGISHI (山岸 勇輝)

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