

A Crossing Alarm That Reads Arrival from Speed Falls Short of 30 Seconds for Accelerating Trains and Runs Long for Stopping Ones

— at constant speed both methods keep at least 30 seconds, but for an accelerating train only the speed-based method shrank, to 22.840 seconds —the separator is whether arrival is read from the present speed or from the position passed — [Paper 969]

Yuuki YAMAGISHI (山岸 勇輝)

Yamagishi Complexity Torus Lab, Japan

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YOI: <https://www.yamagishiyuuki.com/yoi/969>

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Abstract

If a level crossing alarm starts when a train passes a fixed point, slower trains keep it closed longer. A method that predicts arrival from train speed and starts a fixed time ahead shortens closure even for slow trains (Paper 894). There, trains ran at constant speed. This paper adds to the crossing of Paper 894 (30 s alarm, 130 km/h maximum) trains accelerating from a station before the crossing and trains decelerating to stop at a station beyond it, and compares the actual alarm length of the two methods. No new theorem or law is claimed. First, at constant speed, the speed-based alarm is exactly 30 seconds: at 60 and 130 km/h the speed-based alarm was 30.000 s in both cases, and the fixed-distance alarm was 65.000 s at 60 km/h (Section 2). Second, for accelerating trains, the speed-based alarm falls short of 30 seconds: for a train leaving a station 1100 m before the crossing at 1.0 m/s^2 , the speed-based alarm was **22.840 s** and the fixed-distance alarm 42.744 s. In all 8 cases that had not reached 130 km/h by the trigger point, the speed-based alarm was shorter than 30 s (Section 3). Third, for trains decelerating from before the trigger point, the speed-based alarm runs long: for a train stopping at 0.3 m/s^2 at a station 250 m beyond the crossing, the speed-based alarm was **39.837 s** and the fixed-distance alarm 53.455 s. For trains that start braking after the trigger point, the two methods were the same (Section 4). Fourth, the fixed-distance method never fell below 30 seconds: for every train, constant, accelerating or decelerating, the fixed-distance alarm was at least 30 s. As long as speed does not exceed 130 km/h, no train can cover the distance from the trigger point in less than 30 s (Section 3). Fifth, the separator is whether arrival is read from the present speed or from the position passed: read from the present speed, an accelerating train arrives earlier than predicted and a decelerating train later. Read from the position passed, only the speed limit bounds how short the alarm can be (Section 5). **Keywords:** level crossing, warning time, acceleration, arrival prediction, railway, uniformly accelerated motion.

Scope of this paper (scope note): No new theorem or law is claimed: that crossing alarms may start at a fixed point or at a time predicted from train speed, that acceleration and deceleration shift the predicted arrival, and the equations of uniformly accelerated motion, are all known in railways and mechanics. These are set values: the 30 s alarm, 130 km/h maximum and 200 m train length are the model values of Paper 894, and the station positions (1100 to 2500 m before, 250 and 600 m beyond the crossing), accelerations of 0.5 and 1.0 m/s² and decelerations of 0.2 to 1.0 m/s² are set here. They correspond to no crossing or train. Real control is not treated: schemes that correct the prediction for acceleration or deceleration, detection intervals, two trains in succession, and trains stopping before the crossing are not treated. Which method to choose is not discussed, which method to use and how many seconds of alarm are needed are not stated. Relation to earlier papers: Paper 894, in its scope note, took trains as running at constant speed, leaving out acceleration and deceleration, stopping on the way, and two trains in succession; this paper sits in the seat of acceleration and deceleration (no earlier occupant). Paper 894 showed that when a crossing is triggered at a fixed distance, it stays closed longest for slow trains, not fast ones, and that predicting arrival from speed shortens closure even for slow trains. Here it is counted how far the speed-based alarm departs from 30 s for trains whose speed changes. What is added: counting accelerating trains by station position, counting decelerating trains, checking the predicted alarm against a formula, confirming that the fixed-distance method does not fall below 30 s, and placing the separator on “present speed, or position passed”.

1. Notation and the Question

Setting: as in Paper 894, the alarm is $T = 30$ s, maximum speed 130 km/h, the trigger point $D = 1083.333333$ m before the crossing, and the train 200 m long. With the crossing at 0, the front position y (negative before the crossing) and speed v are followed in steps of 0.001 s. The two methods start the alarm when

$$\text{fixed distance: } y \geq -D, \quad \text{speed-based: } \frac{-y}{v} \leq T$$

first holds. The alarm length runs until the front reaches the crossing, and closure until the rear clears it. An accelerating train starts from rest at a station before the crossing and accelerates uniformly up to 130 km/h. A decelerating train brakes uniformly from 130 km/h so that its front stops at a station beyond the crossing.

Question: for trains whose speed changes, how long are the alarms of the two methods?

2. Constant Speed

Computation 2.1: at a constant 60 km/h, the fixed-distance alarm was 65.000 s with closure 77.000 s, and the speed-based alarm 30.000 s with closure 42.000 s. At 130 km/h both gave an alarm of 30.000 s and closure of 35.539 s. The closure at 60 km/h matched the formula of Paper 894 within 0.01 s.

Observation 2.2

at constant speed, the speed-based alarm is always 30 seconds. If speed does not change, arrival read from the present speed equals the actual arrival: the fixed-distance alarm is longer for slower trains (Paper 894).

3. Accelerating Trains

Computation 3.1: alarms (s) for trains accelerating from a station before the crossing. The distance to reach 130 km/h is 1304.012 m at 0.5 m/s² and 652.006 m at 1.0 m/s².

station (before)	acceleration	speed at crossing	fixed distance	speed-based
1100 m	0.5	119.399 km/h	58.168	23.531
1200 m	0.5	124.709 km/h	47.680	23.784
1500 m	0.5	130.000 km/h	36.825	24.583
1800 m	0.5	130.000 km/h	32.416	25.957
2200 m	0.5	130.000 km/h	30.201	28.546
1100 m	1.0	130.000 km/h	42.744	22.840
1200 m	1.0	130.000 km/h	36.011	23.841
1500 m	1.0	130.000 km/h	30.727	27.145

The 4 cases that reached 130 km/h before the trigger point (2500 m at 0.5; 1800, 2200 and 2500 m at 1.0) gave 30.000 s for both methods. In all 8 cases that had not, the speed-based alarm was shorter than 30 s, the shortest being 22.840 s. For 1500 m at 1.0, solving the uniform-acceleration equation from the predicted position –973.499 m and speed 32.450 m/s gave 27.144 s to arrival, within 0.01 s of the stepped value 27.145 s.

Observation 3.2

for accelerating trains the speed-based alarm falls short of 30 seconds. The train becomes faster after the prediction, so it arrives earlier than predicted: the closer the station to the trigger point, the lower the speed at prediction and the larger the shortfall (at 1.0 m/s², from 22.840 s at 1100 m to 27.145 s at 1500 m).

4. Decelerating Trains

Computation 4.1: alarm and closure (s) for trains braking from 130 km/h to stop at a station beyond the crossing.

station (beyond), deceleration	braking starts (before)	speed at crossing	fixed: alarm, closure	speed-based: alarm, closure
250 m, 0.2	3010.031 m	36.002 km/h	65.468, 93.104	38.309, 65.945
250 m, 0.3	1923.354 m	44.092 km/h	53.455, 76.019	39.837 , 62.401
600 m, 0.3	1573.354 m	68.306 km/h	42.689, 54.294	36.755, 48.360
250 m, 0.5	1054.012 m	56.924 km/h	41.410, 58.888	41.410, 58.888
600 m, 1.0	52.006 m	124.704 km/h	30.030, 36.386	30.030, 36.386

Observation 4.2

for trains decelerating from before the trigger point, the speed-based alarm runs long. In all 3 cases braking before the trigger point, the speed-based alarm was longer than 30 s and shorter than the fixed-distance alarm: in the 2 cases braking after the trigger point, both methods start the alarm while the train is at 130 km/h, so they gave the same result.

5. The Separator

Observation 5.1

the separator is whether arrival is read from the present speed or from the position passed. Read from the present speed, a train that later speeds up arrives before the prediction (shortest 22.840 s), and one that later slows down arrives after it (39.837 s and others): read from the position passed, only the speed limit bounds how short the alarm can be, and for every constant, accelerating and decelerating train it did not fall below 30 s.

Observation 5.2

what is not said. Real crossing control, corrections for acceleration, detection intervals, trains in succession, trains stopping before the crossing, and which method to use are not treated. What is shown is, in a model of uniform acceleration and deceleration, in which direction and by how much the speed-based alarm departs from 30 s.

6. Roll Call and Closing

1. the trigger conditions of the two methods (Section 1): **position, or position over speed.**
2. **30.000 s at constant speed** (Computation 2.1): **the speed-based method.**
3. **22.840 s for an accelerating train** (Computation 3.1): **shorter than 30 s in all 8 cases.**
4. **39.837 s for a decelerating train** (Computation 4.1): **longer when braking starts early.**
5. **fixed distance never below 30 s** (Computations 3.1, 4.1): **bounded by the speed limit.**
6. **present speed, or position passed** (Observation 5.1): **the separator; the scope note of Paper 894.**

Closing: A crossing alarm that reads arrival from speed falls short of 30 seconds for accelerating trains and runs long for stopping ones. At the crossing of Paper 894, the speed-based alarm was 30.000 s at constant speed, but 22.840 s for a train accelerating at 1.0 m/s^2 from a station 1100 m before, and 39.837 s for a train stopping at 0.3 m/s^2 at a station 250 m beyond: the fixed-distance alarm did not fall below 30 s for any train. The separator is whether arrival is read from the present speed or from the position passed. Placed among the earlier papers: the two methods Paper 894 compared at constant speed were compared with the acceleration and deceleration that Paper 894 did not include. To be honest: real crossings also have schemes that correct the prediction. For trains with uniform acceleration, in which direction and how far reading from present speed shifts the alarm, and no further.

References

1. Yamagishi, Y. (2026). *When a Level Crossing Is Triggered at a Fixed Distance, It Stays Closed Longest for Slow Trains, Not Fast Ones* [Paper 894]. YOI: <https://www.yamagishiyuuki.com/yoi/894>

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