Modelling the Clayton Tunnel Disaster


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That August morning in 1861 began like so many others on the London–Brighton line: express trains threading their way into the mouth of Clayton Tunnel, controlled by a pair of semaphore arms and the telegraph wires linking two signal cabins. Shortly after 8:30 am, Signalman Killick in the southern box levered his home signal to clear and admitted the approaching train.

Seconds later, the automatic treadle—hidden beneath the sleepers—jammed. Almost at once, an alarm bell clanged in the cabin, announcing that the signal had not returned to danger.

Barely three minutes after the first service entered—well short of the five-minute timetable interval—the whistle of the second express pierced the morning air. Alerted by an alarm, Killick recognized the failure: the mechanical backstop he trusted had betrayed him. He sprinted from the box, red flag in hand, and dashed onto the ballast beside the tunnel mouth, in time to see the second train speeding past. The driver caught that frantic flag warning, braked hard, and ground to a halt deep within the tunnel, his wheels skidding to a standstill on the rails. Obedient to the emergency halt, he then reversed the train slowly toward the portal to comply with the flagged stop signal and find out why.

Back in the box, Killick's telegraph needle flickered with a "Train Out" indication. Believing this belatedly to refer to the halted second express, he realised that the home signal at Clear was appropriate in its failed state, and he would not need to signal stop. Thus, the third express thundered in at full speed. Deep in the darkness, the reversing train and the on-rushing locomotive met in a violent collision. In minutes, the wreckage would claim twenty-three lives and maim nearly a hundred and eighty more.

That day, the alarm bell—intended as the fallback for a failed treadle—proved too late to prevent catastrophe. A single device's malfunction, a compressed timetable, and a mis-read telegraph message had resonated into tragedy, teaching the railway world that no one safeguard, however loud its warning, could be allowed to stand alone.

THE CLAYTON TUNNEL ACCESS CONTROL SYSTEM

The system has been modelled using the Functional Resonance Analysis method. The model produced shows only those critical functions needed to ensure safe passage of Trains in sequence. The model allows a continuous cycling of trains through the tunnel and can keep track of individual trains and recording of the timings involved in carrying them out. It also allows parameters to be varied on a what if basis to see the effect on performance. The FRAM model built is shown below: -

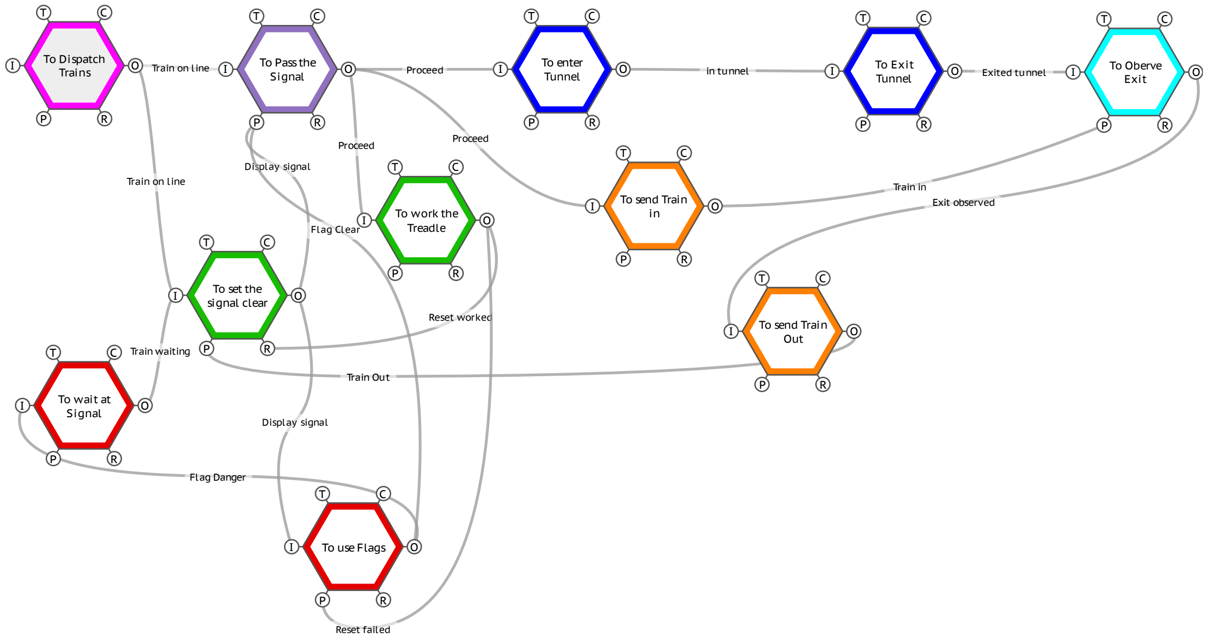

***Figure 1 – The FRAM model used*.**

From the incident reports, there is identification of a number of issues of which the following are addressed here.

- First the overall design of the system.
- Second the possible tardiness of signalman Killick in attempting to flag down the second train.
- The effect of the dispatching trains at three versus five minutes (and allowing the interval to be maintained approaching the tunnel (Holman)
- And the effect of the second train stopping and reversing instead of clearing the tunnel.

Three model runs are thus presented to illustrate these scenarios.

1. The system design

Using nominal timings as in the "book", the system works smoothly and seemed to be stable during the cycling of 100 trains through the system

2. The Flags

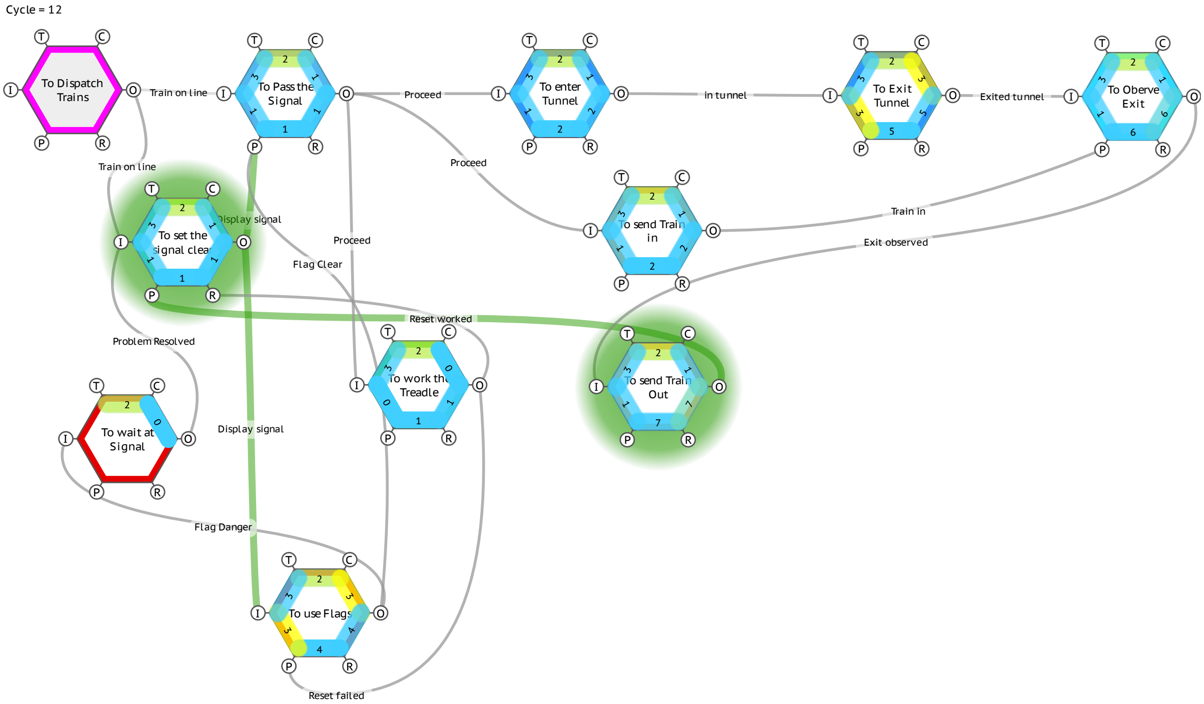

Figure 2 – The Back Up system

The FRAM models the treadle, alarm and flagging as a system that on timetabled separations has ample time to control the flow with little disruption. The Figure 2 above, shows the system working allowing Killick three minutes to discover the problem, get out of the box with his flags and control the trains. How far up the tracks he needed to be to allow the trains to see and stop safely though is a moot point.

3. The Train arrival Intervals

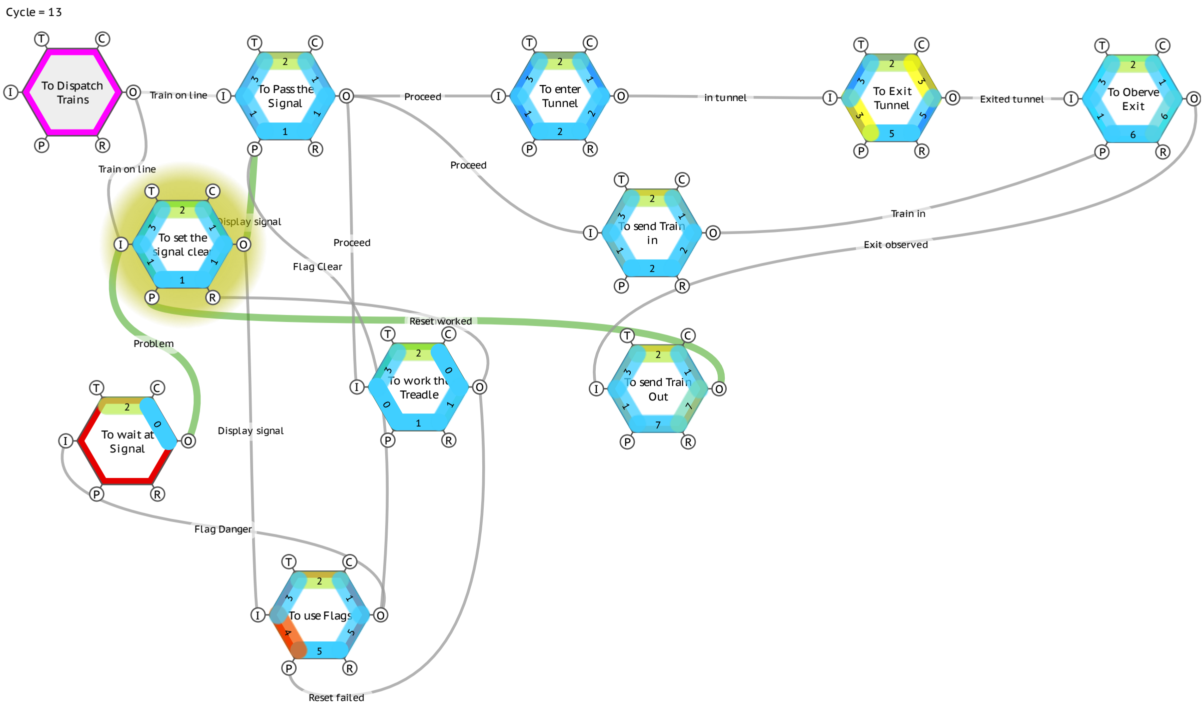

Figure 3 – The Timing Criticality

Runs at 3-, 4-, and 5-minute intervals show that at a 3 minute arrival interval, Killick has little chance, but a 4 minute interval seemed sufficient time to allow the Flags to be deployed.

4. Stopping in the tunnel

Running the model assuming the second train drives through allowing a second Train Out prompt suggests that the system works even with three minute separations,

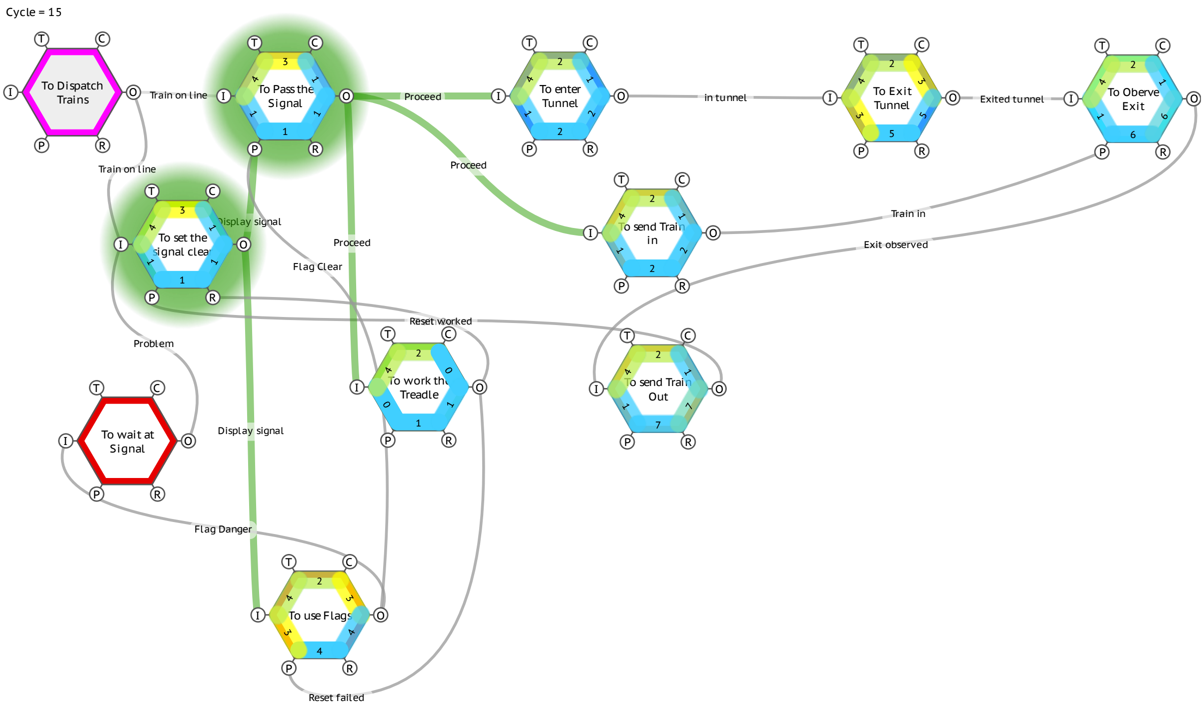

Figure 4 – Situation under control even at 3 minute arrivals.

DISCUSSION - SIGNALS PASSED AT DANGER.

An interesting actual model observation, mirroring the Clayton sequence.

On a Dutch colleague's model railway (built for his grandchildren obviously), there is an interesting signal control mechanism.

When the signal is set to red (stop), the current in the preceding track lengths is cut, so that the locomotives have no power and stop automatically! (illustrated by the train on the furthest right track).

The second locomotive is heavier and more powerful and travels at a higher speed. Approaching the signal, despite the stop signal and no power available, the locomotive has sufficient momentum to travel past the dead tracks, past the signal and can pick up power again after the signal and carries on its way – and as shown, the signal is passed at danger (SPAD)!

The parallel with the second Clayton train seeing the signal late (too late) and travelling on into the tunnel is informative.

If the train driver can see the signal at danger on approach, he can slow and stop.

If the signal is clear, he assumes he can pass at full speed.

If he does not see it until much closer to the signal box, the flag is observed too late, to stop at the signal - the train will take a significant time / further distance to stop (>1000yds?).

So, the design of the back-up system meant that to ensure visibility, the signalman had to move much farther down the tracks. It means that it was definitely unsafe if the trains were too closely dispatched and there was no time to adequately warn the second train.

The "normal" situation as perceived by both the dispatcher and the previous signalman was that with signals working, a 3-minute separation was acceptable. But they had not allowed for, (or had not experienced), a treadle failure and hence the SPAD and consequences.

CONCLUSIONS

This modelling has triggered an alternative line of thinking. Perhaps instead of perhaps "blaming" Killick and the driver, it was the fact that they had acted above and beyond the call of duty, that had unwittingly caused the tragic consequences.

If Killick had been a little slower, the train driver would not have seen the flag and as the model showed the third train could have entered relatively safely as the second train would / should have been emerging at the exit anyway.

If the driver had not tried to obey the Flag, he would not have stopped deep in the tunnel (halfway through?) and reversing sealed the fate of the trains.

The signalman in the box between Brighton and the tunnel (Holman) was also blamed for allowing the trains to approach the tunnel separated by only three minutes, rather than the regulation five.

Perhaps Holman's assessment was not wrong, just as imagined, not as was.

A Tragedy of errors or a resonance of variations in conscientious functions?