

Token Exchange using Random Numbers (In celebration of prototypes)

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TERN – Token Exchange using Random Numbers.

A simple processor-based signal control system for minor railways demonstrated for the first time at the IRSE Minor Railways Section visit to the Ravenglass and Eskdale Railway (R&ER) on April 10 2010.

The TERN equipment was a prototype. Not a pre-production version. No, a real, just-off-the bench prototype. How could you tell? Well there were the odd tell-tale features common to all bits of kit early in their development. There is a compromise to be reached. Spend enough money to show that the effort is serious, but on the other hand do not spend on some of the peripheral gear.

So, looking at the power sources. What drove the TERN units? A pair of car batteries. One was new, one had seen years of service under a bonnet. Then there were the power cables. These were indeed serious pieces of kit, carefully crafted by a company that knows about cabling. Stuart Marsh of Highblade Cables has been supplying cables to the communications industry for years - and you could tell.

The TERN unit itself was an impressive piece of special construction. A true black box with a single enigmatic red button – the only control. There was an LCD display and a keypad, but it was freely admitted that this wasn't connected to anything yet.

And what was the main communications means? Here the true nature of an early prototype shone out. Two ex-Geordie taxi radios showing signs of long and sterling service with their hard plastic microphones swinging limply on their coiled leads. They were Tait 2000 radios built like battleships with casing secured by crosshead screws – again with plenty of evidence that they had been to pieces many times in their life time. Again, the cabling was immaculate between TERN unit, laptop and radios. And that was it. That's all that's involved in the system apart from a laptop and a radio interface.

Predictable computing illusion

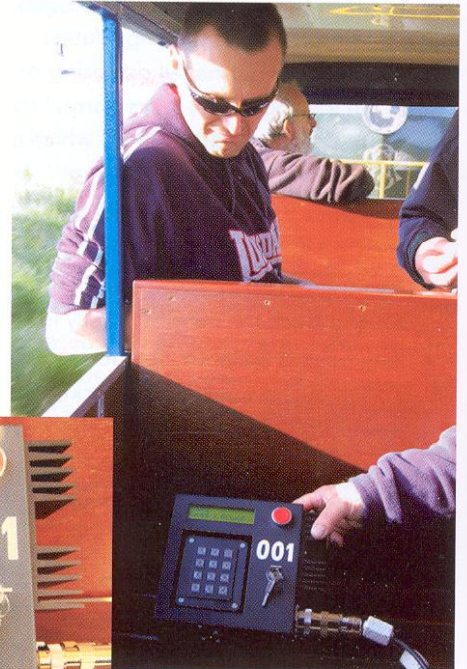
The Minor Railways Section's visit on April 10 coincided with fabulously fine weather all the more welcome after the long and chilly Lakeland winter months. The TERN demonstration was arranged in two parts. There was a brief demonstration in the conference room at the Dalegarth station followed, after the last service train, by a live airing of the system on a special train running under possession between Ravenglass and Irton Road.

The TERN system relies on a simple and entirely predictable computing illusion – the illusion that route tokens can fly between machines. It avoids having any safety critical information passing between master and slave units and so does not use a secure, dedicated communications link.

In the lead-up to the demonstration, the R&ER was very helpful in explaining the practicalities of their paper-based radio dispatch system. TERN attempts to emulate this but adds route interlocking, a secure in-cab train display and a real time train graph. All this is latched on to that basic computer illusion.

The single red button has evolved because of the need to make the unit as practical as possible. All a driver has to do is confirm that he is where the controller understands him to be. The only other control is an 'On' button. At the moment there's a key switch – Signal engineers like keys. There won't be an 'Off' button. Switching the unit off will be via the keypad or, as at present, remotely by the control unit.

There are other features of a prototype that you can spot. A production model will be transported in a box. A prototype comes in at least three boxes. One for the very heavy car batteries, one for the main pieces of kit and a third which contains the soldering irons, the long nose pliers, the insulating tape, the battery chargers and other assorted rescue equipment. All this in turn is supported by a crate containing a monitor, keyboard and mouse just in case the software in the TERN unit needs tweaking.



Solution waiting for a problem

Make no mistake; TERN is in fact a giant leap backwards in computing technology. The programming harks back to the 1960s. However, it has been aided by huge leaps forward in processor power, hardware and support software. It was invented over 20 years ago as way of providing token protection for track gangs on the Redmire and Eastgate branches. In the years leading up to Privatisation it was progressed almost to prototype stage by BR Research. But Privatisation killed it off and the project ran into the deep, long grass.

For several years TERN was almost a solution waiting for a problem. But times have moved on. Minor railways are growing, setting their sights on extending their lines and running more than just the one train. They now have to consider seriously how they are going to manage this extra traffic and benefit from the extra revenue. Fixed signalling systems can be vulnerable to vandalism and can involve significant infrastructure works.

The traffic is seasonal and so there can be issues of leaving equipment to the mercy of the elements in the off season. TERN is being developed specifically with this railway sector in mind to provide a secure method of train management at an appropriate level of technical sophistication.

Test train

The bench top demo in the Dalegarth lecture room went off without a hitch. There was an issue of trying to find something made of steel to which the taxi mag-mount aerials could be fixed. The tables? Made of wood. The chairs? – Plastic. Radiators? – too far away. In the end a couple of crowd control barriers filled the bill.

Working with the aerials four yards apart was hardly a serious test apart from coping with the vagaries of RF flying about in a confined room. The main test, not attempted before on a moving train, was to try out the equipment on a journey up the valley from Ravenglass. But, in the way is Muncaster Fell and so, using it's own VHF frequency rather than an allocated R&ER frequency, the radio transmission had to bounce its way up the valley sides to reach the loop at Irton Road about four miles away. Again, in true prototype fashion there was an issue with the aerial fixings. How do you connect a mag-mount aerial to an aluminium coach roof? The answer was to stick it on with the aid of a mastic gun, something which all pioneers have in their rescue kit.

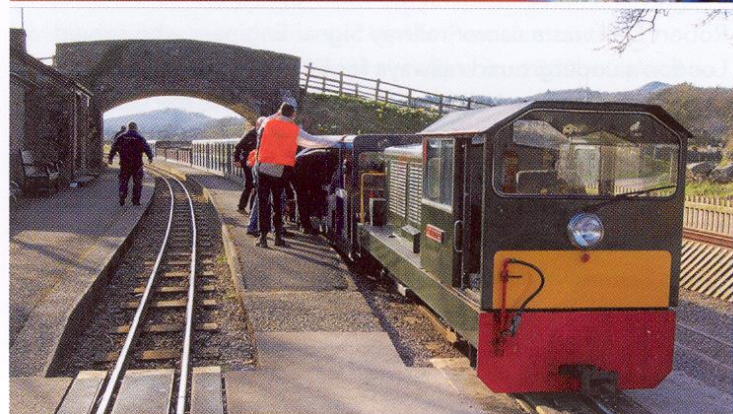
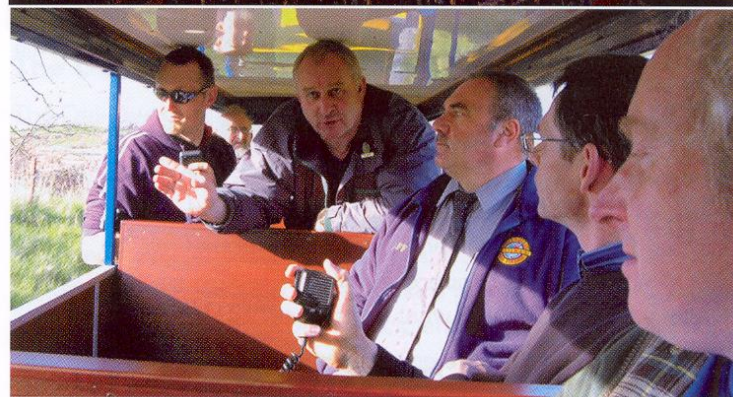
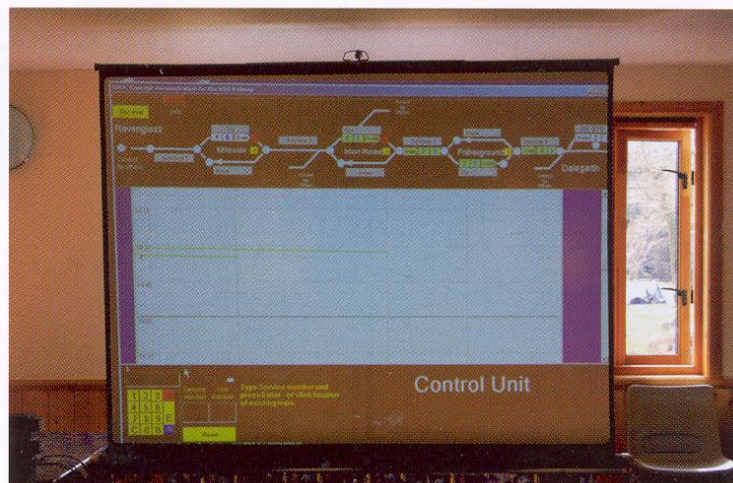
Real-time train graph

At the moment, the TERN system uses a very basic, simple system of Dual-tone Multi-Frequency (DTMF) tones. Why DTMF? Well, it's easy to understand and easy to hear whether a message has been transmitted. So, off went the train with its taxi radio on full volume so that the assembled company could hear the system in action. Beeps echoed through the still evening air as route tokens were allocated to the train by the control unit. The train disappeared from site beeping merrily and like a lunar module going behind the moon, there was an anxious wait for the first position report from the train. Eight minutes can be a very long time.

The silence was broken with the first message from the train which came through as clear as a bell. The position of the train was clicked on the control unit track diagram and thence automatically on the real time train graph below. Further periods of silence followed to be broken by position reports and then by token exchanges allowing the train to go further up the line.

Radio's revenge

At Irton Road there was a final position report before the train was due to run round and return. The TERN unit was programmed to accommodate this run round manoeuvre which was successfully achieved before tokens were allocated for the return journey. But remember, this was prototype kit. One of the radios, after years of picking up fares outside Newcastle nightclubs, decided that it didn't want to broadcast voice audio any more. It would convey the



DTMF tones to the TERN unit computer, but voice coverage there was none. Nevertheless, sufficient communications remained, along with an understanding by the operators, for the remainder of the journey to be carried out under token protection.

As the train approached Ravenglass its presence was announced by the sounds of DTMF tones echoing off the station buildings. There just remained for the kit to be dismantled and the aerial to be wrenched from the carriage roof leaving a tell-tale sticky patch of mastic.

Tail piece

Prototypes can have rough edges, and this one had several, but they are nevertheless heroic ventures. It is comforting that even in this day and age that something as novel as TERN can be put together by a civil engineer and a marine geophysicist and still receive a courteous and encouraging reaction. The IRSE visit had enjoyed wonderful sunshine, warm hospitality from the R&ER, a couple of rides on the trains, visits to workshops and signalbox – and they had also witnessed the very first flight of the TERN system.