Mark Sheahan and **Patrick Andrews,** our two resident inventors, exchange emails on the best ways to modernise Britain's ageing railways

inventors' inbox

BANKING ON RAILWAYS

Patrick: Since the decision was taken to separate the ownership of the two main components of Britain's national railways, trains have generally got faster, but tracks are similar to those laid down in the Victorian era.

Actually, there's not much wrong with that: the Victorian engineers created some of the world's highest technology, much of which is still working. They would be scratching their top-hatted heads, though, at the current state of our infrastructure – while being knocked for six by the four-and-a-half hour journey time between London and Glasgow in a tilting (Italian) train.

The trains could go a lot faster, if only we had better lines. In Japan, 300km/h is not unusual, which makes railways directly competitive with airlines for internal journeys. Post 9/11, many people would seriously like to avoid all that queuing, with one's belt and shoes removed, that air travel now requires. There are moves to have bullet trains operate on the UK network by 2009, but I suspect they will still be under-using the engines' capabilities, given the limitations of even the newest Channel Tunnel infrastructure.

So I started thinking about economic ways to upgrade existing tracks to allow bullet trains to travel safely along them. I'll ignore signalling considerations for now.

One of the problems is that the tracks are too narrow and not banked to enable very high speed cornering. We could tear up and replace large sections of existing track, but this would be massively costly and disrupt the network even more than existing maintenance does.

Mark: What we need from the Victorians is their pioneering spirit rather than just fixing and/or adapting 100-150-year-old systems. There must be a good business case for high-density passenger and freight lines to change completely.

A new rail system could take all the best bits from some of the energy options and natural laws (diesel, electric, battery-powered and magnetic levitation trains plus gravity) and select the best hybrid. It would also take into account the advantages and disadvantages of above-ground and under-ground travel and combine it all into one energy-efficient, quiet, clean, safe and reliable system (ideally, using 'self powered' trains). Sounds simple, doesn't it?

Patrick: Sounds great, but I'm interested to see what the payback period would be. Fixing everything, all at once, seems about as economically likely as handing everyone a flying car.

Mark: Fortuitously, I've travelled on most train types over the last few years, so have some knowledge and experience to draw from. Last year I was escorted onto the bullet train at Tokyo, for Osaka, by a potential Japanese business partner. I also recently travelled on the reported 'fastest train in the world' – the magnetic levitation, or Maglev, from Pudong International Airport to Shanghai's Long Yang Road and back. Yes, it was fast and smooth, but at higher speeds (around 400-430km/h) it was quite loud (95dB) and vibration started to creep in.

I must confess that I am a bit anti-electric trains, having once spent five hours in the same spot when a line came down just outside Birmingham. When they fail, they fail big time; it is catastrophic.

My idea is to harness kinetic energy using gravity (think of a stretched-out roller-coaster) with ancillary energy sources: for low-speed freight – a lithium-ion battery-powered motor using a small wind turbine charger high up on the engine to make it a fully functioning self-powered slow train; for passenger – a diesel motor.

■ **Patrick:** Self-powered? Hang on, this sounds suspiciously like a perpetual motion device. A roller-coaster needs a massive motor to pull its carriages up to the height from which they roll down. If you try to capture energy (to use later in driving a motor) via a wind turbine bolted on top, this just acts as a source of extra drag, slowing the descent.

■ **Mark:** My system will use tunnelling, but will surface every 10-15km to stop at a station for air and to restart the kinetic energy process.

The train needs power to start from the station and to begin its descent into the tunnel. Turn power off and coast down a long gradient, using gravity to propel and accelerate the train. This gradient can last for many miles, with the decline angle dictating the final speed (optimum length and angle to be established). A shorter uphill gradient will come into play at the other end of the tunnel (the optimum length and angle to be established).

The build-up of speed (momentum) should be enough to get the train up the ramp but, if not, it has its own power source to complete the task. It would then stop at the station and start the process all over again (freight, non-stop).

For this concept to be effective, friction and air resistance must be reduced greatly.

Levitation is a good way to counter friction, so I have chosen an adaptation (which only levitates – no propulsion) to the Maglev technology, called 'Inductrack'. It uses permanent magnets (arranged in 'Habach Arrays'), rather than the more conventional electromagnets or superconductors.

I opted for this version because no power is needed to levitate the train while it is moving, so it will prove very cost-effective. Also, the magnetic field is all housed below the train, keeping it a safe distance from onboard critical electrical equipment.

And no, I am not trying to overcome the laws of physics by inventing a perpetual motion device.

■ **Patrick:** Ok, so you are looking at long tunnels (a huge cost and a safety issue) together with minimal friction.

This would also require permanent magnets along the length of the train itself. Wouldn't that increase the mass enormously, making starting, cornering and stopping in an emergency much more difficult? In addition, creating permanent magnets with the required field strength would, I guess, be enormously expensive. I'm not sure I fancy having all my ferrous belongings snatched away by a passing loco.

Not relying on friction with the rails for forward motion would certainly allow much less massive trains, but if there was ever a requirement to brake a 1,000+ tonne vehicle, it would be a challenge (regenerative braking would be a must).

■ **Mark:** Once the train starts to move at approximately walking speed, it takes off (levitates) and only lands upon slowing down below a critical speed, coming to rest on auxiliary failsafe powered wheels. I agree, the energy needed to stop a train is very high. The uphill slope at the end of the tunnel will act as a natural brake (gravitational braking), and the wheels should be designed to come into play at any stage of the journey – for power or to apply braking.

■ **Patrick:** The amount of digging involved wouldn't constitute a very green process. Also, don't neglect air resistance. The reason the Channel Tunnel has a massive ventilation system is that moving air about is hard work. Moving air out of the way of a train demands a large power input too. Even without much rail friction, our train would still need a big motor to allow it to climb uphill to each station.

■ **Mark:** To help reduce air resistance and drag, the tunnels (a two-way system) will need to be built straight (above ground they can be angled to help fit the terrain, if necessary), large and interconnecting along their route for better air displacement and ventilation. Plus the freight train's wind turbine charger should be encapsulated in an aerodynamic subframe and electronically controlled (able to turn into and away from the airflow) to charge the battery-powered motor when in use and on the train's downhill stage only, if needed.

■ **Patrick:** Yes, fair enough, but I regularly get delayed by a near-surface tunnel which erodes when it rains.

■ **Mark::** That is precisely my point. We need new infrastructure.

I realise that the high set-up costs are the biggest drawback to this idea of using new tunnelling, cornering the magnet market and digging for England, but remember: payback would be much faster because of the dramatic fuel/electricity reduction.

■ **Patrick:** My back-of-the-envelope suggests that your tunnels would need to be about 500m deep (to achieve speeds of say 100m/s for a normal passenger train). At this depth, we should consider powering trains using coal collected en route!

■ **Mark:** I do not think we need to go so deep or run so fast, the gradient could be as little as 1-3 per cent for around 10km. If my maths are correct, that is only 60 to 180m. Also, remember that the train is propelled into the tunnels at speed from the start.

As a final point, for commuter comfort and safety, the journey must be smooth in every stage and seamless on crossover – with no 'white knuckle' roller-coaster bars and no arm-waving and/or screaming allowed. ■

■ A search carried out by the British Library Research Service (www.bl.uk/research) on 'kinetic energy for train travel' revealed five patents CN1078946-A (patent not on Espacenet), US4075948-A, US3954064, DE102005007097-A1 and US4148260 which can be viewed on Espacenet. Readers can send their own thoughts to engtechmag@theiet.org