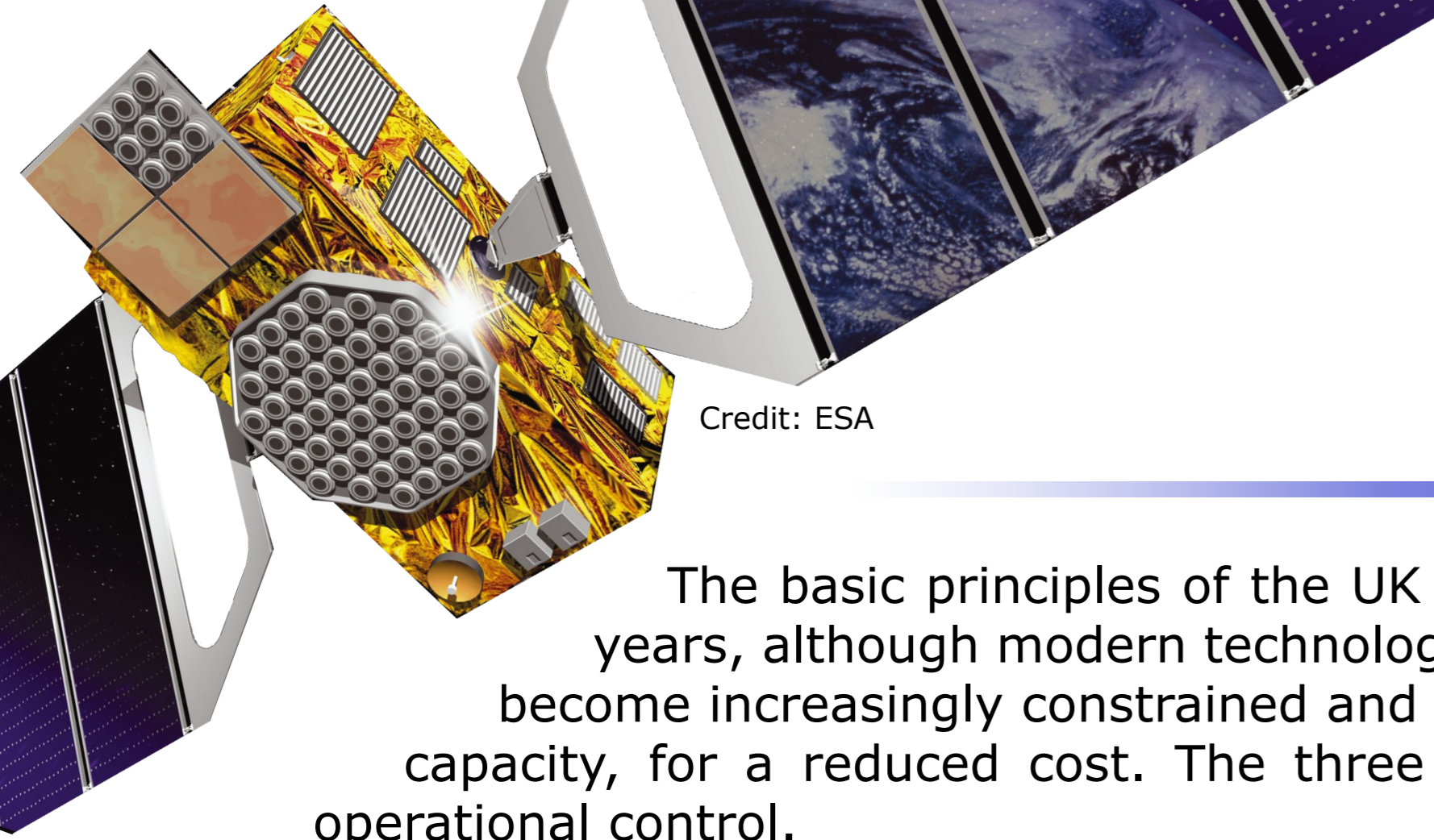


The Use of Satellite Navigation in Automatic Train Control Systems

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The basic principles of the UK railway signalling system have remained the same for at least the last hundred years, although modern technology has greatly improved safety and efficiency. In recent years the UK network has become increasingly constrained and better train detection and control systems are now required to provide additional capacity, for a reduced cost. The three key components of a train control system are train detection, signalling and operational control.

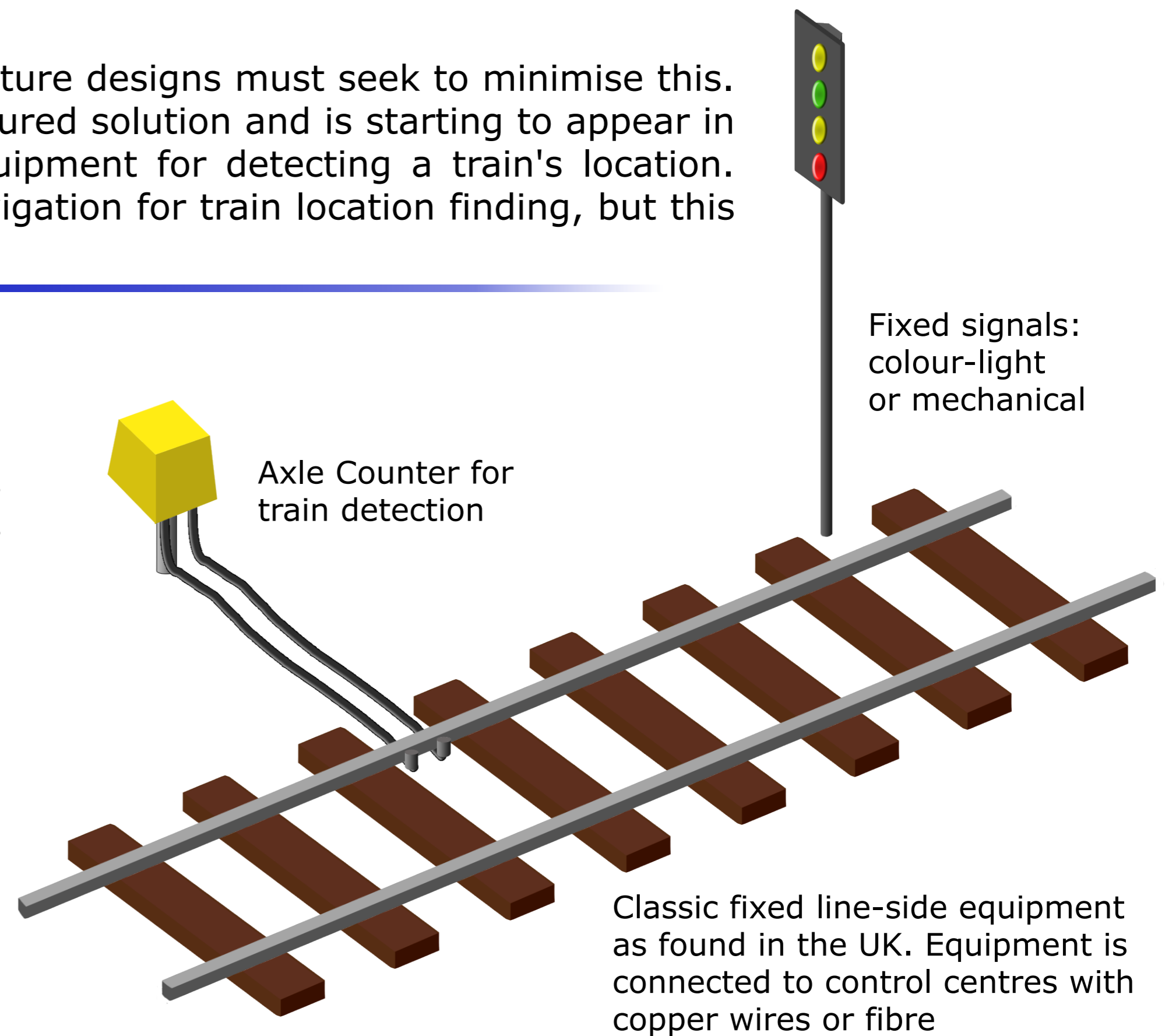
Current systems need large amounts of line-side equipment and future designs must seek to minimise this. The European Rail Traffic Management System (ERTMS) is the favoured solution and is starting to appear in the UK, but will still require substantial amounts of line-side equipment for detecting a train's location. Further equipment savings can be made by the use of satellite navigation for train location finding, but this has a number of technical challenges and complications.

Current Technology

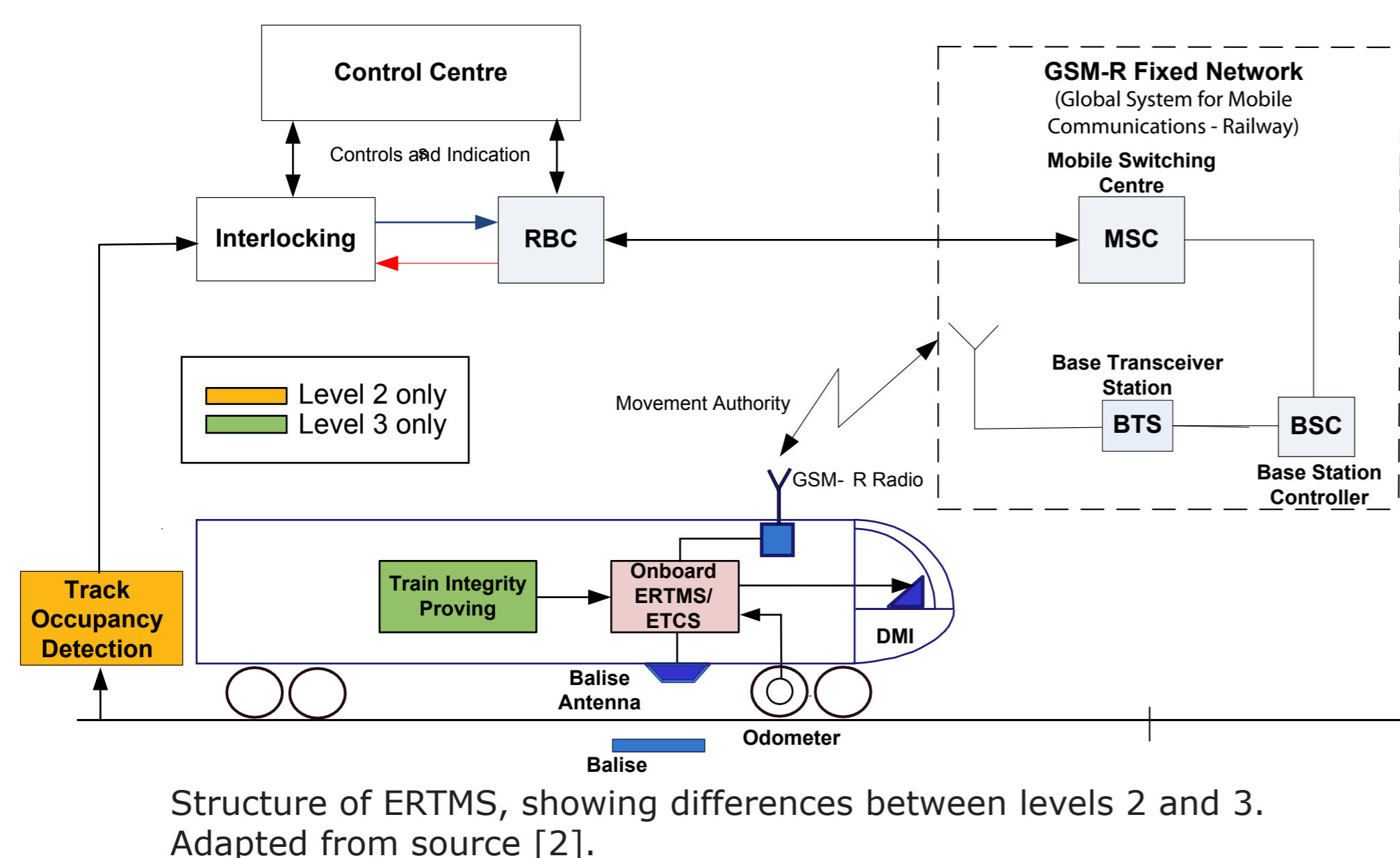
The UK currently uses block signalling (where the track is divided into physical sections) with fixed signals. A block section is considered occupied if any part of a train is in it. Train detection is generally achieved through axle counters or track circuits [1]. Signal boxes exist that control short parts of a route, but there is an increasing move to larger centralised signalling control centres.

Key Problems:

- Large amount of on-track equipment that needs maintenance
- Maintenance is expensive and creates disruption
- Poor reliability of train detection systems cause delays
- Fixed signals limit the maximum train speed
- Fixed block sections reduce flexibility and capacity



European Rail Traffic Management System



The European Rail Traffic Management System is beginning to appear all over the world and is set to become a standard train control system. Standardising the control, signalling and detection interfaces is particularly important in Europe where rail lines regularly cross country borders.

Key Features of ERTMS Level 3 [2]:

- Train control over wireless GSM-R removes fixed line-side wiring
- Cab based signal displays removes need for fixed signals
- Inductance powered beacons (balises) allow trains to work out their own location
- Trains report their location to control centre over GSM-R
- Moving block working allows improved capacity
- Unpowered balises are the only line-side requirements

The UK is planning to implement the more limited Level 2 system so that existing rolling stock can still be used. Level 2 still requires track occupancy detection using track circuits or axle counters, but does implement cab signalling [3].

Satellite Navigation

A further reduction of line-side equipment can be made from ERTMS by replacing the locating balises with a satellite positioning system. Trains continue to report their own positions over a GSM-R radio link.

Galileo is the European satellite navigation system currently in development and promises considerably higher accuracy compared with the US GPS and Russian GLONASS systems. Designed for civilian uses, Galileo would be highly suitable for use in rail control applications currently under development. Galileo also offers safety-of-life protection and encrypted services to protect against spoofing and jamming [4].

A key problem with satellite navigation is that multiple satellites must be in line-of-sight with the train which is an issue with urban or underground routes.

The Future

ERTMS level 2 has been trialled and approved in the UK and is set to be rolled out across the network. Satellite navigation could theoretically be added later with few modifications. Safety verification means that it takes many years for new technologies to be approved, and the Galileo system is not yet operational so it is unlikely that satellite positioning will be seen in the UK within the next 15 to 20 years.

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