

Automatic Train Protection on British Rail: Present Plans and Future Possibilities

K. W. BURRAGE

British Rail has embarked on a 3-year effort to test and select an automatic train protection (ATP) system for national implementation beginning in 1992. Two systems are being pilot tested—one on a high-speed mainline, the other on a suburban railway. For economic reasons, both give intermittent ATP coverage with information transmitted at each signal, rather than continuously as with some metro or high-speed applications in continental Europe. Whichever system is chosen, it must be possible to fit the equipment to a wide variety of vehicles and lineside signaling with minimum disturbance to existing equipment. British Rail plans to finalize its national ATP specification late in 1991 and is committed to a 10-year installation program. Although the program will require considerable investment, British Rail expects the ATP system to yield a number of benefits besides reversing the rail system's rising signals-passed-at-danger (SPADs) statistics.

During the 1980s the number of signals being passed at danger (SPADs) has shown a significant increase and is a matter of serious concern to British Rail:

- Since 1982, SPADs have been on the rise.
- In 1988, there were 843 such incidents, 87 of them derailments or collisions.
- In 1989, there were 963 such incidents.

This concern has been brought into sharp focus by a number of passenger train accidents—such as those at Bellgrove in Scotland and Purley in South London—in which a number of people were killed.

The phenomenon of SPADs has been thoroughly studied from human and technical viewpoints and the conclusion reached that human performance factors are the cause of 85 percent of all SPADs and of the rising trend. This has led to the search for a technical solution to prevent driver error in approaching signals and obeying speed restrictions, and for a solution that can be implemented relatively quickly: an automatic train protection (ATP) system.

The existing driver supervision system on British Rail, the Automatic Warning System (AWS), is based on 1950s technology and only alerts the driver to the presence of a warning or stop signal. It cannot differentiate between the two and has no speed supervision function. It was quickly concluded that this technology could not be adapted to fulfill the needs of ATP on British Rail.

Signal and Telecommunications Engineering, British Railways Board, CP 10 Macmillan House, Paddington Station, London W2 1FT, United Kingdom.

THE PLAN

In autumn 1988, British Rail made a decision to embark on a 3-year program to produce an ATP system that could be available for implementation by early 1992. Given the 3-year timetable, it was impossible to pursue original technical development of a completely new system.

Therefore, British Rail set out to produce a performance specification for the perceived needs of its network and, at the same time, to review the experience of other railway administrations with ATP systems. Then, two pilot schemes were to be run to assess in practice the performance of the proposed specification on British Rail lines, leading finally to the procurement of a system for national application (Figure 1).

PILOT SCHEMES

British Rail decided to engage in large-scale trials (pilot schemes) of two proprietary ATP systems to gain experience before choosing a national system. The choice of an ATP system for a network has significant implications for the capacity and performance of that network as well as for its safety. It can also profoundly influence future signaling and train control strategy. Mistakes could be extremely damaging to the business and very costly to rectify.

Two pilot schemes were devised on two very different routes, one a high-speed mainline, the other a suburban route:

- Great Western Main Line ATP Project
 - Diesel-operated, high-speed mainline trunk railway,
 - London (Paddington) to Bristol via Bath and via Bristol Parkway,
 - 143 route-miles, two tracks to be fitted,
 - 125 mph maximum speed,
 - 350 signals to be fitted,
 - 100 Class 253 high-speed diesel trains to be equipped.
- Chiltern Lines ATP Project
 - Diesel-operated suburban railway,
 - London (Marylebone) to High Wycombe and Aylesbury,
 - 10 trains per hour into London in the peak period,
 - 67 route-miles, mainly two-track,
 - 75 mph maximum speed,
 - 188 signals to be fitted, and
 - 66 Class 165 Network Turbo diesel multiple units to be equipped.

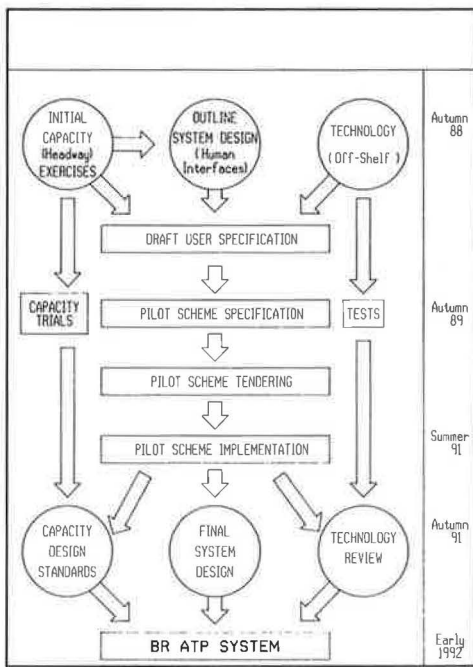


FIGURE 1 ATP development plan.

To select the systems for trial, a competitive tendering exercise was carried out. This used the performance specification as its basis, leaving industry to propose suitable technical solutions based on available technology. A detailed appraisal of the tenders was carried out against performance, technical, operational, and financial criteria.

The response of industry was most encouraging and the two successful companies selected for the pilot trials were ACEC of Charleroi, Belgium, which offered a system for the Great Western Main Line based on their TBL equipment in service with SNCB, and GEC-Alsthom Signals, UK, which offered the SELCAB system from SEL, Germany, for the Chiltern Lines. SELCAB is derived from SEL's continuous ATP products.

Both contracts were let early in 1990, giving the contractors a very demanding timetable to meet, for operation of parts of the pilots was needed by summer 1991. Apart from the needs for physical manufacture, some development of hard-

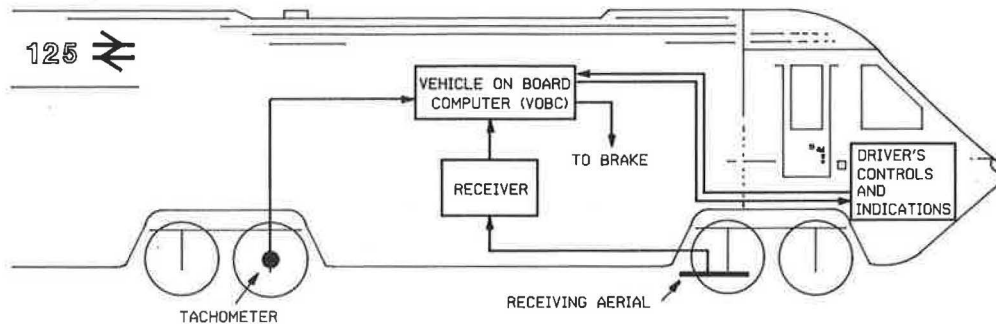
ware and software had to be undertaken to meet the particular operating and technical environments of the two schemes. These challenges have been met, and installation commenced to plan in the first quarter of 1991. The rest of the year will see a major program of testing and evaluation.

THE SYSTEM

In outline and functionality, both systems in the pilot schemes are very similar. The vehicle equipment is shown in Figure 2 and the on-track equipment in Figure 3. The trackside equipment transmits to the train all the information required for the vehicle on-board computer to safely monitor the train's performance to the next transmission point. The information provided is either fixed or derived from the signaling system. Information provided to the train by the ATP at a beacon or loop is as follows:

- Aspect and type of signal,
- Distance to next beacon/loop,
- Distance to stopping point,
- Safe distance available beyond stopping point,
- Maximum line speed,
- Distance to speed restriction,
- Value of speed restriction,
- Length of speed restriction,
- Gradient,
- Differential speed restriction,
- Length of loop, and
- Beacon/loop identity (Great Western system only).

The systems employed give intermittent ATP coverage with information transmitted at each signal, rather than continuously as is the case for metro or some high-speed applications in Europe. The prime reason for this is economic—continuous coverage is much costlier than intermittent and could not be justified for other than relatively small portions of British Rail's network. The downside of an intermittent system can be a degraded performance of the network. This can be overcome by "infilling" part of the signal section to update a train in advance of the signal it is approaching. Both British Rail pilot scheme systems can achieve this with cable loops and, on one, extra beacons are an alternative. Extensive sim-



VBOC REQUIRES INFORMATION ON TRAIN CONSIST AND BRAKE CONDITION WHICH IS ENTERED BY DRIVER. VBOC PROGRAMMED WITH EXPECTED BRAKING PERFORMANCE.

FIGURE 2 ATP train-borne equipment.

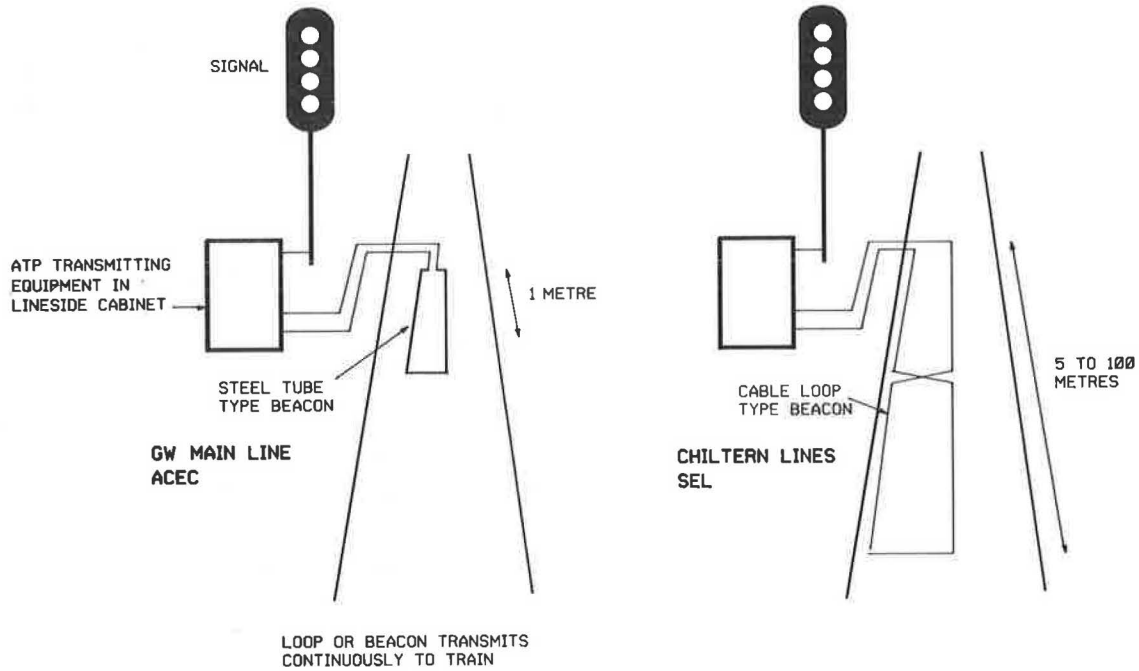


FIGURE 3 ATP trackside equipment (not to scale).

ulations have indicated that, by selecting the level of infill to suit prevailing traffic conditions, performance of the network can be maintained or even enhanced, if this is justifiable (Figure 4).

The loops or beacons being used on the pilot schemes are active (i.e., they transmit continuously to receivers on the trains and hence require the provision of lineside power). The systems only require transmission equipment at signals, so this presents no problems on the British Rail network because power is available at these locations.

One of the key requirements for both the pilot and the national ATP schemes is ease of fitting to the network. It must be possible to fit the equipment to a wide variety of

types and ages of vehicles and lineside signaling with minimum disturbance to the existing equipment.

At the lineside, innovation has been used on the Great Western Main Line to allow the ATP electronics to “read” the signal aspects by means of a device that replaces a link in the lineside equipment cabinet. This will allow installation of ATP with minimum disturbance to existing wiring and limit the amount of the testing required of the relay-based signaling system in use there. On the Chiltern Lines, the ATP electronics connects directly to the outputs of the electronic module driving the lineside signal because this route was recently resignaled with British Rail solid-state interlocking equipment. After the choice of a system is made for national ap-

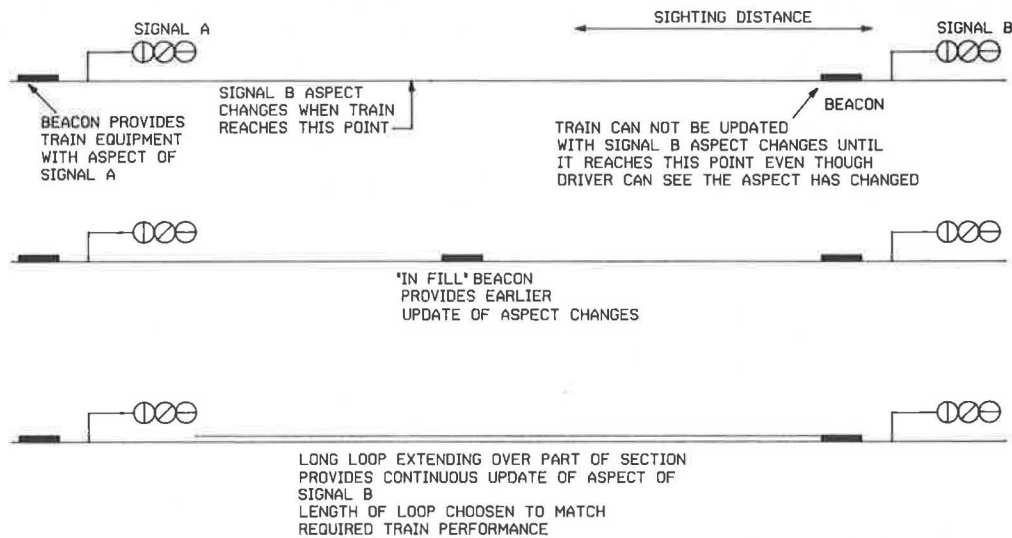


FIGURE 4 Provision of earlier updating of signal aspect changes “infill.”

plication, development work will be undertaken to integrate the two sets of lineside electronics.

On board the vehicle, the receiving antenna is mounted on the leading bogie. The size of the antenna and its mountings is critical for economic fitment to vehicles whose bogies were not designed with this in mind. Space has to be found for the vehicle on-board computer, which can occupy typically 12U of rack space. This has been straightforward for the Intercity 125 trains on the Great Western Main Line, which have ample spare space in the parcels area. But on the Class 165 units on the Chiltern Lines, space is at a premium—as it will be on many of the types of multiple units to be fitted nationally. It is anticipated that the space requirements can be reduced for national application.

The cab display chosen has been based around the speedometer, and each vehicle will require a change of speedometer to accommodate ATP. This will, however, mean that the display can be fitted into all cabs and in a place readily observable by the driver. Figure 5 shows the display and associated driver's control.

The driver also has a key pad for entry of the train consist data and braking condition. Both this and the display are undergoing considerable ergonomic analysis to ensure that the optimal safe solution is found. It is quite possible that a redesign of the display could occur before national implementation.

NATIONAL IMPLEMENTATION

At the end of 1991, British Rail plans to be in a position to finalize the national specification for ATP and to engage in the selection of the system to meet that specification. The selection process will be vigorous and will cover many technical, safety, and performance issues as well as cost.

The problem of how much of the network and fleet is to be fitted will also have to be addressed. It is likely that all

locomotives and multiple units will be fitted in the program—the nature of the British Rail network and use of vehicles means that all vehicles traverse busy sections during the course of their regular duties. To mix fitted and unfitted trains would create a significant gap in the protection afforded by the system. Similarly, gaps in the infrastructure fitted must not be frequent or widespread—the driver must be given a consistent level of security on the journey. Again, the nature of the network is such that only very minor routes are likely to remain unfitted in the longer term.

Having decided the level of fitment and chosen a system, the major challenge will then be to implement those decisions

- On the shortest practicable timetable,
- With maximum impact on safety, and
- With the optimum use of scarce resources.

British Rail is committed to fitment on the minimum practical timetable—the current judgment is that it will take 10 years. The reason for this is primarily one of resources, especially with regard to rolling stock. Each cab will take time to fit for ATP, and a float of vehicles from British Rail's wide variety of fleets will be required. It is British Rail's ability to generate this float and still carry the traffic on offer that is currently seen as a key factor pointing towards a 10-year program.

Current estimates of the cost of fitting ATP to the British Rail network are around £600 million (£1 = \$1.67 U.S.); the final total will be clearer after the results of the pilot trials. This is a significant sum—especially when set alongside British Rail's current investment in signaling and train control of around £100 million per annum. This signaling investment is also vital to the continuing safe and efficient functioning of the network as it will replace aging 1950s and 1960s equipment on some key routes. ATP, therefore, requires additional fund-

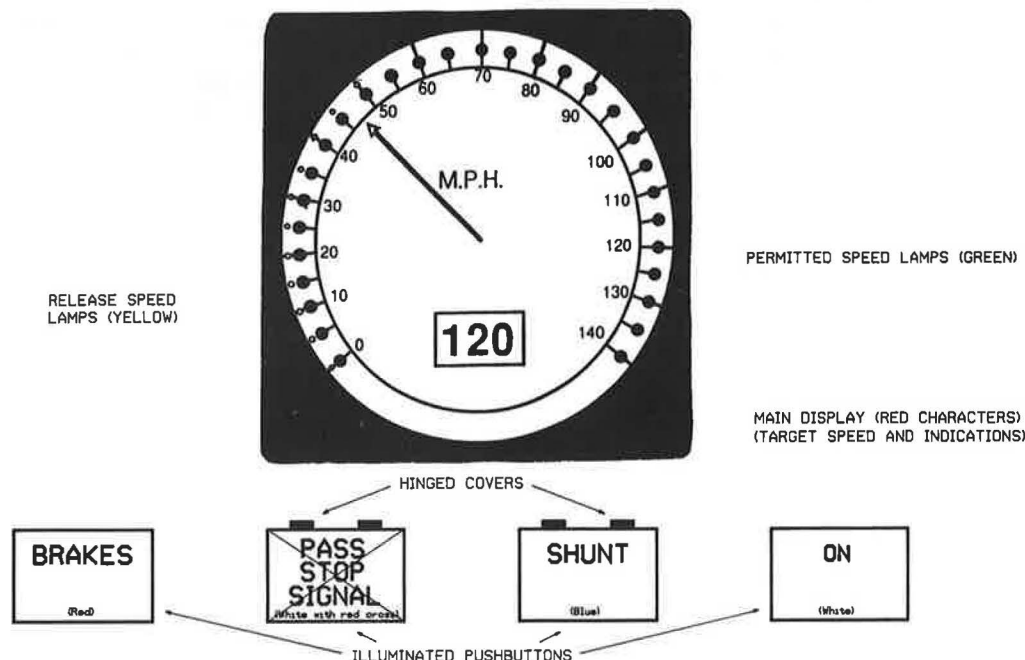


FIGURE 5 Driver's controls and indications.

ing and British Rail is in debate both internally and with government as to the preferred way of generating these funds.

FUTURE DEVELOPMENTS

The ATP system chosen for British Rail will have considerable potential for future enhancement, both in itself and by enabling other developments to be considered that were previously impractical or uneconomic. All the information required to control the train will be resident in the on-board computer and a communications link established between the signaling and the train.

To illustrate the strategic potential of this system, a 1987 study indicated that a move toward in-cab signaling generally on the British Rail network would not be economic, primarily because of the cost of fitting all the requisite rolling stock. With the advent of a national ATP system and the equipping of track and trains with most of the necessary equipment, the balance of the equation shifts. This is especially so if the cab display requirements for ATP and cab signaling can utilize the same hardware—this aspect is undergoing investigation by British Rail.

Other benefits to flow from a move to cab signaling on British Rail include the following:

- Reducing signaling installation costs by replacing a signal with a marker board,
- Reducing maintenance costs by eliminating lamps at the lineside,
- Flexibility over block lengths and layout design,
- Eliminating complex aspect sequences and controls, and
- Potentially reducing driver route-learning needs.

Another development enabled by ATP will be the advent of trains running at speeds over the current maximum permitted in the United Kingdom of 200 km/hr. The InterCity business has identified potential benefits of being able to run at 225 km/hr over some existing routes and is considering 250 km/hr. The United Kingdom's regulatory body has stipulated that ATP is a safety requirement for speeds over 200 km/hr.

The ATP system will also enable authority to travel at higher speed to be given to the driver in the cab, rather than

by introducing extra lineside aspects. However, some modifications will still be required to the lineside signaling to provide the ATP ground equipment with the information that would otherwise have been displayed by a signal.

Over and above ATP's safety signaling role, it may be possible to include advisory speeds for train regulation purposes over the ATP track/train link. Benefits of energy saving and a quicker service recovery from disruption could result. The control center computers and the communications link to the lineside both require development for this to be realized, but the advent of ATP is, again, an enabling factor.

It will also be possible to add train/track communication to the ATP infrastructure. This opens up the following possibilities:

- "Moving block" in heavily trafficked areas such as the proposed Crossrail tunnel under London, and
- Train detection moving away from lineside systems such as track circuits and axle counters toward a train-based system.

The economics of all these future possibilities depend on British Rail's identifying a business benefit from adopting them. The lessons of the past and of recent studies into innovation on the United Kingdom's network have indicated that, because of British Rail's intensively signaled railway and integrated networked operations, this is best achieved by an evolutionary process.

This latter point is particularly important to bear in mind when considering moves to international standards, especially for the European networks. The economics of railway operation in Europe are such that infrastructure assets need to be exploited to the end of their natural working lives. The funds and the resources are not generally available to engage in premature renewal. The new high-speed lines provide a rare opportunity to start with a clean slate and it is unlikely that the crowded United Kingdom will see many of these. Exploitation of new techniques and possibilities will come from the use of intelligence on the train, enabling it to run over a variety of signaling systems. ATP provides that intelligence on the train for the first time on British Rail.