ERTMS/ETCS (European Railway Traffic and Management System/European Train Control System), Europe’s common train control system, has spread to high-speed lines, in the form of Level 2, in Italy, Spain and the Netherlands following full-scale introduction in Switzerland. China also started commercial operation in June 2011 between Beijing and Shanghai at speeds greater than 300 km/h through CTCS Level 3, which has similar system functions and composition to ERTMS/ETCS Level 2. While it seems that ERTMS/ETCS is being deployed smoothly, some initial development objectives have not been fully achieved yet and this suggests what signal and train control systems should be.

The development of ERTMS/ETCS started in the early 1990s at the UIC (International Union of Railways), aiming at smooth train operation over European borders, i.e. interoperability, by homogeneous train control systems, where systems differed country by country. To allow easy introduction in stages, it has application levels from 1 to 3, and consideration was given to migration to higher levels in stages. Level 1 achieves ATP functions, and these functions are carried out by Eurobalise transponder beacons and onboard equipment. Level 2 achieves a cab-signalling-based train control system using GSM-R radio communications that have a specific frequency allotted for dedicated railway use. Both Levels use track circuits to detect trains. Level 3 achieves Level 2 functions without the use of track circuits. However, system development for major trunk lines has not yet been conducted and a system for rural transport lines came into use in Sweden only in the summer of 2011.

The necessity of introducing ERTMS/ETCS and the conditions to be considered differ by country, especially for Level 2 with its higher control functions. Switzerland introduced Level 2 in 2006, and the reasons for that were clear. In the context of “Bahn 2000”, for the improvement of train connection times at hub stations, it was necessary to operate trains to and from those stations with a shorter headway and to reduce train travelling time on a certain section by building a new high-speed line. The existing train control system in Switzerland, however, could not deal with that task, and a new train control system which enables both shorter headways and higher speeds was required. As ERTMS/ETCS can deal with those functions as well as interoperability across Europe, Switzerland actively introduced the system. The power feeding system in Italy is 3,000V DC, and it needed to be changed to an AC feeding system to improve through service with other countries and rolling stock performance. In terms of train control systems, changing from a DC to an AC feeding system entails an update of the existing track circuit system for transmitting train speed data as well as an update of the train control method. For that reason, these countries introduced ERTMS/ETCS Level 2 at an earlier stage than other countries.

In contrast, Germany and France do not seem to be as assertive in introduction of ERTMS/ETCS. These countries have the LZB and TVM430,
developed in their respective countries, which can operate at faster than 300 km/h. The lifetime of the equipment for those will not be reached for some time, so there is not much need to abandon their systems and actively introduce ERTMS/ETCS. Even in Switzerland, where ERTMS/ETCS was introduced early to achieve Bahn 2000, more than ten years is needed for complete migration of rolling stock to ERTMS/ETCS, coping with the migration with interface modules to existing train control systems. Furthermore, to make introduction of ERTMS/ETCS less expensive on lines other than major trunk lines in Switzerland, extension of Level 1 functions was made by means such as limiting speed check pattern generation to locations related to turnouts.

Some of the major issues ERTMS/ETCS is currently facing are settling on the version of software and the updating of GSM-R radio communications. Migration from the existing systems in individual countries must be considered, and these conditions need to be integrated into ERTMS/ETCS software. In addition, linkage between subsystems from differing manufacturers also is difficult at times, and this affects settling on the software version. With some software versions, trains cannot operate between sections having different versions. GSM-R technology is already obsolete, and migration to next-generation LTE is being studied. For the GSM-R update, new radio communications systems need to be developed from a train control perspective, including how to make the migration.

What does ERTMS/ETCS reflect regarding the ideal form of train and signal control systems?

Regarding ERTMS/ETCS, specifications of subsystems including interfaces with other systems are defined in a very detailed manner for the purpose of interoperability. And, as existing train control systems in the various countries have long lifetimes compared to general equipment, a long time is needed for migration to ERTMS/ETCS. Moreover, interoperability is only achieved when ERTMS/ETCS is introduced to lines of the neighbouring countries. This means, because ERTMS/ETCS is put in place over a long span of time, parts such as GSM-R that have become obsolete technologies need updating, and system improvement or innovation by adding new functions to the train control system is difficult. Train and signal control systems should have the intrinsic purpose of fulfilling the railway management vision, and they should have appropriate system scales and lifetimes to achieve that. Seen from outside Europe, as ERTMS/ETCS puts undue emphasis on interoperability, it has not much flexibility and it seems to be difficult to achieve an attractive railway through new functions. Optimal systems differ depending on conditions, and it appears important to pursue systematically what system configurations are the best for the conditions.

The railway-operator perspective on train and signal control systems will become more important from now on. In Europe, the separation of infrastructure and train operation is progressing as an EU railway policy. Train control systems consist of more than onboard equipment; they are built integrated with the wayside systems. In Japan, it is possible to consider, on the basis of the management vision, what new functions should be added to the train and signal control system, and actively working on this issue is important. Furthermore, there are many systems closely related to train and signal systems such as train operation control systems and equipment maintenance management systems. Although those systems have been developed and deployed independently to date, studying the optimal composition of railway systems as a whole with an all-round view is also of significance. Academically, the “system of systems” approach is becoming a new scholarly discipline. That approach deals with conditions to achieve objectives in large-scale, complex systems along with design and assessment methods. As railways are large-scale and complex systems, system of systems efforts from the perspective of a railway operator with a management vision that also considers customers are thought to be beneficial.

Moreover, a railway-operator perspective is important for RAMS (reliability, availability, maintainability and safety), which is an index in train and signal control system development, operation, and maintenance which serves as an international standard stipulating the conditions required to accomplish such tasks. In the lifecycles of the RAMS, although manufacturers bear the major role in the development phase, train operators bear the major role in the phases for operation and maintenance. Train operators also set performance targets for systems and hold the operation results data, and, utilizing that data, strategic efforts can be made on how to shape train and signal control systems. Such efforts are, however, difficult in the situation of separation of infrastructure and train operation.

We can learn much from the March 11, 2011 Tohoku earthquake and tsunami. RAMS has been applied to operational delays from equipment failure, but a new perspective is also needed which, for adaptability to and resilience against large-scale irregularities, includes asignment of roles to and cooperation from the system customers. Such consideration is possible because the railway operator owns the infrastructure and systems as well as operates the trains. For train and signal control, systems based on fail-safe technologies have been built instead of making excessively quantitative safety evaluations. From now on, the prudent approach to train and signal control systems where high levels of safety are required, including safety measures again possible failures large and small, is of greater significance.

It is important to work on train and signal control from both a railway operator and a customer perspective to achieve sustained strategic development of Japanese railway systems in a world that, with the addition of developing nations, is becoming increasingly tough.