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PROJECT NEAR² –NETWORK OF EUROPEAN/ASIAN RAIL RESEARCH CAPACITIES (SIGNALLING SYSTEMS)

Introduction

Railway signalling systems have to ensure the safe movement of freight and passenger trains. Lately, their design and operation has become increasingly complex. Therefore we will make the classification of the European-Asian railway modern signalling systems (on stations, between stations), taking into account possibility of ensuring the safety for various speeds of movement.

Signalling systems in European railways

The European Union's (EU) aspiration for railway systems that are interoperable across Europe is driven by the need to service a market that is open within and across industrial sectors and national boundaries. This in turn requires that the technologies and operational procedures that underpin the railway systems facilitate not only interoperability but also enhancement of safety, capacity and efficiency. The European Railway Traffic Management System (ERTMS/ETCS) is designed to enable interoperability through use of one unique signalling system as opposed to conventional signalling systems [1].

Table 1

ETCS levels and functionality.

ETCS level	Train detection	Driver notification	Description
0	ETCS fitted train travelling on unfitted infrastructure		
1	Balise at signal or balise at signal with infill	Signal and driver machine interface	Communication via balise - no data radio communication. Line-side signals retained. Line-side Equipment Unit Train position is determined trackside. No radio block centre.
2	GSM-R	Signal and driver machine interface	Communication via GSM-R radio. No requirement for line-side signals/line-side equipment unit or track detection device Train position is determined trackside.
3	GSM-R	Driver machine interface	Communication via GSM-R radio. No line-side signals. Train position determined onboard.

The expected status deployment of ERTMS on European railways presented on Fig.1.

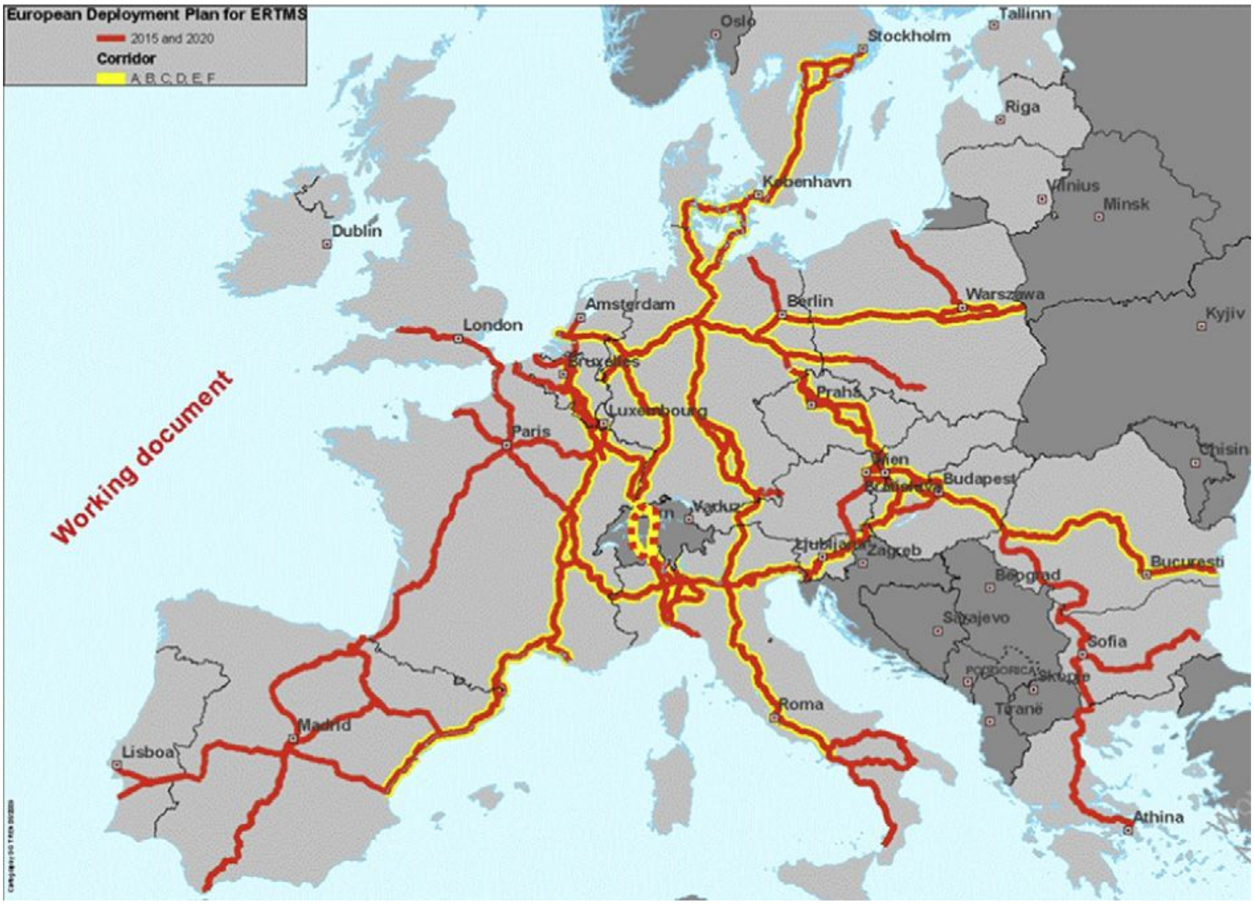

Figure 1. ERTMS deployment throughout Europe [1]

Chinese Train Control System (CTCS)

There are very similar features between Chinese and European Railways in terms of train operation mode and train control. ETCS (European Train Control System), supported by the EU and the European Industrials, has been finalized as the technical standard of train control systems in Europe after more than ten years effort [2].

Modern CBTC systems consist of four parts (Fig. 2):

- the Control Centre System which controls the operation;
- the Wayside System which receives train positions and issues Movement Authorities to assure the safe running of the trains;

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- - the Vehicle System that generates the train position and receives the movement Authorities and assures the compliance of the Movement Authorities;
- the Communication System which allows the transfer of messages to and from the train.

CTCS has several levels:

- CTCS-0: Track Circuit + Cab Signalling + LKJ2000;
- CTCS-1: Track Circuit + Cab Signalling + LKJ2000 + Balise;
- CTCS-2: Track Circuit + Balise + ATP, the track circuit is used both for block occupation detection and movement authorization, its architecture is similar to TVM-300;
- CTCS-3D: Track Circuit + Balise + ATP CTCS-3D is equivalent to the European ETCS Level-1;
- CTCS-3: Balise + GSM-R + ATP, using CTCS-2 as the backup system, CTCS-3 is equivalent to the European ETCS Level-2 + CTCS-2;
- CTCS-4: Balise + GSM-R + ATP, moving block.

Following important railway lines are already completed fitted with GSM-R [3]:
- (115 km Jing-Jin line) HSR Beijing – Tianjin;
- (156 km He-Ning line) HSR Hefei – Nanjing;
- (189 km Shi-Tai line) HSR Shijiazhuang – Taiyuan;
- (357 km He-Wu line) HSR Hefei – Wuhan;
- (279 km Yong-Tai-Wen line) HSR Ningbo – Wenzhou;
- (294 km Wen-Fu line) HSR Wenzhou – Fuzhou;
- (1 956 km Qingzang line) Lhasa-Geermu railway line;
- (653 km Daqing line) Datong – Tianjin railway line;
- (968 km Wu-Guang line) HSR Wuhan – Guangzhou;
- (393 km Jiao-Ji line) Qingdao – Jinan railway line;
- (455 km Zheng – Xi line) HSR Zhengzhou – Xian;
- (275 km Fu-Xia line) HSR Fuzhou – Xiamen;
- (116 km Guang-Shen line) HSR Guangzhou Shenzhen;
- (308 km Chang-Jiu line) HSR Nanchang – Jiujiang;
- (1318 km Jing – Hu line) HSR Beijing – Shanghai;
- (111 km Chang-Ji line) HSR Changchun – Jilin;
- (308 km Hainan line) HSR Haikou-Sanya.

On major sections of the following lines, GSM-R has been installed: (2 553 km Jing-Jiu line)

- Beijing – Hong Kong railway line;
- (261 km Wu-Jiu line) Wuhan – Jiujiang railway line.

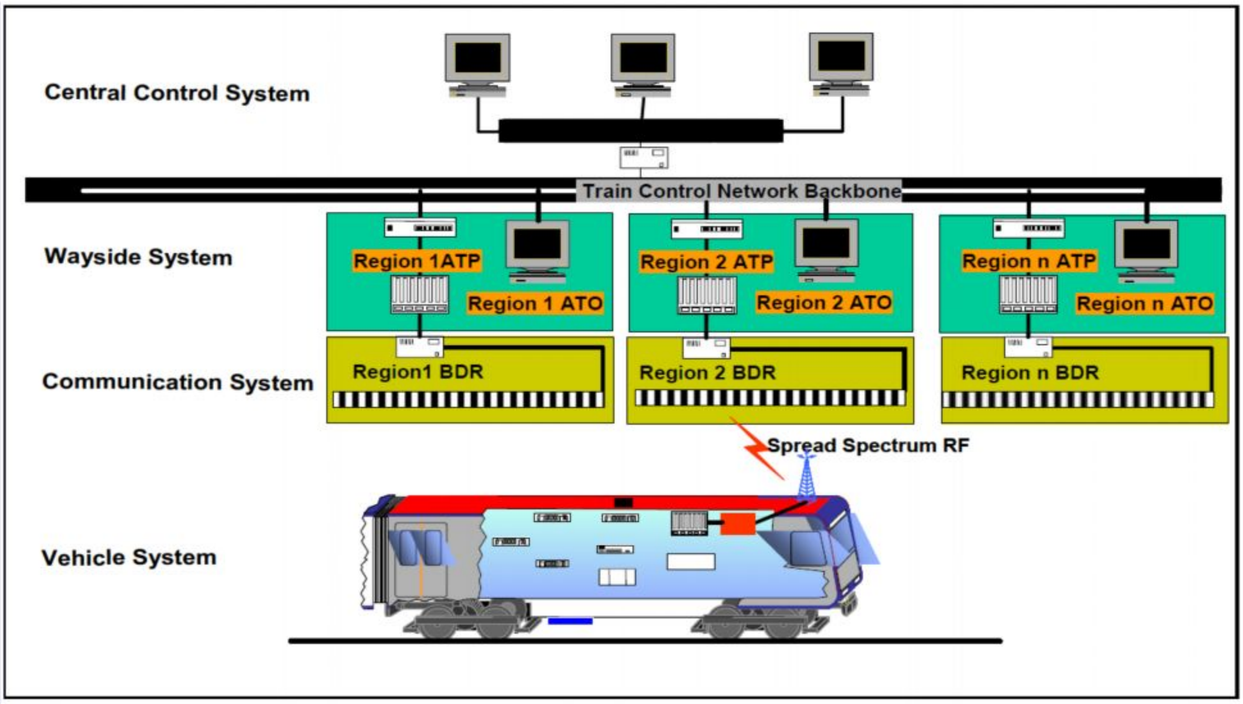


Figure 2. Block Diagram of a modern CBTC system.

CTCS on China railways is presented on Fig.3.

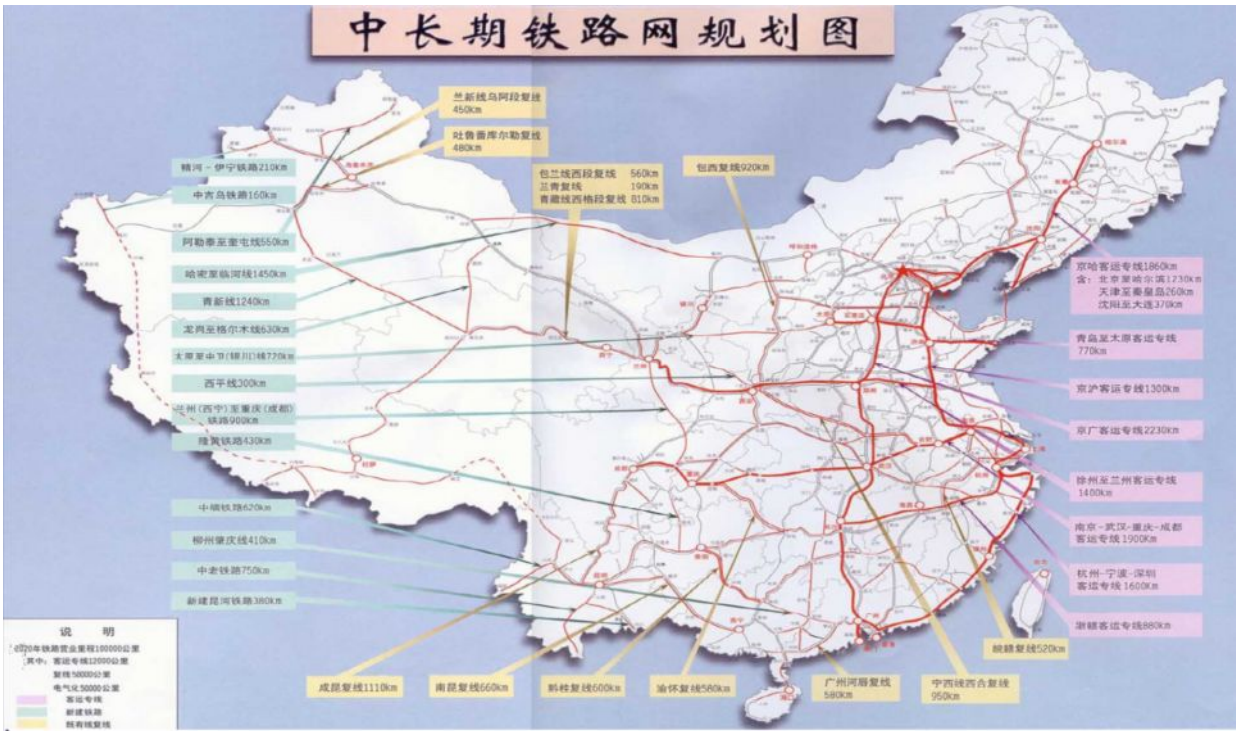


Figure 3. CTCS on Chinese railways

Indian (Pakistan) railway signalling systems[4]

The absolute block system is the most widespread method of train working on Indian railway. The block sections may be handled manually or automatically, or by some combination of those. Some sections still use different forms of physical token systems such as the Neale's Ball Token instruments.

AWS (Automatic Warning System) is an in-cab signal warning system, is used in suburban EMU systems, primarily Mumbai. It was proposed for main lines including New Delhi - Agra, Howrah - Mughalsarai, etc.

A Train Management System (TMS) from Bombardier is used on the Mumbai suburban system (Churchgate - Virar) which provides centralized online monitoring of train positions.

Around Chennai, several suburban stations have their signals automatically controllable from Basin Bridge using a fault-tolerant system that interconnects the signalling of up to 32 stations using a dual fibre-optic ring. This system also provides for 6 voice channels for communication among these stations. This system was developed indigenously by SR, the Dept. of Electronics, and IIT Madras.

A lot of variety of systems areused on the Indian railways, for example:

- Mumbai CSTM – Badlapur: Automatic Multiple Aspect Colour Light Signals;
- Badlapur - Pune - Daund : Manually controlled Multiple Aspect Colour Light Signals;
- Daund - Manmad : Lower Quadrant Semaphore signals;
- Daund - Solapur: Some stretches of Multiple Aspect Colour Light Signals and some sections of Tokenless Upper quadrant semaphore;
- Pune - Miraj - Kolhapur : Neale's ball token instrument;
- Batala - Qadian, GarhiHarsuru - Farukhnagar : One Train Only system;
- Tilwara - TilwaraMela : Train Staff and Ticket system.

In order to ensure that the signalling system never provides unsafe (conflicting) signals and the points are not set for more than one train that might end up proceeding on to the same section of track and hence suffering a collision, various schemes have been developed to coordinate the settings of the points and the signals within the region controlled by a signalbox or signal cabin. On the Indian railways are used the following interlocking systems:

- Mechanically operated interlocking;
- Manually operated interlocking;
- Hepper's Key Transmitter;
- Electrically operated interlocking.

There are three levels of interlocking used by Indian railways:

I - interlocked station has mechanical interlocking.

II - interlocked station may be mechanically or electrically interlocked (usually the latter).

III - interlocked station has points and signals that are either interconnected mechanically within the same mechanism, or electrically as with route-relay and panel interlocking.

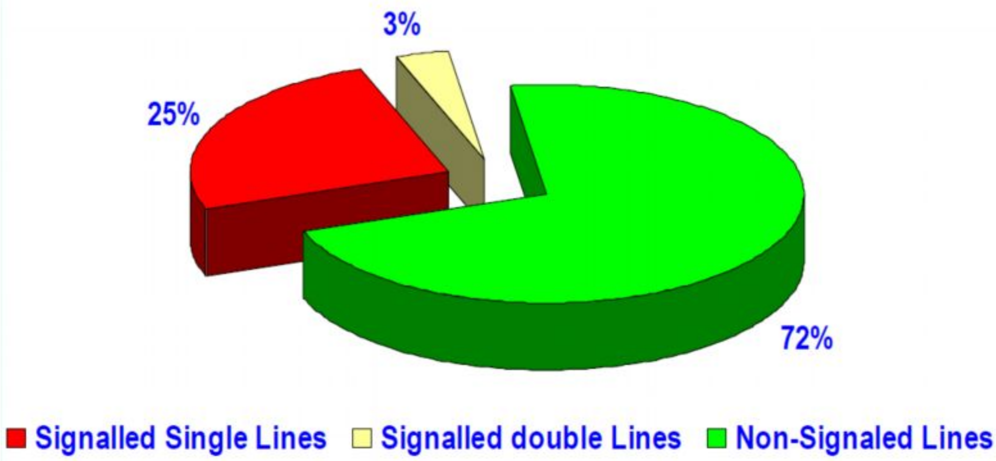
Indian railways department is looking into procuring ETCS level 2 equipment to be installed on the trunk lines between the four major metropolises, and later on other main lines.

Indian railways department is also considering the use of GSM-R technology on parts of its network. Siemens AG is supplying GSM-R equipment for 700 route-km of the NFR in West Bengal, Assam, and Bihar as an initial project for IR to experiment with the technology. The North Central and East Central zones are also setting up some GSM-R services.

A Train Protection and Warning System (TPWS), based on ETCS Level 1 has been proposed for the Chennai Beach - Gummidipoondi section. EMUs will be monitored using track balises and lineside transmission devices (LEU or Lineside Electronic Unit).

ERTMS projects in TCDD (Turkish Railways)

Current situation with signalling systems in TCDD Railway Network:



Length of Railways: 10.991 km
Main Line: 8.697 km,
Secondary Line: 2.294 km
Electrified Lines: 2.336 km
Signaled Lines: 3.111 km

Figure 4. ERTMS projects on Turkish Railways

High speed train projects: Ankara – Istanbul, Ankara – Konya, Ankara – Sivas. New systems which will be introduced within the project:
- ERTMS/ETCS L1 and GSM-R;
- Electronic interlocking (SSI), SIL4;
- CTC in Ankara & Local Control in all stations;
- Way-side signaling system;
- Jointless track circuits, point machines and point;
- Heating system;
- Way-side telephones;
- Wheel detection system.

Signalling systems of the post-Soviet countries (Russian Federation, Ukraine, Belarus, Latvia, Lithuania, Estonia)

The railways of post-Soviet countries use the interlocking systems on stations and the blocking systems between stations.There are used the specially designed electric relays to increase safety in these systems.

A part of interlocking and blocking systems is ALSN. It is a train control system meaning Continuous Automatic Train Signalling used widely on the main rail lines of the post-Soviet countries. It uses modulated pulses inducted into rails similar to the Italian RS4 Codici and American Pulse Code Cab Signaling. On the high-speed lines the variant ALS-EN is used which takes advantage of a double phase difference modulation carrier frequency.

Since the 1990s, the Russian Railways has introduced a computerized successor system KLUB-U which requires either ALSN only or both, ALSN and ALS-EN sensors for compatibility. In ERTMS the ALSN/ALS-EN systems are listed as ETCS Class-B systems.

Types of the signaling systems by countries [5]

- **ALSN** (Russian Federation, Belarus, Estonia, Latvia, Lithuania, Ukraine)

- **ATC** (Sweden, Denmark, Norway, Brazil, South Korea, Japan, Iran). Automatic Train Control (ATC) is the term for a general class of train protection systems for railways that involves some sort of speed control mechanism in response to external inputs.

ATC systems tend to integrate various cab signalling technologies and the use more granular deceleration patterns in lieu of the rigid stops encountered with the older Automatic Train Stop technology. ATC can also be used with Automatic train operation (ATO) and is usually considered to be the safety-critical part of the system.

- **BACC** (Italy). BACC is a train protection system used byItalian railways, which use 3kV DC electrification. The term "**BACC**" is an abbreviation of "Bloccoautomatico a correnticodificate" - automatic block system with codified currents.

- **EBICAB** (Bulgaria, Finland, Norway, Portugal, Spain, Sweden). EBICAB is a trade mark registered by Bombardier for the equipment on board a train used as a part of an Automatic Train Control system. These on-board systems use pairs of balises mounted on the sleepers. The pairs of balises distinguish signals in one direction from the other direction with semicontinuous speed supervision, using a wayside to train punctual transmission using wayside transponders.

- **EVM-120** (Hungary). The EVM-120 (EVM-160) system equips the locomotives, capable to gather the speed of 120 (160) km/h.System have a cab signal, this shows the "lights" of next signals.

- **HKT** (Denmark). HKT-system (Danish: HastighedsKontrologTogstop, SpeedCheck and Trainstop) permits trains with active cab signals to run without the need for lineside signals. Lineside signals are provided on such lines, though only as a fall-back measure for trains with failed cab signals.Trains are permitted to follow each other in blocks sections of so called HKT-sections (Danish: HKT-afsnit), separated by rectangular red and white signs. The Automatic Block Signals are approach lit and normally show the special "Conditional Stop" aspect, permitting trains with active cab signal to proceed.

- **Integra-Signum** (Switzerland). These systems asks the train driver to confirm distant signals that show stop and distant or home signals that show caution. If he does not confirm or passes a home signal that shows stop, the train is stopped automatically. This is achieved by interrupting the power supply to the motors and applying the emergency brake.

- **LZB** (Germany, Austria, Spain). "Linienzugbeeinflussung" (or LZB) is a cab signalling and train protection system used on selected German and Austrian railway lines as well as the AVE in Spain. In Germany, the system is mandatory on all lines where trains exceed speeds of 160 km/h (99 mph) (200 km/h or 120 mph in Spain), but it is used on some slower lines to increase capacity. The German LZB translates to continuous train control.

- **LS** (Czech republic, Slovakia). S (stands for "LiniovýSystém" in Czech, "continuous system" in English) is a cab signalling and a train protection system used on the main lines of the Czech and Slovak railways (on all lines which track speed exceeds 100 km/h in the Czech republic or 120 km/h in Slovakia). This system continuously transmits and shows a signal aspect of the next main signal in driver's cabin and when the driver's activity is needed (e.g. reduction of train's speed), it periodically checks the driver's vigilance (he has to press the "vigilance" button; else the emergency brake is applied). This is the main function of on-board part of the LS-system (continuous cab signalling and checking the driver's vigilance when needed).

- **PZB/Indusi** (Germany, Austria, Romania, Slovenia, Croatia, Bosnia-Herzegovina, Serbia, Montenegro, Macedonia, Israel). PZB/Indusi is a family of intermittent train control systems and it is a predecessor of the German Linienzugbeeinflussung (LZB, "continuous train protection") system. Originally Indusi provided warnings and enforced braking only if the warning was not acknowledged (similar to traditional automatic train stop) but current developments of PZB provide more enforcement.

- **SHP** (Poland). Poland uses an AWS system call SHP (SamoczynneHamowaniePociagu) which uses magnetically coupled resonant circuits operating at 1000Hz. The impact of the railway vehicle in the sphere of electromagnetic compatibility on the rail traffic control systems mounted on the railway infrastructure and onto the rail network, are tested and evaluated in the proceedings concerning the issue of a certificate ofauthorization of a rail vehicle.

- **SCMT** (Italy). "Sistema di Controllodella Marcia delTreno" - SCMT is a discontinuous train cab signalling system used in Italy. It shares many features with the "RipetizioneSegnali" - RS system, the two systems co-existing and working together. The main purpose of SCMT is to control the respect of the speed limit imposed by the signal aspect and the line condition.

- **TASC** (Japan). A Train Automatic Stopping Controller (TASC), also known as a position stopping device, is a train protection system used only in Japan. It allows trains equipped with TASC to stop automatically at stations without the need to operate the brakes manually.

- **TVM** (France, South Korea). Transmission Voie-Machine (TVM, English: track-to-train transmission) is a form of in-cab signalling originally deployed in France and used on high-speed railway lines. TVM-300 was the first version, followed by TVM-430.The line is divided into signal blocks of about 1,500 metres (~1 mi), the boundaries of which are marked by blue boards printed with a yellow triangle. Dashboard instruments show the maximum permitted speed for a train's current block, as well as a target speed based on the profile of the line ahead. The maximum permitted speed is based on factors such as the proximity of trains ahead (with steadily decreasing maximum permitted speeds in blocks closer to the rear of the next train), junction placement, speed restrictions, the top speed of the train and distance from the end of LGV route. Trains at high-speed take several kilometres to stop. Since trains will require more than one signal block to slow down, drivers are alerted to reduce speed gradually, several blocks before any required stop.

- **ZUB 123** (Denmark). The ATC system is technically referred to as ZUB 123 and has since the beginning been fine-tuned to handle all specific Danish traffic situations and rules. Today ATC has been installed in about 500 vehicles and on the majority of all Danish main sections and on some branch lines. ATC has been approved in compliance with Mü 8004 (the safety level that corresponds to CENELEC SIL 4.)

According to the European research project NEAR² (under FP7) identified existing alternative routes for the Europe-Asia railway connection

A: Connection: Western Europe – Russian Far East - Japan

A1: Via main Trans - Siberian railway network: Poland -Belarus or Ukraine-Russia (Moscow- Novosibirsk – Irkutsk-Vladivostok or Nakhoka) – Japan (Sea of Japan)

B: Connection: Western Europe – China via the Trans – Siberian route and its branches

B1: Via branch of the Trans - Siberian railway network and the Manchurian route: Poland-Belarus or Ukraine-Russia (Moscow-Novosibirsk-Karymskaya-Zabaykalsk)– China (Harbin-Beijing via Manchuria)

B2: Via branch of the Trans - Siberian railway network and the Trans Kazakh route: Poland-Belarus or Ukraine-Russia (Moscow-Yekaterinburg-Kurgan)–Kazakhstan (Petrovavlosk–Astana-Dostyk)–China (Lanzhou-Zhengzhou-Beijing)

B3: Via branch of the Trans - Siberian railway network and the Mongolian route: Poland-Belarusor Ukraine-Russia(Moscow-Novosibirsk-Ulan-Ude-Naushki)– Mongolia(Zamyn Uud)-China(Beijing)

C: Connection: Western Europe – China via the TRACECA corridor (Silk Road)

C1: Via the TRACECA – Turkmenbashi rail route

C1.1: WesternEurope–Slovakia(Bratislava)-Hungary(Budapest)-Romania(Bucharest,Constanta) or Bulgaria(Varna)-Black sea-Georgia(Poti-

Gardabani)– Azerbaijan(BoyukKasik-Baku)– Caspian Sea-Turkmenistan(Turkmenabad)– Uzbekistan(KhodzaDavlet–Keles)– Kazakhstan(SaryAgash–Almaty-Dostyk)– China(Lanzhou-Zhengzhou-Beijing).

C1.2: Western Europe-Slovakia(Bratislava)– Hungary(Budapest)-Romania(Bucharest)– Bulgaria-Turkey–Azerbaijan(Boyuk Kasik-Baku)–Caspian Sea-Turkmenistan(Turkmenabad)– Uzbekistan(KhodzaDavlet–Keles)– Kazakhstan(SaryAgash–Almaty-Dostyk)– China(Lanzhou-Zhengzhou-Beijing).

C2: Via the TRACECA – Aktau route

C2.1 (land detour of the Black Sea through Ukraine and Russia): Western Europe– Slovakia(Bratislava)–Ukraine(Chop-Fastov-Dnepropetrovsk)–Russia(Rostov-Krasnodar)-Georgia (Poti -Gardabani) – Azerbaijan (BoyukKasik-Baku) – Caspian Sea - Turkmenistan (Turkmenabad) – Uzbekistan (KhodzaDavlet –Keles) – Kazakhstan (SaryAgash – Almaty - Dostyk) – China (Lanzhou-Zhengzhou-Beijing).

C2.2: In C1.2 the section Caspian Sea - Turkmenistan (Turkmenabad) – Uzbekistan (KhodzaDavlet –Keles) – Kazakhstan (SaryAgash – Almaty - Dostyk) is replaced by the section Caspian Sea - Kazakhstan (Aktau-Makat-Kandagash - SaryAgash – Almaty - Dostyk).

D: Connection: Western Europe – China via the Central Corridor in Kazakhstan

Western Europe - Poland -Belarus or Ukraine - Russia (Moscow - Aksaralskaya) - Kazakhstan (Ganushkino –Makat - Kandagash-Almaty - Dostyk) – China (Lanzhou-Zhengzhou-Beijing).

E: Connection: Western Europe – India via the Trans- Asian railway route

Western Europe - Slovakia (Bratislava) – Hungary - Bulgaria - Turkey –Iran-Pakistan - India (New Delhi).

Results of analysis of signaling systems for identified existing alternative routes for the Europe-Asia railway connection:

Table 2

Signalling systems of the A route

Country/Types of systems	Length of route (km)
Poland/ETCS L1	**500 (3,9%)**
Ukraine/ALSN	**990 (7,6%)**
Belarus/ALSN	**250 (1,9%)**
Russia/ALSN	**11230 (86,6%)**
Total length railway corridors **A1**	**12970 (100%)**

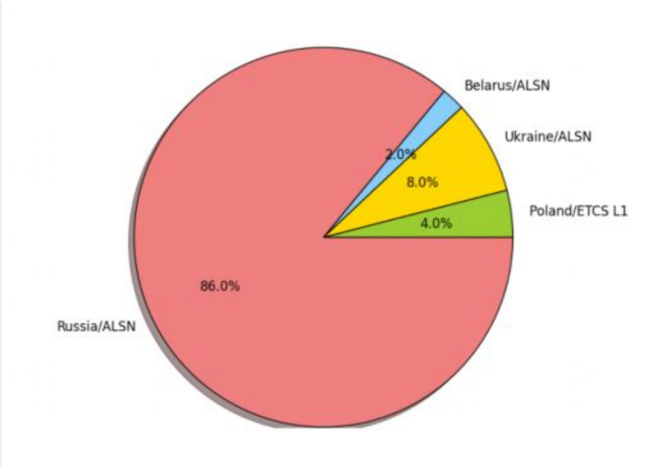


Table 3

Signalling systems of the A1 route

Country/Types of systems	Length of route (km)
Poland/ETCS L1	**500 (4,3%)**
Ukraine/ALSN	**990 (8,5%)**
Belarus/ALSN	**250 (2,1%)**
Russia/ALSN	**7650 (65,5%)**
China/CTCS	**2250 (19,6%)**
Total length railway corridors **B1**	**11670 (100%)**

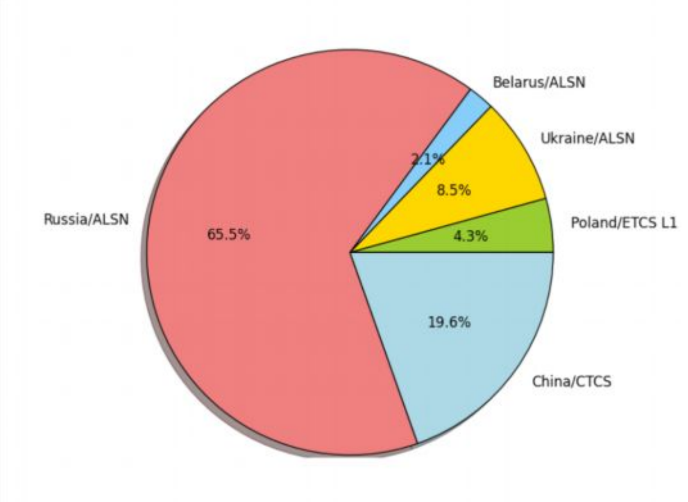


Table 4

Signalling systems of the A2 route

Country/Types of systems	Length of route (km)
Poland/ETCS L1	**500 (4,7%)**
Ukraine/ALSN	**990 (9,5%)**
Belarus/ALSN	**250 (2,4%)**
Russia/ALSN	**2450 (23,5%)**
Kazakhstan/ALSN	**2050 (19,6%)**
China/CTCS	**4200 (40,3%)**
Total length railway corridors **B2**	**10440(100%)**

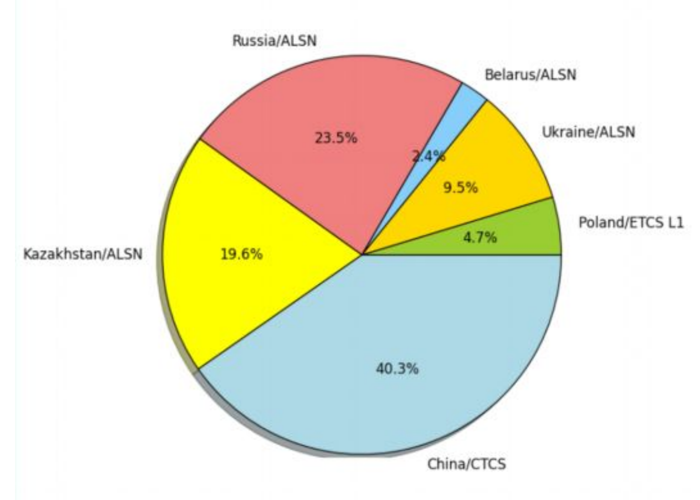


Table 5

Signalling systems of the B route

Country/Types of systems	Length of route (km)
Poland/ETCS L1	**500 (4,3%)**
Ukraine/ALSN	**990 (8,6%)**
Belarus/ALSN	**250 (2,2%)**
Russia/ALSN	**6780 (58,7%)**
Mongolia/ALSN	**2200 (19,0%)**
China/CTCS	**840 (7,2%)**
Total length railway corridors **B3**	**11560 (100%)**

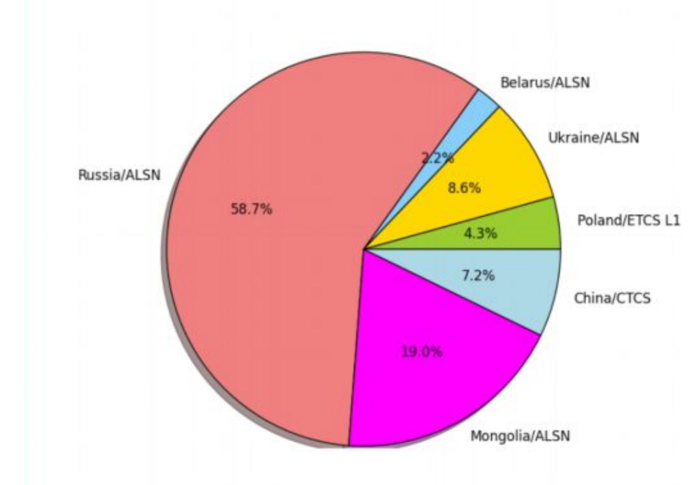


Table 6

Signalling systems of the B1 route

Country/Types of systems	**Length of route (km)**
Slovakia/ETCS L1	**150 (1,3%)**
Hungary/ETCS L1	**300(2,6%)**
Romania/ETCS L1	**900 (7,9%)**
Georgia/ALSN	**370 (3,2%)**
Azerbaijan/ALSN	**500 (4,4%)**
water route	**1270 (11,2%)**
Turkmenistan/ALSN	**1120 (9,8%)**
Uzbekistan/ALSN	**730 (6,4%)**
Kazakhstan/ALSN	**1820 (16,0%)**
China/CTCS	**4200 (37,2%)**
Total length railway corridors **C1.1**	**11360 (100%)**

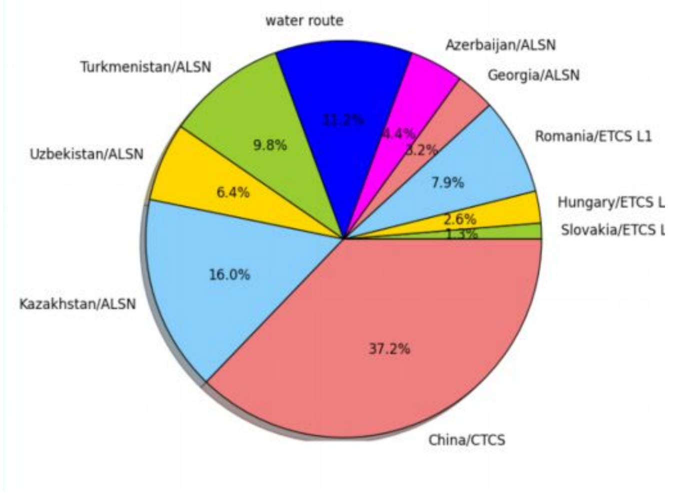


Table 7

Signalling systems of the B2 route

Country/Types of systems	**Length of route (km)**
Slovakia/ETCS L1	**150 (1,2%)**
Hungary/ETCS L1	**300 (2,4%)**
Romania/ETCS L1	**740 (5,9%)**
Bulgaria/ETCS L1	**340 (2,7%)**
Turkey/ETCS	**2000 (16,0%)**
Armenia/ALSN	**160 (1,3%)**
Georgia/ALSN	**110 (0,9%)**
Azerbaijan/ALSN	**500 (4,0%)**
water route	**270 (2,1%)**
Turkmenistan/ALSN	**1120 (9,0%)**
Uzbekistan/ALSN	**730 (5,8%)**
Kazakhstan/ALSN	**1820 (14,6%)**
China/CTCS	**4200 (34,1%)**
Total length railway corridors **C1.2**	**12440 (100%)**

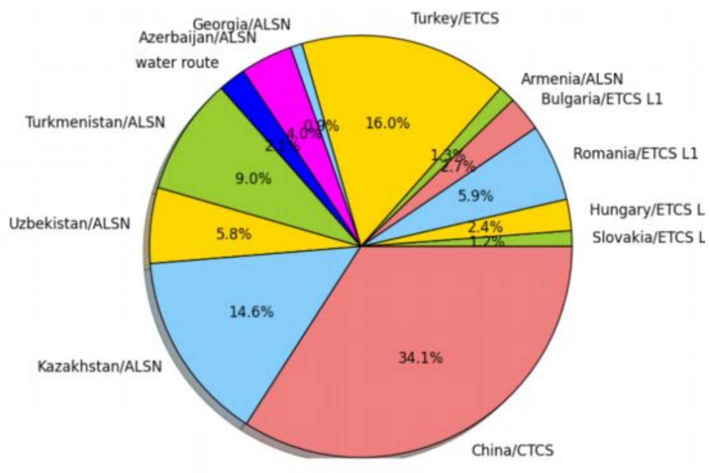


Table 8

Signalling systems of the B3 route

Country/Types of systems	**Length of route (km)**
Slovakia/ETCS L1	**545 (4,6%)**
Ukraine/ALSN	**1670 (14,2%)**
Russia/ALSN	**1200 (10,2%)**
Azerbaijan/ALSN	**210 (1,8%)**
water route	**270 (2,3%)**
Turkmenistan/ALSN	**1120 (9,5%)**
Uzbekistan/ALSN	**730 (6,2%)**
Kazakhstan/ALSN	**1820 (15,4%)**
China/CTCS	**4200 (35,8%)**
Total length railway corridors **C2.1**	**11765 (100%)**

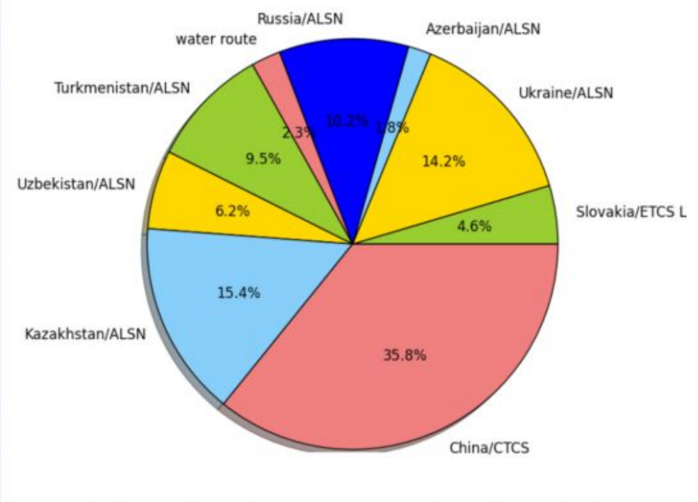


Table 9

Signalling systems of the C route

Country/Types of systems	**Length of route (km)**
Slovakia/ETCS L1	**545 (4,3%)**
Ukraine/ALSN	**1670 (13,3%)**
Russia/ALSN	**1200 (9,5%)**
Azerbaijan/ALSN	**210 (1,7%)**
water route	**370 (2,9%)**
Kazakhstan/ALSN	**4390 (34,9%)**
China/CTCS	**4200 (33,4%)**
Total length railway corridors **C2.2**	**12585 (100%)**

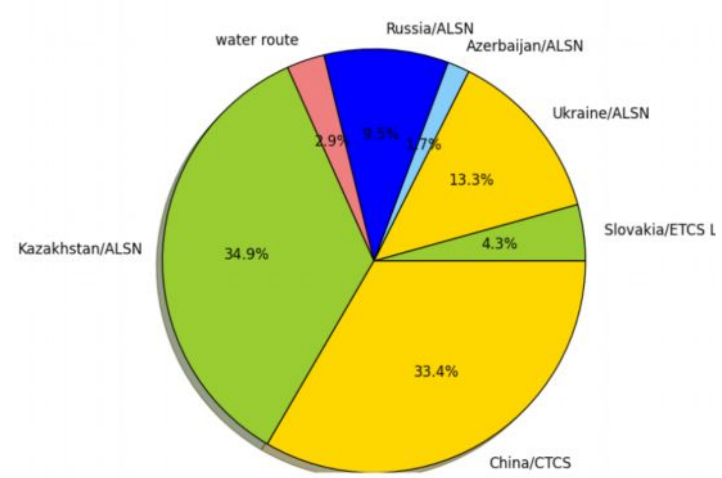


Table 10

Signalling systems of the D route

Country/Types of systems	Length of route (km)
Poland/ETCS L1	**500 (4,2%)**
Ukraine/ALSN	**990 (8,3%)**
Belarus/ALSN	**250 (2,1%)**
Russia/ALSN	**1865 (15,6%)**
Kazakhstan/ALSN	**4140 (34,6%)**
China/CTCS	**4200 (35,2%)**
Total length railway corridors **D**	**11945 (100%)**

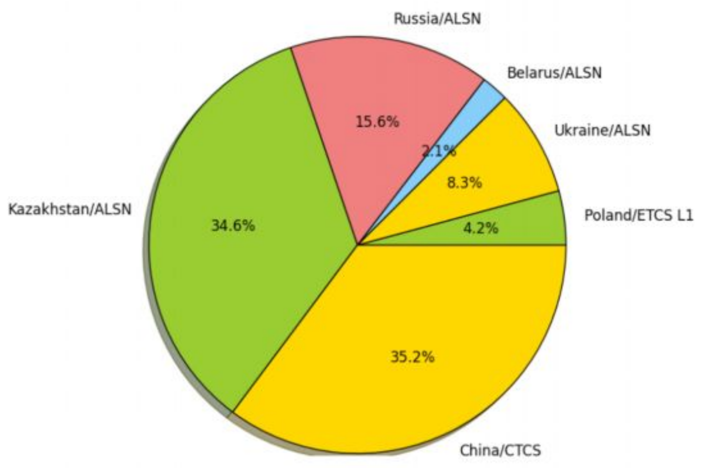
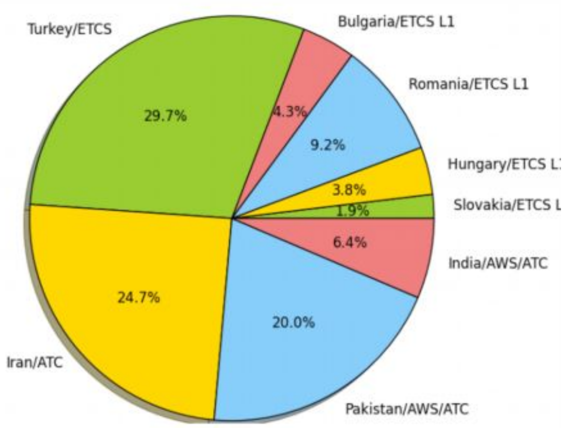


Table 11

Signalling systems of the E route

Country/Types of systems	Length of route (km)
Slovakia/ETCS L1	**150 (1,9%)**
Hungary/ETCS L1	**300 (3,8%)**
Romania/ETCS L1	**740 (9,2%)**
Bulgaria/ETCS L1	**340 (4,3%)**
Turkey/ETCS	**2370 (29,7%)**
Iran/ATC	**1970 (24,7%)**
Pakistan/AWS/ATC	**1600 (20,0%)**
India/AWS/ATC	**500 (6,4%)**
Total length railway corridors **E**	**7970 (100%)**



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Abstracts:

Results of works within the project NEAR² on creation of the European-Asian network of researches regarding infrastructure and the signalling system are presented.

Keywords: NEAR² ,European-Asian network of researches

Представлены результаты работ в рамках проекта NEAR² по созданию Европейско-Азиатской сети исследований в части инфраструктуры и сигнализации.

Ключевые слова: NEAR², Европейско-Азиатская сеть исследований

Представлені результати робіт у межах проекту NEAR² зі створення Європейсько-Азіатської мережі досліджень в частині інфраструктури та сигналізації.

Ключові слова: NEAR², Європейсько-Азіатська мережа досліджень