



西南交通大学
Southwest Jiaotong University



Chinese High Speed Railway Train Control System

Changlin Wang



Outline

■ Overview of China High Speed Railway

- I . China High-speed Railway Definitions
- II . Development Goals
- III. Mid & Long-term Railway Network Plan

■ (CTCS) Chinese Railway Train Control System

- I . The target of CTCS
- II . CTCS Classification

■ CTCS-2

- I . Structure and function of CTCS-2
- II . Operation principle of CTCS-2

■ CTCS-3

- I . Structure and function of CTCS-3
- II . Operation principle of CTCS-3
- III. GSM-R wireless communication network in CTCS-3
- IV. Evaluation of CTCS-3 system



Overview of China High Speed Railway

I . China High-speed Railway Definitions



II .Development Goals



III. Mid & Long-term Railway Network Plan





China High-speed Railway Definitions

China high-speed railway includes 4 parts:

1. Passenger Dedicated Line



2. Intercity Transport System



3. Updated conventional railways



4. New lines for improving railway network





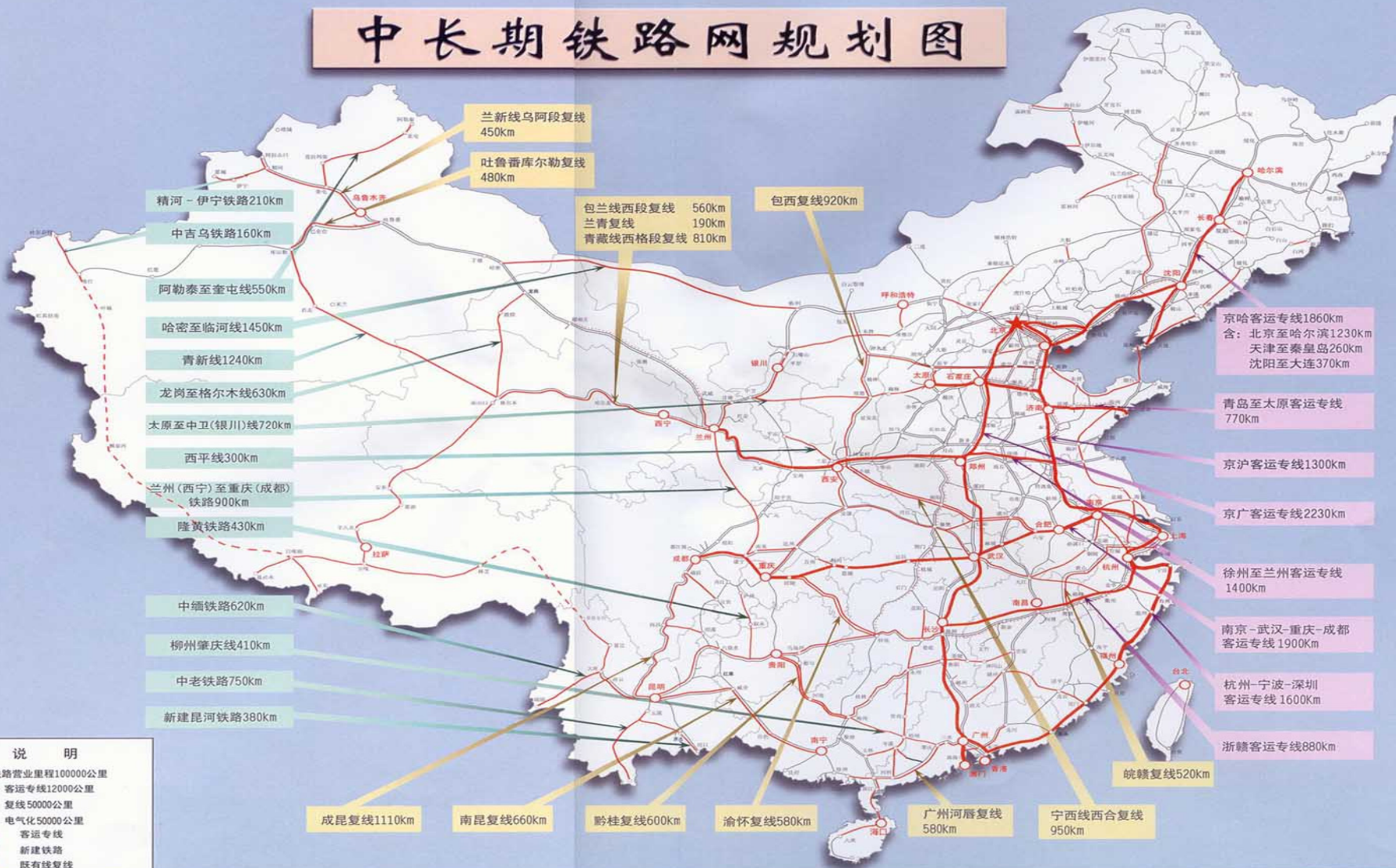
High speed Railway Development Goals

- **Target for 2020:**
 - **The railway length shall exceed 120,000km , double track and electrified account respectively for over 50% and 60%.**
 - **Main busy trunk realize separation of passenger and freight traffic.**
 - **Transport capacity shall meet the need of economic and social development.**
 - **Main technical equipment shall reach or get close to international advanced level.**



Mid & Long-term Railway Network Plan

中长期铁路网规划图





Chinese Railway Train Control System (CTCS)

I . The target of CTCS



II. CTCS Classification





The target of the CTCS

- Learned from Europe Train Control System (ETCS) development and foreign experience in high-speed rail control system, combined with Chinese railway transportation characteristics, and followed the principle of unified planning the whole railway, Chinese Ministry of Railway (MoR) determined to build Chinese Train Control System (CTCS).



The target of CTCS

The target of CTCS is to

- **Improve safety and transportation efficiency**
- **Meet interoperability, and system design specifications**
- **Classification system to meet development needs**



The Classification of CTCS

CTCS-4	<ul style="list-style-type: none">▪ Based on the GSM-R platform of wireless communication, it cancels the track circuit, achieves virtual / mobile block▪ The direction of development in the future
CTCS-3	<ul style="list-style-type: none">▪ Based on the GSM-R platform of wireless communication, the locomotive crew drive the train with the help of cab signal, equipped on-board equipment of ATP which based on 2x2 take 2 vital computer▪ For the 300-350km/h line, the follow-up interval of Bullet-Train reduces to 3 minutes
CTCS-2	<ul style="list-style-type: none">▪ Based on the Balise and the track circuit transmission, the locomotive crew drive the train with the help of cab signal , equipped on-board equipment of ATP which based on 2x2 take 2 vital computer▪ It has been used in current 200-250km/h line, equipped ZPW-2000A type track circuit.
CTCS-1	<ul style="list-style-type: none">▪ Consist of the main cab signal and security operation monitoring and recording devicesLKJ-2000▪ Equiped Localization track circuit of ZPW-2000
CTCS-0	<ul style="list-style-type: none">▪ Consist of universal cab signal, the monitoring and recording devices (Ordinary) , equipped domestic track circuit▪ Apply to existing railway lines



CTCS-2

I . Structure of CTCS-2



II . Function of CTCS-2



III. Operation principle of CTCS-2

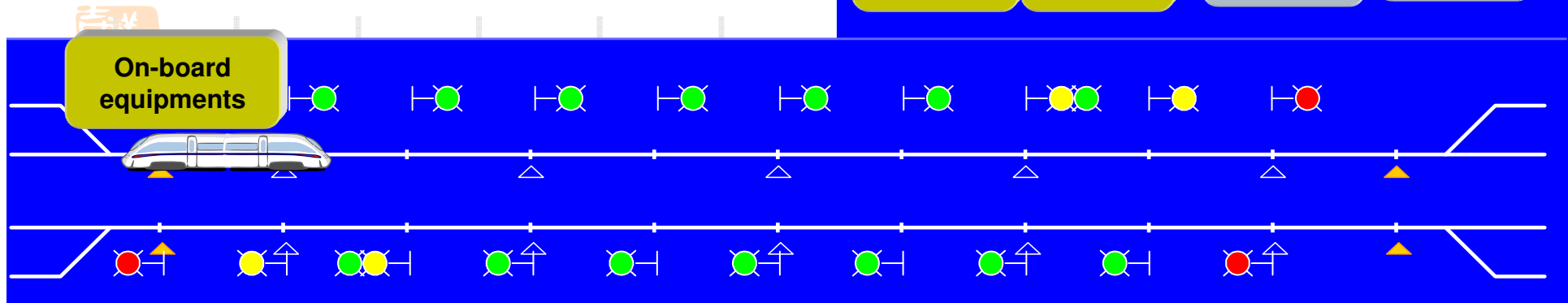
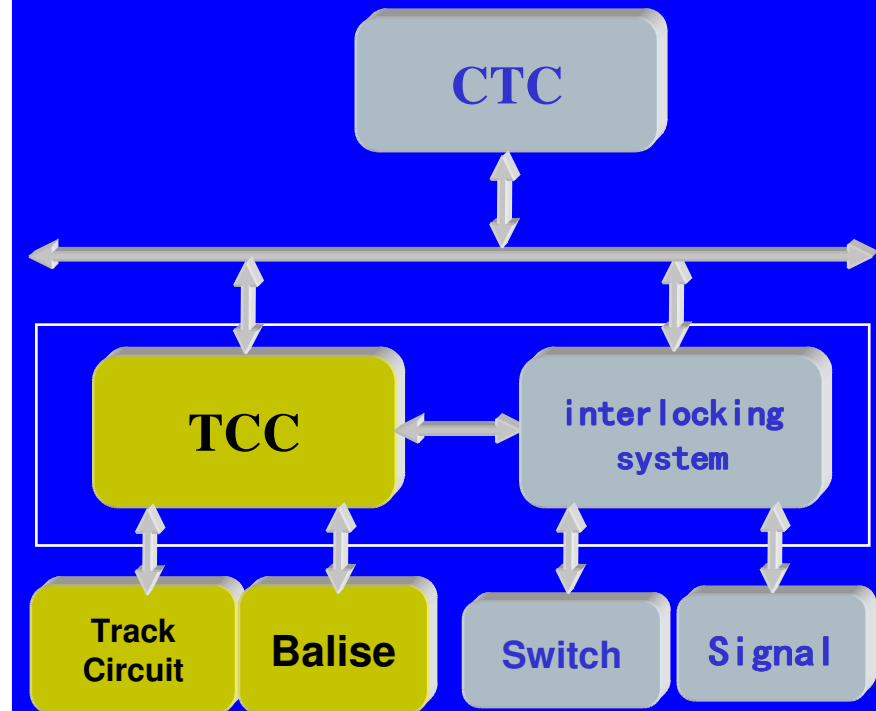




CTCS-2 -- Structure

CTCS-2 level is based on the Track Circuit and the Balise transferring Movement Authority information, which use the distance continuous speed control mode monitoring the safe operation of trains control system.

Include: Track Circuit 、 Balise
TCC、 On-board equipments





CTCS-2—On-board Equipment

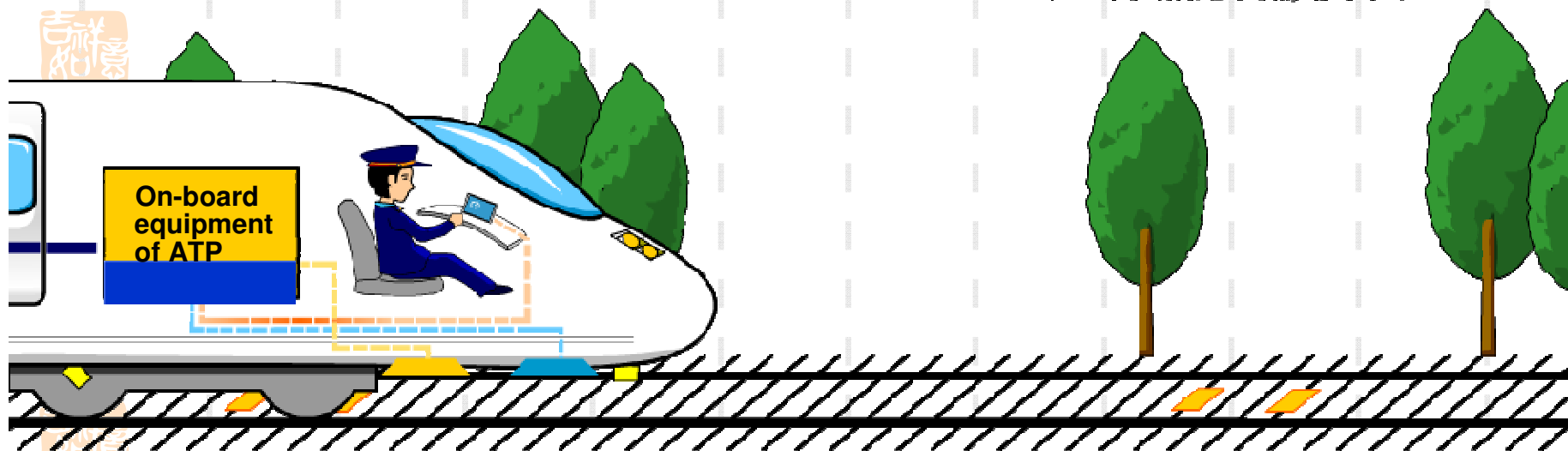
On-board equipment contents:

- Vital Computer (VC)
- Track Circuit Reader (TCR) and its antenna.
- Driver - machine interface (DMI)
- Speed sensor
- Balise transmission module (BTM) and its antenna.



应答器天线 Antenna of Balise

应答器传输模块 BTM

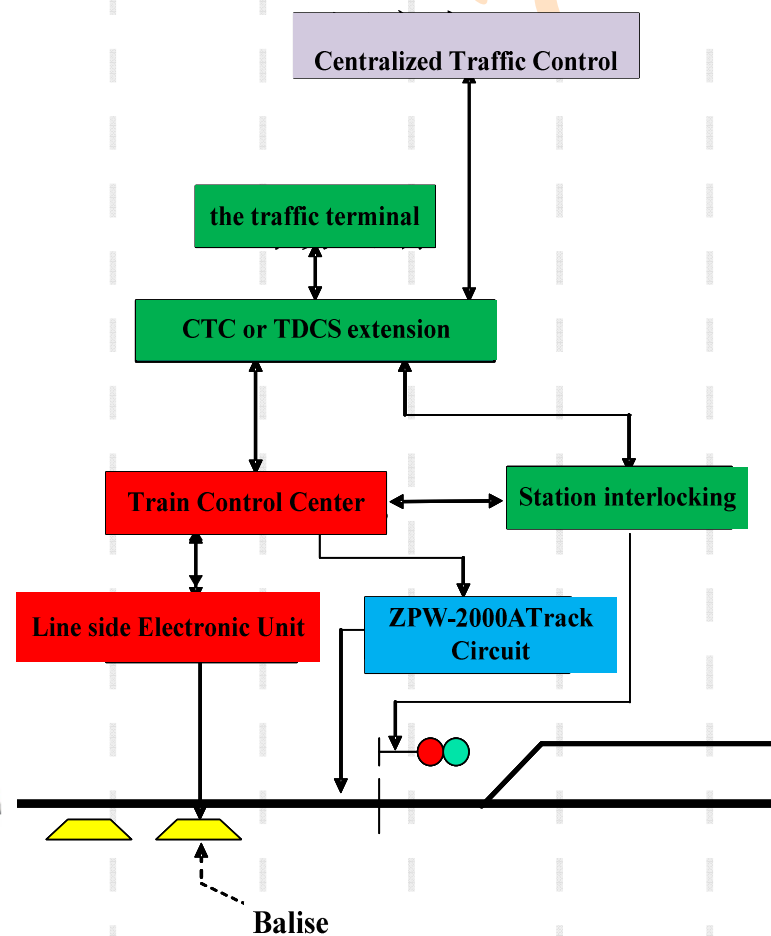
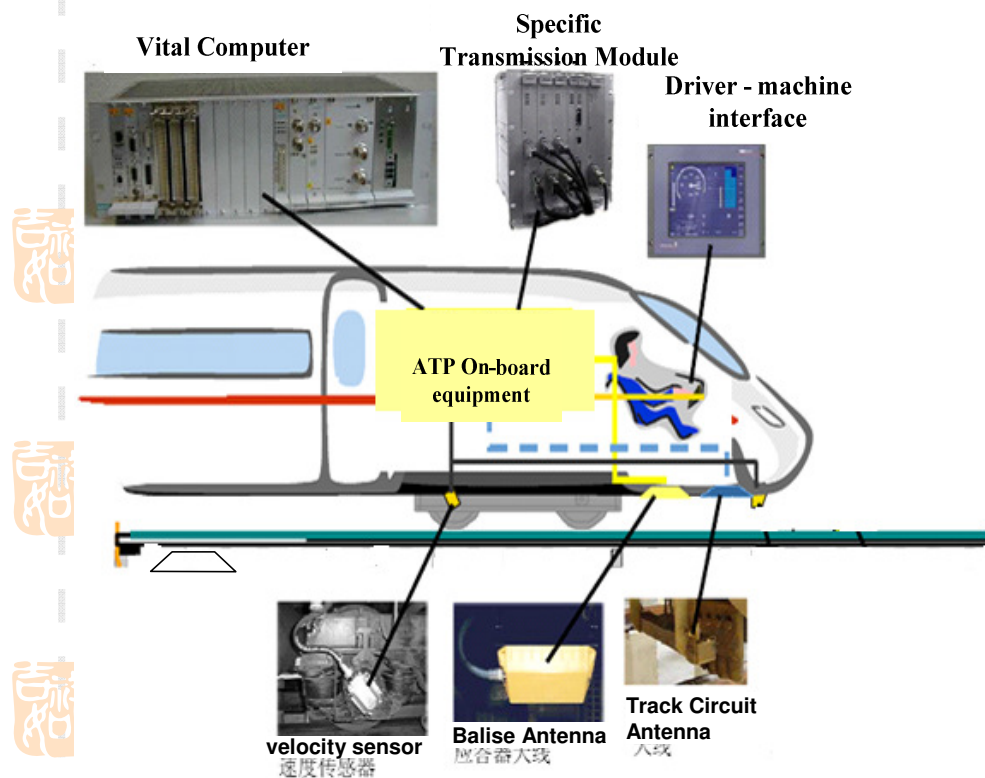




CTCS-2--Device structure

CTCS2系统设备结构

CTCS-2 Device structure





CTCS-2 --Function

Function of Track Circuit:

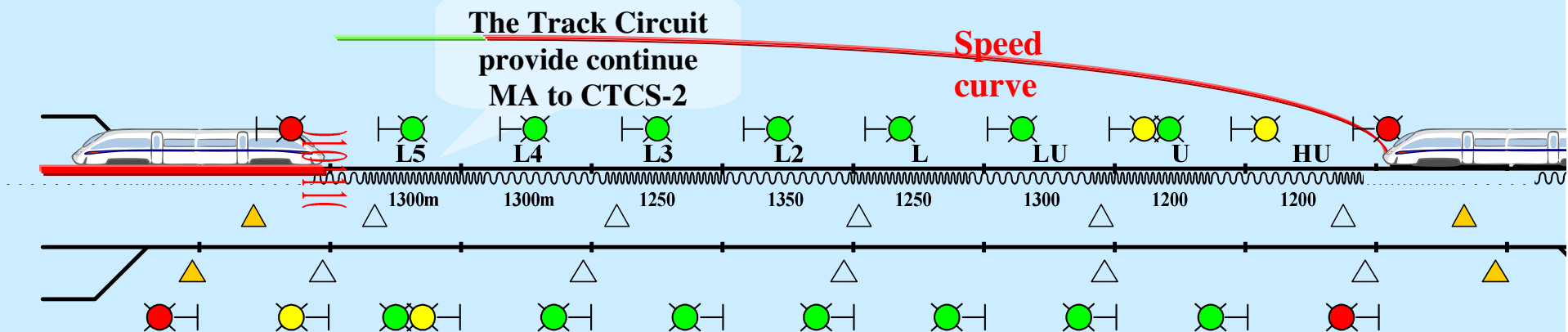
- checks section occupied
- Provide the number of free block area in front of the train

Function of Balise:

- Active Balise: Provide temporary speed restriction and route information
- Fixed Balise: provide line information, permitted speed and length of block section fixed information.

Function of equipment:

Integrated circuit, balise information and EMU parameters, to generate a continuous speed control mode curve automatically, real-time monitor the safe operation.





CTCS-2--Operation principle

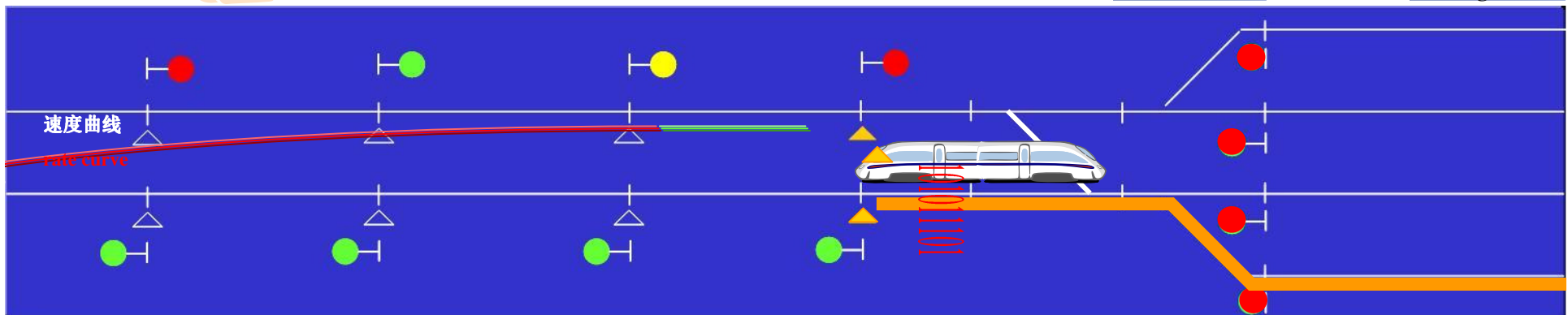
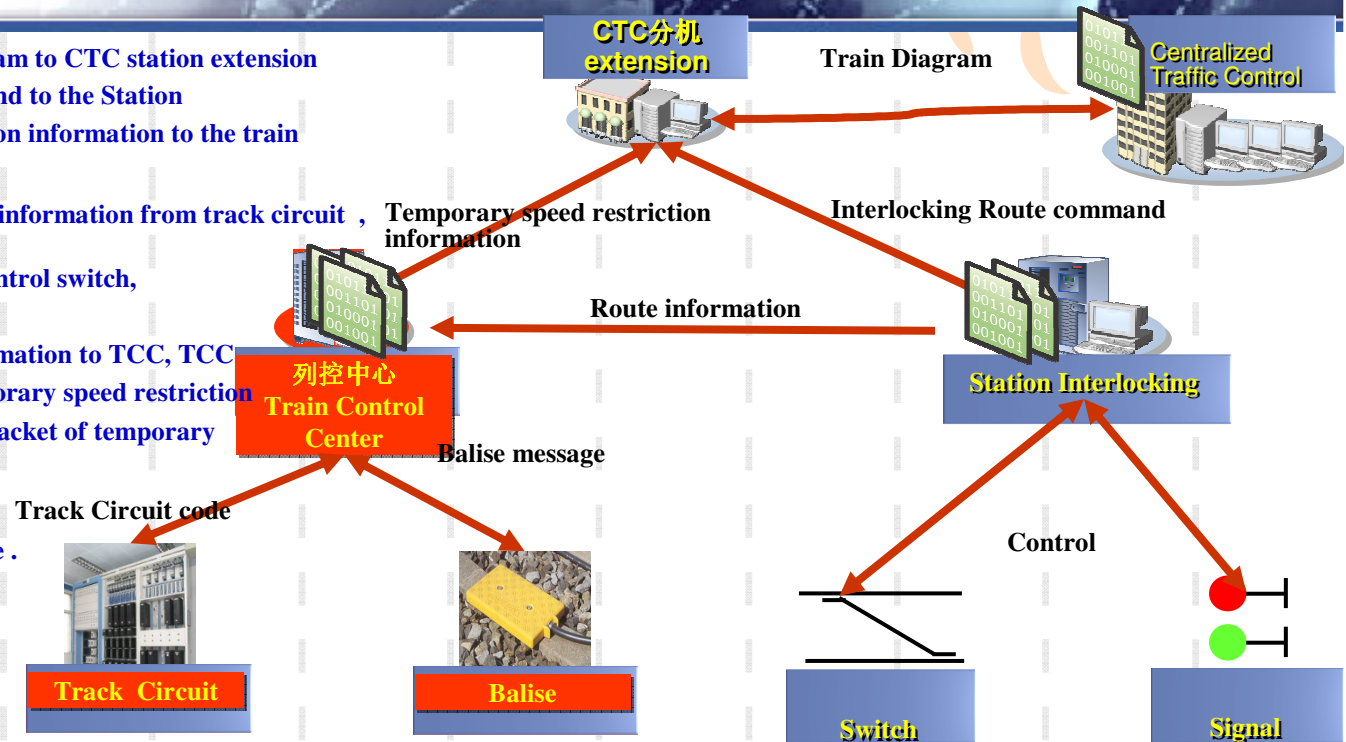
Centralized Traffic Control send the train diagram to CTC station extension
The CTC extension real time send route command to the Station Interlocking, and send temporary speed restriction information to the train control center.

Station Interlocking acquisition train occupancy information from track circuit, switch positions and for processing, accordance with the commands from CTC to control switch, signals, and arranged into the route.

Computer Interlocking will send the route information to TCC, TCC according to the route information and the temporary speed restriction information to generate track circuit code and packet of temporary speed restrict.

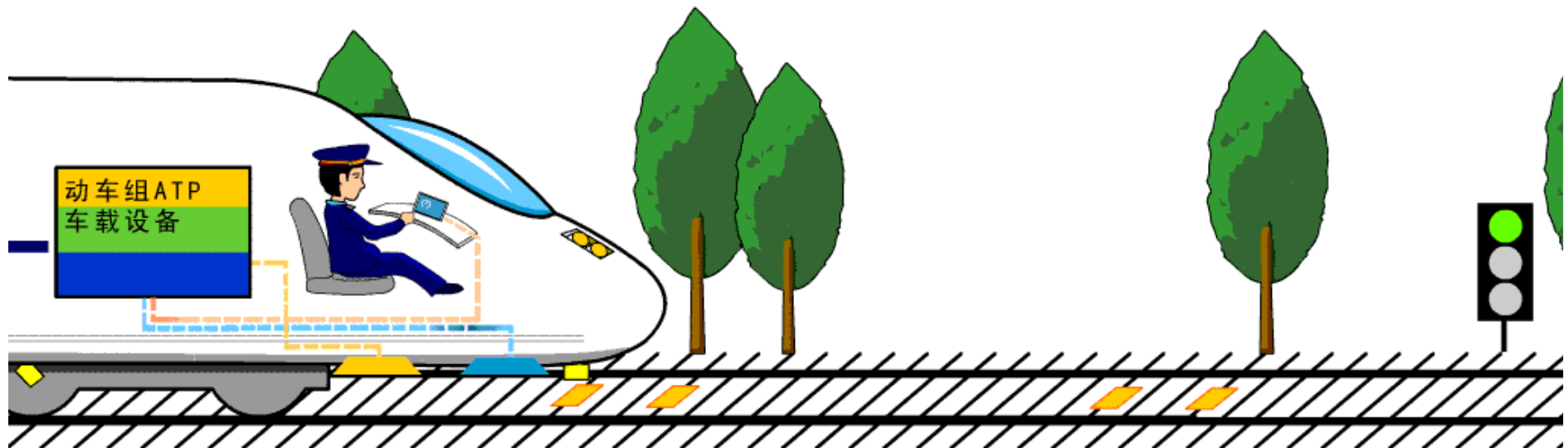
Track circuit code sent to the track circuit.
Temporary speed restriction packe send to Balise.

On-board equipment receive track circuit code and balise message, calculated curve generate control mode, monitoring the safe operation of trains.



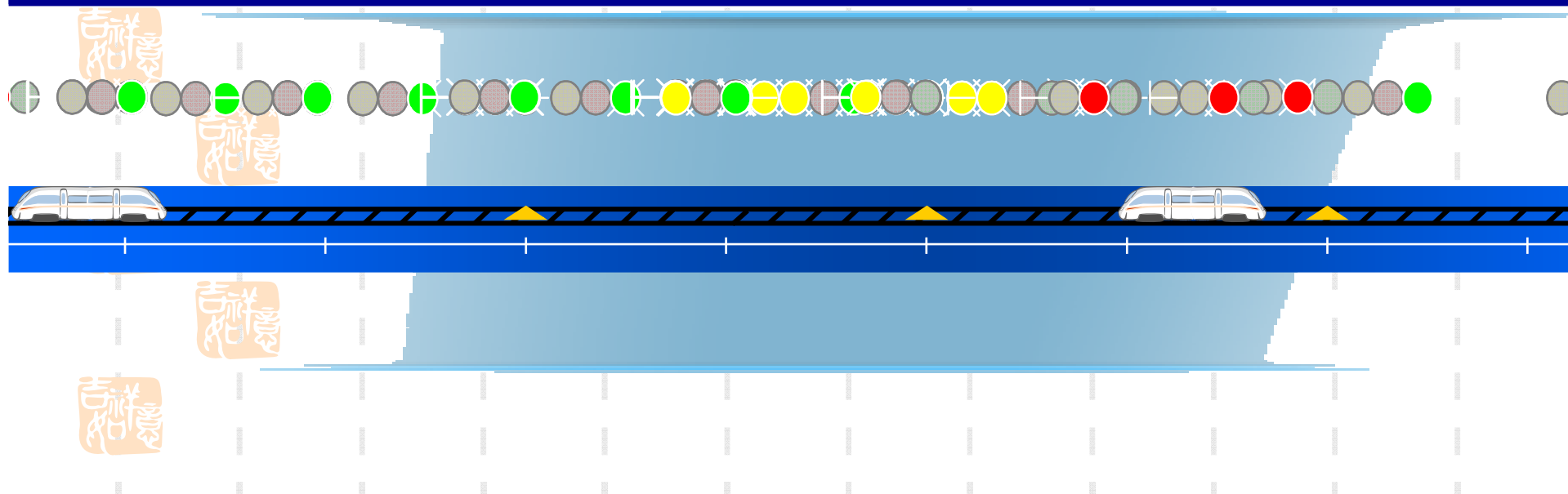


- **Receive continue information about free information of block area from track circuit**
- **Receive information of route when though Balise**





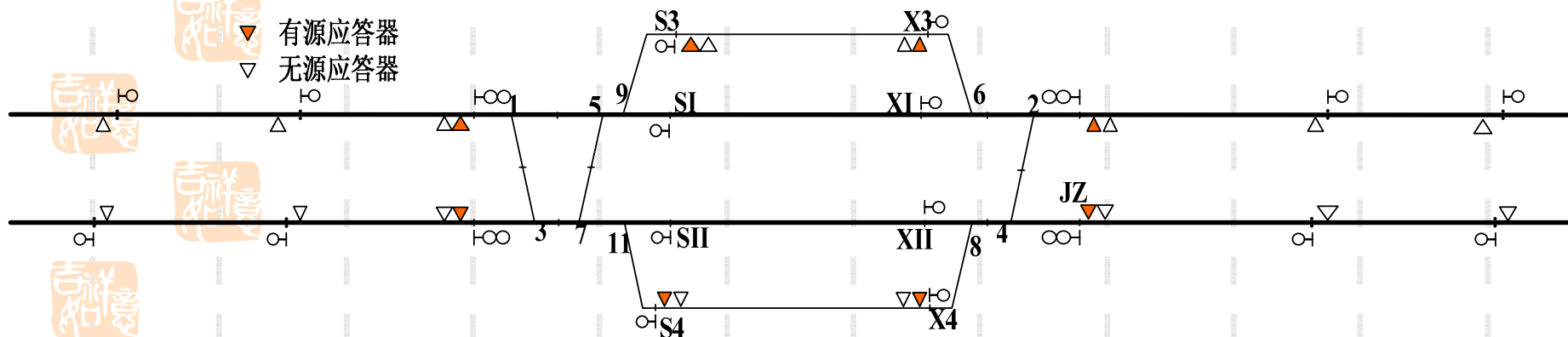
CTCS-2—Section of track running simulation





CTCS-2—Balise arrangement

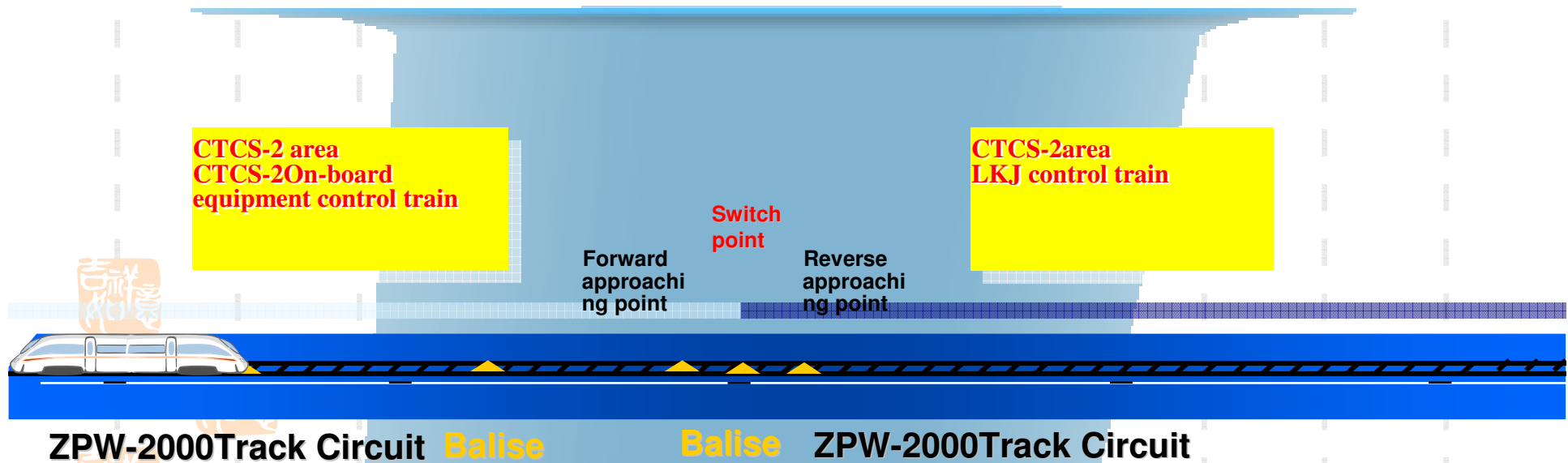
- In / out points
 - ✓ Active Balise + Fixed Balise : provide the information of temporary speed limit and lateral line routes.
- Section Interval
 - ✓ Fixed Balise : Set single fixed Balise to provide line data, each Balise contains the information of 10 track section in front of it.
- Grade of the border
 - ✓ Passive Balise group : Set fixed Balise group to provide the information of grade forecast, grade conversion command.





CTCS-2—Grade Conversion

➤ Conversion of C2 to C0





CTCS-3

I . Structure of CTCS-3

II . Function of CTCS-3

III. Operation principle of CTCS-3

IV. System Features of CTCS-3

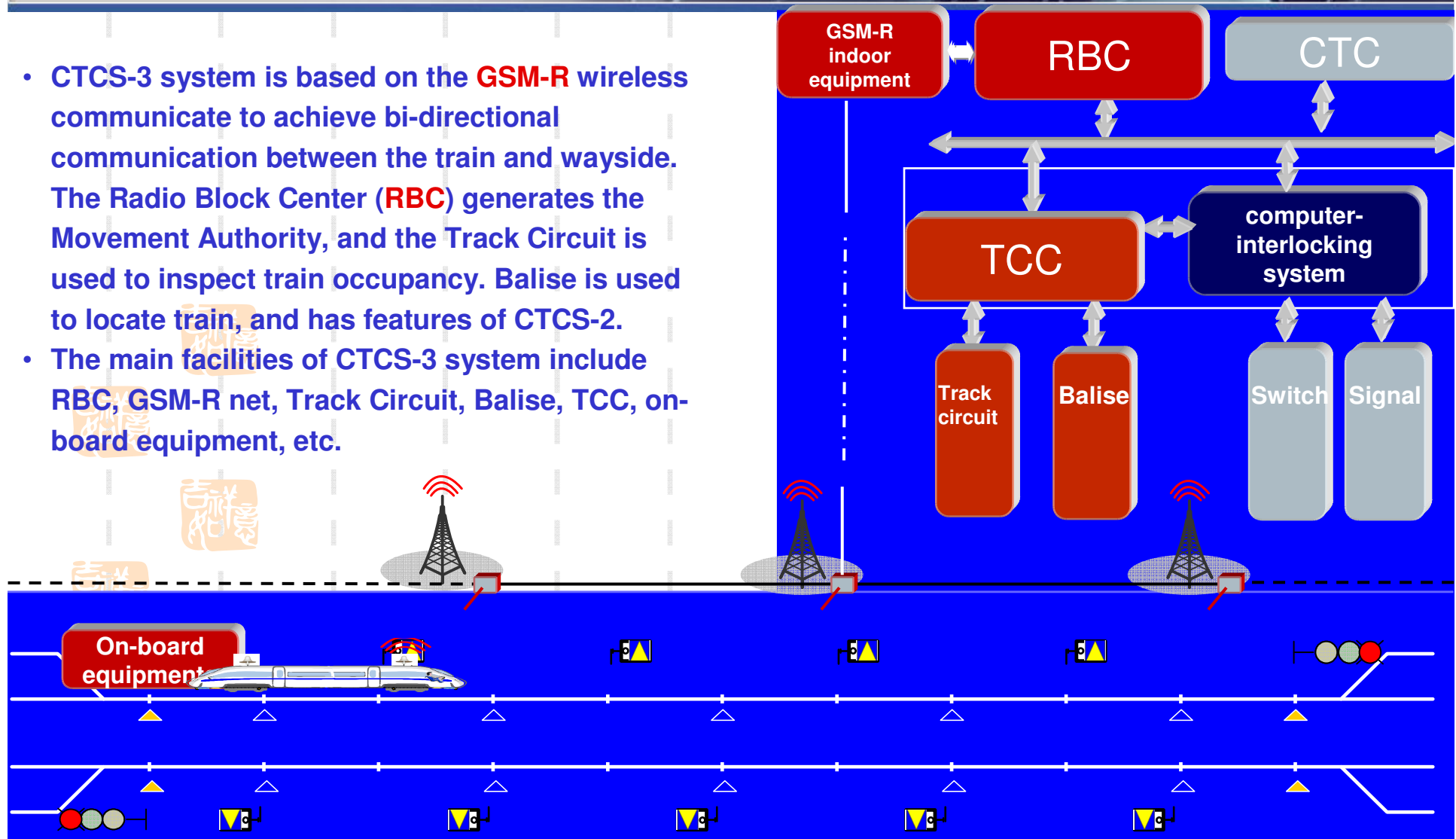
V . GSM-R wireless communication network inCTCS-3

VI. Evaluation of CTCS-3 system



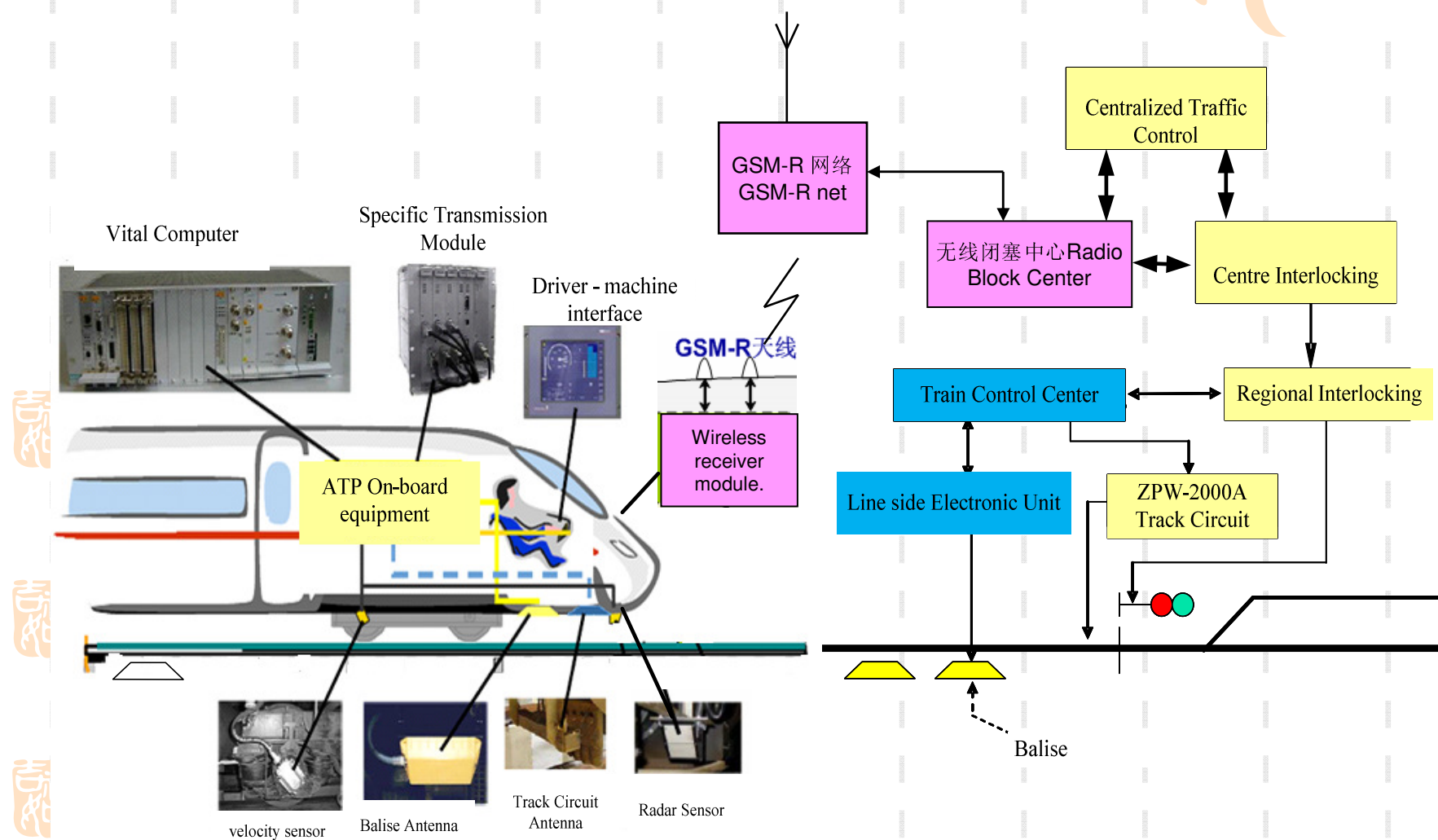
CTCS-3 – Structure

- CTCS-3 system is based on the **GSM-R** wireless communicate to achieve bi-directional communication between the train and wayside. The Radio Block Center (**RBC**) generates the Movement Authority, and the Track Circuit is used to inspect train occupancy. Balise is used to locate train, and has features of CTCS-2.
- The main facilities of CTCS-3 system include RBC, GSM-R net, Track Circuit, Balise, TCC, on-board equipment, etc.





CTCS-3--Device structure





CTCS-3 -- Functions

■ RBC

- According to the track circuit, interlocking route and other information to generate a Movement Authority.

- Via GSM-R wireless communications system, it transmit the Movement Authority, line parameters, temporary speed restriction transmission to on-board equipment of CTCS-3.

- It receives information such as the train's location and train's data sent from on-board equipments by GSM-R wireless communication system.



CTCS-3 -- Functions

- **GSM-R**

- Continuous, bi-directional, information transmission between the on-board equipments and ground equipments.

- **Balise**

- Transmit information about location and transmission of grade to on-board equipment.
- Send parameters of transmission lines to the on-board equipments, such as temporary speed restriction and other information to meet the needs of the standby system.



CTCS-3 -- Functions

■ On-Board Equipments

- Base on the movement authority, line parameters, temporary speed restriction, train parameters provided by on-board equipments, according to the distance and the continuous speed control mode generate dynamic velocity curves. The On-Board-Equipment monitors the safety operation of trains.

■ Track Circuit

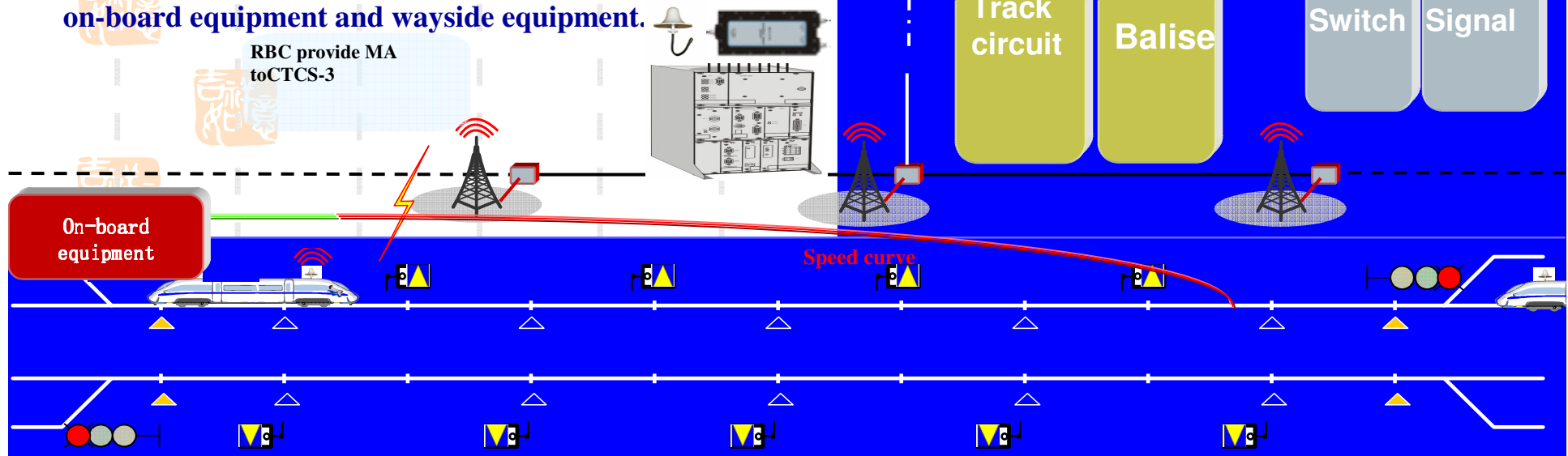
- Achieve to inspect train occupancy.
- Send information of block partition in response to back-up systems.



CTCS-2 Comparison with CTCS-3

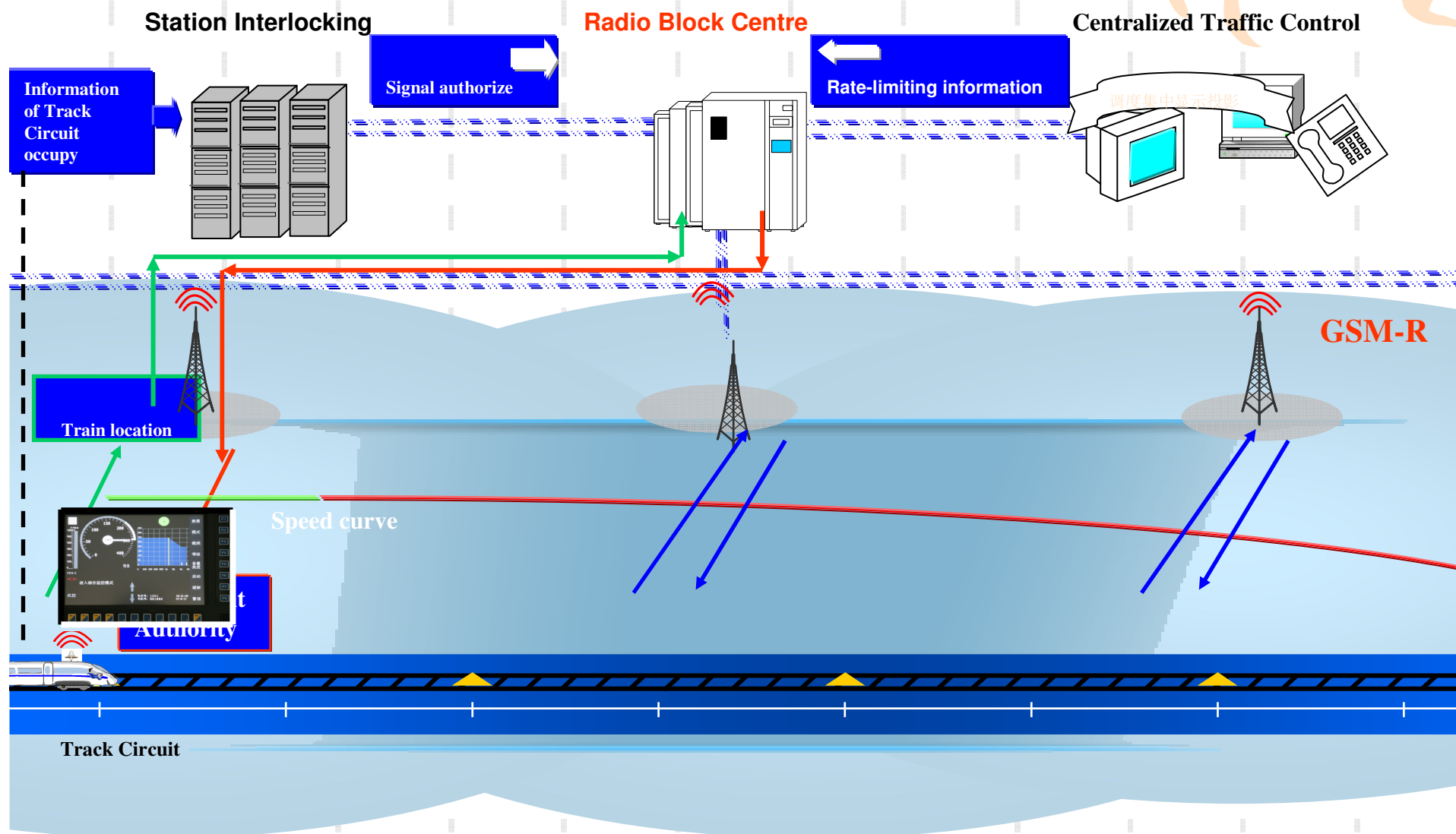
1. Compared with CTCS-2, the wayside equipment of CTCS-3 adds Radio Block Center (RBC), GSM-R wireless communication network.
2. The on-board equipment adds GSM-R wireless communication unit and antenna.
3. CTCS-3 system using RBC provide MA to the train.
4. CTCS-3 system achieve continuous, bi-directional, large capacity of information communication between the on-board equipment and wayside equipment.

RBC provide MA to CTCS-3



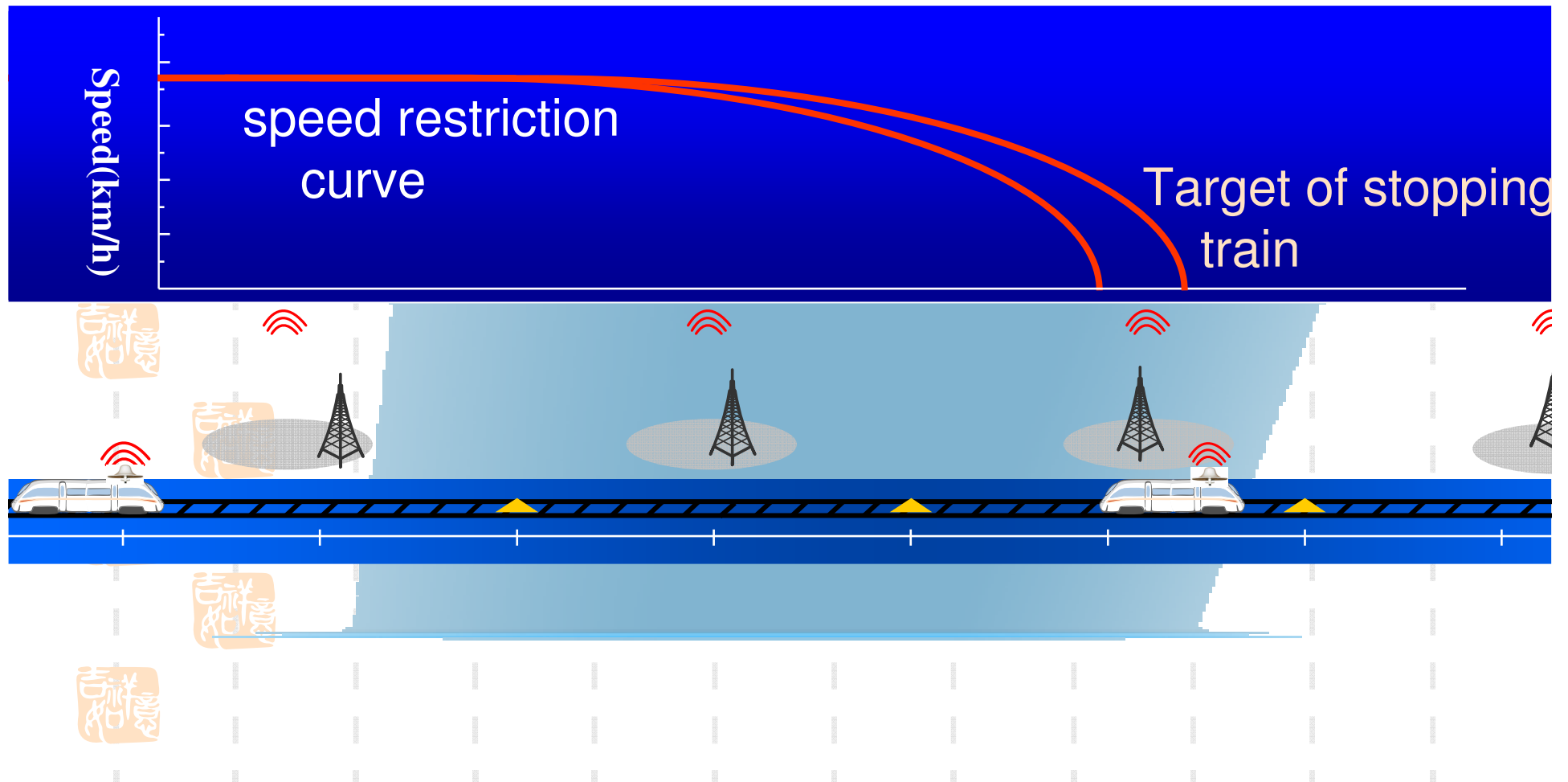


CTCS-3--Operation principle





CTCS-3—Section of track running simulation





CTCS-3 – System Features

- Based on the GSM-R to achieve continuous large capacity information transmission, the system can provide as far as 320km of the target distance, line permitted speed and other information.
- The System can meet operational requirements of different level railways.
- CTCS-3 system, through integrating the message of CTCS-2 in Balise, meet the needs of 200 ~ 250km. At the same time, the CTCS-2 serves as a standby system of the CTCS-3.



CTCS-3 – System Features

- **Bi-directional information transmission between on-board and wayside equipment. The wayside equipment can control train speed, location, work state and other information in real-time, and can display all the information in the CTC system.**



- **The system can set the temporary speed restriction flexibility, it also can achieve temporary speed restrictions setting in arbitrary location, length and number.**



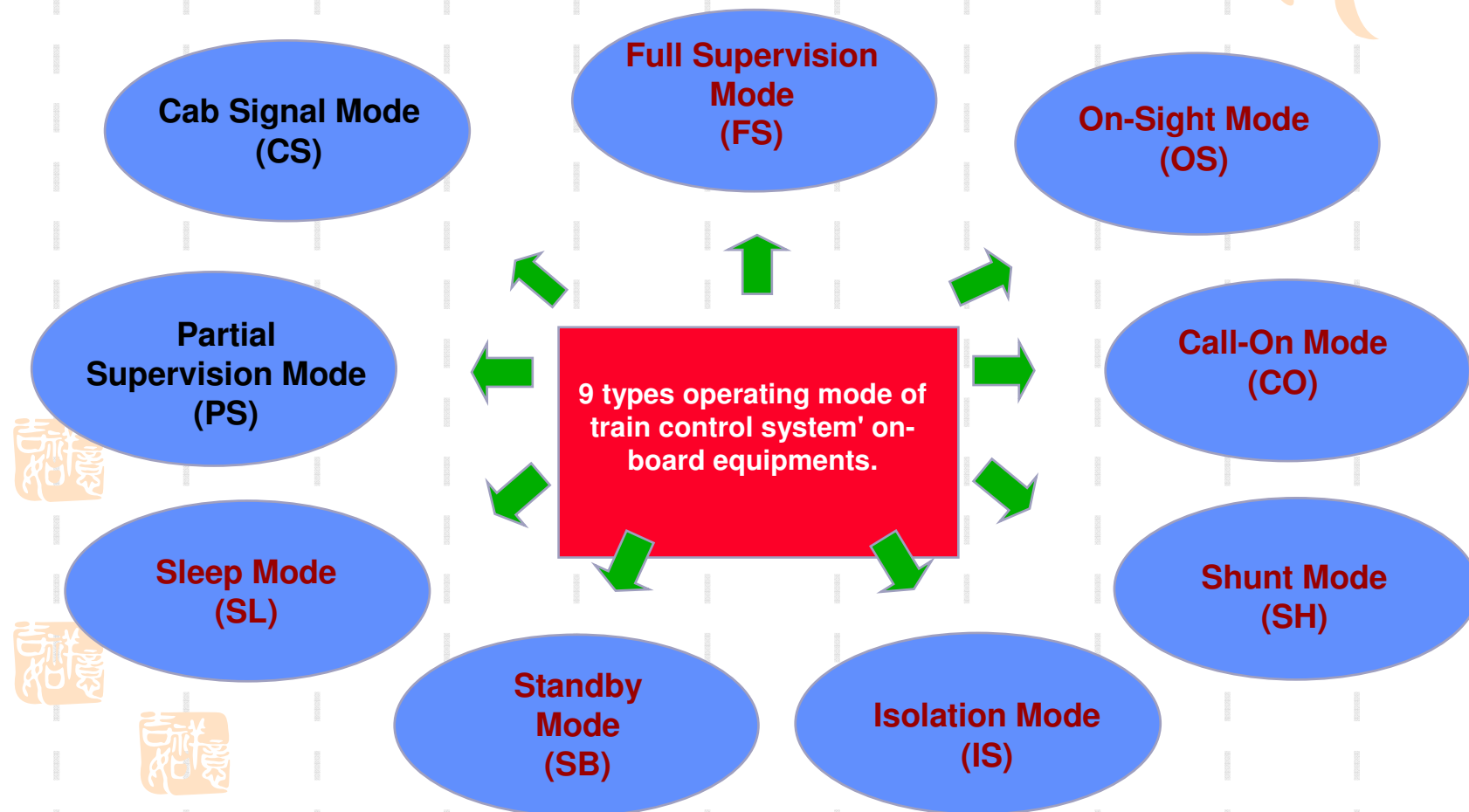


CTCS-3 – System Features

- RBC can be centralized setting and also scattered setting.
- RBC sends information of neutral zone to the train which is equipped with CTCS-3 and Balise sends information of neutral zone to train which equipment with CTCS-2, achieve to automatically over neutral zone .



CTCS-3-- Operation Mode of ATP



The mode of part supervision and cab signal only suit to CTCS-2.



CTCS-3 -- Primary Operating Scene

Operational circumstance : the brief description about way of system working.

Registration
and start

Enter and exit
the segment of
EMU

Grade
conversion

Movement
Authority

RBC switch

Automatic over
Neutral zone

Multiple &
disconnection

Temporary speed
restriction

Case of
degradation

Disaster
protection

Parking and End
of Mission

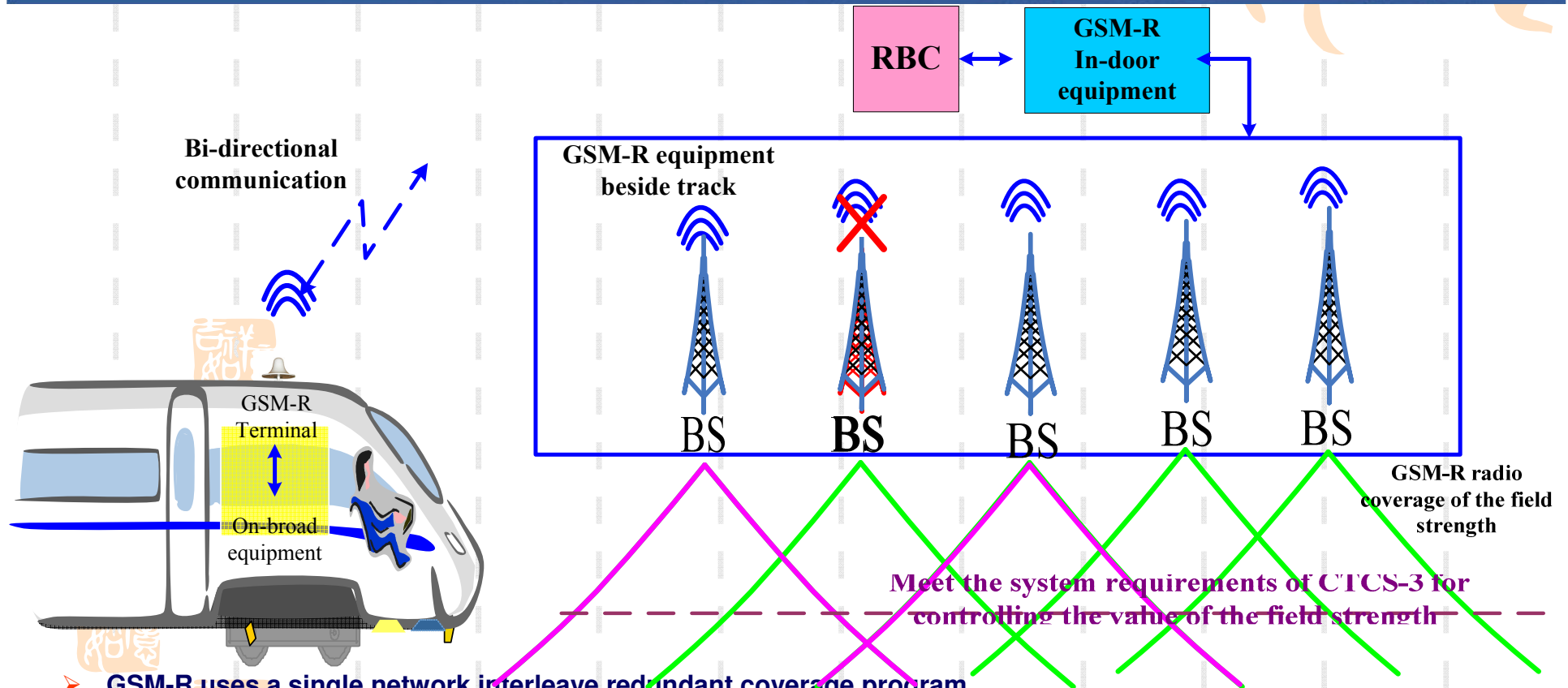
Shunting

Artificial unlock
route

Special route



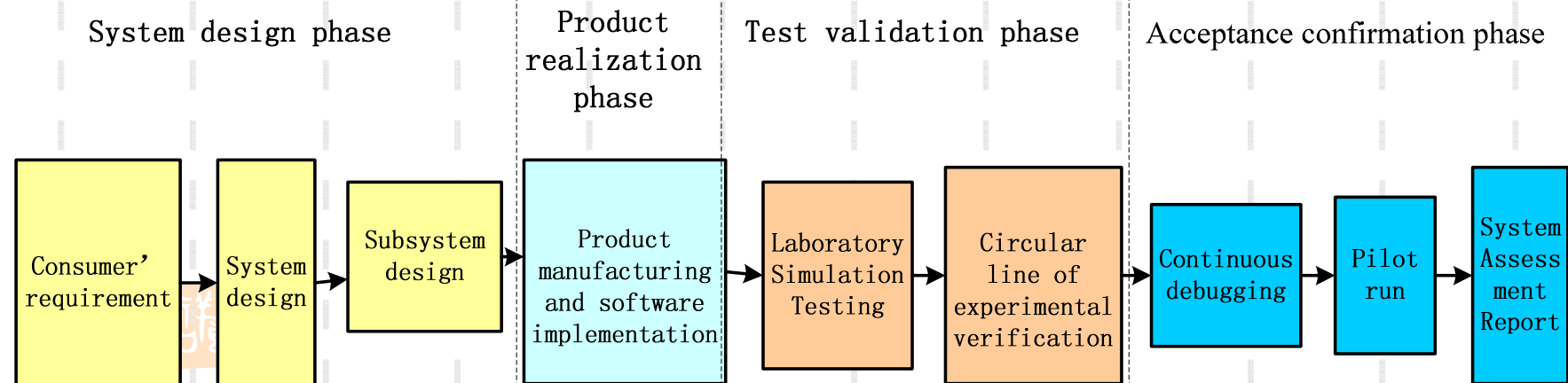
CTCS-3 – GSM-R Network



- GSM-R uses a single network interleave redundant coverage program.
- As long as the adjacent base stations don't fail at the same time, it will not affect the GSM-R network coverage.



CTCS-3 – System Evaluation



➤ Systematic evaluation of the system implementation throughout the whole process is divided into 4 phases:

- ✓ System design phase
- ✓ Product realization phase
- ✓ Test validation phase
- ✓ Acceptance confirmation phase



Thank you for your attention!

Contact Information:
Dr. Changlin Wang, Prof.
13688302230

