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Chinese High Speed Railway Train Control System

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Outline

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
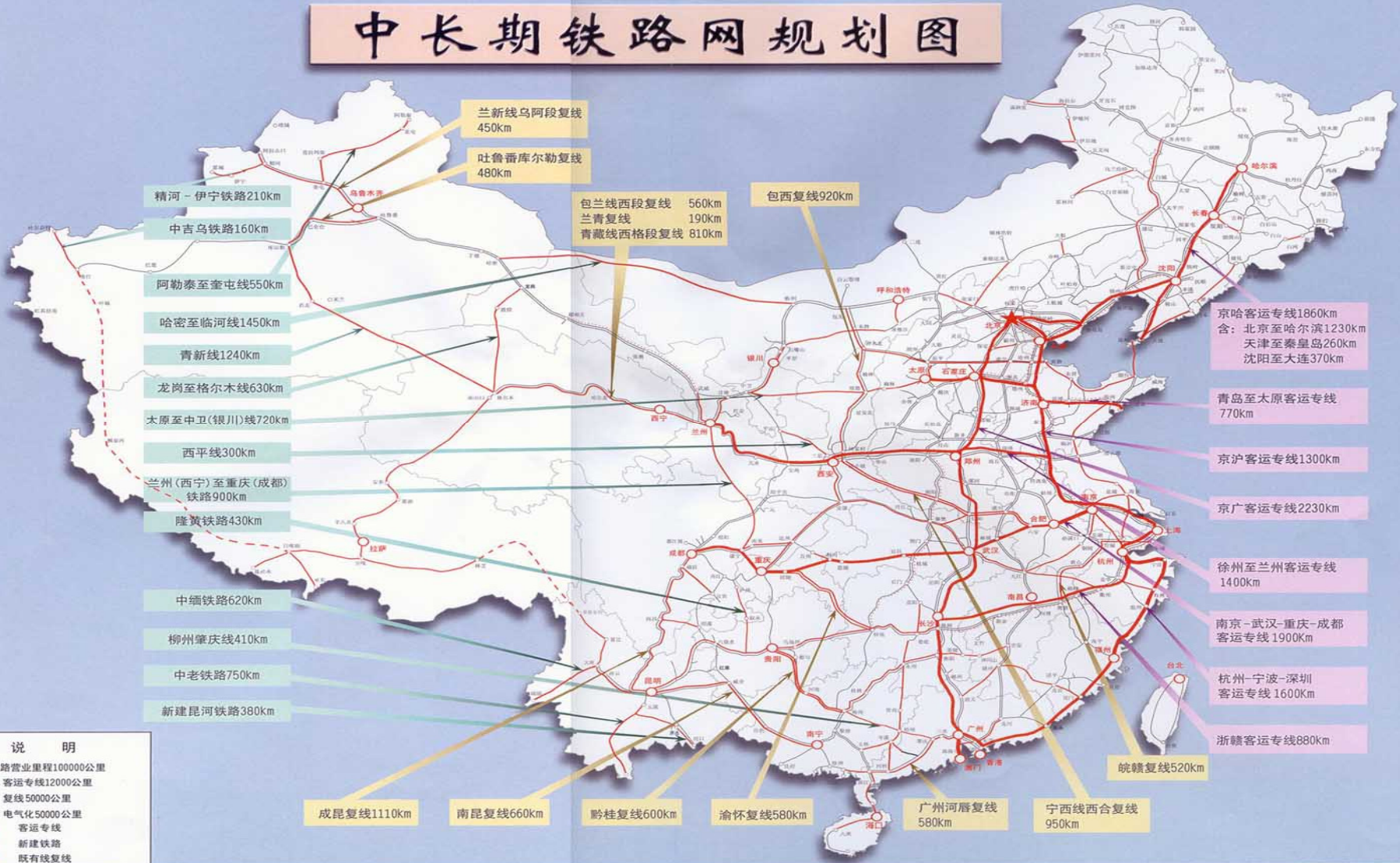
Chinese Railway Train Control System (CTCS)

Ⅰ. The target of CTCS

Ⅱ. CTCS Classification

- **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).**
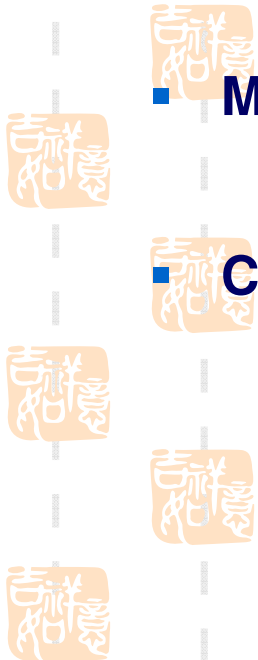
The target of CTCS

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	▪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	▪Based on the GSM-R platform of wireless communication, the locomotive crew drive the train with the help of cab signal，equiped 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	▪Based on the Balise and the track circuit transmission, the locomotive crew drive the train with the help of cab signal , equiped on-board equipment of ATP which based on 2x2 take 2 vital computer ▪It has been used in current 200-250km/h line, equiped ZPW-2000A type track circuit.
CTCS-1	▪Consist of the main cab signal and security operation monitoring and recording devicesLKJ-2000 ▪ Equiped Localization track circuit of ZPW-2000
CTCS-0	▪Consist of universal cab signal, the monitoring and recording devices（Ordinary），equiped 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
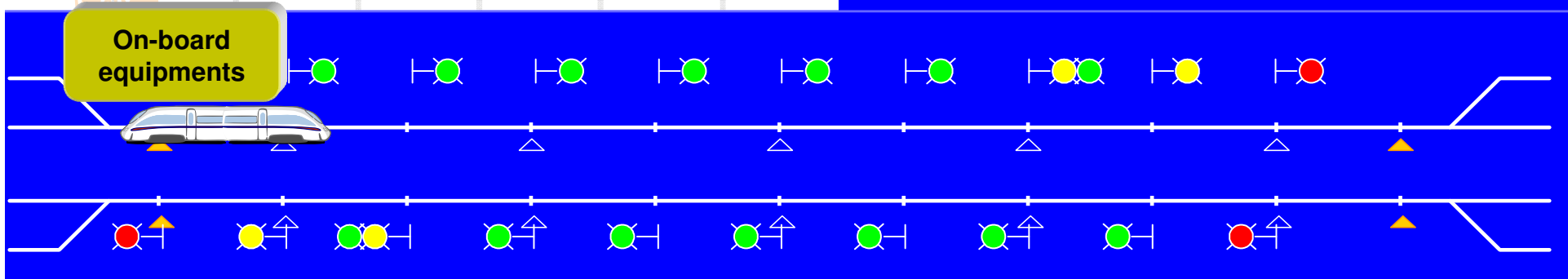
CTCS-2 level is based on the Track Circuit and the Balise transferring Movement Authority information，which use the distance continuous speed control mode monitoring the safe operation of trains control system.

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

CTC

TCC

interlocking system

Track Circuit

Balise

Switch

Signal
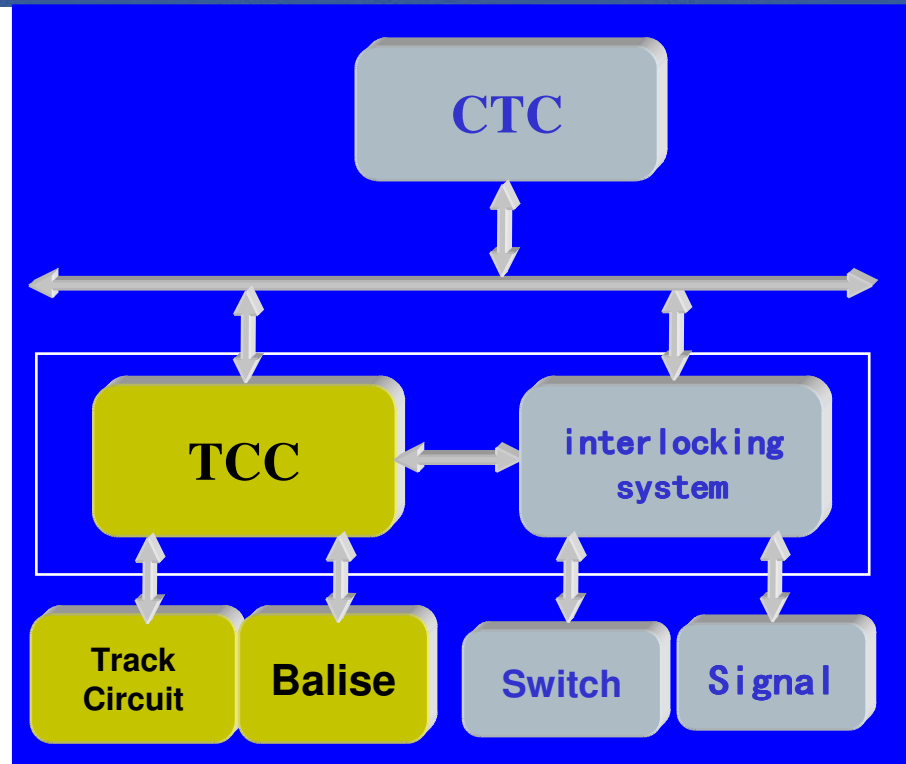
On-board equipments

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

On-board
equipment
of ATP
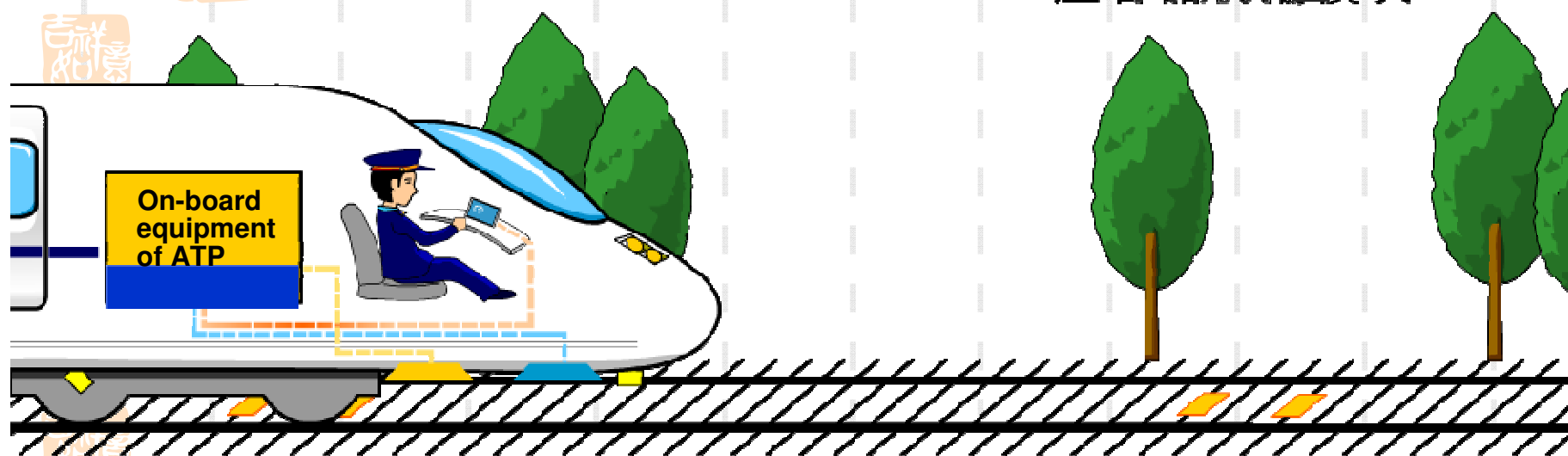
CTCS2系统设备结构

CTCS-2 Device structure

Vital Computer

Specific Transmission Module

Driver - machine interface

ATP On-board equipment

velocity sensor
速度传感器

Balise Antenna
应答器天线

Track Circuit Antenna
八线

Centralized Traffic Control

the traffic terminal

CTC or TDCS extension

Train Control Center

Station interlocking

Line side Electronic Unit

ZPW-2000ATrack Circuit
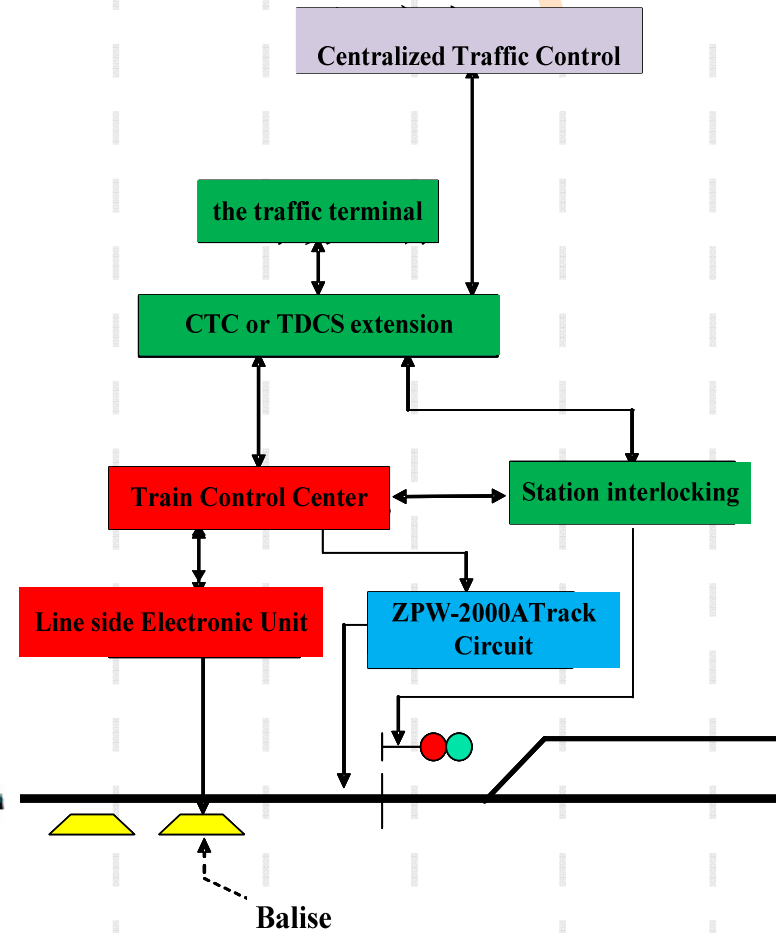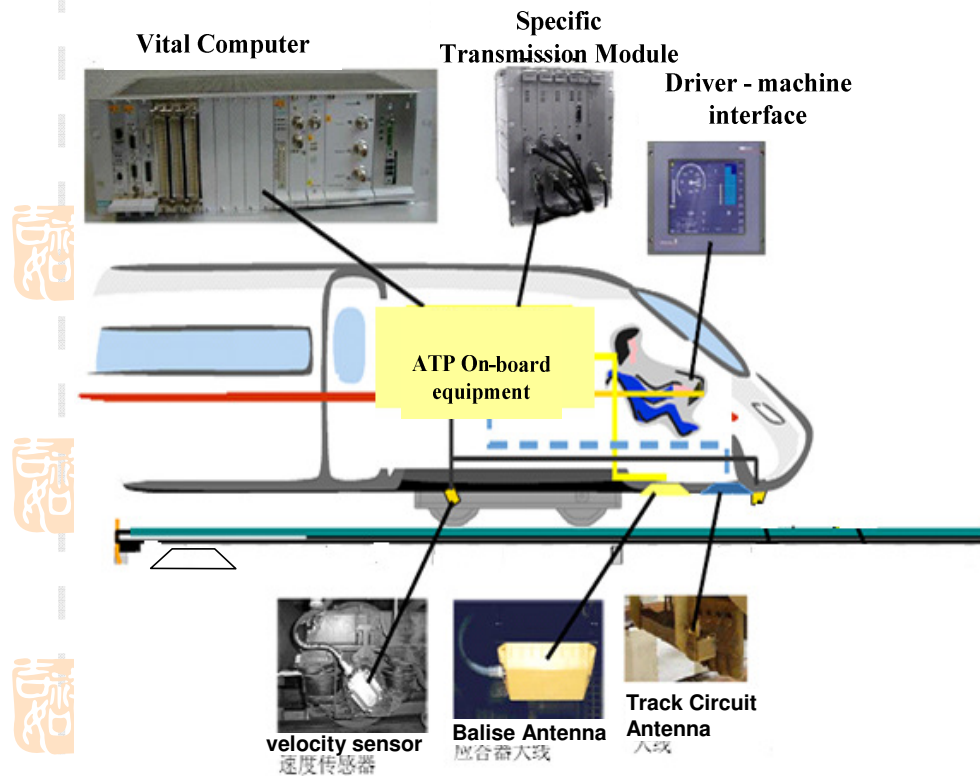
Balise

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.

The Track Circuit provide continue MA to CTCS-2

Speed curve

L5   L4   L3   L2   L   LU   U   HU

1300m   1300m   1250   1350   1250   1300   1200   1200
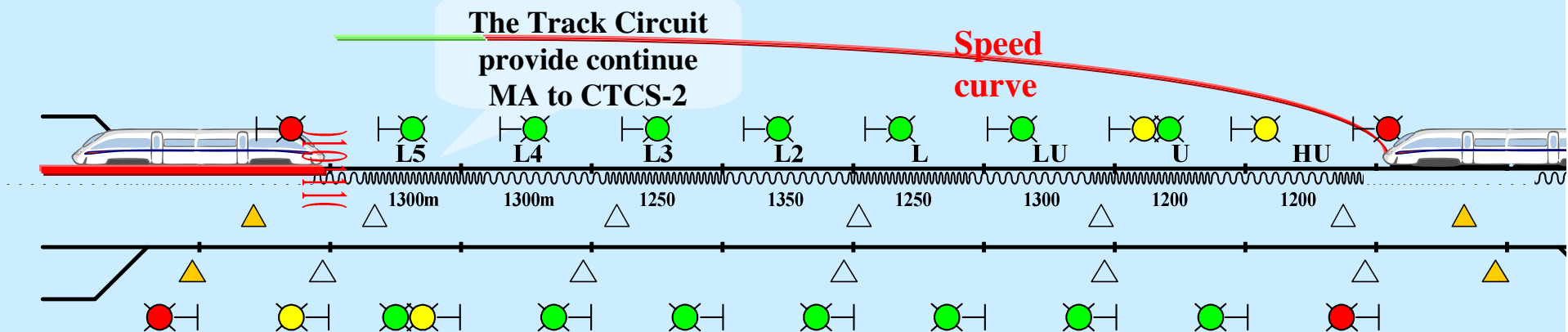
CTCS-2--Operation principle

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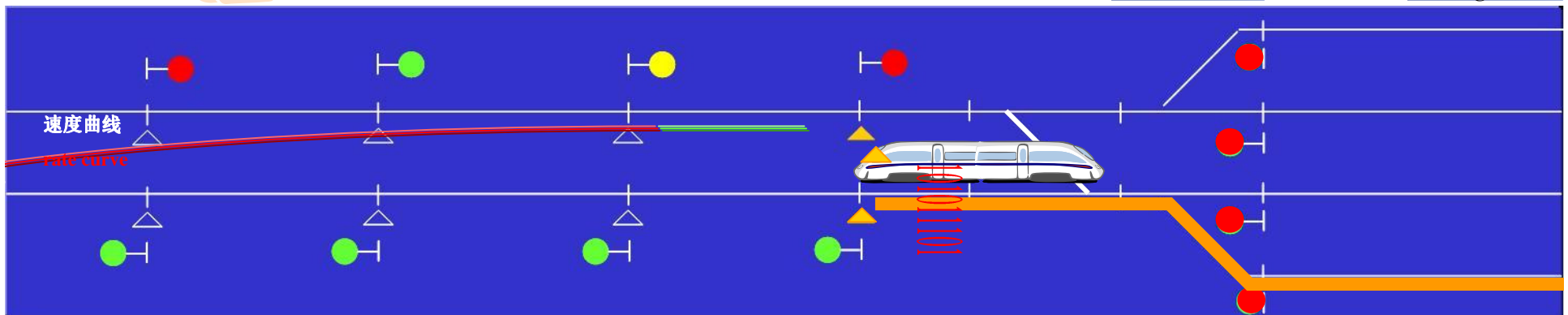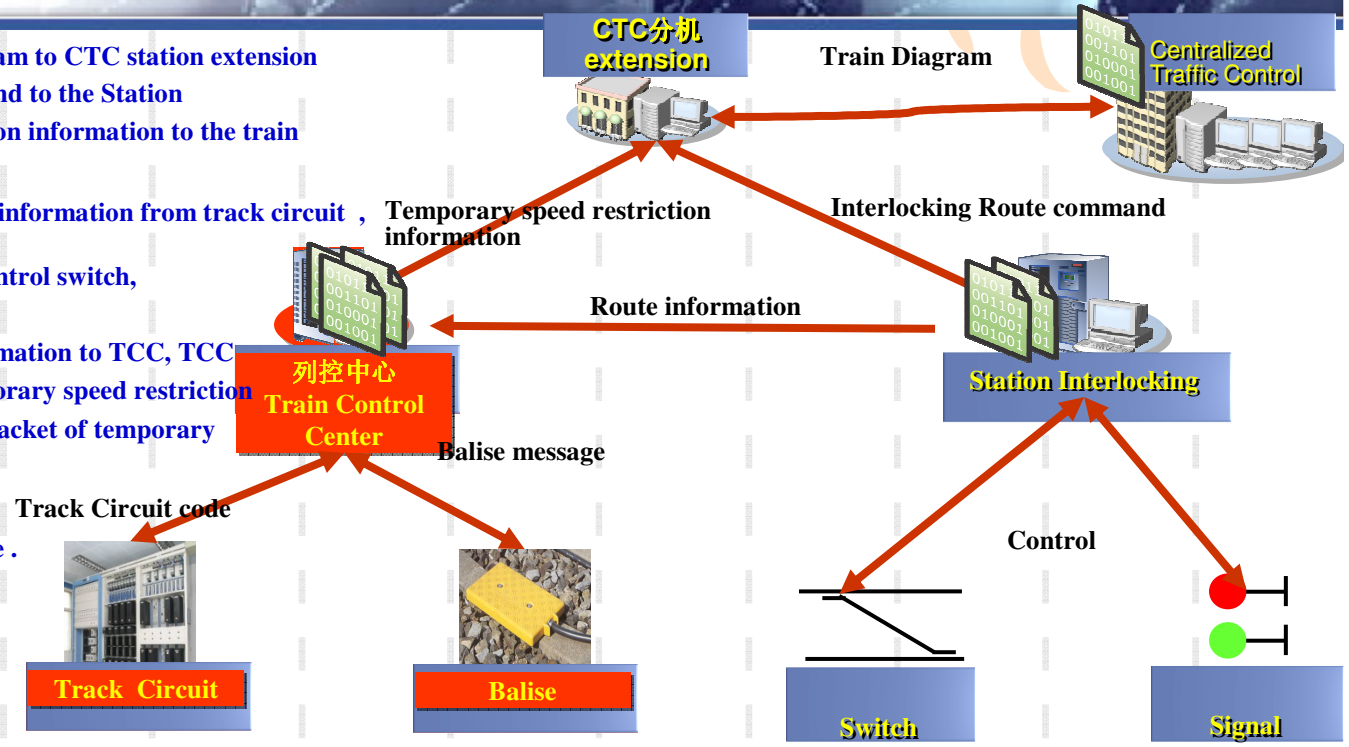
Station Interlocking acquisition train occupancy information from track circuit , switch positions and for processing.
accordance with the commands from CTC to control switch, signals, and arranged into the route.

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.

CTC分机
extension

Train Diagram

Centralized
Traffic Control

Temporary speed restriction information

Interlocking Route command

Route information

列控中心
Train Control Center

Station Interlocking

Balise message

Track Circuit code

Control

Track Circuit

Balise

Switch

Signal

速度曲线
rate curve

Train during operation：

➢ **Receive continue information about free information of block area from track circuit**

➢ **Receive information of route when though Balise**

Speed(km/h)

Target of stopping train

speed restriction curve
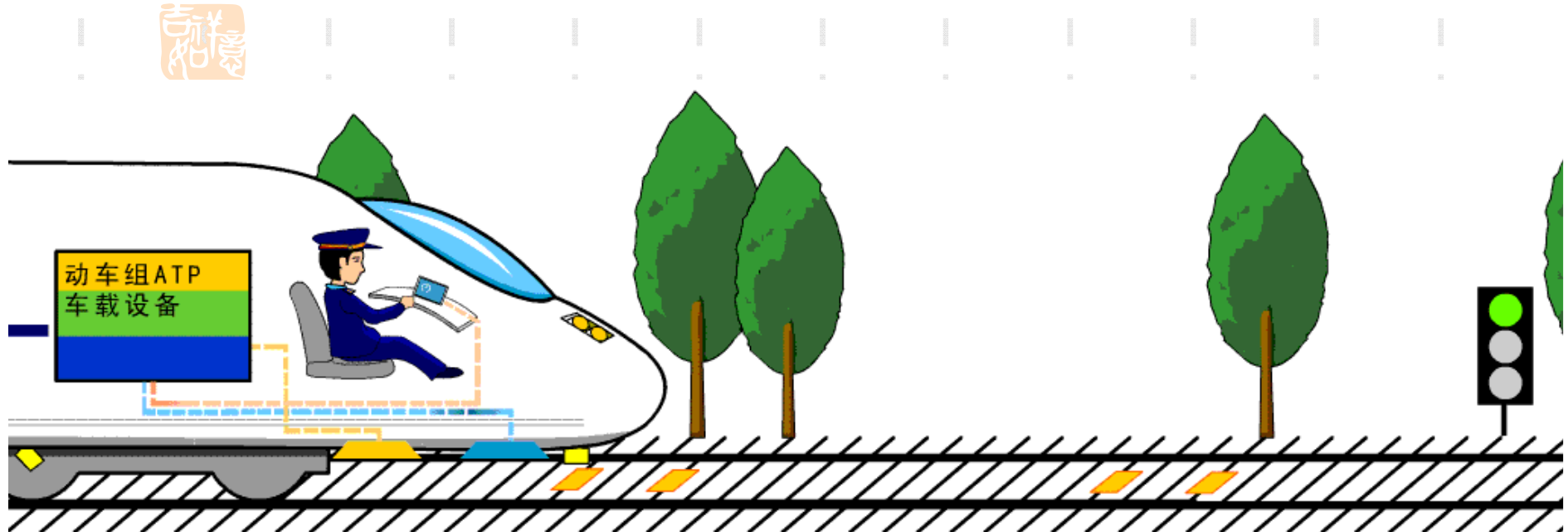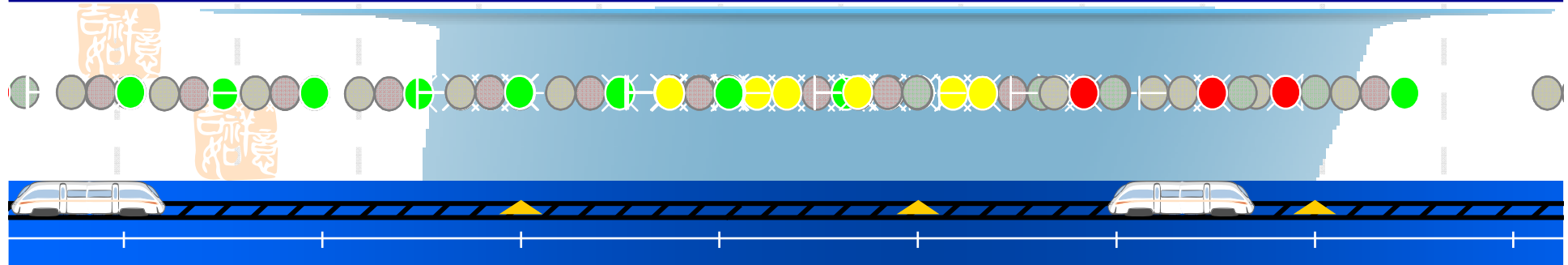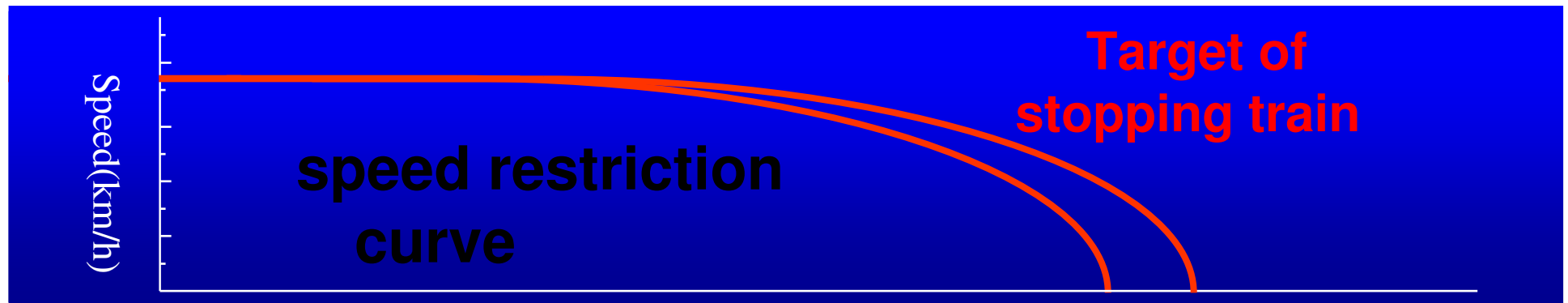
➢ **In / out points**

✓ **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 of10 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.**

➢ Conversion of C2 to C0

CTCS-2 area
CTCS-2On-board
equipment control train

Switch
point

Forward
approachi
ng point

Reverse
approachi
ng point

CTCS-2area
LKJ control train

ZPW-2000Track Circuit **Balise** **Balise** **ZPW-2000Track Circuit**
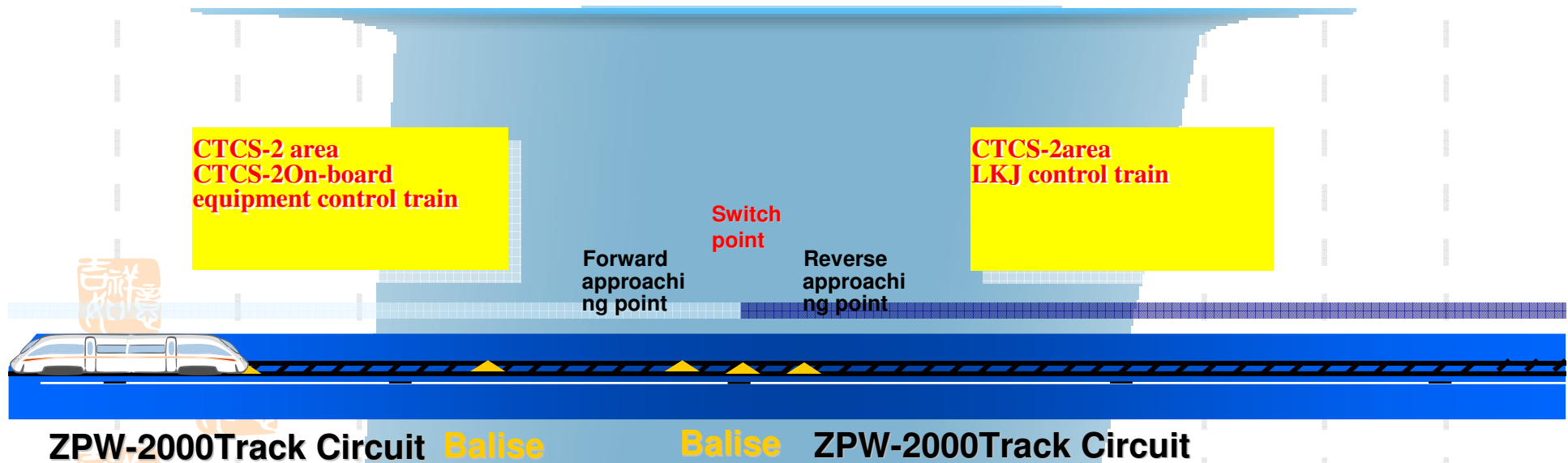
CTCS-3

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.

Vital Computer

Specific Transmission Module

Driver - machine interface

ATP On-board equipment

Wireless receiver module.

GSM-R 网络
GSM-R net

GSM-R天线

Centralized Traffic Control

无线闭塞中心Radio Block Center

Centre Interlocking

Train Control Center

Regional Interlocking

Line side Electronic Unit

ZPW-2000A Track Circuit

Balise

velocity sensor

Balise Antenna

Track Circuit Antenna

Radar Sensor
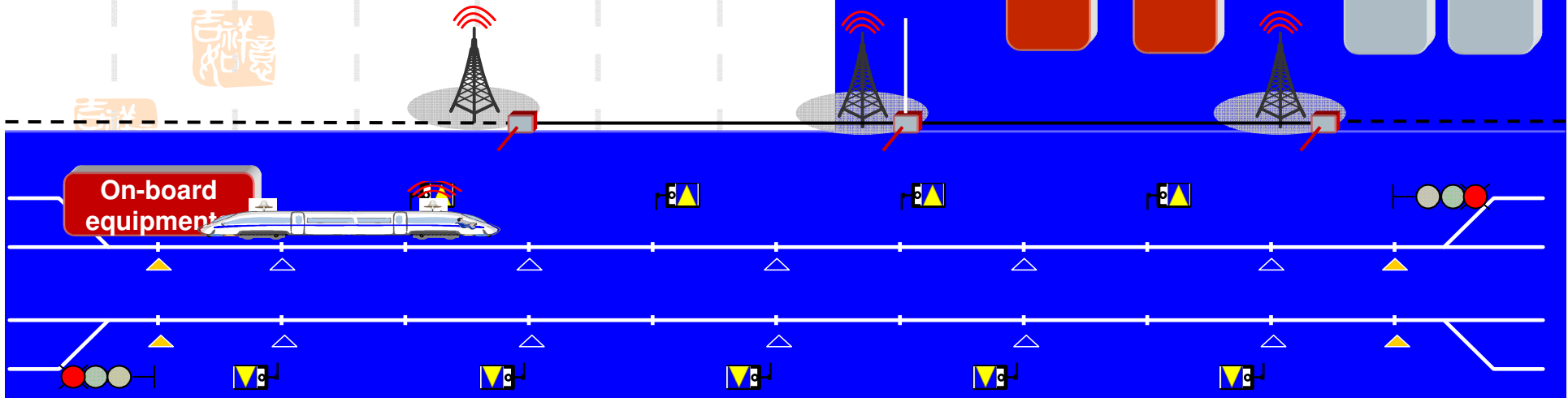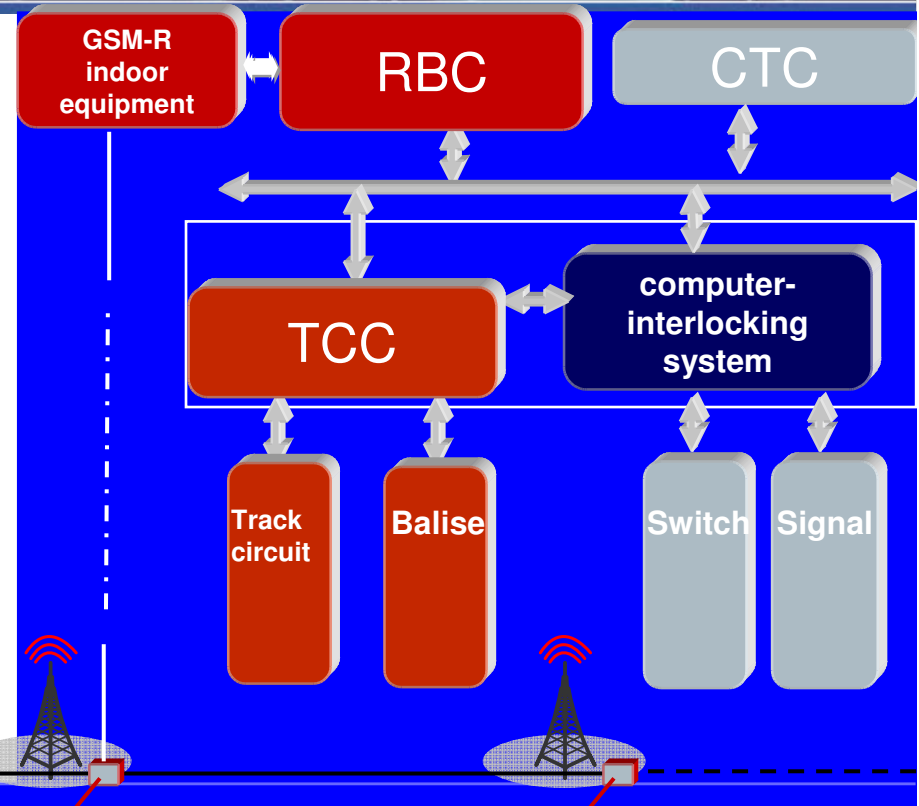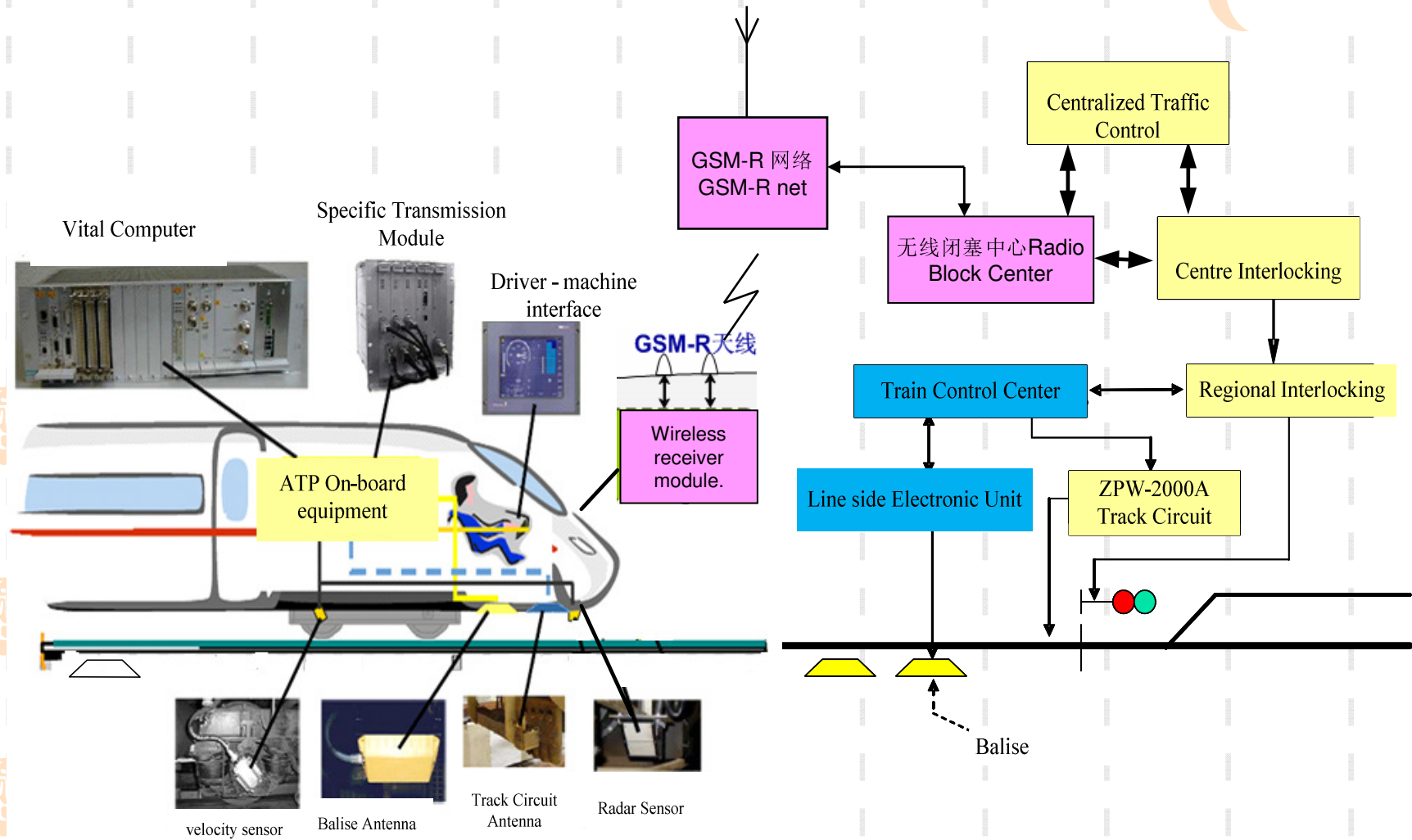
- **RBC**

  - ➤ **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.**

- **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.

- ## 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 toCTCS-3

GSM-R in-door system

RBC

CTC

TCC

Interlocking system

Track circuit

Balise

Switch

Signal

On-board equipment

Speed curve

CTCS-3--Operation principle

Station Interlocking

Radio Block Centre

Centralized Traffic Control

Information of Track Circuit occupy

Signal authorize

Rate-limiting information

GSM-R

Train location

Speed curve

Authority

Track Circuit
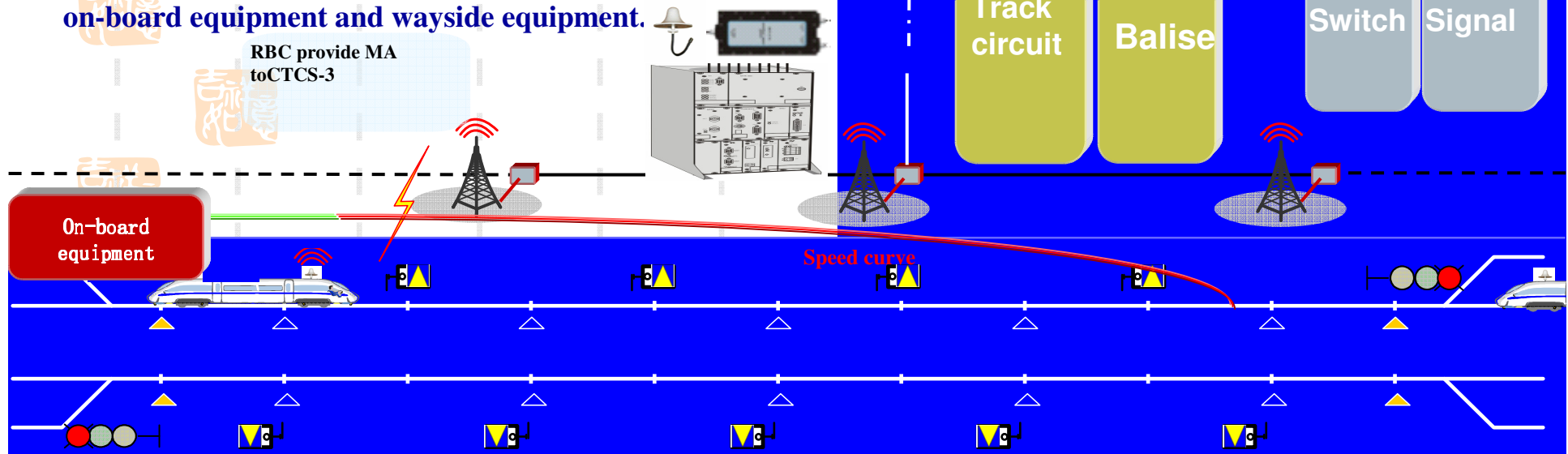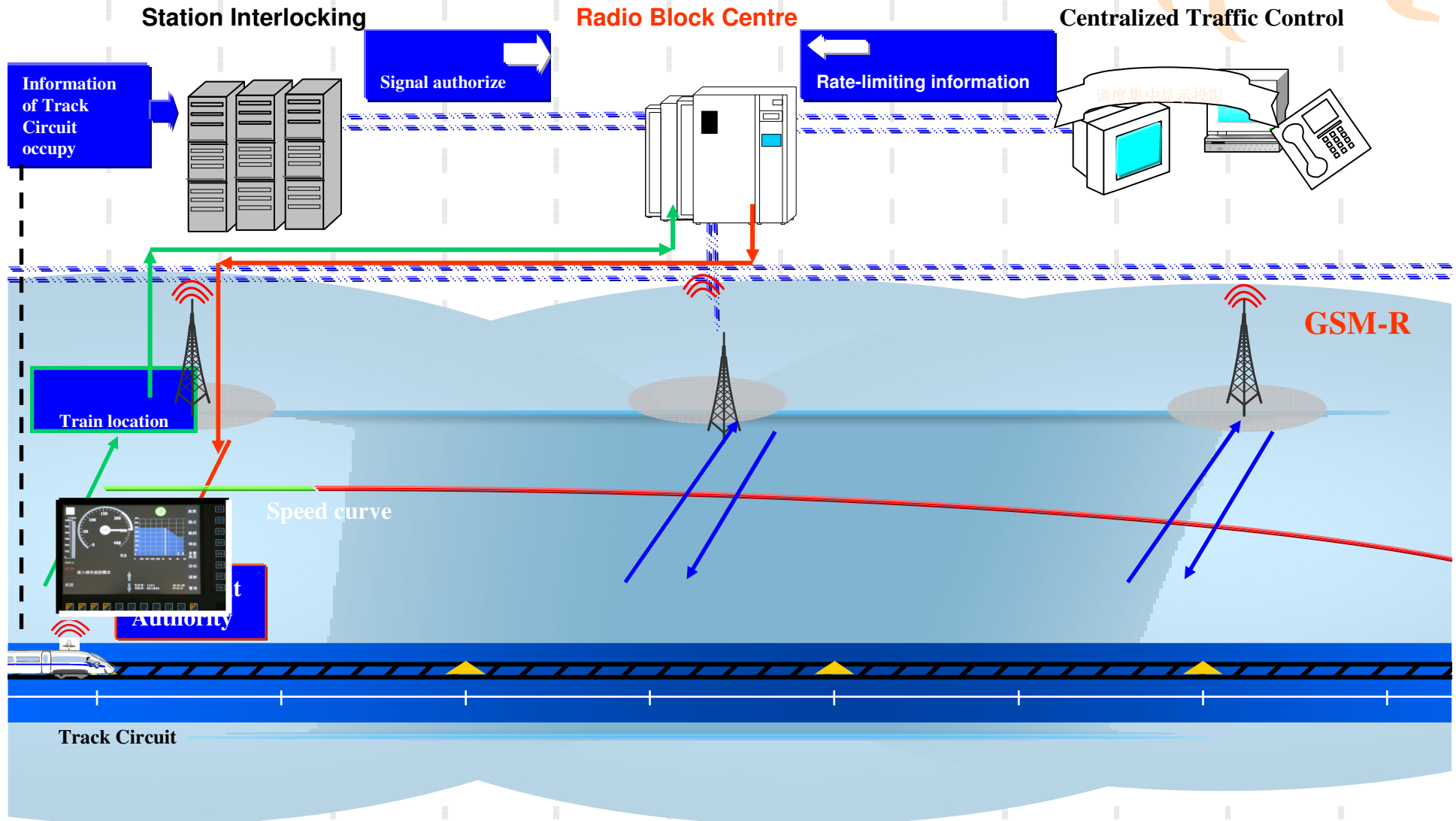
CTCS-3—Section of track running simulation

speed restriction curve

Target of stopping train

Speed(km/h)
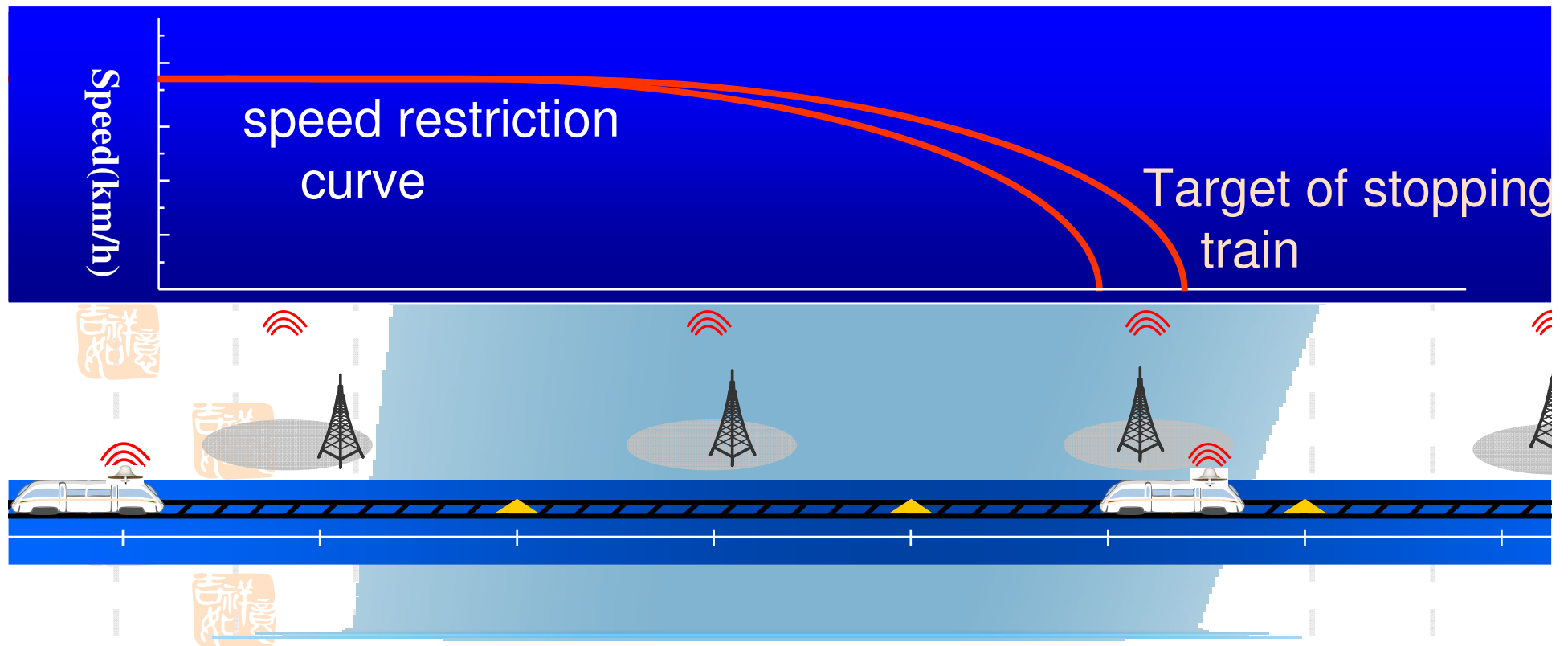
CTCS-3 – System Features

- 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 massage 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.

- 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.
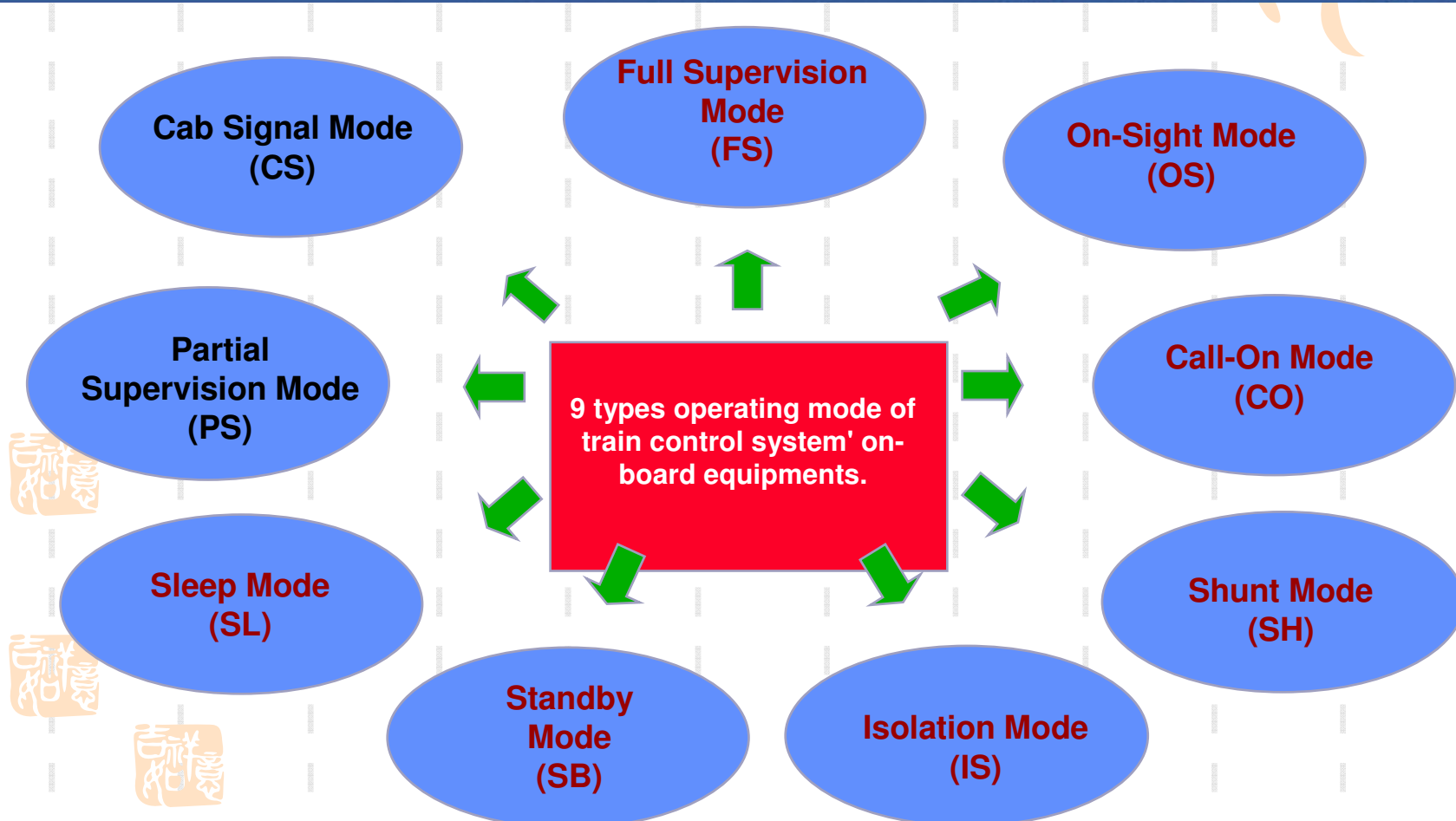
- **RBC can be centralized setting and also scattered setting.**

- **RBC sends information of neutral zone to the train which is equipped with CTCS-3and 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

Cab Signal Mode (CS)

Full Supervision Mode (FS)

On-Sight Mode (OS)

Partial Supervision Mode (PS)

9 types operating mode of train control system' on-board equipments.

Call-On Mode (CO)

Sleep Mode (SL)

Shunt Mode (SH)

Standby Mode (SB)

Isolation Mode (IS)

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
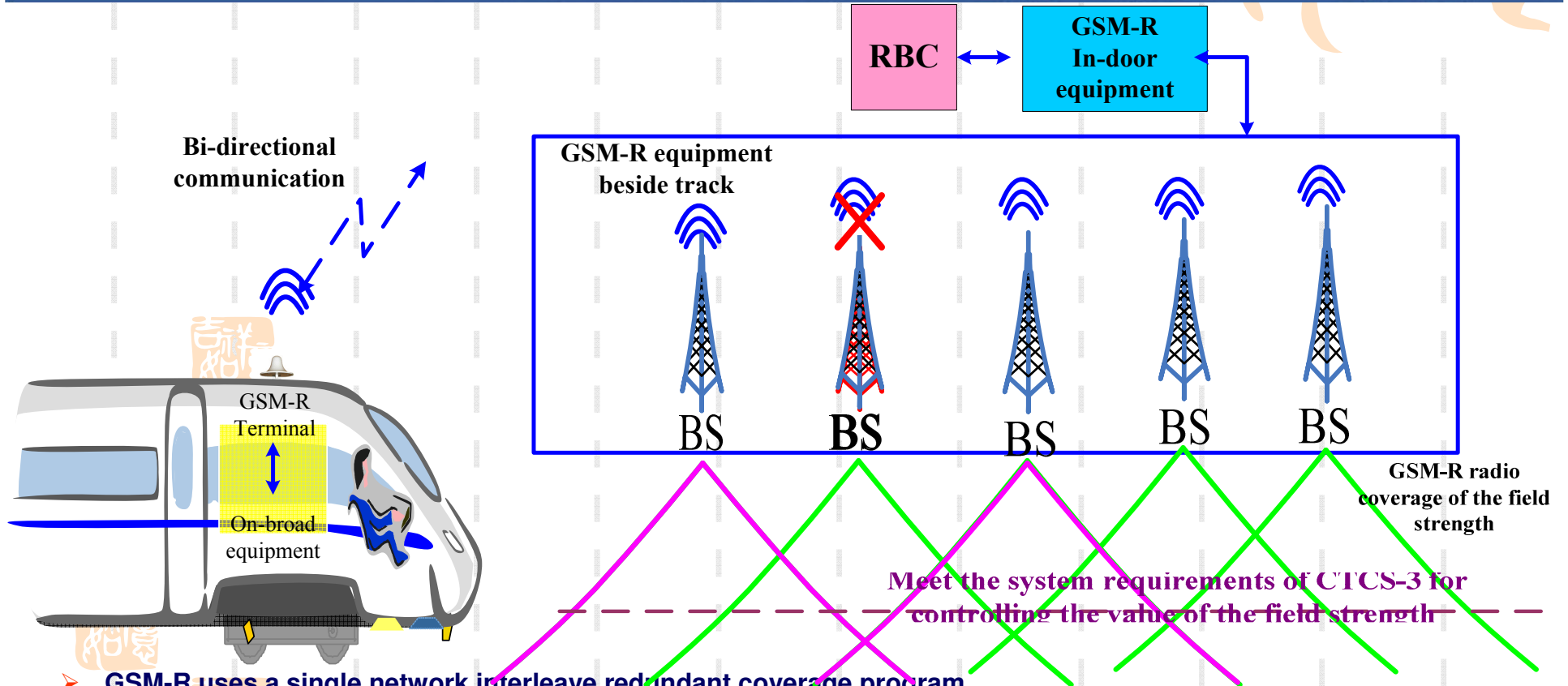- Disaster protection
- Parking and End of Mission
- Shunting
- Artificial unlock route
- Special route

CTCS-3 – GSM-R Network

RBC ↔ **GSM-R In-door equipment**

GSM-R equipment beside track

Bi-directional communication

GSM-R Terminal

On-broad equipment

BS   BS   BS   BS   BS

GSM-R radio coverage of the field strength

Meet the system requirements of CTCS-3 for controlling the value of the field strength
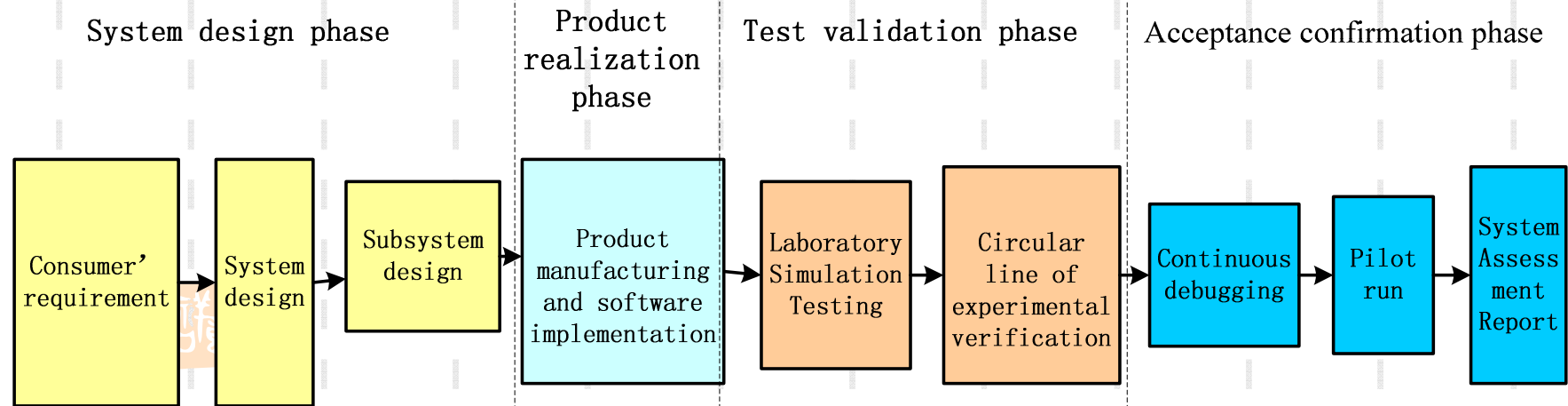
➢ **GSM-R uses a single network interleave redundant coverage program.**

➢ **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

System design phase

Product realization phase

Test validation phase

Acceptance confirmation phase

```
Consumer' requirement → System design → Subsystem design → Product manufacturing and software implementation → Laboratory Simulation Testing → Circular line of experimental verification → Continuous debugging → Pilot run → System Assessment Report
```

➢ **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!
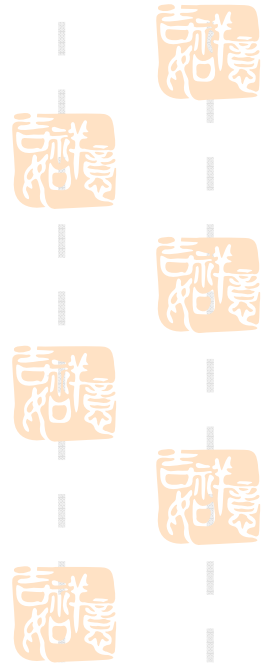
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