Intelligent Transport System of Urban Mass Transit

(Xu Jinxiang , Shanghai TieDao University)

Abstract : With the rapid development of Urban Mass Transit in China ,the Intelligent Transport System becomes inevitable . Based on the brief introduction of the blueprint of Urban Mass Transit in Shanghai, this paper analyses in detail the components and functions of Automatic Train Control (ATC) system applied in Shanghai Metro , presents the key technology of the main three subsystems of the ATC system : Automatic Train Supervision (ATS) subsystem , Automatic Train Protection (ATP) subsystem , Automatic Train Operation (ATO) subsystem .After reading this paper , you will have an general grasp of ATC system . At the end of the paper ,it suggests a good resolution about the ATC system equipment to be made in China . If you are interested in the resolution, we 'd like to exchange our thought .

Keywords : Urban Mass Transit , Intelligent Transport System , Automatic Train Control (ATC) , ATC system made in China

With the application of computer , communication and information technology, the Intelligent Transport Systems (ITS) have been developing rapidly all over the world . The research of the ITS has been paid more and more attention to, the first research project is the road transport supervision . Including automatic car control , the road transport network implements intelligence so that it is suitable for central control and supervision .At the same time ,the driver can acquire all kinds of information corresponding to operation . The ITS can be used not only in road transport system but also in other transport systems such as rail transport including Metro , Light Rail Transit and so on ,which undertake a lot of transport task to ensure the train motion security and to improve the efficiency of train motion .

1 The Blueprint of Shanghai Urban Mass Transit

At present there are more than 35 cities whose population is over one million . These cities have faced many problems such as traffic congestion , environment deterioration ,which seriously restrict social and economic development . The keystone of urban infrastructure development which the new-turn government faces is to broaden the conditions of taking advantage of space , to emphatically develop the public traffic network based on Urban Mass Transit .

The Urban Mass Transit system will consist of Metro, Light Rail Transit in the center of Shanghai ,which is connected with suburb railway .In the near suburb special railway will be built ;in far suburb the high-level double track will be built along the existed line. To partake the traffic flows (15,120,000 persons per day) , it is necessary to build 336 kilometer-long Urban Mass Transit line based on partaking 45,000 persons per kilometer .If we all build Metro , we must invest 200 billion yuan and will need more than one hundred years . So we can consider to build

Transit line based on partaking 45,000 persons per kilometer .If we all build Metro , we must invest 200 billion yuan and will need more than one hundred years . So we can consider to build some Light Rail Transit lines . According to the 1995's urban development schedule , there is 266-kilometre-long Metro and 146-kilometre-long Light Rail Transit line to be built .Now the 22.7 kilometer-long Shanghai Metro line 1 has come into use .The Shanghai Metro line 2 and line 3 are being built .

2 The development of the ITS (Intelligent transport system) of Urban Mass Transit

The ATC (Automatic Train Control) system based on the computer technology telecommunication technology ,and signal technology is the key of the ITS of UMT .At the beginning of the 1960's many countries such as Spain , Barcelona , Moscow, New york ,Tokyo ,London ,And Paris had made experimentation with the automatic train control at spot . The London –Victoria line was the first line in the world which had the automatic train control system in 1968 .From then on ,the single train control has developed into the train group supervision ,and formed the automatic train control system ,and gradually developed into mature technology . The ATC system can generally divide into two kinds as follows :

One kind is based on track circuit , applying digital encoded track circuit instead of the traditional analogous track circuit ,can transmit such information as object speed , object distance ,track circuit length ,etc. in order to attain the optimal speed control and the minimal secure motion interval .The other kind is not based on the track circuit to transfer information . To transfer information from train to wayside , the transmission media is wireless or wayside cross induction cable . Although it doesn't depend on the track circuit to transfer information , it still belongs to the fixed block . At present the ideal motion pattern is moving block .The distance between preceding train and its following train only ensures the minimal brake distance of the following train . But this mode is still at the tentative stage .

3 ATC system in Shanghai Metro

(1) Functions of ATC system :

ATC system has three subsystems : ATS subsystem , ATP subsystem , and ATO subsystem .We can see its equipment at OCC (Operations Control Center),at stations ,and on trains . Figure 1 describes the composition diagram of ATC system .

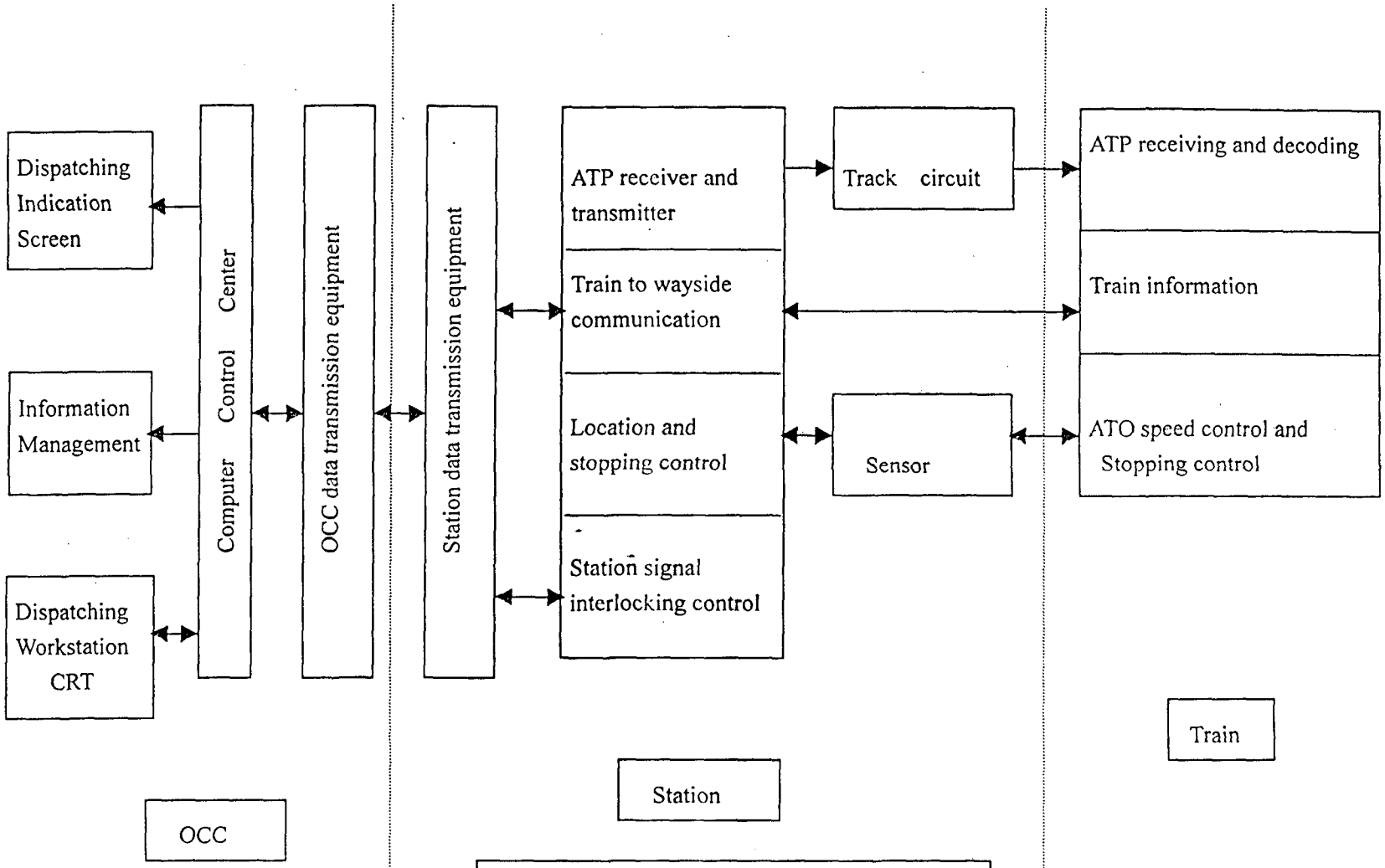

Figure 1. ATC system composition diagram

ATC system's functions as follows:

- Automatically controlling train motion according to the train moving diagram ,the shortest time interval is 120 seconds;
- Limiting the shortest distance between the preceding train and the following train within the safe braking distance
- Real-timely modifying and controlling the maximal operation speed, providing overspeed protection ;
- Ensuring trains stopping at accurate position , stopping accuracy is +/- 25 cm.;
- Supervising location and operation speed grade of all trains on line ;
- Automatically transacting train routes and controlling signal ;
- Allowing manual control when needed , etc.

(2) The main functions of ATC each subsystem

● ATP (Automatic Train Protection) subsystem

The ATP subsystem provides complete protection through the automatic block signal system. It provides such information as safe running interval , safe running speed , train door control command ,etc. It also can ensure route correction and route security .When there is no track section occupancy ,the ATP transmitter sends only the train detection information . When a train is detected entering the track section , the transmitter changes to send speed information . Figure 2 is the ATP subsystem principle diagram .

From figure 2, we know , the ATP transmitter sends train detection information and speed command . Usually, it only sends train detection information to detect train occupancy . When a train enters a track section , it will change to send expected running speed information to the train .

The ATP receiver acquires train detection information from rails to prove whether there is a train occupying . When driver circuit (go circuit) acquires information as follows : the section is occupied ,next section is clear , and route position is correct , then it drivers ATP transmitter to send speed information .

The train-borne ATP equipment consists of ATP command receiver, decoder , and speed compare unit , and so on , they are used to receive and identify train speed commands . it provides overspeed protection and brake . At station it also can control train doors .

There are four frequencies available for train detection information ranging from 2625 Hz to 4275 Hz (2625 Hz , 2925 Hz ,375 Hz ,4275 Hz) .Each train detection carrier will be modulated by one of the two code rates (2 Hz or 3 Hz) .There are six code rates (6.83 Hz , 8.31 Hz , 10.10 Hz 12.43 Hz ,15.30 Hz and 18.14 Hz) providing six speed commands and two code rates (4.5 Hz ,5.54 Hz) providing the door (left and right) control commands . Their carrier frequency is 2250 Hz .

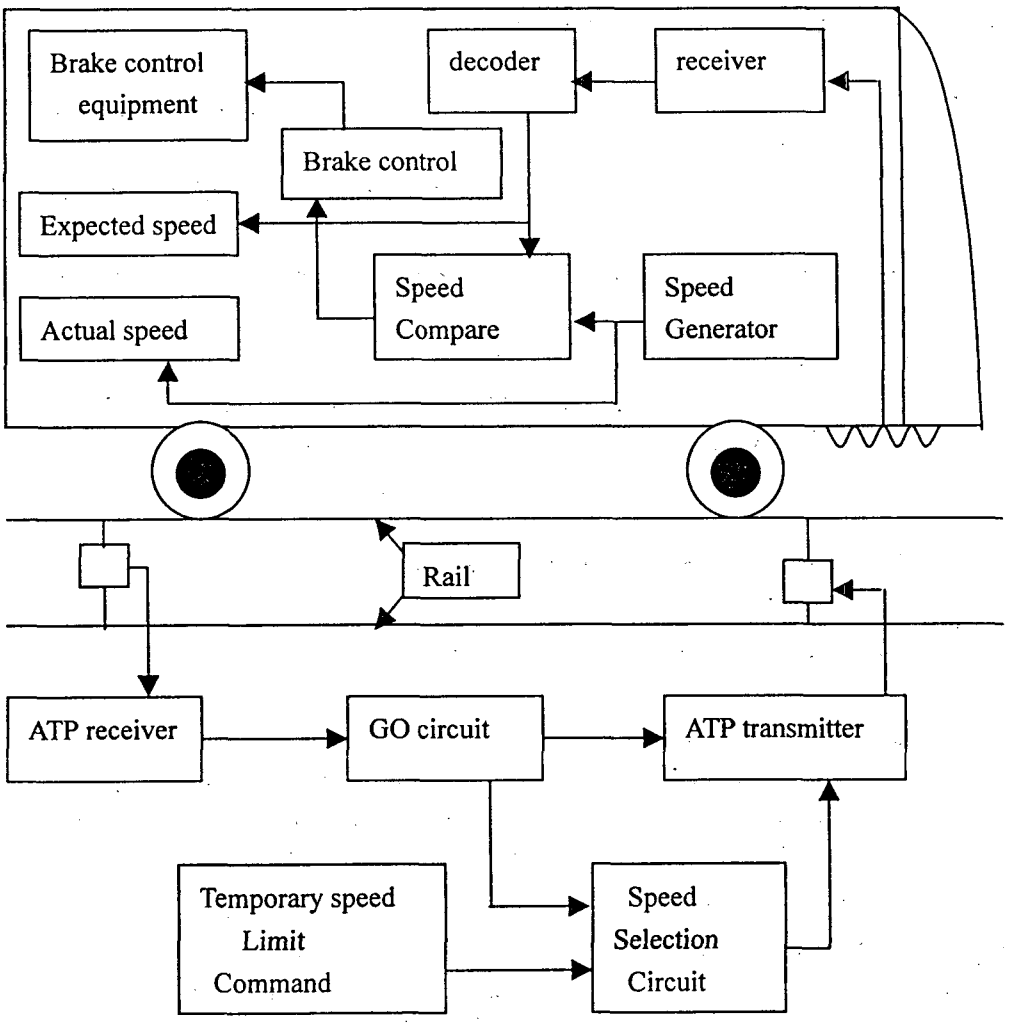

Figure 2. ATP subsystem block diagram

● ATS (Automatic Train Supervision) subsystem

The ATS subsystem is responsible for monitoring and controlling the movement of train. According to the train schedule, it can make the train actual moving diagram, conduct train movement, transact train route , control train departure time , change motion mode , and so on . At the same time it can collect the train motion information and the state of the wayside equipment , including train number, train destination, train signal , etc. . The OCC (Operation Control Center) computer system is responsible for tracing the tracks of train and displaying them on the center indication screen .

The ATS subsystem equipment is installed at OCC and at interlocking station .At the OCC there are :

- Data transmission equipment:

The data transmission equipment is responsible for the data communication between OCC and station ; the location of train ,the state of route ,and so on are displayed on indication screen by light strip , light spot and digit .

- Computer system :

The computer system is used to implement automatic dispatching and operation statistic, to store train moving diagram and to process data .

- Dispatching control workstation :

The dispatching control workstation is used to fulfill dispatching control ,operation management , and equipment maintains

At the interlocking station there are:

- Station data transmission equipment which is responsible for data transmission between station and OCC;
- Tract circuit receiving and transmitting equipment which contacts with block or station sends train detection information or speed information to each section ,reacts the state of track section .
- Train to Wayside Communication (TWC) equipment :

The TWC system provides 2-way communication between the train and the wayside equipment at station platforms. The center can update the following TWC data from wayside to the train: train destination , performance modification . From train to wayside, the TWC transmits the following data : train number ,train destination , train length ,etc.

- Signal interlocking equipment :

According to the commands from the OCC , signal interlocking equipment can transact train routes .It also can be controlled by station

● ATO (Automatic Train Operation) subsystem

The ATO subsystem is connected with ATP subsystem and ATS subsystem .It can take the place of the operator to implement real-time speed control under the ATO mode. When a train approaches a station, via different ATO wayside stopping markers, ATO subsystem equipment sends corresponding indication to stop the train at accurate position.

Near the end of dwell time , after the train receives "time-out "signal ,the operator closes the door manually and presses start-up button .When the train receives the speed command from the ATP wayside equipment ,its ATO speed generator sends corresponding expected speed .Through continuous comparison with the actual speed from the velocity-testing equipment ,ATO sends propulsion , non-propulsion , or braking control commands. The ATO system applies close-loop control technology to reach optimal conditions . Figure 4 is the ATO block running speed control diagram of curve .

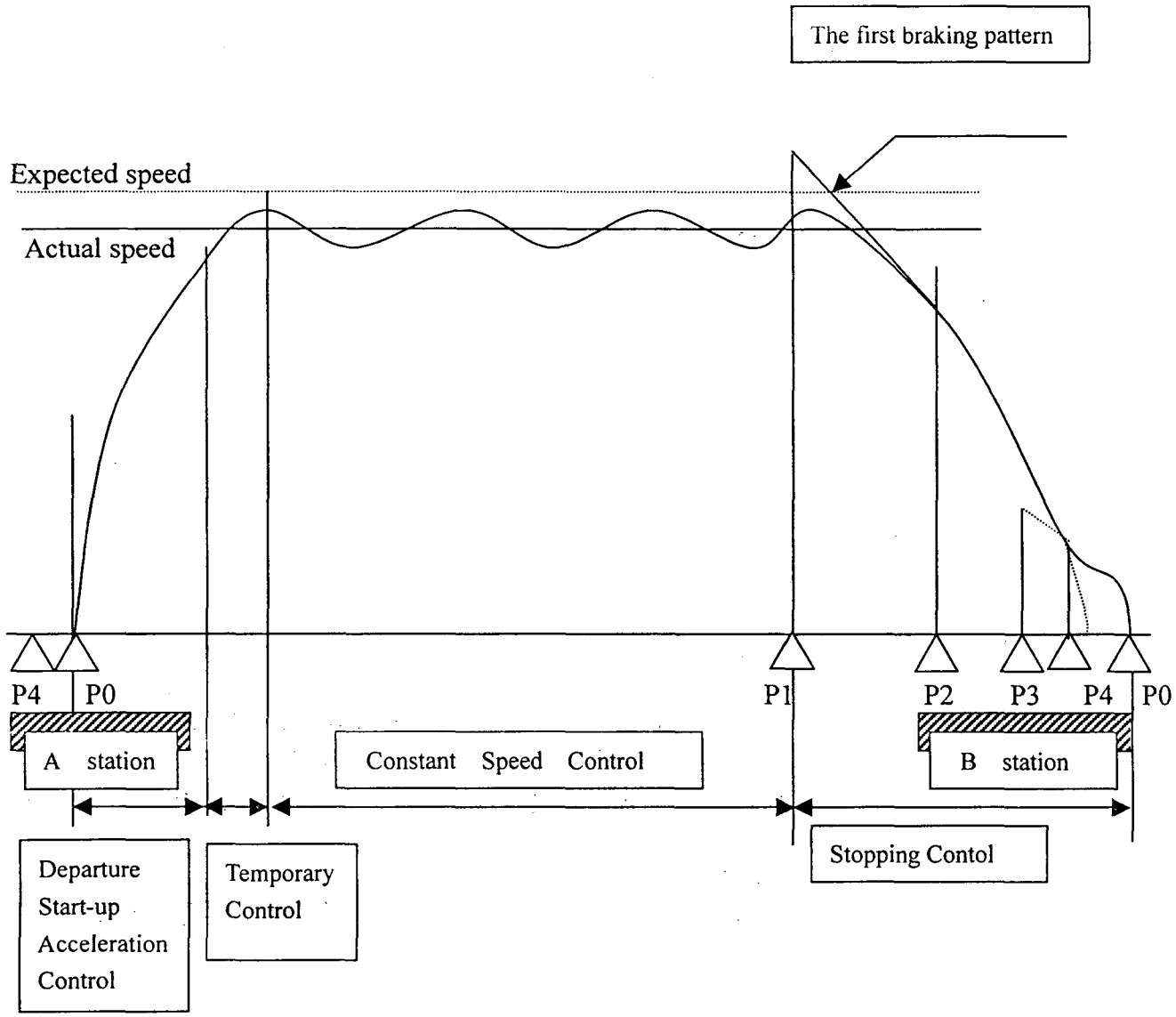

Figure 3. ATO block motion speed control diagram

There are program stopping markers installed at 350m,150m,25m, and 8m stop point and alignment antenna . Figure 4 is the location diagram of the stopping markers and alignment antenna. The wayside markers are sensed inductively when the train's marker detection antenna passes over them. As the train passes over the alignment antenna , ATO equipment sends the stopping signal to brake the train .After having detected the information that the speed of train is zero , it sends the berthing signal , then sends opening door signal via ATP wayside transmitter .Only when the train receives the open door command ,then the appropriated doors are opened .

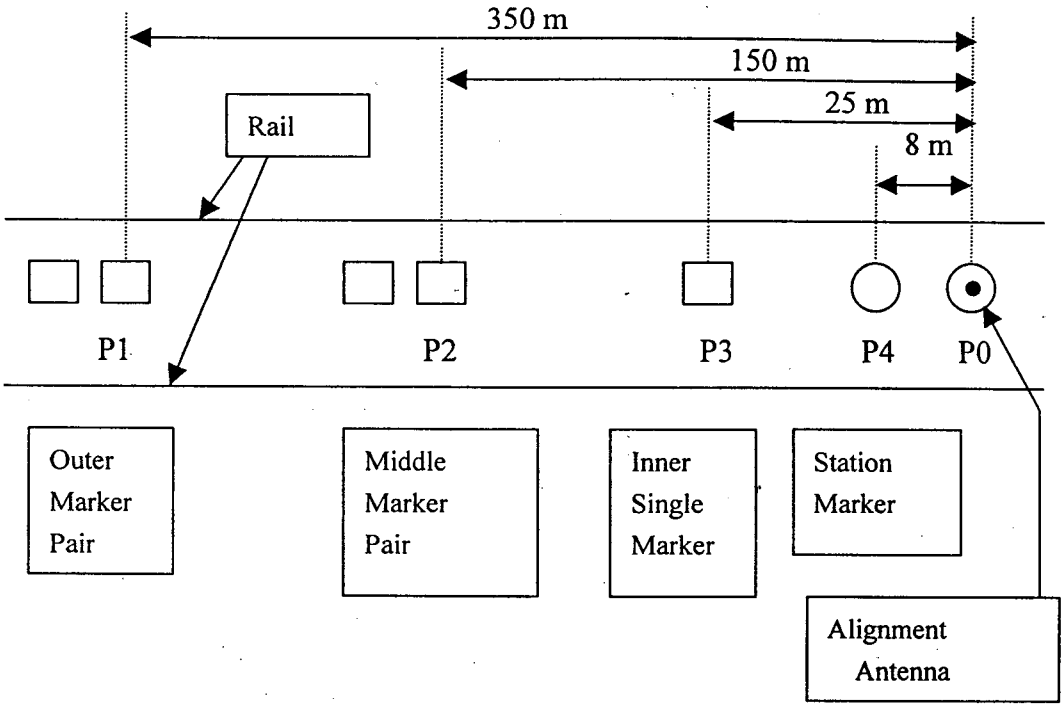

Figure 4 . program stopping marker location

4. Implement the ATC system to be made in China

Although we have develops our Urban Mass Transit for not very long , the Urban Mass Transit system develops rapidly .In many cities such as Beijing , Tianjing , Shanghai and Guangzhou , the Metros have already come into use .In more than 20 cities including Shenzhen , Chengdu , Chongqing , Wuhan ,etc. ,there are 25 pieces of Metro or light-rail transit projects having come into the first design stage. Soon the high-speed rail transport 'will become the main public transport in cities . But by now the ATC system has depended on import. Beijing Metro ATC system mainly is imported from Westing house in Britain ; Guangzhou Metro ATC system mainly is imported from Simens Inc. in German ; Shanghai Metro line 1 ATC system is imported from GRS Inc. in America . The ATC system from different countries decreases its compatibility. In the technology developing opinion they also have many drawbacks : Some are behind the times ; some don't mature yet ; their price is also very expensive. So we must develop our own ATC system, which is suitable for the conditions of our country, and the research work is now being undertaken. ATC system is a combination technology of computer, communication, and automatic control. On one side, We can unit our power to research and manufacture the key-parts of the ATC system exerting the unique advantage of Shanghai. On the other side, we can learn from Korea whose ATC system is partially imported , to carry forward the development of Intelligent Transport System of Urban Mass Transit.

- End -