CHAPTER 2
Block

- Can Li @ 12#503A
- lic@jsnu.edu.cn
- https://sslic.cn/speci_eng

Unit 6 Automatic Train Protection

- ATP Based on Fixed Block
- ATP Speed Codes
- Operating with ATP
- ATP Based on Distance-to-go
- Speed Monitoring
- Operation with Distance-to-go

Introduction

- This unit introduced two kinds of automatic train protection (ATP), one is ATP based on fixed block, and another is ATP based on distance-to-go.

6.1 ATP Based on Fixed Block

- To adapt metro signaling to modern, electronic ATP and the overlaps are incorporated into the block system.
  - This is done by counting the block behind an occupied block as the overlap.
  - Thus, in a full, fixed block ATP system, there will be two red signals and an unoccupied or overlap block between train to provide the full safe braking distance (Fig.6.1).

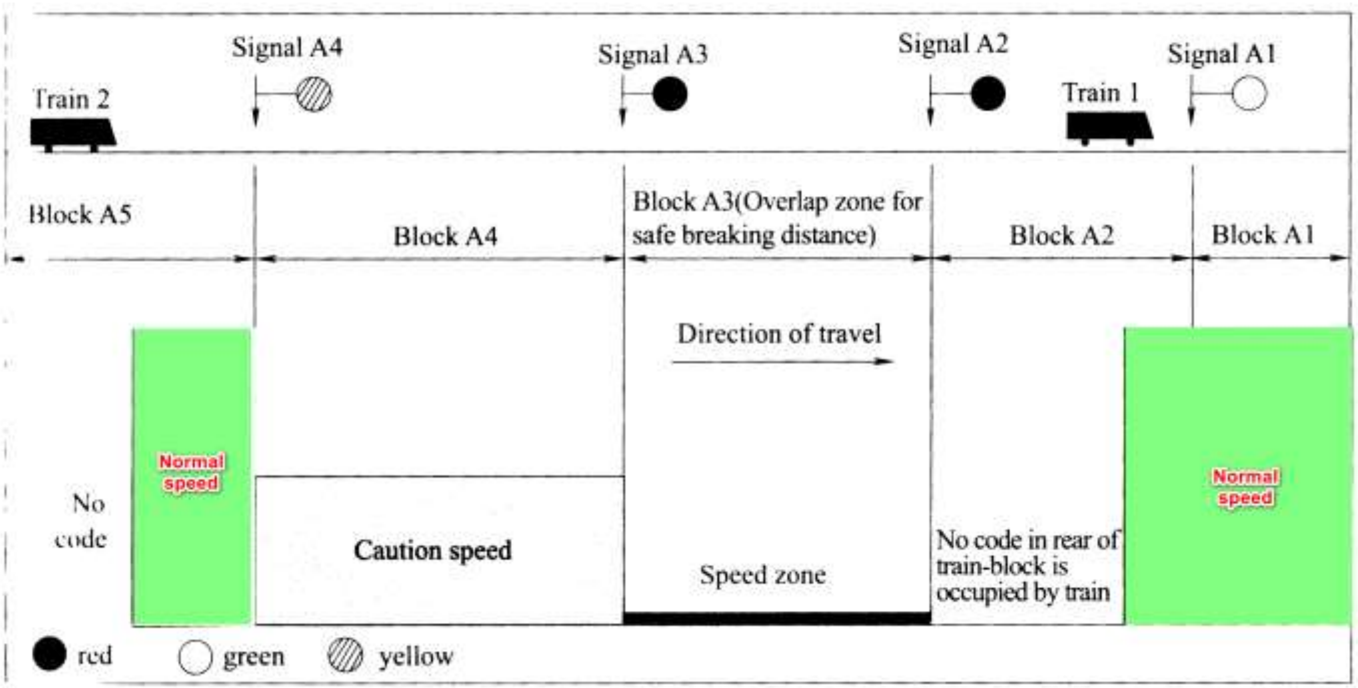

Fig. 6. 1 Diagram of ATP based on fixed block

6.1 ATP Based on Fixed Block

- As an aside, remember that, although I have shown signals here, many ATP equipped system do not have visible line side signals because the signal indications are transmitted directly to the driver's cab console (cab signaling).
- On a line equipped with ATP as shown above, each block carries an electronic speed code on top of its track circuit.
  - If the train tries to enter a zero speed block or an occupied block, or if it enters a section at a speed higher than that authorized by the code, the on-board electronics will cause an emergency brake application.
  - This is the system used by London Underground for the Victoria Line from 1968, the first fully automatic, passenger carrying railway.
  - It was a simple system with only three speed codes—*normal*, *caution* and *stop*.
  - Many systems have been built since then based on it but improvement has been added.

6.2 ATP Speed Codes

- A train on a line with a modern version of ATP needs two pieces of information about the state of the line ahead what speed can it do in this block and what speed must it be doing by the time it enters the next block.
  - This speed data is picked up by antennae on the train. The data is coded by the electronic equipment controlling the track circuitry and transmitted from the rails.
  - The code data consists of two parts, the authorized speed code for this block and the target speed code for the next block.
  - The Fig.6.2 below shows how it works.

6.2 ATP Speed Codes

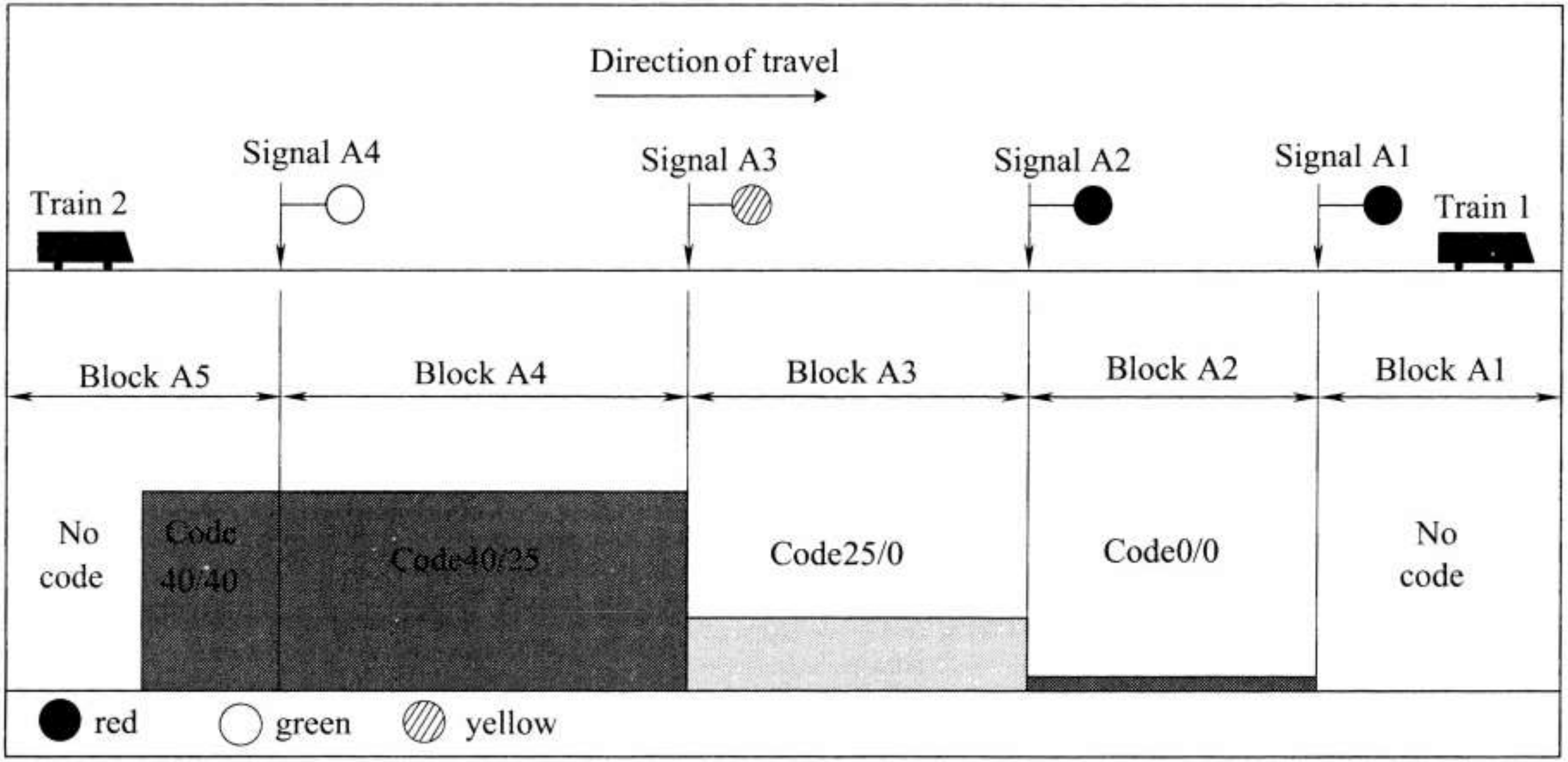

Fig. 6. 2 Diagram of ATP speed codes

6.2 ATP Speed Codes

- In this example a train in block A5 approaching signal A4 will receive 40 over code (40/40) to indicate a permitted speed of 40km/h in this block and a target speed of 40km/h for the next. This is the normal speed data.
- However, when it enters block A4, the code will change to 40/25 because the target speed must be 25km/h when the train enters the next block A3.
- When the train enters block A3, the code change again to 25/0 because the next block A2 is the overlap block and is forbidden territory, so the speed must be zero by the time train reaches the end of block A3.
- If the train attempts to enter block A2, the on-board equipment will detect the zero speed code (0/0) and will cause an emergency brake application.
- As mentioned above, block A2 is acting as the overlap or safe braking distance behind the train occupying block A1.

6.3 Operating with ATP

- **Train operating over a line equipment with ATP can be manually or automatically driven.**
  - To allow manual driving, the ATP codes are displayed to the driver on a panel in his cab.
  - In our example below (Fig.6.3), he would begin braking somewhere around the brake initiation point because he would see the 40/25 code on his display and would know, from his knowledge of the line, where he will have to stop.
  - If signals are not provided, the signal positions will normally be indicated by trackside block marker boards to show drivers the entrances to blocks.

6.3 Operating with ATP

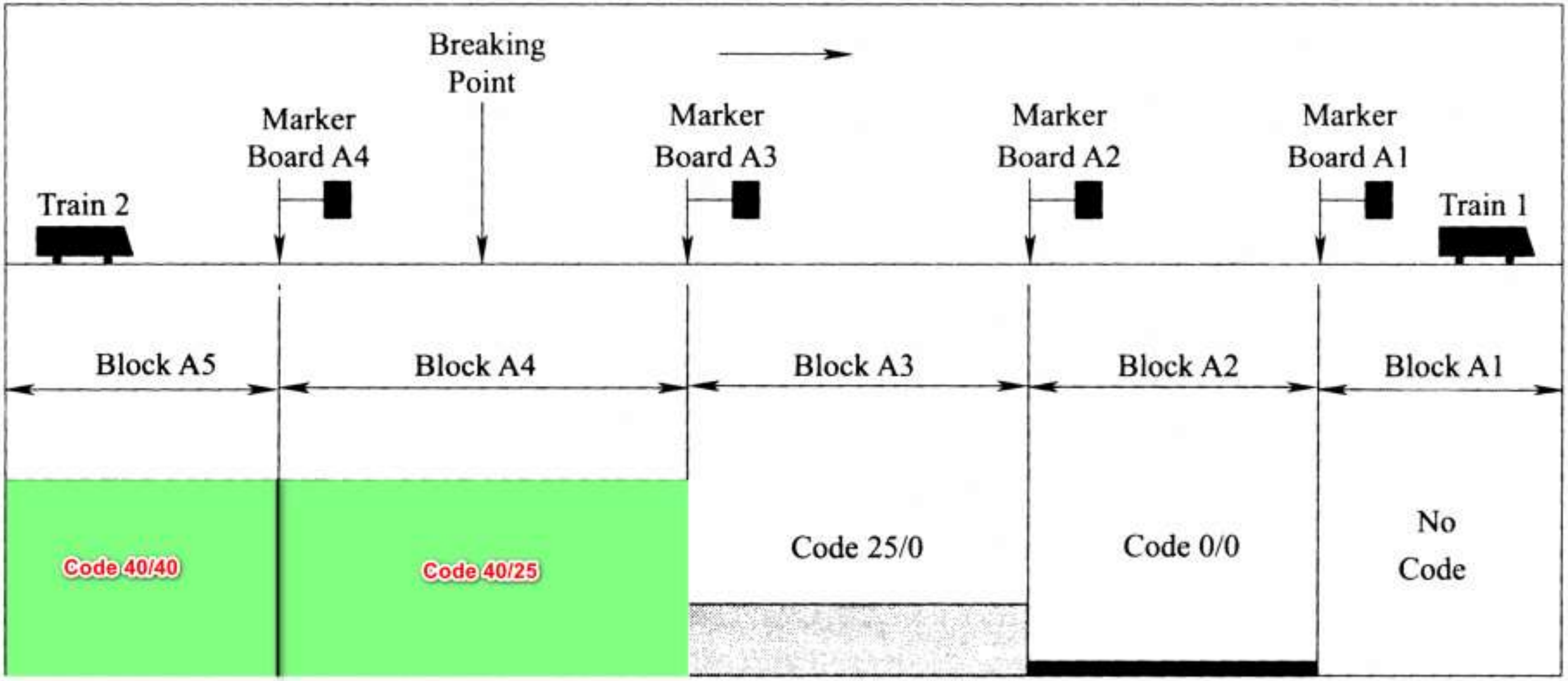

Fig. 6. 3 Diagram of operation with ATP

6.3 Operating with ATP

- If the train is installed with automatic driving, brake initiation for the *reduced target speed* can be by either a track mounted electronic "patch" or" beacon" placed at the brake initiation point or, more simply, by the change in the coded track circuit.
  - Both systems are used by different manufacturers but, in both, the train passes through a series of "speed steps" to the signaled stop.
  - When the first train clear block A1, the codes in block A2, A3 and A4 will change to the next up and any train passing through them will receive immediately a new permitted speed and a new target speed for the next block.
  - This allows an instant response to changing conditions and helps to keep train moving.

6.4 ATP Based on Distance-to-go

- **The next stage of ATP development was an attempt to eliminate the space lost by the empty overlap block behind each train.**
  - If this could be eliminated, line capacity could be increased by up to 20%, depending on block lengths and line speed.
  - In this diagram (Fig. 6.4), the train in block A1 causes a series of speed reduction steps behind it, so that if a following train enters block A6, it will get a reduced target speed.
  - As it continues towards the zero speed block A2, it gets a further target speed reduction at each new block until it stops at the end of block A3.
  - It will stop before entering block A2, the overlap block.
  - The braking curve is shown in Fig.6.4 in orange as the “standard” braking curve.

6.4 ATP Based on Distance-to-go

- To remove the overlap section, it is simply a question of moving the braking curve forward by one block.
  - The train will now be able to proceed a block closer (A5 instead of A6) to the occupied block, before it gets a target speed reduction.
- However, to get this close to the occupied block requires accurate and constant checking of the braking by the train, so an on-board computer calculates the braking curve required, based on the distance to go to the stopping point and using a line map contained in the computer's memory.
  - The new curve is shown in blue in the diagram.
  - A safety margin of 25 meters or so is allowed for error so that the train will always stop before it reaches the critical boundary between A2 and A1.
  - Note that the braking curve should reduce at the final stopping point in order to give the passengers a comfortable stop. To do so, there is no overlap block between the train and the following train.

6.5 Speed Monitoring

- **Both the *older speed step method of electronic ATP* and "distance-to-go" require the train speed to be monitored.**

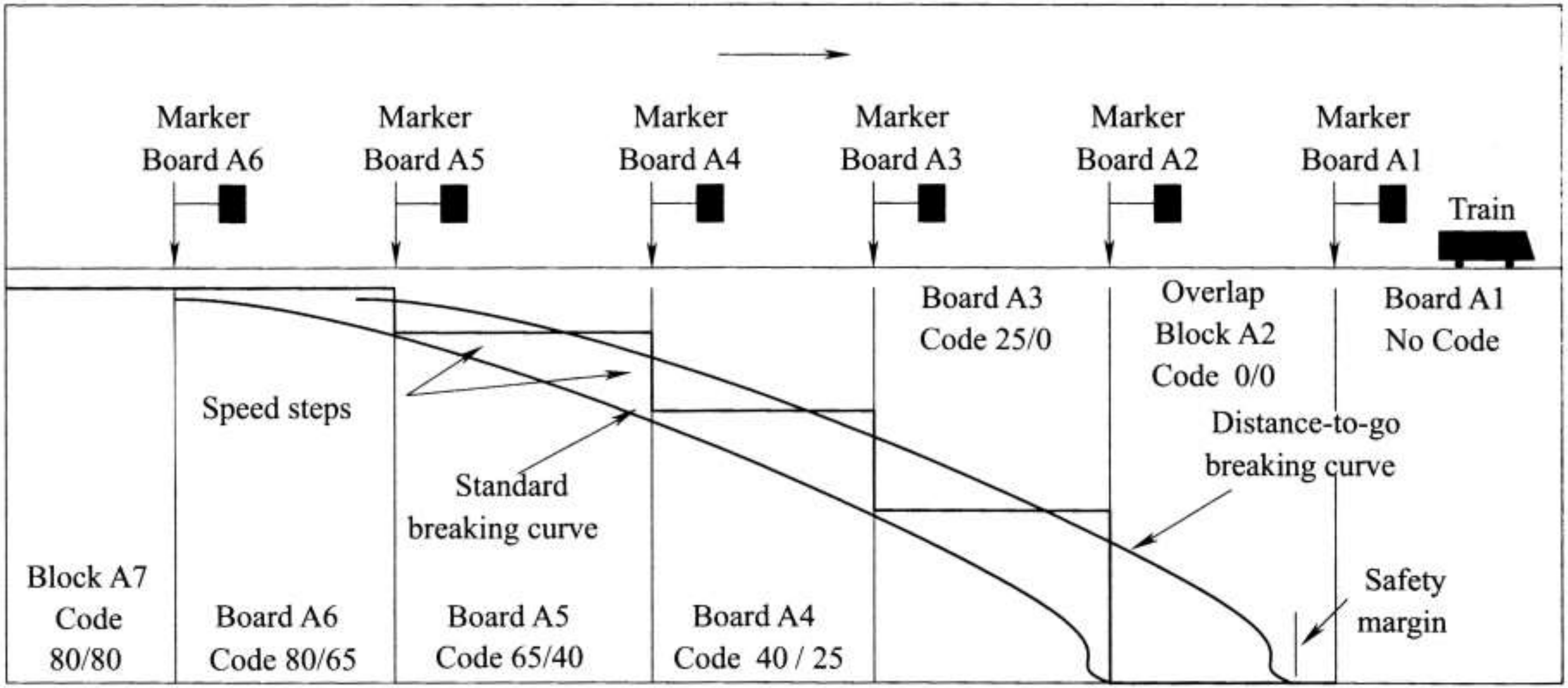

Fig. 6. 4 Diagram of distance-to-go

6.5 Speed Monitoring

- In Fig 6.4 above, we can see the standard braking curve of the speed step system always remains inside the profile of the speed steps.
  - The standard braking curve is shown in yellow in Fig 6.4 , and the profile of the speed steps is shown in orange.
  - The train's ATP equipment only monitors the train's speed against the permitted speed limit within that block.
  - If the train goes above that speed, an emergency brake application will be invoked.
  - The standard braking curve made by the train not monitored.

6.5 Speed Monitoring

- For the distance-to-go system, the development of modern electronics has allowed the brake curve to be monitored continuously so that the speed steps become unnecessary.
  - When it enters the first block with a speed restriction in the code, the train is also told how far ahead the stopping point is.
  - The on-board computer knows where the train is now, using the line “map” embedded in its memory, and it calculates the required braking curve accordingly.
  - As the train brakes, the computer checks the progress down the curve to check the train never goes outside it.

6.6 Operation with Distance-to-go

- **Distance-to-go ATP has a number of advantages over the speed step system.**
  - As we have seen, it can increase line capacity but also it can reduce the number of track circuit required, since you don't need frequent changes of steps to keep adjusting the braking distance.
  - The blocks are now just the spaces to be occupied by train and are not used overlaps as well.
  - Distance-to-go can be used for manual driving or automatic operation.

6.6 Operation with Distance-to-go

- System varies but usually there are some necessary curves which are provided for the train braking profile. This example shows three:
  - one is normal curve within which the train should brake,
  - the second is a warning curve, which provides a warning to the driver (an audio-visual alarm or a service brake application depending on the system)
  - the third is the emergency curve which will force an emergency brake if the driver does not reduce speed to within the emergency braking curve (Fig.6.5).

6.6 Operation with Distance-to-go

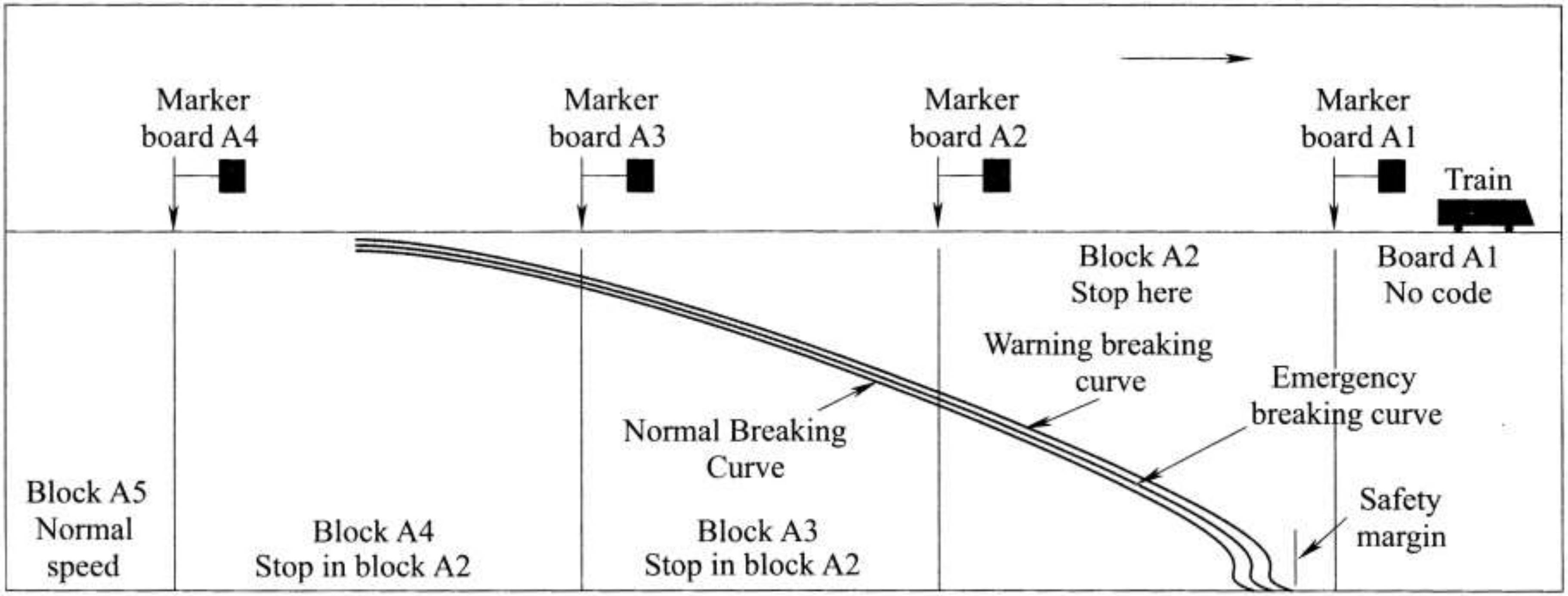

Fig. 6. 5 Diagram of operation with distance-to-go

Homework

- **Pages 26~27**
  - 1
  - 2
  - 3
  - 4