Functional Safety – Relevance to Railways

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Dr. Goundan Profile

- Ph.D from IIT Chennai
- 50 years experience in Railway Signalling and Telecom.
- Chief Signal and Tele Engineer on Eastern and SC Rlys
- Additional Member (Railway Board) and retired as GM
- Post retirement - Joint Dir CEWiT, IIT Chennai from 2007.
- Consultant for Hyderabad, Nagpur, Pune Metro Rails
- 25 publications, Engineer of the year award by the Government of A.P.
- Designed and delivered training programs on railway signalling and RAMS

Functional Safety

1. What is not functional safety?
    - Electrical Insulation
    - Overflow tank
    - Factor of safety in construction
    - Earthing body of electrical equipment
    - Etc.

Functional Safety

- Employs certain functions to achieve safety
- Over voltage protection
- Over current protection
- Level crossing gate
- Speed control of machinery
- Automatic train protection
- Interlocking
- Methods used in chemical industries

Functional Safety in Railways

- Interlocking
- Level crossing gate
- Automatic train protection
- Door control in Rolling Stock (Trains)

Interlocking

- Interlocking means
  - an arrangement of signals, points and other appliances
  - operated from a panel or lever frame
  - so interconnected by mechanical locking or electrical locking or both
  - that their operation must take place in a proper sequence
  - to ensure safety
- Prevents initiation of a hazard

Interlocking

Methods of Interlocking

i) Mechanical interlocking

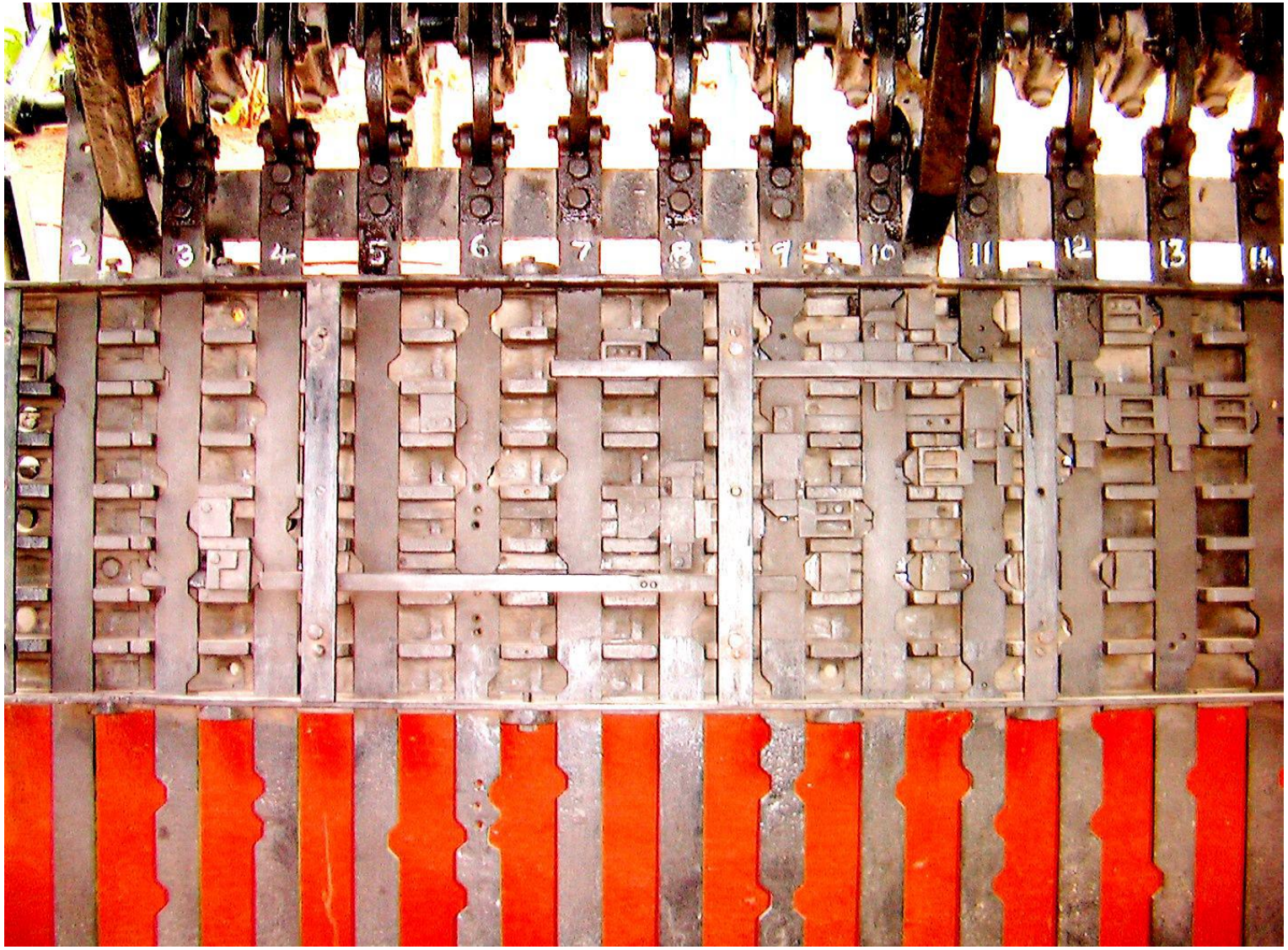
ii) Electro mechanical interlocking

iii) Relay or Electrical interlocking

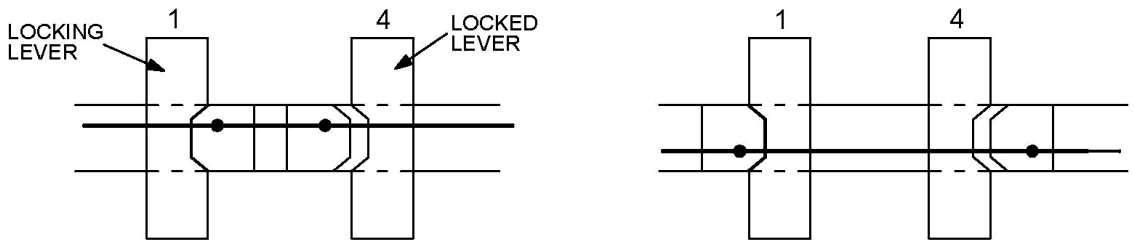
iv) Electronic interlocking

Mechanical locking

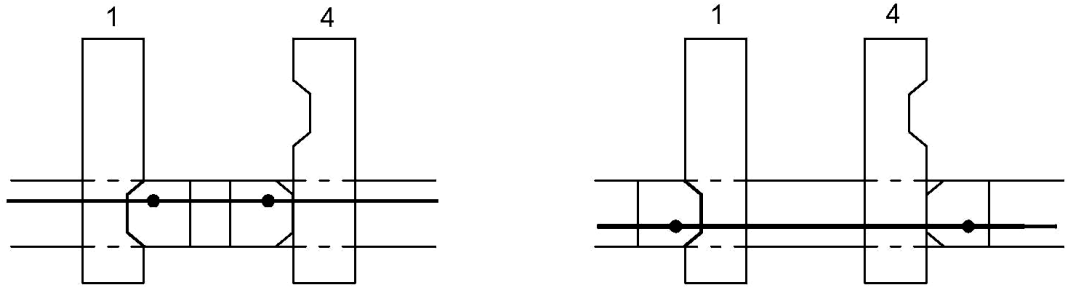
Mechanical locking



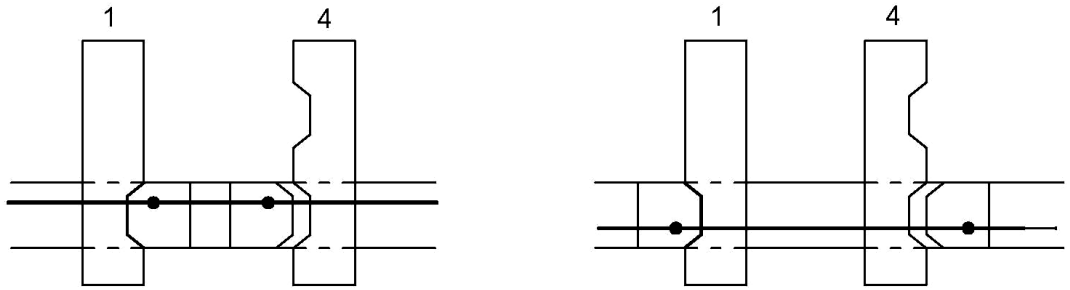
Mechanical locking



(a) Normal Locking 1 Locks 4



(b) Back Locking 1 R.By 4



(c) Bothway Locking 1 Locks 4 B/W

BAR IN COMPRESSION

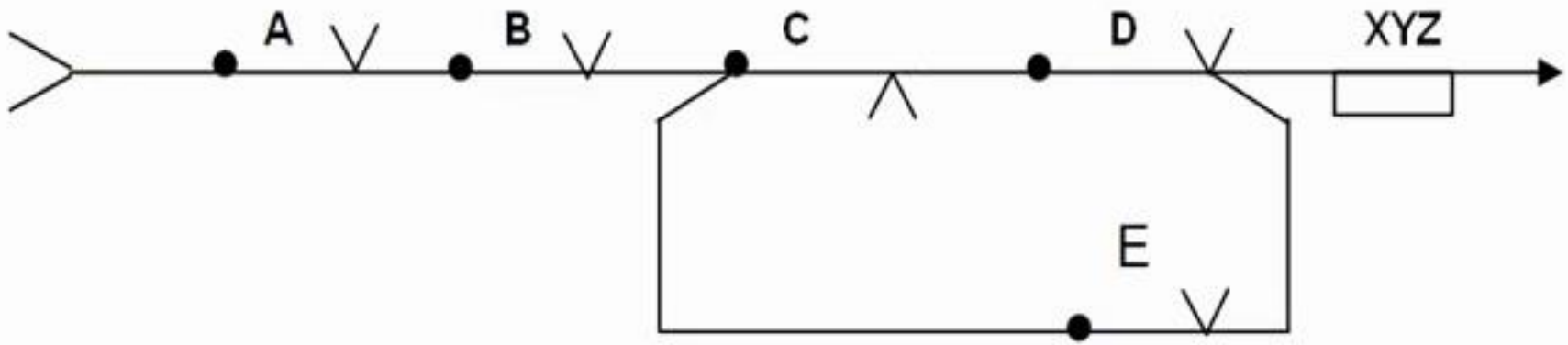
BAR IN TENSION

Relay Interlocking

- This is more safe and suitable for the present level of traffic.
- This interlocking is predominantly available over Indian Railways.
- The interlocking is achieved through electrical relays which is more reliable and absolutely safe.
- The principle of Relay interlocking is ‘Fail Safe’ and less human dependent.

- The human agency is required only to operate the Control panel which controls all the signalling functions from a central place.
- As all the functions are operated electrically, there is no limit in the range of operation in Relay Interlocking.
- Time taken to operate Button/switch on the Control panel to operate functions is very less and least effort is required.
- Therefore Relay interlocking is much superior to Mechanical/Electro mechanical interlocking.

Conversion of Circuit to Boolean Equation



ASSIGN A * B * (~ C * D + E) To XYZ ;

Electronic Interlocking

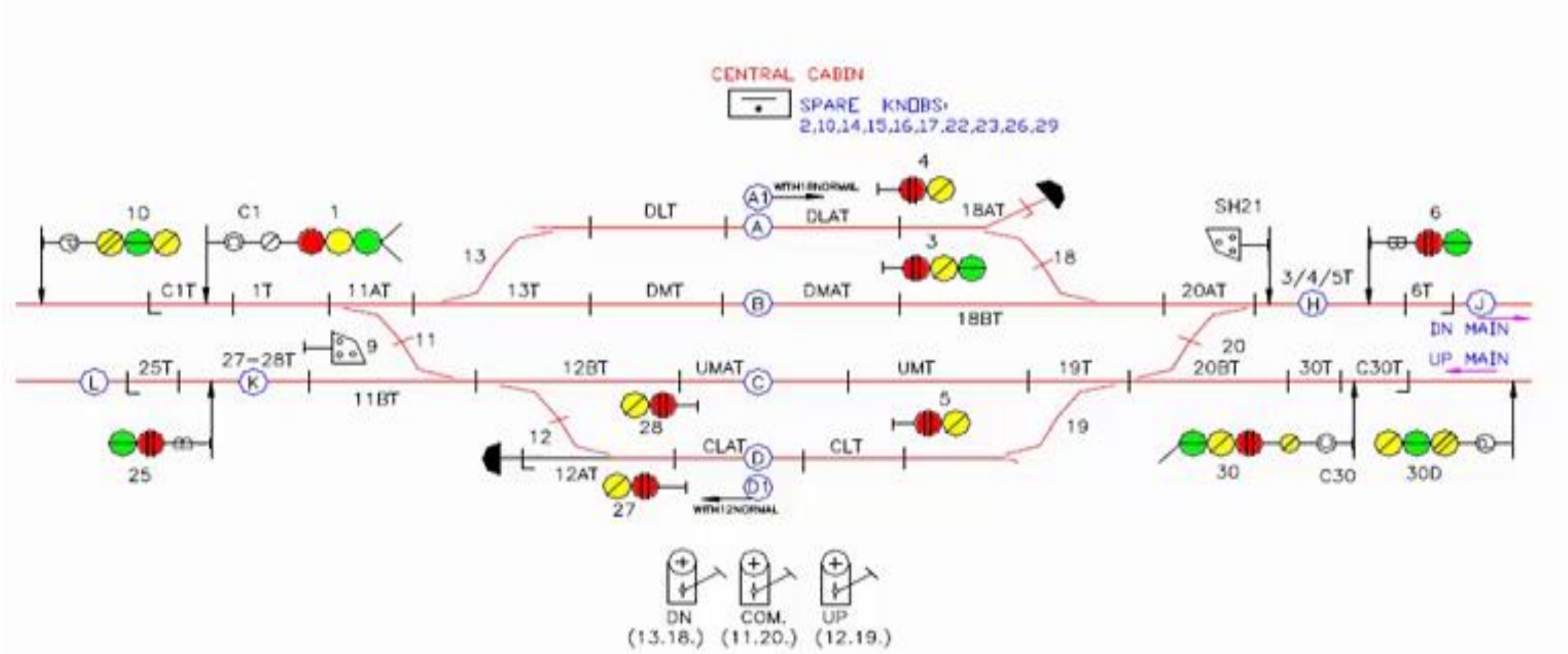
- Interlocking logic is based on Software, requiring no wiring in the system for individual Route/Signal
- Hence the installation time is drastically reduced than for a conventional Relay interlocking
- Alterations do not require major wiring changes

- Only data of the CPU card will have to be changed
- Therefore, Yard Re- modelling will not require large scale wiring alterations and testing, obviating the need for long duration of Traffic blocks
- This is, in fact, the most important advantage of EI system

- No relays are required for interlocking function.
- Only field gear actuating relays are required.
- Power supply, Relays, Relay racks & accessories and indoor wiring get, thus reduced.

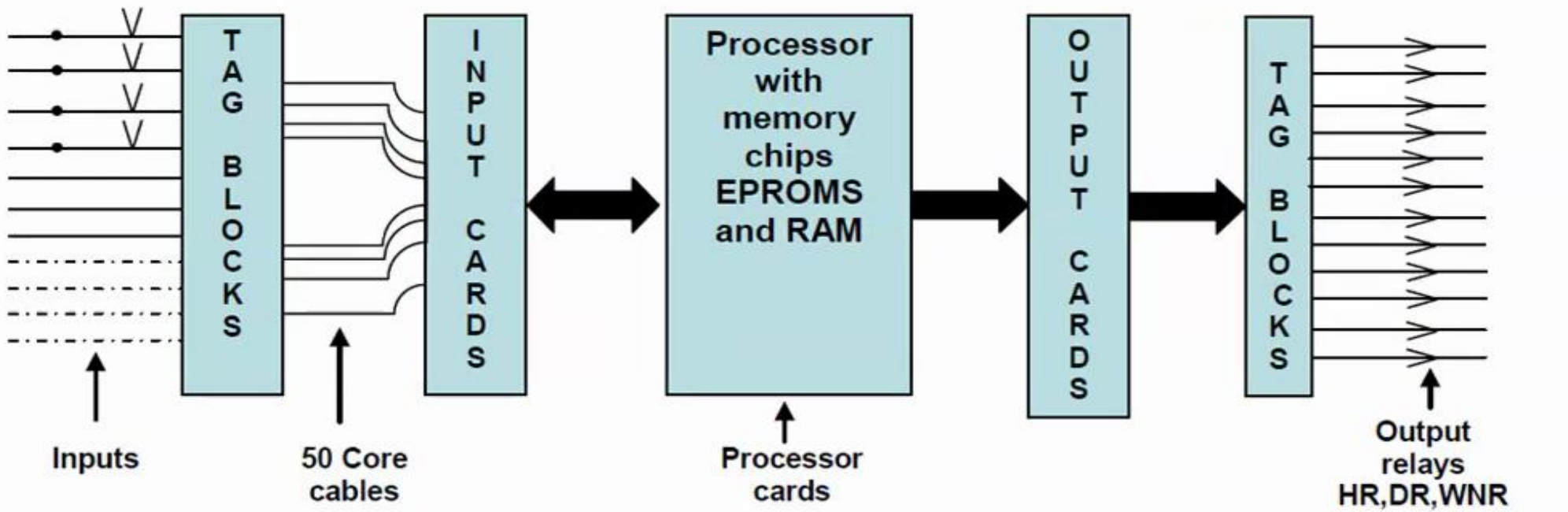
- Consequently, the required space is reduced substantially.
- EI system has got extensive Self-Diagnostic features and helps in quick fault localization.
- the Down time of the installation in case of failure is reduced substantially.

Typical Station Layout

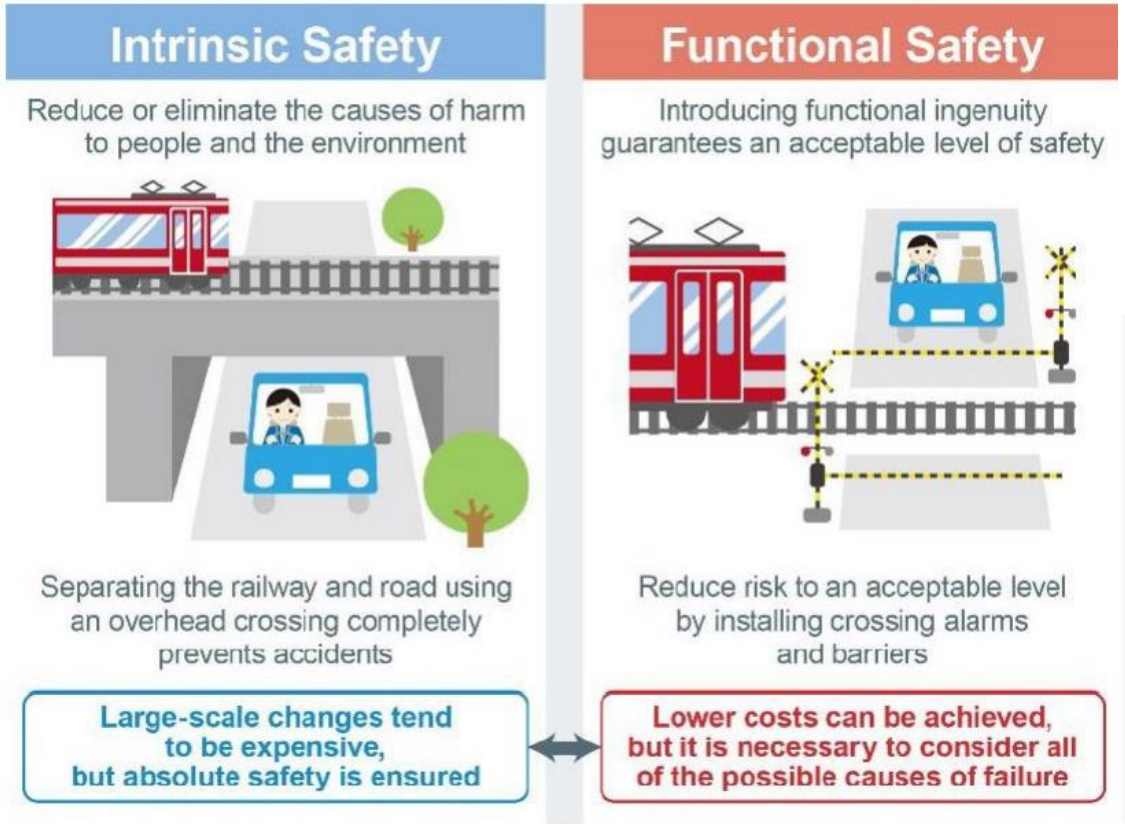


- There are 12 points, 25 track circuits, 15 signals and 3 other gears
- Total 55 field equipments
- Each field equipment is binary (only 2 states)
- The number of combinations to be tested are 2^{55} which is a very large number and virtually impossible to test

Block Diagram of EI

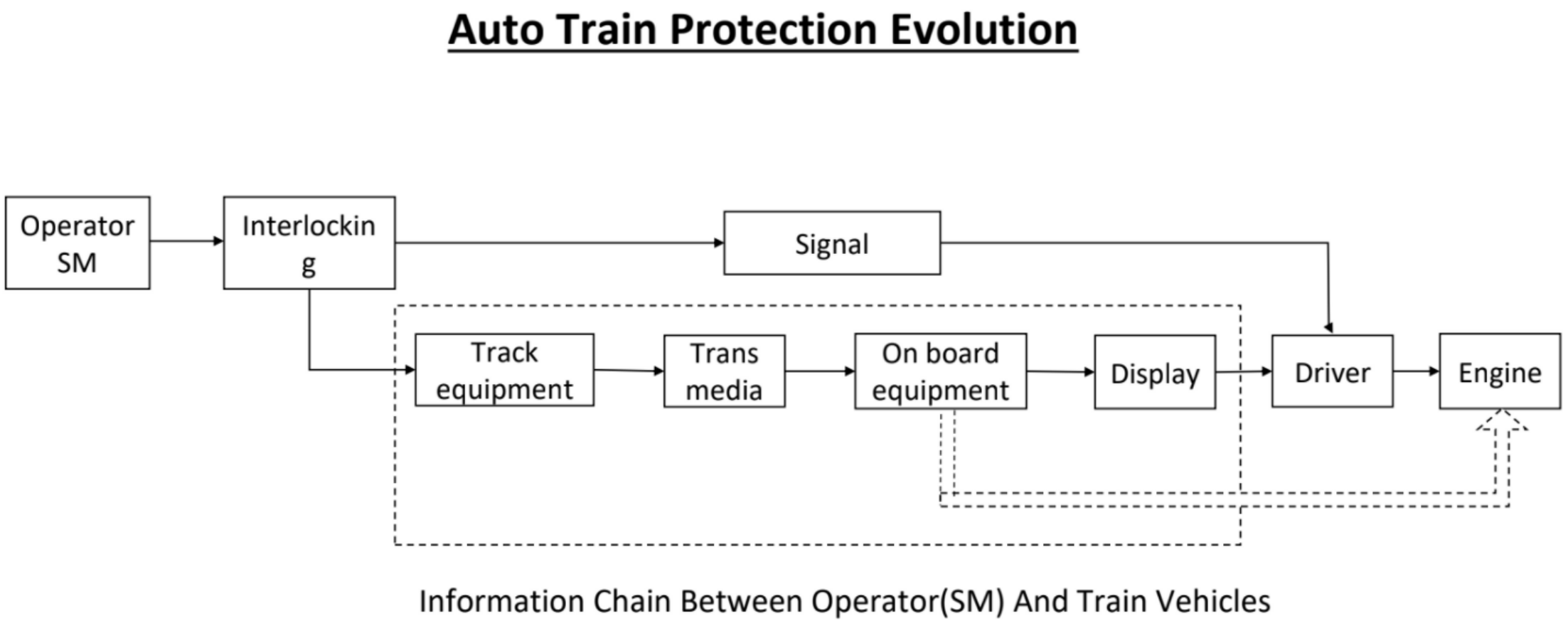


Level Crossing Gates Protection



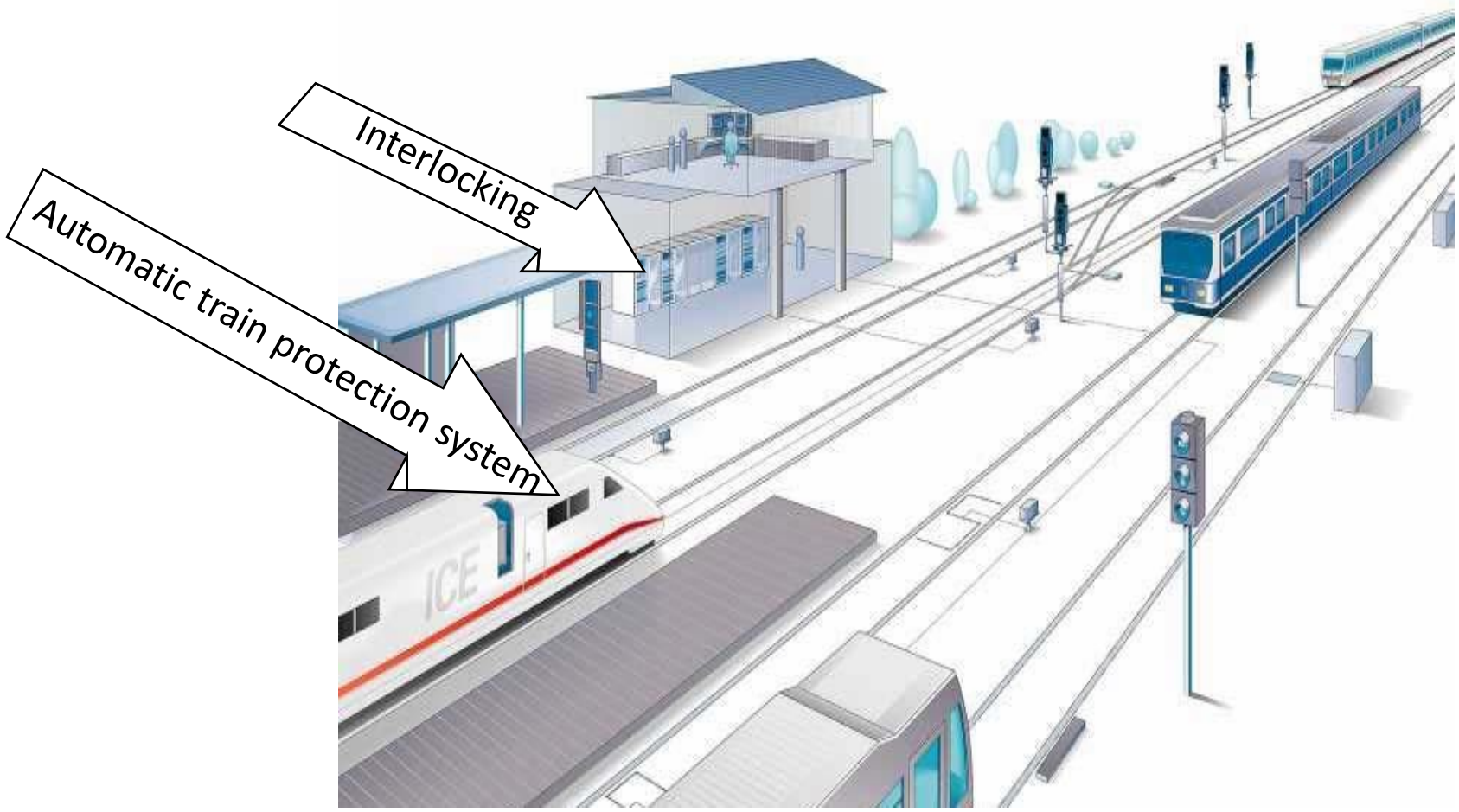
- Intrinsic Safety guarantees absolute safety but very expensive.
- FS is lower cart.
- FS requires to assure safety when additional functions fail.

Automatic Train Protection

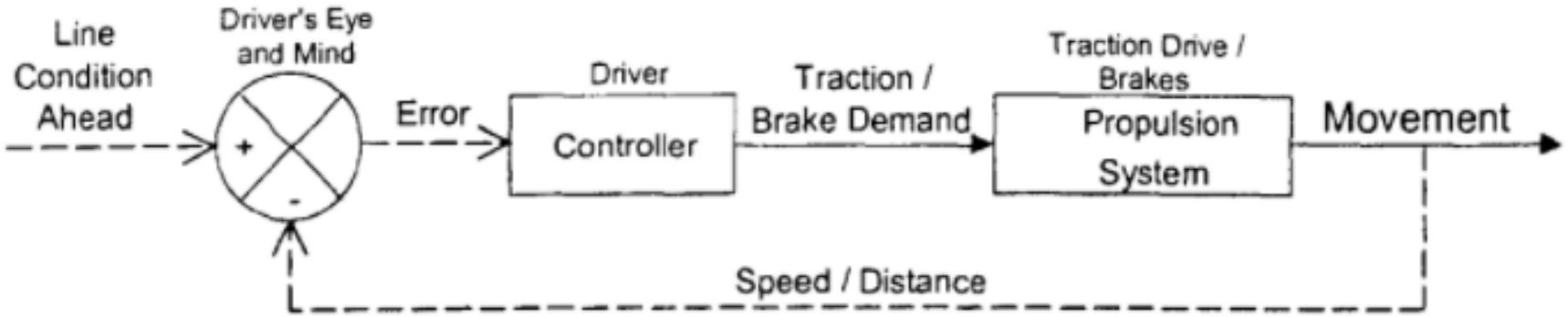


Information Chain Between Operator(SM) And Train Vehicles

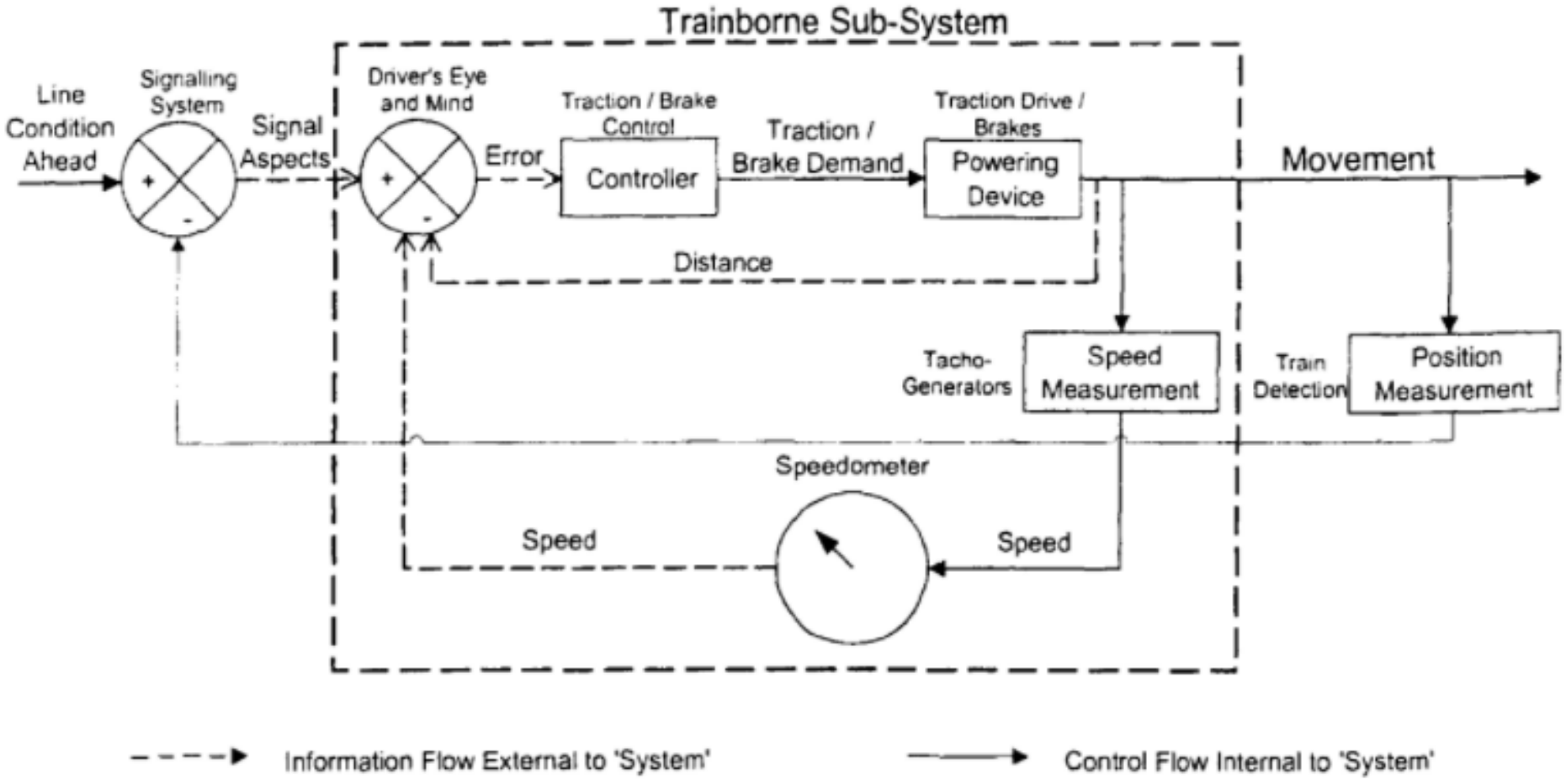
SRS: Railway Sector Application Examples



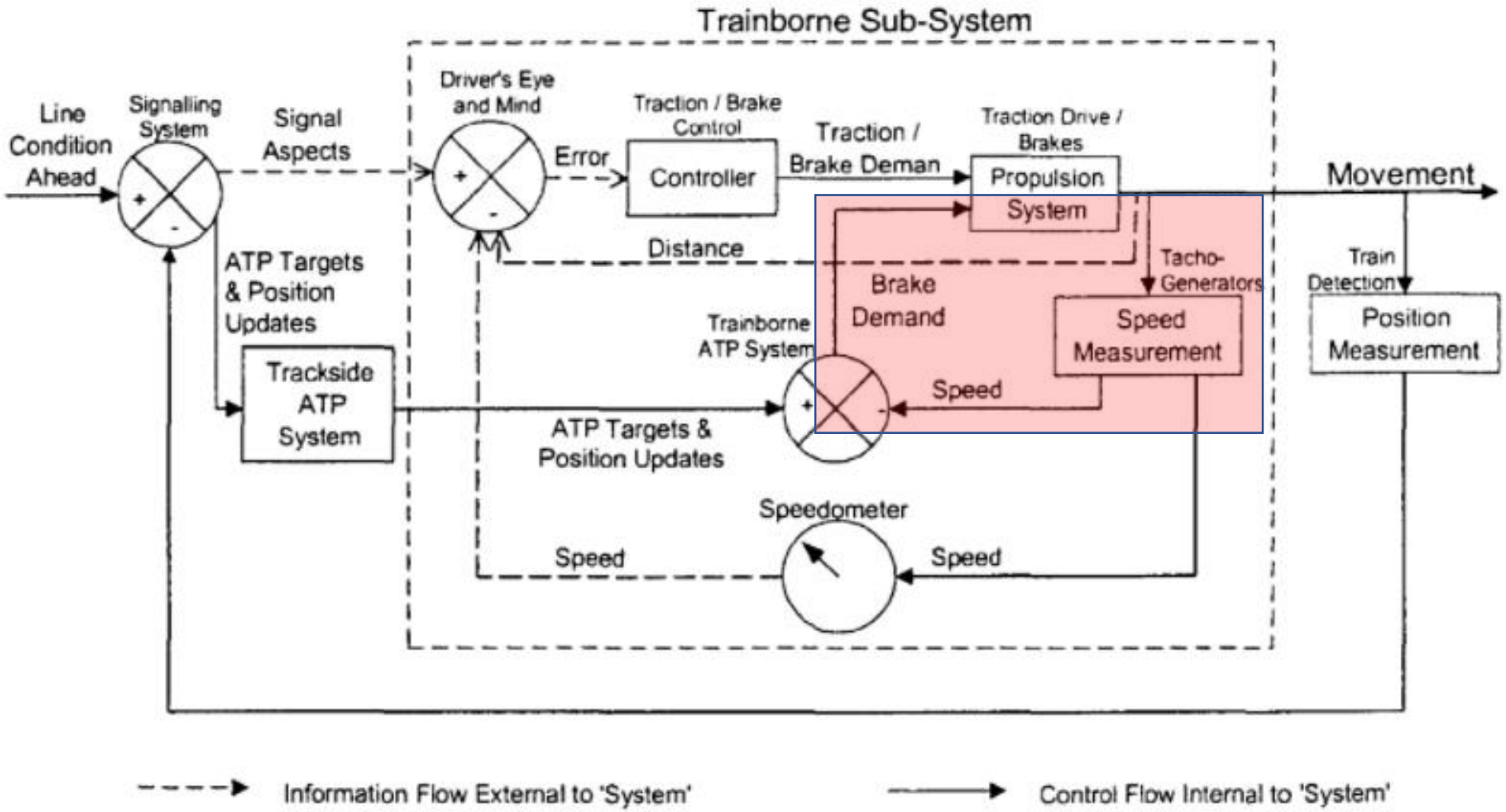
Basic Human-Machine Train Control System



Advanced Human-Machine Train Control System



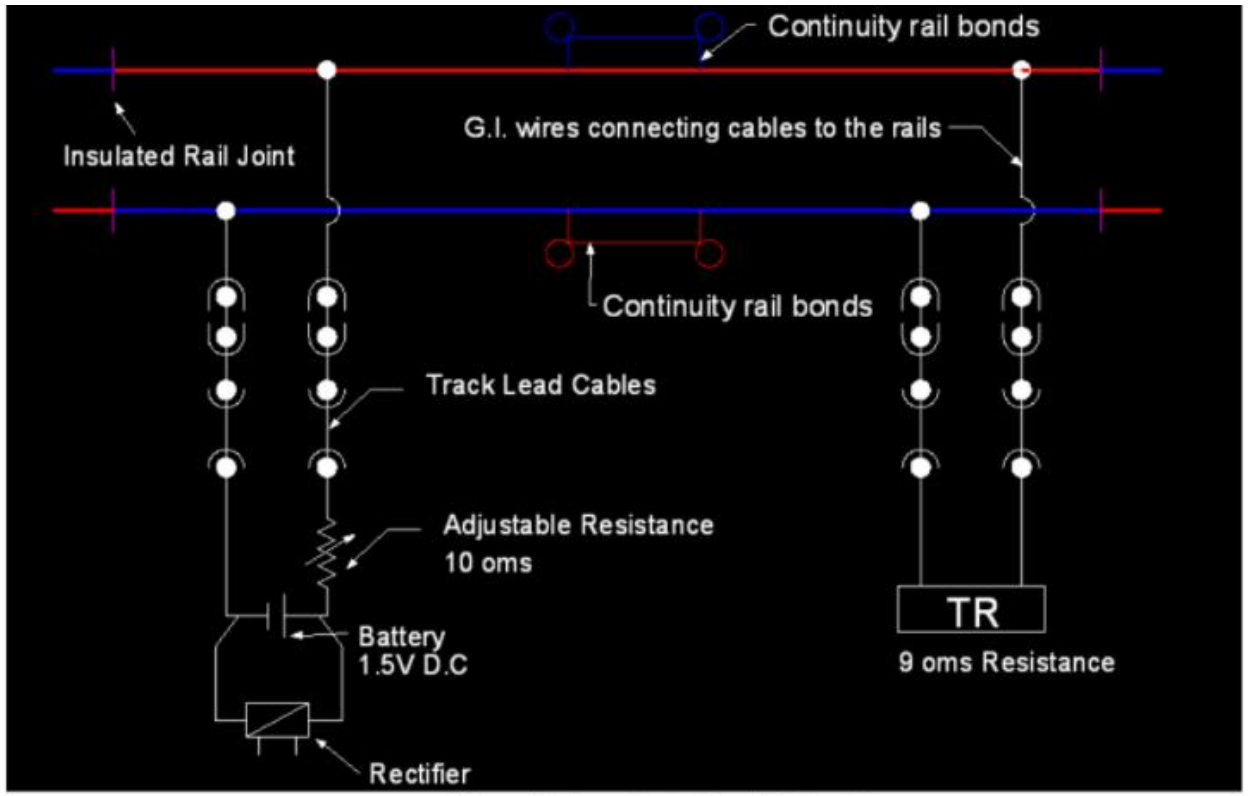
Train Control System with Automatically Closed Safety Loop



Detects onset of a hazard and takes remedial action

Examples of Safety Functions & Functional Safety

Track Circuit – Train Detection



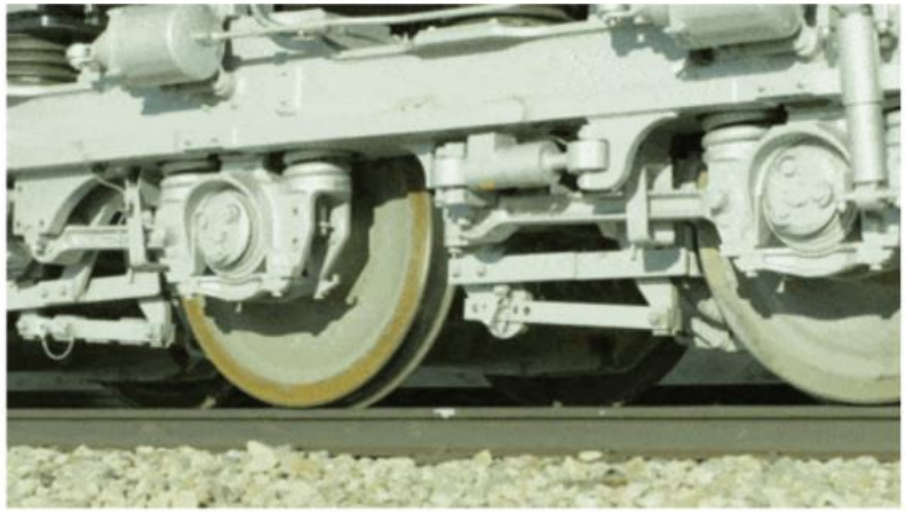
Closed Type D.C. Track Circuit

The circuit gets completed when the track is occupied through the net resistance of the vehicle axles occupying the track circuit.

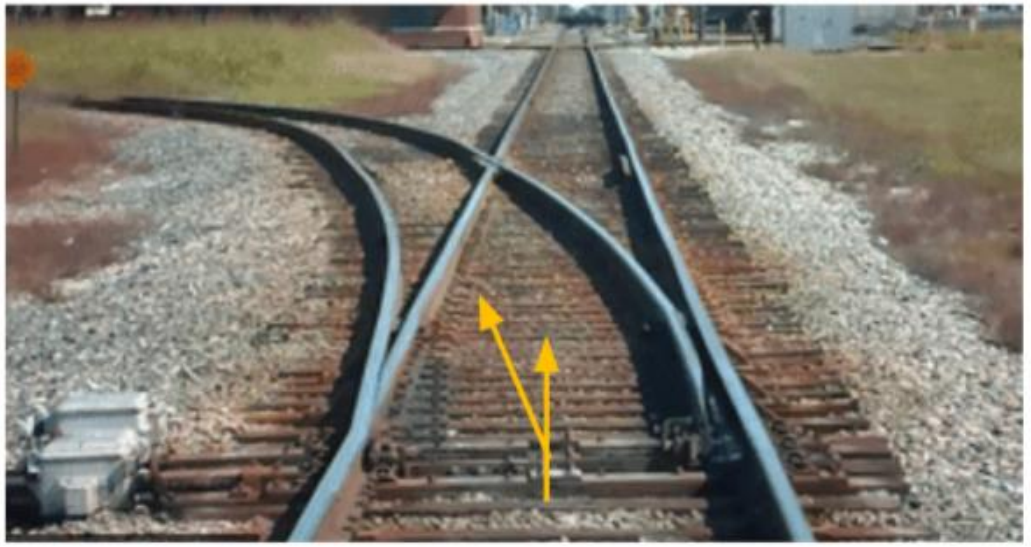
- Hazard – Track circuit does not detect the occupation of train
- Safety Function – Track circuit will correctly detect the shunt produced by a train wheel between the rails

Points & Crossings – Diversion of Train

ROLLING STOCK

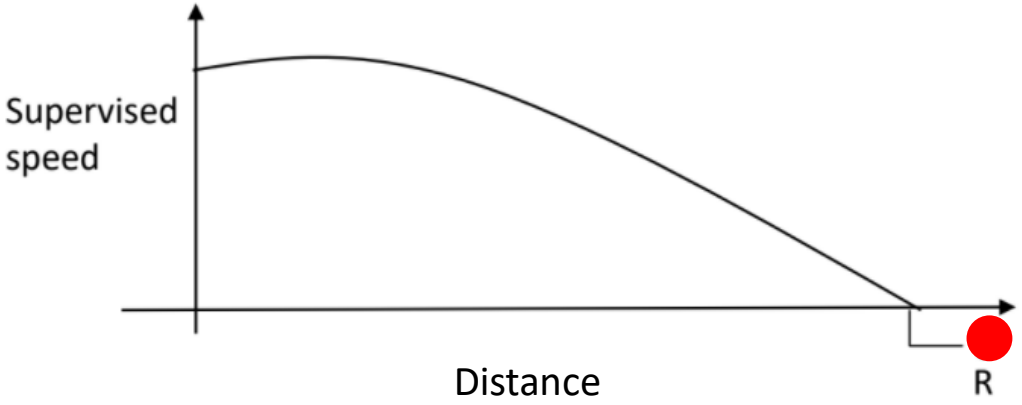


RAILWAY POINTS AND CROSSING



- Hazard – Movement of point under the train
- Safety Function – Detect the presence of train and disable movement of points (prevent rotation of point motor)

Automatic Train Protection



- Hazard – Signal at red
- Safety Function:
  - *Calculate Location from signal*
  - *Calculate speed of train*
  - *Compare speed at any point with the profile speed curve*
  - *Brake accordingly*

Thank you