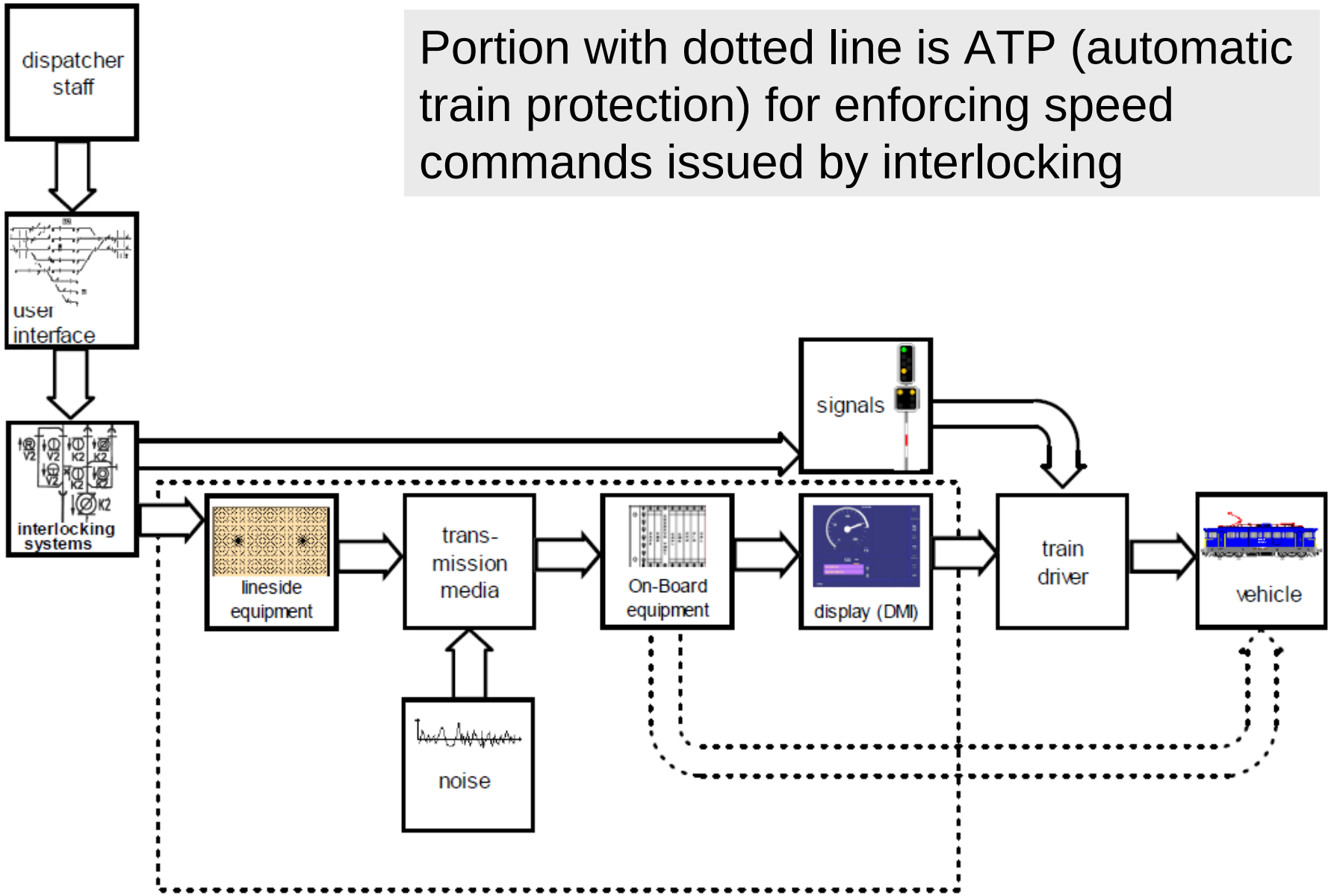
Presentation
to
Sr DOM's at IRITM

30th June, 2011

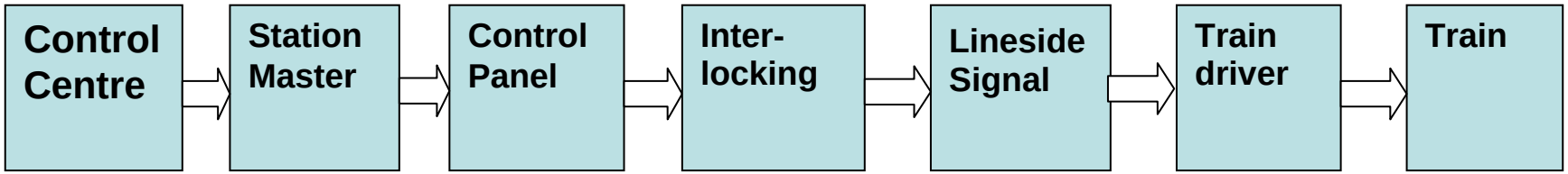
Agenda for presentation

- Introduction
- Comparison of signalling system on IR with advance systems
- Emerging signalling technologies
- Signalling solution to increase line capacity
- Dataloggers for predictive maintenance, safety & operation

Flow chart for signalling system

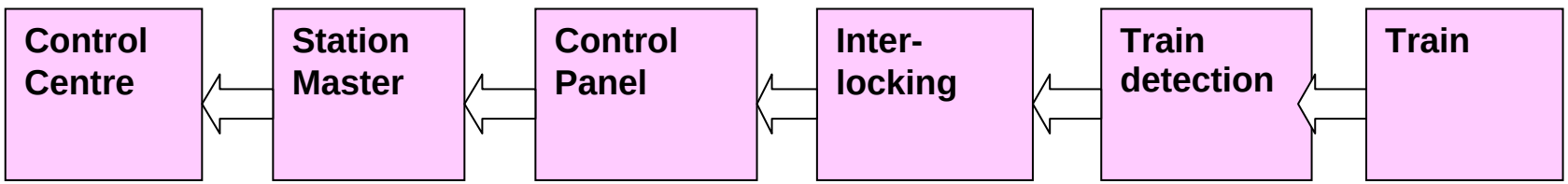


Existing IR signalling system



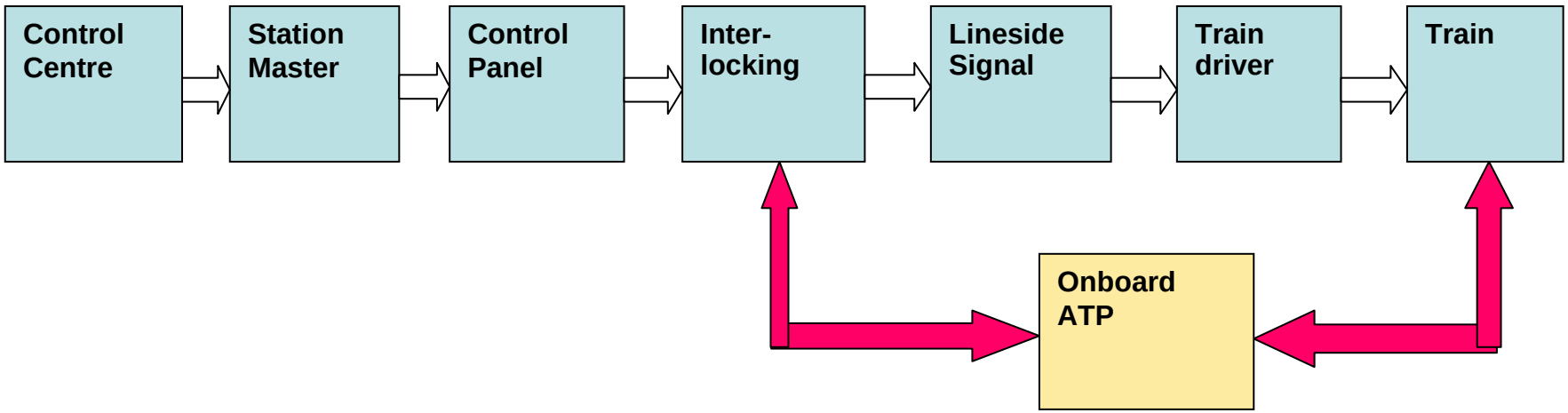
Forward control loop for movement authority

All new signalling technologies strive to reduce the time taken for information flow in both these loops by merging certain elements & automating tasks carried out by human elements.



Reverse control loop for transmission of train location information

Enhancing safety in train operations



By bringing movement authority information onboard through ATP system, it becomes possible to monitor train movement against the permitted safe limits and enforce the same

Signalling for train operation

- Enhancement of Safety
- Augmentation of Line Capacity
- Efficiency, Productivity & Flexibility in Train Control
- Real Time Train Running Information Services
- Condition Monitoring & Diagnostics for Predictive Maintenance

Key elements of Signalling



Command & Control



Interlocking system



Block Working



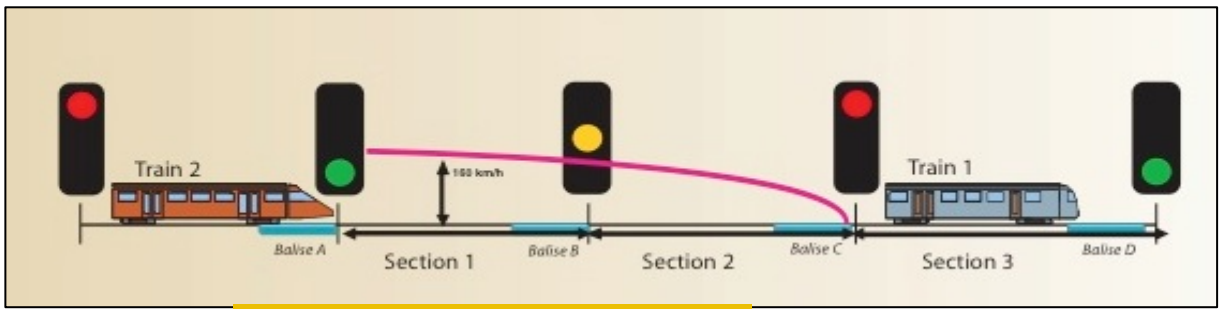
Train Protection System



Train detection System



Point Machine



Signals & Indicators



Level Crossing

Signalling system on IR vis-à-vis advanced railways

Key differences between IR & others

Following are the key technological differences between IR signalling systems & other major Railways of the world:

- **Command & Control systems: IR still uses old distributed control whereas world has moved to centralized integrated systems for efficiency**
- **Interlocking systems: IR still uses relay based system whereas world has moved to electronic interlocking with object controllers**
- **Block Working: IR still uses manual block whereas all the major railway have there double line sections converted to automatic block signalling**
- **Train Protection System: IR still does not have a proven train protection system whereas other railway systems with similar train densities are using ATP systems for last so many decades. Now radio based ATP system like ERTMS, ATACS, ITCS, PTC etc. are being used on mainline abroad**

Command & Control system

Abroad	▪Centralized network control ▪Centralized monitoring of all trains over controlled section ▪Automated planning tools like conflict resolution, time table operation ▪Automated Route setting	
India	▪Distributed control system ▪Voice commands from control centre to wayside ▪Command execution at wayside by local operation ▪Distributed monitoring ▪Voice information back to control for train location	

Interlocking system

Abroad	▪Electronic Interlocking is preferred ▪Object controllers are in use for more than a decade, removes most of relays ▪Redundancy in communication and control for higher availability ▪Centralized interlockings at control centre for better maintainability	
India	▪Relay based panel interlocking is preferred method ▪Electronic interlocking started (<10%) but still retains 30% relays ▪Object controllers are yet to be deployed to reduce relay usage ▪Interlockings distributed at wayside due to distributed control system	

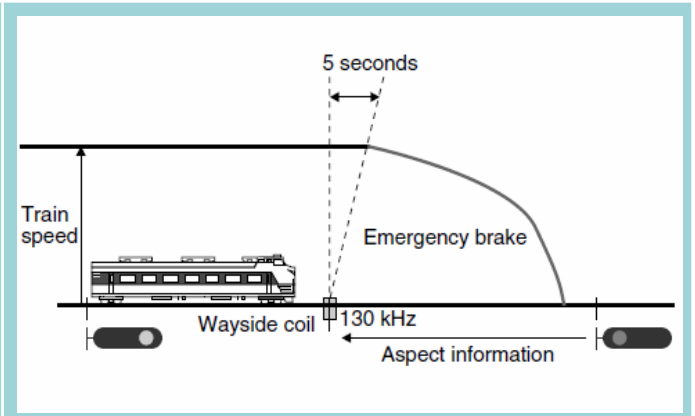
Block Working

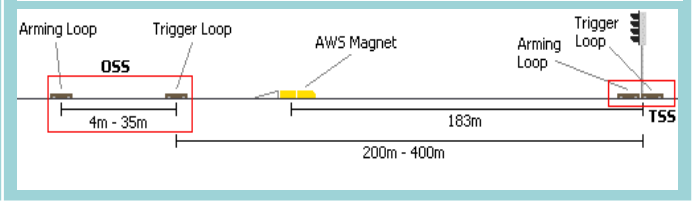
Abroad	▪Mostly track circuit block with automatic signalling ▪Shorter Block section for higher throughput ▪Radio based RETB signalling in secondary lines	
India	▪Mostly manual block using block instruments on IR ▪Longer Block sections means lesser throughput ▪Automatic signalling in suburban systems of 4 metros & on few sections	

Train Protection System

Abroad

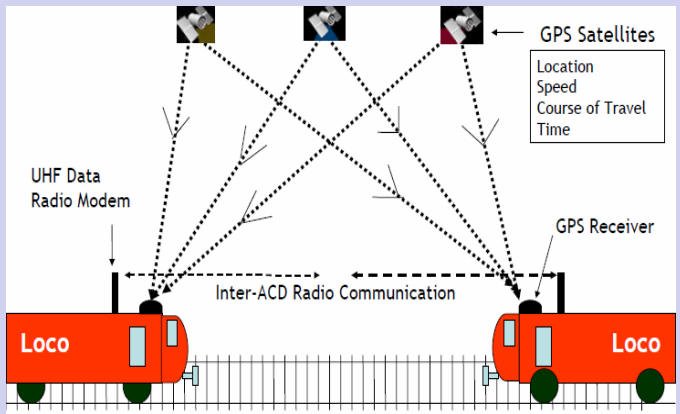
- Third & fourth generation ATP systems in use
- Earlier intermittent systems were used (AWS-UK, Indusi-Germany, ATS-Japan)
- Now continuous system (LZB, TVM, ERTMS, ITCS) are used





India

- AWS in Mumbai suburban since mid eighties
- Most of the mainline signals devoid of any SPAD protection
- GPS based ACD (non-vital) in 1700 RKm of NFR
- ETCS L1 based TPWS (full ATP) under trial in SR and NCR

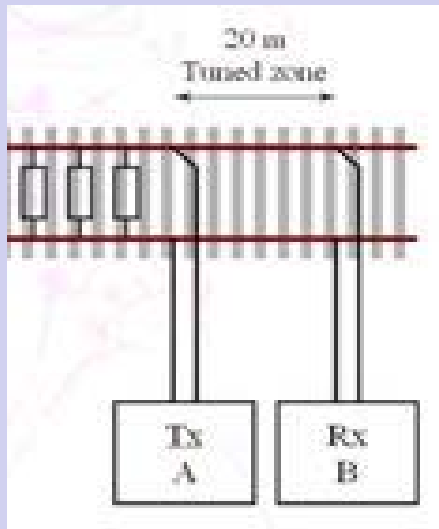


Working of "on-board" ACDs

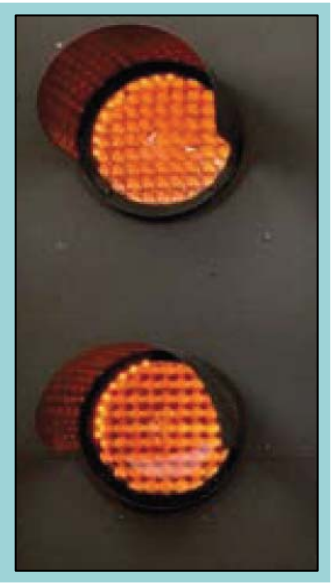
Receive inputs from satellites, communicate with each other using radio modems & use intelligence to act

- To prevent 'dangerous' Collisions

Train Detection System

Abroad	▪DC, HVI, AFTC, axle counters ▪AFTC used in dual rail configuration only ▪Axle counter is preferred method ▪Technical & procedural methods to deal with engineering vehicles ▪No push trolleys in operational railway without engineering block	 Axle counter head
India	▪DC, AFTC, axle counters ▪OHE mast connection to track is an issue for AFTC ▪Duplicated train detection being tried ▪Engineering vehicles a source of problem for axle counters ▪Push trolley suppression by axle counters required	 AFTC tuned zone

Signals

Abroad	▪Integrated LED signals used in UK ▪Same LED unit can display three aspects making signal unit shorter & lighter ▪Comprehensive signal sighting exercise, visibility required for 8 second run time at mps ▪Signal spacing based on published braking charts and maximum speed in the section	
India	▪LED based main signals, route indictors, shunts etc used in India ▪LED unit can display only single color 4 different LED units required ▪Signal sighting is mandatory, visibility required 400/200m fixed distance ▪Signal spacing generally 1 km. Braking charts are generally not used.	

Signal Gantries

Abroad	▪Usage of signal gantries is quite common in multiple lines territories ▪Requires line block for maintenance ▪Support structure designed for quick maintenance	
India	▪Usage of gantries is not common in India even in congested suburban lines ▪Some post are difficult to maintain within SOD ▪In some cases Height of post is increased & ladder is removed to maintain SOD	

Point operation

Abroad	•In-bearer clamp lock is preferred switch mechanism •In-bearer system enables machine packing without disconnecting •Multi-drive & multi-detection system for high speed turnouts •High speed turnouts ~ 60kmph	
India	•High thrust point machine is popular switch mechanism •Mostly single drive & detection •Condition monitoring system under development •low speed turnout <30kmph •Clamp lock specified for speeds > 130kmph	

Advanced signalling Technologies in advance Railways

Advanced Technologies- Common features

Signalling systems basically carry out two main tasks:

- **information processing (interlocking, control)**
- **information transmission (between control & field)**

Both processing & transmission technologies have witnessed tremendous increase in capabilities and reduction is size in last two decades. Because of this it is now possible to implement many functions onboard the locomotive. All the required inputs from trackside are sent via mobile Radio. Hence we have two common features in all these systems:

- **Mobile Data Radio for communication**
- **Onboard processing of vital information**

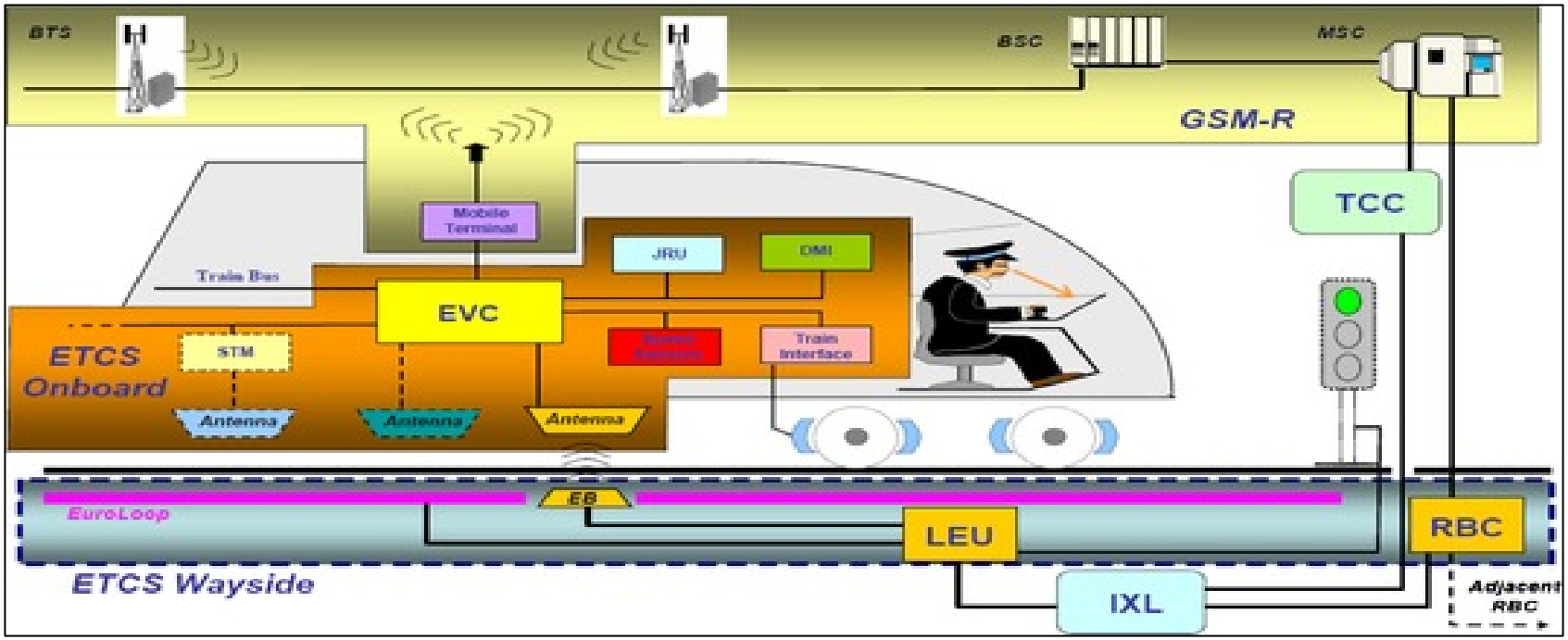
ERTMS

ERTMS is the European Rail Traffic Management System, a cab signalling and automatic train protection system mandated by European union and supported by major signalling suppliers (Alstom, Bombardier, Siemens, Thales, Invensys and Ansaldo).

Key Characteristics :

- **Cab signalling (display of movement authority)**
- **Continuous Speed monitoring**
- **Comparison with safe speed profile for the train**
- **Automatic Train Protection**
- **Overcomes capacity loss due to mixed traffic (since different trains can be configured for different braking characteristics)**

ERTMS – Key Subsystems



ETCS–Signalling part

- **Driver machine interface**
- **Onboard Computer**
- **Onboard Odometry**
- **Track side Balises**
- **RBC- Radio Block Centre**

GSM-R: Data radio part

- **MSC:Mobile switching centre**
- **BCS-Base station controller**
- **BTS- Base transceiver station**
- **Onboard radio receiver**

ERTMS – Application levels

Level 1

- Basic cab signalling system overlayed on existing signalling
- Movement authority & train location are both upadted intermittently
- Continuous speed supervision- ATP
- Has almost no effect on capacity of automatic signalling system

Level 2

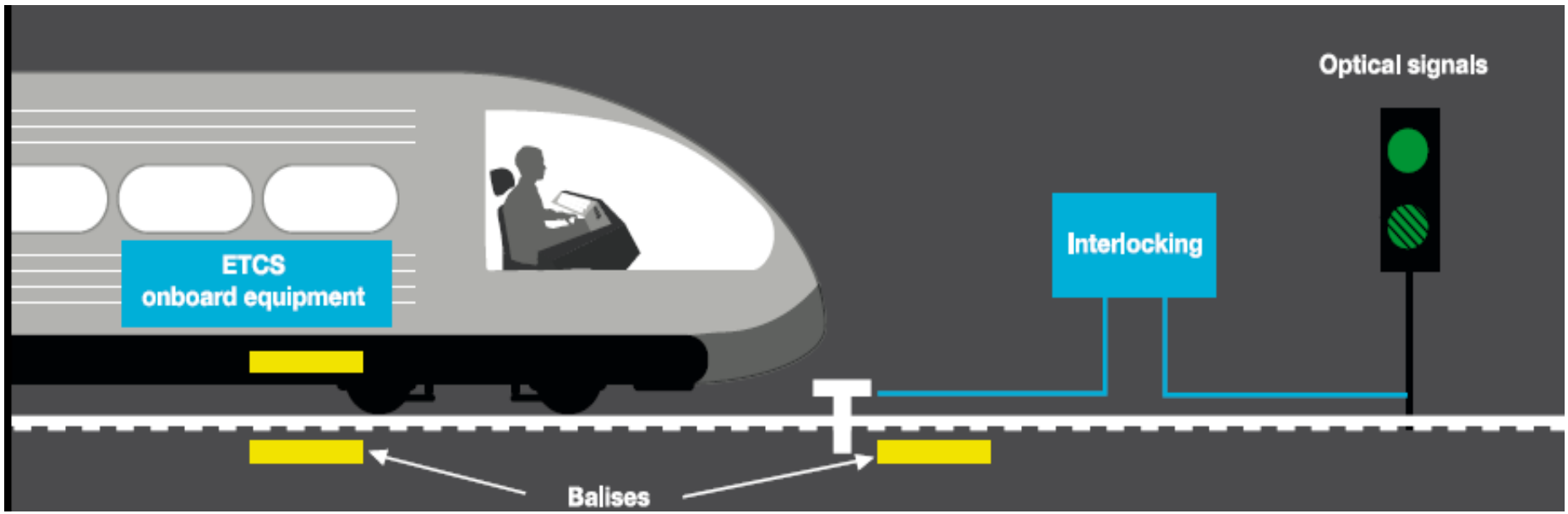
- GSM-R is prerequisite
- Continuous update on movement authority via GSM-R radio
- Capacity gain over automatic signalling since blocks can be optimised
- Line side signals are not required (optional)

Level 3

- Moving Block signalling with onboard train detection & train integrity
- Continuous update on movement authority & train location Both
- Maximizes capacity since train are just barking distance apart
- Not yet developed due to train integrity requirement

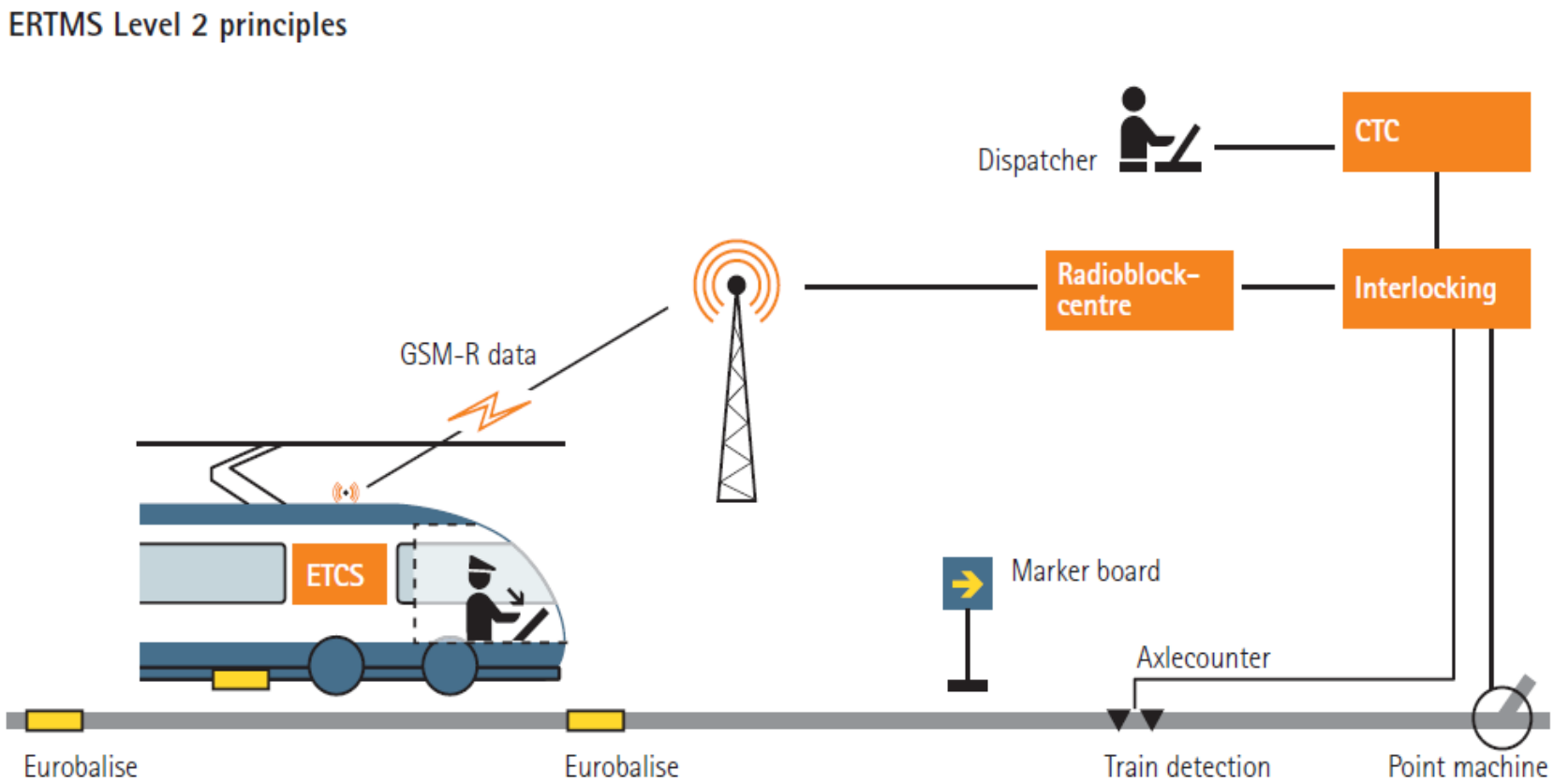
ERTMS - Level 1

Level 1 has lineside signals, track circuits and balises along the line. The balises contain information on speed and movement instructions, as well as other necessary information. The Track circuit checks that the line is free from obstacles and that the train is complete. Movement authority (e.g. from an existing lineside signal) is passed to the train on a cab display (DMI/MMI) via a switched 'balise'. If the driver reacts too slowly to a signal change for braking, the train will brake on its own.



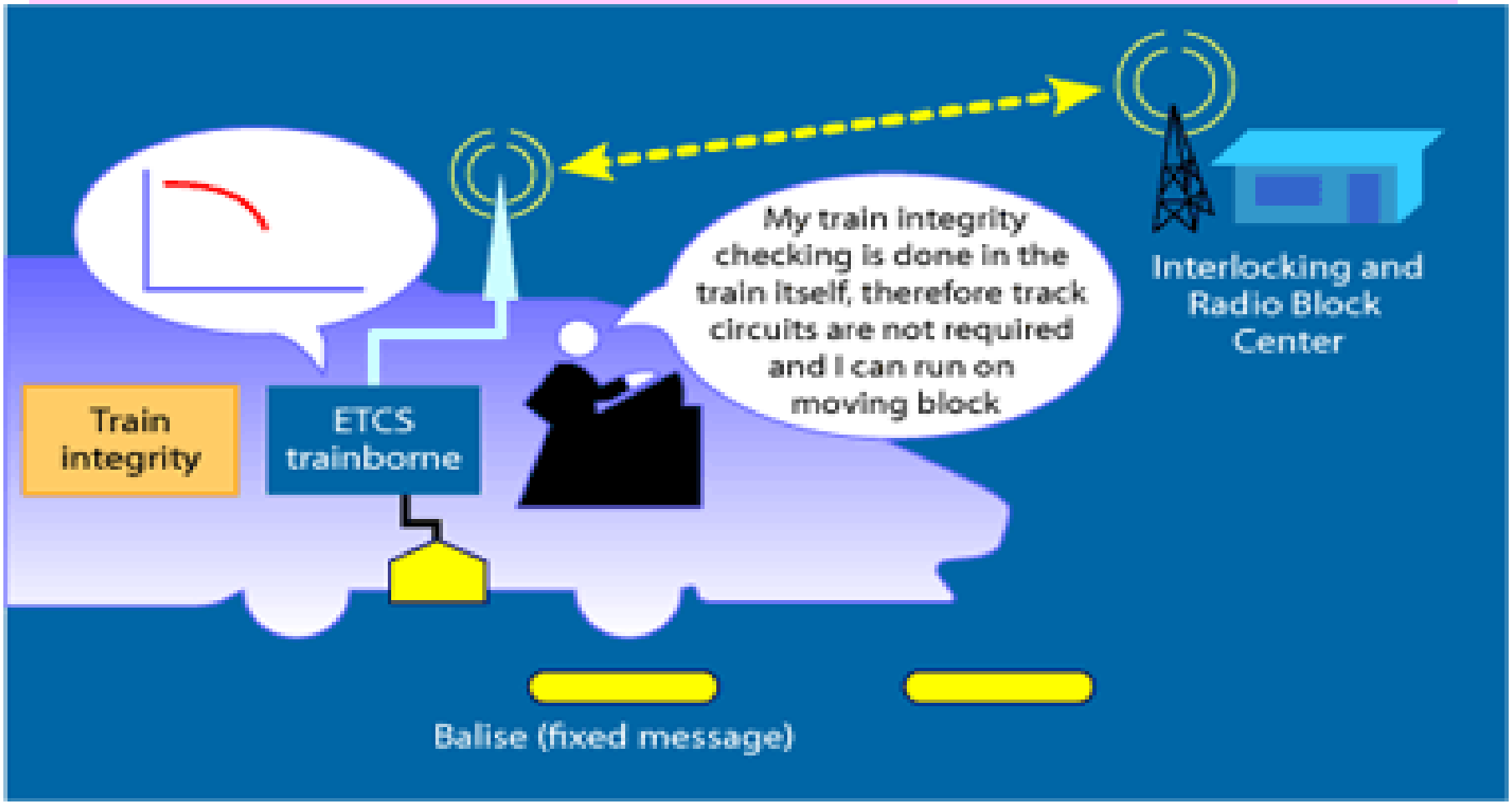
ETCS - Level 2

Level 2 requires no lineside signals. <u>All basic information is obtained via GSM-R</u> from a Radio Block Centre (RBC). The signals transmitted to the locomotive are always up-to-date .



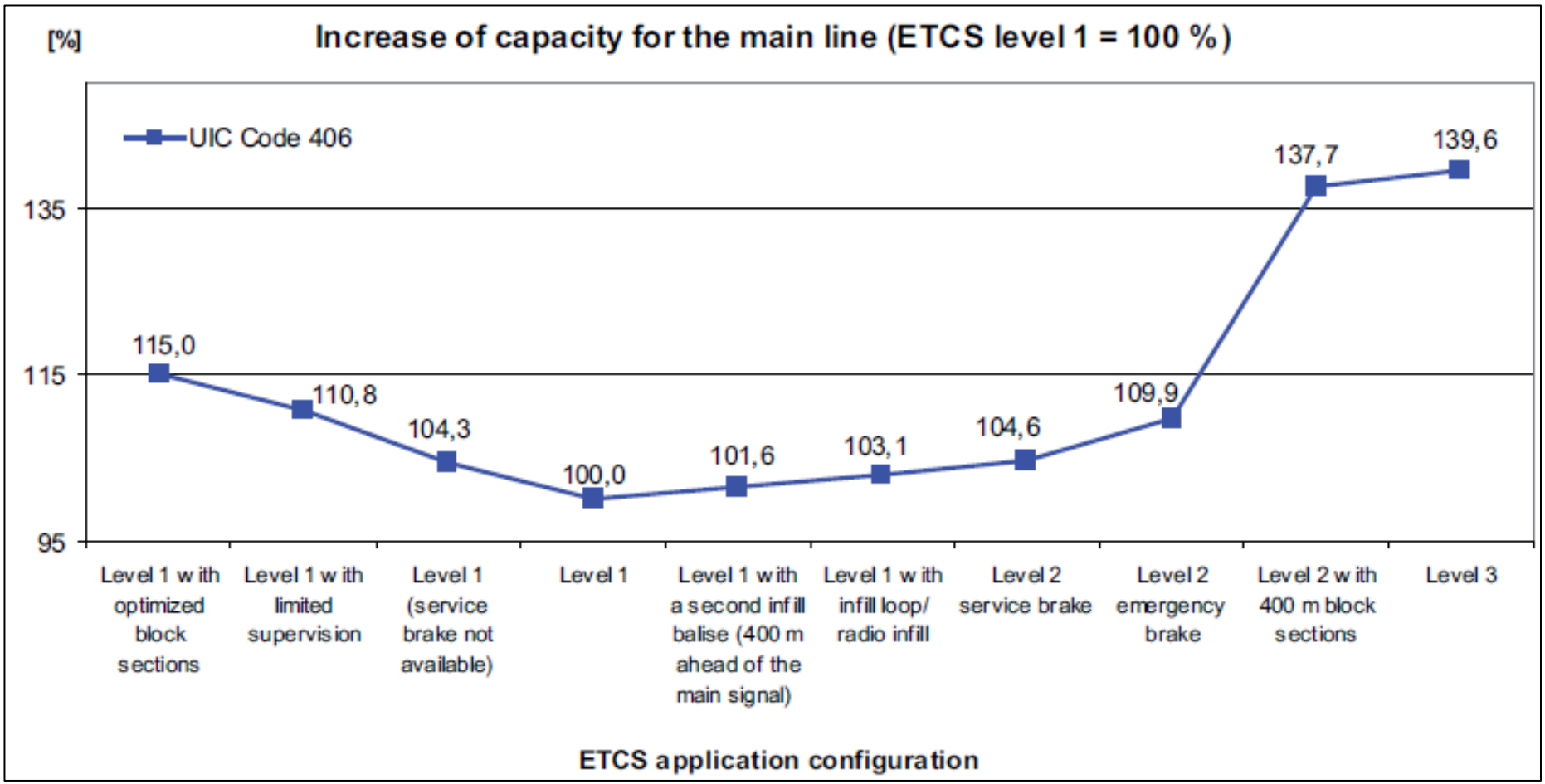
ETCS - Level 3

Uses concept of moving block since track circuits used in earlier versions are dispensed with. Not yet proven, still under development. Critical aspect being train integrity in absence of



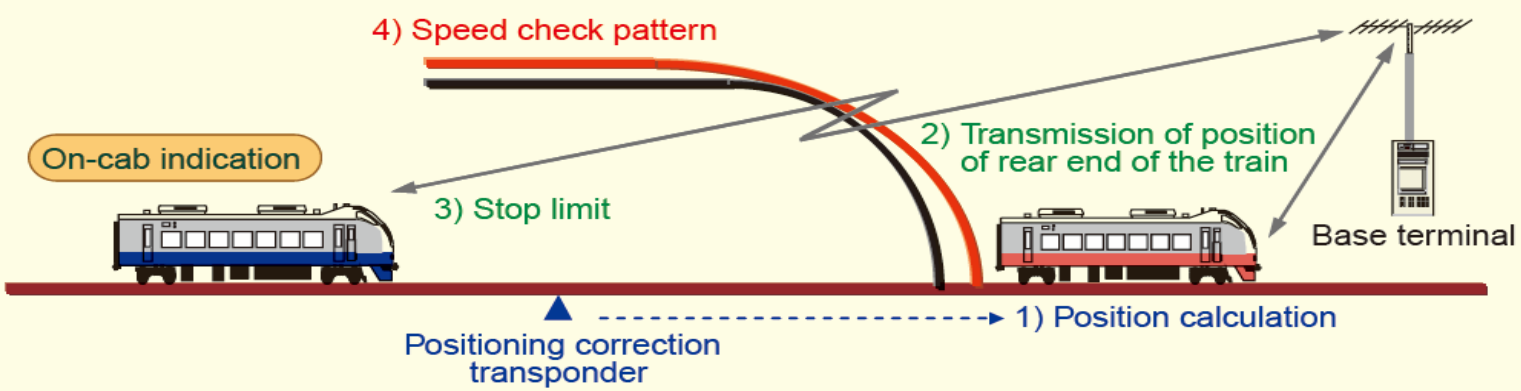
ETCS – effect on line capacity

Study conducted by UIC has revealed that ETCS L1 has almost no effect on capacity if automatic signalling is already existing whereas ETCS L2 can increase capacity by 30-40% by using optimized block lengths.



Advanced Train Administration and Communications System (ATACS) - Japan

JR East has developed a train control system for urban railway systems by using radio communication. This is equivalent to ERTMS L3 Moving block technology. It is an innovative new train control system that uses IT and autonomous distribution technology. ATACS uses 400Mhz digital radio system for data communications. First deployment was scheduled for Mar'11, but delayed due to destruction by recent earth quake in Japan.



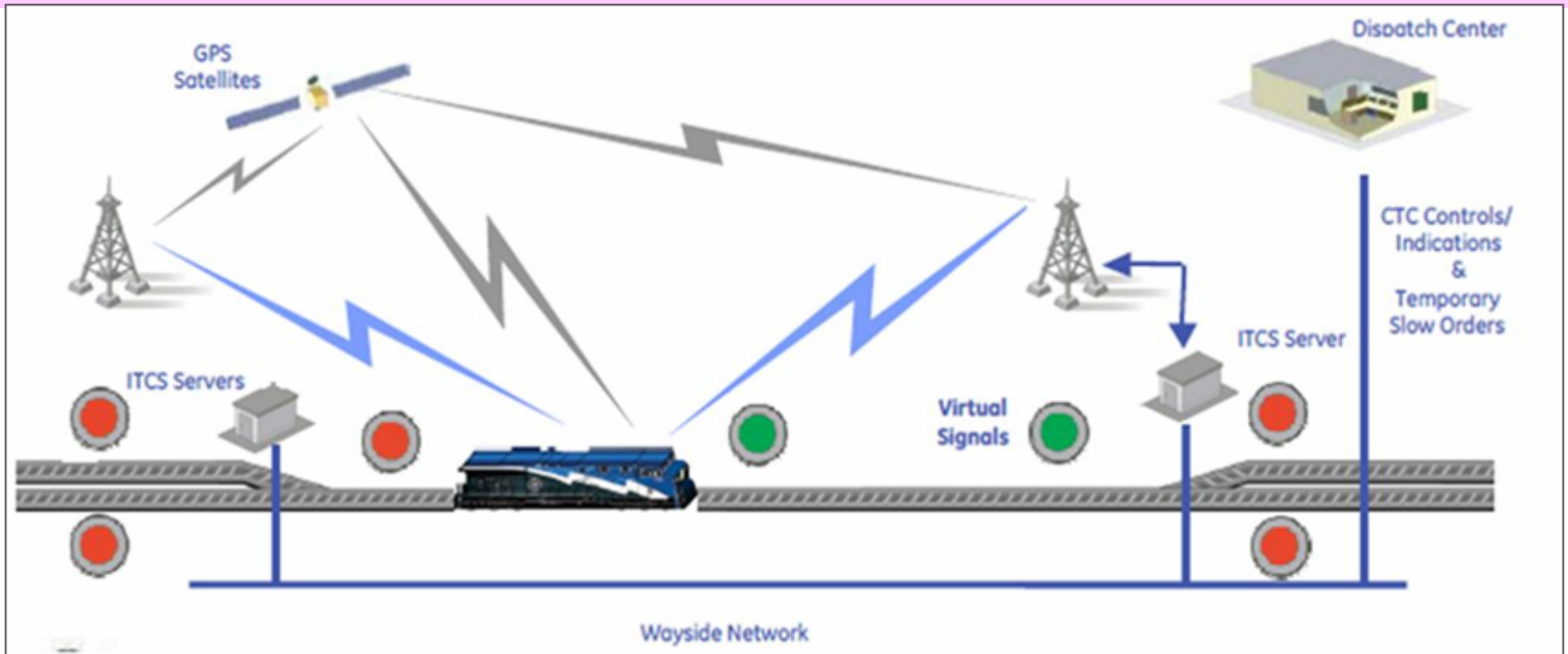
Train control process

1) Calculating of train's own position using positioning correction transponder and axle rotation distance
2) 3) Radio transmission of stop limit (rear end of the train ahead) to following train
4) 5) Following train makes speed check pattern to find stop limit and controls braking.

Incremental Train Control system (ITCS)

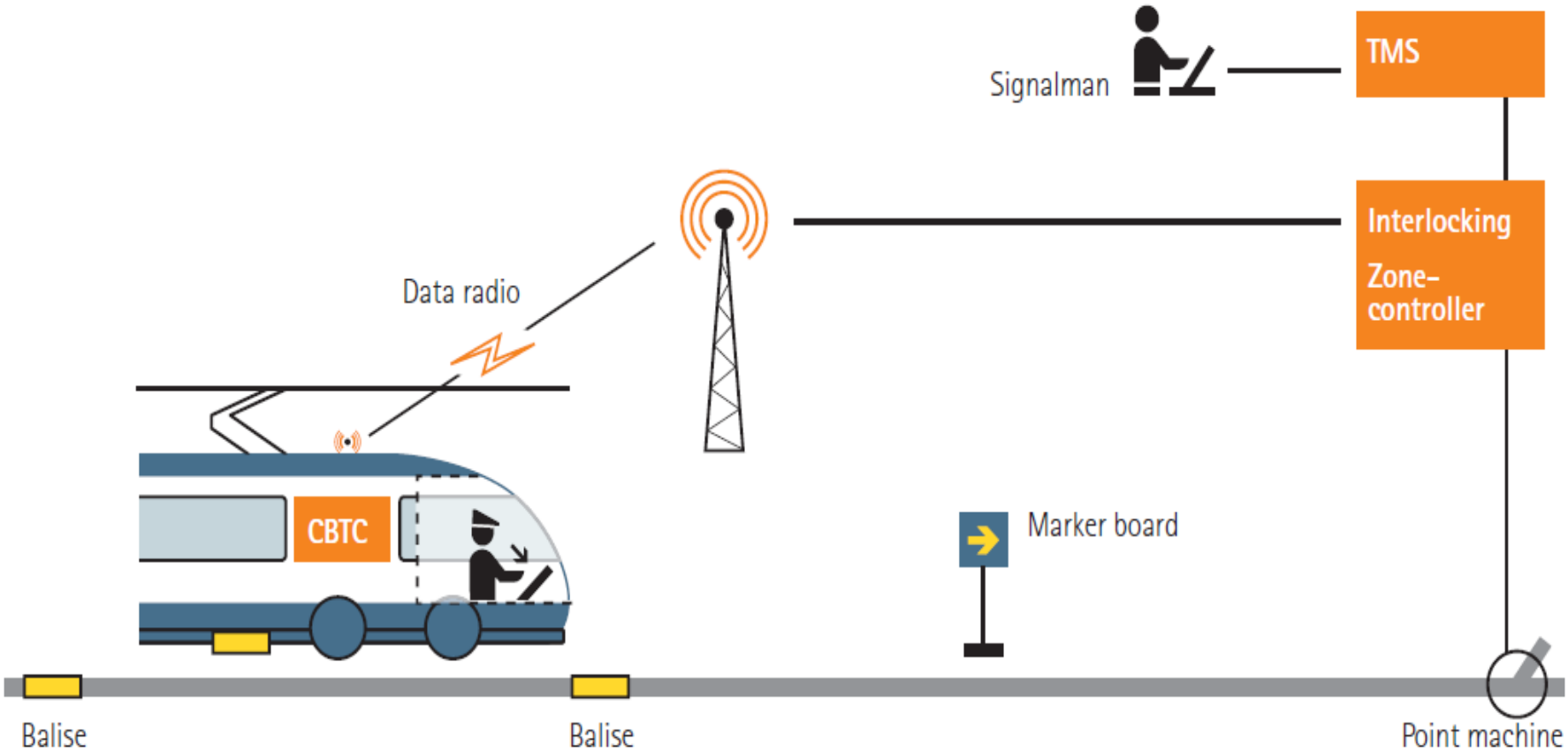
ITCS is a communications-based, onboard-centric train control system that transmits wayside signal and level crossing information to a locomotive onboard computer, safely separating trains and enabling the driver to adjust speed limits according to track conditions and speed restrictions. ITCS uses GPS for train location and radio for communications.

- **71 Miles long Michigan in USA and since 2000.**
- **1100+ Km. Track in Western China (Tibet Line) since 2006**



Communication based Train Control (CBTC):

Communication based train control has been used in metro systems world over for more than a decade. The change which has taken place recently is that radio has become the bearer of data communication instead of cable loops or coded track circuits.



Growth of signalling on Indian Railways

Signalling - Growth on IR

Signal System	1969	1979	1989	2001	2008	2010
• Interlocked Stns		4815	5091	5403	5647	6151
• MACLS Stns	-	997	1899	3009	4684	5097
• PI Stns	-	314	895	2103	3462	3830
• RRI Stns	-	90	123	219	223	255
• EI Stns	-	-	-	14	229	401
• Auto Sig (TKm.)	825	1437	2051	3419	3672	2020 (RKM)
• Interlocked Gates	-	-	5223	6283	8413	9335
• Gate Phone	-	-	9615	14227	14729	16903
• BPAC					1421	2452
• Data loggers					2650	3816
• LED Signal						3549
• IBS						342

Line capacity of a section

tr= top + tv + tapp + trb + tc

- where tr= time taken by a train to cross a block section
- top = operating time or the time taken for taking decision and operating signals to permit the train to move
- tapp = time taken to cross all signal on approach of station
- tv = visibility time or the time for the driver to perceive the signal and respond
- trb = actual running time in a block section
- tc = clearing time or train length travel time

C = [(24 hrs x 60 min/hr)/tr] R

where C= Maximum Line capacity (number of trains)
and R = efficiency factor

Improvements in line capacity with signalling system

- **As per a paper by Dr. Ashok Jhunjhunwala & P.R. Gondan, the increase in throughput with various measures is:**
  - **IBS gives improvement by factor of 1.5**
  - **Providing better method of information may improve throughput by factor of 2**
  - **BPAC can give improvement by factor of 1.4**
  - **Twin single line can give improvement by factor of 1.3**

The use of ICT & change in signalling practices can enhance throughput considerably without increase in speed & compromising safety.

Line capacity improvements

- **Actual line capacity depends upon many factors including protection system provided. However, based on formula & actual field data, the improvement for double line section is as under:**

Signalling system	App No. of trains/day per line
Double line	60 – 70 trains
With IBS	90 – 100 trains
With auto signaling	130 – 160 trains

As per MDT report peak capacity /day on UMB-SIR(53kms) is about 140 trains, VR-DRD (64 kms) is 225 trains & on Vadodara – Geratpur section(79 kms) has been observed as 95 to 103 trains.

Means for line capacity on single line sections

- Tokenless block working and may be with block panel
- Provision of simultaneous reception facility
- Track circuiting of station yards, Electrical/ Electronic Interlocking & BPAC
- Splitting of block section
- Automatic signalling
- Centralised traffic control (CTC)

Radio based signalling system for single line section for remote area

Radio based signalling

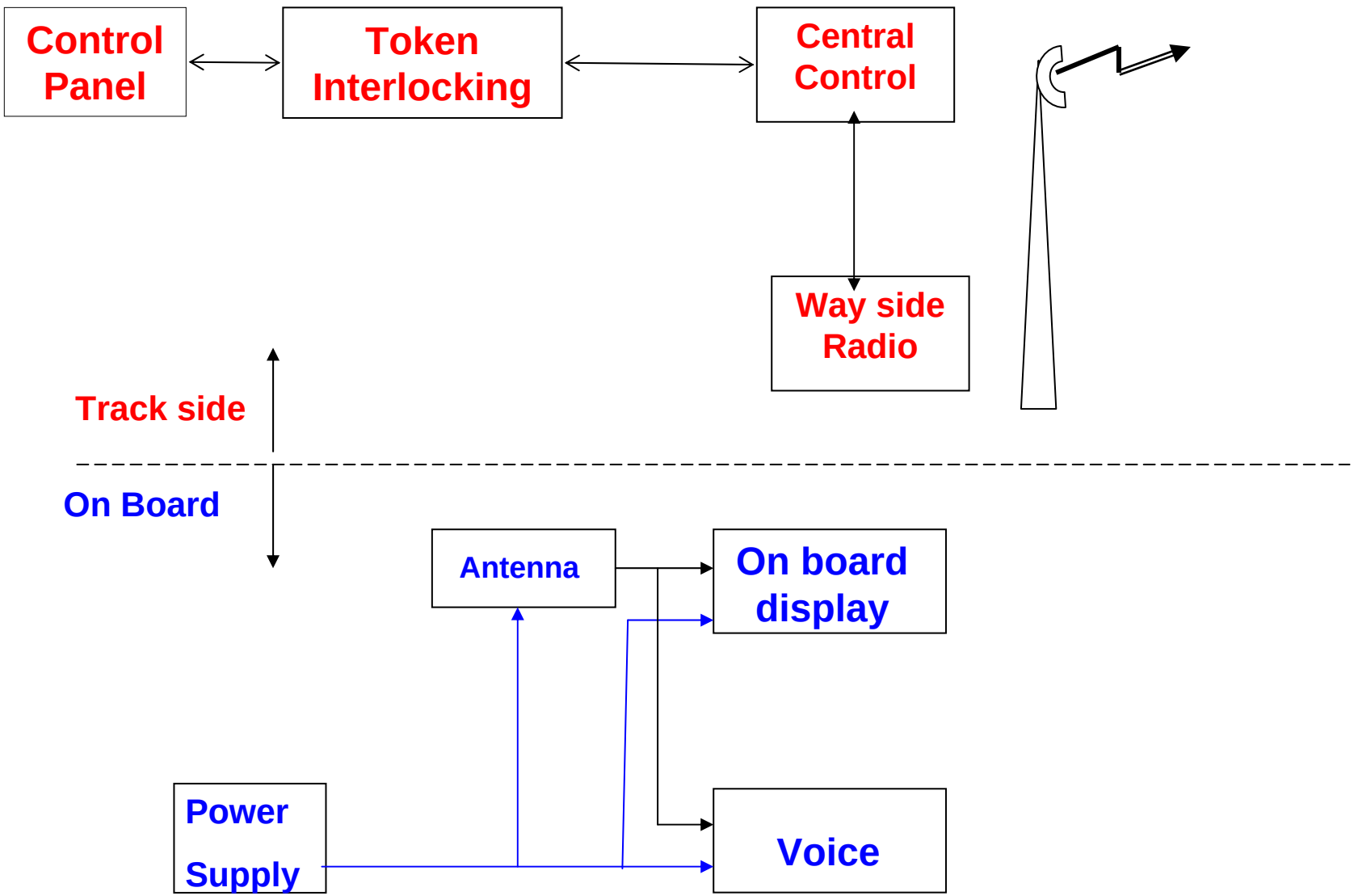
- Currently sections with low density lines are also provided with signalling systems as used for any other line resulting in wastage of infrastructure and manpower required to man way side equipments.
- In remote area particularly where mainly freight trains operates, trains mostly run through the station except when crossing is to be done.
- Operation & maintenance of signalling gears in remote areas poses serious problems due to non availability of access routes, transport services etc.

Radio based signalling

- **Many countries are using Radio Electronic token block system which reduces line side infrastructure and life cycle costs for O&M considerably.**
- **The controller is provided with a computer controlled radio system to:**
  - **Allocates the coded tokens for each section**
  - **prevents more than one token being issued for an occupied section.**
  - **It also receives the tokens sent back by each train as it reaches the end of the single line section.**
- **Every train in the control area is provided with radio equipment and a Cab Display Unit (CDU) inside the cab to facilitate the transfer and display of tokens.**

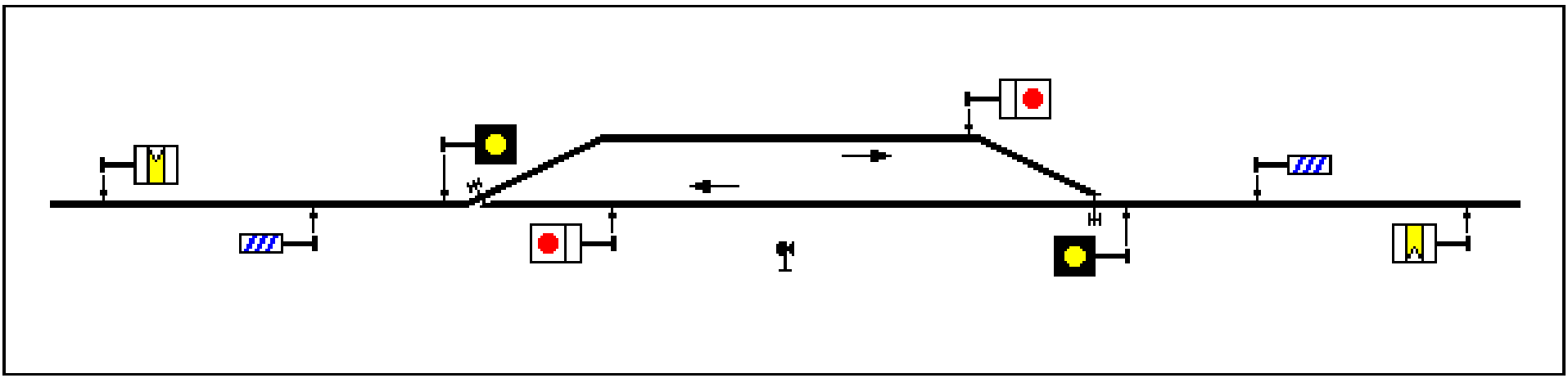
❑ **The controller will have display of positions of trains on VDU screens inside the control centre.**

Radio based signalling



Radio based signalling

Typical layout for low density single line sections



1. No trackside infrastructure other than radio
2. Hydro pneumatic points – restore to normal after passage of train.
3. Section divided into blocks controlled by electronic tokens
4. Reflectorised distant board, Train stopping /warning board for driver guidance.

Radio based signalling





- Reduced signal gears hence enhanced availability of system.
- No equipment to be operated at wayside stations for train control.
- Direct information to driver by cab display controlled from section control.
- Reduced requirement for O&M staff in remote areas.
- Improved emergency communication through proposed radio system.

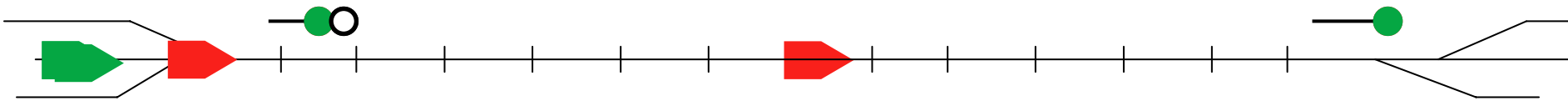
Means for line capacity on double line section

- Provision of second distant signal
- Provision of block proving by axle counter
- IBS
- Twin Single Line Working with Absolute Block System
- Automatic signalling
- Twin Single Line Working with Absolute Permissive Block System (APB) i.e bothways Automatic Signalling on both lines.
- CTC with train management system
- Cab signalling systems such as ETCS 2 or 3, CBTC, ITCS etc..

Proposed Auto signalling with ETCS 2 system on IR

- It may not be possible to equip all Motive Powers at the same time while implementing ETCS Level 2. As such, the existing signalling system should work as the main system for unequipped trains and as a backup for trains equipped with ETCS.
- In order to implement auto signalling with ETCS level 2 without line side signals, the last stop signal of the station from where automatic signalling starts in the block section, can be provided with a flashing white light
  - equipped trains can pass the this signal based on the authority received through radio block centre irrespective of the aspect of the signal
  - Unequipped train will follow the aspect of the signal and unless the block section is clear it will not be allowed to pass the signal.
- With this, the equipped train will be able to get the benefit of automatic signals and the unequipped trains will also be able to move following the absolute block system. This will increase the line capacity substantially in proportion to equipped trains.
- It will also be possible to reduce block length to 400 m or less to get additional benefit of line capacity.

Mixed movement of trains on ETCS L2 section



Unequipped train

Equipped train

Expected line capacity for double line

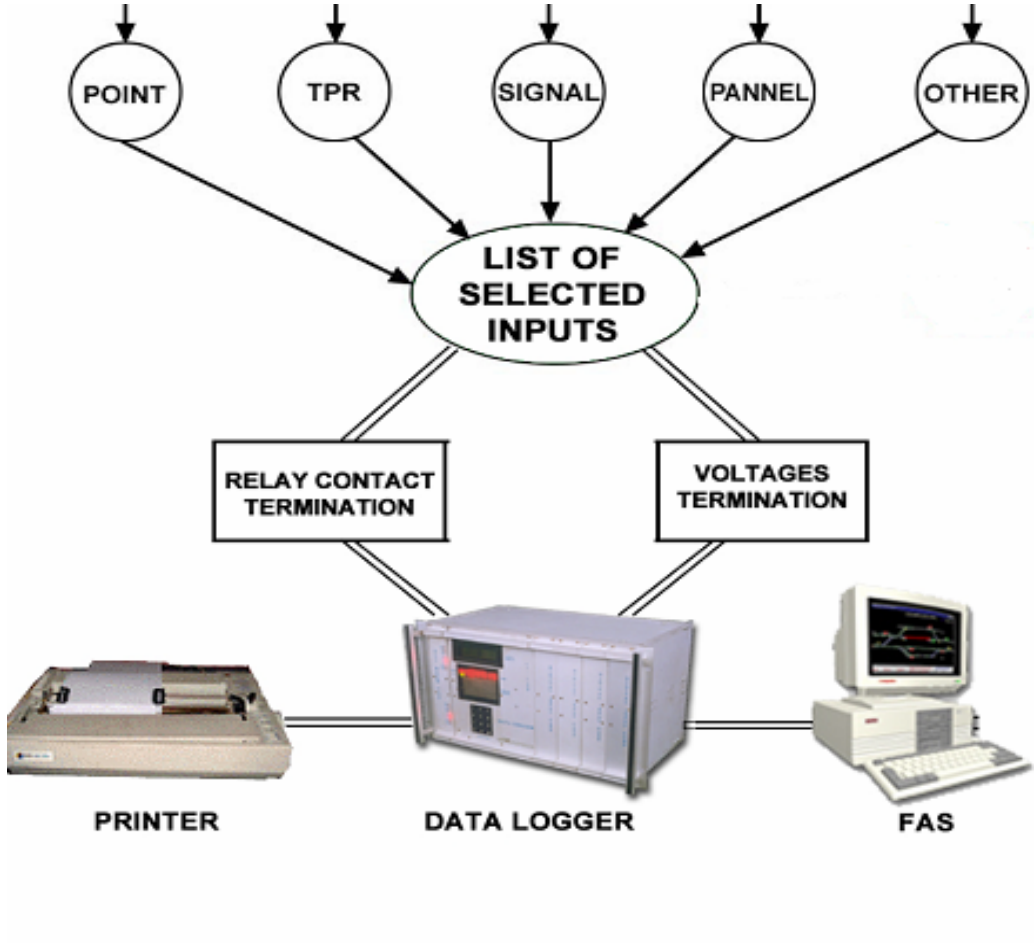
Signalling system	Line capa-city	Increase in line capacity with		
		absolute block	IBS	automatic block
Absolute block system	66	-	-	-
IBS	92	40%	-	-
Automatic block signalling	168	154%	82%	-
ETCS level 2 with auto signalling	211	220%	129%	26%
TMS with auto signalling	214	-	-	27%

Datalogger – A tool for predictive maintenance and for safety & operation

Data loggers for online condition monitoring

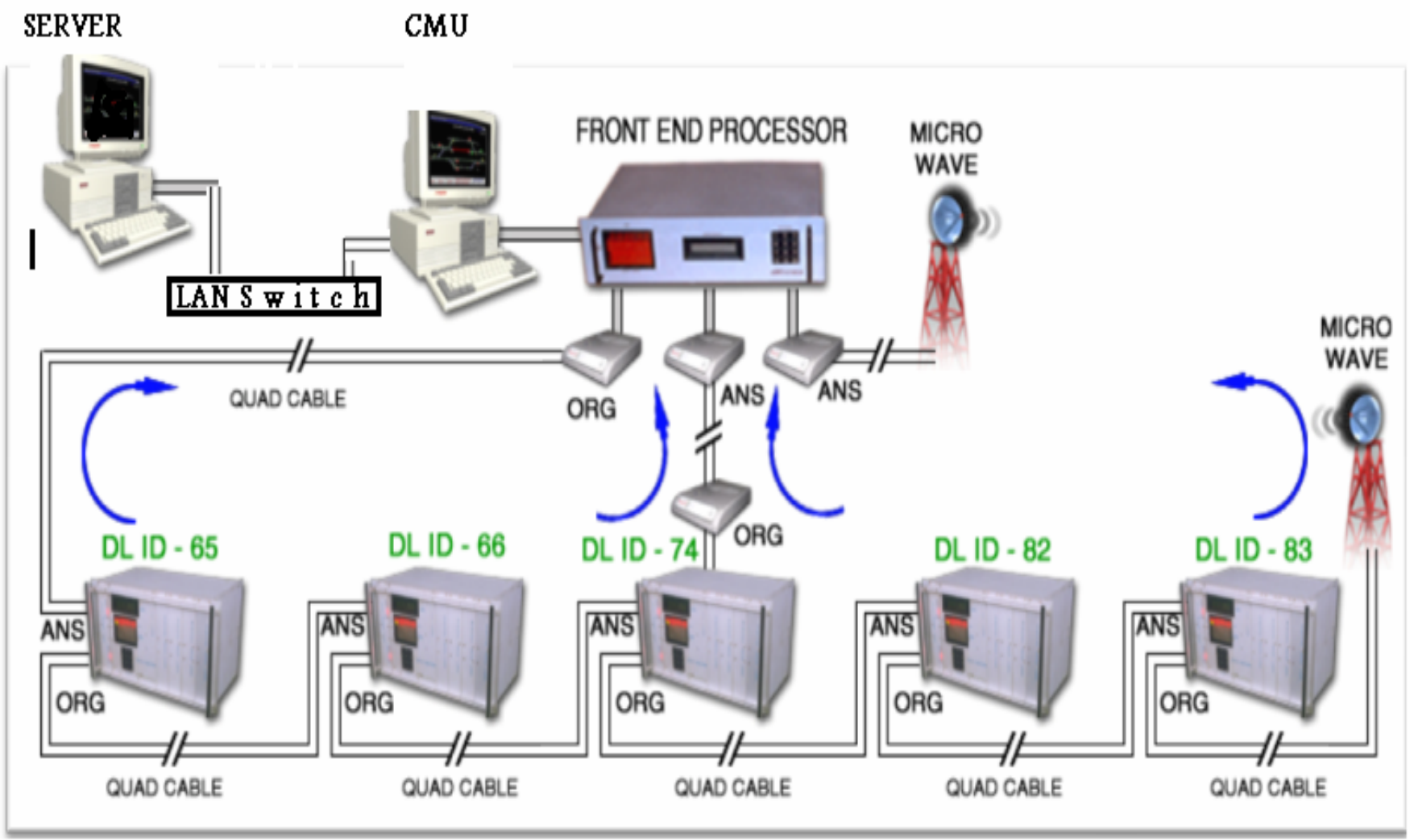
A Microprocessor based system Interfaced with Signalling Logic & Systems to Sense, Log & Record Changes in the Status of Relays & Important Analog Parameters.





It is very useful for analysis of any accidents in yards

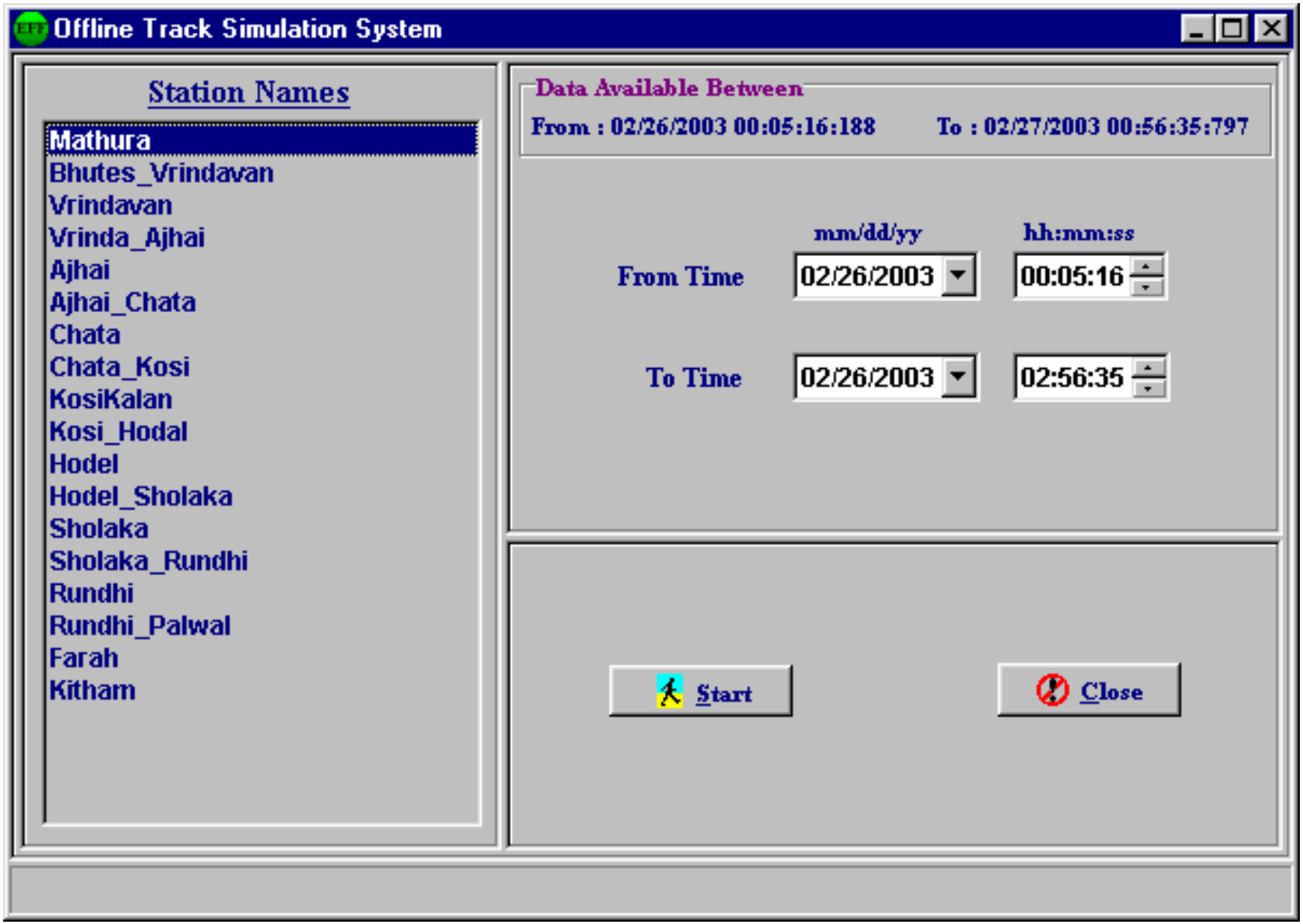
Networked Data loggers



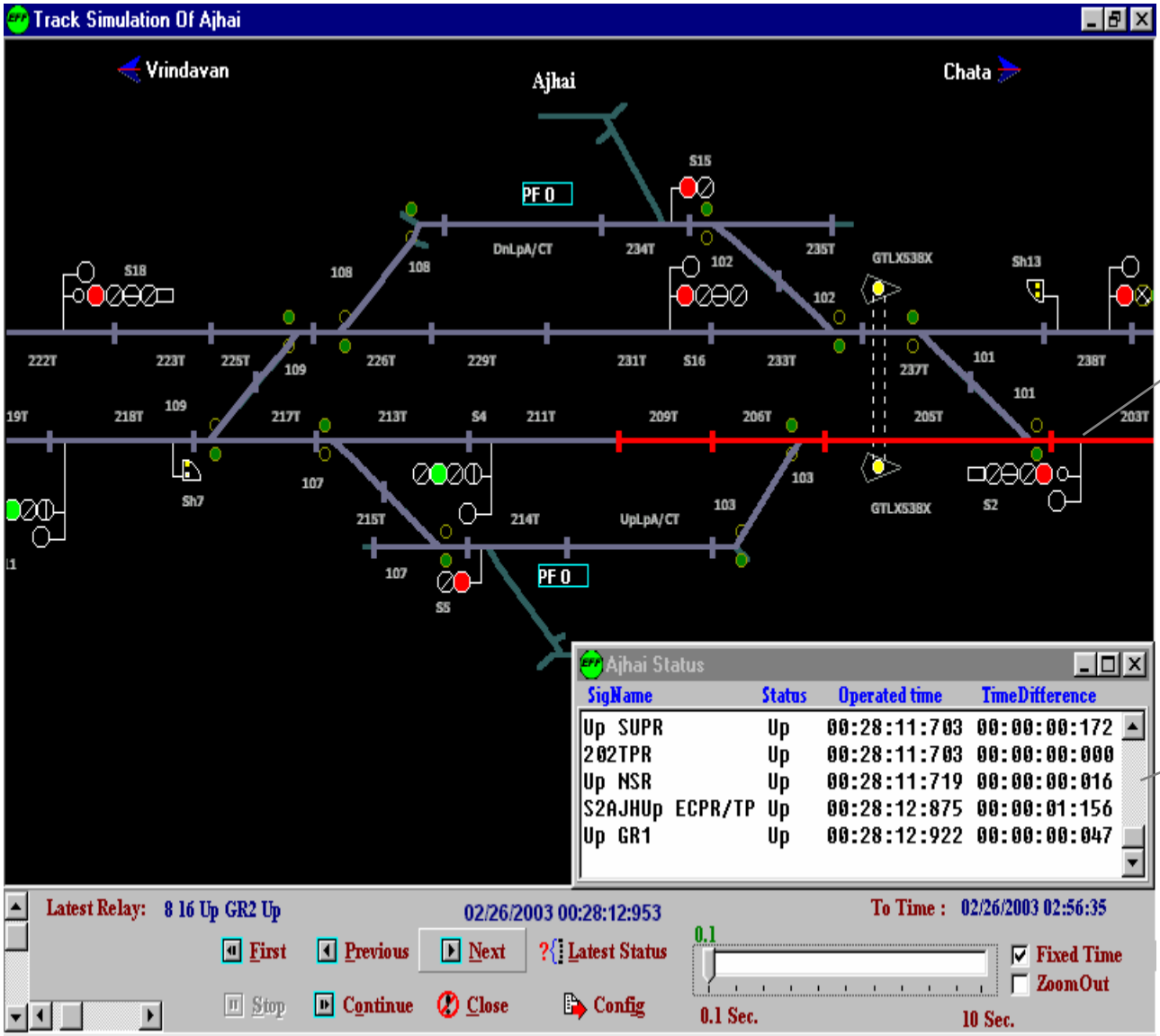
Various faults detected for signalling

- Blanking of Signals
- Fusing of Signal Lamp
- Signal Bobbing
- Signal Passed at Danger
- Track Bobbing/failure
- Point Failure
- Point Loose Packing
- Point Sluggish operation
- Point Bobbing
- Point Burst
- Route setting failure

Filtering Information for Simulation



Simulation



Train Passing through

Textual Display of changed Relay status

Real time monitoring of stations



Real - time status of yards display to controller

- Displays status of signals, line occupancy, LC gates and failure status of signaling to controller ON real-time basis
- At what time the line is occupied/cleared ,time of signal clearance, train movement can be seen
- Controller can cross check the station master's train reporting
- In case of unusual incidences and accidents whole yard status is available with the control office to take collective decision comfortably
- Detentions to trains due to speed restrictions can be assessed correctly
- Can be done at about 15% to 20% cost of data logger

Auto Train Charting

- Gives truthful information of train running
- Controller need not enter the timings of train arrival and departure manually
- Predictive software incorporating temporary and permanent speed restrictions helps in decision making
- Statistics of Train running (LTM etc) is automatically created
- Easy-to-find out traffic bottle necks -- Justification for traffic facility works made easy and scientific (with evidences)
- Availability of section-wise and station-wise statistics helps in streamlining the train working (Ex. Platform utilization, Platform nomination , crossings)

Useful information for operation

- **Late start of train**
- **Late clearance of Home Signal**
  - if the home signal is cleared after approach track is occupied it is declared as late clearance.
- **Unusual occurrence like point /signal /track circuit failures which affect running of train**
- **Over speeding of train**
  - whether train is touching the first track of the station with full speed or not on through signals
  - whether the driver has followed speed restriction on points
- **Passing of defective /danger signal by Driver**
- **Occupancy of platform lines at a station**

Useful information for operation

- **Wrong operations monitoring – helps in assessing performance of panel operator**
- **Ensures discipline at inter change stations by correct timing recordings**
- **Evaluation of usefulness of auto signaling**
  - how many trains have passed signals in red/yellow ?
- **Monitoring delay in clearance of signal in end panel stations**
- **Setting the points against occupied line by station master**

Thanks