# Layout Design For Signaling



http://home.comcast.net/~kb0oys

July 11, 2015

# Download This Presentation

## Documentation

Each of the programs has a user manual/guide. The manuals for designer and CATS are included the release20xx zip file. The manual for TrainStat is included in the TrainStat zip file.

In addition, I have posted links to the PowerPoint presentations I gave at the 2010, 2011, and 2014 NMRA National conventions and the 2013 NMRA RMR convention: wiring clinic, panel building clinic, magnet board example, and CTC example, RMR 2013 clinic, National 2014 clinic.

# Outline

1. Why Signal a Layout
2. How the Prototype Uses Signals
3. Signal Placement and Control Basics
    a. Automatic Block Signals (ABS)
    b. Absolute Permissive Signals (APB)
    c. Centralized Traffic Control (CTC)
    d. Train Order Board
4. Right of way issues

Disclaimer: much of this clinic is based on panel discussions from pervious conventions and an excellent paper by Seth Neumann and Byron Henderson

# Why Signal a Layout

Signals add

- Color and Animation – make the layout come alive
- Realism – set the layout in time and(possibly) space
- Operating interest – mimic the prototype
- Functionality – provide safety for trains and control movement

They are cool!

# Layout Signals

- Cosmetic (dummy)
- Semi-functional
- Fully functional on layout
- Fully functional with or through repeaters

# Prototypical Signals on Layouts

Every railroad had unique signal systems.

- Research your prototype
- If free lancing, there is probably an example
- This clinic will address generic concepts

# How the Prototype Uses Signals

1. Train order boards
2. Safety overlay
3. Interlocking plants
4. Traffic control

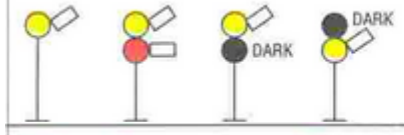
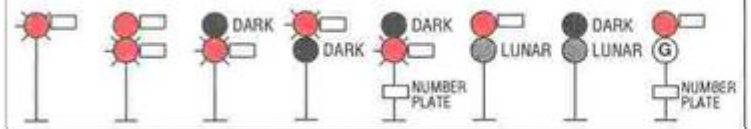
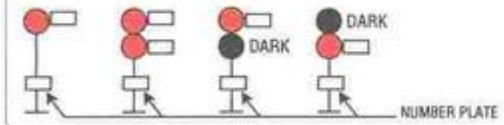
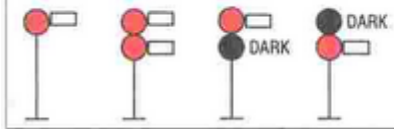
# Nomenclature

1. Aspect – how the signal appears in the field (e.g. “red”)
2. Name – the name of the indication (e.g. “Clear”)
3. Indication – the meaning of the signal – how the crew should respond (e.g. “Proceed prepared to stop at second signal”)
4. Route signals – the indication shows the path through a plant
5. Speed signals – the indication shows the safe speed for the train before the next signal

# Signals are about Safety

- Prevent a train from running into something
- Prevent a train from running off the rails
- Provide a train time (distance) to stop or adjust speed
- Facilitate movement

# Basic Aspects and Indications

| Aspect | Rule | Name | Indication |
|---|---|---|---|
|   | 9.50 | CLEAR | Proceed. |
|   | 9.56 | APPROACH | Proceed prepared to stop at next signal, trains exceeding 40 MPH immediately reduce to that speed. |
|   | 9.60 | RESTRICTING | Proceed at restricted speed. |
|   | 9.61 | STOP AND PROCEED | Stop, then proceed at restricted speed. |
|   | 9.62 | STOP | Stop. |

"permissive" stop

"absolute" stop

ATSF example

http://www.railroadsignals.us/rulebooks/cora/cora1.htm

# Layout Design Considerations

- Placement
- Functionality
- Layout requirements
- Where appropriate

# Train Order Boards

- Signals at manned stations
- Operator transcribes orders from a dispatcher, delivers them to the train crew, and reports train arrivals to the dispatcher
- The board appearances were quite unique for railroad, era, and location
- Simple on/off
- Appropriate for TT&TO

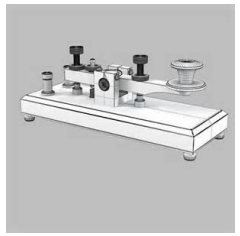

http://www.railroadsignals.us/rulebooks/ALLaspects.pdf (Todd Sestero)

# Train Order Boards

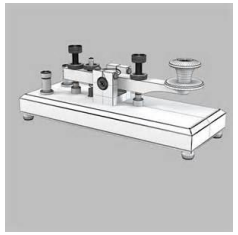
- LEDs
- Tortoises
- Servos
- Twin coils

layout

dispatcher



Orders

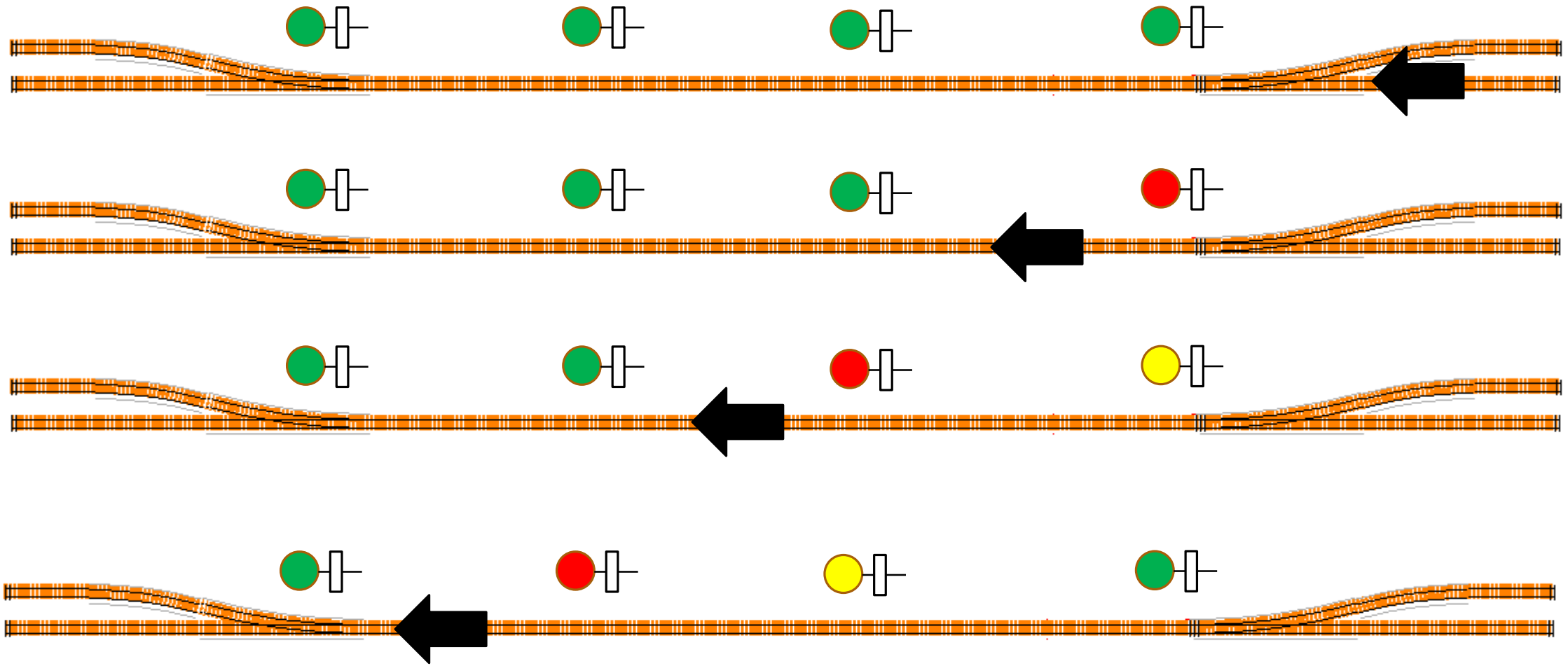


Reports

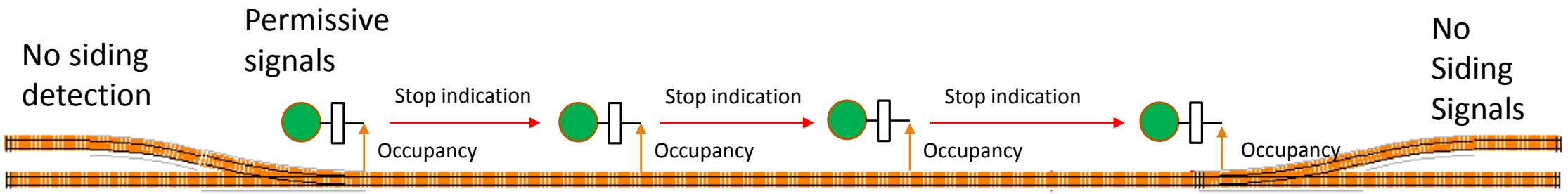
# Safety Overlay (Automatic Block System)

- Electronic checking to prevent trains from running into each other
- Alternative to Rule 99 (“Flag protection required against following trains on the same track”)
- Unbonded (undetected) sidings
- Augments track occupancy authorization (except for some roads)
- Appropriate for all operating schemes (TT&TO, DTC, TWC, CTC)

# Safety Overlay (Automatic Block System)

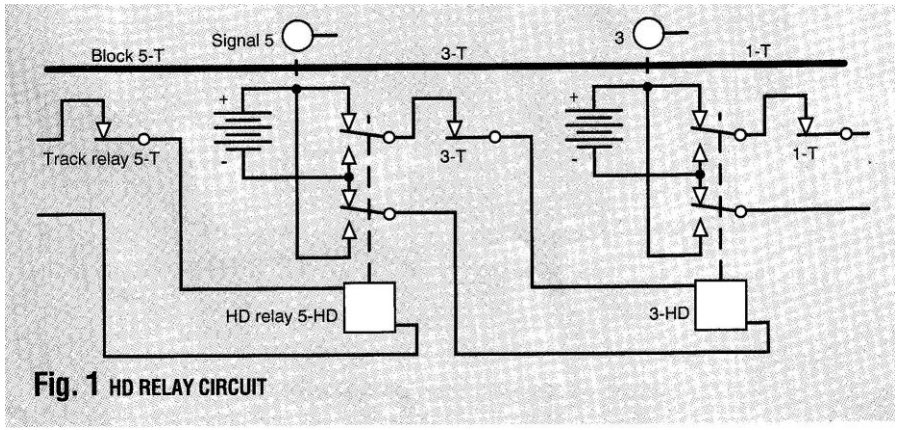


# Safety Overlay (Automatic Block System)




Uni-directional: Indications travel opposite train direction

Signals show condition of track to next signal – not authority to occupy track

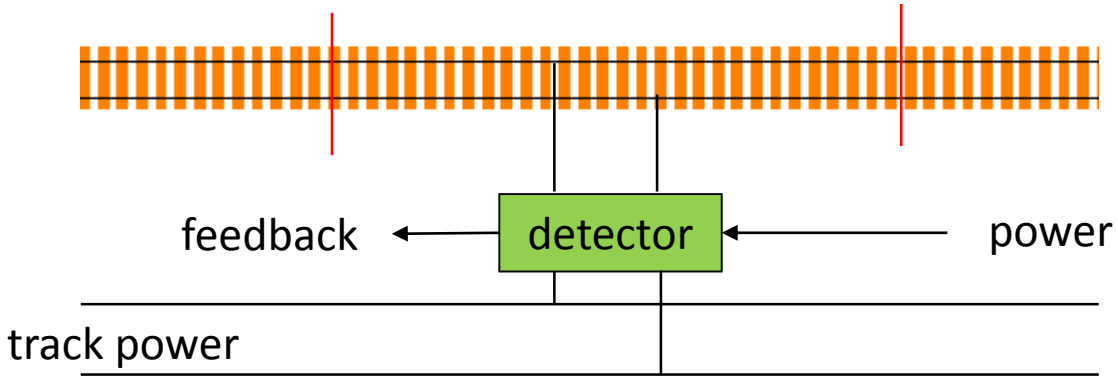



Jay S. Boggess

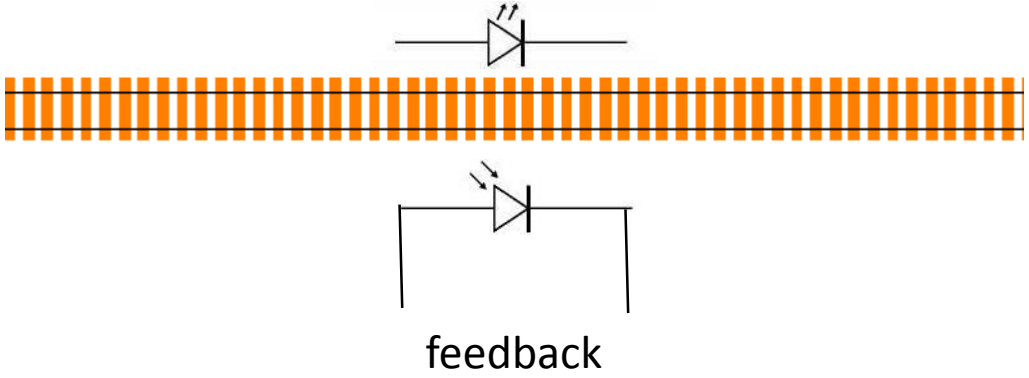
If block is occupied then red
Else if next signal red then yellow
Else green

# Occupancy Detection

Block detection
(e.g. coil, diode voltage drop)




Point detection
(e.g. photo, magnetic reed switch)

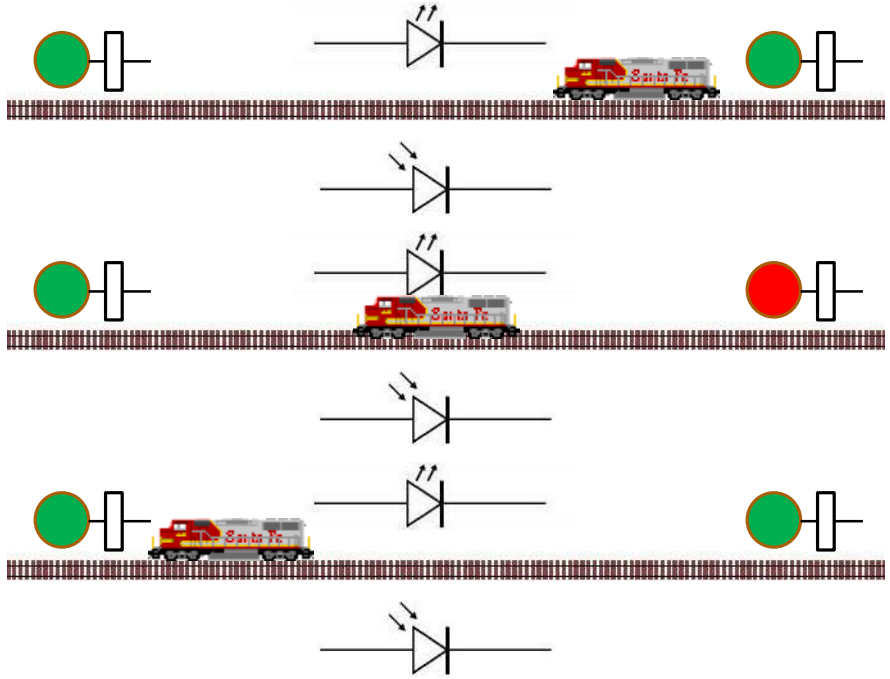



- Solid – no blinking
- Accurate – no misses, no false reports

# Point Detectors

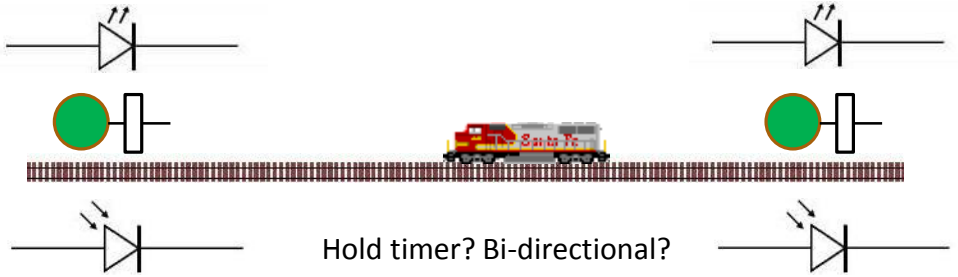
Pros

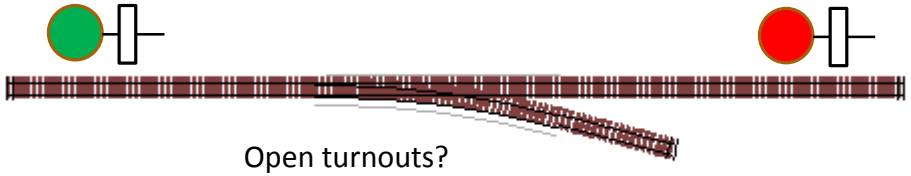
- No equipment modification
- Precise location determination
- No track gaps



Cons

- Precise location determination
- Sensitive alignment
- Trains must be longer than longest distance between detectors



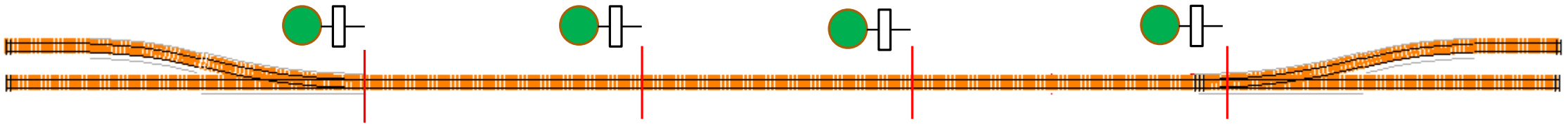



# Block Detectors

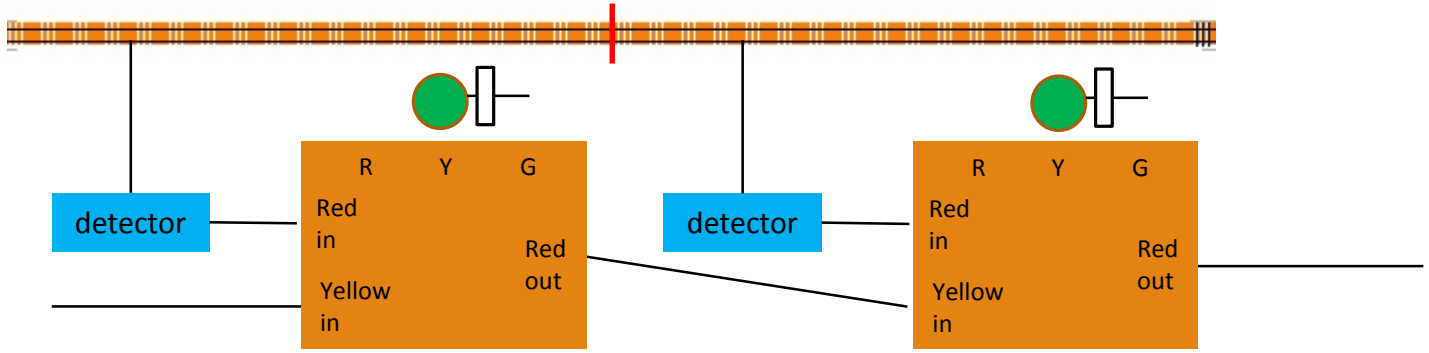
Pros
- Prototypical
- Covers an area
- Effective

Cons
- Gap tracks
- Rolling stock modifications (metal resistor wheels)
- Shortest block must be longer than longest distance between two resistor wheels
- Dirty track/wheels do not detect

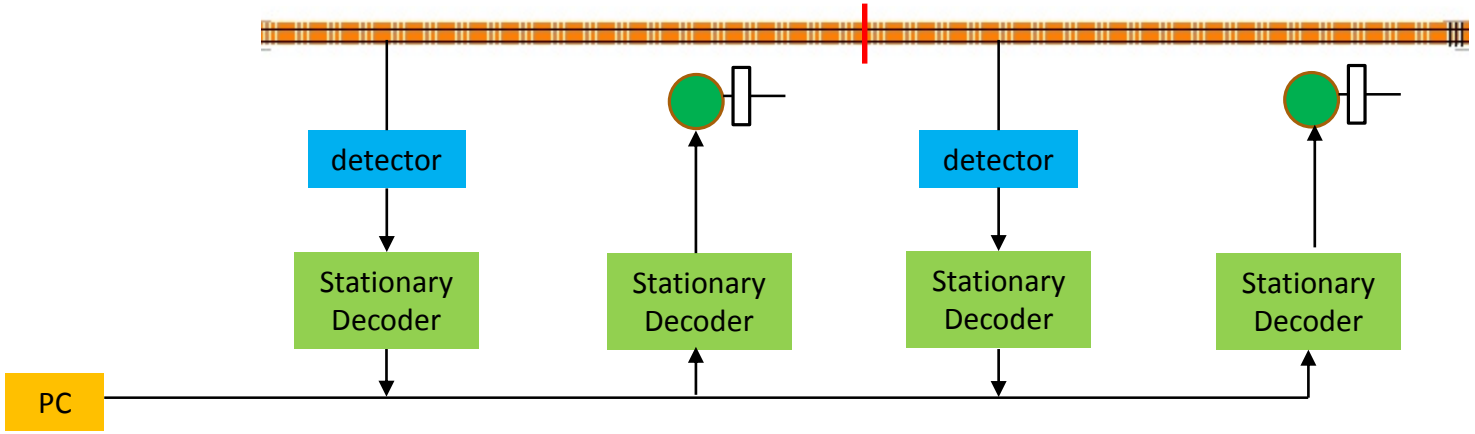
Place gaps at signals



# Implementing ABS



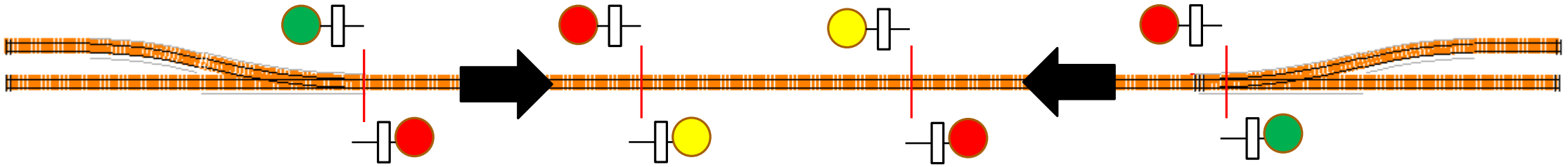

- Power not shown
- Custom boards (FPGA)
- January 1992 MR
- Inexpensive
- No PC
- Approach lighting?




- Power not shown
- Commercial boards
- Flexible
- JMRI
- Chubb (chapter 19)

# Safety Overlay (Bi-directional ABS)

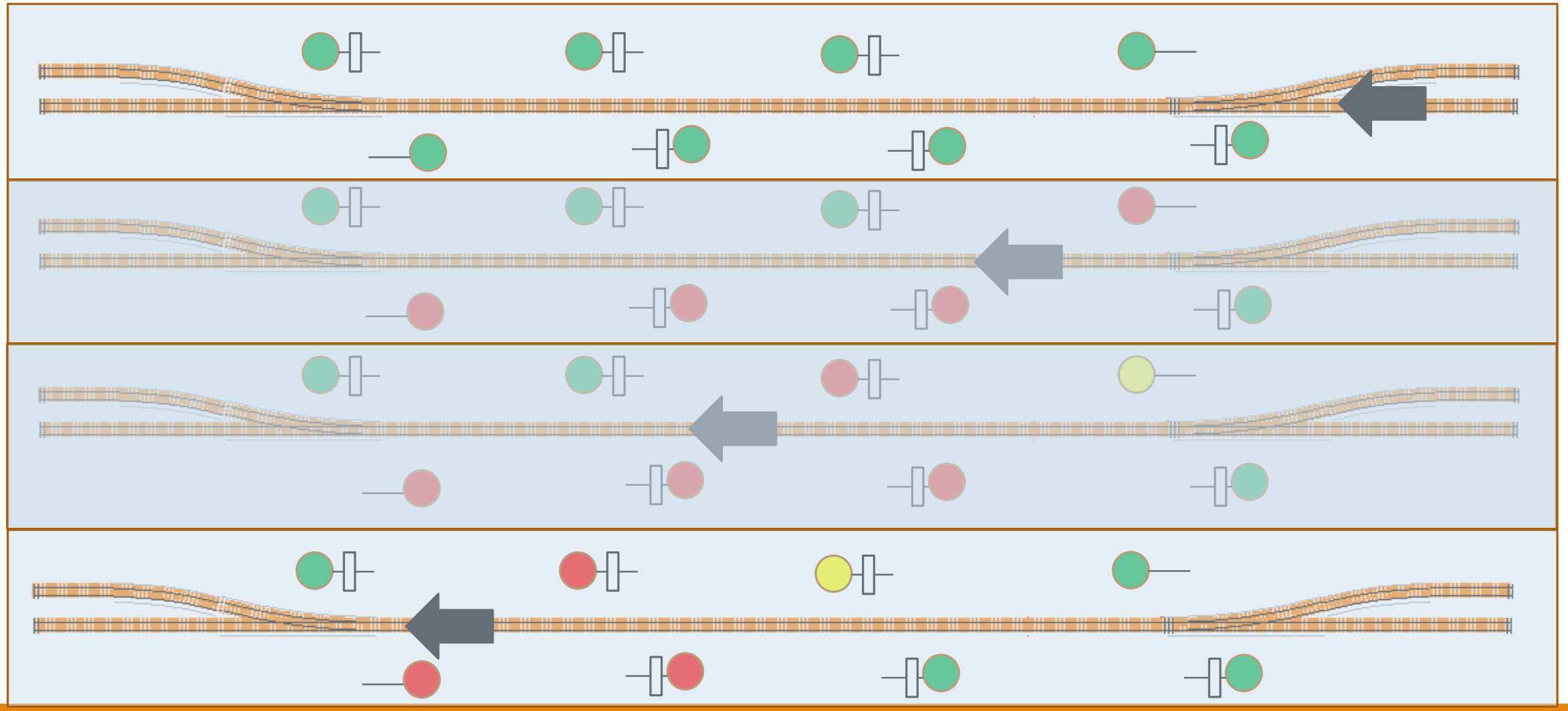
Does not protect well against opposing movement



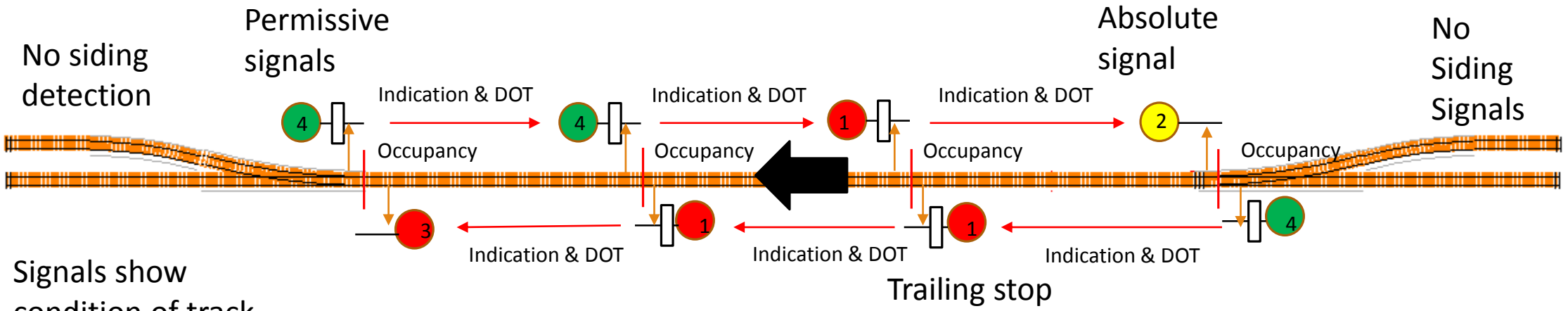
# Safety Overlay (Absolute Permissive Blocks)

- Electronic checking to prevent trains from running into each other – “siding to siding protection for opposing moves and signal to signal protection for following moves”
- Alternative to Rule 99 (“Flag protection required against following trains on the same track”)
- Unbonded (undetected) sidings
- Augments track occupancy authorization (except for some roads)
- Appropriate for all operating schemes (TT&TO, DTC, TWC, CTC)

# Safety Overlay (Absolute Permissive Blocks)



# Safety Overlay (Absolute Permissive Blocks)




Signals show condition of track to next signal – not authority to occupy track

Indications travel opposite train direction; Tumbledown travels in train direction

DOT is Direction of Travel (Traffic Stick)

Reverse movement protection

<u>Signal determination</u>:

1 If occupied or neighbor DOT is enter then red
2 Else if next is red and next DOT is enter then yellow
3 Else if next is red and next DOT is not enter then red
4 Else green

tumbledown

<u>Occupied:</u>

If neighbor DOT is exit then DOT is enter
Else DOT is exit

<u>Unoccupied:</u>

DOT is none

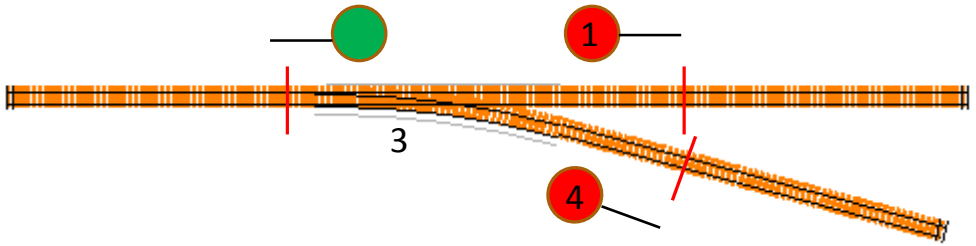
Implementation:

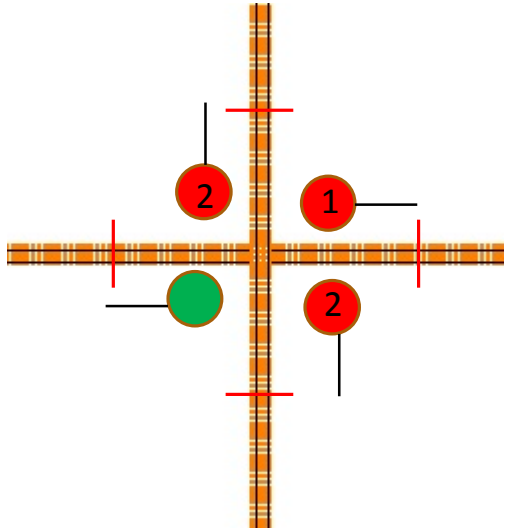
- January 1992 MR
- Chubb chapter 20
- JMRI

# Interlocking Plants

- Protect crossings and junctions
- Protecting multiple routes multiplies the complexity
- Appropriate for TT&TO and TWC, as well as CTC
- CTC can be as simple as remote controlled interlocking plants connected by dark territory or safety overlay

# Interlocking Plants

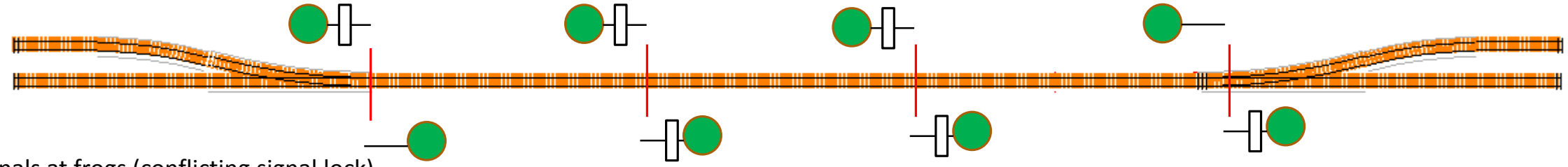


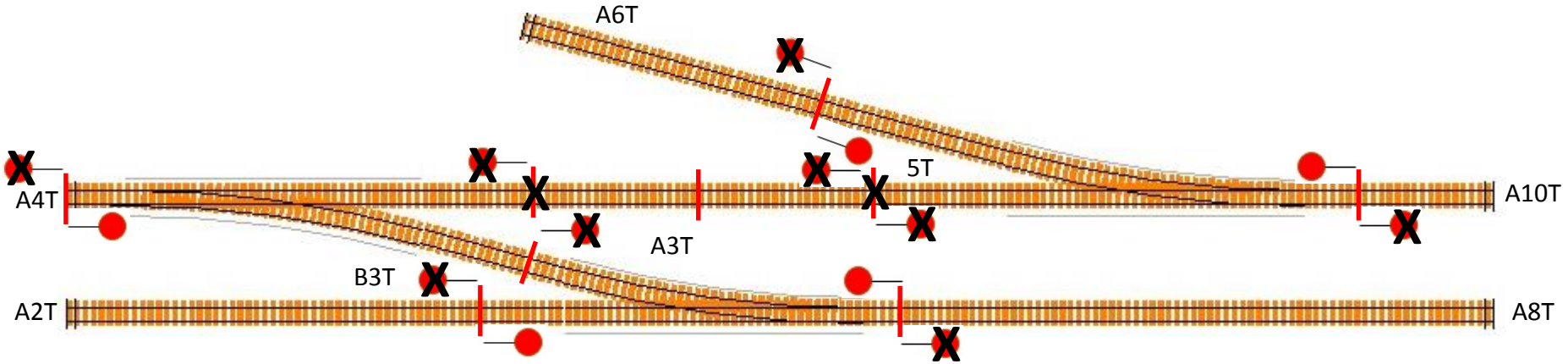

Interlocking because

1. Opposing Signal Lock – a signal cannot clear if an opposing signal is cleared
2. Conflicting Signal Lock – a signal cannot clear if a conflicting signal is cleared
3. Indication (Route) Locking – a cleared signal will lock a switch
4. Switch Indication Locking – a signal cannot clear through a fouling switch
5. Detection Locking – a switch is locked if the track circuit is occupied

# Signal Placement in Interlocking Plants



1. Signals at frogs (conflicting signal lock)
2. Signals at points (opposing signal lock)
3. Pair up signals (detection)

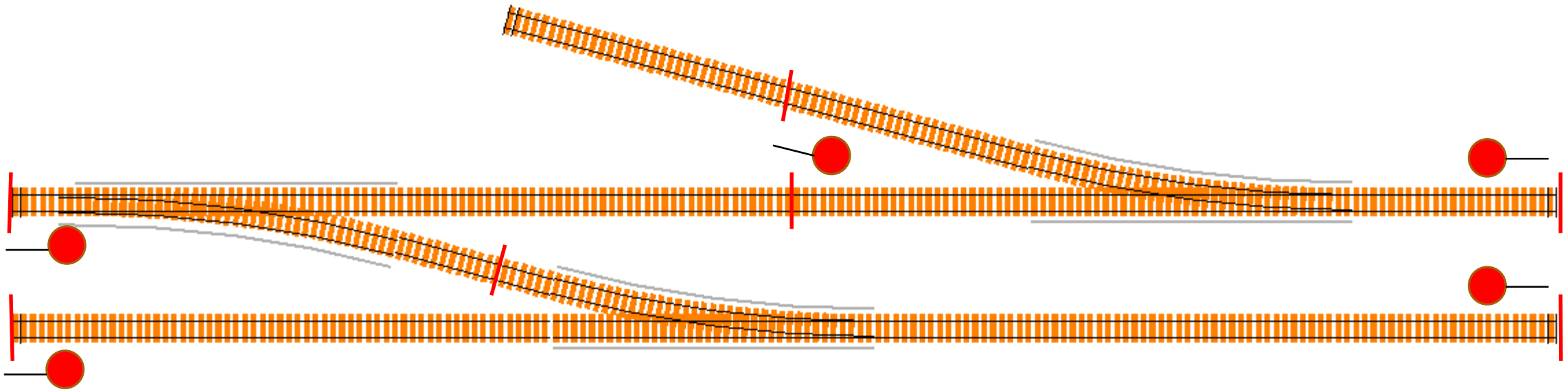



Routes

1. A2T→A8T
2. A8T→A2T
3. A4T→A10T
4. A10T→A4T
5. A4T→A3T→B3T→A8T
6. A8T→B3T→A3T→A4T
7. A6T→5T→A10T
8. A10T→5T→A6T

"Introduction to North American Railway Signaling"

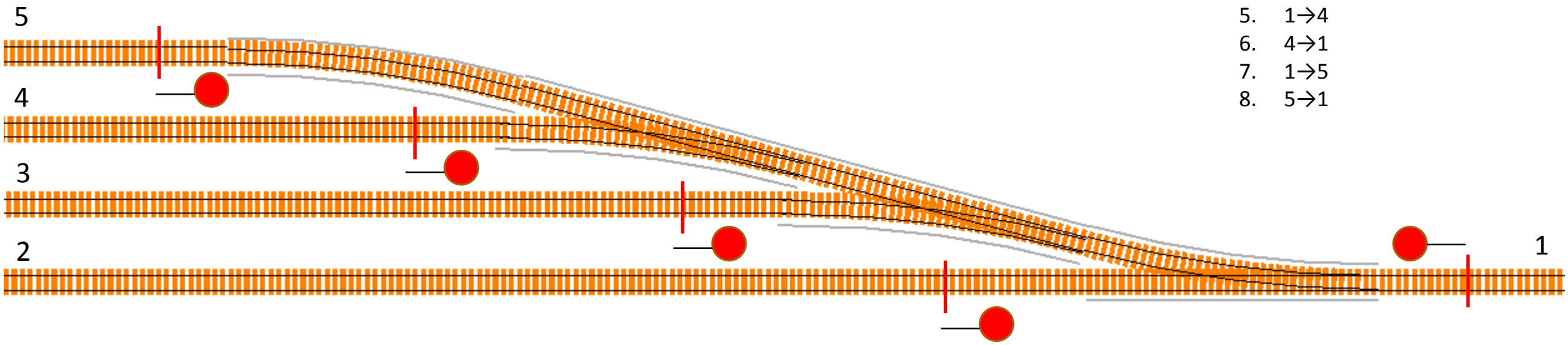
# Signal Placement in Interlocking Plants



# Signal Placement in Interlocking Plants

Routes

1. 1→2
2. 2→1
3. 1→3
4. 3→1
5. 1→4
6. 4→1
7. 1→5
8. 5→1

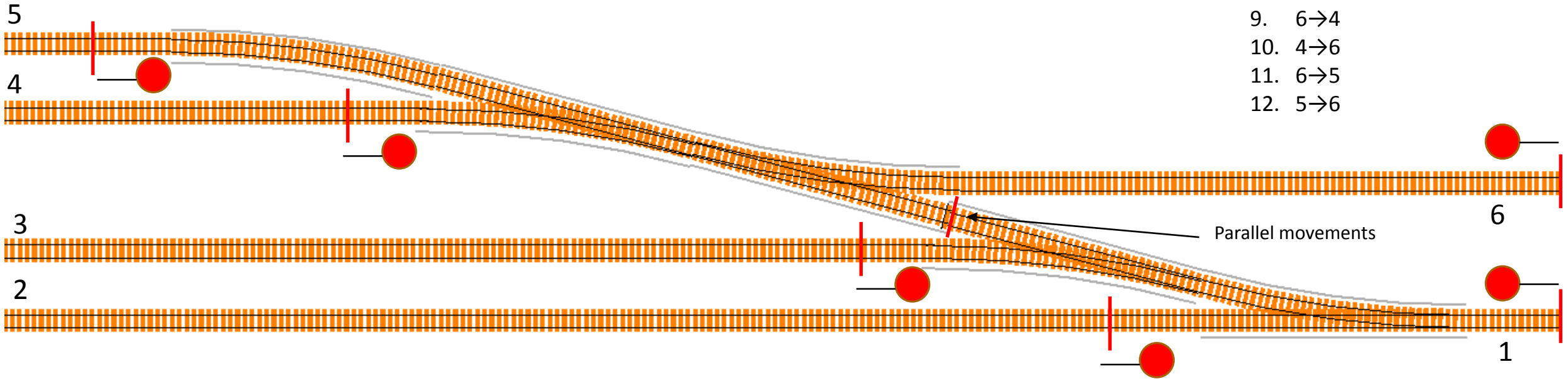


# Signal Placement in Interlocking Plants

- Place signals on perimeter
- Add interior track circuits for parallel routes

Routes

1. 1→2
2. 2→1
3. 1→3
4. 3→1
5. 1→4
6. 4→1
7. 1→5
8. 5→1
9. 6→4
10. 4→6
11. 6→5
12. 5→6



# Centralized Traffic Control (CTC)/ Traffic Control System (TCS)

- Eliminates manned stations
- Allows fine control (micro-managing) traffic flow
- Control points (security elements, OS sections) are like simple interlocking plants
- Control points are linked with safety overlays
- Extension of safety overlay - “Proceed on signal indication”

# Example CTC Control Point


Exit Signal
(Main)

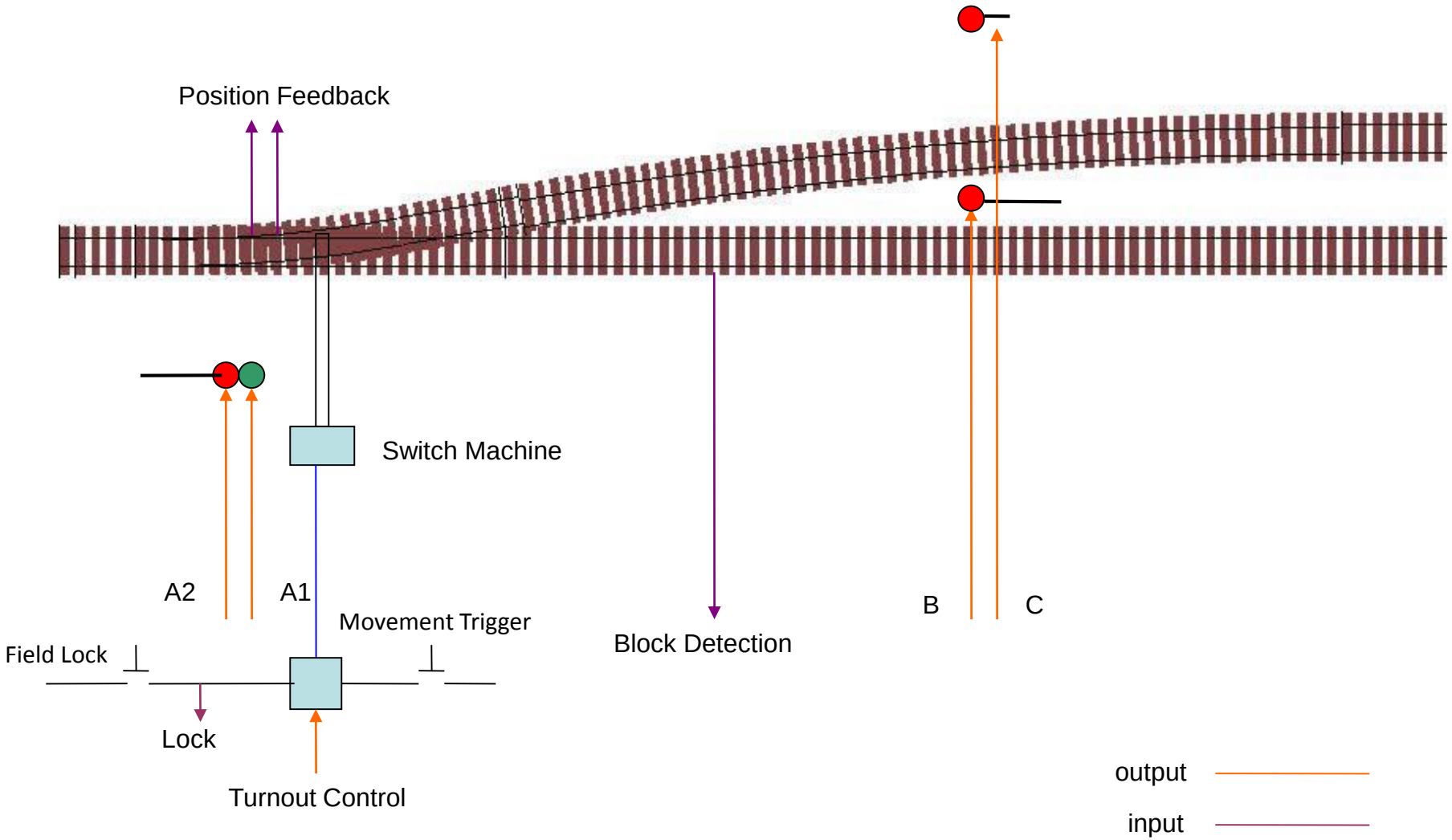
Exit Signal
(Siding)

Field Equipment
(Vital Logic)

Approach Signal

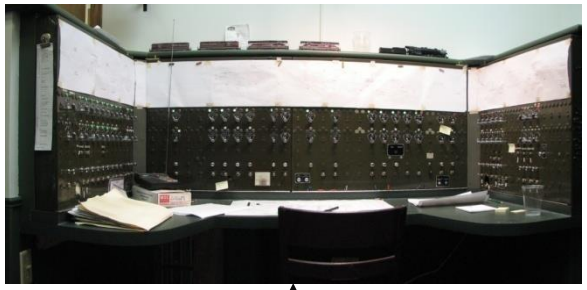
Automatic (Dual Control) Switch Machine

# Control Point Schematic



# Prototype CTC Architecture

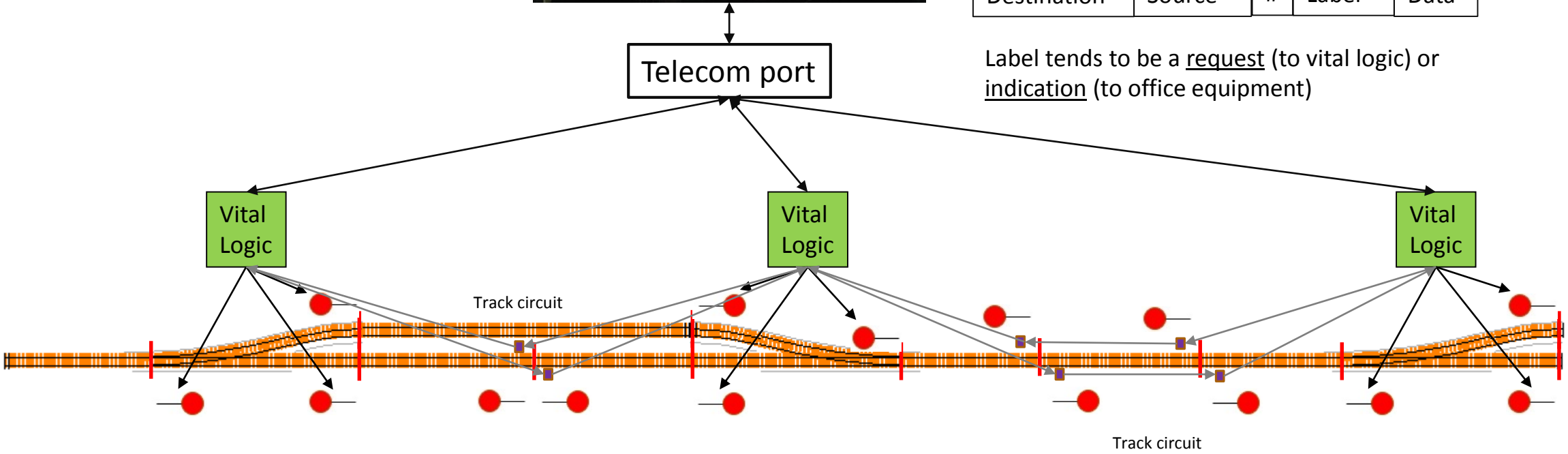
Vital Logic performs the bulk of the safety checking



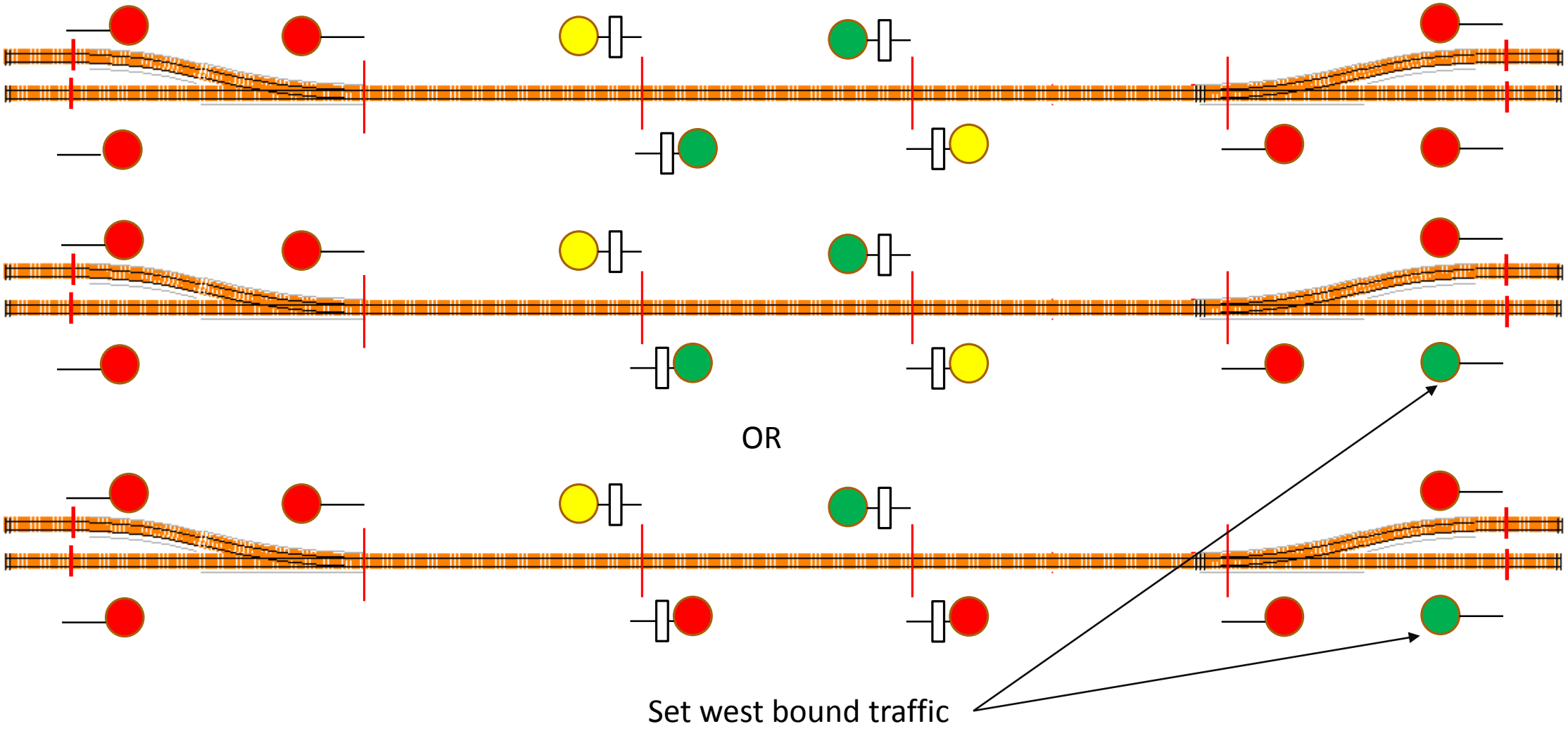
Advanced Train Control System

| Destination | Source | # | Label | Data |
|---|---|---|---|---|

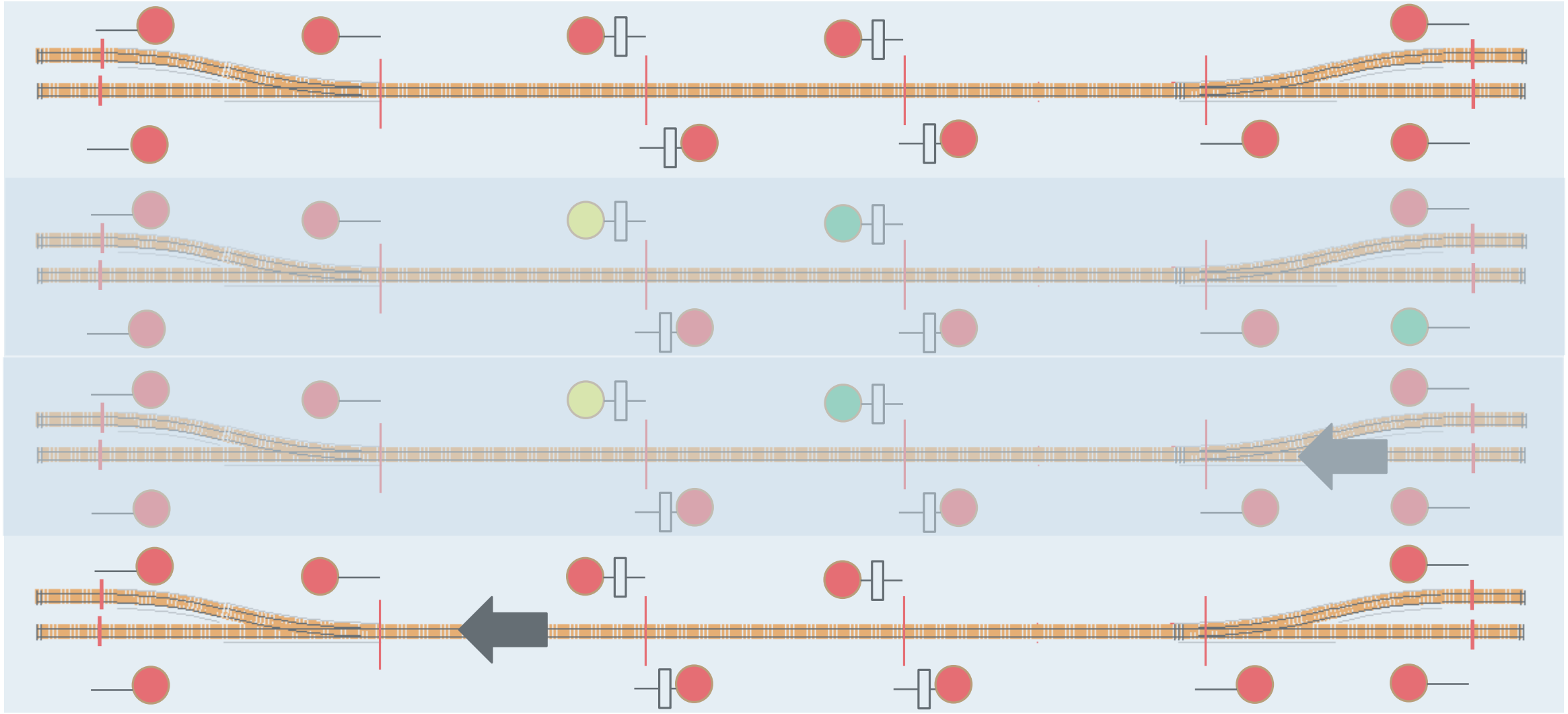
Label tends to be a request (to vital logic) or indication (to office equipment)



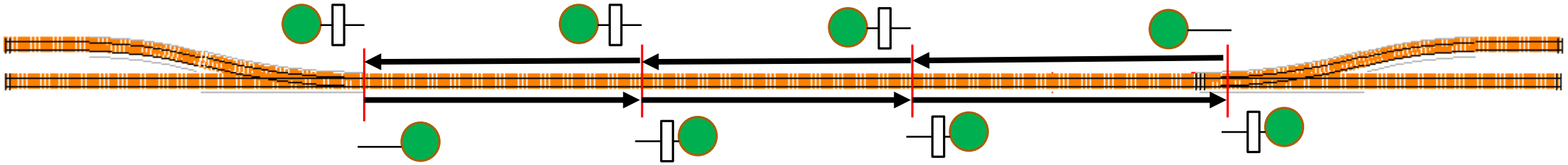
# Dispatcher Control with CTC (Alternative 1)

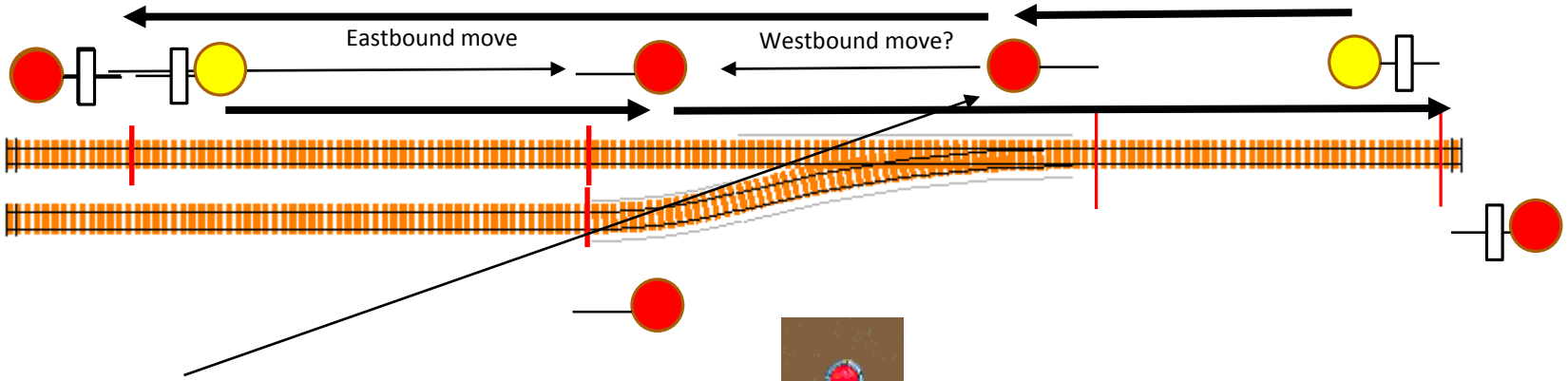


# Dispatcher Control with CTC (Alternative 3)



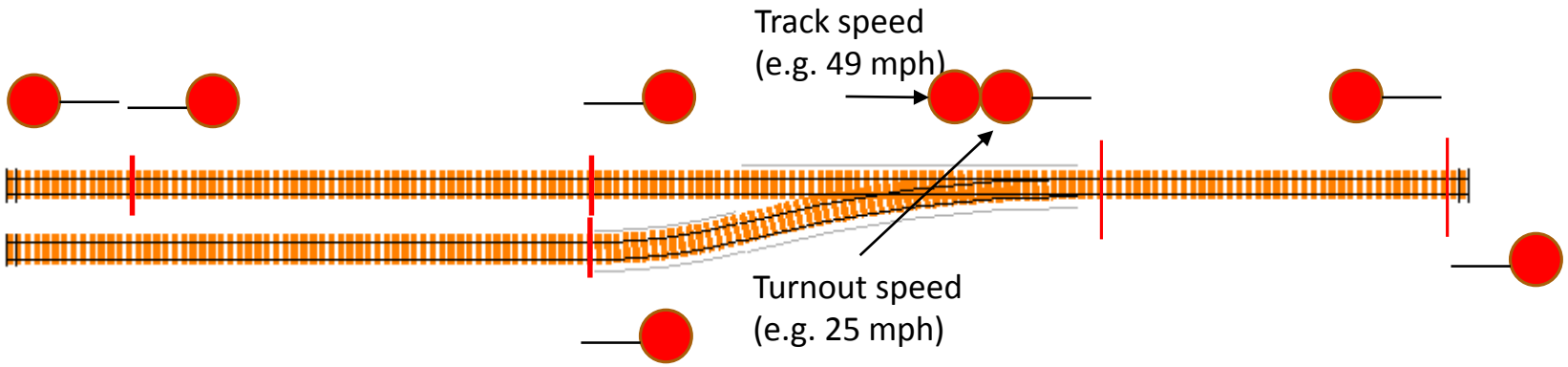
# Overlapping Protection



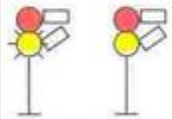



Opposing Signal Lock propagates to first opposing signal at or after next signal in advance

# More Complicated Indications



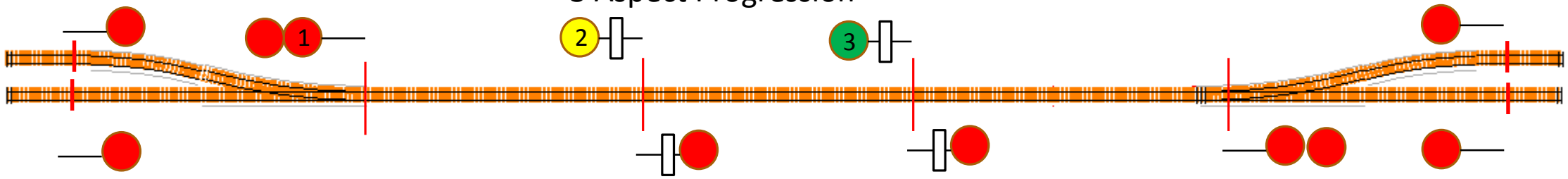

- Add second “arm” (head)
- Account for next signal being green, yellow, or red
- Excluding high speed turnouts, route based signaling is similar to speed based signaling

| | | | |
|---|---|---|---|
|  | 9.57 | DIVERGING CLEAR | Proceed on diverging route not exceeding prescribed speed through turnout. |
|  | 9.58 | DIVERGING APPROACH | Proceed through diverging route; prescribed speed through turnout; approach next signal preparing to stop, if exceeding 40 MPH immediately reduce to that speed. |

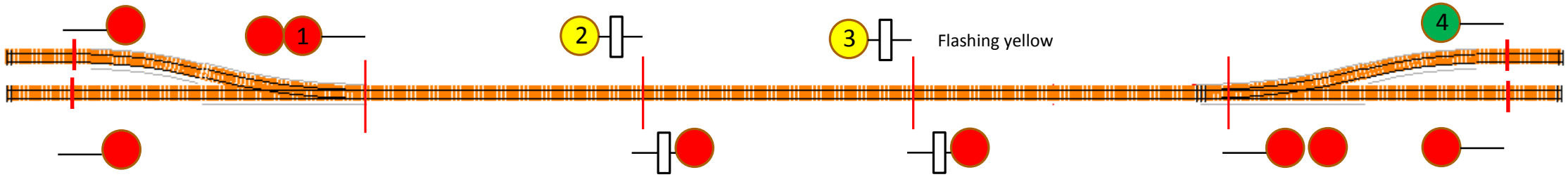
http://www.railroadsignals.us/rulebooks/cora/cora1.htm

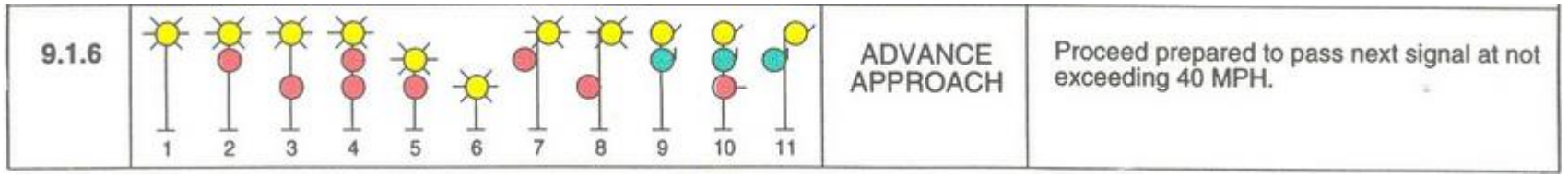
# Even More Complicated Indications

3 Aspect Progression




4 Aspect Progression



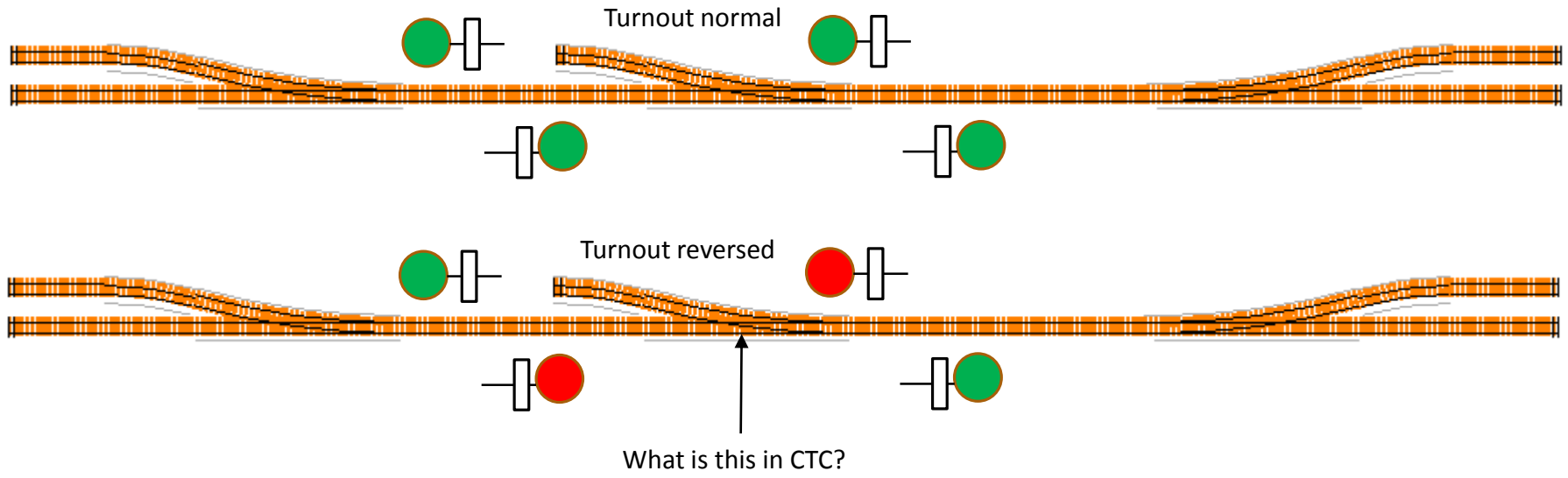

Advance signals are railroad specific!

http://www.railroadsignals.us/rulebooks/cora/cora1.htm

# Turnouts (Points, Switches)

Turnout Taxonomy

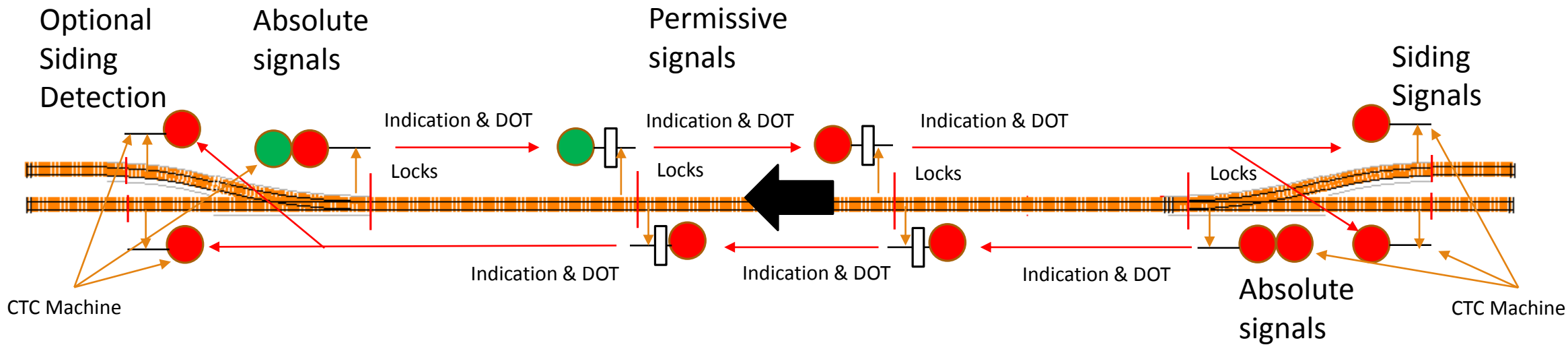
1. Manual – signals drop when points move by trainman
2. Automatic Electrical – signals drop when turnout is “unlocked” by trainman
3. Controlled Electrical – dispatcher unlocks turnout, trainman operates
4. Dual control – dispatcher can unlock and move points; trainman can move unlocked turnout



# CTC Signal Indication Dependencies

1. Occupancy of protected track circuit(s)
2. Next (advance) signal indication in direction of travel
3. Next (advance) signal indication in opposing direction of travel
4. Conflicting signal indications
5. Alignment of protected turnouts
6. Lock/unlock status of protected turnouts
7. Occupancy of track circuits(s) in approach
8. Other things (e.g. slide fence, draw bridge)
9. Dispatcher/Towerman actions

# CTC Connections




Signals show authority to occupy track

Indications travel opposite train direction; Tumbledown travels in train direction

DOT is Direction of Travel (Traffic Stick)

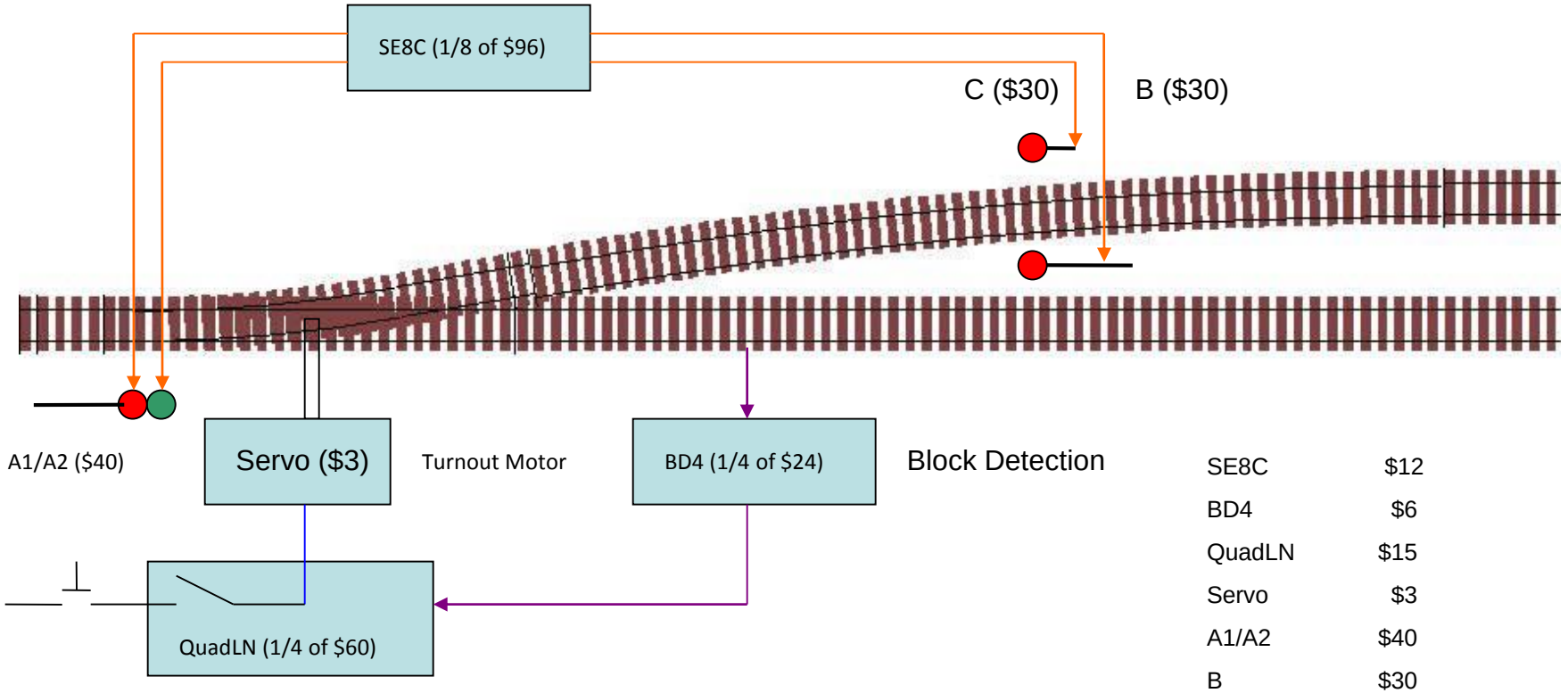
Computer is essential for dispatcher interface

Different ways of implementing intermediates

Implementation:

- Chubb chapters 21-25
- JMRI
- CATS

# CTC Implementation




| | |
|---|---|
| SE8C | $12 |
| BD4 | $6 |
| QuadLN | $15 |
| Servo | $3 |
| A1/A2 | $40 |
| B | $30 |
| C | $30 |
| --- | --- |
| Total | $136 |

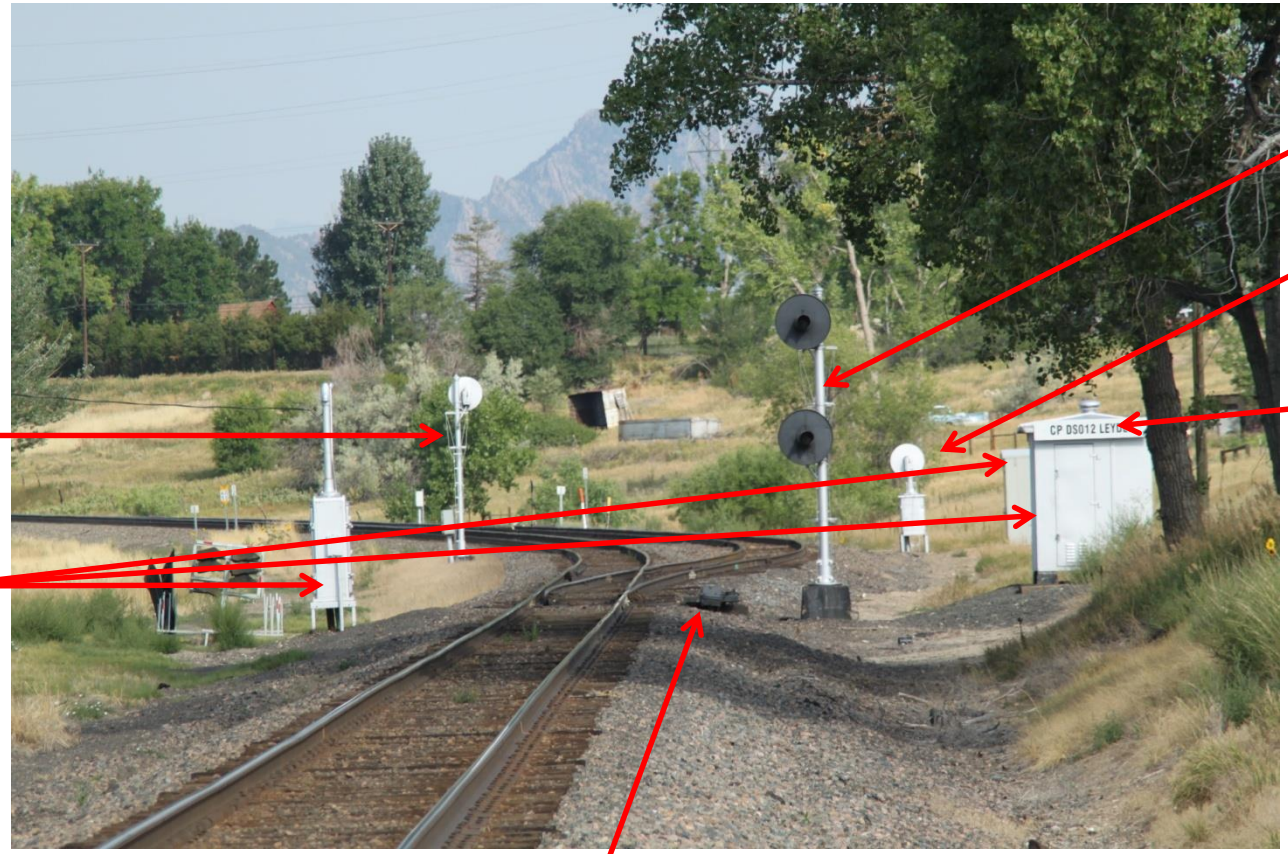
# Right of Way Issues

1. Clearances – NMRA gauge and actual for equipment
2. Support structures (switch machines, equipment sheds, etc.)
3. Telephone/code poles, lines, signs, access roads
4. Distance between signals – how long is a block?
5. Protection from damage

# Right of Way Issues - Clearance

# Right of Way Issues - Clearance

# Right of Way Issues - Details



# Right of Way Issues - Protection

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