Route and Speed Signaling Clinic

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May 19, 2017

Louisville, Kentucky

Complexity Disclaimer

- Signaling is a very complicated subject
- It's confusing in the real world
- But much less so in the modeling world
- My goal is to make the concepts:
  - easier for you to understand
  - easier to apply to your layout

Why Signals

- Signals designed to help trains move safely
- Signals allow a higher density of traffic
- Protect following trains
- In modeling:
  - property and lives are not at stake,
  - signals are a great benefit and
  - a lot of fun for the model railroad operator.

What do Signals tell us

- Variety of aspects or “looks”
- Track conditions
- Their primary role, “Stop the Train”
- But no real standards among railroads
- Industry mergers have had a big impact
- Hardware and signaling rules vary
- Diversity remains the norm

Signaling Aspect Systems

Two types

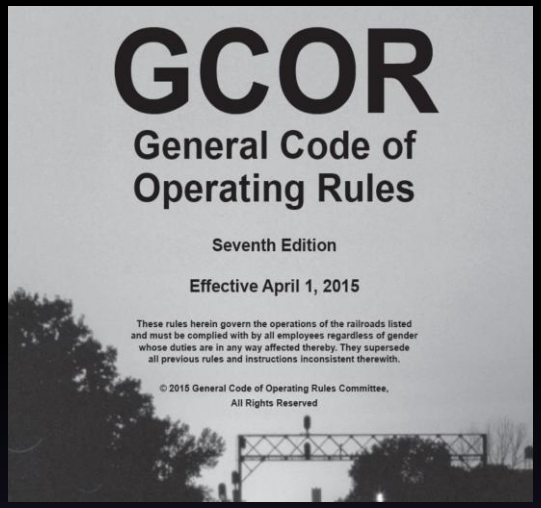
- Speed Signaling – out in the country
- Route Signaling – Around yards and branches

Speed Signaling

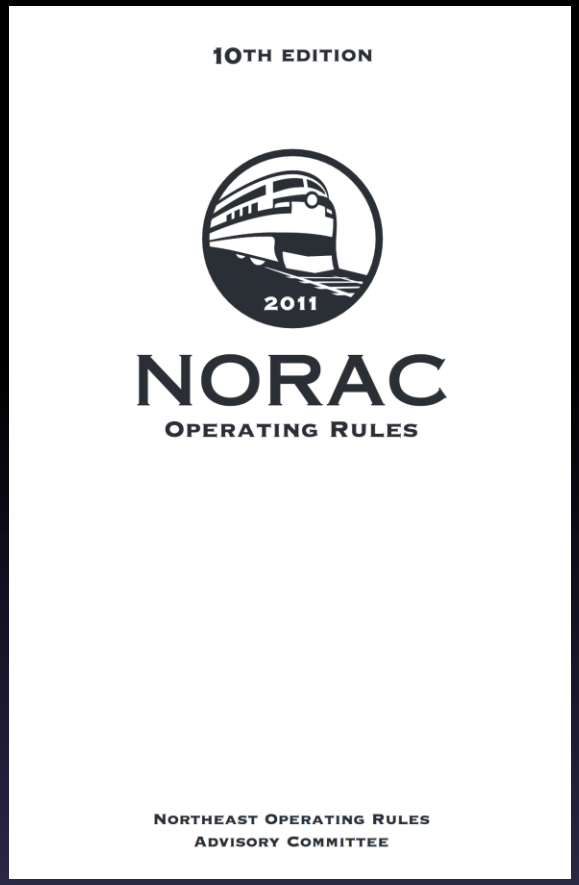
- How fast can/should the train go
- Considers the upcoming segment of track
- Engineer must govern the train speed accordingly

Route Signaling

- Signals indicates the detail of the upcoming route and speed is not typically conveyed
- Mostly indicate the single fact of a diverging or straight route, each having a predictable range of known speeds



The General Code of Operating Rules (GCOR) is a set of operating rules for railroads in the United States. The GCOR is used by Class I railroads west of the Mississippi River, most of the Class II railroads, and many short line railroads.



The Northeast Operating Rules Advisory Committee (NORAC) is a set of operating rules for railroads in North America. The NORAC rulebook is used by full and associate member railroads, located mostly in the Northeast United States.

Operating Rules

- General Code of Operating Rules - GCOR
  - Employee Responsibilities
  - Signaling equipment
  - Procedures for safe train movement
  - Dealing with accidents
  - Railway safety
- Supplemented by Special System Instructions

Signaling System Types

- Automatic Block System (ABS)
- Absolute-Permissive Block System (APB)
- Centralized Traffic Control (CTC)
- Direct Traffic Control (DTC)

Modern Double Track

- Double track (DT) is signaled for operation in only one direction
- 2MT usually has bi-directional signaling
- Depends on how the segment is dispatched

Double Track (CTC)

- Most double track systems have a preferred travel direction
- The track is signaled in that direction
- Right hand running most common
- Requires additional traffic control, i.e., train order or track warrant control

2MT (CTC 2MT)

- The big transcontinental systems (BNSF and UP) use double track, bi-directional dispatching but this requires fully automated controls such as CTC
- The track setup can be changed every few miles so double crossovers rule the territory and might be located every 10 miles or so
- The dispatcher is totally in charge and the engineer just follows the signals
- Officially, this activity is governed by Rule 261

Signal Types

- Absolute - Connected to an interlocking
- Automatic – Logic systems detect the presence of trains
- Semi-Automatic –Use additional explicit signals

Absolute Signals

- Usually connected to interlocking segments and controlled by a dispatcher.
- Most restrictive is “Stop” and trains can not pass them without specific authority
- They display no number board and may also have a “A” board below the signal

Automatic Signals

- Governed by logic connected through track circuits
- Most restrictive is a red “Restricted Proceed”, meaning stop and proceed at a restricted speed
- Least restrictive is a green “Proceed at track speed”
- Signals usually display a number board, in most cases the MP number

Semi-automatic Signals

- Typically act like Automatic Signals
- Can be set to display an absolute stop signal by displaying an explicit absolute stop aspect

Signal Hardware

High Signal

- 1-3 heads, each with up to four signals in a vertical stack

Signal Hardware

- Dwarf Signal
  - Used in low speed or restricted clearance areas, typically in a yard
  - Usually with a single multi-colored head

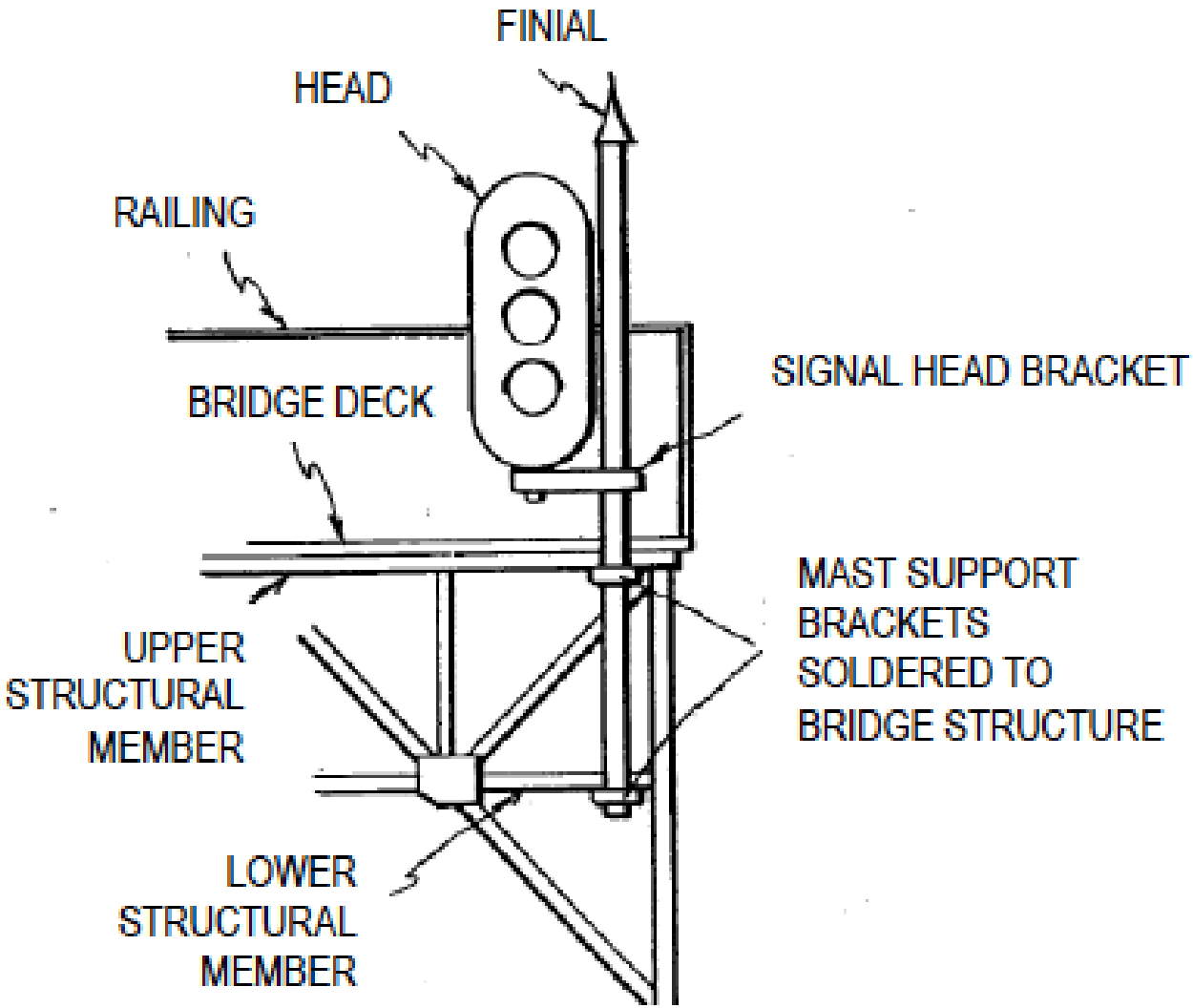
Environmental Issues

- A target is usually placed behind the signal head
  - Improves visibility on a bright day
- A hood/shroud is sometimes placed over the signal head or all the heads
  - Improves the performance in snow or sleet

Targets and Shrouds

Types of Signal Mounting

- Most signals are on trackside masts, 12 – 15’ high
- Also mounted on signal bridges or cantilever masts Need 20-25’ clearances above track
- In 1985, the signal had to be mounted above and to the right of the track being governed.
- Signals can be mounted back to back on bi-directional single tracks


FINIAL
HEAD
RAILING
BRIDGE DECK
SIGNAL HEAD BRACKET
MAST SUPPORT BRACKETS SOLDERED TO BRIDGE STRUCTURE
UPPER STRUCTURAL MEMBER
LOWER STRUCTURAL MEMBER

Modern Light Positioning

- Green on the top
- Amber/Yellow in the middle
- Red on the bottom
- Opposite of auto traffic lights

Signal Lighting Standards

- Low power incandescent or LED lamps
- Lenses focus the light into narrow beam
- Can be seen 3500 feet in clear daylight
- Standard diameter of 8 3/8”

Signal Color

- Green – Used to indicate “Clear” or proceed
- Yellow – Used to warn of impending stop or speed reduction ahead
- Red – Used to indicate a full stop
- Lunar White – Restricted proceed, different than yellow

Flashing Signals

- Flashing is generally less restrictive than steady lights
- Creates a different signal aspect based on the color
- In the US, signals typically flash only one signal head at a time
- In Canada, two heads can flash at same time

Speeds

- Normal Speed – Maximum Authorized Speed – 79 MPH (on Class 5 track)
- Limited Speed – Not exceeding 45 MPH
- Medium Speed – Not exceeding 30 MPH
- Reduced Speed - Proceed prepared to comply with flagging signals and stop short of train or obstruction.
- Restricted speed - Proceed prepared to comply with flagging signals and stop short of train or obstruction.
- Slow Speed – Not exceeding 15 MPH
- Restricted Speed – Used entering un-signaled territory set by railroad rules

Types of Signals

- Semaphores (not included in this clinic)
- Searchlight
- Color Position Light
- Vertical Color Light

Searchlight Signals

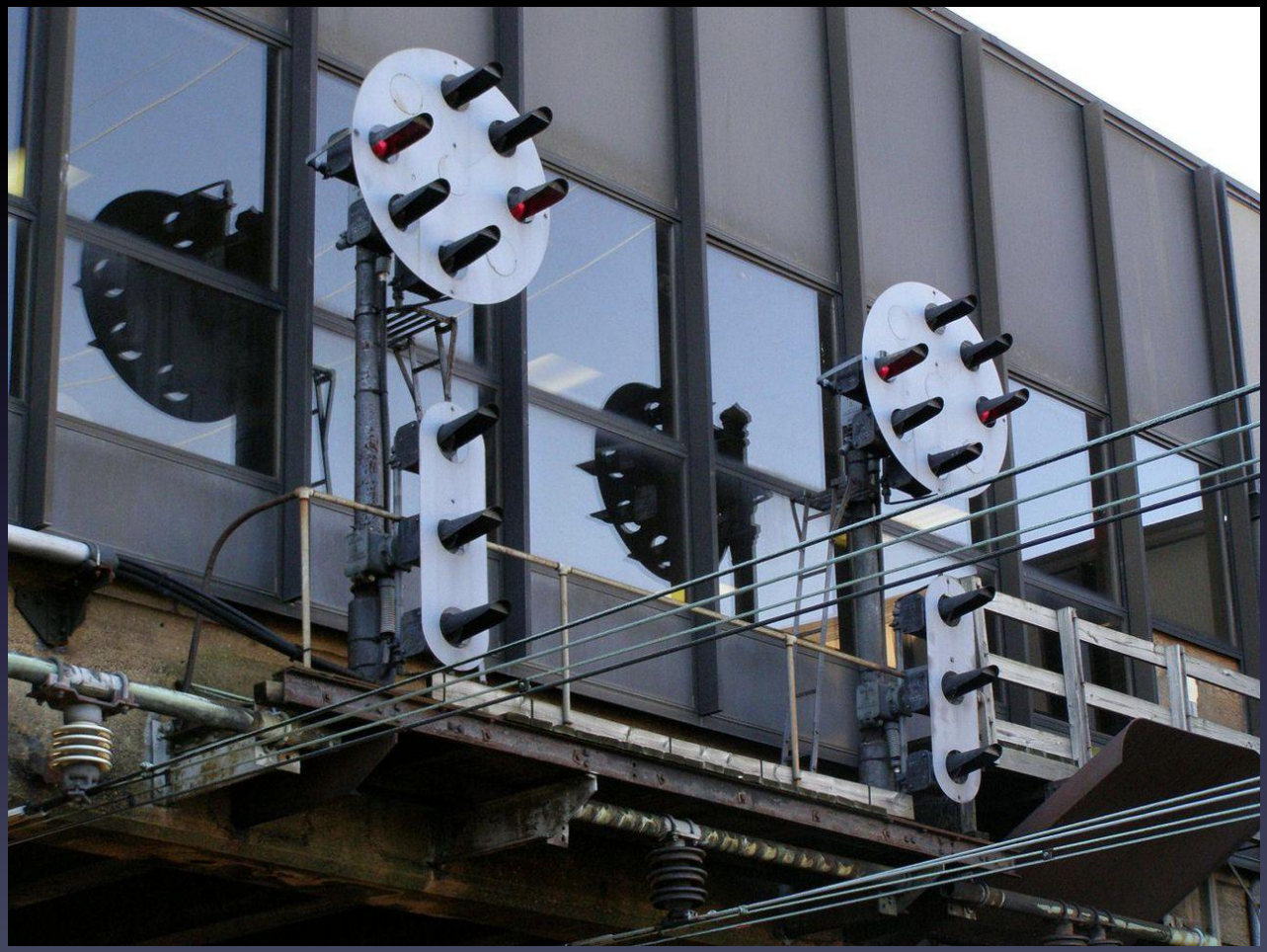
- Invented in 1914 by Corning
- Single lamp with color internally controlled by lenses
- Used a doublet lens
- Use shades to improve visibility
- Expensive signal relay
- Dominant until the late 1980s

Searchlight Signal

Color Position Signal

- Signal shows aspects using rows of lights that mimic aspects of upper quadrant semaphores
- Round target with lamps located around the outer section of the target
- The aspect is a color pair located vertically, diagonally or horizontally across the target

Color Position Signal



Color Light Signal

- Invented in 1915
- Vertical orientation, usually 2 or 3 lights, similar to road traffic signals
- Uses parabolic mirrors to increase intensity
- Uses special optical techniques to assure high visibility

Vertical Color Signal

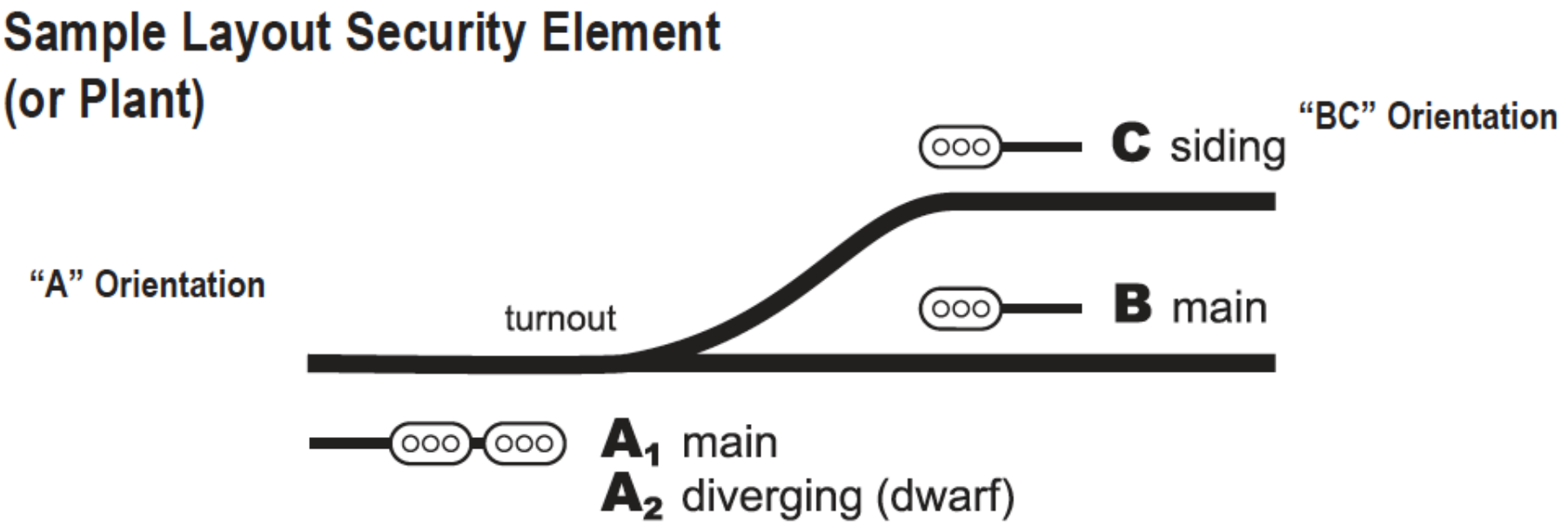
Signal Terminology

- Name – What the signal is called in the rule book
- Aspect – Visual appearance of a lit signal
- Indication – The meaning of the signal
- Home Signal - Governs the entrance to interlocking plant or a controlled point
- Distant Signal – Used preceding a home signal to give advance warning of the condition of that signal

Signal Terminology

- Absolute Signal
  - Must not be passed when displaying a stop aspect
- Permissive Signal
  - When displaying a stop aspect, the train must stop but then can proceed at a specified slower speed. Distinguished from absolute signals with a marking such as a mile post number plate or letter markings

Security Element



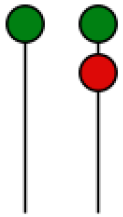
- U.S. prototype railroads call turnouts "plants."
- Only discussing dispatcher controlled turnouts
- Includes most modern passing sidings
- Includes all branch and foreign interconnect

Route Signaling

- Signaling is required when passing through a switch
- Two position signaling placement of the signal heads indicates which route is lined up
- In the simplest situation,
  - the top signal governs movement on the primary route
  - the bottom signal governed movement on the diverging route
- In advanced signaling, a third signal provides additional information about speed restrictions through the switch

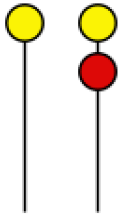
Interlocking Signals

BNSF Signal Rules



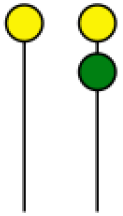
CLEAR
Proceed at authorized speed

Diverging Clear
Proceed on diverging route not exceeding prescribed speed through turnout

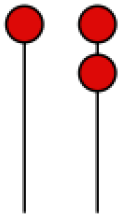


APPROACH
Proceed prepared to stop at next signal. Trains exceeding 30 MPH immediately reduce to that speed.

DIVERGING APPROACH
Proceed on diverging route not exceeding prescribed speed through turnout, and approach next signal preparing to stop. If exceeding 30 MPH immediately reduce to that speed



ADVANCE APPROACH
Proceed prepared to pass next signal not exceeding 50mph and be prepared to enter divirging route at prescribed speed



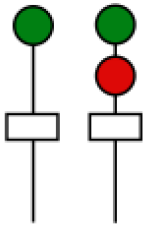
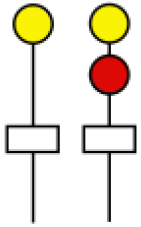
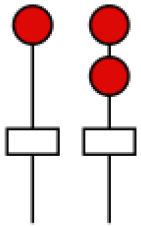
ABSOLUTE STOP

Speed Signaling

- Used in Block Control Systems to indicate the speed allowed in the next block.
- Usually use only a single head
- Would normally use double heads (home and distant) to indicate the approach to route signaling
- Speed Signaling is controlled by detection circuits and thus would have number plates on the mast

Intermediate Signals

BNSF Signal Rules

Aspect	Name	Indication
	Clear	Proceed at authorized speed
	Approach	Proceed prepared to stop at next signal. Trains exceeding 30 MPH immediately reduce to that speed.
	Stop	Stop. Then proceed at Restricted Speed Number Plate required

Distant (Approach) Signals

- Used to either an automatic signal before an interlocking, or the interlocking signal itself when interlockings are back to back
- Warns of diverging movements ahead
- When a train enters the approach block, timers take over to prevent routing a conflicting movement

Approach
Amber over Red

Other type of signals

- Train Order Signals (official verbal)
- Yard Limit signs
- Crossing whistle signs
- Maintenance signs
- Safety appliances such as
  - Slide fences
  - High wind warnings
  - Derail devices

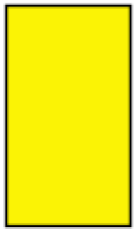
Yard Limit Signs

All movements entering the yard or moving within Yard Limits must be made at restricted speed unless operating under a Block signal indication that is more favorable than *approach*.

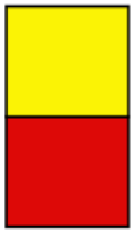
Blue Flag Signs

Whistle Sign

Maintenance Flags



YELLOW FLAG (SIGN)
A temporary speed restriction begins in 2 miles or other distance as specified by track bulletin, warrant, or order. Do not exceed the speed specified in the covering track bulletin, warrant, or general order once movement has proceeded 2 miles or the indicated distance past this sign. If there is no covering bulletin, then do not exceed 10 MPH 2 miles past this sign. Do not exceed appropriate speed until end of train has passed Green Flag.



YELLOW-RED FLAG (SIGN)
Yellow-red flags warn a train to be prepared to stop because of men or equipment. Proceed, prepared to stop at Red Flag 2 miles after passing the Yellow-Red Flag, or other distance as specified by covering track bulletin, warrant, or general order. If no Red Flag is encountered, proceed at Restricted speed and increase speed only after receiving permission from the employee in charge, or the leading wheels are 4 miles beyond the Yellow-Red Flag.

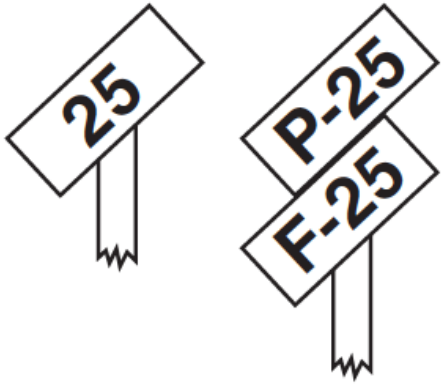
RED FLAG (SIGN OR LIGHT)
Yellow-red flags warn a train to be prepared to stop because of men or equipment. Proceed, prepared to stop at Red Flag 2 miles after passing the Yellow-Red Flag, or other distance as specified by covering track bulletin, warrant, or general order. If no Red Flag is encountered, proceed at Restricted speed and increase speed only after receiving permission from the employee in charge, or the leading wheels are 4 miles beyond the Yellow-Red Flag.

GREEN FLAG (SIGN)
One or more temporary speed restrictions ends at this point. Resume maximum permissible speed once the end of the train has passed this sign.

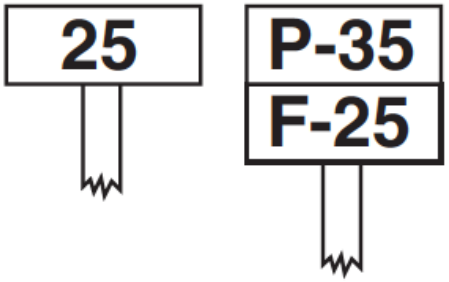
Speed Limit Signs

Speed Limit Signs

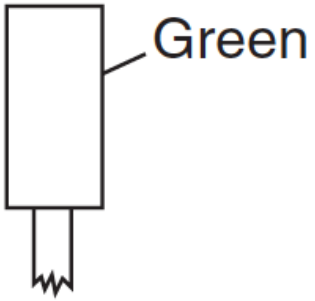
Advance warning sign



Speed sign



Resume speed sign



Break Signs

Positive Train Control

- Next best thing to happen to signaling
- Won’t really change the way signals work
- Will dramatically change the interface between the engineer, the dispatcher and the signaling system
- Deadline is December, 2018

PTC Implementation

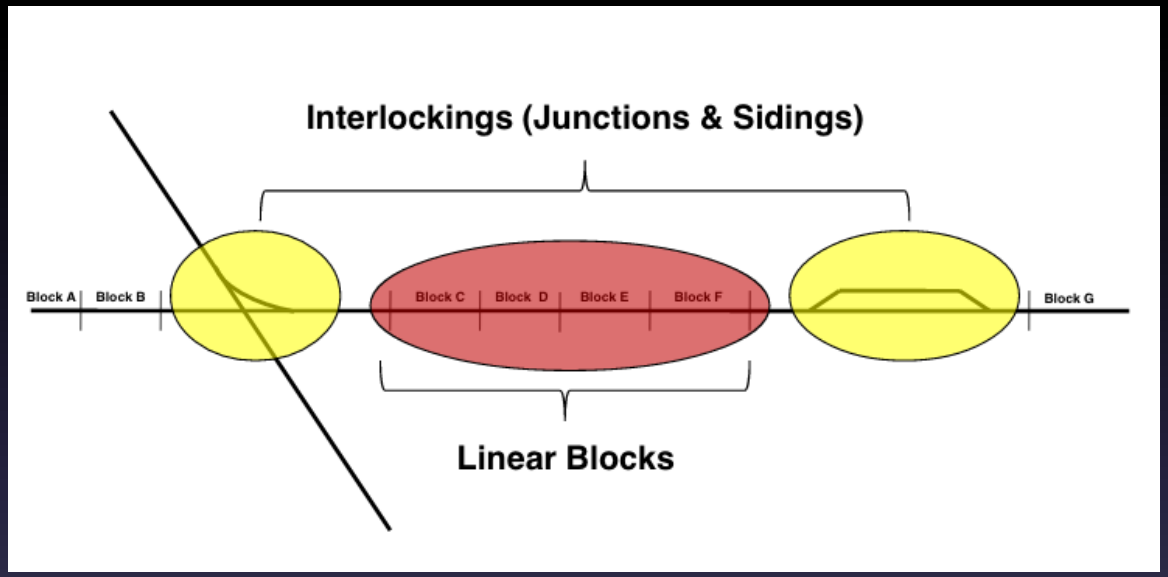
- BNSF, 89% of locos, 51% track segments, 92% of towers, 56% of route miles in PTC operation, safety plan conditionally certified
- CN, 34% of locos, 8% track segments, 69% of towers, 0% of route miles in PTC operation, safety plan is not submitted
- CP, 29% of locos, 4% track segments, 75% of towers, 0% of route miles in PTC operation, safety plan is submitted
- CSX, 46% of locos, 22% track segments, 47% of towers, 28% of route miles in PTC operation, safety plan is conditionally certified
- KCS, 13% of locos, 24% track segments, 76% of towers, 0% of route miles in PTC operation, safety plan is not submitted
- NS, 45% of locos, 17% track segments, 75% of towers, 0% of route miles in PTC operation, safety plan is submitted
- UP, 2% of locos, 26% track segments, 85% of towers, 0% of route miles in PTC operation, safety plan is submitted

Lets now take the throttle down to notch 4 and slow down a bit to see how I have implemented all this stuff

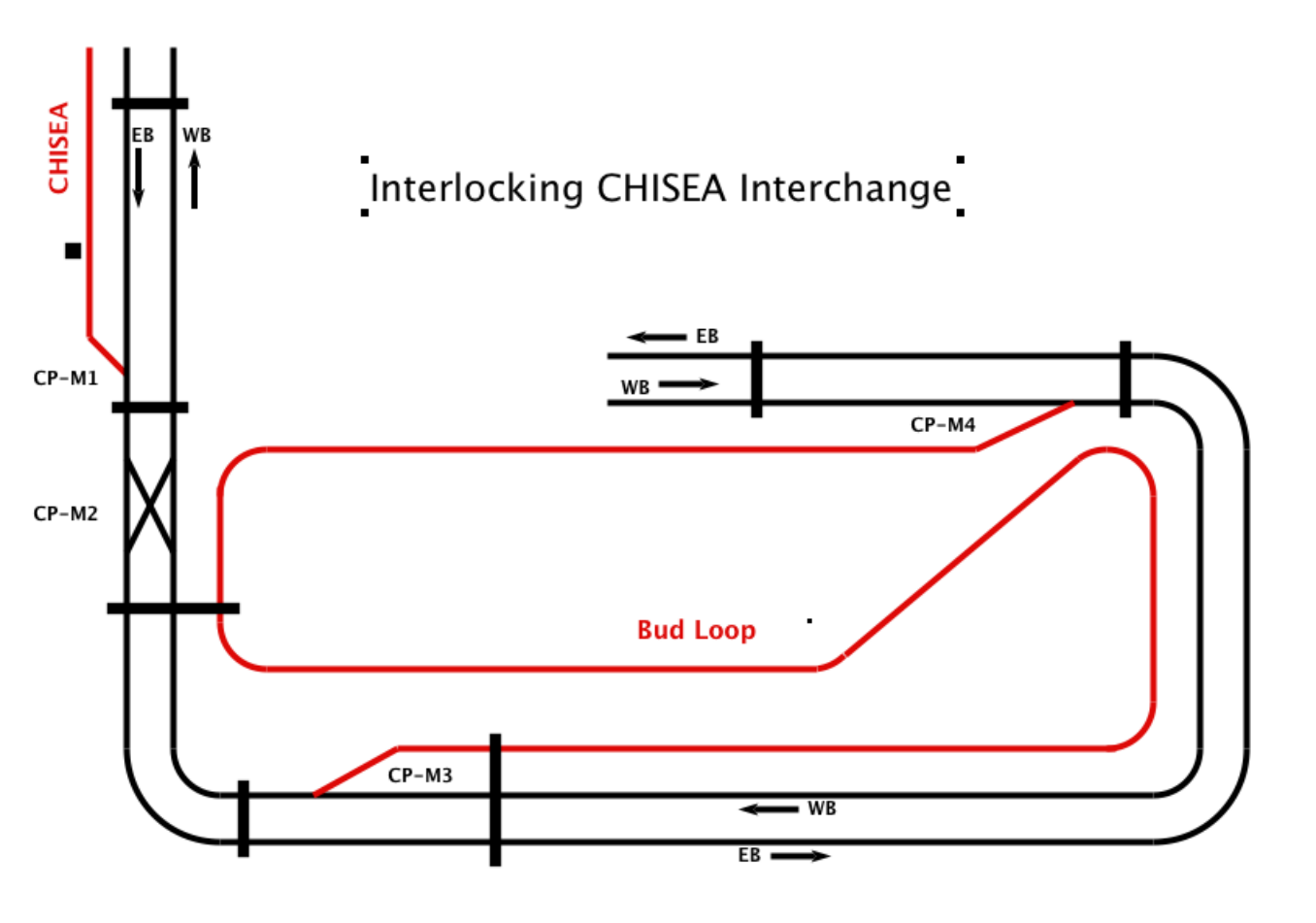
My Layout Operating Rules

- Dispatcher Control
  - Dispatcher is the only person who can change main line turnouts and will do so by JMRI.
  - Signals are controlled Arduino microprocessor/electronics
  - JMRI messages on LocoNet control the turnouts and reports those changes back to the dispatcher on the layout map
  - Dispatcher radio notifies the train engineer of the route changes ahead
  - Engineer radio confirms (calls) the signal conditions to dispatcher when approaching the interlocking section
  - Engineer reacts to the signal aspect to control speed through the interlocking

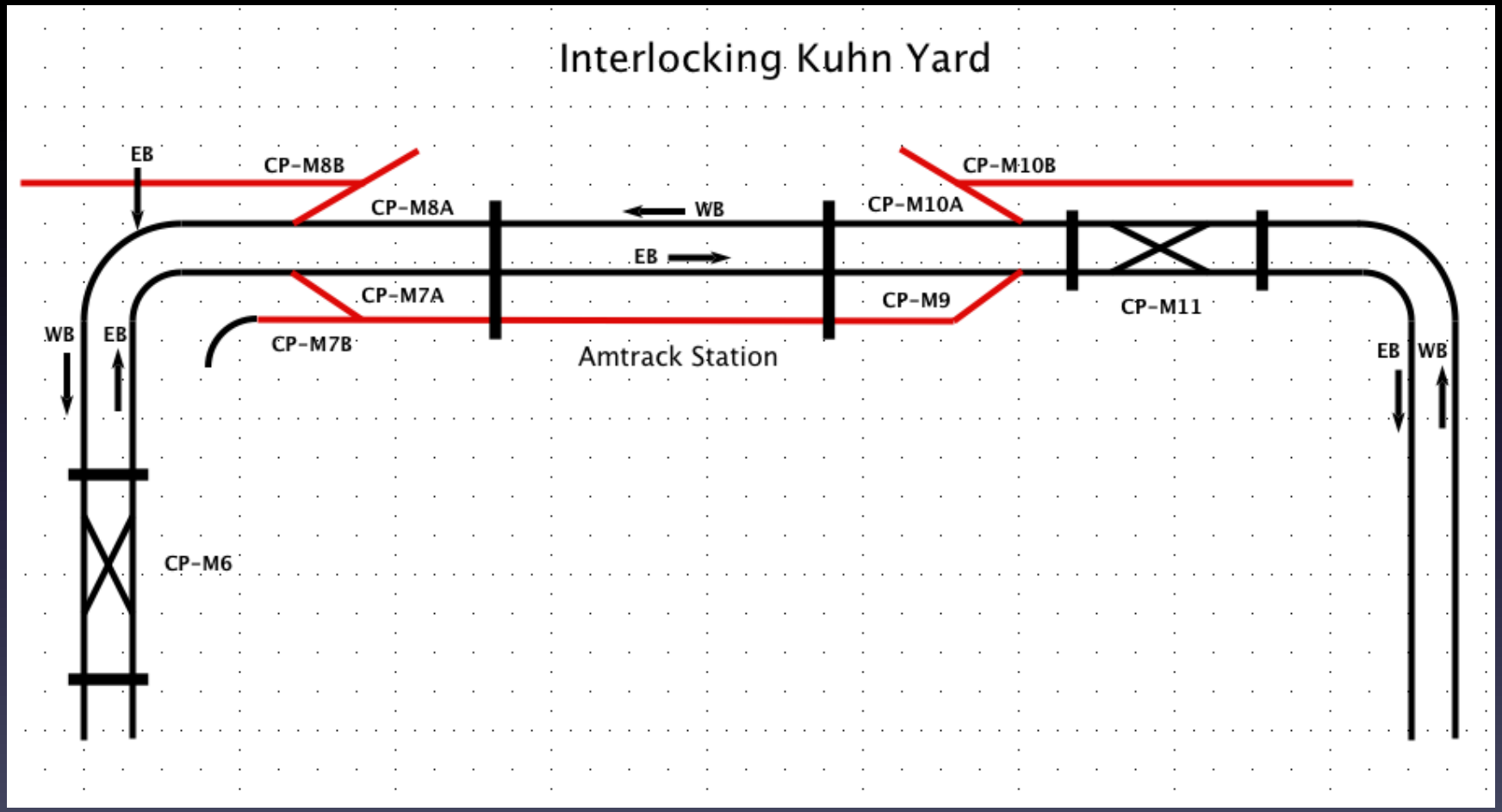
Typical Signaling Sections



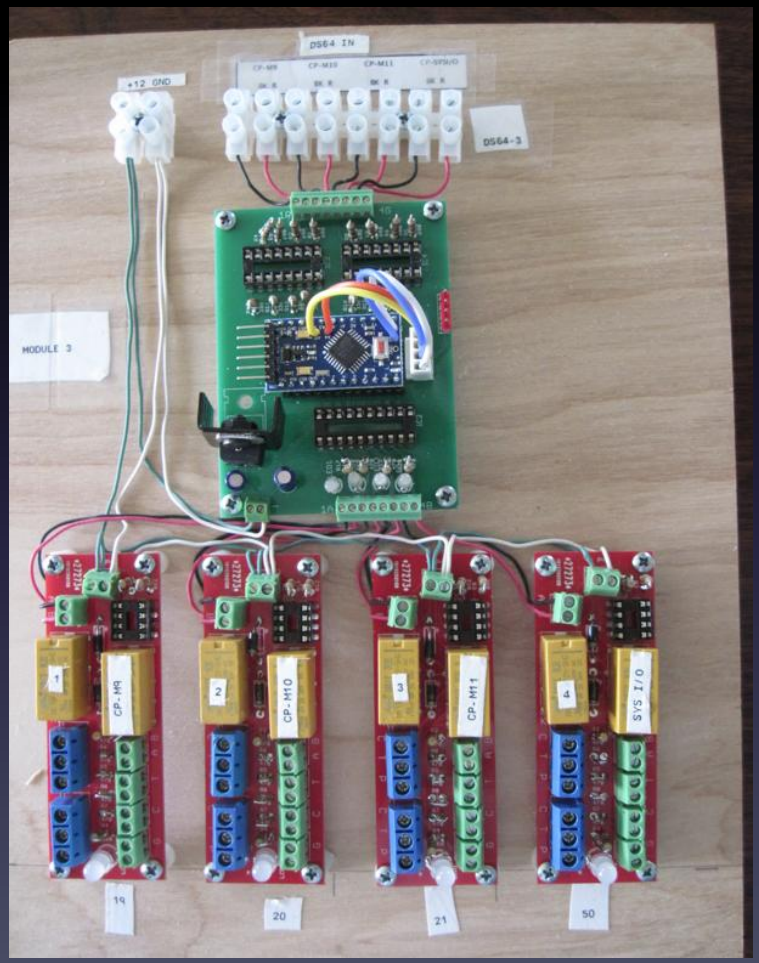
Interlocking #1CHISEA



Interlocking #2 Kuhn



Arduino Pro-Mini Turnout Electronics



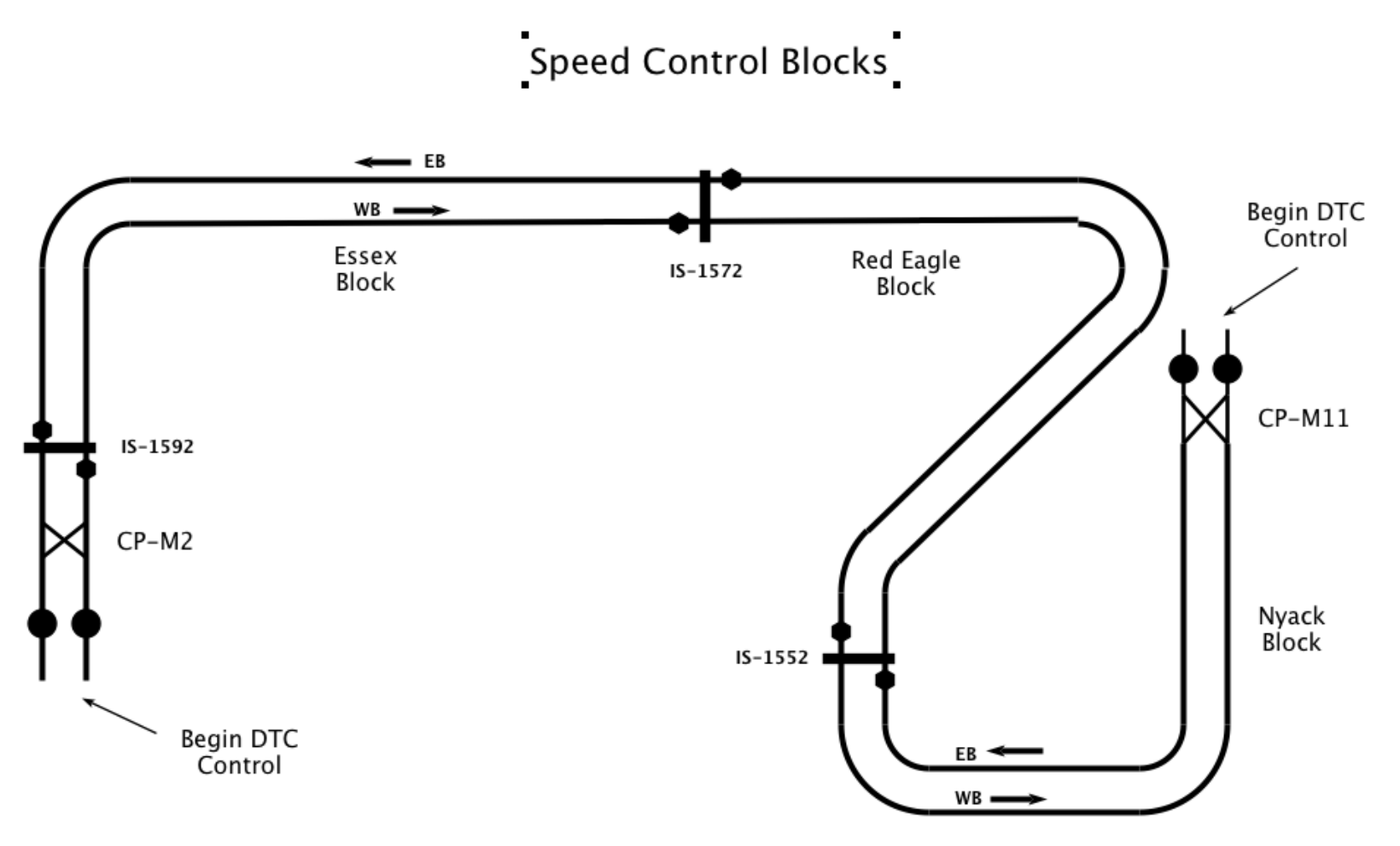
Direct Traffic Control - DTC

- Dispatches trains by radio and uses fixed blocks
- My layout will operate with Direct Traffic Control as 2MT-DTC. Movement will be right hand running normal, but trains can run on either main in either direction
- All dispatching to train crew will be done by radio
- The main tracks in DTC territory are divided into named blocks.
- A train gets permission from the dispatcher to occupy one or more of these blocks.

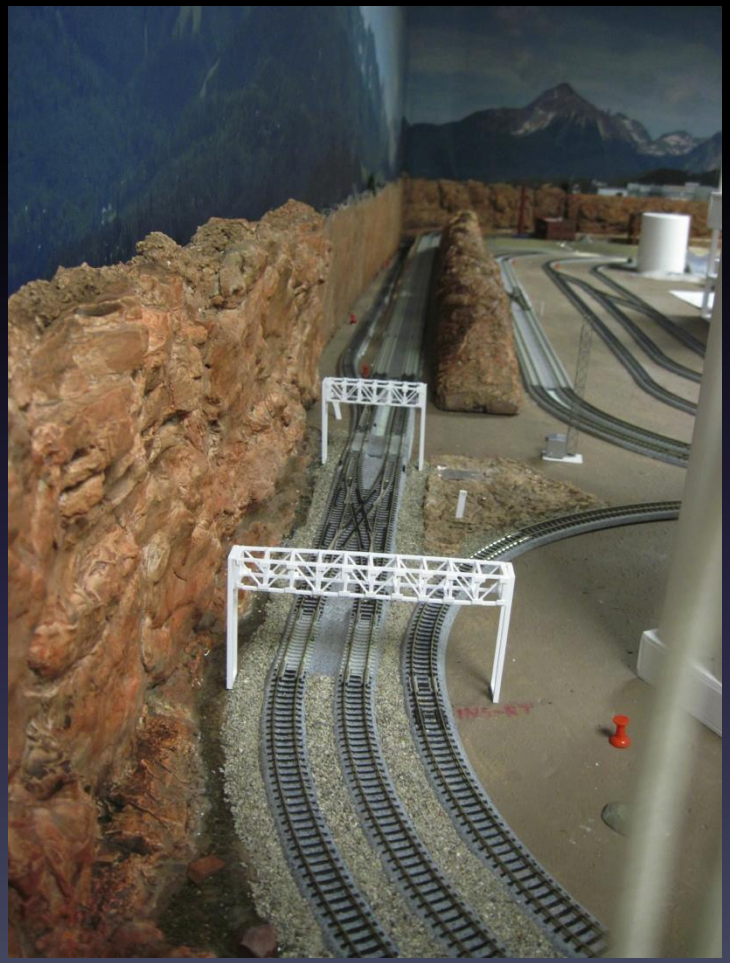
DTC Rules

- DTC rules specify fixed wording for messages concerning the grant or release of DTC Blocks.
- The train crews must keep a written note of the DTC blocks their train is authorized to occupy.
- The crew releases the DTC Block Authorities after it has cleared the DTC Blocks.

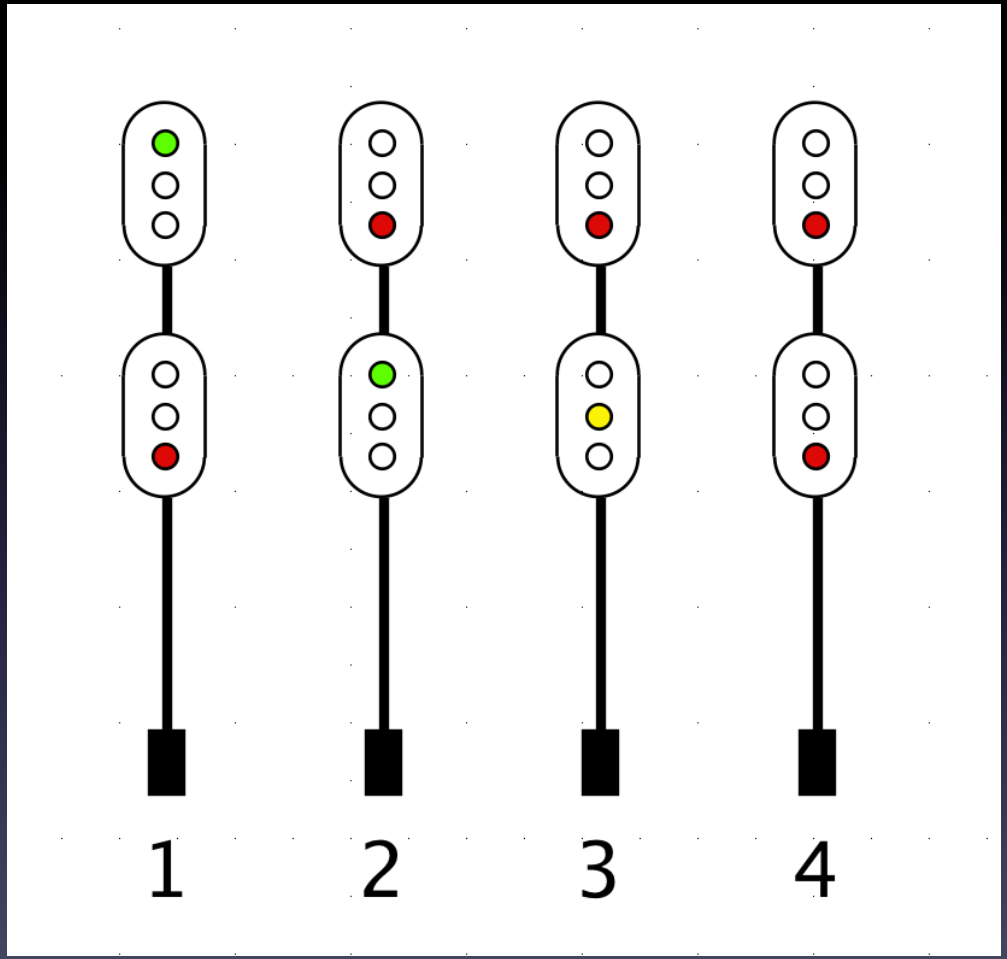
DTC Speed Control Blocks



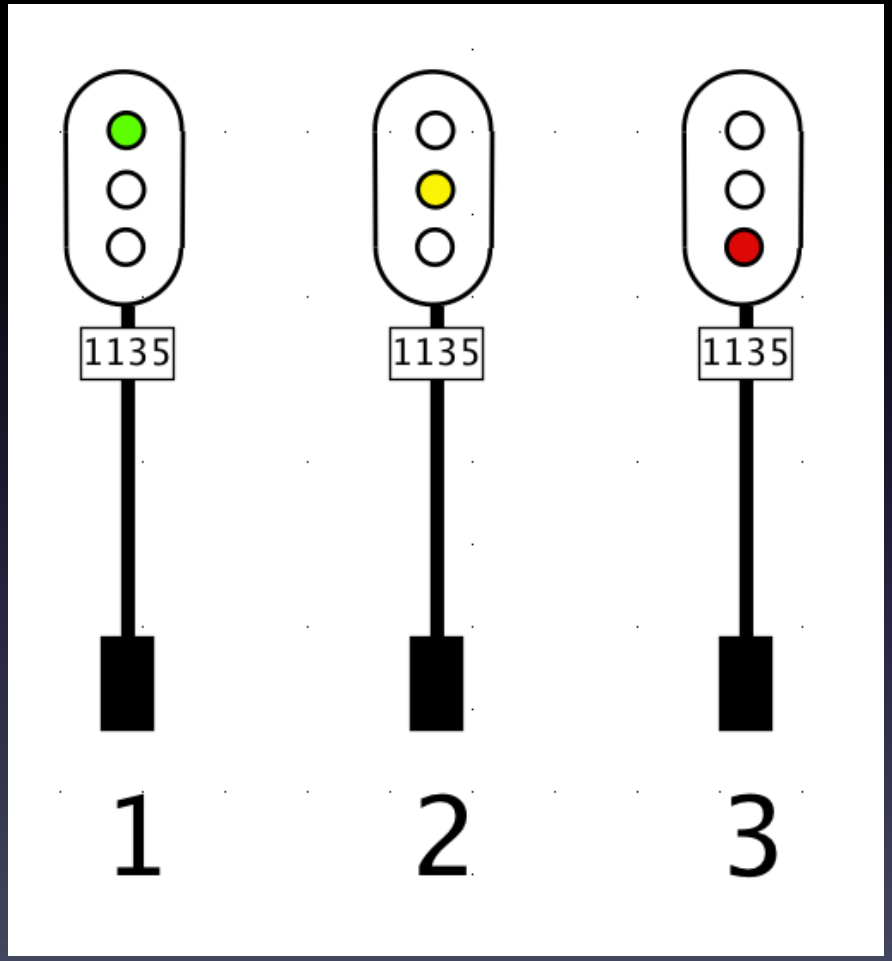
Beta Signal Bridges on Layout



Final Exam Part 1



Final Exam Part 2



Wrap up Questions