Signal Aspects & Indications for Modelers

NMRA James River Division Meet
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Presented by John Vogler

- **Overview**
  - Pick up after "What's a Railroad Signal?"
  - Quick review of basics
  - ASPECTS
  - INDICATIONS
  - A few FRA rules
  - Design a chart of signal aspects and indications
  - Design 4 different applications of signals to your railroad
  - Presenter's background
- **Who am I?**
  - Model Railroader (with breaks) since 1950s; member of JRD since 2018
  - Licensed Professional Engineer
  - Retired railroad signal engineer
    - 38 years' experience; retired twice:
    - 2006: Chief Engineer Communications & Signals for NJ Transit
    - 2014: Senior Director of Signal Maintenance & Compliance for Amtrak
  - Broad background in various railroads' signal systems
  - Member of various professional associations including AREMA, IEEE Standards Association CBTC Working Group, APTA Signal Training Working Group, AAR's & FRA's PTC Working Groups, and the Eastern Signal Engineers
  - First-hand exposure at Conrail, NJT, Amtrak, and while working for supplier US&S
    - These are the systems on which I remember working or analyzing issues: PRR, NYC, RDG, CNJ, LV, L&HR, Erie, DL&W,, E-L, EJ&E, WMATA, MARTA, MUNI, BART, CALTRAIN, SP, BNSF, NJT, Amtrak, NH, NYCTA, CN, CP, NS, CSX, B&LE, Union, CR, SEPTA, MNCRR, LIRR, PATH
      - Each property *seemed* to have "unique" systems
      - All shared common elements
      - Many requirements are now force of law in the FRA Signal & Train Control Rules & Regulations
  - Was qualified on NORAC rules and spent many years advising the committee chairman on signal rules.

- **Quick review: What's a Signal Anyway?**
  - Definition: Webster (3): something (such as a sound, gesture, or object) that conveys notice or warning
  - NORAC rulebook:
  - BLOCK SIGNAL: A fixed signal displayed to trains at the entrance of a block to govern use of that block.
  - AUTOMATIC BLOCK SIGNAL: A block signal that is activated either by track circuit or in conjunction with interlocking or controlled point circuits. This block signal automatically indicates track condition and block occupancy
  - INTERLOCKING SIGNALS: The fixed signals of an interlocking.
- Review continued
  - Prototype "history" and need
  - Line of sight vs spacing and stopping distance; opposing traffic
  - Manual block requires communication and authority from "other" end.
  - Some systems used track circuits through the block, too—more later.
  - Works well for light traffic densities and/or scheduled operation
  - Modern equivalent eliminates need for block operators. Authority delivered/repeated directly to train crew.

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- Review continued
  - Protection at junctions
  - Safety requires Interlockings
  - Manual vs. remote control (CTC)
  - Automatic block signaling (ABS): increased traffic density and efficiency
  - Invention of track circuit made this practical
  - Signals are spaced and configured to adequately warn trains stopping distance away
  - Traffic-control circuitry implemented in the automatic block signal system allowed bi-directional traffic on single-track segments of railroad; modern systems use the rails themselves as the communications medium as well as the detection circuit

- **Aspects vs Indications**
  - What you see vs what it means
  - Rulebooks including NORAC & GCOR
  - Definitions similar; here's how to remember:
  - **ASPECT**: the way a signal ***appears*** to ***approaching*** trains
  - **INDICATION**: ***interprets*** the aspect and provides ***instruction*** on what to do when an aspect is seen

- **What Basic Indications do we need?**
  - Of course STOP. There's a hazardous condition ahead or a need to keep a train from proceeding
  - Go ahead looking out for a restriction (maybe broken rail, open switch, following another train)
  - Approach the next signal prepared to stop
  - Approach the next signal at some reduced speed
  - Proceed at maximum authorized speed; no restrictions within stopping distance
  - These are basics. Let's name them and put them in a chart:

- **What Basic Aspects do we need?**
  - Signal ASPECTS communicate the INDICATIONS (instructions) to the train
  - Caveat: These are either pre- or supplemental to Positive Train Control. (Most PTC is overlaid on top of a wayside signal system and brings that information directly to the operating cab of the locomotive)
  - FRA Rules require that:
  - ASPECTS shall be shown by the position of semaphore blades, color of lights, position of lights, flashing of lights, or any combination thereof.
  - Fundamental INDICATIONS of signal aspects shall conform to the following:
  - A red light, a series of horizontal lights, or a semaphore blade in a horizontal position shall be used to indicate STOP.
  - A yellow light, a lunar light, or a series of lights or a semaphore blade in the upper or lower quadrant at an angle of approximately 45 degrees to the vertical shall be used to indicate that speed is be restricted and stop may be required.
  - A green light, a series of vertical lights, or a semaphore blade in a vertical position in the upper quadrant or 60 or 90 degrees in the lower quadrant shall be used to indicate proceed at authorized speed.

- **How do we show basic aspects?**
  - Drawing symbols:
  - Start with mast
  - Use a upper-quadrant semaphore blade to represent any of the 3 possibilities required
  - Add the possible signals to the mast
  - Add any qualifications: flashing, markers, numbers, normal "position"

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- **Build a simple 2-block signal system**
  - We previously talked about blocks as sections of track
  - Our blocks are stopping distance long
  - Signals will be located at the entrance to the blocks, making them stopping distance apart.
- **Build a 3-block system**
  - Blocks are shorter than stopping distance
  - 2 blocks are at least stopping distance apart
  - Additional aspect is needed: approach the second signal prepared to stop
- **Add a diverging route**
  - Blocks are stopping distance
  - Reuse aspect: Approach Medium (diverging)
  - New Diverging aspects are needed:
  - Add a "head"?
  - Continue to use the top one for normal route
  - Bottom for diverging route
  - This generates 4 new aspects to add to chart:
  - "Diverging" stop
  - "Diverging" approach
  - "Diverging" approach diverging
  - "Diverging" clear

- **Basic Diverging Route Signals**
- **Allow for movements toward a restriction**
- **Dwarf signals**
  - Either on the ground or on very short masts
  - Intended for short-range visibility
  - Usually without a background
  - Different optical system than a high signal
  - Indications are *usually* only for slow speed moves, following similar pattern as high signals (B&O CPL does not distinguish)
  - High signals can be configured for slow-speed aspects by adding another (3rd) head

- **This is the basis of all signal systems**
  - Differing rulebooks call them different things, but all basically are the same
  - Eastern US roads today favor speed signaling where each aspect is associated with a particular track speed (the way it's shown on our chart)
  - Western roads (and particularly E-L, C&O, NKP and others in that group) used the "diverging" rule
    - Required the train crew to know the diverging speeds at the particular location.
    - More burden on the crew, but simplifies the signal rules and design

- **Variations and similarities of prototype**
  - Semaphores
    - Day aspect by blade position
    - Night aspect by a dim lamp, usually without a good optical system
    - Cannot do "flashing" aspects
- Variations and similarities of prototypes (2)
  - Color light
    - Multi-unit (typically 2 or 3 colors) in vertical or triangular configuration in each head
    - Least complex and most cost-effective
    - Each unit has its own optical system (colored internal lens, and high-powered Fresnel clear outer lens--standard is 8 3/8" diameter)

    - Only 1 lamp unit in each head is lit simultaneously
    - Heads are spaced on mast to provide good "legibility" of the signal from a great distance
    - LEDs replacing colored lenses where light-out detection is not a factor
        - Better color saturation
        - Long life=less maintenance/expense
        - Extraordinary lumens/watt important at remote locations where power availability is limited
- Variations and similarities of prototypes (3)
    - Searchlight (*photo from title page)*
        - Widely used into the 1950s and many are still in use
        - "Mechanism" similar to a vital signal relay moves a colored disk in front of the lamp to change colors
        - Only 1 small lamp and a very powerful optical system is necessary per head
        - Could be directly controlled over pole line circuitry, eliminating additional relays
        - Two very big disadvantages:
            - Mechanism requires periodic inspection and testing for safety
            - The background around the lens is known as a "target" for good reason
                - Especially in rural areas, common to be shot out
                - This can potentially result in an extremely hazardous condition if the mechanism gets jammed displaying the wrong color

- **Full Aspect & Indication Chart**

- **CPL Aspect Chart**

- **Model Needs vs Effect**
    - By balancing complexity vs appearance we only need the 8 signal aspects we developed today
    - Dwarf aspects can be similarly employed, or simply give a red for stop and yellow for restricting
    - These aspects can give a very realistic array of meaningful animation providing train crews with some real operating information
    - The logic to control the signals is a topic in and of itself! It can be deduced from the simple designs presented
    - Several good examples are in service in the area [i.e. Bob Burke, Bob Macionis, Bob Rodriguez, and soon Rick (NOT A BOB!!) Lull]