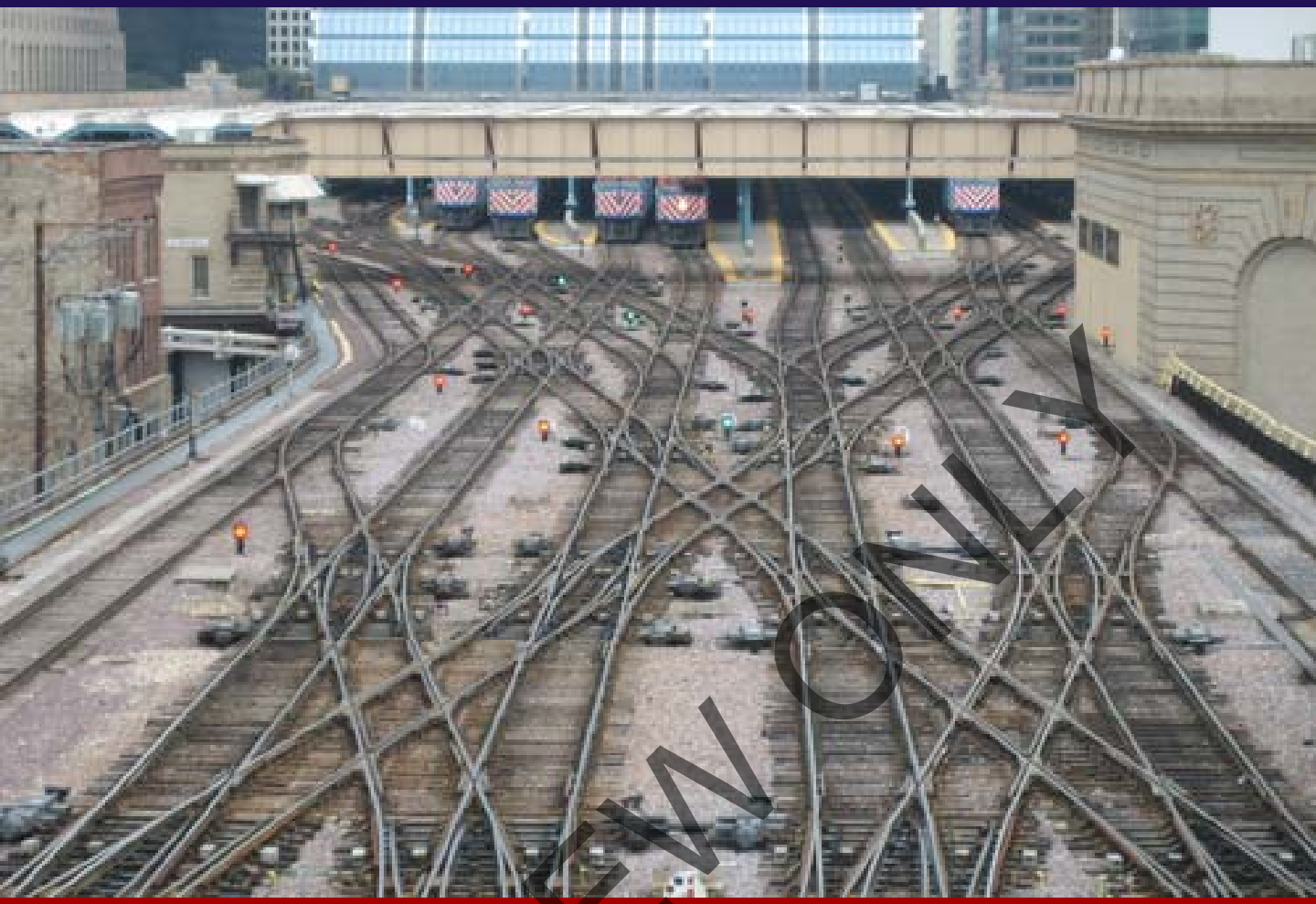

# Introduction and Overview to Interlockings

## Course 106

PARTICIPANT GUIDE

SIGNALS TRAINING CONSORTIUM

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# LIST OF FIGURES

# Module 1

## *OVERVIEW OF INTERLOCKINGS*

### Outline



### Purpose and Objectives

The purpose of this module is to provide the participants with an introduction to rail interlockings. This introduction will include basic interlocking terminology and regulations, as well as the purpose and function of different types of interlockings and their operation in rail signaling.

Following the completion of this module, the participant should be able to complete the exercises with an accuracy of 70% or greater:

- Define interlocking
- Define basic interlocking terminology
- Identify the applicable FRA and agency-specific standards related to interlockings
- Describe FRA and agency-specific interlocking-related safety guidelines
- Describe theory of operation and purpose of interlocking
- Describe different types of interlockings
- Describe how signal apparatus interacts in an interlocking system

***Figure 1.1 Tower and Tracks at Deval Interlocking, Des Plaines, Illinois 1993***

To see the early days of railroad interlocking and the evolution of interlockings, watch the video below.

Watch **Video 1.1 the Historical Development of Interlockings**.
(https://www.youtube.com/watch?v=3Sow8O1_ZNA )
[*Note: Begin the video at 6:33 and stop at 8:03*]

**Interlocking Principles**

Interlockings consist of signals and usually include additional **appliances** also known as *apparatus* such as switches and derails, and may include railroad grade crossings and movable bridges. Some of the fundamental design principles of an interlocking include:

- Signals may not be operated to permit conflicting train movements to take place at the same time.
- Switches and other appliances in the route must be in the proper position before a signal may be displayed to allow train movements to enter that route.
- Once a route is lined and a train is given a signal to proceed over that route, all switches and other movable appliances in the route are locked in position until either:
  - The train passes out of the portion of the route affected, or
  - The signal to proceed is cancelled or restored to stop, and sufficient time has passed to ensure that a train approaching that signal has had opportunity to come to a stop before passing the signal.

This module will explore modern interlockings, specifically those installed since the late 1980s, including the purpose, principles and basic design of an interlocking. It will also review regulations and standards specific to interlockings; provide basic interlocking terminology and nomenclature. This module will focus on various types of interlockings and their related apparatus.

## 1-2 BASIC TERMINOLOGY

The following are basic interlocking terms and definitions per AREMA standards.

**Interlocking**
An arrangement of signals and signal appliances so interconnected that their movements must succeed each other in proper sequence and for which interlocking rules are in effect. It may be operated manually or automatically.

- **Automatic -** An arrangement of signals, with or without other signal appliances, which functions through the exercise of inherent powers as distinguished from those whose functions are controlled manually, and which are so interconnected by means of electric circuits that their movements must succeed each other in proper sequence, train movements over all routes being governed by signal indication.
- **Manual -** An arrangement of signals and signal appliances operated from an interlocking machine and so interconnected by means of mechanical and/or electric locking that their movements must succeed each other in proper sequence, train movements over all routes being governed by signal indication.

**Interlocking Limits -** The tracks between the extreme opposing home signals of an interlocking

**Interlocking Machine** (Historical)
- Electric - An interlocking machine for the control of electrically operated functions.
- Electro-mechanical - An interlocking machine for the control of both power and mechanically operated functions.
- Electro-pneumatic - An interlocking machine for the control of electro-pneumatically operated functions.
- Mechanical - An interlocking machine for the control of mechanically operated functions.
- Table - An interlocking machine for the control of power-operated functions and designed for mounting on a table or desk

**Interlocking Relay -** A relay having two independent magnetic circuits with their respective armatures so arranged that the energization of either armature insures that the opposite armature cannot be in an energized position.

**Interlocking Signals -**The fixed signals of an interlocking (Standard Code)

**Intermittent Control** (Cab Signal, Train Control, etc.) - A type of control in which the locomotive apparatus is affected only at certain designated points, usually at signal locations

**Interlocked Switch -** A track switch within the interlocking limits, the control of which is interlocked with other functions of the interlocking

**Moveable Bridges -** Moveable bridges (Figure 1.2) are protected by interlockings; these interlockings may also include power switches and power derails. The bridges are interlocked with

the signal system such that the bridge may not be opened until: 1) all signals are at STOP; 2) approach or time locking is released; and 3) interlocking track circuits are unoccupied. Once the bridge has closed, in order to display a signal to proceed over the moveable bridge, the rails must be properly aligned and the bridge must be locked in place.



***Figure 1.2 Moveable Bridge***

**Plant** - An assembly of switch and signal appliances is generally referred to as a **plant.** Plants are called electric, electro-pneumatic, or mechanical, not because of the manner in which the interlocking is accomplished, but according to the method of operating and controlling the various switches and signal devices.

# Module 2

## *INTERLOCKING TERMS & CONCEPTS*

### Outline



### Purpose and Objectives

The purpose of this module is to provide the participant with an overview of interlocking specific nomenclature, basic routing and traffic control.

Following the completion of this module, the participant should be able to complete the exercises with an accuracy of 70% or greater:

- List nomenclature specific to interlockings
- Describe basic routing processing
- Define interlocking relays
- Identify the interlocking relay logic and their functionality on the locking process on associated diagrams

### Key Terms

- Approach locking
- Automatic train operation (ATO)
- Detector locking
- In advance of
- In rear of
- In approach
- Indication locking
- Locked up
- Relay locking
- Remote access terminal (RAT)
- Route locking
- Route check (RC)
- Switch indication locking
- Switch correspondence (WC)
- Time locking
- Traffic line circuit
- Traffic locking
- Traffic rectifier
- Traffic stick circuit

## 2-1 OVERVIEW

As explained in module one of this course, interlockings are used to control train movement over switches in many directions. They are designed to prevent conflicting or unsafe train movement. They are installed where multiple routes are possible, usually where there are multiple tracks and switches, or rail crossings. They are also installed where trains must not be allowed to proceed under certain conditions, such as at moveable bridges. This module focuses on nomenclature specific to interlockings and reviews basics routing concepts and traffic control. Much of the information presented here can be found in the publication, *Introduction to North American Railway Signaling*.

Be reminded that various rail agencies use different terminology and various interlocking procedures. As always refer to your agency's specific guidelines and regulations.

**Follow Agency Specific Guidelines!**

Always refer to your organization for specific guidelines and regulations.

## 2-2 INTERLOCKING SPECIFIC NOMENCLATURE

There is specific nomenclature with regard to interlockings. Table 2.1 Nomenclature for Operating Units Related to Interlocking lists items according to AREMA and provides space to include differences and information specific to your rail authority.

***Table 2.1 Nomenclature for Operating Units Related to Interlocking (*Source: AREMA Volume 4, Section 16.1.1 pages 12-17)***

| Item* | Abbreviation | | Notes |
|---|---|---|---|
| | AREMA* | Your Location | |
| Eastward interlocking of crossing relay, likewise north, | EXR | | |
| Electric light operating relay (flasher relay). | EOR | | |
| East (Directional) Stick Relay | ESR | | |
| West (Directional) Stick Relay | WSR | | |
| North (Directional) Stick Relay | NSR | | |
| South (Directional) Stick Relay | SSR | | |
| Route Check Relay | RCR | | |
| Normal Switch Correspondence Relay | NWCR | | |
| Reverse Switch Correspondence Relay | RWCR | | |
| Normal Switch Correspondence Repeater Relay | NWCPR | | |
| Reverse Switch Correspondence Repeater Relay | RWCPR | | |
| A Signal Home Relay | AHR | | |
| B Signal Home Relay | BHR | | |
| C Signal Home Relay | CHR | | |
| A Signal Distant or Green Relay | ADR | | |
| B Signal Distant or Green Relay | BDR | | |
| B Signal Flasher Relay | BEOR | | |
| B Signal Flasher Repeater Relay | BEOPR | | |
| Lock Relay | LR | | |

***Table 2.1 Nomenclature for Operating Units Related to Interlocking (*Source: AREMA Volume 4, Section 16.1.1 pages 12-17) continued***

| Item* | Abbreviation | | Notes |
|---|---|---|---|
| | AREMA* | Your Location | |
| Lock Repeater Relay | LPR | | |
| Lock Stick Relay | LSR | | |
| Signal Request Relay | GZR | | |
| Time Element Relay | TER | | |
| Approach Stick Relay (Controls Time Locking) | ASR | | |
| Red Signal Repeater Relay | RGPR | | |
| Traffic Relay | FR | | |
| Traffic Stick Relay | FSR | | |
| Call on (Restricting) | CO | | |
| Approach Lighting Relay | AER | | |
| Loss of Shunt | LOS | | |
| Normal Switch Indication Relay | NWKR | | |
| Reverse Switch Indication Relay | RWKR | | |
| Traffic Indication Relay | FKR | | |
| Approach Relay | AR | | |
| Train Control Stick Relay | VSR | | |
| On Station (also known as Plant Circuit) | OS | | |
| Track Combination Repeater Stick | TYPS | | |

# 2-3 BASIC ROUTING CONCEPTS

Before introducing basic routing concepts view this interlocking video which demonstrates the operation of remotely controlled relay logic based interlocking. This video was produced by the Long Island Rail Road.

Watch **Video 2.1 Relay Logic Based Interlocking** to see the operation of a remotely controlled relay logic interlocking,
Video (http://youtu.be/a2bmVK-8OCk).

## Route Processing

Described below is the sequence of events in a typical interlocking control system for a route request that will result in the clearing of a route (displaying of a signal).

### Requesting a Route

A route request is a transmitted signal to the interlocking plant to initiate the route clearing process. Route requests can originate from one of several different sources: Local Control panel, Mechanical Interlocking machine, Central computer, **Remote Access Terminal (RAT), Automatic Train Operation (ATO)**, Train-to-Wayside (TWC) and Automatic Vehicle Identification (AVI). In addition, there may be a manual push button request.

For most rail agencies there are several different ways to send route requests to an interlocking via the Control Panel. One method is a route request which uses one input to request the route. A separate switch is provided for each route request. A second method of route request occurs when the position of the track switch 'determines' the entrance route and then the exit location is requested. Track switches that are in the route, but do not determine the route, do not need to be requested. The third called a NX request, which occurs when a route request is made through the Local Control Panel. In this method, the route is defined* by selecting the entrance and exit locations. (*Switch position requests are selected via non-vital relay logic.)

Other methods of requesting a route involves requests sent from a Central computer. These requests are transmitted to the microprocessor interlocking (MicroLok, VPI, VHLC, GEOLOC, etc.) over a secure network. Another method involves the Remote Access Terminal (RAT). The RAT system uses high security modems and a telephone line to communicate with the interlocking. In an Automatic Train Operation (ATO) system, the ATO generates ID cleared route requests. These are route requests that are generated when ATO decodes a train's ID and generates a route request based on the train's destination code which is embedded in the train's ID. In addition, some agencies use an AVI or TWC loop selection to request a route, sometimes in combination with automatic routing functionality that utilizes track circuit detection in combination with Route IDs to request routes for trains that are in approach to the interlocking. Finally, in some rail agencies, an interlocking can generate its own route requests. An Approach Cleared route request can be generated when the train occupies the entrance approach zone. This type of route request is used for double routes where there are no switches in the route.

# Module 3

## *INTERLOCKINGS & RELAY LOGIC*

### Outline



### Purpose and Objectives

The purpose of this module is to provide the participant with an overview of functions and types of locking along with associated prints and a review of the basics of establishing routes.

Following the completion of this module, the participant should be able to complete the exercises with an accuracy of 70% or greater:

- Define locking
- Describe different types of locking circuits and their function
    - Switch Indication
    - Traffic
    - Signal Indication
    - Route
    - Detector
    - Approach
    - Time
- Identify types of locking on a given print design/layout and their main purpose
- Differentiate between single and universal interlockings
- Describe signal control circuits and the basic circuits used in an interlocking when requesting routes

### Key Terms

- Approach locking
- Approach-locking relay
- Detector locking
- Indication locking
- Locking
- Route locking
- Route check
- Route check relay (RCR)
- Signal indication locking
- Single switch interlocking
- Switch indication locking
- Time locking
- Traffic locking
- Universal interlocking

# 3-1 OVERVIEW

A key element to interlocking logic is "locking". There are different types of **locking** utilized in connection with interlocking plants and other types of signaling systems, each type having a definite purpose. This module will focus on the function of the following types of electric locking circuits listed below. Below are some general descriptions of locking terms.

**Indication Locking** – Prevents manipulation of levers that would result in an unsafe condition for a train movement if a signal, switch, or other operative unit fails to make a movement corresponding to that of its controlling lever, or which directly prevents the operation of a signal, switch, or other operative unit, in case another unit which should operate first fails to make the required movement.

- **Signal indication locking** – Prevents changing the route (position of the switch points) when a home signal is clear. This is what locks the route before a train enters the interlocking.
- **Switch indication locking** – Prevents a signal from being cleared over a route with turnouts moveable point frogs, derails, etc. that are not in correspondence with requested route.

**Traffic Locking** – Electric locking which prevents the manipulation of levers or other devices for changing the direction of traffic into a section of track on which a route is lined, occupied, or locked.

**Route Locking** – Effective when a train passes a signal displaying an aspect for it to proceed, which prevents the movement of any switch, movable point frog, or derail in advance of the train within the route entered. It may be so arranged that as a train clears a track section of the route, the locking affecting that section is released (aka Sectional Route Release).

**Detector Locking** – Effective when the detector track circuit (OS) is occupied. Detector locking prevents the operation of any power operated switch, movable point frog or derail and the display of any signal indication more favorable than 'proceed at restricted speed' within the limits of the detector track circuit.

**Time Locking** – A method of locking, either mechanical or electrical, which, after a signal has been caused to display an aspect to proceed, prevents, until after the expiration of a predetermined time interval after such signal has been caused to display its most restrictive aspect, the operation of any interlocked or electrically locked switch, movable point frog, or derail in the route governed by that signal, and which prevents an aspect to proceed from being displayed for any conflicting route.

**Approach Locking** – Effective while a train is approaching, within a specified distance, a signal displaying an aspect to proceed, and which prevents, until after the expiration of a predetermined time interval after such signal has been caused to display its most restrictive aspect, the movement of any interlocked or electrically locked switch, movable point frog, or derail in the route governed by the signal, and which prevents an aspect to proceed from being displayed for any conflicting route.

This module also covers interlocking nomenclature and basic routing concepts. Note that circuit nomenclature varies from agency to agency. For example, the **approach-locking relay** is commonly called an ASR (Approach Stick Relay), but it is also known as NPSR (Normal Repeater Stick Relay). Also, prints of a single switch and universal interlockings are depicted here. While terminology and details may differ, the basic principles are the same.

Since prints, examples and terminology presented here may differ from your rail agency, always refer to your organization for specific guidelines and regulations. It may be useful to refer to the Interlocking Specific Nomenclature Table provided in *Module 2 Interlocking Terms and Concepts* of this course.

**Follow Agency Specific Guidelines!**

Always refer to your organization for specific guidelines and regulations.



## 3-2 FUNCTIONS AND TYPES OF LOCKING

### Single Switch Interlocking

A **single switch interlocking** is usually confined to a limited area, and normally will not contain extended lengths of plain track (track without switches or crossings). A single switch interlocking is depicted in the following locking prints.

## Signal Indication Locking

**Signal indication locking** is electric locking that prevents changing the route (position of the switch points) when a home signal is clear. This is what locks the route before a train enters the interlocking. When semaphore and searchlight signals were used it checked the position of all signal mechanisms; if a signal was stuck in the green or yellow position but not requested the interlocking remained locked. The Dispatcher requests a signal and the corresponding RGPR and/or ASR is de-energized.

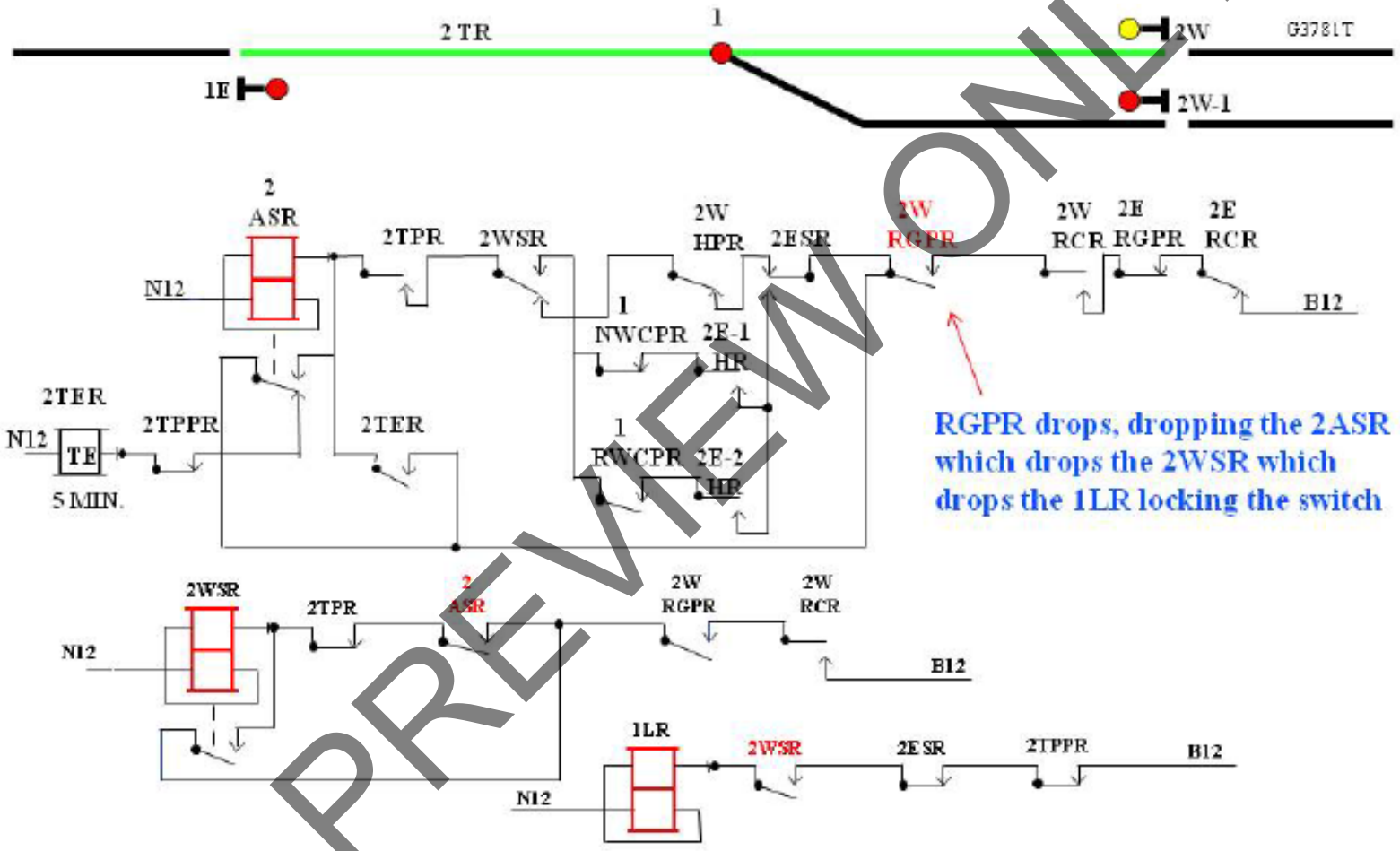


*Figure 3.1 (1 of 3) Signal Indication Locking*

Figure 3.15 is a stand-alone sample of a more complex Interlocking Route Alignment flow chart. It shows the interlocking routing processes. Each agency may approach complex interlocking route alignment differently and use different nomenclature. As always, utilize an interlocking on your property to fully detail how to establish a route and clear a signal.

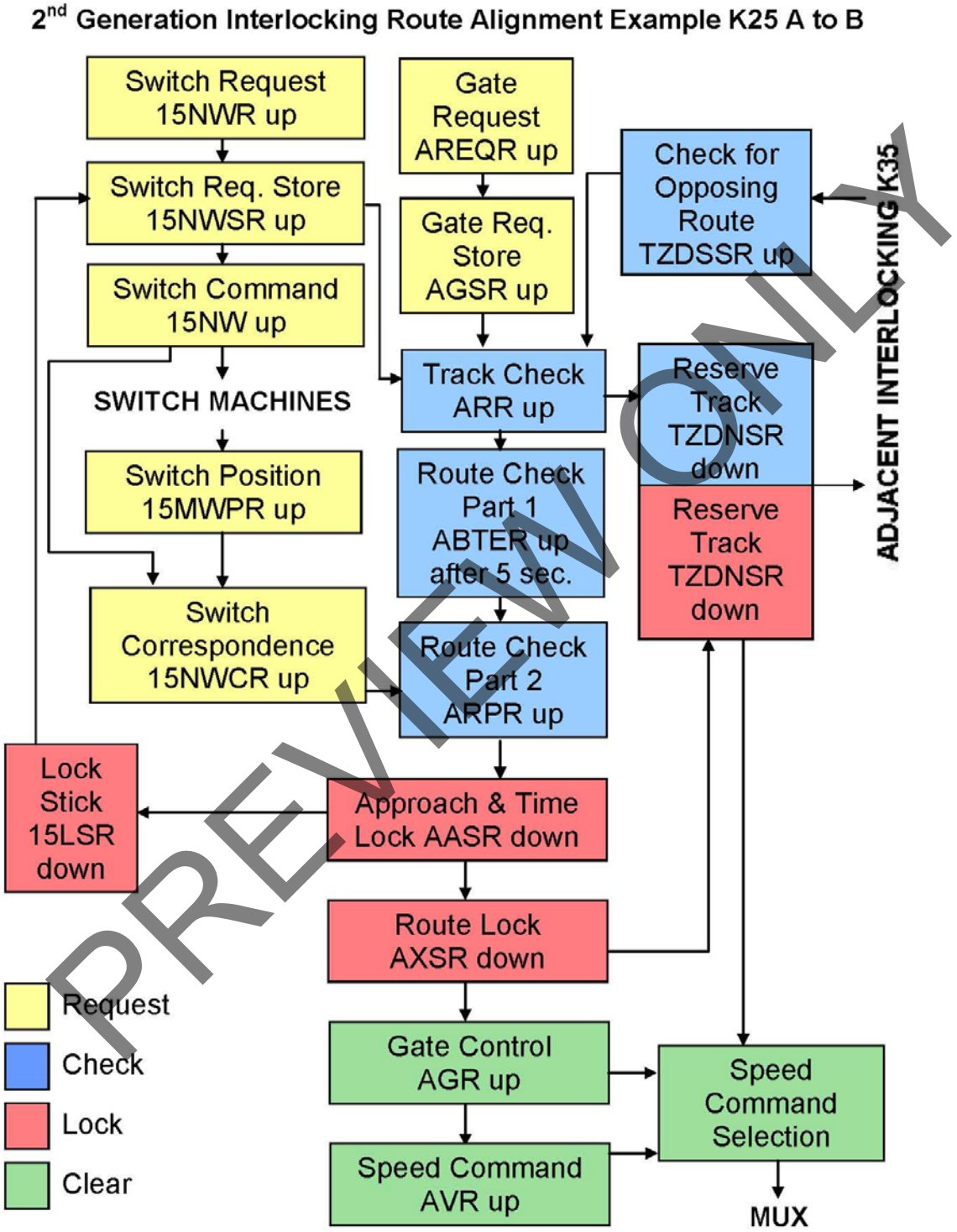


***Figure 3.15 Sample Stand-Alone Interlocking Route Alignment-Courtesy BART***

## 3-4 SUMMARY

To conclude the overview of interlockings, this module concentrated on interlockings and relay logic. Since locking is a key element to interlocking logic, the basic types of electric locking circuits and their functions for single switch interlockings was discussed. In addition, a review of a typical universal interlocking was provided. Participants were also given the opportunity to practice the basics of how to establish routes.