SIEMENS

USER'S HANDBOOK

TRAIN SENTINEL

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REVISION HISTORY

Rev.	Date	Author	Description
A	2/2011	DLW	Initial release
A.1	06/2014	TP	Change to Siemens Branding

1.0 INTRODUCTION

1.1 SCOPE

This operations guide provides a brief overview of Train Sentinel® system structure and operation.

- Section One provides an overview of the system and its architectural elements.
- Section Two describes the Human Machine Interface (HMI).
- Section Three describes system operations.
- Section Four describes external communications and interactions necessary as part of an overall train control system.

NOTE

NOTE

The contents of this document represent all possible features available with the Train Sentinel® system. Be aware that not all features may be present in the system you are using.

1.2 THE TRAIN CONTROLSOLUTION

Train Sentinel® is a non-vital component of the Train Control solution. This Positive Train Control (PTC) system is designed to provide a cost-effective, reliable and safer means to operate trains within a railroad network.

PTC consists of four system segments including locomotive equipment, the office environment, wayside devices and a communications network.

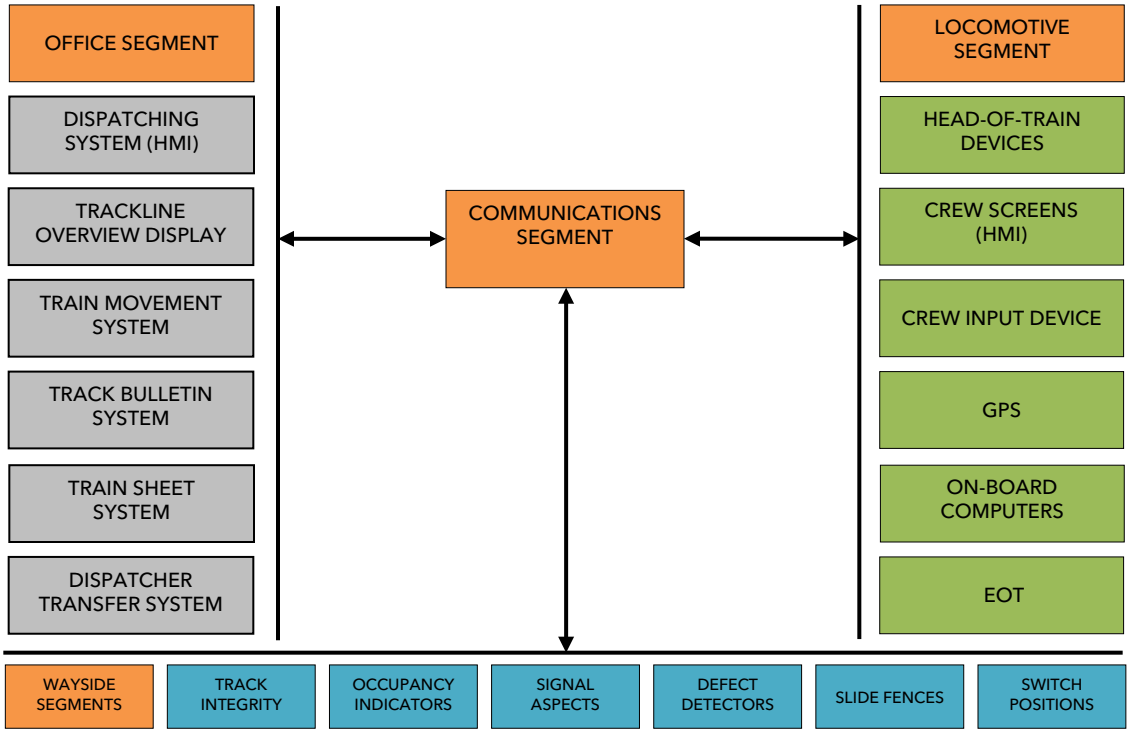

Figure 1 Train Control System Elements

The major functions performed by the Train Control system are:

- electronic delivery, monitoring and enforcement of Track Warrant;
- electronic delivery, monitoring and enforcement of Bulletins (speed restrictions);
- monitoring of wayside, including switches and signals.

The Train Control system operates as an overlay to existing railway operations. Dispatch staff plan and manage safe train movements through a Computer-Aided Dispatch (CAD) system. Electronic movement authorities are communicated to the locomotive via the communications segment. Once acknowledged by the locomotive engineer, the movement authorities are monitored and enforced by the locomotive equipment.

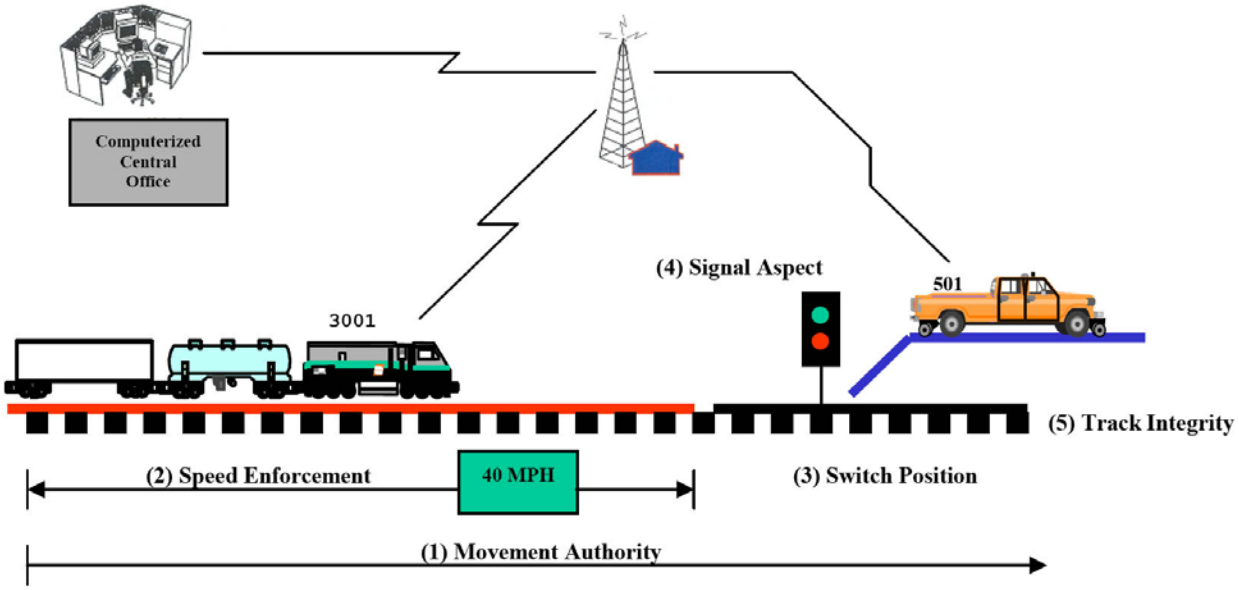

Figure 2 The Train Control System

1.3 TRAIN SENTINEL®

Train Sentinel® is the locomotive segment of the Train Control solution. Train Sentinel® uses GPS and speed sensors to locate the train relative to an on-board track database. The track database includes layout information, grades, curvature, milepost references, signal locations, speed limits, and highway crossings. Train Sentinel® equipment continuously monitors train speed and location against the speed limits and movement authorities. By predicting the train braking distance, the system warns the crew of potential safe movement violations. If no action is taken, the locomotive brakes are activated.

1.3.1 Train Sentinel® On-Board Equipment

Figure 3 on the following page illustrates a typical Train Sentinel® equipment configuration in the locomotive. The rack assembly is designed to be installed in the locomotive LSI equipment rack. The touch-screen display with integrated keypad is installed in the crew cab.

Primary Control Components		User Components
• Control Module	• Brake Interface Module	• Touch-screen Display
• Head of Train (HOT) Module	• Communications Module	• Keypad

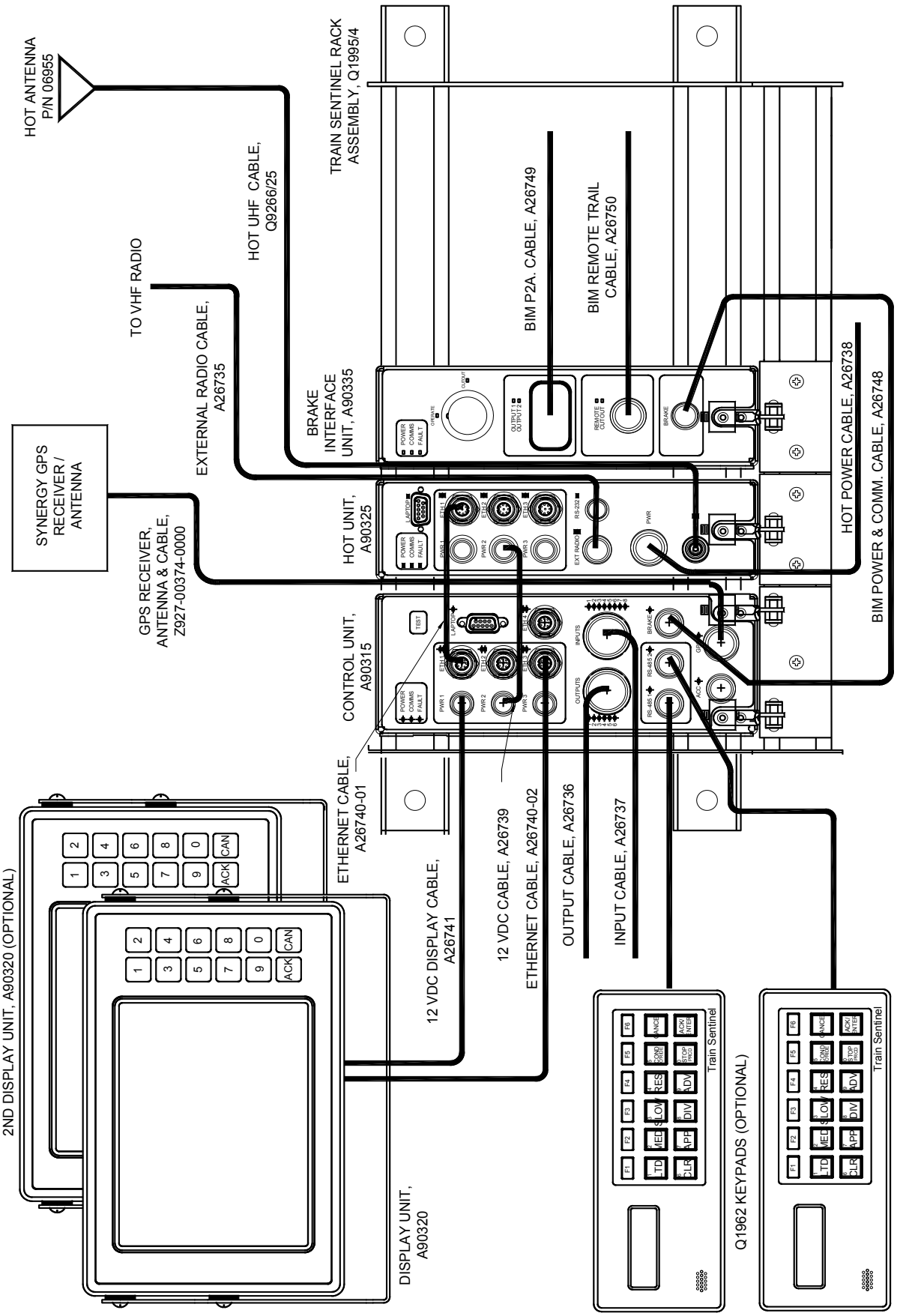

Figure 3 Typical On-Board Equipment Configuration

WARNING

THE POSSIBILITY OF A MINOR SHOCK EXISTS WHEN CONNECTING TRAIN SENTINEL® TO 74-VOLT LOCOMOTIVE BATTERY POWER.

WARNING

SPECIAL CARE NEEDS TO BE TAKEN TO ENSURE THAT 74 VDC IS NOT SHORTED TO THE PENALTY ELECTRO-MECHANICAL PNEUMATIC VALVE (e.g., P2A) PREVENTING THE TRAIN SENTINEL® SYSTEM FROM REQUESTING A PENALTY BRAKE APPLICATION. SPECIFICALLY, DO NOT ALLOW +74 VDC TO SHORT TO PIN 5 (OUT1P) AND PIN 8 (OUT2P), OR 74 VDC GND TO SHORT TO PIN 6 (OUT1N) AND PIN 7 (OUT2N) ON THE BRAKE INTERFACE UNIT OUTPUT CONNECTOR.

1.3.2 Locomotive Display

The Train Sentinel® locomotive equipment configuration includes a Human Machine Interface (HMI) for the train crew. This touch-screen display is ruggedly designed to withstand typical locomotive vibration and temperature extremes, environmental conditions such as dirt, dust, and diesel exhaust, plus it has push-button keys for operator input. The display utilizes user-friendly concepts of display flexibility and easily understood control inputs.

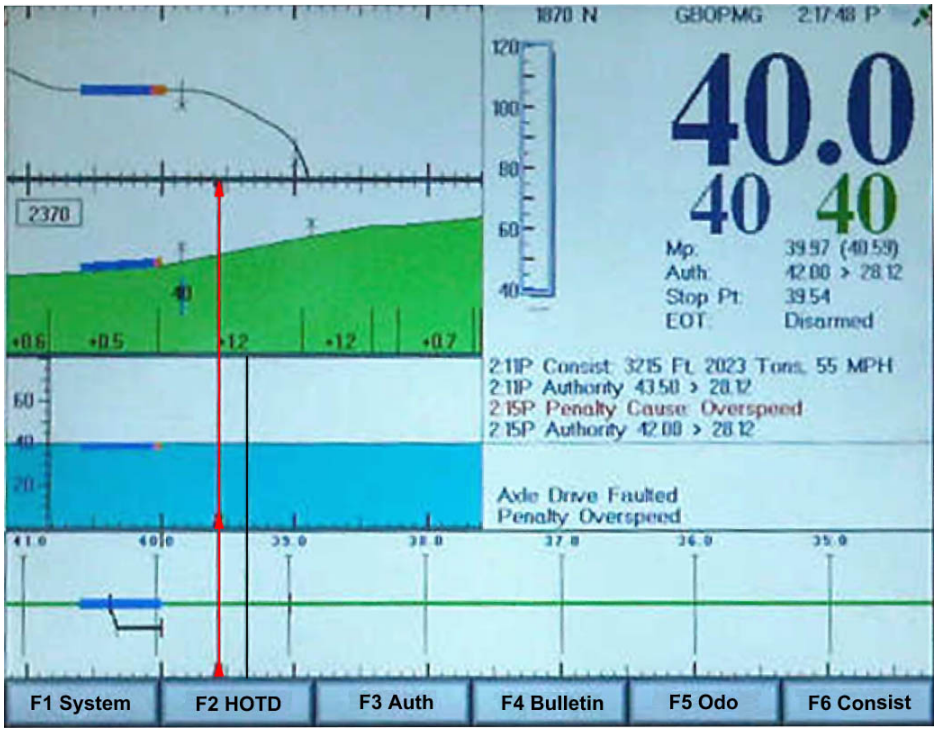

Figure 4 Typical Train Sentinel® HMI Display

The display elements are identified in paragraph 2.0 of this manual.

The HMI displays necessary operating information to the crew including train status, commands, consist information, authorities, restrictions, and topographic information. The display has a sub-screen to indicate the status of the GPS system, the current status of the locomotive/train speed coupled with a track warrant pictorial showing where the locomotive/train is in relation to existing speed and authority limits. Displays are presented in both text and graphics. The display shows the relative stopping distance, in feet, from the present location to the stopping point based on the relative deceleration. An audible warning is contained within the display assembly to alert the operator should the train approach the authority limit or attempt to exceed the boundary condition of the brake/stopping profile.

1.3.3 Train Integrity Monitoring

Train integrity is monitored by an end of train (EOT) device, which monitors the brake pipe pressure and GPS position of the end of the train. The EOT communicates with the Train Sentinel® Head of Train (HOT) module via a VHF radio. Separation of train consist is determined by loss of radio or inconsistency of reported information. Train integrity status is reported to the locomotive crew.

1.3.4 System Failure and Cut-Out

If any failure compromises safe operation, locomotive operation is halted through penalty brake application and a message is sent to the dispatcher giving notification of the event. Train Sentinel® will continue to operate under loss of communication until the limit of current authority is reached.

The engineer may take manual control of the locomotive by activation of the cut-out switch on the Brake Interface Module. However, when the engineer does so, a message is transmitted to the dispatcher advising that a manual locomotive is operating within the Train Sentinel® equipped subdivision. The “failed and/or cut out” locomotive is uniquely identified to the dispatcher via the dispatch system. The locomotive engineer will be required to contact the dispatcher for approval to cut out PTC because some failures may be of a nature that when cut out, no transmission will occur.

To Cutout the system the railroad personnel can do any of the following procedures:

1. Move the switch on the Brake Interface Module to the “CUTOUT” position,
2. Press F1 System -> F4 Cutout using the function keys either on the keypad or LCD display, or
3. Activating the Cutout input on the Control Module.

For trailing locomotives that include the Train Sentinel® system, a Trail Mode is used. Trail Mode is entered when the Equalizing Reservoir input on the Control Module activates signifying that the Equalizing Reservoir pressure is low. Trail Mode is similar to Cutout mode in that the system will remove any loaded Movement Authorities and send a message to the dispatcher giving notification of the event.

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SECTION TWO – HUMAN MACHINE INTERFACE (HMI)

2.0 TRAIN SENTINEL® HUMAN MACHINE INTERFACE (HMI)

The touch-screen display is the Human Machine Interface (HMI) for the Train Sentinel® system. This interface provides an electronic form of communication between the CAD-ACT and the train crew. The HMI digitally displays information without the need for verbal communications. This process ensures proper compliance to movement instructions as well as provides additional information to the train crews while in route. The various message types are 1) operational, 2) informational, and 3) train crew acknowledgements.

The following paragraphs describe the various display elements and the menu structures associated with the six function keys located at the bottom of the display.

2.1 TOUCH-SCREEN DISPLAY ELEMENTS

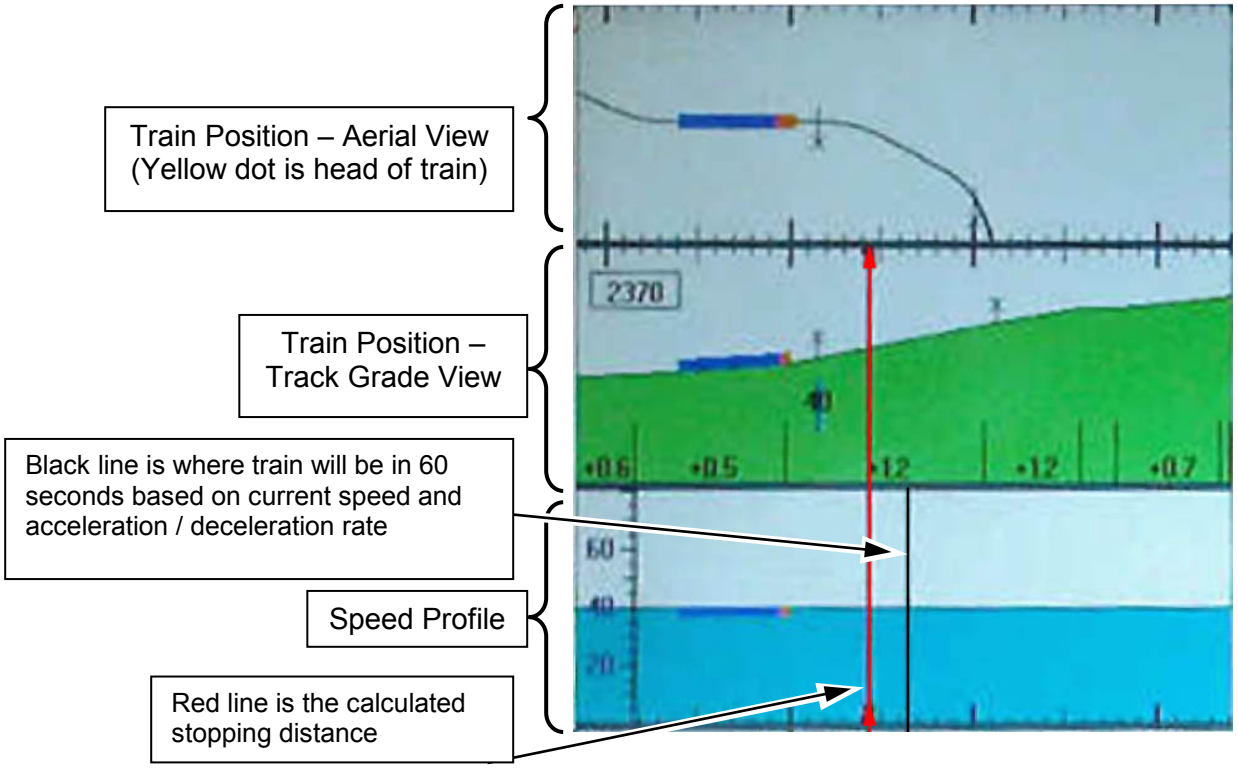
The Train Sentinel® display is divided into three main areas:

- Upper left is graphic display of train location, wayside devices, and train speed and braking information.
- Upper right is digital display of dynamic train information and message tracking.
- Lower portion is track layout view showing train location by milepost.

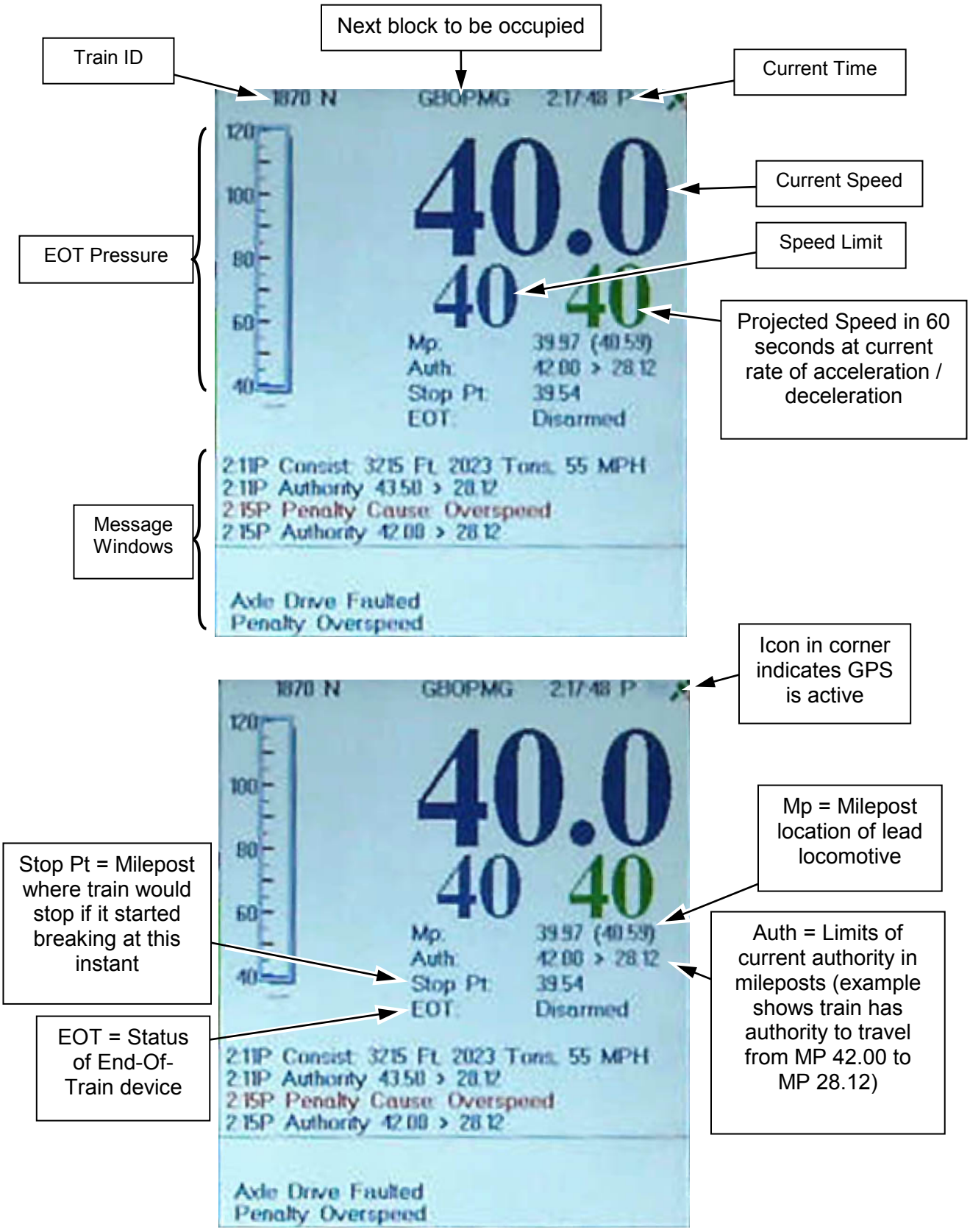
Detailed descriptions of the data presented in each area are provided in the following figures.

2.1.1 Upper Left Display Area

The train position on this display area remains constant while the track layout and grade displays move from right to left to indicate train motion.

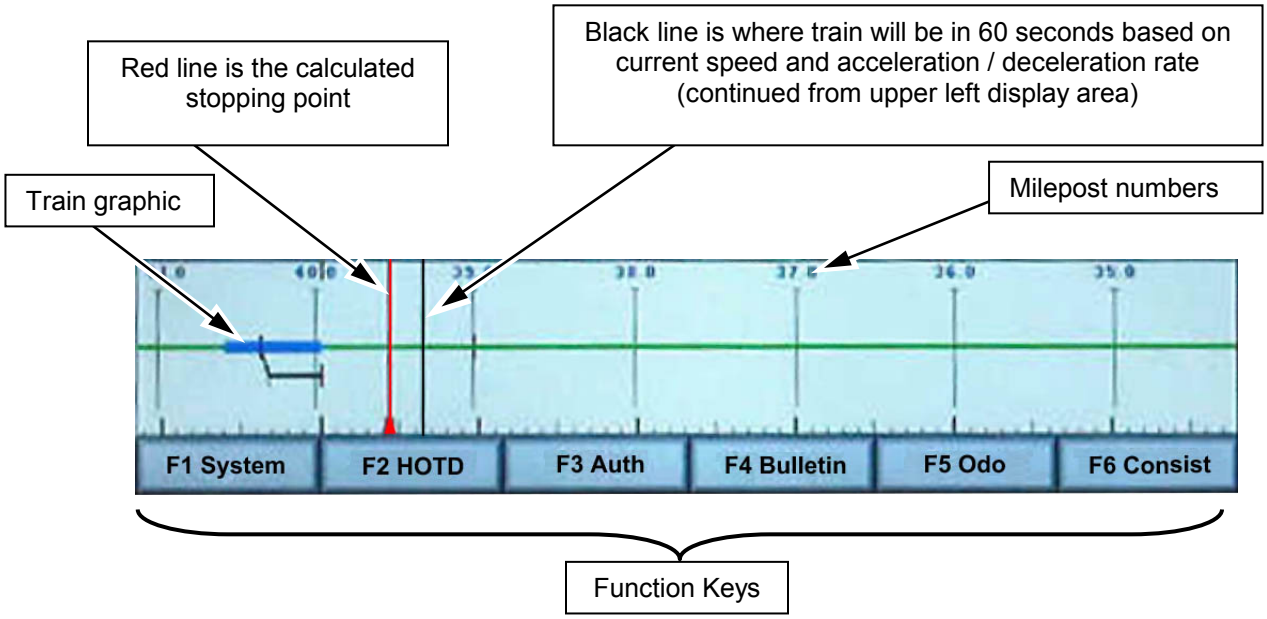


2.1.2 Upper Right Display



2.1.3 Lower Track Layout Display Area

The train position on this display area remains constant while the track layout and milepost numbers move from right to left to indicate train motion. This motion is in sync with the display motion in the upper left display area.



When a message such as a movement authority is received from the dispatch center, it is displayed over the top of the visual display to inform the train crew of operational changes or notifications (see example below).

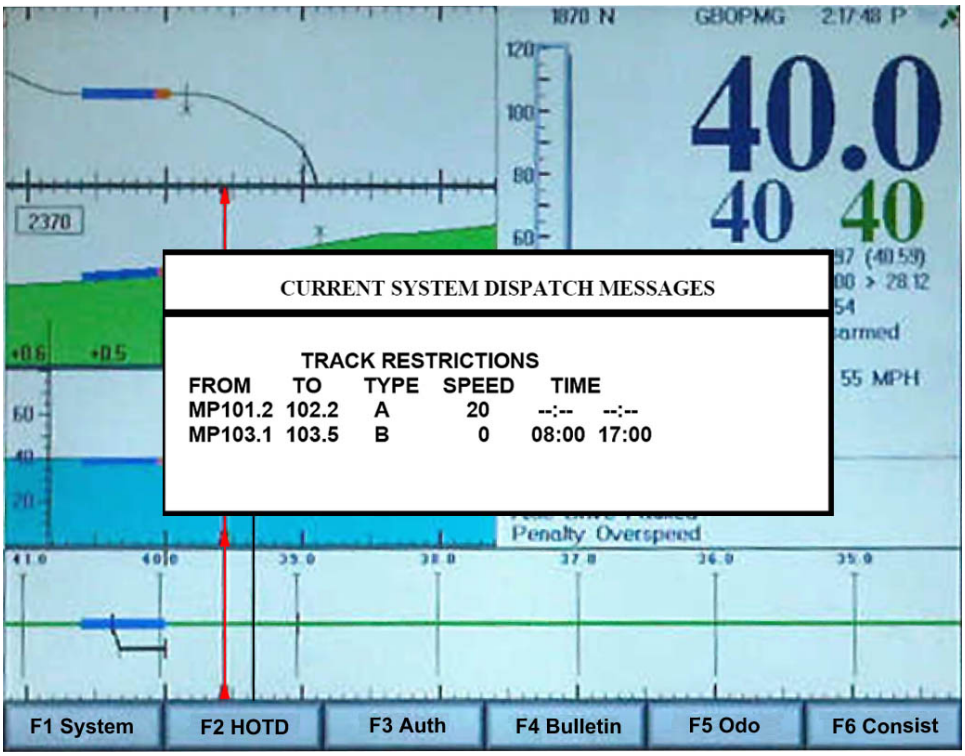


Figure 5 Typical Movement Authority Window

2.2 FUNCTION KEY HIERARCHY

Each of the function keys at the bottom of the Train Sentinel ® touch-screen display provides access to an additional set of function keys. The menu hierarchy for each function key is diagramed in the following tables. Figure 6 is a graphic representation of the menu hierarchy for function button **F1 System**. The hierarchy for each of the other function buttons follows a similar pattern.

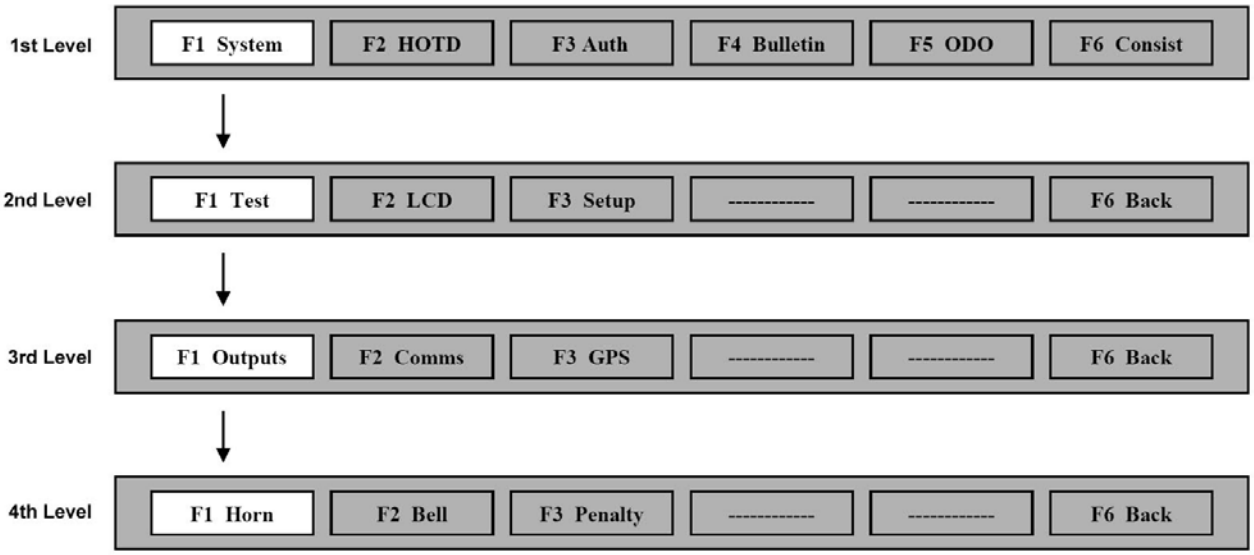


Figure 6 Button Hierarchy for Function Button F1 System

Table 1 Menu Hierarchy for Function Button "F1 System"

1st Level Key Label	2nd Level Key labels	3rd Level Key labels	4th Level Key Labels	Options	Comments
F1 System					
	F1 Test				
		F1 Outputs			
			F1 Horn		Test horn output (run sequence)
			F2 Bell		Test bell output (toggle)
			F3 Penalty		Test P2A valve

			F4 Back		
		F2 Comms			
			F1 HOTD		
				1200	Transmit 1200 Hz tone
				1800	Transmit 1800 Hz tone
				Emer	Send Emergency Dump command
				Off	Turn off all tests

				Back	
			F2 RF Test		CAD-ACT dispatch RF test

1st Level Key Label	2nd Level Key labels	3rd Level Key labels	4th Level Key Labels	Options	Comments
			F6 Back		
		F3 GPS			View GPS status
		F4 Depart			
		F5 Send Err			
		F6 Back			
	F2 Display				
		F1 Backlight			Adjust backlight level
		F2 Contrast			Adjust contrast
		F3 Scale			Set display scale
		F4 Reverse			

		F6 Back			
	F3 Setup				
		F1 Time			Adjust display time units
		F2 Zone			Set current time zone
		F3 Loco			

		F5 USB			
			F1 To USB		
				F1 Logs	

				F6 Back	
			F2 FromUSB		
				F1 Images	• **F1 Loadimages,** • **F2 Write2Flash,** • **F3 ResetSystem** • **F6 Back**
				F2 Database	
				F3 Config	

				F6 Back	
			F3 FormatUSB		

			F6 Back		
		F6 Back			
	F4 Cutout				
	F5 Send Now				
	F6 Back				

Table 2 Menu Hierarchy for Function Button "F2 HOTD"

1st Level Key Label	2nd Level Key labels	Comments
F2 HOTD		

Table 3 Menu Hierarchy for Function Button "F3 Auth"

1st Level Key Label	2nd Level Key labels	3rd Level Key labels	Comments
F3 Auth			
	F1 List		
	F2 Request		
		F1 Enter	Request to enter controlled track
		F2 Exit	Request to operate manually (exit)
		F3 Chg Lead	Request Lead Locomotive Change
		F4 Read Bk	
		F5 Clear	
		F6 Back	
	F3 OS Clear		
	F4 Cancel		
		F1 W/B	

		F6 Back	
	F5 Select		
		F1 Position	
		F2 EOT Pos	

		F5 Working	
		F6 Back	
	F6 Back		

Table 4 Menu Hierarchy for Function Button "F4 Bulletin"

1st Level Key Label	2nd Level Key labels	Comments
F4 Bulletin		
	F1 Form B	Permission to enter Form B received
	F2 L Car	Cancel (last car clear)
	F3 List	List all in advance

	F6 Back	

Table 5 Menu Hierarchy for Function Button "F5 Odo"

1st Level Key Label	2nd Level Key labels	Comments
F4 Obo		
	F1Count +	
	F2 Count -	
	F3 Stop	

	F6 Back	

Table 6 Menu Hierarchy for Function Button "F6 Consist"

1st Level Key Label	2nd Level Key labels	Comments
F4 Consist		
	F1 Setup	Set the initial consist completely
	F2 Pickup	Picked up cars (locos)
	F3 Drop	Set aside cars (locos)

	F6 Back	

2.3 DISPLAY CONSOLE KEYPAD

The keypad adjacent to the touch-screen display contains 12 special function keys. The functions controlled by each of these keys are described below.

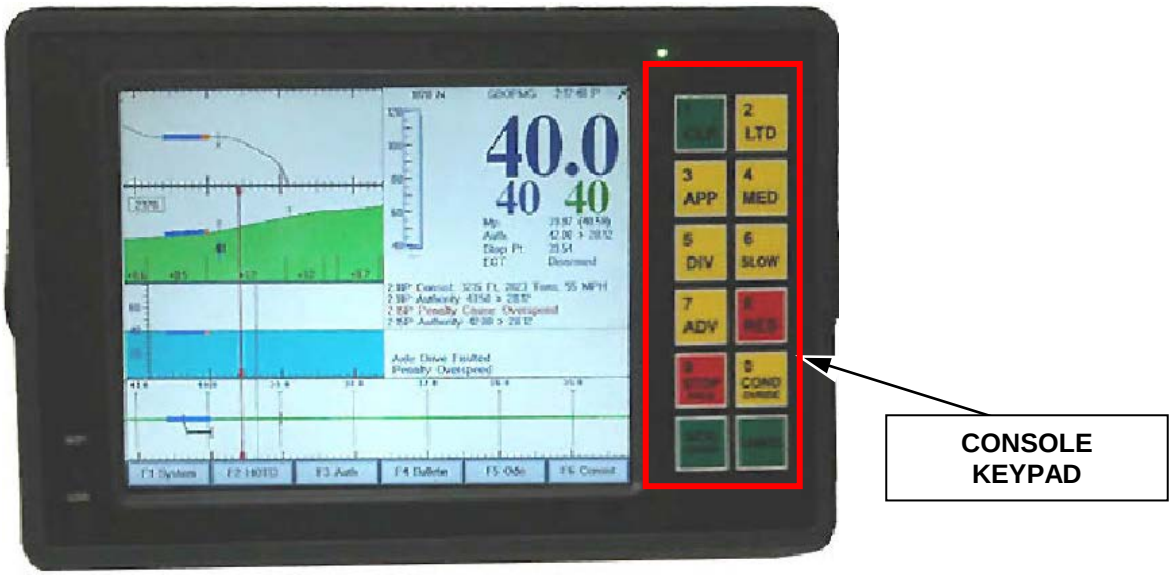


Figure 7 Display Console Keyboard

Table 7 Display Console Keypad Function

Key label	Primary Function	Secondary Function
1 / CLR	Press to enter digit 1	Clear
2 / LTD	Press to enter digit 2	Limited
3 / APP	Press to enter digit 3	Approach
4 / MED	Press to enter digit 4	Medium
5 / DIV	Press to enter digit 5	Diverge
6 / SLOW	Press to enter digit 6	Slow
7 / ADV	Press to enter digit 7	Advance
8 / RES	Press to enter digit 8	Restricted
9 / STOP PRCD	Press to enter digit 9	Stop and Proceed
0 / COND OVRIDE	Press to enter digit 0	Conditional Override
ACK	Acknowledge	Acknowledge
CANCEL	Cancel	Cancel

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SECTION THREE – OPERATIONS

3.0 OPERATIONAL DESCRIPTION

Train Sentinel® operations can be divided into major functions which are used to manage the movement of trains. The system is organized according to these major functions:

- Locomotive initialization
- Train Initialization
- Train Movements
- Speed Restrictions
- Train Termination

3.1 LOCOMOTIVE INITIALIZATION

Each Train Sentinel® equipped locomotive undergoes initialization in order to ensure that the loaded data on board is not corrupt. Once complete, the Train Sentinel® system allows the locomotive operator to execute a departure test to ensure proper system to locomotive/train operation.

3.2 TRAIN INITIALIZATION

At an original departure location, CAD—ACT provides Train Sentinel® with the necessary train composition (loads, empties, tonnage, and length) typically before the train departs. This dynamic train data is used to allocate track, as appropriate, based on the CAD—ACT movement authorities. The dynamic train data includes the following:

- Train ID
- Locomotive consist
- Car consist (quantity and types)
- Planned consist changes (adding/deleting locomotives, car pickup/setouts)
- Displayable Authorities and Bulletins
- Movement Authorities
- Speed Restrictions

Dynamic train data for a specific train may not be available prior to the train‘s departure. Before departing, at a minimum a train must be defined with a locomotive consist and movement authority by the CAD—ACT system; but aside from that, Train Sentinel® is designed to handle receipt of additional and changing train data throughout the life of the train.

3.3 TRAIN MOVEMENTS

Authority granted by the CAD system is required for a locomotive/train/MOW to occupy a track. Once the authority is received on board, the system will permit the engineer to operate the locomotive/train over the authorized track. The system may receive authority from the dispatcher system for each Train Sentinel® equipped train. The dispatching system generates a movement authority, a Work Between, or another form of authority for a train, which specifies the route for which the train has authority. The on-board displayable authority is a textual and graphical representation of the train‘s authority. The authority is passed from the dispatching system

without modification to the Train Sentinel® on-board system and made available to the crew via the locomotive HMI.

Train Sentinel® has a representation of the railroad's track in the on-board database. The CAD–ACT system allocates track to all Train Sentinel®-equipped trains with respect to their movement authorities. The on-board system, using the track profile, allocates track based on the received authority. A single train may occupy a block section, also referred to as an absolute block. In special situations, a dispatcher may place more than one train in the same track segment using a restrictive or joint authority.

Loss of the communications signal from the wayside (base station or wayside device) to the locomotive for a prescribed period of time (user selectable and factory programmable) will result in the locomotive/train being able to operate to the last limit of authority in the OBC. Once communication has been reestablished, the locomotive will be allowed to continue. Since there are no overlapping authorities generated by the system other than at restricted speed, this precludes any locomotive operating into the path of another at track speed, even if the most catastrophic events would render the digital communications system inoperative. In this case operations would revert to manual direct train control (DTC) operation without the Train Sentinel® system. Enforcement would not be evident under these conditions.

3.3.1 Displayable Authorities

TRAIN Sentinel® has the capability to accept the following displayable authorities:

A **Train Movement Authority** (TWC) is used in non-signaled territory to authorize a train to occupy the main track within designated limits. The train must travel in the direction specified only, unless authorized by bi-directional authority for the purpose of performing work. Note that the last train can be relieved of providing rear end protection if its train movement authority specifies that it is not allowed to foul the limits ahead of any preceding train. Also, train movement authorities can overlap when two or more trains are authorized with a "Work and Time" between two specific points at restricted speed, or when trains are authorized to move through another train's "Work Between" area at restricted speed. Note that Train Sentinel® does not enforce train separation in a "Work Between" limit, but does enforce speed.

All of the displayable authorities described above are available for display on board the locomotive. The lower Track Layout window will display the current (and next, if issued) movement authority under which the train is currently operating. The crew may view more detailed information about specific instructions or authorities by selecting the Movement Authority Summary window.

The PTC Authority function enables the dispatcher to issue an authority for train movement or maintenance-of-way (MOW) or on-track equipment (OTE) movement in non-signaled (Positive Train Control) territory. This function gives the dispatcher the capability to issue a new authority, recall an unreleased authority, release all or part of an existing authority, extend an existing MOW authority, or perform a meet/pass (Memorized or Stored).

In non-signaled territory, traditional means have been to either use DTC (Direct Train Control, fixed blocks) or TWC (Track Warrant Control, variable blocks). Positive Train Control takes the best of both operations to allow for flexibility of train operations. For equipped trains, communicating with the office, the use of the traditional TWC format will apply. For unequipped, the use of DTC will apply for "block" protection for trains and equipment. The DTC format

emulates the same requirements that exist using Centralized Traffic Control blocking rules, if signals would exist.

The concept of Positive Train Control is not intended to increase the overall speed assigned to a particular track, but it is intended to keep trains moving at or near the maximum track speed in order to increase track capacity and train performance.

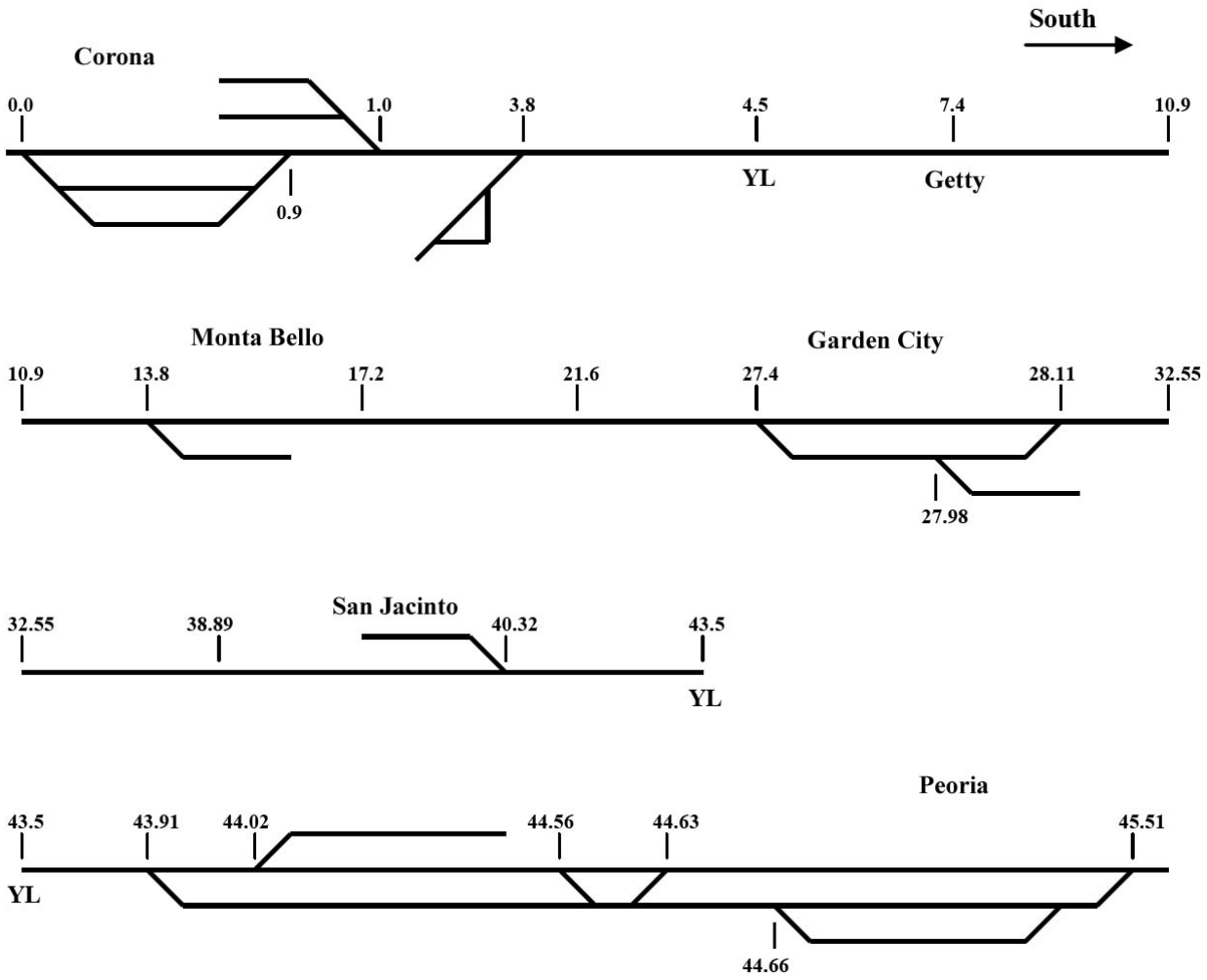

Figure 8 Typical CTC Display Graphic

3.3.2 Movement Authority

The Positive Train Control System protects the trains and maintenance personnel and equipment by allocating the track on which the dispatch system has authorized them to travel, or work. The allocation is accomplished through fixed blocks that are allocated in accordance with operational parameters identified by the railroad. Main Track and sidings are considered “controlled track” and as such require authorization for occupancy. Switches are a dispatchable component of the track architecture. Track is allocated to the trains via a “Train Movement Authority” and “Work and Time” which identify the individual track segments the train or equipment is allowed to traverse.

3.3.3 Authority Enforcement

A primary goal of the Positive Train Control System is to improve safety by enforcing movement authorities such that no actual violation of authority occurs. The Train Sentinel® system predicts an imminent violation and prevents it from occurring. This is referred to as predictive enforcement. However, there are some scenarios where Train Sentinel® cannot prevent an authority violation. An enforcement that is initiated after the violation has occurred is referred to as a reactive enforcement.

The Train Sentinel® locomotive equipment will notify the crew of a pending enforcement action. If the crew initiates a full service brake application during the pre-enforcement warning time, the pre-enforcement audible and textual warnings would terminate and the penalty application would be averted. After the initiation of the enforcement and the accompanying enforcement warning, prompt action by the crew may not be sufficient to avert the enforcement action. The Train Sentinel® system may not have sufficient time to determine that the braking actions of the crew will prevent a violation, so the penalty action may occur regardless of their action.

3.4 SPEED RESTRICTIONS

The on-board Train Sentinel® receives speed restriction information from the CAD—ACT system for each equipped train. The speed restriction information includes restrictions derived from Form A and Form B bulletins issued to the train. The bulletin is passed from CAD—ACT dispatch segment to the Train Sentinel® on-board computer and made available to the crew via the locomotive HMI. The dispatch system generates a speed restriction for a train which specifies the actual speed restriction and the limits where the speed restriction is effective. The Train Sentinel® system uses the dynamic speed restriction, along with any existing track and/or train speed restrictions, and enforces to the lowest speed restriction.

3.4.1 Bulletin Speed Restrictions

The on-board Train Sentinel® system handles track bulletins from the CAD—ACT system. Form A and Form B track bulletins are used to affect additional speed restrictions. The Form A bulletin typically instructs the train to travel at less than the normally authorized speed due to track condition, such as unstable ballast due to water erosion or extremely high temperatures in an area. Form B bulletins are intended to protect maintenance of way crews and their equipment while performing repairs on or around the track. Form F bulletins are intended to provide additional free-form information to the train crew. The Train Sentinel® system has the capability to accept the following displayable bulletins:

- Form A
- Form B
- Form F

Two options exist to provide bulletin information to trains. The options include an initial bulletin that contains all speed restrictions that the train will encounter during the crew‘s tour of duty, or the dynamic delivery of bulletins matching the authority limits generated to the train. However, occasionally a need arises to notify the crew about a new bulletin, one not listed in the warrant for bulletins.

Unlike permanent speed restrictions imposed by the timetable, speed restrictions derived from Form A and Form B bulletins expire and can be voided. When a bulletin is voided or expires, a configuration option within the Train Sentinel® system determines the enforcement behavior for a

train already within the limits of bulletin. The configuration option either immediately ends enforcement, or continues to enforce the restriction until the train clears the limits.

There are two methods available in Train Sentinel® for providing the Form B Stop Enforcement. When the dispatcher system sends the Form B bulletin to the Train Sentinel® system, the dispatcher also sends a speed restriction equal to zero which starts and ends at the FROM limit of the Form B bulletin. Once the train complies with the stop, the on-board computer allows the train to continue at the speed authorized by the track foreman, but not to exceed the most restrictive speed limit within the track bulletin limit boundaries. The second option forces the train to proceed through the Form B limits at restricted speed (less than 20 MPH, watching for men and equipment).

Form F bulletins are often used to convey safety information, such as notification of stumbling hazards or other similar information, to the crew. Train Sentinel® displays this information for convenient reference by the crew.

All of the bulletins described above are available for display on-board the locomotive. The crew may view detailed information about specific instructions or bulletins by selecting the Bulletin button on the display.

3.4.2 Timetable Derived Speed Restrictions

The Positive Train Control System enforces various speed restrictions derived from the railroad's timetable, including permanent and temporary speed restrictions, and restrictions based on train type.

3.4.3 Speed Enforcement

The Train Sentinel® system initiates penalty enforcement when such action is required to bring the train into compliance with an upcoming restriction. Enforcement, once initiated, continues until the train is completely stopped. In addition, the Train Sentinel® locomotive equipment will initiate penalty enforcement on a train that has violated the current speed restriction. Speed violations that are minor or of brief duration can be exempted from enforcement by properly configuring the speed tolerance.

3.5 TRAIN TERMINATION

From the perspective of the Positive Train Control System, train "termination" refers to the train reaching its ultimate destination. Once the train is terminated, the system provides protection against individual locomotives not assigned to any train from entering the main track.

Similar to train termination, a Positive Train Control equipped train can also exit protected track, perhaps to enter an industry. The Positive Train Control System will not manage the movements of the train or monitor its movements once a train has exited mapped track. The on-board Train Sentinel® equipment will be in a state waiting for initialization and authority to move upon the train's return to controlled track.

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SECTION FOUR – EXTERNAL COMMUNICATIONS AND SYSTEM INTERACTION

4.0 COMMUNICATIONS BETWEEN OFFICE AND TRAIN SENTINEL®

As described in Section One, the operational PTC solution requires coordination between an office-based dispatch center and the Train Sentinel® locomotive system via a communications network. Operating procedures involving the dispatch and locomotive crews must also be executed to safely perform train movement and control.

This section describes the messages between Train Sentinel® and the office, as well as the operational processing performed.

4.1 MESSAGE TYPES – OFFICE TO LOCOMOTIVE

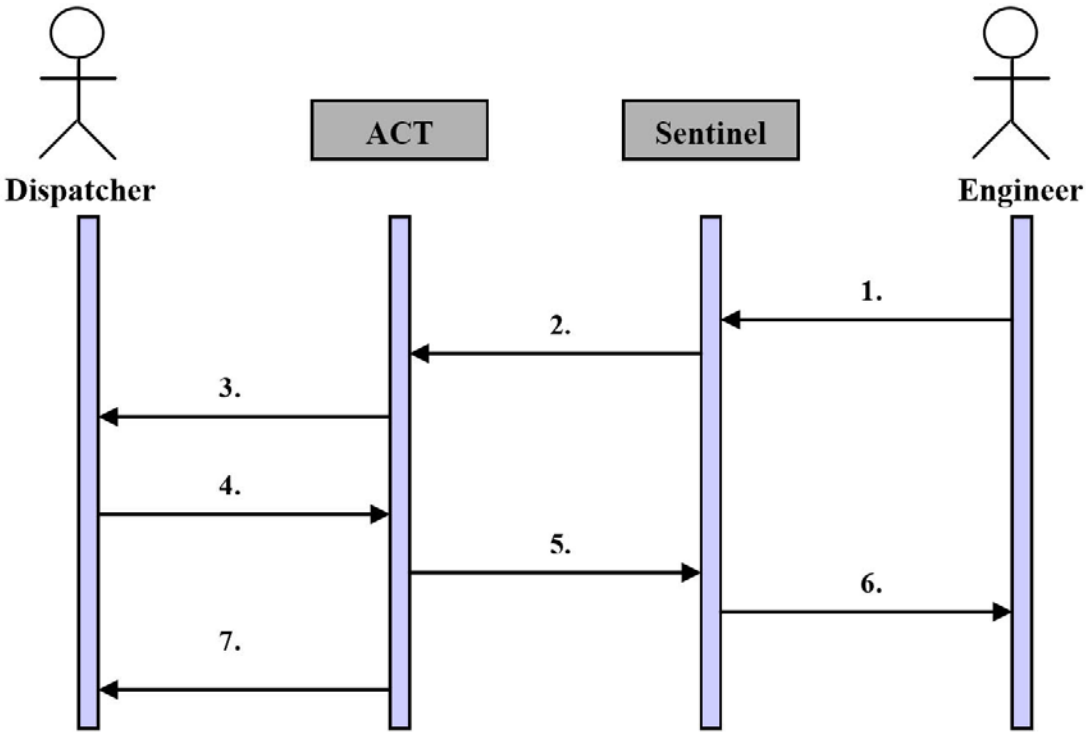
Message Number	Message Type
Message 31	Authority to Enter the Track
Message 32	Movement Authority
Message 33	Request to Cancel Movement Authority
Message 34	Modify Movement Authority
Message 35	Restricted Movement Authority
Message 36	Joint Movement Authority
Message 62	Correct (Final) Validation for Movement (“Have a Safe Trip”)

4.2 MESSAGE TYPES – LOCMOTIVE TO OFFICE

Message Number	Message Type
Message 01	Request Authorization Get on Track (Manual)
Message 02	Confirm Movement Authority (Automatic)
Message 03	Confirm Cancel (Manual – Y/N) M-33
Message 04	Confirm Alteration of Movement Authority M-34
Message 06	Actual Position (Automatic)

4.3 TRAIN MOVEMENT AUTHORITY MESSAGING SCENARIOS

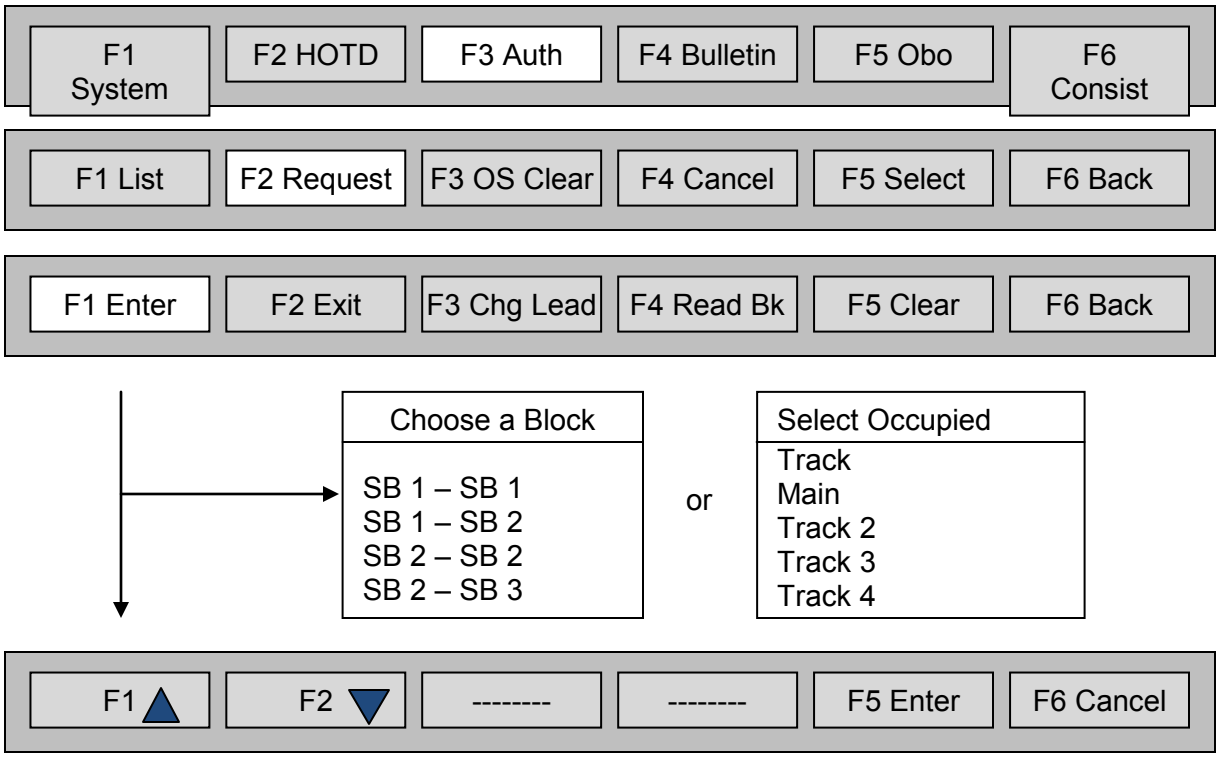
4.3.1 Train Movement Authority – Train Requests Authorization Get on Track



The authorization to enter the track must occur in the following way:

1. The Engineer/Conductor requests authorization to enter controlled track through Train Sentinel®.
2. Train Sentinel® sends CAD–ACT a message (01) requesting authorization to enter the track.
3. CAD–ACT displays on the track-line overview to the Dispatcher the request to enter the track.
4. Dispatcher authorizes the entrance of the train on the controlled track through CAD–ACT.
5. CAD–ACT responds to Train Sentinel® and authorizes the entrance into the track with a Message 31.
6. Train Sentinel® passes the single section movement authority to the Engineer/Conductor that he has authorization to enter the track and passes a confirmation to CAD–ACT.
7. CAD–ACT shows the Dispatcher the representation of the entrance of the train on the controlled track.

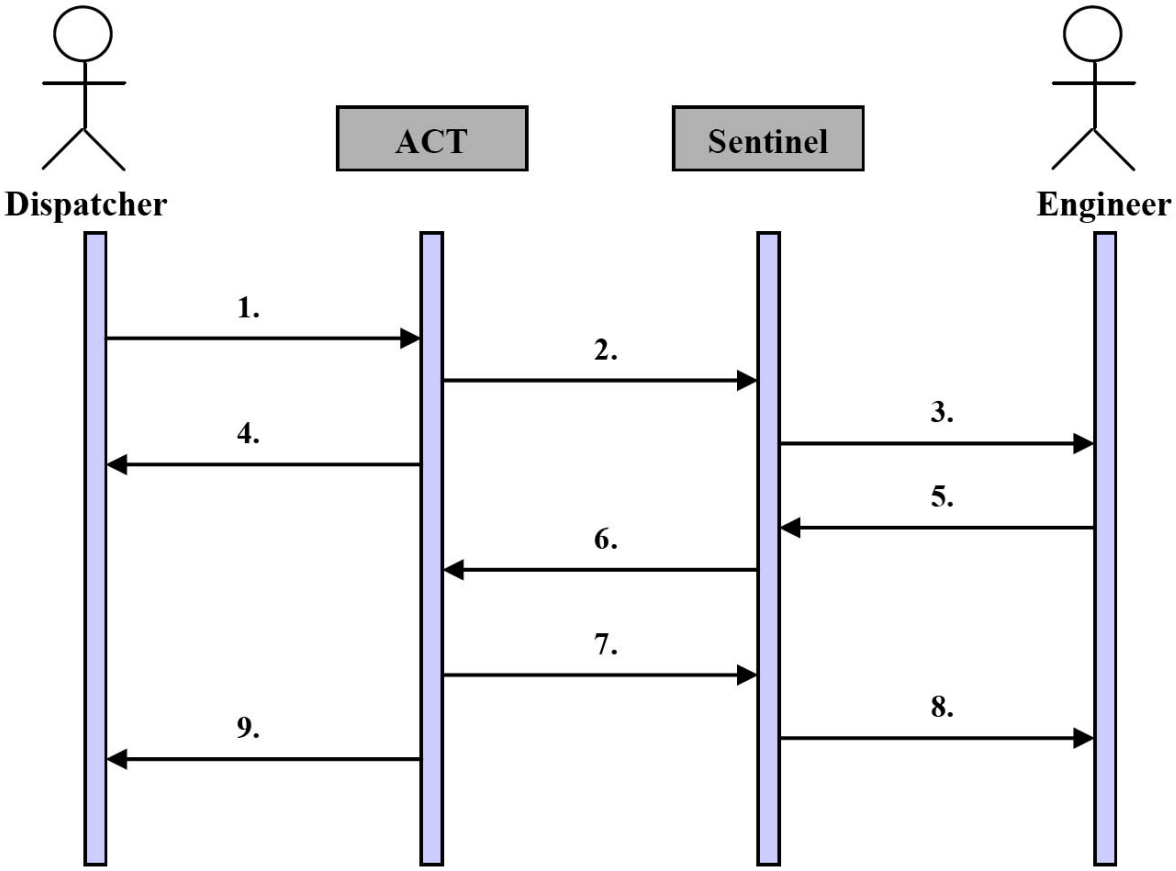
4.3.1.1 Train to Dispatcher – Message 01 (Request Authorization Get on Track)



The train is requesting authorization to enter the track:

1. Engineer/Conductor initiates the process by pressing the **F3 Auth** key.
2. Engineer/Conductor presses the **F2 Request** key and when the next menu line appears, presses the **F1 Enter** to designate the block in which the train will enter the track.
3. Engineer/Conductor "scrolls" through a pop-up list of blocks using the "up" and "down" keys to designate the entry block.
4. When the correct block is identified the Engineer/Conductor presses the **F5 Enter** key to enter the block.
5. Engineer/Conductor presses the **F3 Auth** key.
6. Engineer/Conductor presses the **F2 Request** key and when the next menu line appears, presses the **F1 Enter** to designate the track the train will enter.
7. Engineer/Conductor "scrolls" through a pop-up list of tracks using the "up" and "down" keys to designate the entry track.
8. When the correct track is identified the Engineer/Conductor presses the **F5 Enter** key to enter the track.
9. The key display returns to the default key labels for the next command.

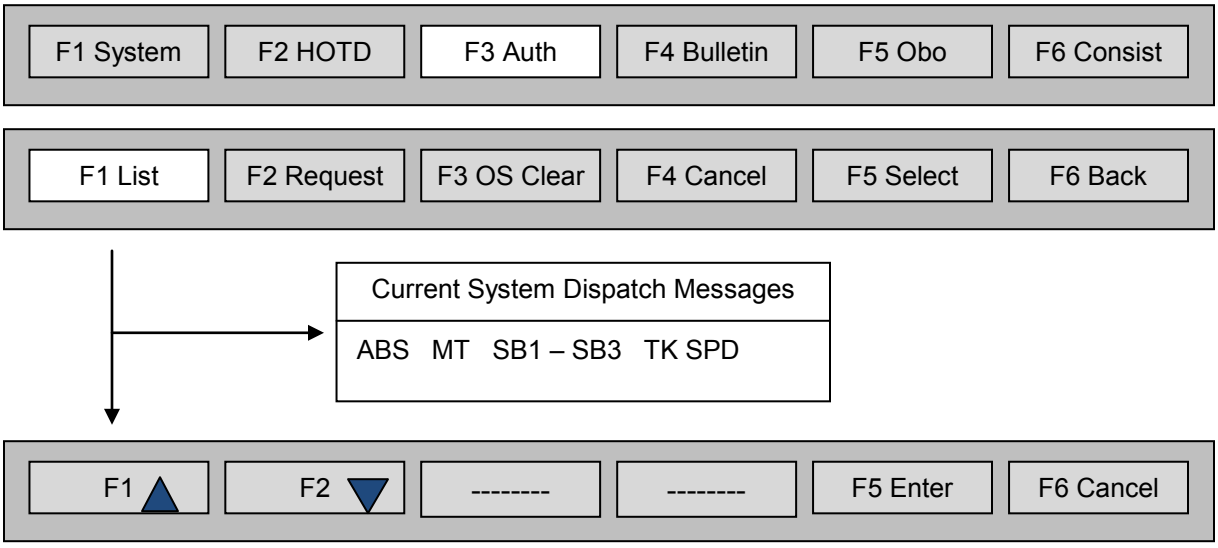
4.3.2 Train Movement Authority (Absolute)



The Train Movement Authority procedure must occur as follows:

1. The dispatcher generates a Train Movement Authority (Message 32);
2. CAD–ACT checks if the warrant can be granted, and then sends a Train Movement Authority message to Train Sentinel®;
3. Train Sentinel® displays to the Engineer/Conductor the train movement authority received (Message 32) and waits for the Engineer or Conductor confirmation;
4. CAD–ACT shows the Dispatcher the indication of the Train Movement Authority sent and waiting to be confirmed.
5. The Engineer/Conductor confirms the Train Movement Authority received (Message 02);
6. Train Sentinel® replies to CAD–ACT, confirming the acknowledgment of the movement authority;
7. CAD–ACT analyzes the movement confirmation and responds to Train Sentinel® with a “that is correct” message (Message 32);
8. Train Sentinel® shows the Engineer/Conductor the received message (Message 32);
9. CAD–ACT shows the Dispatcher the indication that the movement authority was confirmed;

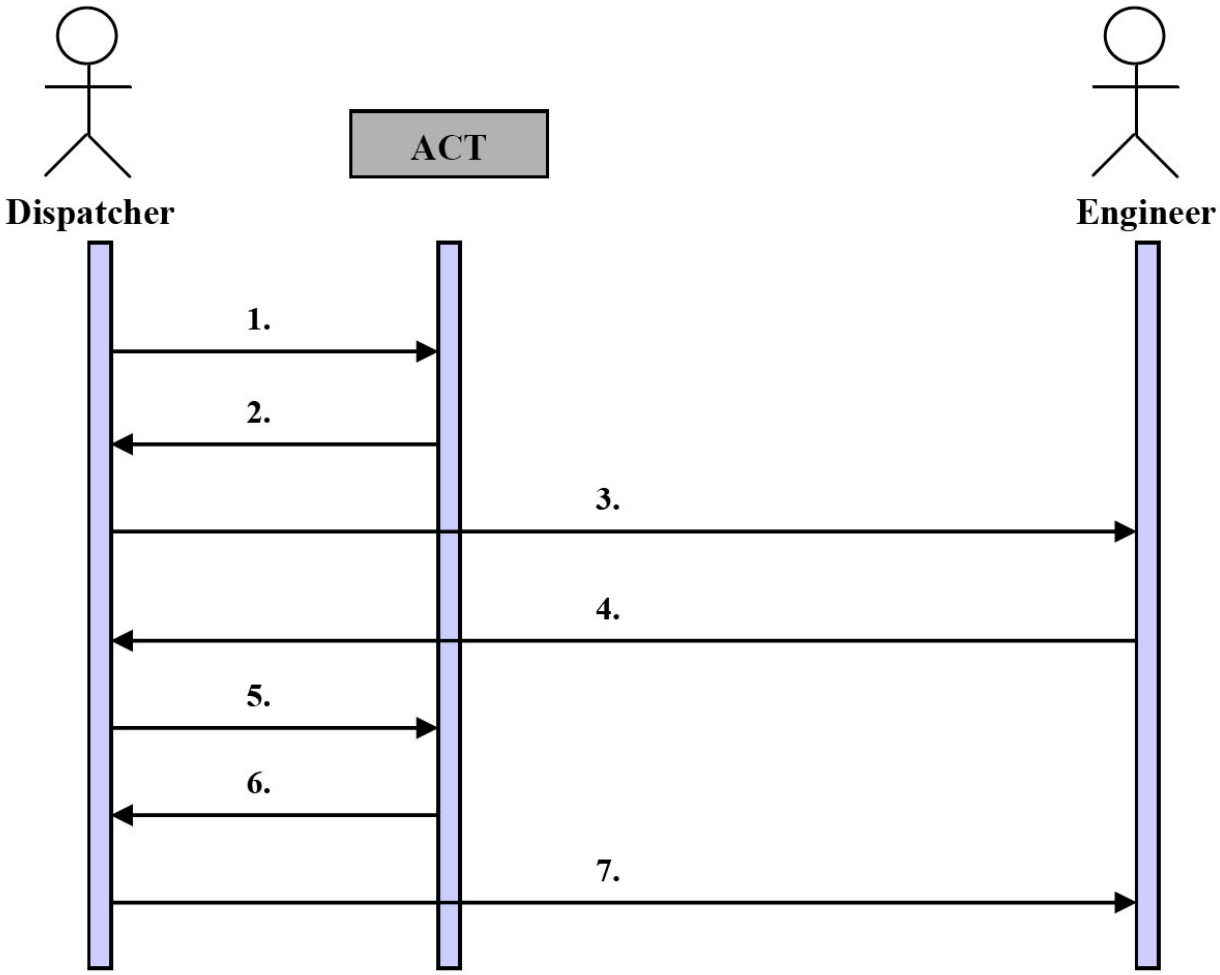
4.3.2.1 Dispatcher to Train – Message 32 (Train Movement Authority)



The Dispatcher will generate a movement authority to the train:

1. Dispatcher performs an entrance/exit command through CAD–ACT to move the train; the system sends a Message 32 to the train.
2. Engineer/Conductor presses the **F3 Auth** key, then **F1 List** to display the list of authorities.
3. Engineer/Conductor "scrolls" through a pop-up list of authorities using the "up" and "down" keys to designate the appropriate movement authority.
4. When the correct movement authority is identified the Engineer/Conductor presses the **F5 Enter** key to enter the confirmation of the receipt of the movement authority.
5. The key display returns to the default key labels for the next command.

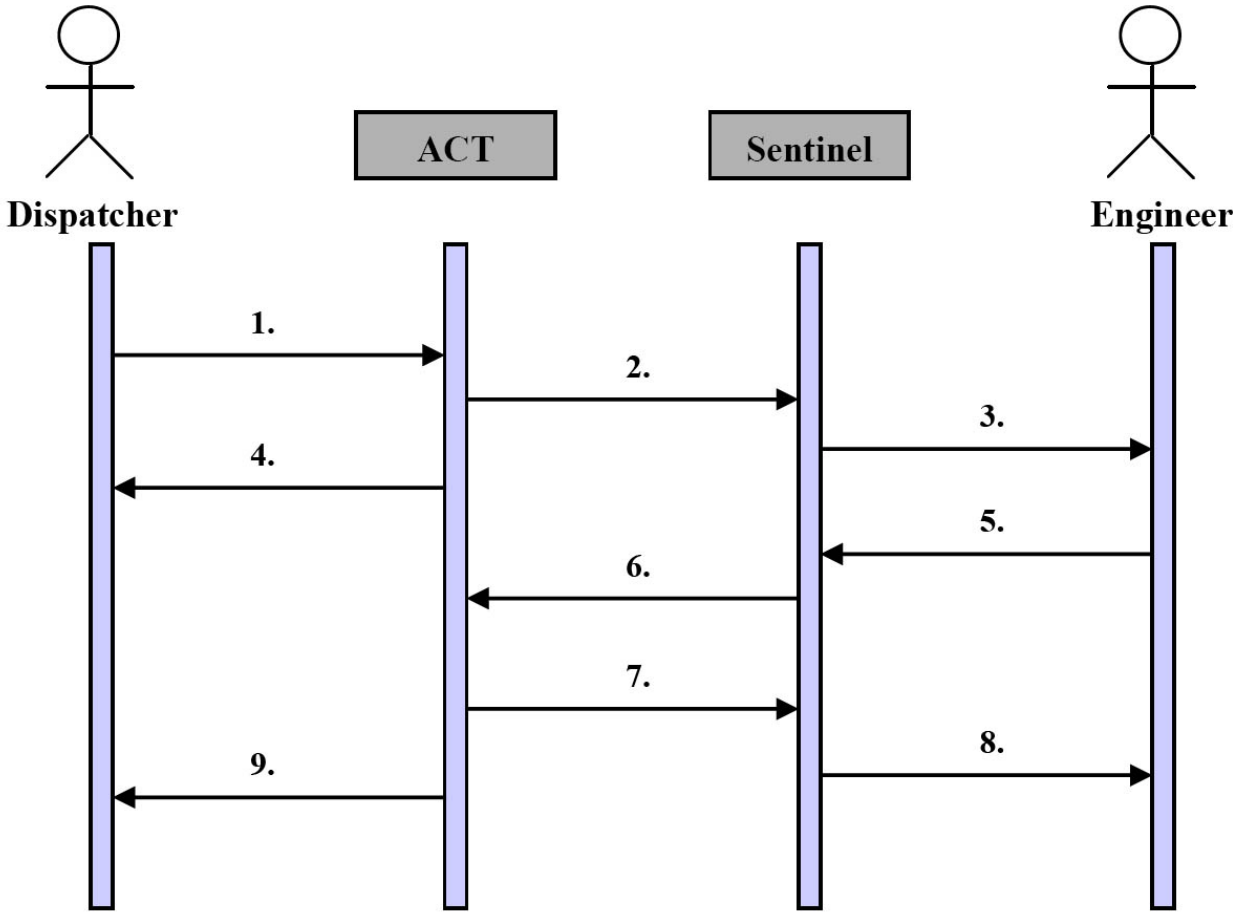
4.3.3 Train Movement Authority (to trains operating without Train Sentinel®)



The process to grant a Train Movement Authority to trains operating without Train Sentinel® must occur as follows:

1. Dispatcher creates a Train Movement Authority.
2. CAD–ACT checks if the movement authority can be granted and indicates to the dispatcher that the movement authority is waiting to be confirmed.
3. Dispatcher reads the Train Movement Authority to the Engineer/Conductor.
4. Engineer/Conductor confirms the Train Movement Authority to the Dispatcher.
5. Dispatcher provides a movement authority confirmation to CAD–ACT.
6. CAD–ACT shows to the Dispatcher the indication of the confirmed movement authority.
7. Dispatcher reads to the Engineer/Conductor a “That is correct” message.

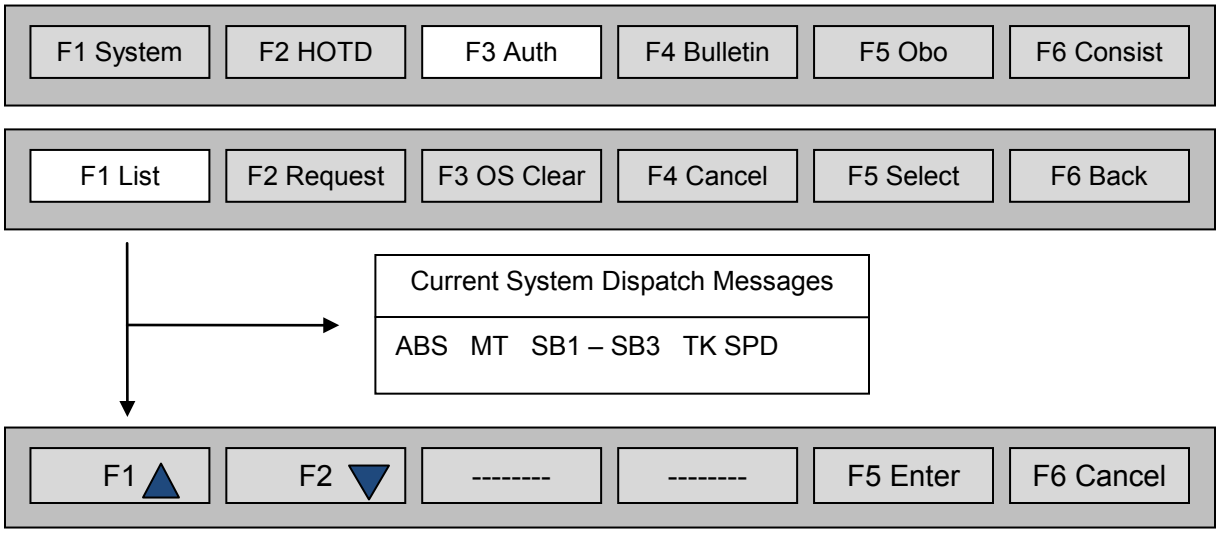
4.3.4 Joint Track Movement Authority



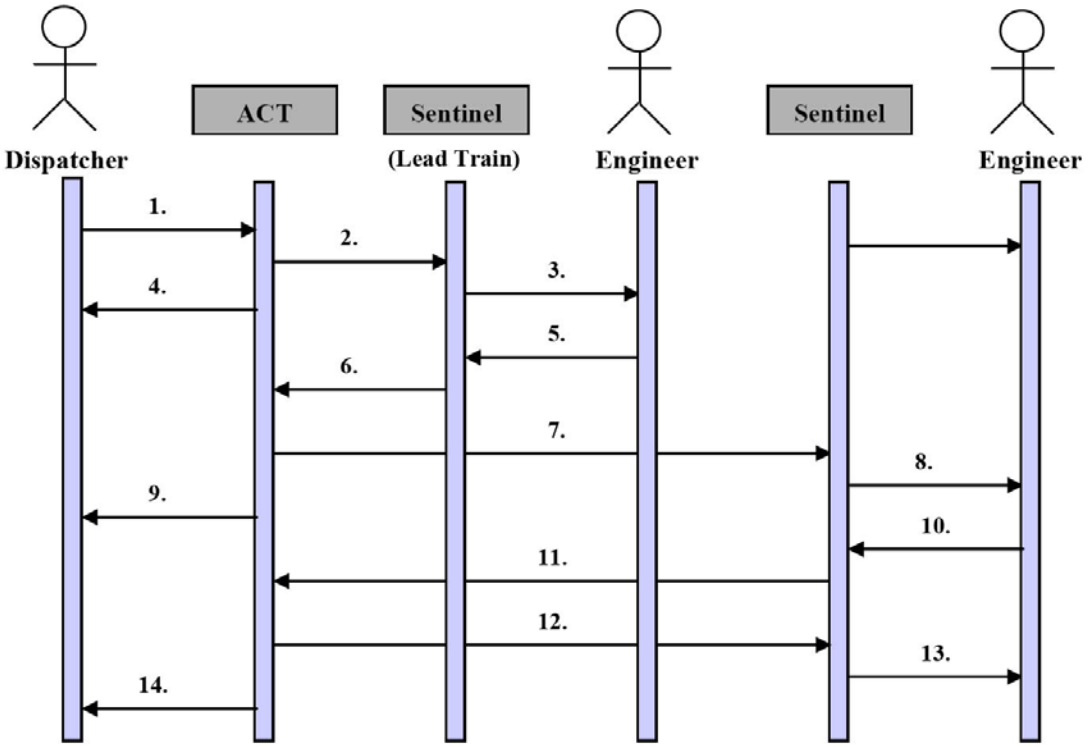
The Joint Track Movement Authority procedure must occur as follows:

1. Dispatcher will generate a Joint Track Movement Authority.
2. CAD–ACT checks if the authority can be granted, and then sends a Joint Track Movement Authority (Message 36) to Train Sentinel®.
3. Train Sentinel® displays to the Engineer/Conductor the received Joint Track Movement Authority and waits for its confirmation.
4. CAD–ACT shows to the Dispatcher the indication of the Joint Track Movement Authority sent and waiting to be confirmed.
5. The Engineer/Conductor confirms the Joint Track Movement Authority that was received.
6. Train Sentinel® responds to CAD–ACT (Message 02), confirming the acknowledgment of the Joint Track Movement Authority.
7. CAD–ACT checks the authority confirmation and responds to Train Sentinel® with a “that is correct” message (Message 62).
8. Train Sentinel® displays to the Engineer/Conductor the received message.
9. CAD–ACT shows to the Dispatcher the indication that the authority was confirmed.

4.3.4.1 Dispatcher to Train – Message 36 (Joint Track Movement Authority)



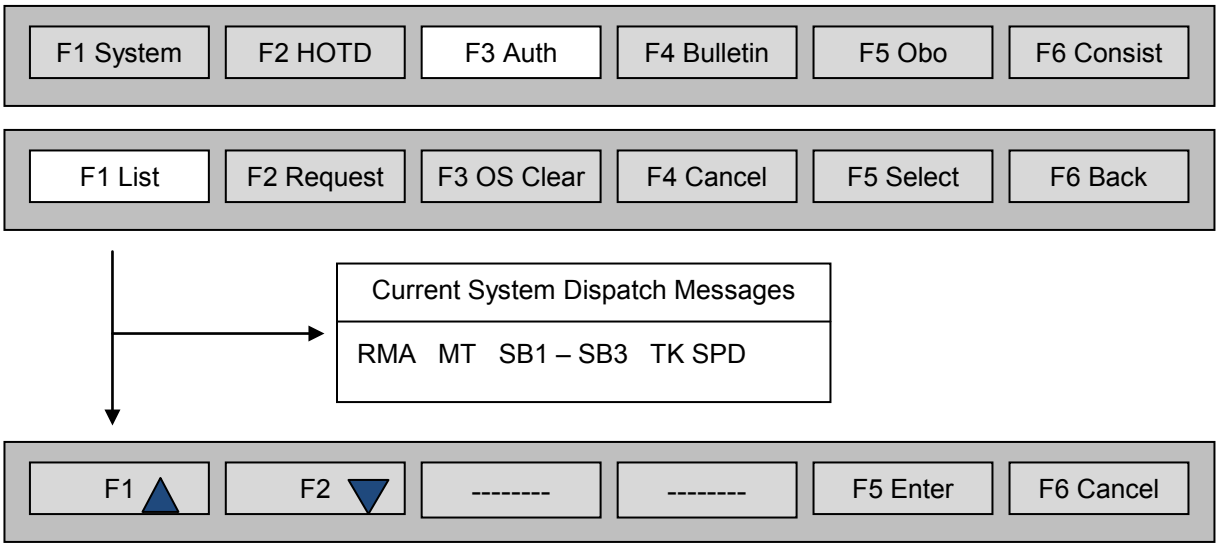
4.3.5 Restricted Train Movement Authority (Joint also)



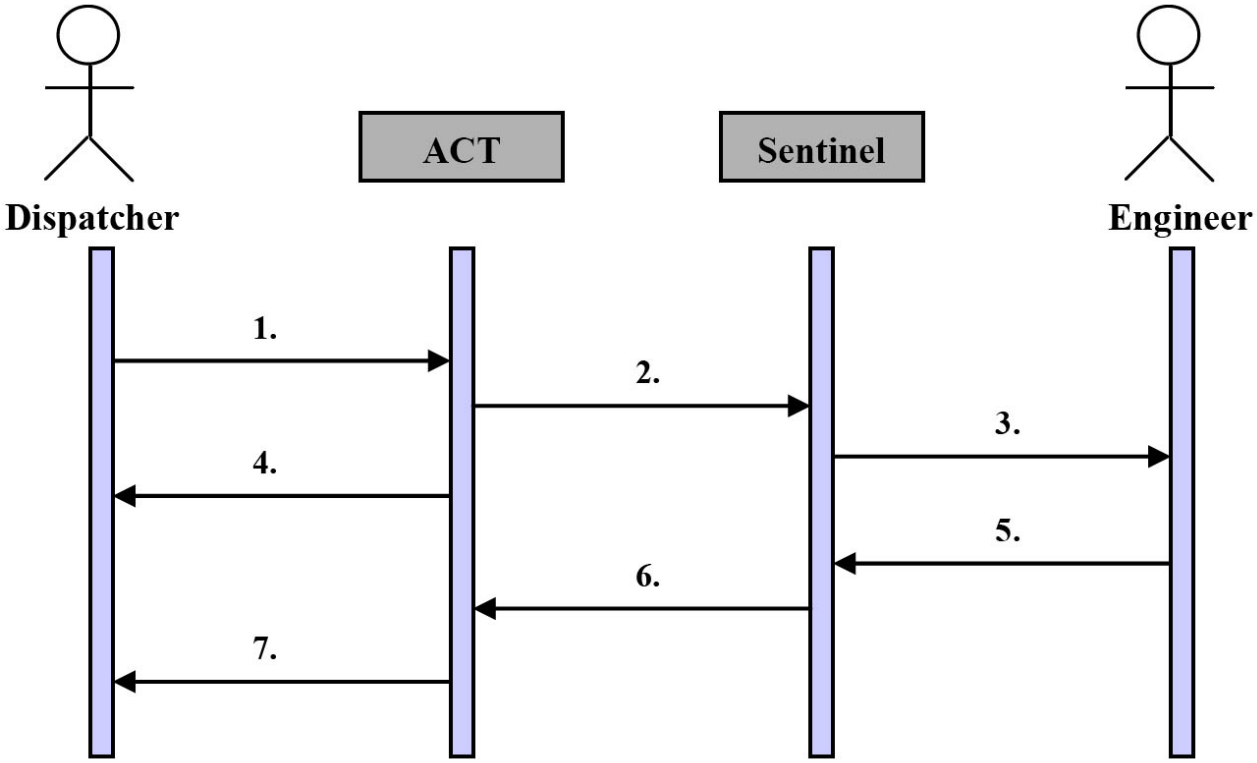
The Restricted Movement Authority (RMA) must occur as follows:

1. Dispatcher creates an RMA.
2. CAD–ACT sends to Train Sentinel® (to the train that is currently occupying the selected BS) a message requesting confirmation of another train to occupy the same BS (Message 36).
3. Train Sentinel® shows to the Engineer/Conductor the RMA "request" and waits for its acceptance.
4. CAD–ACT shows the Dispatcher the indication of the RMA sent and waiting to be accepted.
5. Engineer/Conductor of the front train (which is currently occupying the BS) accepts the RMA.
6. Train Sentinel® sends to CAD–ACT the acceptance of the RMA (Message 02).
7. CAD–ACT sends to Train Sentinel® (of the train that will enter the BS that is already occupied) the RMA (Message 35).
8. Train Sentinel® displays to the Engineer/Conductor the RMA and waits for its confirmation.
9. CAD–ACT shows the Dispatcher the indication of the RMA sent and waiting to be confirmed.
10. Engineer/Conductor confirms the received RMA.
11. Train Sentinel® responds to CAD–ACT, confirming the acknowledgment of the RMA.
12. CAD–ACT analyzes the confirmation and responds to Sentinel with a "That is correct" message.
13. Train Sentinel® displays to the Engineer/Conductor the received message.
14. CAD–ACT shows the Dispatcher the indication that the RMA was confirmed.

4.3.5.1 Dispatcher to Train – Message 35 (Restricted Train Movement Authority)



4.3.6 Train Movement Authority Cancellation

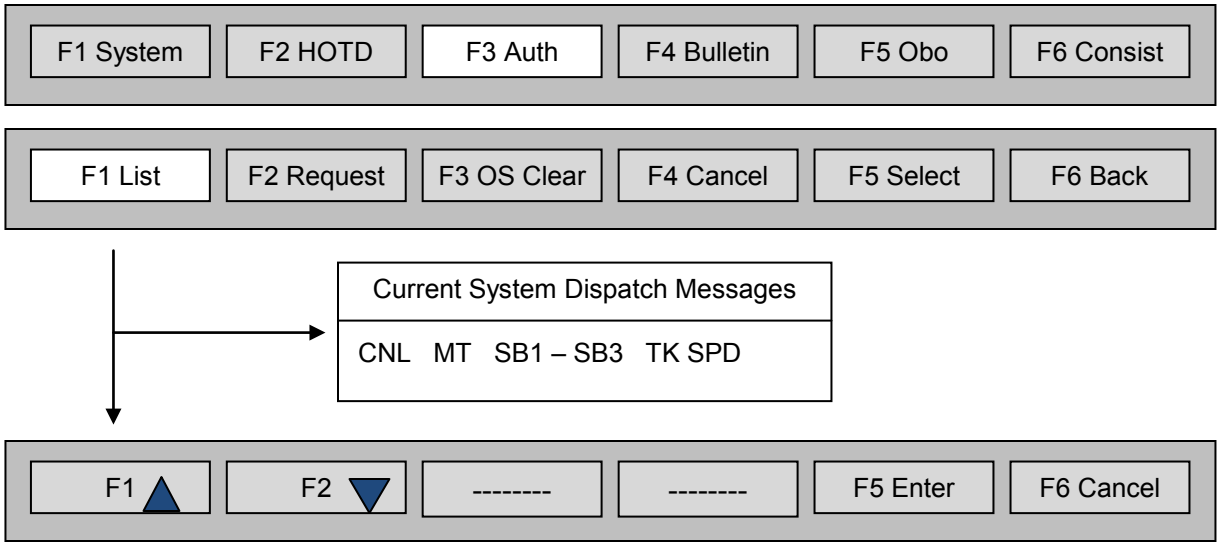


The cancellation of a Movement Authority will indicate an invalidation of a previously executed and confirmed movement authority. The authority that was granted cannot be used, in whole or part, making the train remained stopped at the TS of origin of the Movement Authority.

The Movement Authority cancellation procedure must occur as follows:

1. Dispatcher generates a Movement Authority cancellation.
2. CAD–ACT sends Train Sentinel® a message of Movement Authority cancellation (Message 33).
3. Train Sentinel® displays to the Engineer/Conductor the Movement Authority cancellation and waits for it confirmation.
4. CAD–ACT shows to the Dispatcher the indication that the selected Movement Authority is in a cancellation process.
5. Engineer/Conductor confirms the Movement Authority cancellation (Message 03).
6. Sentinel answers to CAD–ACT, confirming the Movement Authority cancellation.
7. CAD–ACT shows to the Dispatcher the indication that the Movement Authority was cancelled.

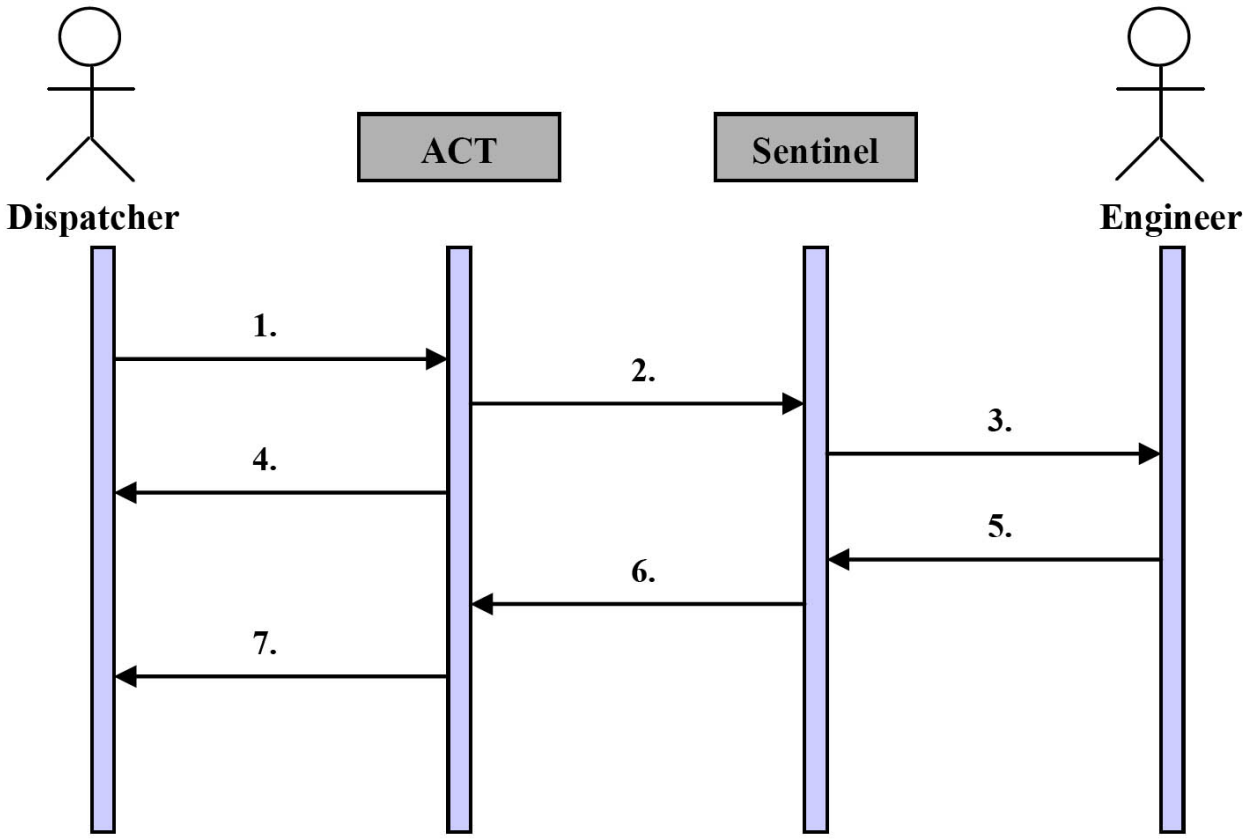
4.3.6.1 Dispatcher to Train – Message 33 (Request to Cancel a Train Movement Authority)



The Movement Authority cancellation procedure must occur as follows for a previously confirmed Movement Authority:

1. Dispatcher will generate a Movement Authority cancellation (Message 33).
2. CAD–ACT sends Train Sentinel® a message of Movement Authority cancellation.
3. Train Sentinel® displays to the Engineer/Conductor the Movement Authority cancellation and waits for it confirmation.
4. CAD–ACT shows to the Dispatcher the indication that the selected Movement Authority is in a cancellation process.
5. Engineer/Conductor confirms the Movement Authority cancellation.
6. Train Sentinel® responds back to CAD–ACT (Message 03), confirming the Movement Authority cancellation.
7. CAD–ACT shows to the Dispatcher the indication that the Movement Authority was cancelled.

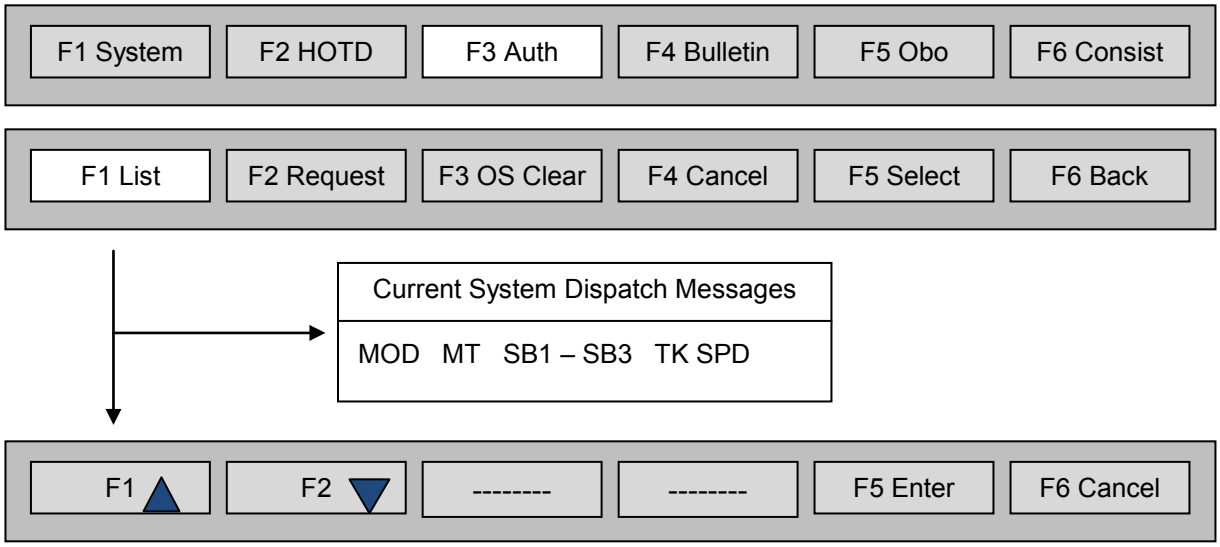
4.3.7 Modification of a Train Movement Authority



A Train Movement Authority modification may occur under two conditions. The Movement Authority must be active and the "from location" may be shortened, but not the "to location". The Train Movement Authority modification must occur as follows:

1. Dispatcher recalls an active Movement Authority for modification.
2. CAD–ACT sends Train Sentinel® a Train Movement Authority modification message (Message 34).
3. Train Sentinel® displays to the Engineer/Conductor the Movement Authority modification and waits for the confirmation.
4. CAD–ACT displays to the Dispatcher on the track-line overview display the indication that the Movement Authority request is pending for modification.
5. Engineer/Conductor confirms the requested modification.
6. Train Sentinel® responds to CAD–ACT (Message 04), confirming the requested modification.
7. CAD–ACT displays on the track-line overview to the Dispatcher the indication that the movement authority was modified.

4.3.7.1 Dispatcher to Train – Message 34 (Request to Modify a Train Movement Authority)



4.4 OPERATIONAL RESTRICTIONS

Operational restrictions are used to inform a train of the places within its route where the train must move at restricted speed in relation to its current speed. In some cases the train will even be required to come to a complete stop before proceeding. This second condition is usually caused by maintenance-of-way or malfunctions at highway-rail grade crossings.

There are currently two defined types of restrictions:

- Form A Track Bulletins— these bulletins consist of a starting and ending milepost location of the restriction. It will also designate the speed for the train, either full train or head-end.

- Form B Track Bulletins— these bulletins are used to inform the train crews of work being performed by maintenance-of-way employees. The bulletin will contain the beginning and ending mileposts as well as the time of the restrictions and the foreman in charge of the working authority.

Execution of these restrictions is normally sent with the movement authority for the designated route. The restrictions will be assigned within a particular track section for notification.

If a restriction becomes active after a movement authority has been issued to a train over the particular track section, the restriction is immediately sent to the train crew for acknowledgement.

NOTE

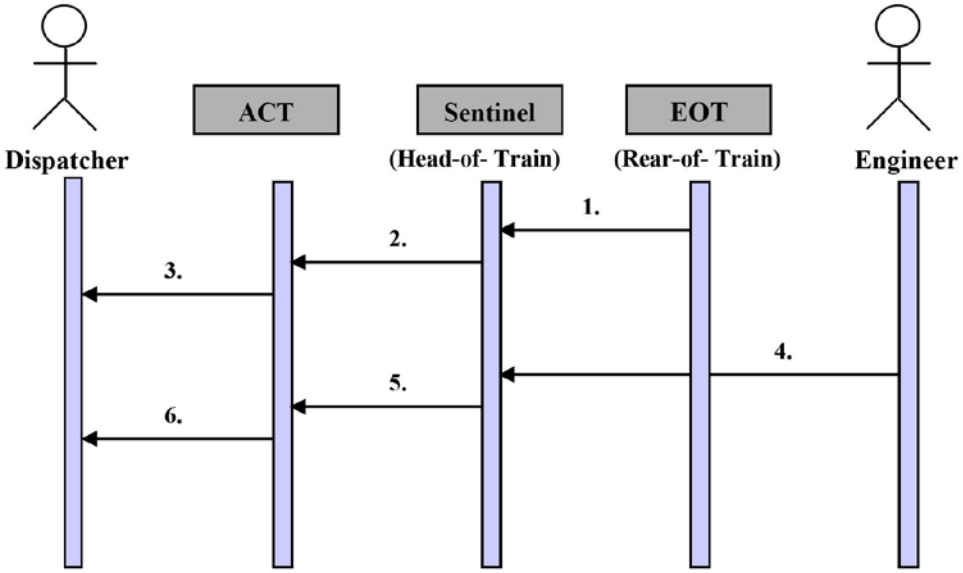
NOTE

Form F bulletins only pertain to informational directives to the train crews and are not enforced by Train Sentinel®.

4.5 TRAIN POSITION

With the train position process, the train sends to CAD–ACT the current position of the rear of the train (Rear-equipped) on the track. This process allows the Central Control Office (CCO) to monitor train activity by accurate locations of all trains within the system.

A train with an active movement authority sends its position within a track segment to CAD–ACT. When received, CAD–ACT creates an occupation of the train within the track section. When a message is received by the CCO that the rear-of-train has passed a unique location, CAD–ACT clears (or rolls-up) any valid track sections behind that train. When this occurs, the last position will be the last reported position of the train. If the end-of-train has not reported the actual position, the roll-up will not occur and the last position of the train will be shown to the dispatcher on the track-line overview display.



The Train Position procedure occurs as follows:

1. GPS End-of-Train device communicates with the head end Train Sentinel® equipment to relay actual location of the rear of the train.
2. Train Sentinel® sends a message to CAD–ACT containing the “rear of train position” report (Message 06).
3. CAD–ACT clears or rolls-up the track segments behind the train to note the actual location of the train at the report time.
4. If the rear end of the train is known and the GPS End-of-Train device is not functioning, the train crew may indicate to Train Sentinel® the actual position.
5. Train Sentinel® sends a message to CAD–ACT containing the “rear of train position” report.
6. CAD-ACT clears or rolls-up the track segments behind the train to note the actual location of the train at the report time and as reported by the train crew.

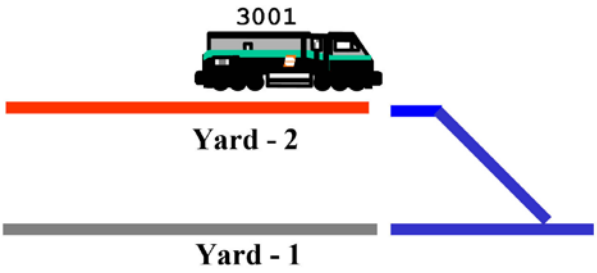
NOTE

NOTE

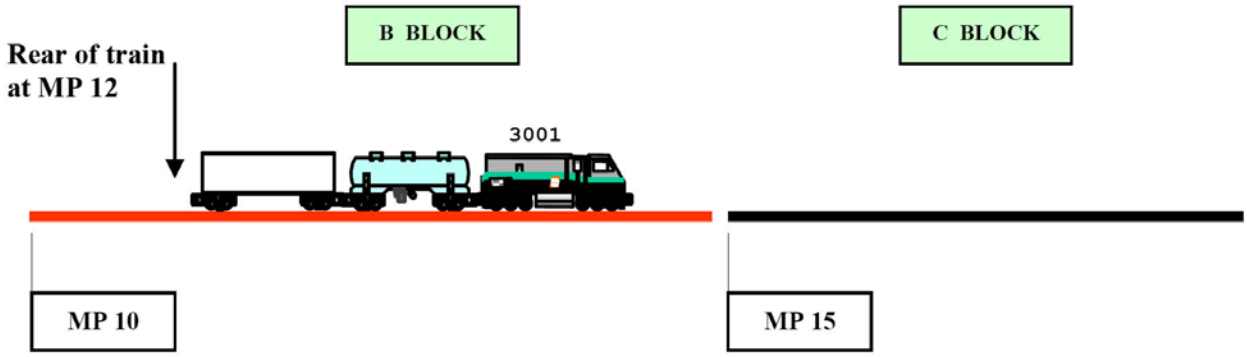
There is no automatic clearing of track segments or roll-up if the End-of-Train device is not functioning or is not a Siemens Rail Automation GPS End-of-Train device.

4.5.1 Train to Dispatcher – Message 06 (Train Position)

No action for train crew for this process — performed electronically



When a train leaves the yard on the initial trip, with a movement authority in place, Train Sentinel® transmits to CAD–ACT a notification of departure with a Message 05.



When a train is operating on main track with a movement authority, the End-of-Train device, with GPS, makes a position report to the head-of-train device as to the position of the rear of the train. Train Sentinel® transmits to CAD–ACT a notification of position with a Message 06. In the example above, the rear of the train is noted at MP 12.

GLOSSORY OF TERMS

Absolute Signal	A block or interlocking signal without a number plate, or designated by an “A” marker.
Acknowledgment, Machine-to-Machine	Computer-generated message, sent from a Train Sentinel® - equipped locomotive to the CAD–ACT Dispatch System, confirming that a digital message has been received on board.
Authority	Authority to occupy a main track or other controlled track, generated by a dispatch system or by the dispatcher using a dispatch system, conveyed through signal indications in CTC and, track warrant, track and time, or other means, and supplied to the Train Sentinel® system as the basis for an enforceable authority.
Authority Enforcement	– Positive Train Control system capability of preventing a violation of movement authority through an automatic full service application of train brakes to stop the train before a violation occurs; under certain conditions, capability of stopping a train following detection of an authority violation.
Authority Limits	Segment of controlled track defined by mileposts or station names, over which a train has authority to occupy and move on a main track.
Automatic Interlocking	An interlocking through which train movements are governed by means of the track circuitry without human intervention.
Automatic Train Control	A system to enforce compliance with cab and wayside signal indications. If the train exceeds a predetermined speed for a given signal indication and speed is not reduced at a sufficient rate, brakes are automatically applied.
Bi-directional Authority	Authority for a train or maintenance vehicle to occupy a specified main track or controlled siding and move in either direction within designated limits.
Block	A length of track between consecutive block signals or between a block signal and the end of block system limits. Designated by timetable of a block in non-signaled territory.
Block Signal	A fixed signal at the entrance of a block that governs trains entering and using that block.
Brake Pipe Pressure	The amount of air pressure supplied to the brake pipe from the locomotive air compressor, expressed in pounds per square inch (psi).
Braking Curve	Dynamic calculation of the point at which full-service braking must be applied for a train to be stopped within its movement limits or for its speed to be reduced short of a speed restriction limit. This may be portrayed graphically as a curve plotting train speed against distance remaining to the enforcement reference point; used in triggering braking for predictive enforcement.
Braking Distance	Distance required to stop a train, measured from the point at which a full-service (P2A) application of braking begins; projected by the onboard computer through a calculation based on train speed, weight, and length, consist detail, brake pipe pressure, track gradient, and other possible inputs.
CAD-ACT System	Computer-Assisted Dispatching – Advanced Control of Trains system, a computer hardware and software system that automates some dispatching functions and provides information support for dispatching.

Cleared Route	One or more consecutive blocks in CTC territory over which a train is authorized to move, as by signal indication.
Positive Train Control (PTC)	Dispatcher office, on-board, wayside and data radio network segments integrated to provide safety and efficiency gains in railroad operations.
Communications Infrastructure	Basic installations and facilities, such a railroad‘s communication radio base stations, on-board communication devices, required to support data communications for the Positive Train Control System.
Communications Outage	Loss of data communications over a limited geographic area, as through a failed radio base station, or on-board communication device.
Configuration Information Module (CIM)	A module in the data radio that stores the radio script and the node unique information such as ID, Site Name, etc. The CIM is used in configuration management control.
Controlled Track	Track on which occupancy and movement by a train engine or on track equipment require authority issued through some method of train control.
Crossing	Point of intersection at grade between two tracks belonging to the same or different railroads.
Crossing Move	Movement of a train through a railroad crossing at grade or gauntlet track.
Centralized Traffic Control (CTC)	A block system that uses block signal indications to authorize train movements.
Dark Territory	Railroad tracks not equipped with signals; also known as *Non-ABS, DTC or TWC.*
Non-signaled Territory	Track without signals, over which train movements are governed by timetable, track warrants, or operating rules (aka: Dark Territory).
Database Speed Restriction	Enforceable speed limit defined in a database and associated with train attributes, with track location, or with a combination of train attributes and track location.
DTC	Direct Train Control, an alternative to Track Warrant Control in dark territory.
Effective Date	Date on which a track bulletin restriction takes effect, designated in a track bulletin line item or heading.
Effective Time	Time at which a track bulletin restriction takes effect, designated in a track bulletin line item.
Engineering Change Notice (ECN)	Document that identifies all modifications made to hardware and software documentation and drawings.
End-of-Train Interface	Electromechanical means of monitoring end-of-train brake pipe pressure and train integrity through systems installed in the locomotive cab.
Enforceable Authority	Computer-readable authority defining limits of train movements that are subject to Collision Avoidance System enforcement.
Enforceable Speed Limit	At any given location, the nominal maximum speed at which a train can move before invoking a response from the onboard enforcement function; may differ from the actual speed limit, as in the case of an enforceable speed limit dictated by signal aspect, and from the actual speed at which enforcement braking is triggered, which may reflect a margin of over-speed tolerance.

Enforcement Braking	Automatic application of full service to stop a train either before it violates its authority limits or an upcoming speed limit (*predictive enforcement)* or in response to a detected violation of authority limits or a current speed limit (*reactive* enforcement).
Equipped Train	Train equipped with the onboard communications, computing, and location-tracking systems required for Positive Train Control System functions; required equipment includes data radio, onboard computer, location-tracking device (such as GPS receiver), and a computer interface with the braking and throttle systems.
Flag Protection	A method of manually protecting the rear end or head end of a train to prevent collision.
Field Service Bulletin (FSB)	Document update containing information pertaining to hardware modification.
Following Move	Authorized movement by a train constrained by another train ahead moving on the same track in the same direction.
Form A	Track bulletin item establishing a temporary speed limit over a specified track segment.
Form B	Track bulletin item establishing protection for men or machines on track within specified limits and limiting train movement within the limits to restricted speed or another speed negotiated with the maintenance foreman.
Form F	Form F bulletins provide informational directives to the train crews.
Forward Move	Authorized movement to a specified limit ahead of a train, conferred by signal indication in CTC territory, or by track warrant item 2 or 3, or track and time, or other means.
Global Positioning System	A satellite-based radio navigation system deployed and operated by the Department of Defense, providing highly accurate three-dimensional position, velocity, and time data; input to Train Sentinel® train location tracking.
Head-End-Only Speed Restriction	Timetable speed restriction in effect for a train until the train's leading engine moves past the far limit of the restriction.
Human Machine Interface (HMI)	Interface between human operator and IR–PTC equipment that identifies necessary operations information.
Interlocking	An arrangement of signals and signal appliances, either manually or automatically controlled, interconnected so that their movements occur in a proper and safe sequence. Interlocking may be operated manually or automatically.
Joint Authority	Movement authorities issued to multiple trains, to a combination of trains and track forces or multiple maintenance crews with the same or overlapping limits.
Limit, Speed	Maximum speed in force for a train at a given track location.
Limits, Authority	Segment of track, defined by mileposts or location names, over which a train has authority for occupancy and movement.
Limits, Speed Restriction	Segment of track, defined by mileposts or station names, over which a train is subject to a specified speed restriction.
Location Tracking	Positive Train Control System through which an equipped train's location is determined for train control and enforcement purposes; also known as *positioning.*
Main Track	A track extending through yards and between stations that must not be occupied without authority or protection.

Main Track Permission	Method of train control, closely resembling track warrant control, authorizing track occupancy within designated yard limits subject to Main Track Permission rules.
Management Information System (MIS)	A railroad's computer system providing data on resources and operations.
Manual Input Function	On-board Train Sentinel® function requiring a manual input by a train crew member in order to initiate a data request or transaction, acknowledge a digital message, or provide information on train movement to the Positive Train Control System.
Manual Interlocking	An interlocking, through which train movements are controlled by a human operator, such as a dispatcher, who must manually request the desired route for each movement.
Meet	Opposing trains authorized to move past one another at a designated location, where one train clears the main track onto a siding while the other holds to the main.
Non-ABS	Railroad tracks not equipped with signals; also known as *dark territory*.
Non-controlled Territory	Tracks on which trains are free to move with Timetable Special Instructions authorization. Their movement may be governed by signals.
Non-equipped Train	Train not equipped with the onboard communications, computing, and location-tracking systems required for Collision Avoidance System functions.
Normal Switch Position	Position of a switch such that a train moving on the main track through the switch remains on the main track.
On-board Computer (OBC)	Computer installed on an equipped train and used for running on-board Train Sentinel® functions, including location tracking, authority and speed limit enforcement, and various display and input functions.
Opposing Train	Train authorized to move toward a given train on the same track but in the opposite direction, requiring a meet.
Overlapping Authorities	Movement authorities issued to multiple trains, multiple maintenance crews, or a combination of trains and maintenance crews having the same or overlapping limits.
Pass	One train passing another train moving in the same direction at a designated location, where one train clears the main track onto a parallel track, while the other holds to the main.
Passing Train	Train authorized to move past a given train, which is required to wait on a parallel track.
Position, Rear-End	Location of a train's rear end, calculated by subtracting the train length from the head-end position, or obtained from a GPS device on the rear of train.
Position, Head-End	Location of a train's lead locomotive as determined by a wheel tachometer or a GPS device.
Position Report	Message sent from an on-board computer to the dispatcher office indicating the current train location, speed, and direction.
Positioning	Positive Train Control System function by which an equipped train's location is determined for train control purposes; also known as *location tracking.*
Power Braking System (PBS)	Train Sentinel® subsystem used to stop Train Sentinel® equipped locomotive using a full brake application.

Predictive Enforcement	Application of enforcement braking to prevent violation of authority limits or violation of an upcoming speed limit.
Pre-enforcement Alert	Textual message, accompanied by an audible alert, warning the train crew of an impending application of enforcement braking unless the engineer acts to take control of the train.
Protection	Prevention of train collisions through various measures, such as block signals, flagging, or the intervention by the Positive Train Control System.
Reactive Enforcement	Application of enforcement braking to stop a train that has violated a current speed limit or authority limits.
Release of Limits	Relinquishment by a train crew of all or a portion of their authority limits.
Restricted Speed	Speed that allows stopping within half the range of vision short of a train, engine, railroad car, men or equipment fouling the track, a stop signal, a derail, or an improperly lined switch, not in excess of 20 mph; enforced as a 20 mph speed limit in Positive Train Control System operations.
Revocation of Authority	Action by the Train Sentinel® system to shorten a train's authority in response to a new constraint, such as a signal changing to *Stop.*
Reverse Movement	Train movement in the direction opposite of the authorized direction.
Reverse Switch Position	Position of a switch such that a train moving on the main track through the switch leaves the main track.
Rollup	Manual or automatic process whereby a train's authority is released behind the train after the train passes, making the track available for other traffic.
Rollup Location	Location to which a train's authority has been rolled up.
Siding	A track connected to the main track and used for meeting or passing trains.
Signal Aspect	The appearance of a fixed signal.
Signal Indication	The action required by the signal aspect.
Speed Enforcement	Positive Train Control System capability of preventing violations of speed limits through an automatic application of braking either in anticipation of or in response to over speeding.
Spur Track	A short track connected to a main track, often serving an industry location.
Stacked Route	CTC route requested but not yet cleared because of one or more previously requested overlapping routes having precedence; having been requested, the route will line automatically once traffic permits.
System Problem Report (SPR)	Reports used to document and trace a problem or change requirement initiated by either the vendor or the railroad.
TBD	To Be Determined.
TBS	To Be Specified.
Threat Alert	Textual message accompanied by an audible signal alerting the train crew to a threatening condition, such as an absolute signal ahead that has changed to *Stop,* or a train in the vicinity in violation of its authority.

Track and Time	Authority granted verbally in CTC territory for a train or track forces to occupy designated limits and move in either direction within those limits. The Positive Train Control System enforces a speed of 20 mph or less within the limits.
Track Bulletin	A notice of conditions affecting train movement, including speed restrictions for designated limits, authority for a maintenance crew to work on or about the track.
Track Database	Database containing locations and attributes of track over which trains are subject to location tracking and enforcement.
Track Forces Terminal	Device installed on-board a maintenance vehicle, such as a hi-rail, and used for running collision avoidance or proximity warning functions requiring the input or attention of track maintenance forces.
Track Warrant	Standardized form used to authorize the movement of trains or track forces on a main track within specified limits in a territory subject to Track Warrant Control (TWC), as designated in the timetable.
Train Control Speed Restriction	Enforceable speed limit derived from temporary movement instructions generated through the dispatcher system, as through a track warrant or track bulletin, or from timetable train handling instructions and the train consist.
Train Movement Authority	Authority for movement given to a train in a specified manner. Primarily pertains to non-signaled territory.
Train Sentinel® System	Refers to the locomotive on-board railroad safety system developed by Siemens Industry, Inc. Rail Automation.
TWC	Track Warrant Control, a method of authorizing train movements or protecting track forces on a main track within specified limits in a territory so designated in the timetable.
Unconditional Authority	Movement authority effective immediately upon issuance, not contingent on fulfillment of any condition.
Undefined Track	Track not represented in the track database and, therefore, not subject to location tracking or enforcement functions.
Visible Authority	Movement authority issued to the human operators of a train, by means of signals, track warrant, or other visible instrument, as distinct from the computer-readable enforceable authority, which is not displayed to the human and may differ in extent from the visible authority.

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