

Introduction to Wayside Detectors on Norfolk Southern Railroad

Wayside defect detectors are used to identify mechanical defects on rolling stock. The identification of these defects allows the train to be inspected and can prevent derailments and damage to company property. The most common detectors used on Norfolk Southern include hot box/bearing (HBD), hot wheel (HWD), dragging equipment (DED), high/wide load (HCD/WCD), wheel impact load (WILD), and sliding wheel (SLD/SLW). In addition, Automatic Equipment Identifiers (AEI) are used to help identify rolling stock and its position within a train's consist.

Hot Bearing (Box) Detector

HBDs scan the temperature of roller bearings on rolling stock. As bearings begin to fail, friction will increase, causing higher and higher temperatures until failure is imminent. The purpose of the HBD is to alert the train crew to a failing bearing before it completely fails. If the bearing is above a certain temperature threshold a radio announcement will be made so that the crew can stop and inspect the bearing. This inspection is typically done with a Tempilstik, which is a crayon like device that melts at a specific temperature. HBD locations are typically spaced ~15 miles apart to ensure adequate protection against catastrophic bearing failures. Norfolk Southern primarily uses the Progress Rail MicroHBD and Southern Tech NG/NG2 detectors.

Current HBDs in-service on NS utilize pyrometer (pyro) based scanners to determine the temperature of the bearing. These pyros are limited in that they do not read absolute temperature, but rather the change in temperature on the surfaces they are scanning. Therefore, the value recorded is always a referenced value. Typically, it will be the temperature of the bearing read, minus the ambient temperature. When the scanners are between axles/ bearings, the pyro will be referencing off of the bottom of the car bodies. These car body temperatures are considered to be equal to the ambient temperature, since they are sitting out in the elements. Once the bearing comes into view, it will typically be a higher temperature than the car bodies, which is the change in temperature detected by the pyro. This type of technology has several drawbacks. It requires the train to be travelling at a minimum speed (no slower than 7 mph) in order for the pyro to properly reference and detect changes in temperature. It can also give flawed readings if the "cold" sky or "hot" sun is in the view of the pyro instead of the car body. A view of the sky or the sun can cause false alarms for different reasons. The sky can be considered colder than the underside of the car bodies, and therefore has a larger temperature difference to the bearing. This can cause the pyro to record a higher temperature than is actually present. The sun itself is a much warmer reference and will saturate the pyro, potentially causing false alarms. Each of these circumstances will only occur if a car with the right body type that allows an unobstructed view of the sky or sun. Sun shots only occur at specific times of the year and day, during which the sun is at a 45 degree angle in the sky and directly in the view of the scanner.

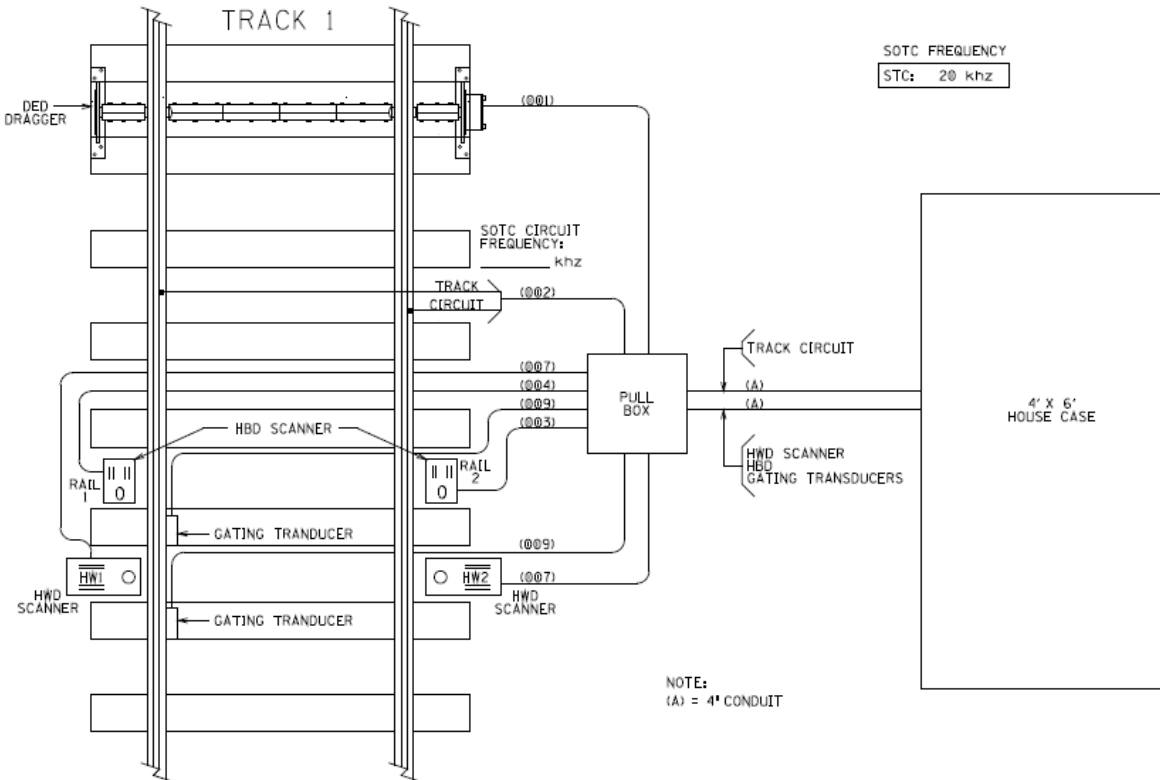
Each scanner has a shutter that remains closed until a train is being actively scanned. This shutter serves to protect the pyro lens assembly and keep dust/debris out of the scanner head. On the back of this shutter is an integrity resistor. This resistor will be

heated up post train, and the shutter will be closed so that the pyro can read the temperature of the resistor. This will serve as an integrity test to ensure that the pyro has not failed and is still reading changes in temperature. The latest firmware version requires this test to fail for 3 trains in a row before a "detector not working" announcement is made. In addition, the software will look at temperatures read for all bearings across the train, and if a minimum required temperature value is not met it will consider that a "cold train". Default alarms settings will not announce an integrity failure unless 3 cold trains in a row are detected. Cold trains can be considered normal depending on the traffic at a specific location. Amtrak passenger trains will be considered a cold train because their wheel bearings are on the inside of each wheel and won't be in the view of the scanners. Local traffic or trains that have only just begun moving may have lower bearing temperatures if they haven't built up much heat in the bearings.

While the scanners are vital to system operation, the transducers are equally important. These two single-element devices, typically spaced 24" apart, identify the location of the axle and control the timing of the entire HBD system. Once the first transducer is triggered, multiple samples of heat recorded by the scanners are saved, until the second transducer is triggered and the scan is completed. This window is considered the "gate", consequently when the axle is between transducers it is "in-gate". The scanners themselves are aligned pointing upwards to the center of the gate (the location where the bearing would be if the axle was centered between the transducers). This allows multiple samples of heat to be taken across the entire width of the bearing. The most common transducers used on NS are magnetic. As the wheel flange passes over the transducer it disturbs the flux field of the magnet, causing a sin-wave pulse to be generated. This pulse is processed by the system electronics and detects train presence, coordinates gating, determines train direction, calculates speed, calculates approximate length, and identifies locomotives and rail cars types based off of axle spacing.

In addition to the transducers, each HBD location will use an overlay track circuit. This circuit is usually set up to extend about 75 feet on either side of the equipment, and serves to "wake up" the system before the first axle arrives at the transducers. This allows the shutters to open and the system to be fully operational before scanning begins.

A secondary function of all HBD locations is to report the train data recorded into the back office (JWDS/WDS). This data is then used to "trend" wheels and bearings. The wayside detector help desk will receive alerts from this data and can use it to assist the train crews with their inspection. This function will be covered in more detail in the JWDS/WDS section.



Hot Wheel Detector

The HWD is very similar to the HBD, differing only in that it scans the temperature of the wheel instead of the bearing. The main purpose of the HWD is to identify wheels with brakes inadvertently applied. This is usually caused by a hand brake left on, or sticking brakes. HWDs can also be used for "cold" wheel detection by placing them in areas where train traffic is known to be braking (typically going down a grade). Since each car should be braking, if the wheel/axle does not present any heat it can be surmised that the brakes are inoperative. HWD locations are strategically placed, typically being the second detector outside of yard limits. This gives the wheels time to build up the necessary heat for detection.

Typically the HWD will be an add-on to an existing HBD location. The PR Micro uses a separate HWD unit for processing, while the STC NG/NG2 directly supports the addition of the two scanners. The wheel scanners will be placed in the center of the gate pointing directly at the wheel (a few inches above and perpendicular to the rail).

Dragging Equipment Detector

DEDs are used to identify any equipment that may be hanging or dragging too low. Depending on the severity, these defects can cause harm to track structure and wayside equipment, or even derail a train. A DED will consist of a rotating base with paddles attached. These paddles are level to the top of the rail, on the outside and inside of the rail, and serve to actuate the base when they are struck. The rotating

base uses a torsion bar to “spring” back into the upright position after it is actuated. Either end of the DED has roller bearings that should be lubricated frequently to aid in smooth operation. Older DEDs will use a set of adjustable contacts that will be adjusted such that the circuit is broken after the dragger is actuated 8-10 degrees from center. Newer units will use a “Magamp” assembly that consists of a relay board and magnetic contact assembly (magnet and coil). When the DED is actuated the distance from the coil to the magnet is changed, activating the circuit. Almost all HBD locations will have a DED. There are also many DED only sites on the Northern Region (Harrisburg, Pittsburgh, Dearborn).

High/Wide Car Detector

High and wide car detectors are used to help protect areas, such as tunnels or bridges, which may have closer than normal clearances. These detectors use infrared emitters and receivers to create a beam at a certain height or width. If the beam is broken an alarm will be announced to the train crew. This alarming functionality will typically only be enabled for travel in the direction of the area being protected (if the tunnel is east of the location, only eastbound traffic will have alarms announced). High/Wide detectors are typically an additional alarm input into an HBD system, although some are standalone.



Wheel Impact Load Detector (WILD)

WILD detectors are used to identify multiple types of rolling stock defects, the most common of which are wheel flat spots, and imbalanced loads. A WILD detector will consist of a track panel with concrete ties and an asphalt under bed to give it a stable base. The “instrumented zone” will have multiple holes drilled into the rail in which strain gauges are installed. These gauges read the vertical and lateral forces applied to the rail in kips. Depending on the severity of these forces, alarms can be announced to the train crew. WILDs are an independent Salient (LB Foster) system.

They use a Progress Rail MicroTalker for radio announcements and receive real-time tag feeds from a co-located AEI.



Sliding Wheel Detector

Sliding wheel detectors, as their name suggests, identify sliding wheels. Sliding wheels are caused by a variety of factors, but they are typically seen when brakes are **firmly** applied to cars with little or no load (empty). If the wheel begins sliding, heat is only present at the rail to wheel interface point. This does not allow enough heat to build up and trigger a standard HWD. Therefore, a special detector is required to identify these events. Norfolk Southern is currently testing a thermal imaging solution provided by Comet Industries. It utilizes an AEI's APU2 along with a thermal camera add-on. The thermal camera collects the images of the wheels and the APU2 uses image processing to identify defects. If a wheel slides for long enough, flat spots and slag/tread buildup can occur. This can cause the car to derail if the brakes release and the wheel begins rotating again.



Automatic Equipment Identifier (AEI)

AEIs are used to identify equipment and build a consist for any train passing the site. They do not generate alarms of any kind and are solely used for informational

purposes. Each piece of rolling stock will be equipped with RFID tags programmed with the car owner and unique identifying number (ex: NS 99999). The AEI uses antennas to read this tag information and create a consist. This information is sent into back office servers and consumed by numerous parties (mainly Transportation). The AEI is triggered similar to a HBD location. There is an overlay track circuit that allows the system to wake up before train arrival. It also uses a dual element transducer (one transducer body with two sensors) for axle processing. AEIs typically use zero-speed transducers so that trains at any speed will be recorded. AEIs will report their train information to the real-time server via telephone/dial-up modem or cell modem. They are also used for other purposes, such as feeding real-time tag data to WILD detectors.

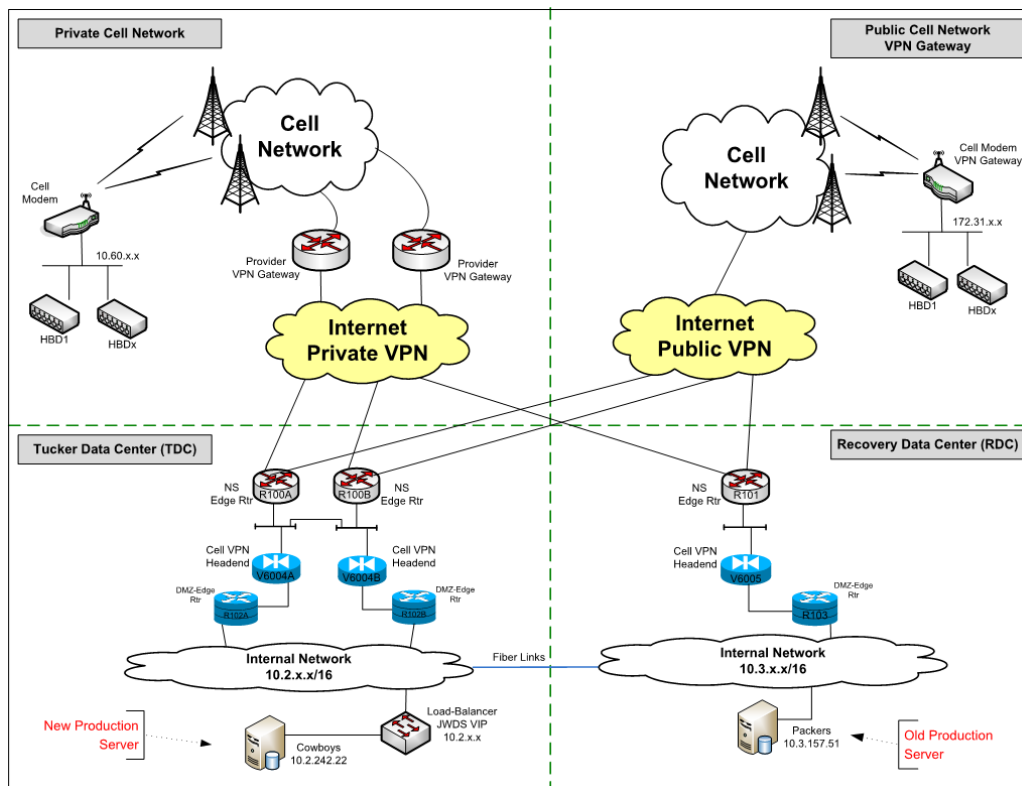
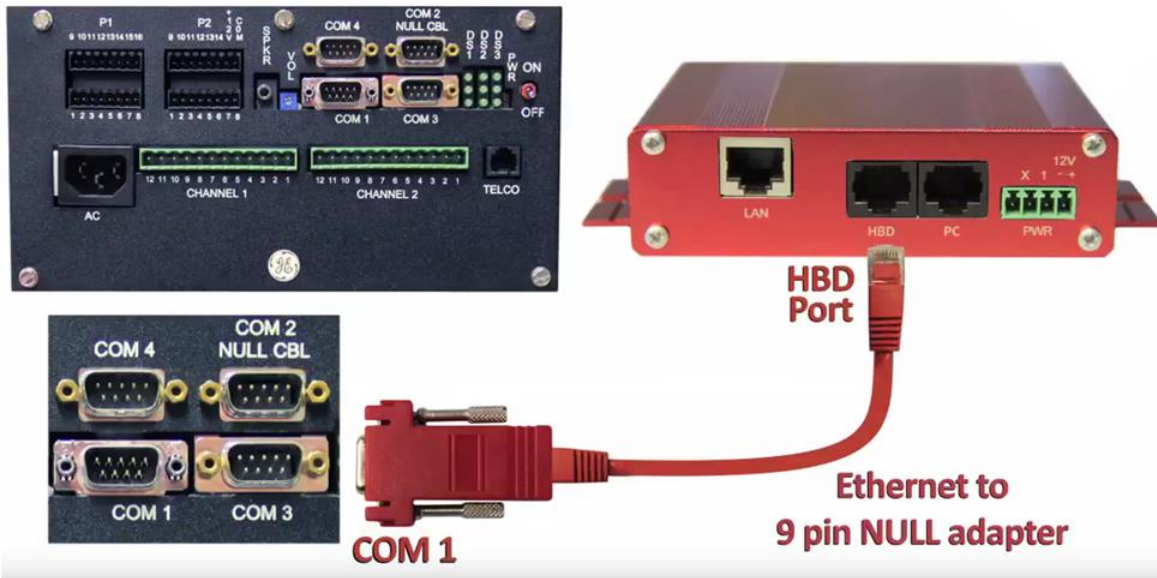


Detector Reporting: Velocity/SDM, VHF Backhaul, and the JWDS/WDS Server

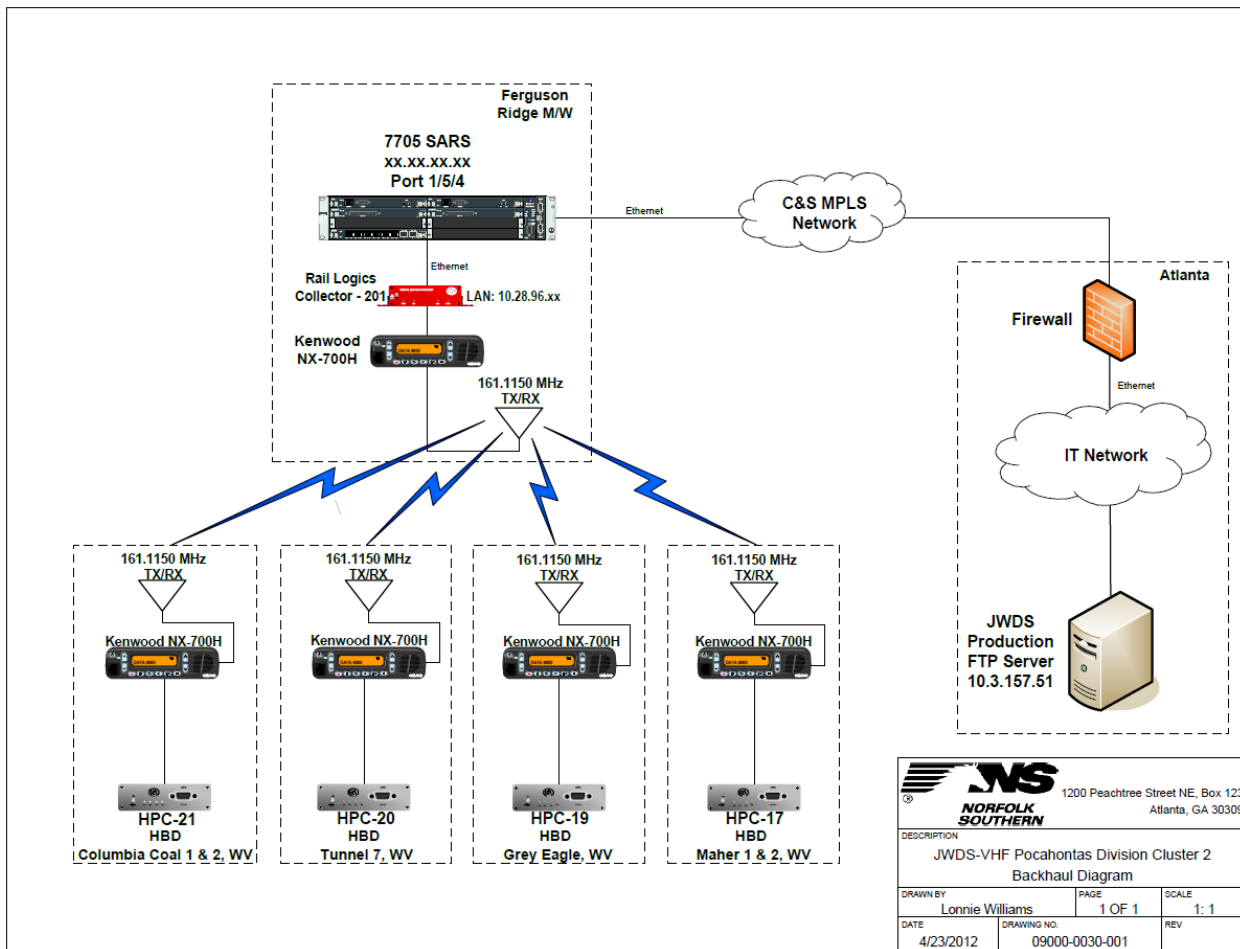
Almost all HBD/HWD locations will report the train data they record into the JWDS/WDS server. This network connection is accomplished via cell modem or VHF backhaul. An added benefit of having the detectors network connected is that they are remotely accessible, typically via telnet.

In addition to the detector's electronics, there are protocol converters/data collectors installed at each HBD/HWD location. These devices are the Serial Device Manager

(SDM), which is a standalone unit used with the PR Micro detectors, and the Velocity card, which is installed inside the STC NG/NG2. Both devices are made by the same company, Rail-Logic. The primary purpose of these converters is to collect all train data from the detectors, generate s918B/s9203B reports for each train, and transmit these reports to the server. When connecting via telnet, the user will first be connected to the Velocity or SDM. In addition to storing received train data, the SDM/Velocity allows the user to pass into the HBD and access its menus directly.



In areas with little to no cell coverage, VHF backhaul is used to transmit train reports to the server. The devices used for VHF backhaul are also Rail-Logic products. These include the Saturn-R, which is remote unit installed at the HBD location along with a VHF radio. The Saturn-B, also called a collector, is installed at a microwave or VHF radio site and also has a VHF radio of its own. The Saturn-R will transmit train data via VHF to the Saturn-B, which will store and use the network connection on site to transmit it to the JWDS/WDS server. The collector can “collect” reports from multiple HBD locations as long as there is an appropriate path to allow good VHF connectivity. These connections allow very limited remote connectivity to the HBD location because of bandwidth restrictions, and therefore are used as a last resort.



The JWDS/WDS server collects all train data sent in from the various detectors across the network. These reports are compiled and used to display train data to the Wayside Detector Help Desk (Mechanical/Transportation Department). This help desk will alert trains of any trending notifications and help them determine where inspection is required.