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Transportation

**Federal Railroad
Administration**

Status of the Transportation Technology Center - 2015

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Washington, DC 20590

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Final Report
March 2016

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13. ABSTRACT (Maximum 200 words) The Transportation Technology Center (TTC) is a Federally owned, privately operated test facility in Colorado. It has over 50 miles of test track arranged in different configurations for testing all aspects of vehicle-track interaction. Maximum test speed is 165 mph (265 km/h). Overhead and 3rd rail electrification is available. Eighteen large buildings house offices, test fixtures, workshops and maintenance facilities. Outside facilities include the Security and Emergency Response Training Center, a crash wall, a rail vehicle squeeze test frame, and a fully functioning Positive Train Control test bed. Investment in TTC since its construction in the 1970s has ensured most of the assets are in good working order. Some long-life assets are at the end of their useful lives and are due to be replaced.			
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METRIC/ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC

LENGTH (APPROXIMATE)

1 inch (in)	=	2.5 centimeters (cm)
1 foot (ft)	=	30 centimeters (cm)
1 yard (yd)	=	0.9 meter (m)
1 mile (mi)	=	1.6 kilometers (km)

AREA (APPROXIMATE)

1 square inch (sq in, in^2)	=	6.5 square centimeters (cm^2)
1 square foot (sq ft, ft^2)	=	0.09 square meter (m^2)
1 square yard (sq yd, yd^2)	=	0.8 square meter (m^2)
1 square mile (sq mi, mi^2)	=	2.6 square kilometers (km^2)
1 acre = 0.4 hectare (he)	=	4,000 square meters (m^2)

MASS - WEIGHT (APPROXIMATE)

1 ounce (oz)	=	28 grams (gm)
1 pound (lb)	=	0.45 kilogram (kg)
1 short ton = 2,000 pounds (lb)	=	0.9 tonne (t)

VOLUME (APPROXIMATE)

1 teaspoon (tsp)	=	5 milliliters (ml)
1 tablespoon (tbsp)	=	15 milliliters (ml)
1 fluid ounce (fl oz)	=	30 milliliters (ml)
1 cup (c)	=	0.24 liter (l)
1 pint (pt)	=	0.47 liter (l)
1 quart (qt)	=	0.96 liter (l)
1 gallon (gal)	=	3.8 liters (l)
1 cubic foot (cu ft, ft^3)	=	0.03 cubic meter (m^3)
1 cubic yard (cu yd, yd^3)	=	0.76 cubic meter (m^3)

TEMPERATURE (EXACT)

[(x-32)(5/9)] °F = y °C

METRIC TO ENGLISH

LENGTH (APPROXIMATE)

1 millimeter (mm)	=	0.04 inch (in)
1 centimeter (cm)	=	0.4 inch (in)
1 meter (m)	=	3.3 feet (ft)
1 meter (m)	=	1.1 yards (yd)
1 kilometer (km)	=	0.6 mile (mi)

AREA (APPROXIMATE)

1 square centimeter (cm^2)	=	0.16 square inch (sq in, in^2)
1 square meter (m^2)	=	1.2 square yards (sq yd, yd^2)
1 square kilometer (km^2)	=	0.4 square mile (sq mi, mi^2)
10,000 square meters (m^2)	=	1 hectare (ha) = 2.5 acres

MASS - WEIGHT (APPROXIMATE)

1 gram (gm)	=	0.036 ounce (oz)
1 kilogram (kg)	=	2.2 pounds (lb)
1 tonne (t)	=	1,000 kilograms (kg)
	=	1.1 short tons

VOLUME (APPROXIMATE)

1 milliliter (ml)	=	0.03 fluid ounce (fl oz)
1 liter (l)	=	2.1 pints (pt)
1 liter (l)	=	1.06 quarts (qt)
1 liter (l)	=	0.26 gallon (gal)
1 cubic meter (m^3)	=	36 cubic feet (cu ft, ft^3)
1 cubic meter (m^3)	=	1.3 cubic yards (cu yd, yd^3)

TEMPERATURE (EXACT)

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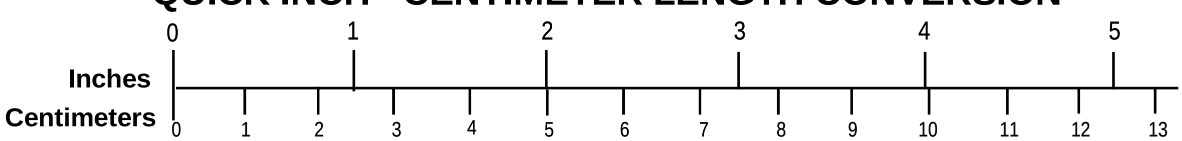
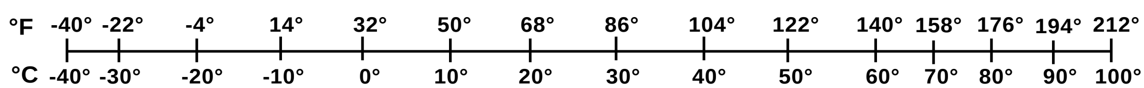
QUICK INCH - CENTIMETER LENGTH CONVERSION



QUICK FAHRENHEIT - CELSIUS TEMPERATURE CONVERSIO



For more exact and or other conversion factors, see NIST Miscellaneous Publication 286, Units of Weights and Measures. Price $2.50 SD Catalog No. C13 10286

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Acknowledgements

This report was produced with the help of the Transportation Technology Center, Inc., (TTCI) the current contractor responsible for the care, custody and control of the Federal Railroad Administration's (FRA's) Transportation Technology Center. Much of the content of this report was taken from other documents supplied by TTCI to FRA.

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Executive Summary

This report describes the current status of the buildings, laboratories, test tracks and equipment at the Federal Railroad Administration's Transportation Technology Center (TTC) located near Pueblo, Colorado.

TTC is located on 52 miles of high prairie and is accessible by rail from nearby rail line operated by BNSF Railroad. It has over 50 miles of test track arranged in different configurations for testing all aspects of vehicle-track interaction. Maximum test speed is 165 mph (265 km/h). Overhead and 3rd rail electrification is available.

Eighteen large buildings house offices, test fixtures, workshops and maintenance facilities. Outside facilities include the Security and Emergency Response Training Center, a crash wall, a rail vehicle squeeze test frame, and a fully functioning Positive Train Control test bed.

Investment in TTC since its construction in the 1970s has ensured most of the assets are in good working order. Some long-life assets are at the end of their useful lives and are due to be replaced.

TTC is currently operated by Transportation Technology Center, Inc., a wholly owned subsidiary of the Association of American Railroads (AAR), under a care, custody and control contract with the Federal Railroad Administration. It is used to perform research and testing for the Government, the AAR and other private parties.

1. Introduction

This report describes the current status of the buildings, laboratories, test tracks and equipment at the Federal Railroad Administration's (FRA) Transportation Technology Center (TTC) located near Pueblo, Colorado. TTC is currently managed and operated by Transportation Technology Center, Inc. (TTCI) (a wholly owned subsidiary of the Association of American Railroads) under a care custody and control contract with FRA.

FRA's mission statement for TTC is "To maintain state-of-the-art research and test capabilities to support D.O.T. and other Government and private entities in problem solving, personnel training, product evaluation, and support of research and development of new emerging technologies to improve the safety, security, efficiency and environmental impact of transportation."

1.1 Background

1.1.1 Location

TTC is located predominately in Pueblo County, Colorado (see Figure 1). The address is 5550 D.O.T. Road, PO Box 11130, Pueblo CO 81001.

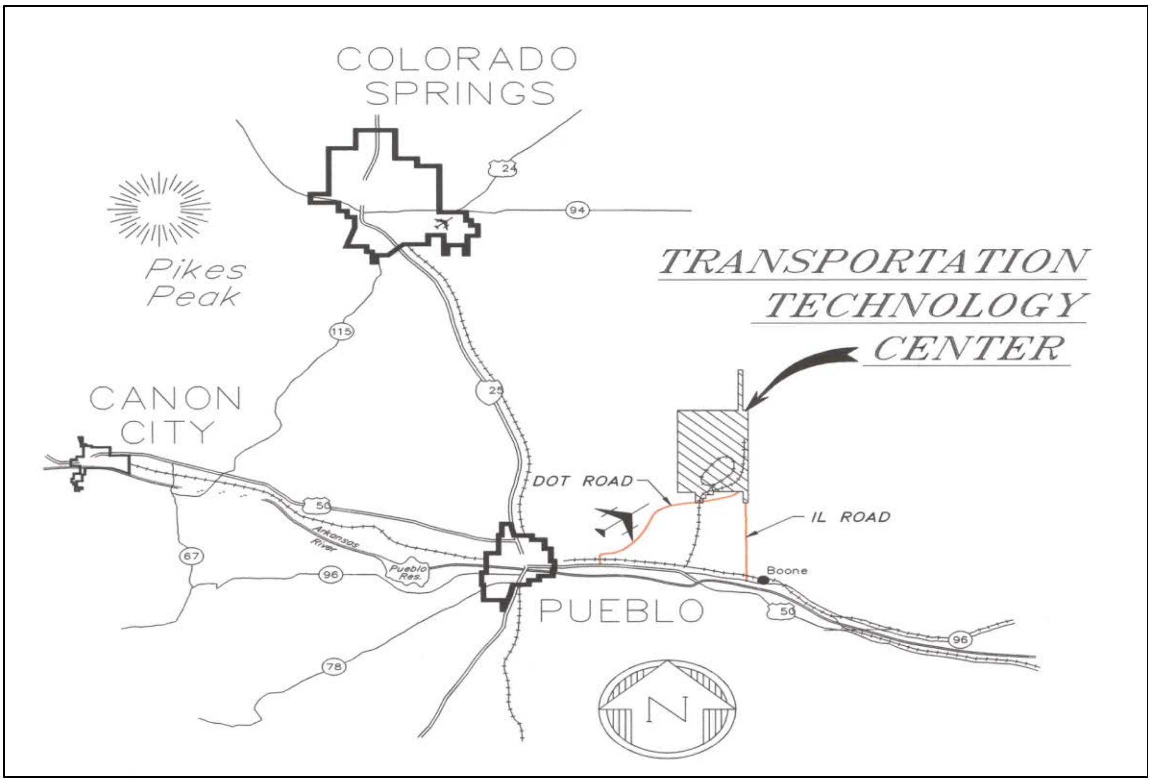

Figure 1. Location Map for the Transportation Technology Center

1.1.2 Authorization

Development of the test facility was authorized by The High Speed Ground Transportation Act, Public Law 90-423, 90th Congress, H.R 16024, dated July 24, 1968, which provided the Secretary of Transportation the authority for test site acquisition. The site near Pueblo was selected from an original list of 75 candidate sites throughout the United States. Construction began in 1970 on land previously used for livestock grazing.

1.1.3 Real Estate

TTC is on land owned by the State of Colorado. The land was leased to the Department of Transportation (DOT), Federal Railroad Administration (FRA) on August 22, 1970. The lease agreement, covering 33,492.13 acres (135,533.78 hectares) approximately 5.5 miles (8.85 km) wide and 9 miles (14.5 km) long, was for a 50-year period ending on August 22, 2020, with an option to renew for two more 50-year periods with no change of terms. The first extension option has been exercised, with the lease period extended to August 22, 2070.

The FRA has a lease only for the surface use of the land. The State of Colorado retains all rights to the minerals of the site. The FRA cannot explore, drill or mine for any minerals on the land.

1.1.4 Topography and Geology

TTC is located on semi-arid rangeland. Generally it consists of rolling plains. Most of the land is void of erosional channels due to the high permeability of the soil. Some, normally dry, shallow arroyos exist to the south and west where clay soils surface. The terrain is generally treeless, covered mainly with sparse bunchgrass, sagebrush, tumbleweed and cactus.

Elevations vary from 5,300 feet (1,615 m) above sea level in the northeast part of TTC to about 4,830 feet (1,472 m) in the southwest. The surface varies from gently sloping and slightly undulating terrain in the south and west parts of the site to progressively more sharply rolling sand hills to the north and east.

Exposed geologic deposits at the TTC site are the Nussbaum formation (tertiary) and dune sands (quaternary). Beneath these is the Pierre Shale formation.

The U.S. Department of Agriculture Soil Conservation Service prepared a Resource Conservation Plan for the site in 1973. The Plan, which is on file at TTC, details the climate, soils, vegetation, wildlife, hydrology, geology, and archeology of the site.

1.1.5 Climate

The climate at TTC is semi-arid, marked with large daily temperature variations, bright sunlight and low humidity. Climatological data presented here were recorded by the National Weather Service at the Pueblo Memorial Airport some 20 miles (32 km) southwest of the TTC and reported by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Data Service, Local Climatological Data for Pueblo, Colorado.

Average daily temperatures range between a minimum of 15°F (-9°C) in January and a maximum of 92°F (33°C) in July. The lowest temperate on record is -31°F (-35°C), the highest on record is 108°F (42°C). Mean daily temperature changes are about 30°F (17°C) with extreme changes sometimes in excess of 60°F (33°C). Freezing temperatures occur during 152 days of the year. Annual precipitation (including the equivalent from snow) averages 12 inches (305 mm) with greater precipitation during the summer. The average annual snowfall is 32 inches (815 mm).

Thunderstorms average 44 per year, occurring mostly in the afternoons of July and August. High winds up to 80 mph (129 km/h) are common in all seasons with frequent dust storms in the spring. Wind speeds average about 8 mph (13 km/h) during the year with a prevailing wind direction out of the south-southeast. The average relative humidity in early morning is 64 percent, and in the afternoon it is 34 percent. Barometric pressure averages 25.2 inches (640 mm) of mercury.

The sun, shines during about 73 percent of the daylight hours, creating significant radiant heat in metallic and other exposed surfaces. Averages of direct and diffuse solar radiation are approximately 650 langley in July and 260 langley in January. At ground level there is typically some 25 to 75 percent more solar radiant energy than appears along the northeast coastal regions of the U.S.

Real time, short term forecasts, and historical weather data can be accessed from the internet. Three regional sites available are; http://www.weatherbug.com, www.weather.com, and www.crh.noaa.gov using Pueblo as the local source point. TTC also has basic weather stations at the Operations Building and at the Facility for Accelerated Service Testing.

1.1.6 Environmental Factors

The site of TTC has little diversity of plants and animals. Lack of water is the primary limiting environmental factor throughout the region. Strong winds, temperature extremes and loose, sandy soil are also negative environmental factors.

Prairie dogs have established communities at TTC, but population densities fluctuate widely with available food supply and disease. Antelope are fairly common and represent a hazard if not controlled and herded away from high-speed test operations. The Colorado Parks and Wildlife is invited to catch and remove antelope at around 5-year intervals, when rail vehicle impacts start to rise. Various raptors prey on rodents and other small animals at TTC. Reptiles are also present – most notably the prairie rattlesnake.

Areas, which have been disturbed, or over grazed by wildlife, are sparsely covered with annual and perennial herbaceous weeds. Tumbleweed is prevalent and was a problem during initial construction of the facility. Tumbleweeds can accumulate in large quantities around structures or in depressions, impeding operations. The weeds also act as a lubricant when mashed on the rail surface.

Air quality at TTC is currently good, with concentrations of most of the major pollutants being well below national primary and secondary standards. Pueblo County is classified as being in an attainment area for air emissions for regulatory purposes. Suspended dust particles can be a problem, especially along dirt roads and in places where the soil is disturbed by operations.

There are no significant amounts of surface water on the facility. Surface water is intermittent on the south edge of the property in the Haynes Creek channel, and on the west side in the Black Squirrel Creek channel.

The only significant causes of noise at TTC are the test programs. Such noises can be loud in localized areas at times but are usually of very short duration.

Other than some surface artifact sites, there are no known archaeological or historical sites on the facility or in its vicinity. TTC has not been used for public recreation; however, the surrounding areas are used for hunting. Hunting or the possession of firearms on TTC property is prohibited.

A programmatic Environmental Assessment (EA) for TTC has been developed and issued by the FRA. The document evaluates the potential direct, indirect, and cumulative effects on the human and natural environment resulting from the continued and future operation of TTC. TTCI is responsible for implementation of any minimization or best management practices identified in the EA. The EA document can be found at: https://www.fra.dot.gov/eLib/details/L17192.

1.1.7 Hazardous Weather Shelters

There are two fallout shelters at TTC. One is in the Rail Dynamics Laboratory building (capacity of approximately 225 persons) and the other is in the Operations Building (capacity of approximately 200 persons).

1.1.8 Safety and Security

Transportation Technology Center, Inc. (TTCI), the current contractor, is responsible for safety and security at TTC. TTCI has a full time Fire Chief who is on 24-hour call to coordinate emergency response efforts. TTC security personnel are trained Emergency Medical Technicians.

TTCI has a pool of volunteer Fire Brigade Responders (currently 14 members) to respond to fires during normal business hours. The members are on-call outside of working hours.

Site security at TTC is provided 24 hours a day, seven days a week. The Main Gate Guard House controls entrance to the facility. The entire perimeter of the facility is fenced. Gates at supplementary access roads are locked and warning signs are posted around the perimeter. Additional security fencing within TTC is provided around some restricted areas and facilities.

Public access to the facility is by invitation only. Federal staff can use their official identity badges to gain access. TTCI and authorized contractor personnel, as well as official visitors are issued badges, which authorize access to the facility in general. Visitors and some contractor personnel have restricted access or escort requirements, which are assigned depending on the business being conducted. Entrance to specific test areas is further controlled by verification against an approved access list, or by an authorized TTCI employee or designee.

Fire prevention and security patrols are performed after hours and on weekends and are verified by radio contact, with all radio transmissions being recorded on a master tape.

1.2 Objectives

The objective of this report is to record the current status of FRA's Transportation Technology Center. This information is useful to potential users of the facility. It also establishes a base case for planning site investments.

1.3 Overall Approach

The information in this reported has been gathered from the site master plan, TTCI's reports on asset condition and the authors' inspection of the facility.

1.4 Scope

This report only describes the status of assets owned by the FRA at TTC. It does not cover assets owned by TTCI unless they are specifically mentioned.

1.5 Organization of the Report

Following this Introduction, the main sections of this report are:

Section 2 – Buildings, including electrical substations and the main pump house.

Section 3 – Test tracks, yards and service tracks.

Section 4 – Laboratory and test facilities, both inside and outside buildings.

Section 5 – Motor vehicle fleets and locomotives.

Section 6 – Roadways to and inside TTC.

Section 7 – Utilities, including electricity, water and telecommunications.

Figure 2 shows the general layout of the facility and is a useful reference for the sections that follow.

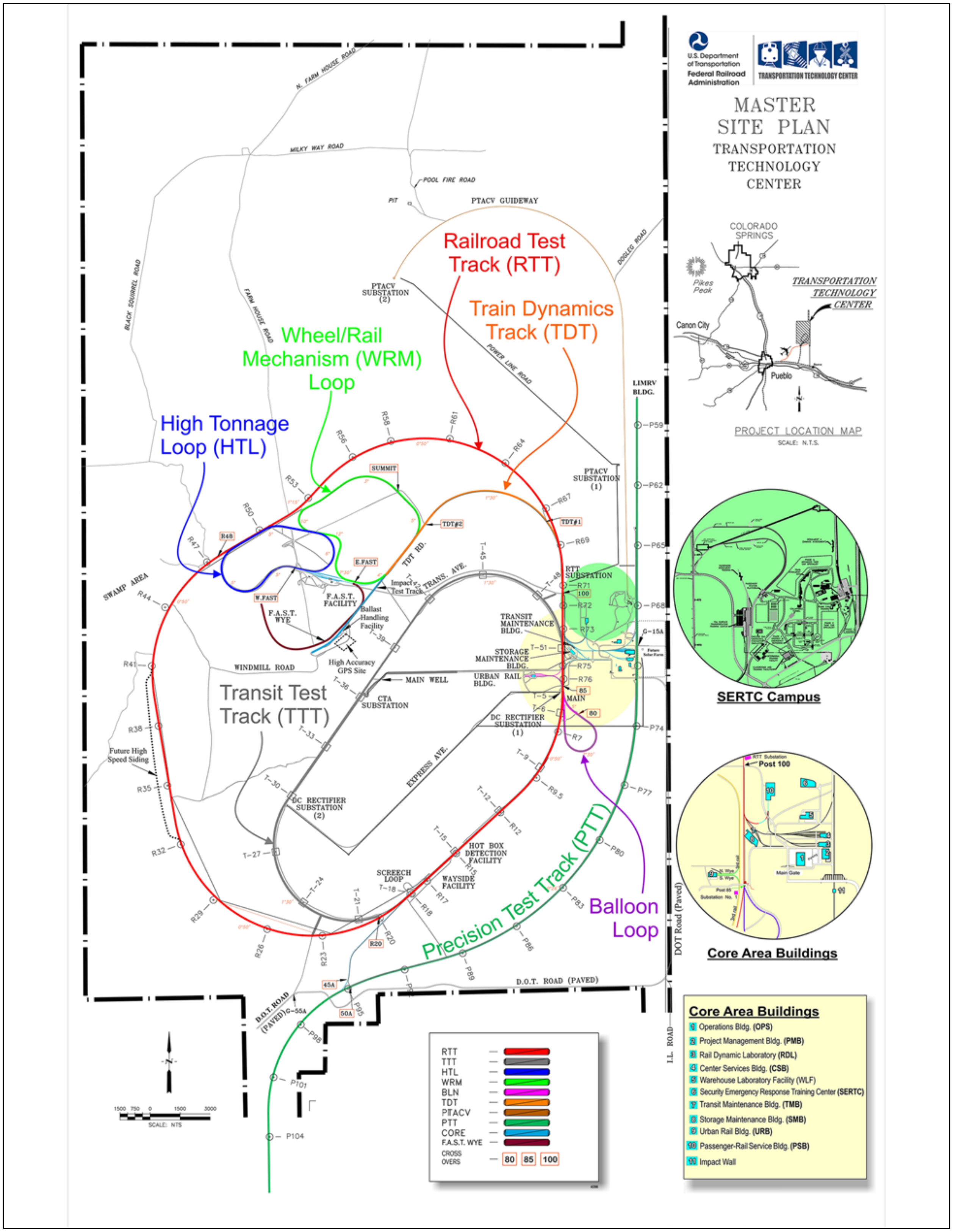

Figure 2. General Layout of the Transportation Technology Center

2. Buildings

There are eighteen buildings at TTC that each has a floor area greater than 2,000 square feet (186 m^2). These buildings house offices, laboratories, test equipment, storage, maintenance services and support facilities for ongoing research work at TTC. Figure 3 shows the core area where several of the principal buildings are located.

Figure 3. Core Area at the Transportation Technology Center

2.1 Main Gate Guard House

The Main Gate Guard House, shown in Figure 4, is located directly west of the Operations Building (OPS) on the main entrance road to the facility. The original structure, which was constructed with the OPS in 1975, was replaced in 2013. It now has many of the improvements recommended in a Physical Security Assessment that was conducted in April, 2012. Such items include bullet resistant glass and exterior wall construction, surveillance monitoring capability, panic alarm to local emergency response station, secured storage for firearms not allowed into the facility, badge reader system for employee entrance and exit, and improved vehicle barrier protection.

The central fire alarm station and a satellite water system monitoring station are located in the Main Gate Guard House.

Figure 4. Main Gate Guard House

2.2 Operations Building (OPS)

Figure 5. Front View of the Operations Building (OPS)

The Operations Building (OPS) (see Figure 5) is the main office building on site. The primary structure was constructed in precast concrete in 1976, followed by a southern addition in 1980. The combined building contains 54,487 square feet (5,062 m^2) of floor area. It includes a 42 by 24 feet (12.7 m by 7.3 m) conference room called Harris Hall. A data processing area and the Operations and Control Center (OCC) share a raised floor 75 by 55 feet (22.8 m by 16.8 m). In addition, the building houses the TTC cafeteria and a dining area. A removable wall system opens to Harris Hall from the dining area to create a large meeting room. The basement area (6,300 square feet (585 m^2)) is used to store records, and also serves as an emergency shelter.

Building sustainability improvements to the OPS started in 2011, and are still in progress. To-date, the windows, exterior wall and roof insulation, boiler, air handlers and condensing units of the heating, ventilating and air conditioning (HVAC) system, fire suppression system, water efficient faucets, LED office lighting, LED parking lighting, Energy Management System (EMS) have been replaced with high energy efficient components. To bring the building to LEED Silver standard would require refurbishment of the kitchen and restrooms, as well as landscaping around the building.

The general interior and exterior condition and appearance of the OPS Building is good.

2.3 Project Management Building (PMB)

Figure 6. The Project Management Building (PMB)

The Project Management Building (PMB) (see Figure 6) was constructed of pre-cast concrete panels supplemented with steel and aluminum trim work in 1972. This one-story building is 180 feet (49 m) long and 100 feet (33.5 m) wide, providing 17,400 square feet (1,616 m^2) of office space.

The PMB has not been used since 2007. The exterior is in good condition. The ceilings in the interior contain asbestos, which needs to be mitigated before the building can be reoccupied. A preliminary design was performed in 2011 to refurbish the PMB and convert it into a multiple use training and conference center. All lighting fixtures, heating and air cooling systems are original to the building.

The structure of the PMB is in good condition, but the interior finishes are showing normal wear for a 44 year old building.

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2.4 Rail Dynamics Laboratory (RDL)

Figure 7. The Rail Dynamics Laboratory (RDL)

The Rail Dynamics Laboratory (RDL) (see Figure 7) houses three major rail vehicle simulators, several smaller test stands and facilities to support laboratory testing. Construction began in June 1972 and occupation started in April 1974. The high-bay area of the building is constructed of structural steel and has exterior walls covered with fabricated metal panels. The walls of the low-bay area are constructed of concrete masonry units and pre-cast concrete panels. The floors of both sections of the building are of cast-in-place concrete. Built-in provisions to reduce noise and vibration permit most activities in the low-bay area to continue while testing is being conducted in the high bay. The high-bay area is served by two 100 ton (91 tonne) rated overhead cranes with hook heights of 42 feet (11.2 m). The cranes with support rigging are capable of lifting fully loaded freight cars, locomotives, or passenger vehicles and setting them on the simulators.

The RDL high bay is 355 feet (106.7 m) long by 103 feet (45.7 m) wide and is 55 feet (16.7 m) from grade level to bottom of roof structure. The main pit is 22 feet (6.7 m) deep by 220 feet (67.1 m) long and 84 feet (25.6 m) wide. The low bay area of the building consists of two floor levels approximately 265 feet (125 m) long by 50 feet (23.6 m) wide. The high-bay area is where most of the testing takes place, while all support equipment and service areas are housed in the low-bay portion.

The structure of the RDL is in good condition, but finishes are showing normal wear for a 40 year old building except in some office areas that have been recently refurbished. The roof of the building was replaced in 2014. Installation of LED light fixtures, high efficiency windows and wall insulation in the high bay was completed in 2015.

The mechanical heating and ventilating systems are original to the building. The air conditioning systems have R-22 Freon, and will need replacement in the near future.

2.5 Center Service Building (CSB)

Figure 8. The Center Service Building (CSB)

The Center Service Building (CSB) (see Figure 8) is located in the core area. It is the primary maintenance facility for TTC, providing for minor overhauling, repair, maintenance and test preparation in the high bay. The facility also provides office space, motor pool area, parts storage, and craft shop areas for vehicle and building maintenance. Located outside the CSB are a loading dock, a rail car squeeze fixture, yard tracks, vehicle fueling stations, and a locomotive servicing facility.

The high-bay service area is constructed of a structural steel frame covered with prefabricated steel panels. The interior walls of the low-bay area are constructed of concrete masonry units with a structural steel roof support system, and the exterior walls are precast exposed aggregate concrete panels.

The high-bay service area, measuring 367 by 100 feet (112 m by 30.5 m) has a clear height of 50 feet (15.2 m) to the roof structure and accommodates all major services performed on rail vehicles. This space is served by two 30 ton (27.2 tonne) cranes with 43.6 feet (13.2 m) hook heights.

Four tracks enter the high-bay area from the west. The most northern track (Track #4) continues through the building, to a concrete slab on grade east of the building. This features a repair pit with air, water, and power at convenient locations. A drive-on, wheel-truing machine is located at the center of the building on this track (see Figure 9). Installed in 1975, it is an under-floor, tracer lathe fabricated by Hegenscheidt MFD Corporation. The lathe was refurbished in the late 1980’s for hydraulic lines and components, and in 1990 for a control system upgrade. A review of costs to refurbish the main hydraulic cylinders showed them to be economically cost prohibitive. Wear in this area will degrade tolerance control over time, limiting use to freight wheels where tolerances are not as critical as higher speed passenger applications.

Figure 9. Wheel Truing Machine in the CSB

The second track from the north (Track #3) has a pit and services, but extends only to about mid-length of the building, terminating adjacent to the wheel-truing pit. The southern two tracks (Tracks #1 & 2) are surface tracks (without pits); with Track #2 also extending to about mid-length of the building. Track #1 extends to the far end of the high bay. The floor structure under the two southerly tracks will support 60 ton (54 tonne) jack loads at any point along the tracks.

Six additional tracks north of the building serve as storage tracks, with one leading to the Squeeze Test Fixture (Track #7) and one to the loading dock (Track #8).

Craft areas include workspace for maintenance and storage of equipment related to the high-bay activities. Areas include a Machine Shop, Weld Shop, Electrical Shop, Wood Shop, Plumbing Shop, Motor Pool, Locksmith, and Rail Vehicle Maintenance Shops. The Machine Shop includes Computer Numerically Controlled (CNC) milling machines, digitally controlled lathes and milling machines, drills to a 6-foot (1.8 m) radial arm drill press, power shear, power nibbler, table grinder, cutoff saws, and an assortment of tools and equipment to perform high precision machining on a variety of metals. The Weld Shop includes a tracer torch cutter and table, Arc, MIG and TIG welders, portable vacuum and blast cleaner, with both shop and field welding equipment. The Motor Pool has a 5-bay vehicle maintenance area, with two bays having hydraulic lifts to perform light vehicle maintenance. The total shop area within the CSB is approximately 15,000 square feet (1,393 m^2).

The first floor area also contains restrooms with showers and lockers for craft personnel. There are also two small office areas on the first floor level currently being used as customer field offices. Located on the second floor of this building are approximately 3,600 square feet (334 m^2) of office and break room space. The building's mechanical and electrical service rooms are located on the second floor.

The structure of the CSB is in good condition, but finishes are showing normal wear for a 40 year old building. The mechanical heating and ventilating systems were replaced with modern, energy efficient propane boilers in 2015. The air conditioning systems have R-22 Freon, and will need replacement in the near future.

2.6 CSB Storage Building (TTX Building)

Figure 10. The CSB Storage Building (aka the TTX building)

The TTX Building (see Figure 10) was constructed in 2007 under a joint funding agreement between TTCI and TTX. The building is FRA real property, with TTX receiving long term use under an agreement with TTCI.

The building is a pre-engineered metal construction 60 feet (18.3 m) wide by 80 feet (24.4 m) long, and is extendable to the west by an equal amount for future storage.

The TTX Building is in very good condition.

2.7 Warehouse Laboratory Facility (WLF)/Components Test Laboratory (CTL)

Figure 11. Warehouse Laboratory Facility (WLF) and Components Test Laboratory (CTL)

The building shown in Figure 11 was constructed in two phases, with the initial phase currently called the Warehouse Laboratory Facility (WLF) and the second phase called the Components Test Laboratory (CTL). Both phases were constructed in between 1979 and 1980. The completed building is a pre-cast, pre-stressed concrete structure. The total floor space is 53,428 square feet (4,964 m^2).

The CTL houses dynamic test equipment including the dynamometer for railroad wheel and brake testing, rolling load machines for rail and component wear and fatigue testing, and a tie wear machine.

The WLF contains a warehouse facility with a 21 feet (6.4 m) high ceiling, storage racks, forklift access, loading docks, receiving area, walk-in freezer, and a flammable materials storage room. A portion of the space has been sectioned off for the air brake laboratory.

Calibration equipment is also maintained in the WLF, including a controlled environmental room for specific equipment and calibration procedures. The Metallurgy Laboratory is on the second floor, mezzanine area of the WLF. Equipment includes an x-ray microscope, ultrasonic equipment, and other crack detection and metal properties testing equipment. The laboratory is set up with chemical handling equipment including an exhaust hood, storage, and the means to clean and prepare metal samples for inspection and testing.

From 2009 to 2010, the WLF roofs and the sloping wall on the front of the building (which were originally covered with solar panels) were replaced.

The structure of the WLF/CTL building is in good condition, but finishes are showing normal wear for a 35 year old building. The mechanical heating and ventilating systems are original to the building. The current diesel fired boiler was designed to handle half of the design load, with a second boiler planned, but never installed. The air conditioning systems have R-22 Freon, and will need replacement in the near future.

2.8 Security and Emergency Response Training Center (SERTC)

Figure 12. Security and Emergency Response Training Center (SERTC)

The Security and Emergency Response Training Center (SERTC) (see Figure 12) provides classroom and full-scale simulation training for emergency responders to rail and highway incidents. The initial building was constructed in 1973 to house and maintain the Prototype Tracked Air Cushion Vehicle (PTACV). The main structure is a pre-engineered metal building, 60 feet (18.3 m) wide by 120 feet (36.6 m) long. The PTACV program was completed in 1974, with the building modified in 1978 for testing of insulated tank car test assemblies.

In 1985 the building was used to start the Hazardous Materials Training Facility. In 1995, a major extension was added to the building to provide four auditorium style classrooms. The building addition is 60 feet (18.3 m) wide by 80 feet (24.4 m) long extending along the west side of the existing structure. Several portable office trailers and modular units are used to house the instructors and support technicians.

In 2009 the facility name was changed to the Security and Emergency Response Training Center (SERTC) to better reflect the full range of training being offered. In 2011, initial construction of a Highway and Emergency Response Training Area was added directly south of the Train Derailment Site. Roads are currently gravel surfaced, with truck accident simulations in place for training purposes. An open building style safety shelter has been installed with water and power supplies.

A crude-by-rail (CBR) derailment scenario was added to the north of the SERTC area in 2014. It includes a training shelter, a containment pad with container vans to store drums of crude oil and E-III training fluid. There is a power line extension to the CBR site and a water line extension with a fire hydrant for emergency use.

The main SERTC building interior is maintained in a like new condition. The exterior finish is in good condition, but showing some oxidation of the paint coating. The five modular units used for personnel offices are in poor condition and require a lot of maintenance.

2.9 Transit Maintenance Building (TMB)

Figure 13. The Transit Maintenance Building (TMB)

The Transit Maintenance Building (TMB) (see Figure 13) was constructed in 1973 as a temporary facility for mass transit vehicle testing. It is currently used as a project maintenance facility. The building is pre-engineered metal construction, insulated and heated, 40 feet (12.2 m) wide by 192 feet (58.5 m) long, with a single through track. The building has a 100 feet (30.5 m) long service pit between the rails with flat track for the remainder of the building.

An overhead catenary line extends from the Railroad Test Track (RTT), through the building and terminates on the inside end of the building wall. The catenary power can be isolated outside the building or at the RTT. Minimum catenary clearance height is 17 feet (5.2 m) inside the building.

An air table and pit are located on one end. These are capable of floating a two axle truck under a rail vehicle to measure resistance to curving. A parallel track to the south east of the building allows access from either end of the building. A rail vehicle weighing scale is located on this track directly outside the center of the TMB.

The TMB also contains a small office, storage area, fenced outside storage on paved surfaces, a restroom, and a small compressed air system.

The building structure is in good condition, but both exterior and interior finishes are in fair condition. The fiberglass light panels on the exterior walls, although intact, are oxidized with excessive weathering.

2.10 Storage and Maintenance Building (SMB)

Figure 14. The Site Storage and Maintenance Building (SMB)

The large one-story Site Storage and Maintenance Building (SMB) (see Figure 14) with track access was constructed in 1973 as interim warehousing and offices. The building is pre-engineered metal construction with a non-insulated and un-heated high bay, 130 feet (39.6 m) wide by 277 feet (84.4 m) long. A single track runs through the building. This building serves several purposes, including; craft material storage, lading and damage material staging, and emergency response vehicle staging. Areas available for project use, include ballasted track through the building for staging (no jacking), limited inside secured and un-secured storage, outside secured storage, large office space area (4,000 square feet (372 m^2)), which includes separate offices, conference rooms, a break room with kitchen, and restrooms with showers.

A fenced, gravel lay-down yard lies northwest of the SMB, and occupies an area approximately the same size as the building. This secured area is used for outdoor storage of material, supplies, and equipment, which cannot be housed inside the building.

The structural frame and exterior walls are in good condition. Half of the roof decking was replaced to remove excess penetrations in 2010. The other half over the storage area will need replacing when the fiberglass light panels degrade and weather seals on screw fasteners fail. The existing deck panel is an obsolete rib design that buckles under personnel traffic causing cracks at the top of the rib. Exterior and interior finishes are worn, but in an acceptable condition for the type of building use.

2.11 Urban Rail Building (URB)

Figure 15. The Urban Rail Building (URB)

The Urban Rail Building (URB) (see Figure 15) and adjacent yard tracks were constructed in 1980 as a permanent maintenance facility for vehicles using the Transit Test Track (TTT). A Wye track extends to the building from the TTT to allow turning of vehicles without leaving the TTT test area. Third rail power is extended along the Wye track into the building, with the power source controlled from the building. A portable stinger system can move rail cars from the end of the 3rd rail into the building. The DC power supply is separate from the TTT, allowing isolation of the URB facility from TTT testing. Each of the two rectifiers in the URB can provide up to 1,000 volts DC, with 1,000 amps.

Two yard tracks extend through the URB and an additional 350 feet (107 m) to the west of the building. Two additional yard tracks were added to the facility on the north side of the main access track.

The north track inside the building extends over a 40 feet (12.2 m) long service pit, with the south track and portions of the north track constructed as a flat track with jacking capability. The building is pre-engineered metal construction, insulated and heated, 102 feet (31 m) wide by 190 feet (57.9 m) long. Rooms are provided along the south wall, including a break room, offices, equipment storage, and restrooms with shower facilities. The side sloping walls were designed to allow for the building to be retrofitted in future with a solar system for building heating.

The exterior and interior finishes of the URB are generally in good condition.

2.12 Passenger-rail Services Building (PSB)

Figure 16. The Passenger-Rail Services Building (PSB)

The Passenger-rail Services Building (PSB) (see Figure 16) was constructed in three sections. The initial phase was constructed as the Japan Rail Facility (JRF) in 1999 and 2000. The initial building is pre-engineered metal construction, insulated and heated, 40 feet (12.2 m) wide by 230 (70.1 m) long, with a single track running through the building. It has a 12 feet (3.7 m) wide by 82 feet (25 m) long vehicle service pit, with movable jacking stands for lifting vehicles over the pit. The remainder of the track in the building is a flat track with jacking capability.

The facility name was changed to the PSB when the second phase was added from 2005 through 2008. The second addition includes a 90 feet (27.4 m) by 300 feet (91.4 m) high bay for rail vehicle activity, with a 31 feet (9.4 m) by 150 feet (45.7 m) low bay. A third phase was added in 2009 to convert the lower bay into a rail transportation training facility for the Transportation Security Administration (TSA). An additional 31 by 75 feet (9.4 m by 22.9 m) low bay extension was added for TSA training purposes. The total floor area of the PSB is now 46,160 square feet (4,288 m^2).

Three tracks extend through the building. Track #1 (west track) has an overhead catenary line that extends through the building to provide electrified cars access under power from the RTT. The height of the contact wire is 22.5 feet (6.86 m), which accepts all full height vehicles into the building that are allowed in interchange. The catenary power can be isolated at the building or at the RTT. The track south of the building includes a Wye track for turning vehicles, with access to either the core area buildings and facilities or the RTT. The track length inside the building is 550 feet (167.6 m).

Tracks #2 and #3 also extend through the building and have two 75 ton (63.5 tonne) rated overhead cranes with 10 ton (9.1 tonne) auxiliary hoists to service vehicles on the tracks. A service pit was also installed for a future 125 ton (113 tonne), 3-axle drop table to span between the two tracks. The service top and bi-fold doors have been integrated into the floor slab in preparation for the unit. A wheel truing pit was also installed in Track #3 for a future in-floor, CNC wheel truing machine (see the yellow panels in Figure 16). In addition to the tracks that extend through the building, Track #4 runs parallel and to the east side of the building. All four tracks extend approximately 300 feet (91.4 m) north of the building.

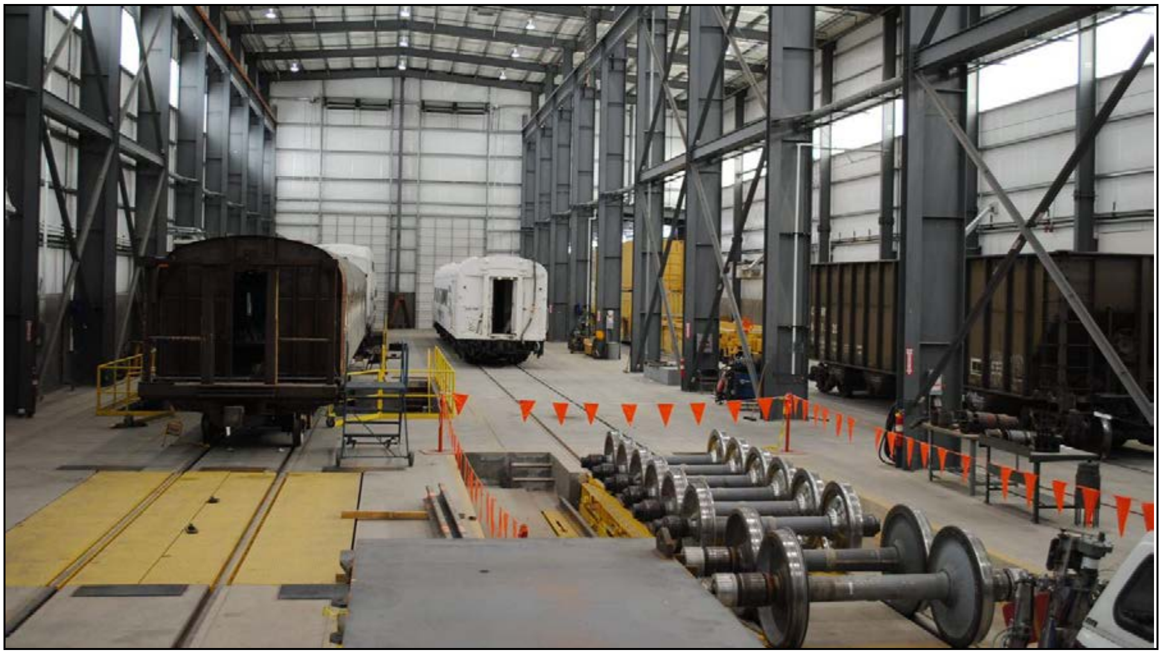

Figure 17. PSB High Bay, Facing South

The PSB is in very good condition. The HVAC systems are modern and in good working order.

2.13 FAST Maintenance and Office Buildings

Figure 18. The FAST Modular Building (left) and the FAST Maintenance Building (right)

The FAST Facility contains two primary structures to house project personnel and to perform routine maintenance on equipment and vehicles associated with the program – a maintenance building and a modular unit (see Figure 17). The FAST maintenance building is pre-engineered metal construction, 60 feet by 140 feet (18.3 m by 42.7 m) in size, insulated, and heated. It has two service tracks extending through the building, with a service pit under one of the tracks. The FAST modular unit is 3,600 square feet (334 m^2) in size, containing offices, restrooms, and a break room.

2.14 DC Rectifier Substations #1 and #2

Figure 19. DC Rectifier Substation #1

Figure 18 shows one of the two substation buildings that were constructed in 1976 to house the DC Rectifiers and associated controls for the Transit Test Track (TTT) loop. The units are a mirror image of each other, with DC Rectifier Substation #1 located on the east side of the TTT near the Post 85 road crossing, and DC Rectifier Substation #2 near the west side of TTT. Each building is 62 feet by 65 feet (18.9 m by 19.8 m), masonry wall and steel roof deck construction.

The two substations are located to provide power to the contact rail at equal distances around the 9.1-mile (14.6 km) TTT loop. Each is capable of providing a voltage up to 1,150 volts DC at 5,000 amps continuous, with substation rectifiers in parallel. Overload protection is set at 5,500 amps DC for two hours.

The rectifiers in the substations can be modified to operate in series. This allows the voltage to be increased to a maximum of 2,500 volts DC, but limits the maximum current at that voltage to 2,500 amps DC. Some light rail systems operate at 1,800 volts DC.

DC Rectifier Substation #2 transformer was rebuilt in 2013 after it was damaged by a lightning strike.

2.15 CTA Rectifier Substation Building

Obtained from the Chicago Transit Authority, this facility was used as a temporary DC substation to power the TTT 3rd rail system while the two permanent substations were in construction. The substation has been dismantled, and the existing pre-engineered metal building, 2,200 square feet (204 m^2), is currently being used for storage of materials and components.

The CTA Rectifier Substation Building is in good condition for its current purpose.

2.16 TLRV Maintenance Building

Figure 20. The TLRV Maintenance Building

The building shown in Figure 19 was constructed in 1973 to house and maintain the Tracked Levitated Air Cushion Vehicle (TLRV). It is located at the north end of the concrete “U” Channel (TLRV) Guideway. The building is pre-engineered metal construction, 40 feet (12.2 m) wide by 62 feet (18.9 m) long, with a concrete floor. The building is currently used for storage of site materials and equipment.

The interior of the TLRV maintenance building was insulated in 2014. The exterior walls, although intact, are oxidized with severe weathering.

2.17 LIM Maintenance Building

Figure 21. The LIMRV Maintenance Building

The building shown in Figure 20 was constructed in 1971 to house and maintain the Linear Induction Motor Research Vehicle (LIMRV). The building is pre-engineered metal construction, 32 feet (9.75 m) wide by 100 feet (30.5 m) long, insulated, electrical heat, with the track extended inside the building. The building is located at the north end of the LIMRV Test Track, now called the Precision Test Track (PTT). The LIMRV maintenance building is in fair condition and is used for storage of materials and equipment, as well as project space for test programs.

3. Test Tracks

3.1 Railroad Test Track (RTT)

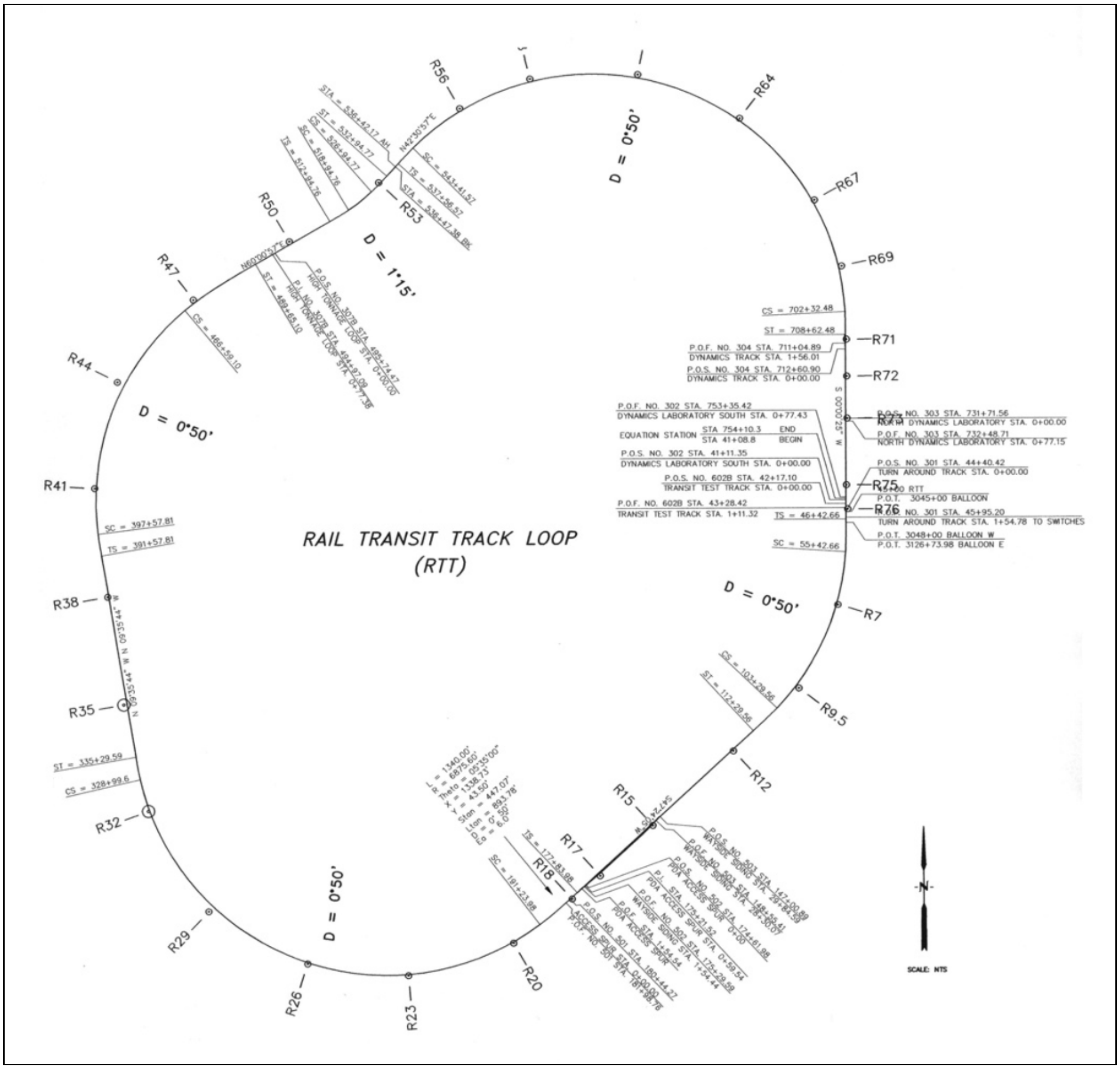

Figure 22. The Railroad Test Track (RTT)

The Railroad Test Track (RTT) loop with its overhead catenary system is located west of the TTC core area. It was constructed in phases during the early to mid-1970s to form a 13.5-mile (21.7 km) loop. Initial construction was predominantly ballasted track with softwood ties and cut spike fasteners. Rail used for the RTT is standard 136 lb/yard (67.5 kg/m), AREMA specification. Approximately two-thirds of the rail was initially installed as continuous welded rail (CWR), with the remaining in 39 feet (12 m) section jointed rails. The jointed rail section was converted to CWR in 1996.

Between 1995 and 1998, the RTT went through a major restoration program to upgrade the track by replacing the 25-year-old ties and upgrading to elastic fasteners. Concrete ties were installed on approximately 11 miles (8 km) of track, with hardwood ties used in the remainder of track under various test section conditions.

The RTT alignment is designed to test passenger vehicles with tilt technology at a maximum speed of 165 mph (265 km/h), to certify the vehicle for use at a maximum operating speed of 150 mph (241 km/h). Maximum speed for non-tilting vehicles is typically145 mph (233 km/h). Freight vehicle testing is limited to 80 mph (129 km/h) operating speed, unless qualified for higher speeds. The track is maintained to FRA Class 8 safety standards.

All curves around the RTT are 0º 50' curvature, except for the reverse curve, which has a 1º 15' curvature. This curve is speed limited based on the passenger vehicle’s ability for overbalance. All curves have a 6 inch (152 mm) super elevation.

The east tangent section of the RTT is 5,100 feet (1,550 m) long, with transition grades to 1.31 percent. The southeast tangent section is 6,500 feet (1,980 m) long, with a 1.47 percent grade at the upper and transitioning to 0.26 percent grade on the low end. The west tangent section is 5,900 feet (1,800 m) transitioning from a 0.62 percent grade at the low end, to 0.15 percent grade on the upper end. Elevation is at a low point at the south end of the loop at 4,861 feet (1,482 m) above mean sea level, and at a high of 5,035 feet (1,535 m) in the north east area of the loop, a difference of 174 feet (53.0 m).

A 60 feet (18.3 m) long section of track at station R38 has been installed with experimental ladder type concrete longitudinal ties. Vehicle dynamic performance often changes noticeably when the train passes over this section.

Figure 22 shows a Precision Geometry Slab Track section installed on the RTT in 2014. The section is 500 feet (152 m) long located on the tangent in section R16 where the maximum speed for testing in this section is at 165 mph (265 km/h).

Figure 23. RTT Precision Geometry Slab Track and Adjustable Fastener

The Precision Geometry Slab Track has 250 ties spaced 24 inches (610 mm) apart. The rails can be lowered or raised with shims at each tie location to create vertical geometry anomalies. The maximum dip that can be created is 2 inches (51 mm) in 1/16 inch (1.6 mm) increments. Lateral geometry anomalies are made with adjustable tie plates that can be moved and tightened into place as needed. The maximum allowable lateral adjustment is +/- 1.5 inches (38 mm) at 1/8 inch (3.2 mm) increments.

The RTT overhead system consists of a 4-wire compound catenary that receives power from the RTT substation located north of Post-100 and provides a continuous loop pattern around the track, as well as extensions around the Balloon Loop and extensions to two maintenance buildings (TMB and the PSB). The system may be configured for single continuous voltage, dual voltage, or broken single voltage depending on test requirements. In single continuous voltage mode, endurance testing and certification testing may be achieved at one of the adjustable voltage settings. In dual-voltage mode, tests may be conducted at 12.5 kV AC on half of the RTT loop and 25 kV AC on the other half of the loop simultaneously. The system can also be configured for 50 kV AC operation. In broken single voltage mode, testing of catenary power loss or phase break applications can be simulated.

The compound-catenary system design, shown in Figure 23, allows for electric-powered train sets to operate at velocities up to top speeds of 165 mph (265 km/h) with optimal pantograph pressures of 17 to 24 psig (117 kPa to 165 kPa) uplift.

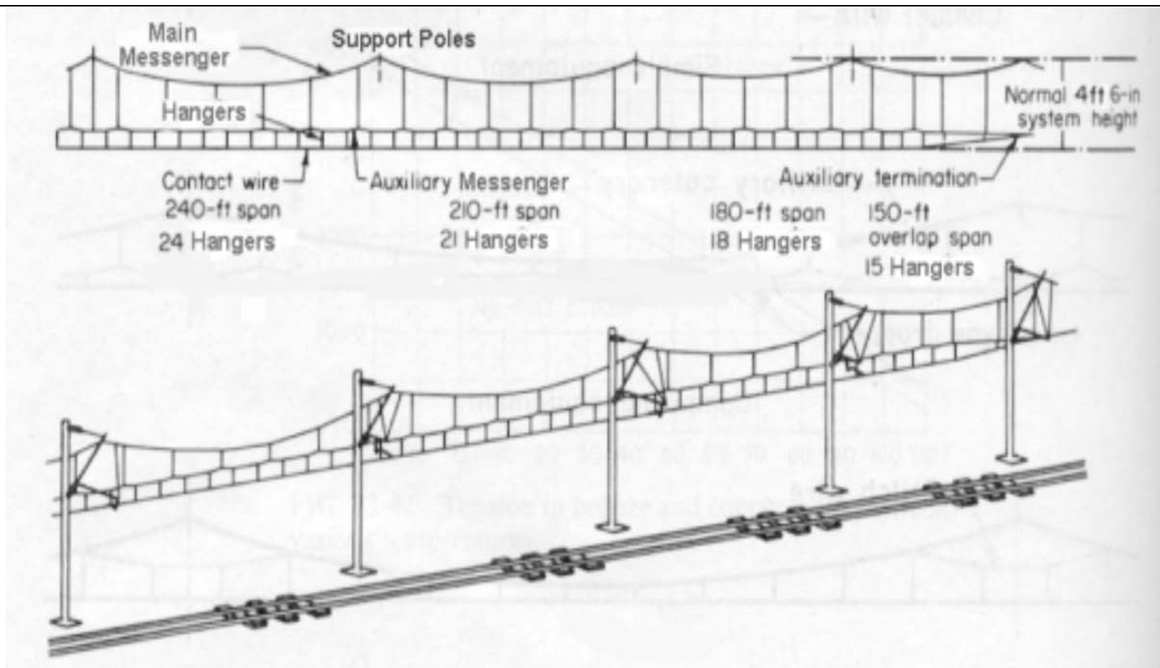

Figure 24. RTT Compound Catenary

The normal system height (the distance between the main messenger support point and the contact wire at the support pole) is 4.5 feet (1.37 m). For the normal wire height of 22.5 feet (6.86 m), the support height is 27 feet (8.23 m) above rail.

Design of the compound catenary system was performed by IECO (now part of the Morrison Knutsen group). The catenary support style varies around the track to represent different styles used on the North East Corridor at the time of design, since it represented the only example of a modern high speed catenary system currently installed in North America at that time. The complexity of the compound catenary is highlighted by the number of hangers used to support the contact wire. Each 30 feet (9.14 m) length of contact wire requires three hangers for support.

In recent years, the sagged-simple catenary has generally become the system of choice for high speed applications in Europe and is the system which was installed on the New Haven to Boston extension of the Northeast Corridor. The sagged-simple catenary is considerably less expensive to install than the compound catenary because of the reduced number of components in the contact wire support system.

The RTT catenary system has some extensive wear in the hanger support system and contact wires from more than 34 years of operation and exposure to wind action. Phased replacement will be needed in the near future. It has been recommended that tension sections (approximately 1 mile (1.6 km) long), are replaced as needed. All serviceable material recovered from such replacements will be recycled as spares for the compound equipment remaining in service.

The RTT was retrofitted with a switch point indication and broken rail detection system in 1997. The system is an Electrified Electro Code System, as manufactured by Harmon Industries, similar to what is currently used on the North East Corridor. The RTT is divided into 12 blocks, each approximately 6,000 feet (1,830 m) long, with an AC track circuit using a 156 Hz carrier frequency. A 4-ohm impedance bond is located at the end of each block to provide a low impedance path for the traction current return around the insulated joints at the ends of the blocks. An impedance bond is also located on the RTT adjacent to the AC substation for traction current return. Switch points and derails are also wired into the system to indicate correct alignment of the turnouts for running on the RTT. Dwarf indication lights have also been installed at the turnouts to give a visual indication of correct turnout alignment.

Radio signals from each block are transmitted to a main receiving station in the Operations Control Center (OCC) where the information is displayed on a computer screen. Vehicle travel can be tracked on the OCC display screen, as well as other track conditions. A portable tracking unit is also used in the cab of the test locomotive to display the same information available at the main receiving unit in OCC.

The detection system has also been upgraded to support standard cab signaling. It works on systems operating on 100 Hz cab signal, which is a typical North American freight railroad cab system, and on 250 Hz cab signal, which is unique to the North East Corridor. This system has been modified by adding signal lights, additional zone control, and other indication equipment as a test bed for Positive Train Control (see Section 4.14).

A 4,000 feet (1,220 m) long track siding was also added to the RTT between the two road crossings on the east tangent section. The two road crossings on the RTT, Post 100 and Post 85, have been retrofitted with crossing warning systems using lights and safety arm barriers. Sensors detecting rail vehicle movement activate the devices prior to reaching the crossing, and deactivate after leaving the crossing.

The rail on the RTT has good surface condition and is lightly worn. The crossties on the RTT are in good condition.

3.2 Train Dynamics Track (TDT) and Impact Track

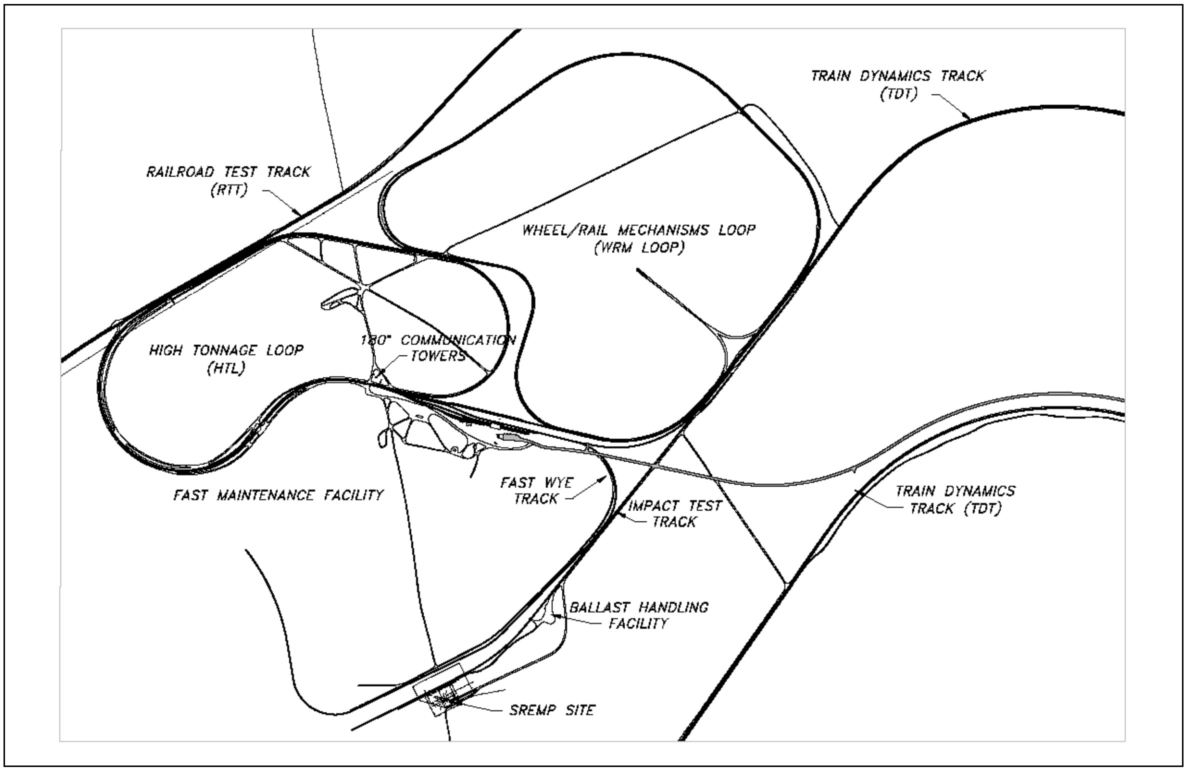

Figure 25. Train Dynamics Track (TDT) and Impact Track

The Train Dynamics Track is currently an access track to the FAST Facility, Impact Track, and Ballast handling Facility (see Figure 24). The TDT is maintained to FRA Class 4 standards, with maximum operating speeds of 60 mph (96.5 km/h) freight and 80 mph (129 km/h) passenger trains. The curve on the TDT has 1º 30' curvature with a 4.25 inch (108 mm) super elevation. The TDT is approximately 1.7 miles (2.7 km) long and 90 percent within grade.

The Impact Track is used for impact and derailment testing. The Impact Track is straight (tangent), 4,400 feet (1,341 m) long, with moderate (less than 1-percent) grades. This track is used to simulate and analyze carefully controlled “accidents” and various emergency situations. Impact tests at up to 60 mph (96.5 km/h) have been performed here. A section of the track near the FAST Wye Track has been set up with an at grade road crossing and wayside power outlets to run instrumentation and photographic equipment.

3.3 Transit Test Track (TTT)

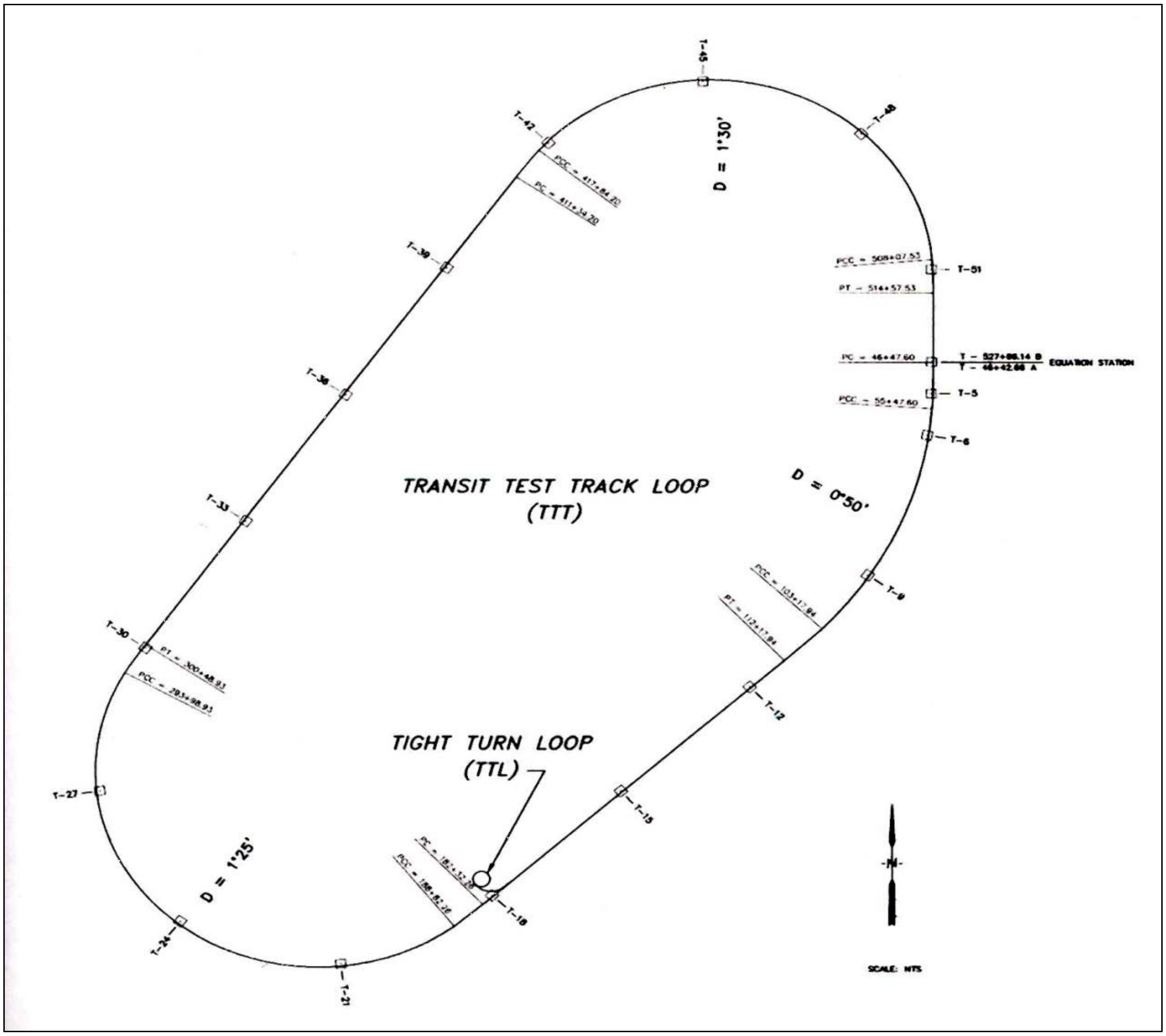

Figure 26. Transit Test Track (TTT)

The Transit Test Track (TTT) (see Figure 25) is located inside the RTT. It is a 9.1-mile (14.6 km) closed loop maintained to FRA Class 5 standards. The north and south curves have a super elevation of 4.25 inch (108 mm) on the 1° 30' curves. This allows the track to be used at the maximum operating speed of 80 mph (129 km/h) for freight vehicles in portions of the track, with passenger vehicles at a maximum operating speed of 89 mph (142 km/h), based on a 3 inch (76 mm) underbalance. Passenger vehicles may be allowed higher operating speeds if the class of track is upgraded, and the passenger vehicles are qualified for higher underbalance conditions.

The TTT's primary design purpose was to serve as a reference track for testing and evaluating urban rail vehicles including light, rapid and commuter rail cars. Secondary purposes are the development, test, and evaluation of vehicle subsystems and alternative types of track structures.

The rail on the TTT is moderately worn and requires grinding to restore it profile. The original crossties on the TTT are in poor condition and are undergoing phased replacement. In 2002 the pads, clips and bolts on all 8,300 concrete ties from station T33 CW to station T51 were replaced. From 2008 to 2015 4,000 wood ties were replaced. In 2013 150 ties were replaced at station T16, which has adjustable plates. Currently, approximately 48 percent of the crossties on the TTT are in very good condition.

The TTT consists of three tangent and three curved sections. The western tangent section, 11,000 feet (3,353 m) in length has approximately 4,200 feet (1,277 m) of level track (zero grade) and 7,700 feet (2,341 m) at 0.69 percent grade. The easterly portion contains approximately 5,200 feet (1,581 m) at 1.47 percent grade, part straight and part on a wide curve. The curves at the north and south end of the loop have 1° 30’ curvature, with a 3,820-foot (1,164 m) radius, and 4.5 inches (11.4 cm) of super elevation. The curve near the middle of the eastern side has 0° 50’ curvature and 3 inches (76 mm) of super elevation.

The TTT was constructed with six different test zones, in which the type of tie and tie spacing were varied. Figure 26 and Figure 27 show the two tie type configurations.

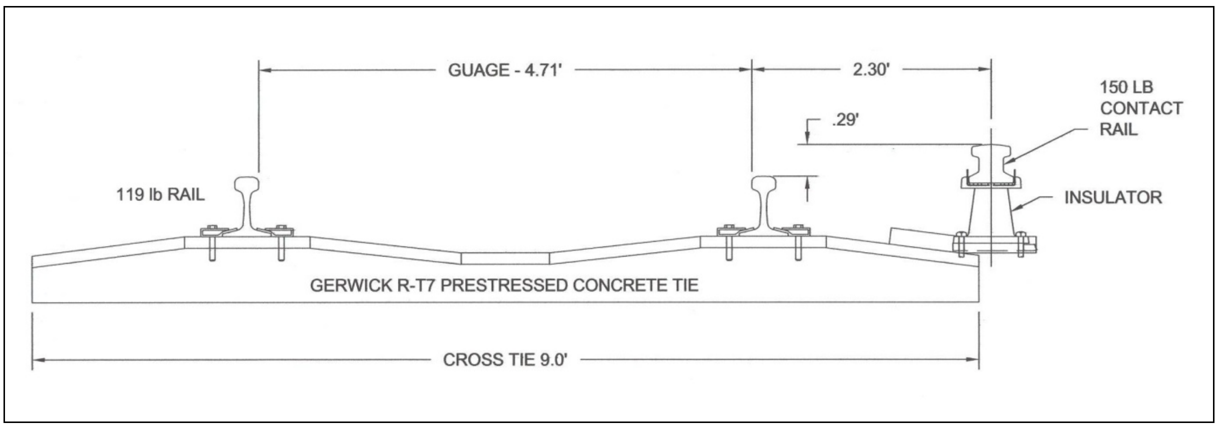

Figure 27. Typical TTT Cross Section, Track Assembly I, II, and III

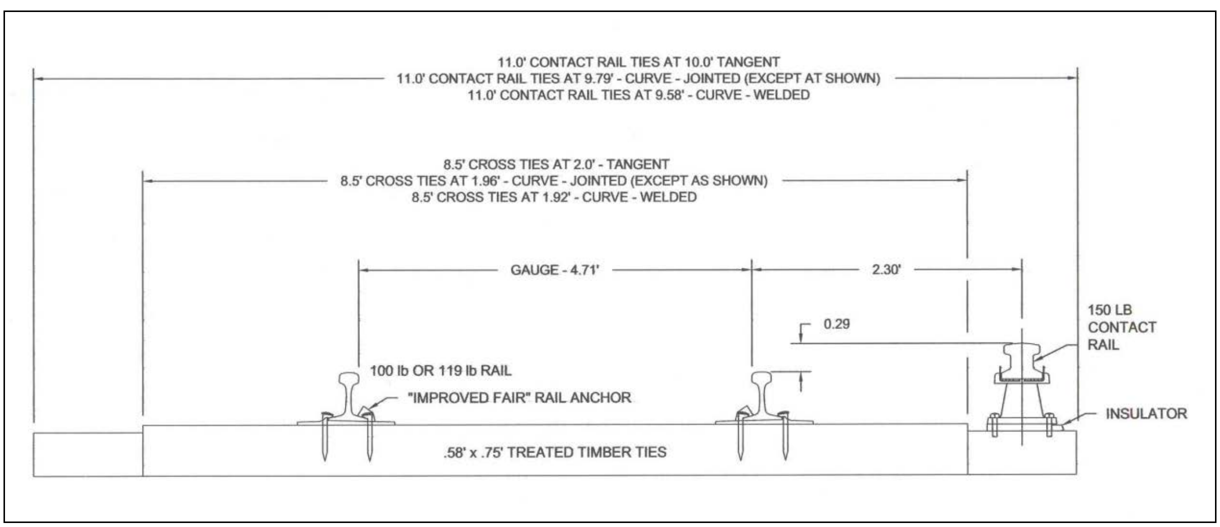

Figure 28. Typical TTT Cross Section, Track Assembly IV, V and VI

Each of the six test sections has a type of construction currently being used by transit systems. Sections I, II, and III employ hardwood ties spaced at 24 inches (610 mm) on straight track and spaced at 23 inches (584 mm) on curved track for jointed rail. The remaining track sections are laid on concrete ties. Section IV ties are spaced at 30 inches (760 mm) on straight track and at 27 inches (686 mm) on curved track. Section V, which is all curved, uses 23-inch (584 mm) center-to-center tie spacing and Section VI, also all curved, uses a center-to-center tie spacing of 33 inches (838 mm).

Two different weights of running rail are used in the TTT. Section I, IV, V and VI employ rail weighing 119 pounds per yard (59 kg/m), laid as continuous welded rail. Sections II and III use rail weighing 100 pounds per yard (50 kg/m), the rail in Section II being continuously welded, while that in Section III is jointed.

The track sections thus permit evaluating vehicle performance on the following types of track construction:

- 119 lb/yard (59 kg/m) continuous welded rail on wood ties
- 119 lb/yard (59 kg/m) continuous welded rail on concrete ties, at three different tie spacings
- 100 lb/yard (50 kg/m) continuous welded rail on wood ties
- 100 lb/yard (50 kg/m) jointed rail on wood ties

The lengths of each of the above combinations are sufficient to give meaningful data on factors such as noise, vibration and ride comfort.

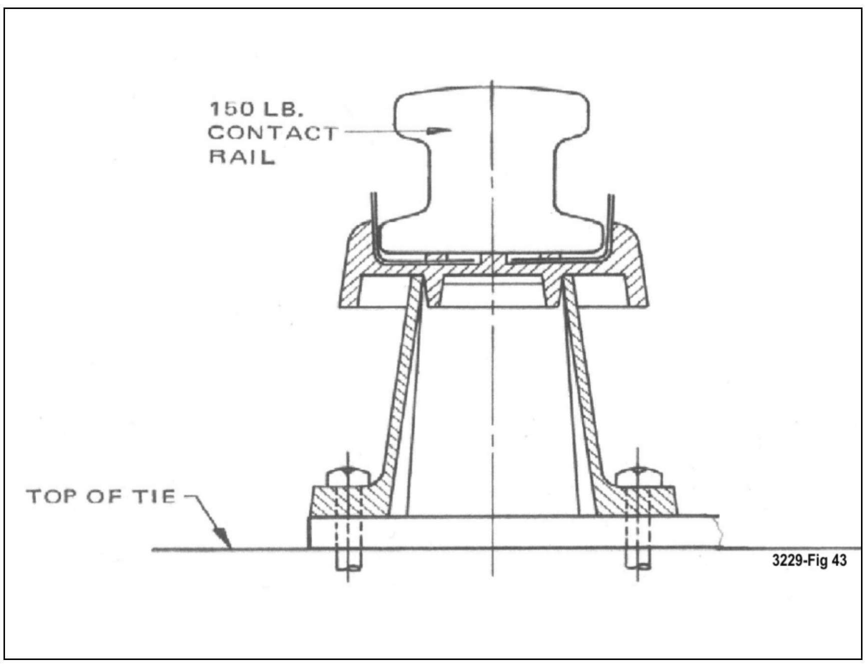

Figure 29. Detail of Contact Rail (Third Rail) and Support

The 3rd rail system on the TTT consists of two grounded running rails and a parallel contact rail powered by two DC substations. Figure 28 shows the 3rd rail support structure. Each substation is capable of providing 5.5 MW of DC power to the contact rail. The substations are configured in parallel and each substation contains two rectifier banks in parallel. This configuration allows the two 6-pulse rectifier substations to operate out of phase with each other to provide the appearance of 12-pulse rectification of AC power to DC power.

A 2-mile (3.2 km) section of overhead trolley style catenary was installed on the west tangent section of the TTT in the 1970s. A wayside track was recently added in the tangent section, with the overhead catenary reconfigured and reconditioned to provide power to both tracks.

The TTT was retrofitted with a switch point indication and broken rail detection system in 2015, similar to the RTT system. The system is an Electrified Electro Code System, manufactured by Harmon Industries, similar to that currently used on the North East Corridor. The TTT is divided into 8 blocks around the 9.1 mile loop.

3.4 Balloon Loop

The Balloon Loop is located on the eastern side of the RTT, south west of the TTC core are (see Figure 29). It was designed to allow trains to be turned on the RTT and to turn vehicles in the core area prior to the construction of the Wye track leading to the PSB building. It is 1.4 miles (2.25 km) long and has the same construction as the RTT. The track is maintained under FRA Class 3 safety standards. There is a 5º (349 m radius) curve on the east side of the loop. The rest of the loop is a 7º 30’ (233 m radius) curve.

The turnout from the RTT to the Balloon Loop and the turnout connecting the loop back to itself are #20 turnouts. A #10 turnout was installed in the west tangent section of the Balloon Loop, with a side spur track parallel to the tangent section. A car loader ramp assembly is located on the end of the spur track to load double stack car carriers.

Overhead catenary for the Balloon Loop transitions from compound style on the RTT, to a simple style catenary. The catenary around the loop can be isolated from the RTT to remove clearance restrictions when working on the track.

The Balloon Loop has also been modified to install the Rail Defect Test Facility (RDTF) (see Section 4.13). Rail defects have been added to the track on a set of parallel rails installed on the same set of cross ties. Movable switch points are used at each end of the parallel rails for access to the defect set of rails.

Figure 30. Balloon Loop Looking Northwest

The ties on the Balloon Loop are in poor condition. All wood ties on the RDTF portion of the loop need to be replaced with 10 foot wood ties equipped with an elastic rail fastening system.

3.5 Pueblo Chemical Depot (PCD) Access Track

The BNSF Railway provides interchange service to TTC indirectly. TTC is connected by an access track that extends through the Pueblo Chemical Depot (PCD) to a railroad siding and the Avondale Wye Track. The east leg of the Wye is Track #678, and the west leg is #679 for identification purposes. The Union Pacific Railroad also has tracks and yards in the local area, and is available for special local moves, subject to scheduling. All other pick-ups and deliveries must be scheduled through the BNSF.

Logistics moves to the interchange siding are coordinated with PCD personnel, but are performed with TTC locomotive power and personnel. All vehicles entering PCD are subject to search by PCD security personnel. All vehicles offered for shipment to the private carriers at the North Avondale Siding must be inspected by the designated carrier under the AAR Interchange Rules, and be accepted prior to pick-up. TTCI currently maintains the PCD access track.

The PCD is currently going through a program of environmental remediation of hazardous waste sites, destruction of hazardous ordinances, and site closure as a military base. The PCD facility is in a staged process of ownership transfer to the Pueblo Reuse Commission as the Department of Defense (DOD) decommissions sections of the facility. FRA is discussing long term access with the DOD.

3.6 Precision Test Track (PTT)

The Linear Induction Motor Research Vehicle (LIMRV) Program used a designated 6.2-mile (10.0 km) precision test track located near the east boundary of TTC. The program was completed in 1978, with a land speed record on conventional track set at 257 mph (414 km/h).

The 7.36-mile (11.8 km) track section is now called the Precision Test Track (PTT) (from LIMRV Maintenance Building to turnout 901). The track connects directly to the Pueblo

Chemical Depot (PCD) access track and is used as a primary access to interchange for shipping and receiving railcars off site.

The track is currently being used to test vehicle dynamic response under perturbed track conditions that all cars must meet under AAR Specification M-1001, Chapter 11, Paragraph 11.8. The primary curvature on the PTT is 0º 26', with a super elevation of 6 inches (152 mm).

Three Chapter 11 test sections have been installed:

1. Paragraph 11.8.2 Twist and Roll test section in the north tangent section (PTT Stations 1644+10 to 1651+70). Due to the location of these perturbations, and the limited acceleration capability of TTC locomotives, the maximum test speed through this test section is about 70 mph.
2. Paragraph 11.8.3 Pitch and Bounce test section in the south end of the same tangent section (PTT Stations 171+00 to 171+50).
3. Paragraph 11.8.4 Yaw and Sway test section on the south end of the PTT (approximately PTT Stations 192+10 to 192+70).

These perturbations limit operational speed to 30 mph (48 km/h) on the PTT when not testing.

Ballast on the PTT was stabilized with an adhesive during the LIMRV program to reduce flying rocks at high speeds. The adhesive bond will be broken when the track is resurfaced with spot tie replacement operations.

Initial track construction was in 1970 with phased spot tie replacement initiated in 2011. Initial construction used 119 lb/yard (59 kg/m) rail on 6-inch (152 mm) base tie plates, using adjustable shims to fine adjust horizontal alignment. Existing wood ties are being replaced with new hardwood ties and 5.5-inch (140 mm) base tie plates. At some point in time, the existing ballast will be undercut, screened, and re-installed with new ballast.

The perturbation sections for twist and roll, pitch and bounce, and yaw and sway were re-built in 2013 and 2014 using elastic fasteners, hardwood ties, and steel plate shims to set perturbation conditions. To date 15% of ties on the PTT have been replaced; the rest are in poor condition.

3.7 FAST Service Facility

The Facility for Accelerated Service Testing (FAST) was first constructed in 1976 as a 4.8 mile (7.7 km) test loop. The test loop was used in that configuration until 1983, when it was split in two to form the High Tonnage Loop (HTL) and the Wheel/Rail Mechanisms (WRM) Loop.

The service yard tracks and maintenance building were constructed in 1977. A locomotive fueling station was added with two 25,000 gallon (95,000 liter) above ground fuel tanks and two dispensing stations to fuel FAST locomotives, and a separate dispensing unit to service heavy equipment.

In 1996, the FAST Wye track was added to the facility to allow the FAST train consist (80 car unit train at that time) to be turned without accessing the RTT and Balloon Loop. The crossover from the HTL to the RTT was removed at that time to reduce the number of turnouts on the RTT.

From 2009 to 2010, the FAST Wye Track was extended 1,200 feet (366 m) to accommodate a longer consist (110 car unit train) as a result of an upgrade to the high tonnage train consist.

3.8 High Tonnage Loop (HTL)

The High Tonnage Loop (HTL) is a 2.7-mile (4.3 km) loop used to conduct accelerated testing under heavy axle loads. See Figure 30 for track alignment and test section locations. The original FAST Program used conventional interchange standards with maximum axle loads of 33 tons (100 Ton loaded vehicles) (27.2 tonne axle load). The HTL Program currently uses heavier, 39 tons (35.4 tonne) axle loads. Test train operations are designed to accumulate 1 million gross tons (MGT) per day (0.9 million gross tonnes per day).

3.8.1 HTL Track

The HTL is maintained as a FRA Class 4 Track, and is restricted to 40 mph (64 km/h) maximum freight operating speed due to track geometry. There are three 5 degree curves and one 6 degree curve. The rail is lubricated with gauge face lubricators in the curves.

The HTL is divided into test sections that generally correspond to tangents, spirals, curves and turnouts. Past experiments in the various test sections include: rail performance, evaluation of ties, fasteners, turnouts, ballast, subgrade, and other track related materials, equipment, or systems in an accelerated wear and fatigue environment. The track is equipped with a broken rail detection system as a safety precaution.

3.8.2 HTL Bridges

There are three bridges located in the HTL. The East Steel Bridge is within the tangent of Section #5, and the other two are in the 5 degree curve in Section #3. The East Steel Bridge in the tangent section was installed in 1997 and recently reconfigured to have two riveted plate girder spans with open deck construction. Spans are 55.5 and 65 feet (17 and 20 m). All girders are supported on concrete caps with steel piling. The spans date from 1912 and 1954. Deck ties include conventional timber crossties of various species, as well as alternative tie materials including glued-laminated timber ties and fiberglass composite ties.

The other two bridge foundations were installed in 2003. Originally both bridges had concrete spans. One bridge now has 24 and 32 feet (7 and 10 m) long riveted steel girder spans dating from 1904 and 1913 and is called the West Steel Bridge. These spans were recently installed to complement the riveted steel girder fatigue testing effort. They are both open deck with timber deck ties.

The second bridge in Section #3 is known as the State-of-the-Art Concrete Bridge. The middle span is 42 feet (13 m) and has double-cell-box type girders made from high performance concrete. The flanking spans are a 30 feet (9 m) double-cell-box and a 15 feet (5 m) slab span. Both of the bridges have standard timber ties in a ballast section, with a ballast depth of 15 inches (305 mm) under the low rail, and 19 inches (406 mm) under the high rail.

The concrete bridge span designs of all but the 42 feet (13 m) spans are based on Cooper E-80 loadings and follow AREMA Chapter 8 design guidelines and Burlington Northern & Santa Fe or Union Pacific design practices. The 42 feet (13 m) span was designed by Canadian National based on E-90 loading. Foundations of all HTL bridges are based on a Cooper E-100 design. The girders are supported on precast pile caps supported by steel H-piles.

The original 55.5 foot welded steel span from the East Steel Bridge, as well as the original concrete spans from the west bridge are still at FAST for possible re-installation or other test, inspection, or training purposes.

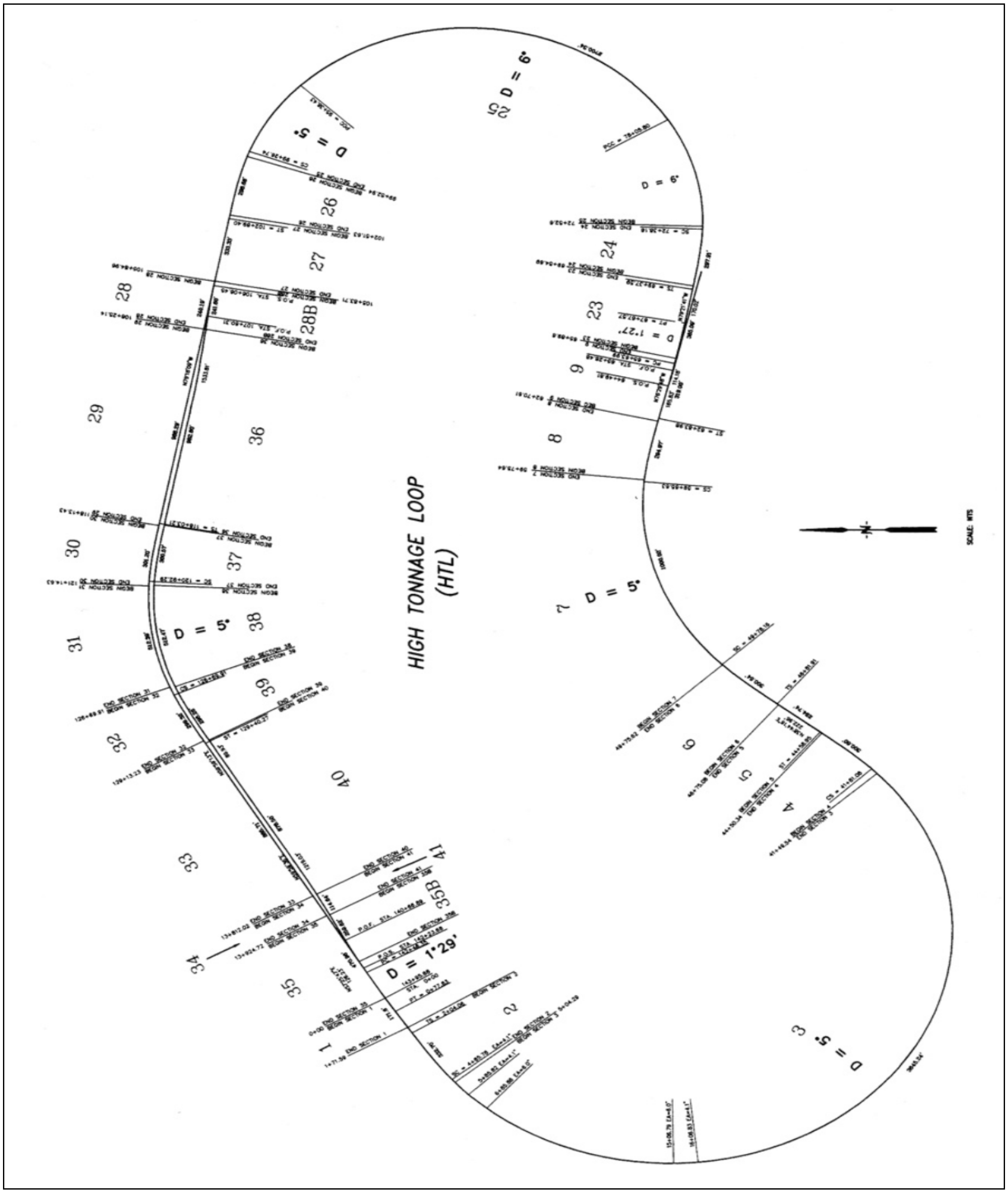

Figure 31. High Tonnage Loop (HTL)

3.9 Wheel/Rail Mechanisms (WRM) Loop

When the Wheel/Rail Mechanisms (WRM) loop was separated from the original FAST loop, additional curve variations were incorporated to meet the curved track test requirements of AAR Specification M-1001, Chapter 11. Figure 31 shows the WRM track layout.

The WRM is accessed from the TDT on the east side with a crossover consisting of two #14 turnouts.

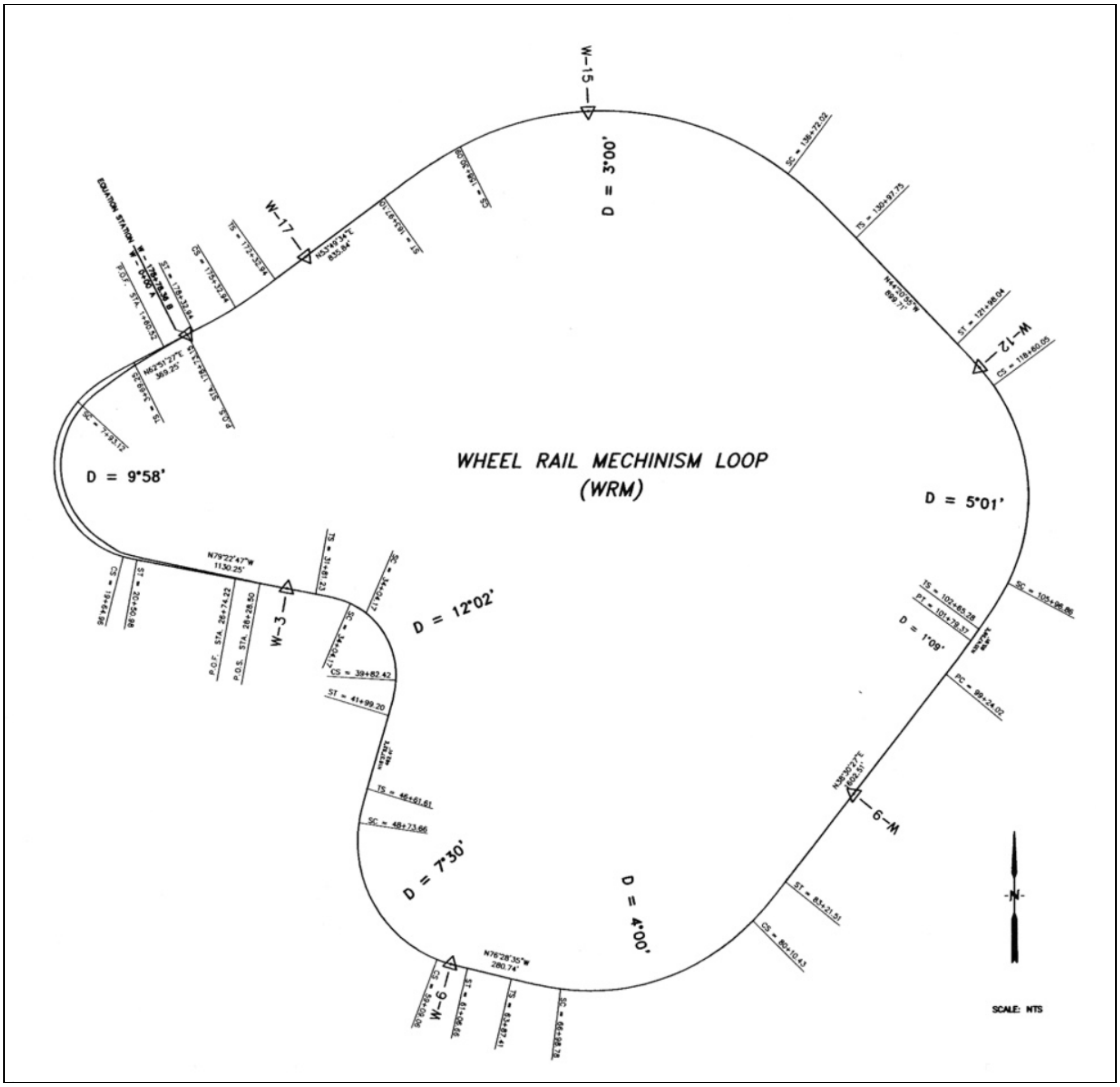

Figure 32. Wheel/Rail Mechanisms (WRM) Loop

The rail on the WRM is unlubricated for test purposes. Strain gages have been installed in some of the curves for measuring wheel-rail interaction forces. A section of the 5º curve has a 2 percent grade that can be used for braking performance tests, such as those required by AAR S-2043 Performance Specification for Trains Used to Carry High-Level Radioactive Material.

The curvature on the siding on the east of the WRM is approximately 10 degrees and is used for dynamic curve track perturbation testing to meet the requirements of Chapter 11, Paragraphs 11.7.3, 11.7.4 and 11.8.5. In 2011 this perturbation section was reconstructed using a prototype system of adjustable tie plates (Figure 32). These are intended to reduce maintenance and adjustment costs for the perturbations, and allow alteration of the perturbations to different amplitudes.

Figure 33. Adjustable Tie Plates for Vertical and Lateral Track Geometry Perturbations

The clockwise spiral entry to the 10 degree siding is constructed to meet the requirements of the Chapter 11, Section 11.7.4 Spiral Negotiation (Limiting Spiral). The clockwise exit spiral of the 12º 2’ curve is constructed to meet the requirements of the now obsolete Chapter 11 bunched spiral. The bunched spiral differs from a normal spiral in that all the super elevation change occurs in the middle 100 feet of the 200 foot long spiral. Although no longer required as a Chapter 11 test, this test section has been retained because it provides a useful benchmark of vehicle dynamic performance over severe spiral and track twist conditions.

3.10 Tight Turn Loop (Screech Loop)

The Tight Turn Loop (TTL) (also called the Screech Loop) is located at the lower end of the south east tangent section of the TTT. Figure 33 shows the TTL layout. It consists of a 150 feet (46 m) radius loop (a 38.9 degree curve) constructed as ballasted track with 119 lb/yard (59 kg/m) continuous welded rail on wood ties. Track construction is as shown in Figure 34. Third rail power has been extended into the TTL. The loop is connected with a short spur track having a 17 40’ curve. The main purpose of the TTL is to provide a facility for the detailed investigation of wheel noise, truck curving behavior, and rail vehicle stability under extreme curvature conditions.

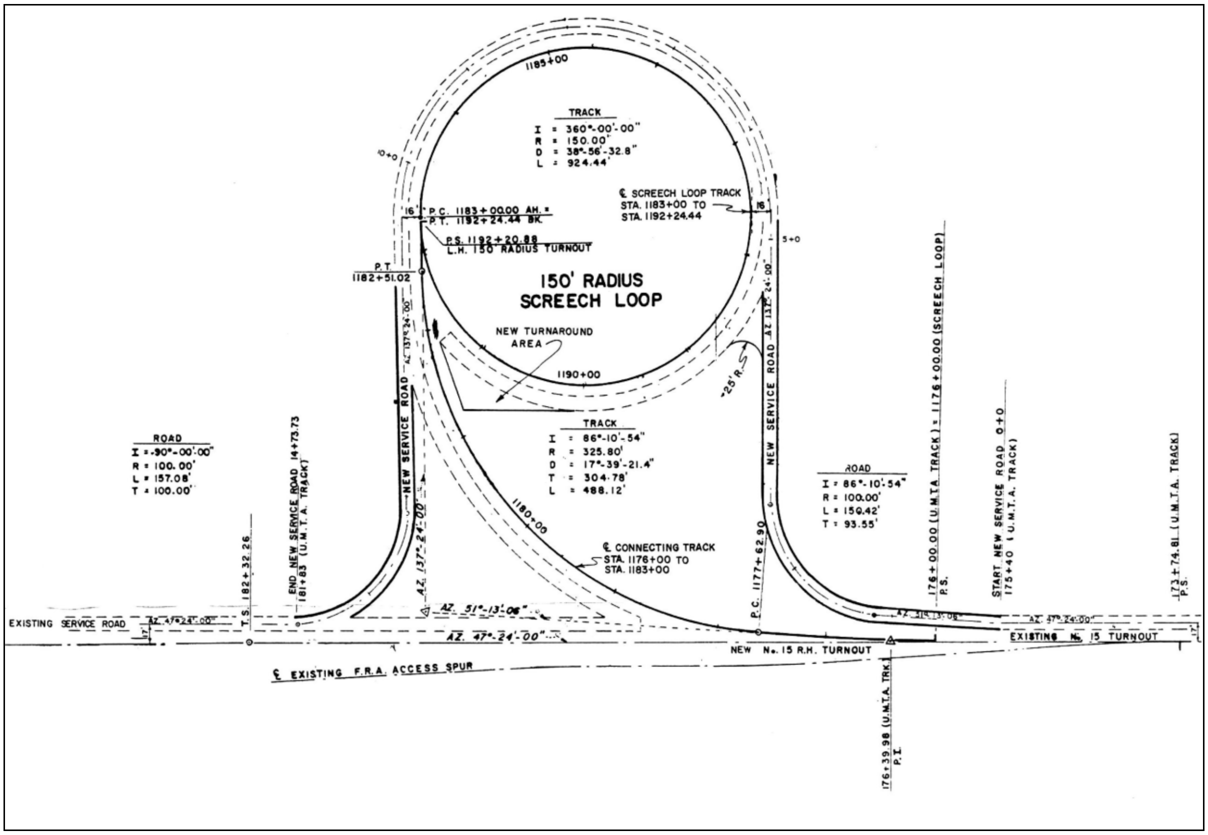

Figure 34. Tight Turn Loop Layout

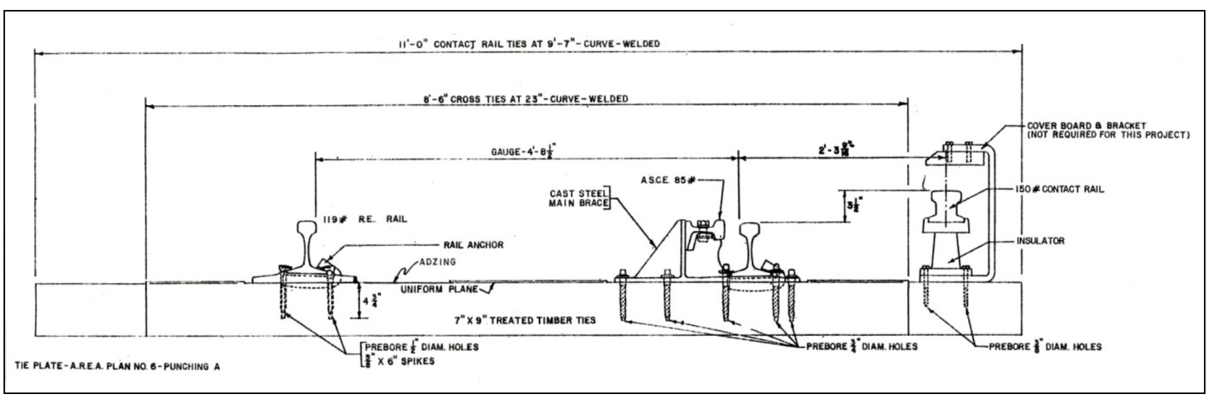

Figure 35. Tight Turn Loop Cross Section

3.11 Core Area Tracks

Yard and service tracks for the core area are shown in Figure 3. Tracks were constructed using recycled materials with predominately wood ties. Tracks are maintained to FRA Class 2 safety standards. Maximum track curvature is 12 degrees.

Overhead catenary has been extended to the TMB and PSB facilities allowing access of electrified vehicles to those maintenance facilities under their own operation. Switches allow for the isolation of the catenary power to those facilities when not in use.

A locomotive service facility is located on the access track to the CSB and PTT. The facility consists of; one fueling station, sanding tower with dispensing station, used oil collection, bulk oil filling station, and a horizontal lifeline for top of vehicle access.

3.12 Prototype Track Air Cushion Vehicle (PTACV) Guideway

An inverted "T" Guideway was designed to accommodate the Prototype Track Air Cushion Vehicle (PTACV) at speeds up to 150 mph (241 km/h). The PTACV Guideway is 5.7 miles (9.2 km) long with a 10 degree super elevation in the curves. It was designed with a 33-inch high (838 mm) continuous welded aluminum reaction rail, which served as the secondary for the linear induction motor and also guided the vehicle. The first 3 miles (4.8 km) of the reinforced concrete guideway was overlain with a one-inch (25 mm) layer of bituminous pavement. A power rail assembly attached to the guideway slab supplied electrical power to the test vehicles. The power rail assembly was covered to protect against lightning, falling objects, and accidental contact. Power supplied was at 4,160 volts, 3-phase, 60 Hz. Two substations of 5,000 kVA are located about four miles (6.4 km) apart, near each end of the guideway. The PTACV program was completed in the late 1970s.

In 2000, the aluminum reaction rail and power rail assembly were removed. The concrete slab and portions of the electrical substations still remain. The oil filled transformers in both substations were removed in 2004 due to oil seal leaks. The concrete guideway slab remains in good condition to serve as a sub base for a future test loop.

3.13 Tracked Levitated Air Cushion Vehicle (TLRV) Guideway

The Tracked Levitated Air Cushion Vehicle (TLRV) Guideway was used between 1973 and 1976. The 5-mile (8.0 km) long TLRV Guideway remains in place, but sections have been integrated into other facilities and are no longer accessible as a continuous guideway. A large section of side panels has been removed in the core area, with the panels used as lading for testing on site. The core area access track coming off of the PTT crosses over the TLRV Guideway. A spur track has been installed on the TLRV Guideway slab extending to the Vehicle Impact Wall directly south of the overpass bridge.

The TLRV Guideway is a U-shaped concrete channel, 18 feet 7 inches (5.66 m) wide, with a levitation surface approximately 12 feet (3.66 m) wide. The TLRV Guideway wayside power system has been removed.

4. Laboratory and Test Facilities

4.1 Vibration Test Unit (VTU)

Located in the RDL, the Vibration Test Unit (VTU) is a computer controlled device for evaluating the dynamic behavior of full-size rail vehicles (see Figure 35). The VTU is used to determine rigid body roll, pitch, bounce, yaw, and flexible modes of vibration of railcars, locomotives, and lading. It is also used to evaluate ride quality.

The VTU uses 12 actuators with piston capacities varying up to 50 kips (222 kN) and with up to 6 inch (152 mm) stroke. It shakes a rail vehicle vertically and laterally through the wheels to simulate, through computer modeling, the track interface with the vehicle over varied track geometry. Computer generated track profiles, or recordings of actual track profiles, are used to drive the actuators, which can be positioned to accept a variety of truck spacings or axle arrangements. The wheels of the test vehicle do not rotate.

The VTU can induce vibrations in the frequency range of 0.2 to 30 Hz to the test car. It can be modified to accommodate a 4-axle rail vehicle up to 90 feet (27.4 m) long and 160 tons (145 tonne) weight, and up to a 66-inch (1,676 mm) wheel gage. It can also be used to test non-rail vehicles such as buses and off-road construction equipment.

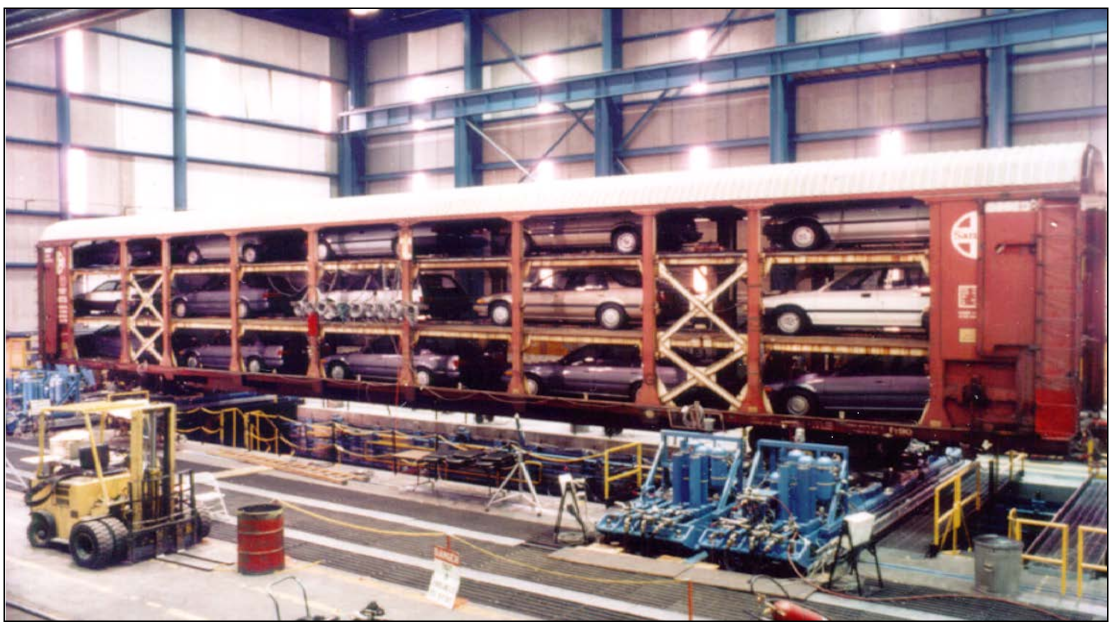

Figure 36. Vibration Test Unit, With Autorack Car in Test Mode

Although the unit is operational, it is nearly 30 years old, and in need of a major upgrade for future use.

4.2 Simuloader (SMU)

Located in the RDL, the Simuloader is a computer controlled, electro hydraulic device for applying dynamic forces directly to a full-scale railcar body, highway vehicle or other heavy structure. It is used for full-scale multi-axial fatigue and durability testing of railcars, locomotives, on an off highway vehicles, and truss sections (see Figure 36).

The SMU uses random parameter control to input motions directly into the vehicle's body, typically through the car body bolster. It uses up to 13 actuators with piston capacities varying up to 750 kips (3.34 MN) and up to 12 inch (305 mm) stroke.

The SMU is designed to simulate stress accumulated over a long period of train operations in a very short time, making fatigue life predictions available in weeks instead of years.

The SMU is in the final stages of a general overhaul and upgrade of the control system, actuators, and modifications to the foundation anchor system.

Figure 37. Simuloader (SMU)

4.3 Mini-Shaker Unit (MSU)

The Mini-Shaker Unit (MSU) is located on Track #2 in the RDL, directly north of the VTU. It is used to measure rail vehicle suspension system characteristics through a system of reaction masses and a computer controlled hydraulic actuator capable of applying vertical, lateral, or roll input dynamic forces (see Figure 37). It is useful in modal characterization of suspension components and assembled suspension systems.

The test vehicle can experience up to 210 kips (934 kN) through its suspension during a full stroke. The MSU is equipped with special instrumented rail sections to measure wheel-rail forces. Airbag assisted bearing tables under the wheels of the test vehicle allow for inter-axle shear and yaw stiffness measurements.

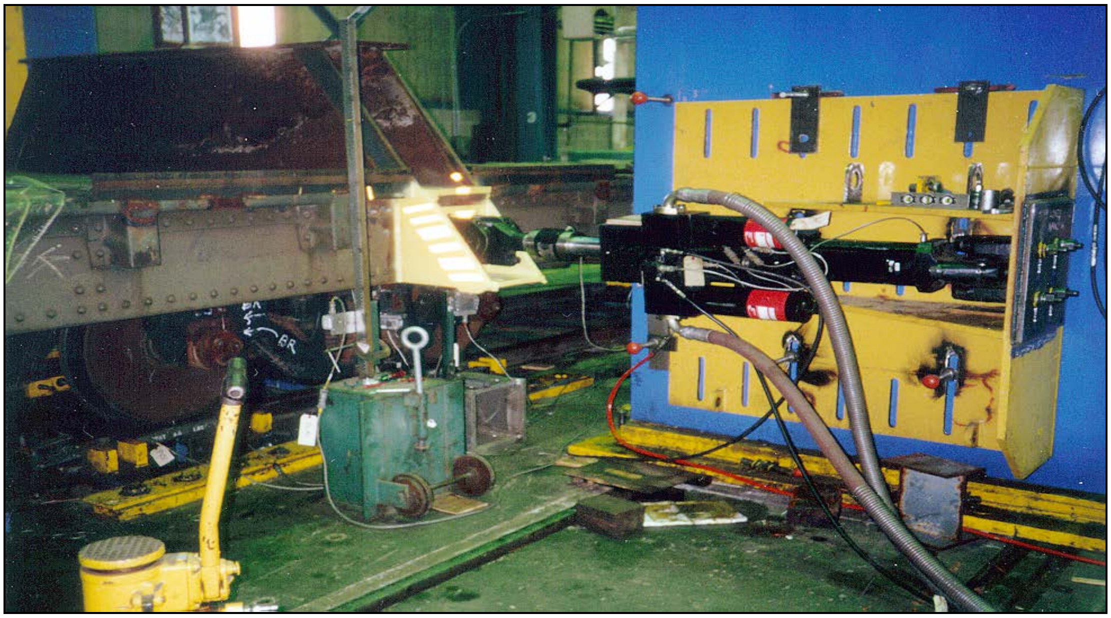

Figure 38. Mini-Shaker Unit Attached to Flat Car

4.4 Roller Bearing Test Facility

The Roller Bearing Test Facility (see Figure 38) was set up in the original RDL clean room in 1995. The test area houses three full-scale bearing test units that are capable of simulating the in-service environment of roller bearings. One unit is housed in an environmental enclosure capable of maintaining temperature from ambient to 150 ºF (66 ºC). The Roller Bearing Test Facility is also used periodically to certify bearing performance under current AAR Standards.

The test units are operational, but need complete upgrades of the control and data collection systems.

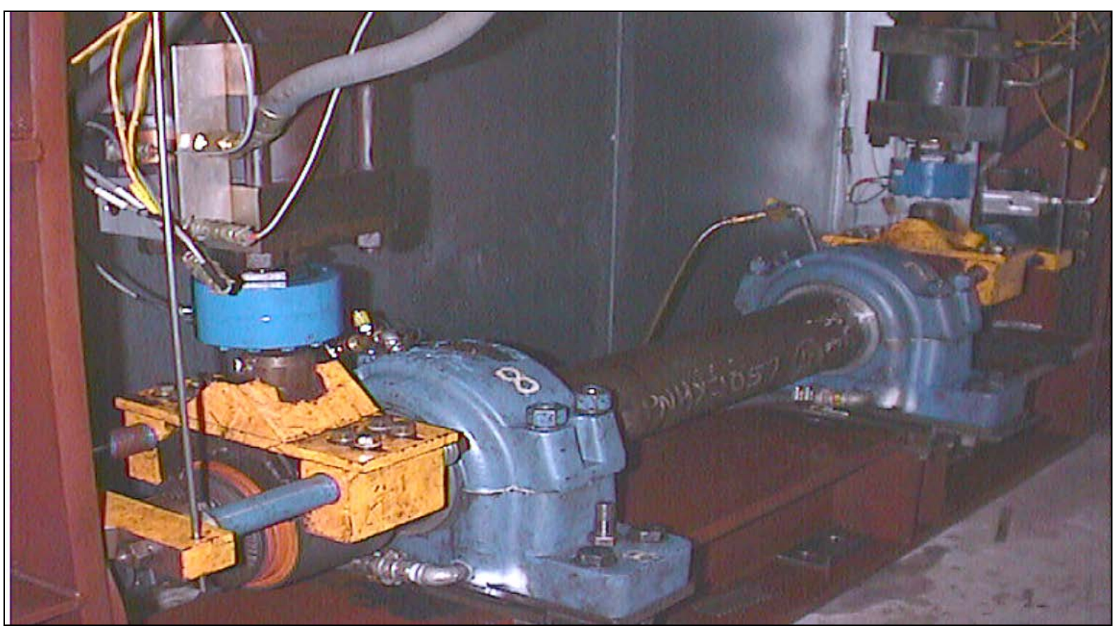

Figure 39. One of Three Units in the Roller Bearing Test Facility

4.5 AAR Center Plate Test Facility

Located in the RDL, the AAR Center Plate Test Facility (see Figure 39) is used to test center bowl liners and lubricants in accordance with the AAR standard for use on double stack cars (AAR Recommended Practice RP-261-97).

The test unit includes a truck bolster with a 16-inch (406 mm) center bowl capable of receiving horizontal and vertical wear liners and a standard center plate configuration for the 2-inch (51 mm) bowl depth of a 125-ton truck. The truck bolster is suspended from a structural test frame with four tie rods to allow rotation about a vertical axis. The car body center plate is mounted on a spring-backed simulated car body bolster to allow for a controlled static center plate load of 127,000 lbf (565 kN) and center plate rotation (simulating 6-degree curve entry and exit) and for center plate (car body) roll (6-degree peak-to-peak roll).

The endurance duty cycle consists of a minimum of 50,000 cycles, (equivalent to 2 years of revenue service) of full rotation applied consecutively. The yaw rotation rate is approximately 7 cycles/min. Roll cycles are applied at approximately 14 cycles/min. Time to complete the standard AAR test is approximately five days running 24 h/day.

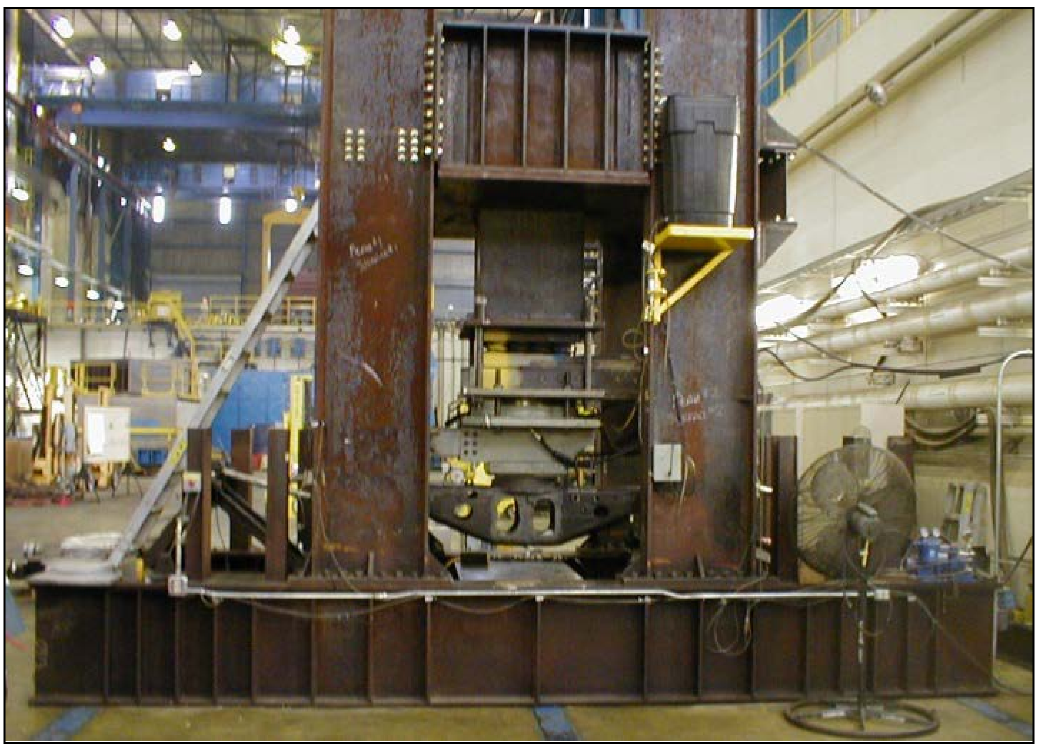

Figure 40. AAR Center Plate Test Facility

4.6 Rolling Contact Fatigue Simulator (RCFS)

A laboratory test rig for investigation of rolling contact fatigue (RCF) was installed in the RDL low bay in March 2015. The rig, , called the Rolling Contact Fatigue Simulator (RCFS), can generate RCF on wheels and rails. It was manufactured and installed by MTS Corporation (see Figure 40).

Figure 41. Rolling Contact Fatigue Simulator (RCFS)

The RCFS uses a fully controllable table with the wheelset firmly clamped to a rigid reaction frame. Loads and motions are imparted via a moving rail support carriage. The carriage is supported and controlled with large hydrostatic bearings. These bearings have no moving parts and no mechanical contact other than seals. They also act as actuators to apply vertical and lateral force.

This design allows fine control of the position and attitude of the wheelset relative to the track. The elements used to guide the table and maintain its position are not subject to wear or fatigue; consequently, positional control is consistent, and dynamic effects due to table guidance that might develop over time (and cycles) are eliminated.

The table has a 48-inch (1,220 mm) stroke with a 6 to 24-inch (152 to 610 mm) "working zone". The RCFS can impose vertical wheel loads up to 72,000 pounds (equivalent to 45 tonne axle loads) and wheelset angles of attack (AOA) up to 40 mrad. The RCFS operates at 0.5 cycles per second in the AOA range of 0 to 12 mrad. Cycle rates and loads are reduced as AOA increases.

There are plans to use a longer table stroke to enable special trackwork (e.g. switches and frogs) to be tested and to add traction and braking capabilities.

4.7 Dynamometer

The AAR Railroad Wheel Dynamometer was moved from the Chicago Technical Center to the WLF in July 1995 (see Figure 41). The dynamometer can apply a wide range of normal and excessive thermal and mechanical loads to railroad wheels. A unique feature is the large circular reaction rail through which vertical and lateral contact forces can be applied. It is designated by the American Society of Mechanical Engineers (ASME) as the 91st National Historic Mechanical Engineering Landmark.

The control system provides repeatable automatic control of test sequences, speed, and brake shoe force (or torque control). The data acquisition system provides automatic digital data collection, storage, and reduction. The control and data acquisition systems were upgraded in 2004.

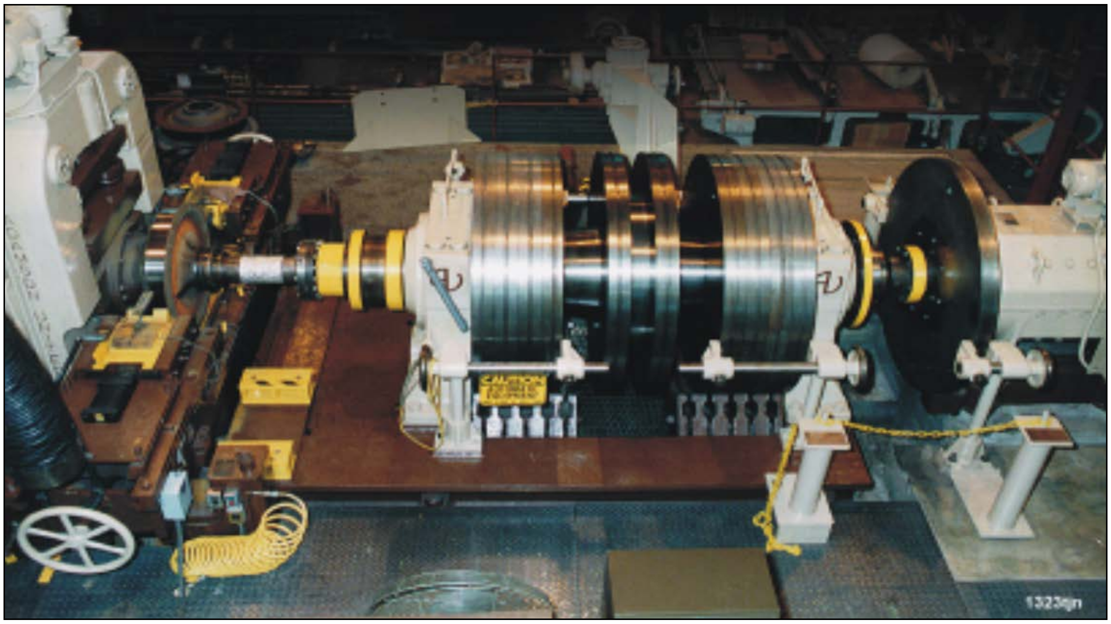

Figure 42. Dynamometer

The Adamson-United dynamometer was designed to test railroad wheels at speeds, and with vertical, lateral, inertial, and brake shoe load conditions that duplicate and exceed service conditions. For example, the machine can be driven at 1,500 rpm, or 147 mph (237 km/h) for a 33-inch (838 mm) diameter freight car wheel.

Vertical and lateral load capabilities are 60,000 pounds (267 kN) and 15,000 (67 kN) pounds, respectively. By comparison, maximum static loads on railroad wheels in interchange service range from 24,000 (107 kN) to 39,000 pounds (173 kN). A 110-inch (2.8 m) diameter rail wheel, in combination with a motor-driven screw and a hydraulic cylinder, provides the contact loads.

The inertial load capacity of the dynamometer ranges from 65,000 to 128,000 pounds (290 to 570 kN) equivalent wheel load, depending on wheel diameter. The original braking capacity of 50,000 pounds (222 Kn) on each of the two, 180-degree opposed, brake actuators was reduced when new brake air cylinders were installed. The braking capacity is now 6,500 pounds (28.9 kN) for one brake actuator, and 13,000 pounds (57.8 kN) for the other brake actuator. Brake shoe loads normally do not exceed 6,000 pounds (26.7 kN) for freight car wheels, or 12,000 pounds (53.4 kN) for locomotive wheels braked with high friction composition brake shoes.

4.8 Rolling Load Machines

Six rolling load machines of different size and capability are located in the CTL high bay. These units were originally designed to perform wear and fatigue tests on rail, rail joints, and components. These tests do not reproduce the actual stress conditions developed in service, but by producing measurable stresses, comparative evaluations can be made.

There are two general types of rolling load machines: 1) a 12-inch (305 mm) stroke cantilever machine, and 2) a 33-inch (838 mm) stroke cyclic fatigue test machine. These units are adaptable for modification to perform load conditions on various components.

The rolling load machines are in operational condition.

4.9 Tie Wear Machine

Tie wear machines are used to evaluate rail seat deterioration and fastener system performance in heavy axle load environments due to repeated loads. The original tie wear test machine at TTC was replaced by a new machine in the CTL high bay in 2014.

The new tie wear machine consists of a load frame with two servo-controlled dual action hydraulic actuators (see Figure 42). Vertical and lateral actuators are joined by a steel block that is attached to the rail head at the approximate location where a train wheel would make contact. The tie is restrained from movement and a combined vertical and lateral load is applied. The load is cycled at 3 Hz in a sine wave. A typical test is run for 3 million cycles.

There are currently two test load configurations. The first simulates an axle load of 50,000 pounds (222 kN). The loads applied through the actuators are 25,000 pounds (111 kN) vertical and 13,000 pounds (58 kN) lateral (L/V ratio=0.52). The second configuration simulates an axle load of 65,000 pounds (289 kN). The loads applied through the actuators are 32,500 pounds (145 kN) vertical and 16,900 pounds (75 kN) lateral (L/V ratio=0.52). A 1,000 pound (4.4 kN) return force mechanism is attached to the rail base to maximize repeated rail base travel and simulate actual field conditions.

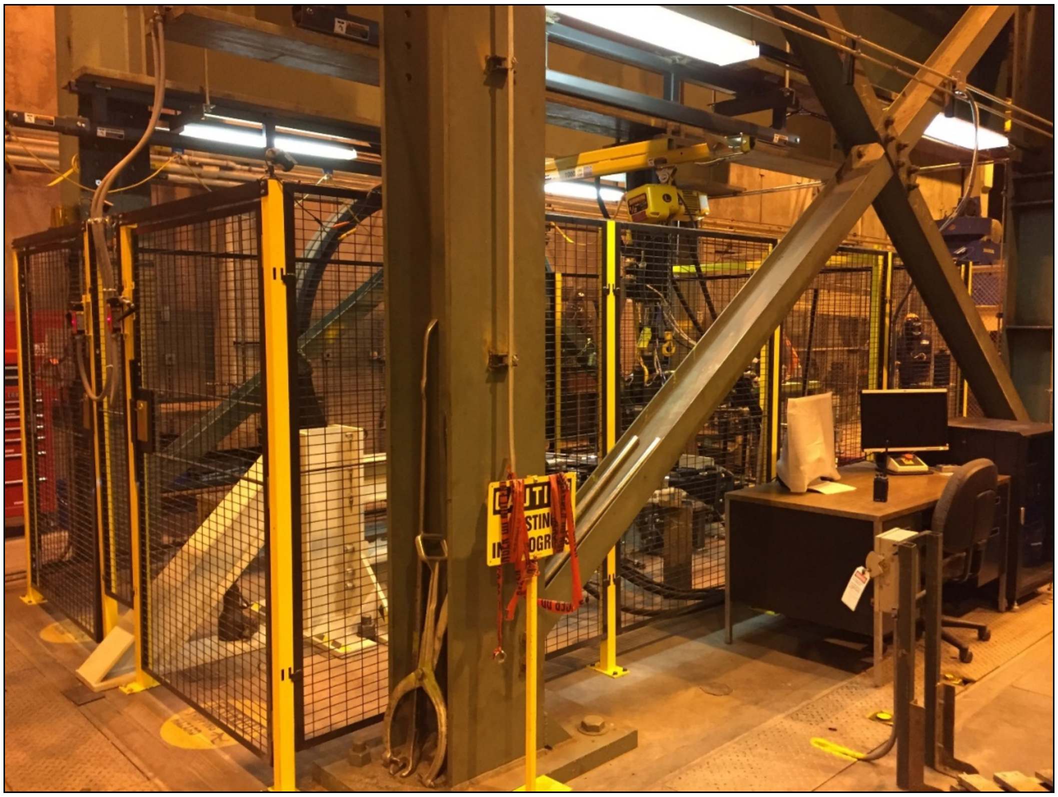

Figure 43. New Tie Wear Machine in the CTL

4.10 Train Air Brake Research Facility

The Train Air Brake Research Facility consists of 150 complete car sets of air brake equipment as shown in Figure 43. The facility is used to evaluate the performance of different air and electric valve systems. Independently operated from the air brake manufacturers, the air brake rack can be used for performance research. A broad range of train types and lengths can be simulated to analyze ways of improving current air brake systems. The air brake facility can be a key in developing new and advanced braking systems as well as a live demonstration tool for proper use of single line air brake systems.

The air brake lab is owned by the AAR. It has not been used since 2000.

Figure 44. Air Brake Lab

4.11 Vehicle Impact Wall

The vehicle impact wall shown in Figure 44 was constructed at TTC in October 2008. An inclined railway track leads to the rigid barrier, which is constructed from structural steel and reinforced concrete and backed by an earth embankment. The wall is capable of taking an impact load of approximately 3,000,000 pounds (13.4 MN).

Figure 45. Vehicle Impact Wall

The barrier is constructed on the site of the TLRV Guideway. The approach track is approximately 2,500 feet (760 m) long, laid on wooden ties directly onto the concrete guideway and keyed into vertical concrete pillars along the side of the guideway. The slope of the guideway is 0.86 percent running down towards the wall. The concrete barrier is keyed into the concrete guideway through its steel reinforcing.

The front wall is 2 feet (610 mm) thick reinforced concrete, 25 feet (7.62 m) wide by 18 feet (5.49 m) high. This wall is supported by three longitudinal walls (see Figure 45) each 2 feet (610 mm) thick by 36 feet (10.97 m) deep and 18 feet (5.49 m) high. In between these three walls there are another two vertical support walls 18 inches (457 mm) thick by 20 feet (6.10 m) deep and 8 feet (2.44 m) high, designed to adsorb high impact loads associated with side sills on railcars. Native soil was compacted into the gaps between these walls and piled up against the two side walls and the rear. Over 1,000 tons of earth was used in the construction.

The wall is faced with a 3-inch (76 mm) steel plate. Anti-climb bars or vehicle body ends can be mounted on the front of the wall if such a test is required. It is also possible to mount a target wall separated by load cells from the main barrier if a direct measurement of force is required.

Figure 46. Vehicle Impact Wall Under Construction

Further additions have been made to the Vehicle Impact Wall since its original construction. A concrete pad with the rails built-in has been constructed immediately in front of the wall. This allows easier access to the wall and fixes the rails rigidly in front of the barrier. This concrete pad has a pit to allow a camera and lights to look up at the impact zone. Extra power outlets have been provided either side of the wall and at the top of the wall for cameras and lights.

4.12 Squeeze Test Fixture

The Squeeze Test Fixture shown in Figure 46 was designed to apply compressive forces at standard rail coupler height through the bodies of rail vehicles. The fixture is used to show compliance with compressive end load tests under AAR Standard Specifications for Freight Cars, M-1001, Chapter XI, Service - Worthiness Tests and Analyses for New Freight Cars.

The Squeeze Test Fixture was upgraded in 2011 to allow compressive load tests of passenger cars equipped with crash energy management (CEM) systems. Four longitudinal actuators have the ability to be operated in stroke control, meaning that all actuators move in unison. Actuators can also be operated in force control if a test requires it. Two actuators have 1,000,000-pound (4.45 MN) load capacity, and two have 300,000-pound (1.33 MN) capacity. The total longitudinal load capacity is 2,600,000 pounds (11.6 MN). Locations of the actuators can be adjusted to the particular needs of a test vehicle.

Eight load cells measure forces applied by the actuator and forces reacted by restraints at the passive end of the car. Measurement of all applied and reacted longitudinal loads allows determination of the load path through a test vehicle when multiple actuators are used.

The Squeeze Test Fixture is in good condition.

Figure 47. Squeeze Test Fixture

4.13 Rail Defect Test Facility (RDTF)

The Rail Defect Test Facility (RDTF) is on the Balloon Loop and allows for development and evaluation of rail flaw detection systems. The RDTF is constructed with rail that has a wide variety defects including, but not limited to, transverse defects, transverse defects underneath shelling and crushed heads, vertical split heads, web and base defects. These defects also vary in severity and flaw location.

Figure 47 shows the three RDTF sections. The first section is called the Technology Development Zone. It is 1,440 feet (439 m long) and is used to assist in the development of rail flaw detection systems. The second section is 65 feet (20 m) long and called the System Calibration Zone. It is configured according to the description in AREMA Volume 1 Chapter 4 Section 4.6 “Recommended Calibration Rails for Rail Flaw Detection System.” The third section is the 4,000 feet (1,219 m) long System Evaluation Zone. It has a confidential “ground truth" map of defects that is not shared with system developers in order to fairly evaluate each detection system.

The track gage on the RDTF is between 56 and 57.5 inches (1,422 and 1461 mm). The track is maintained to FRA Class 3 standards with a maximum speed of 40 mph (64 km/h).

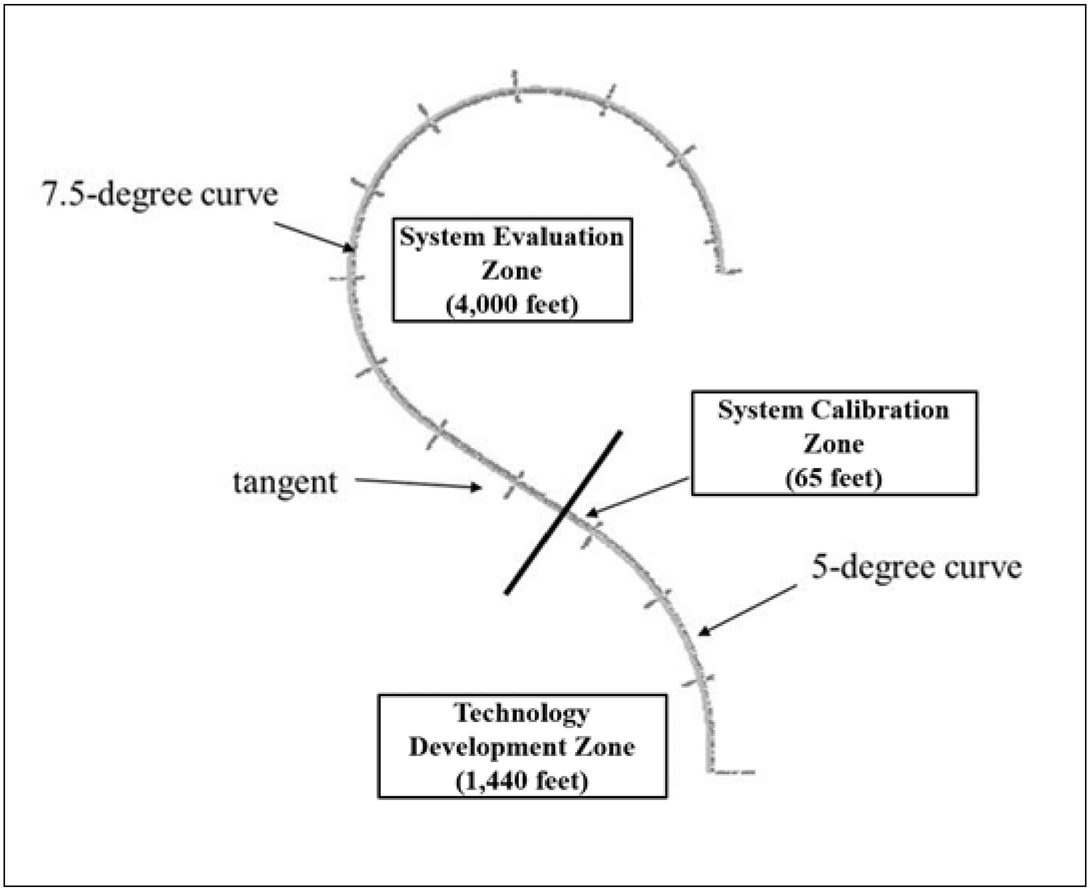

Figure 48. Layout of the Rail Defect Test Facility (RDTF)

4.14 Positive Train Control (PTC) Test Bed

A Positive Train Control (PTC) Test Bed has been developed and installed at TTC to support the industry in developing, implementing, and maintaining PTC. The PTC Test Bed provides a controlled test environment for conducting functional testing, safety testing, interoperability testing, regression testing, performance evaluations, and development support for current and future PTC systems, components, and related equipment. The Test Bed integrates PTC and communications equipment with existing railroad and communications infrastructure on the RTT and TTT to provide a realistic operating environment that is independent of the revenue service operation of any railroad.

Current Features

- Wabtec Train Management Dispatch System (TMDS) configured for Centralized Traffic Control (CTC) on RTT and Track Warrant Control (TWC) on TTT.

- Signaling system on RTT configurable to 4-aspect freight or 9-aspect cab signaling, with 12 signal blocks, including a 4000 feet (1,220 m) signaled siding
- Complete Interoperable Train Control (ITC) system, including Wabtec Back Office Server (BOS), two locomotives equipped with I-ETMS® onboard equipment, wayside interface units (WIU), two 220 MHz base stations, and 220 MHz locomotive and wayside data radios and message servers
- Capability to operate and test ITC onboard with simulated back office and wayside inputs
- Complete Advanced Civil Speed Enforcement System (ACSES), including two locomotives equipped with Automatic Train Control (ATC) and ACSES equipment, Safety Temporary Speed Restriction Server, in-track transponders, wayside interface units (WIU), and two base stations
- ACSES communications system configurable for 900 MHz or 220 MHz operation
- Capability to operate and test ACSES with simulated WIUs
- Data collection systems to record messages and the time messages are generated at all interfaces of the PTC components
- Capability to incorporate simulators of PTC-equipped trains and wayside equipment
- Capability to test communications network loading with software to generate message traffic based on railroad traffic

Future Features

- The PTC Test Bed is currently being upgraded to include cab signaling and Advanced Civil Speed Enforcement System equipment on the TTT
- Capability for the test bed to be configurable to allow the addition and removal of simulated tracks, crossings, monitored switches, and control points
- Capability for "hardware in the loop" operation in which tests using actual PTC equipment, such as PTC equipped locomotives and WIUs, can be augmented with simulators, such as locomotive simulators and WIU simulators, to allow test scenarios that could not otherwise be performed safely or economically with PTC equipment alone
- Capability for intermediate signals, control points, and crossings to respond to simulated trains as they would to a real train
- Capability for test scripting, remote monitoring, connection to railroad back office systems and other special test capabilities

5. Motor Vehicles

FRA's light duty motor vehicles at TTC have been replaced over time with TTCI purchased equipment. The remaining vehicles are a Chevrolet 2013 Tahoe and two 1995 Jeep Cherokees.

5.1 Shop and Heavy Equipment

Table 1 lists the fleet of heavy duty trucks and equipment at TTC.

Table 1. Heavy Duty Trucks and Equipment

Equipment	Description
Terex 50-Ton Crane	Was purchased new in 2000 and is in good condition. This crane meets site needs for light to medium load support.
John Deere 670 Grader	This 1999 model was purchased new and is in good condition. IT continues to meet basic site road maintenance and construction project needs.
John Deere 624 Loader	This 1999 model was purchased new, and is in good condition.
International Dump Truck	This unit was built in 1978 and is in poor condition.
Kenworth Fuel Truck	TTCI purchased this 2005 model vehicle in good condition.
Case 586-B Backhoe	This unit was built in 1972 and is in poor condition.
Kenworth 5th Wheel	This unit was manufactured in 1984 and is rated as fair to good condition.
Daewoo 10-Ton Forklift	This equipment was purchased new in 2005 and is in good condition.
International Bucket Truck	This item was built in 1976 and is rated in poor condition. It has a maximum reach of 95 feet (29 m), which is needed to reach some of the overhead power lines, CSB and RDL high bays, and water tower for maintenance activities.
FRA High Railer Vehicle	This item was built in 1974 and is in fair condition.
High Railer Vehicle	This item was built in 2000 and is in good condition.
Caterpillar D-7 Bulldozer	This unit is pre-1970 and is in poor condition.
Bucket Truck	2003 International 7300 in good condition.

5.2 Locomotives

The DOT locomotives 005 and 006 were taken out of service at TTC and moved to SERTC. Table 2 lists the locomotives owned by FRA in operation at TTC.

Table 2. Locomotive Fleet

Name	Description
DOT 203	Electro Motive Division of General Motors built this locomotive for the DOT in 1978. The 3000 horsepower unit is equipped with modified trucks and gearing. These modifications allow operating speeds of up to 107 mph (172 km/h).
DOT 004	Electro Motive Division of General Motors originally built this locomotive for the P.N.T. Railroad in 1954. It was rebuilt by Precision National Corporation in 1980 and then delivered to TTC. This unit is rated at 1,850 horsepower and has a top speed of 65 mph (105 km/h).
AAR 2000	Electro Motive Division of General Motors originally built this GP-40 locomotive in 1966. This unit is geared for 107 mph (172 km/h) but does not achieve this speed. It is in moderate condition, but spare parts are difficult to obtain.
TTCI 2001	Electro Motive Division of General Motors originally built this GP-40 locomotive in 1977. This unit is geared for 107 mph (172 km/h) but does not achieve this speed. It is in moderate condition, but spare parts are difficult to obtain.
DODX 413 Locomotive	Electro Motive Division of General Motors originally built these GP-40PH-2 locomotives in 1977. This unit is geared for 107 mph (172 km/h) and it is in moderate condition.

5.3 Track Maintenance Machinery

Table 3 lists the track maintenance machinery at TTC.

Table 3. Track Maintenance Machinery

Machine	Description
Pandrol Jackson 6700 Tamper	Purchased new in 2000 and is in good condition.
Pandrol Jackson Rail Grinder	Prototype machine purchased in the late 1970's. The control system was refurbished in 2013. The unit is in fair to good condition.
Electromatic 2000 Jr. Tamper	Purchased new in 2002, high use, in fair condition.
Tie Inserter	Purchased new in 2002, and is in good condition.
Switch Grinder	This machine is in fair condition, but beyond economic use. Unit recommended for replacement.
Kershaw Ballast Regulator	This Model KBR-875 was purchased new in 2005, and is in good condition.

Fairmont Ballast Regulator	This is a 1981 model in fair condition.
Track Mobile	A rebuilt unit was purchased used in 2004, and is in good condition.
Speed Swings	TTC #16401 was purchased in 1996 and is in fair condition. TTC #28030 was purchased in 2000, and is in good to fair condition. TTC #28640 was purchased in 2004 and is in fair condition.

5.4 Emergency Vehicles

The type of research and testing activities undertaken at TTC have inherent fire risk. Diesel fuel is used in the locomotives and maintenance equipment. Welding and rail grinding operations are common practice. There is a significant fire risk from dry vegetation, which once ignited could easily spread to buildings that are occupied by government staff, contractors and valuable test equipment.

The DOT and IL roads used to access TTC are not in any recognized fire or rescue protection district. In the past five years emergency response has been required to 10 accidents on the DOT road involving injuries.

Table 4 lists the current emergency vehicles at TTC.

Table 4. Emergency Vehicle Fleet

Vehicle	*Description*
Med#1 ambulance	2013 Ford F-350 in excellent condition
Brush Trucks #1 and #2 (B-1 and B-2)	2014 and 2015 Ford 550s in very good condition. They replaced two 1977 Ford F-600s.
Brush Truck # 3 (B-3)	2005 Ford F-750 in good condition
Pump Engine #1 (E-1)	1998 Emergency One C400 in good condition
Pump Engine #2 (E-2)	2014 Freightliner chassis in very good condition

6. Roadways

TTC can be reached by either one of two Pueblo County roads. The DOT road runs from Pueblo airport and industrial area. The IL road runs from Boone on Hwy 96. The Pueblo County Road and Bridge Department maintains the paved access road up to the overpass bridge at TTC. TTCI maintains this bridge all other roads on site. A network of internal roadways leads to each of the test areas and building sites for maintenance, operations, and emergency response. Additional pioneer roads have been established in the more remote locations to aid in firefighting wild land type fires.

There are approximately 9 miles (14.5 km) of bituminous paved roadways, and 50 miles (80.5 km) of gravel surfaced roads on site. Areas still requiring refurbishment or replacement include:

- Core area roads to WLF, SMB, CSB, RDL and Post 85 road crossing.
- Road to FAST
- WLF parking areas and adjacent roads

7. Utilities

7.1 Electrical Power

Power to TTC is provided through a 115-kilovolt overhead transmission line located along the east side of the IL Road and TTC. The line is approximately 12.5 miles (20 km) long, coming from the Boone Substation. Power is metered and switched at the main substation located directly east of the CSB and PTT.

Black Hills is the regional distributor, with most of the power from this area coming from the Comanche Power Plant located in southeast Pueblo, approximately 30 miles (48 km) from TTC. Maximum rated load on the transmission line is 55 MW at 95% power factor.

A 115 kV overhead line extends to the DC Rectifier Substations, PTACV Substations, RTT Substation, and Main Core Area (RDL and CSB) Substation. Table 5 shows the primary transformer sizes in these substations.

Table 5. Main Substation Locations and Sizes

Location	*Power(MW)*	*Voltage Out (V)*
TLRV Substation	12	4160
PTACV Substation #1	12	(Removed)
PTACV Substation #2	12	(Removed)
RTT Substation	16	50k / 25k / 12.5k
DC Rectifier Sub. #1	10	4160
DC Rectifier Sub. #2	10	4160
Main Core Sub. East	12	4160
Main Core Sub. West	12	4160
Total Installed	86	

The Main Core Area Substation (see Figure 48) is located between the CSB and RDL Buildings. The two primary transformers feed a common switch gear bus system that has 17 air circuit breakers (six spares) divided into three sections for metering and control. The switch gear can be configured to feed the system with either primary transformer for redundancy, or zoned to feed separate sections. Individual circuit breakers feed secondary building or facility transformers that further reduce the voltage to 480 volts, 3-phase. Common building power voltage is 480 / 208 / 120 volts. Power demand for 220 volt supply is available in some locations.

Figure 49. Main Core Area Substation

One of the circuits from the Main Core Area Substation feeds the secondary SMB Substation. This transformer boosts the voltage from 4,160 V to 13.8 kV. Power from this substation feeds the URB, FAST, CTA Building, Main Well, TTT wayside power, and RTT wayside power. The increase in voltage is performed to reduce power transmission loses due to the large distances involved in transmission. A combination of overhead lines and buried lines are used to distribute the power to other buildings and facilities. Step-down transformers are then used to put the power in a useable form.

A new 1.1 MW standby generator was installed in 2007 in the Standby Generator Building between the CSB and the RDL. The new generator has a reciprocating diesel engine, as manufactured by Caterpillar. This replaces the two turbine engine generators installed as re-built units in 1974. The primary core area buildings have emergency power circuits that can be automatically switched to the generator system during power outages. Primary power has been very stable since operations started at TTC, with the emergency generator system seeing very little usage.

The switchgear is obsolete. If it fails and needs repair, a completely new system will be required.

7.2 Water System

7.2.1 Groundwater Wells and Disinfection System

TTC has two groundwater wells in the unconsolidated alluvium known as the Black Squirrel and Haynes Creek Basin, a part of the Arkansas River Basin. The wells are permitted under the Colorado Division of Water Resources, State Engineers Office under Permit # 15829-F for the Main Well, and #20730-F-R for the Backup Well. Maximum pumping rate of the Main Well is listed at 850 gallons/minute (gpm) (3,200 L/minute). The maximum rate on the Backup Well is listed at 120 gpm (454 L/min).

Together, the wells are permitted for 40 acre-feet per year combined, under Case No. 81CW24. As a result of being in an over allocated water basin, TTC must replace the water consumed through an augmentation plan. This is purchased through the Arkansas Groundwater Users Association (AGUA), as TTC's augmentation plan manager. Because of current water storage in the basin, TTC now has sufficient augmentation water to draw the full amount decreed for pumping. For the past 5-years, TTC has averaged using less than 20 acre-feet of water. However, the implementation of the Crude by Rail (CBR) training facility a SERTC has increased usage by an estimated 12 acre-feet. Environmental concerns and the potential for water use will require a reuse system to be installed.

The Main Well and chlorination system is housed in the Main Well Pump House located in the CTA Substation Building west of the TTT. The Backup Well is located in an adjacent pump house, with the discharge line tee'd into the Main Well discharge line in front of the chlorination feed line. Electronic controls for activation of the well pumps have a selector switch to identify the pump to be operated on demand (signal from the Distribution System Pump House). Only one well is operated at a time. Use of each well is rotated on a monthly basis to exercise each well and maintain both in an active status. The Backup Well serves as a second water source should the Main Well fail. This is to meet the requirements of a water supply system for fire protection under the National Fire Protection Association Codes.

Recent water sample testing for copper and lead have resulted in minor threshold exceedances, sporadic in nature, but requiring response action to the state regulators. An engineering study reviewed the problem and recommended a corrective action. The report indicates that the water is borderline corrosive, and may require a form of treatment to improve water quality. A system design has been submitted to the state regulators for review. If exceedances with lead and copper continue, then implementation of the design will be required.

7.2.2 Water Transmission Lines and Storage Reservoir

The wells pump chlorinated water into two reservoirs located in the TTC Core area, approximately 2.5 miles (4 km) east by northeast of the Main Well (see Figure 49). The water reservoirs are steel tanks, 26 feet (7.9 m) diameter by 90 feet (27.4 m) high, each with a rated capacity of 300,000 gallons (1,140,000 L) when full. Both reservoirs are set at the same elevation, and operate in parallel. The south tower was installed in 1973, and the north tower was installed in 2011. Both towers received new coatings to bare metal surface, interior and exterior, in 2011.

Water level is maintained between a height of 82 and 89 feet (25.0 and 27.1 m) with remote activation of the well pump. A pressure transducer is installed in front of the valve to the tank drain line, with logic controls located in the Main Pump House. Water level alarms are located in the Pump Station and Main Gate Guard House.

The water transmission line is a 6 inch (152 mm) diameter PVC line installed in 1972. There are several buildings that tap into the transmission line for water supply, including the URB, DC Substation #1, SMB, TMB, and FAST Facility. The FAST Facility service line extends from the Main Well Pump House north by north west approximately 1 mile (1.6 km). The line is a 2.5 inch (63.5 mm) diameter PVC line installed in 1977. Water pressure for the buildings serviced from the transmission lines varies from 40 to 50 psi (276 to 345 kPa) when there are normal operating levels in the water towers.

Figure 50. Water Reservoir and Distribution Pump House.

7.2.3 Distribution Pump House (Main Pump Station)

A new Distribution Pump House (Main Pump Station) was commissioned in April 2002, and is located close to the water towers (see Figure 49). The Main Pump Station is designed to provide both domestic and fire protection demand requirements.

There are two jockey pumps to meet domestic flow requirements, and a fire pump that will activate to meet the higher fire protection design flows required for the core area buildings. The primary jockey pump (Pump #1) is a 160 gpm rated pump at 100 psi (689 kPa), with a 120 psi (827 kPa) deadhead pressure, which runs continuously to pressurize the distribution system. If system pressure falls below 90 psi (620 kPa), the second jockey pump (Pump #2) activates. Pump #1 will shut down after Pump #2 activates. Pump #2 is a variable frequency drive pump is rated with a range of 0 to 1,000 gpm (0 to 3,785 L/min) at 100 psi (689 kPa). System pressure is set at 105 psi (724 kPa) with Pump #2. This pump will handle larger domestic flows and minor fire protection flows associated with testing and use of a single fire hydrant. Pump #2 will reset to allow Pump #1 to reactivate when the flow rate drops below 120 gpm (454 L/min) for more than 2 minutes. Both pumps can operate independently of the other during repair periods.

Pump #3, the fire pump is rated for 3,000 gpm (11,400 L/min) at 125 psi (862 kPa) discharge pressure. This will activate when the system pressure drops below 80 psi (552 kPa) for more than 2 minutes. The system has a 12 inch (305 mm) diameter pressure relief valve set at 128 psi (883 kPa) to bypass flow from the fire pump to maintain system pressure during the fire emergency condition. The fire pump must be manually turned off to reset the system back to a normal operation.

In addition to the distribution pump automatic controls, activation and shutdown of the groundwater pumps are controlled at the Main Pump Station. A pressure transducer at the water tower initiates the activation and shutdown when water storage is at 84 and 89 feet (25.6 and 27.1 m) respectively within the tank. Overflow elevation is at 90 feet (27.4 m) within the tank. The signal is sent to the Main Pump Station via single mode fiber optics line and controls.

All conditions at the Main Pump Station are displayed at the station controls. The controls are also linked to a satellite display at the Main Gate Guard House, where they are monitored by security staff 24 hours per day, 7 days per week. Audible alarms activate when; the fire pump activates, power loss / power quality at the Pump Station, water overflows or drops to a low level alarm (75 feet (22.9 m)), system pressure drops to low level (60 psi (414 kPa)), Pump House low temperature alarm (40ºF (4.4ºC)), or water level alarms in Pump House pit (system leak inside the building). Security is required to routinely monitor the system for signs of leaks (flow meter readings), proper pumping conditions during after-hour periods, and log the results.

7.2.4 Distribution Piping

Discharge from the Distribution Pump House is 12 inch (305 mm) diameter, and ties into a loop system with 8 inch (203 mm) diameter piping. Off of the loop, services are extended to the ERTC Training Facility, CSB, RDL, PMB, OPS, and WLF/CTL buildings. A 10 inch (254 mm) diameter line tees off of the discharge line and extends to the PSB. This line could serve future extensions to the proposed training facilities for TSA and SERTC.

7.3 Sanitation System

7.3.1 Domestic Wastewater Handling

All major facilities at the Test Center have septic tanks and leaching fields for domestic wastewater disposal. Each building or group of buildings is served by a separate system. Under the Federal Facility Compliance Act, septic systems now fall under State and local regulations for corrective maintenance and construction. Five of the septic systems at TTC are classified as Large Capacity Septic Systems, and were reviewed for compliance as a post condition by the Colorado Department of Public Health and Environment (CDPHE) and Pueblo County. The systems are for the OPS, RDL/PMB, CSB, WLF/CTL, and SERTC buildings. A Site Application Approval (#4459) was given for the systems in 2001. A Discharge Permit has been issued by CDPHE for the five systems under the Colorado water discharge regulations.

7.3.2 Industrial Wastewater Handling

TTC uses a double lined surface impoundment system for industrial wastewater disposal. The system was issued a certificate of designation from the Pueblo County Commissioners on October 19,1994, under Resolution No. 94-382, and modified under Resolution 97-20. The system consists of an oil and water separation system for pretreatment of wastewater, and a Class I designed surface impoundment with two membrane layers of 45 mm reinforced (HPDE) polyethylene liners. The impoundment has a working capacity of 467,000 gallons, with discharge by evaporation only. It was designed to handle an average volume of 600 gallons per day, five days per week for a total of 156,000 gallons of waste per year.

The system includes pretreatment equipment to remove and collect suspended and floating oils from the wastewater before being discharged into the surface impoundment. The pretreatment equipment is housed in a room attached to the CSB High Bay. Wastewater from the RDL and CSB High Bay pits are connected to the pretreatment room, along with CSB above ground fuel storage containment pit, CSB Locomotive Fueling Facility, WLF Metallurgy Laboratory area, and the CTL High Bay (Dynamometer) Pit. Other above ground fueling containment pits and building service pits on site are routinely pumped when wastewater is present, and hauled to the pretreatment room for handling.

A second impoundment cell was added in 2013 with similar construction as the existing cell. It will be needed when the cell needs the top liner replaced, or when industrial wastewater generation exceeds the design load of the first cell. The second unit will provide the redundancy needed to work on one unit while the other remains in service.

7.3.3 Solid Waste Disposal

Solid waste generated at TTC consists of garbage, glass, plastic, paper, metal, wood, miscellaneous construction waste, used grease and oil, septic tank solids, etc. Presently all solids wastes are removed from TTC by truck and hauled to appropriate licensed receiving facilities. Efforts are in place to recycle as much of the solid waste stream as practical by setting up containers and collection areas for sorting and accumulation.

7.3.4 Hazardous Waste Disposal

A Hazardous Waste Management Plan has been developed and implemented for TTC outlining policies and procedures for management of hazardous waste as a “Conditionally Exempt Small Quantity Generator” (CESQG), in accordance with Environmental Protection Agency (EPA) and Colorado Department of Public Health and Environment (CDPHE) regulations (40 CFR Part 262). As a CESQG, TTC generates less than 100 kilograms (kg) per month; however, specific test requirements may periodically increase the monthly waste generation, elevating the facility classification to “Small Quantity Generator” (SQG) status, which is greater than 100 kg/month, but less than 1,000 kg/month. During those months where hazardous waste generation may be increased, TTC is prepared to meet the additional requirements identified in 40 CFR Part 262 for that month, and then return to CESQG status when hazardous waste generation quantities are reduced below 100 kg/month. TTCI manages hazardous waste, utilizing satellite accumulation areas in various buildings, near the point of hazardous waste generation. Once the satellite drum is filled, TTCI transfers the drum to the main hazardous waste accumulation area, which is located inside a security controlled storage area where it is managed prior to transportation offsite for final disposal.

7.4 Communications Systems

The Transportation Test Center is presently using a 75-watt, 25 kHz bandwidth, two-way radio system, with nine VHS radio base stations. To supplement this system, numerous portable five-watt transmitter-receivers are used, with some locomotives equipped with twenty-watt transmitter receivers.

Century Link supplies telephone and internet service at TTC. A direct buried fiber optic line installed in 2013 provides up to 78 strands of fiber service. A total of eight T-1 are brought in over DS3 licensed microwave band to the main switching station located in the OPS server room for a redundant internet link. Three DS3 T-1 lines are being used for local and long distance voice service. An additional two DS3 T-1 lines are being used for customers.

The DS3 radio system with a microwave dish mounted on the Operations Building roof provides additional capacity to the hard wired system. Currently twelve of twenty eight T-1 lines are activated with the system, with lines running to the Operations Building server room. The DS3 system sends signals to a repeater station to the west side of Pueblo, and then to the main terminal located in downtown Pueblo. Century Link owns the DS3 equipment. All other equipment and lines are a part of the facility.

Communications lines extending to the buildings and facilities consist of both traditional copper pair cables, and fiber optics stranded cable. Most buildings have fiber optics cable extended to improve telephone and LAN connections. The OPS server room is the hub for the telephone system as well as the LAN network. TTC also has a wireless LAN System that encompasses the majority of the southern half of the site. The system consists of a total of twenty 802.11 A/B/G/N mesh routers. Twelve of these are positioned every 6000 feet (1,830 m) around the RTT at the C&TC Test Bed instrument cases. The remaining eight are located at various LAN gateway sites inside of the RTT including the following: WLF, URB, DC Substation 2, Main Well, Fast Tower, OPS, R14 bungalow and Post100 bungalow.

An additional communications tower is located adjacent to the CTA Substation building, located inside the TTT Loop. The tower belongs to TTC. Verizon Wireless Communications has installed repeater station equipment attached to the tower for shared beneficial use to improve coverage for the area.

7.4.1 Radio System

TTC's Communications System migrated from a legacy single site, multi-repeater wide band analog communications system to a state of the art NXDN multisite, multichannel narrow band digital trunking communications system. This provides for wide area coverage of the entire TTC property, in addition to the required within building coverage. As site wide tests, customer projects and work flow has changed, the communications system has morphed to meet the requirements of the engineers and technicians. Digital talk groups have increased unit count from approximately 125 to 350 plus users. This feature allows separating work activities by assigning dedicated channels to each activity which provides an increased efficiency and safety around the facility.

To meet current FCC rules for effective radiated signal and narrow band technologies, site wide signal density from each tower site was reduced to meet the current requirements. Two locations on the North and South of the property are shaded from both towers and therefore have lower signal density than before. VHF railroad frequency operation from within steel enclosed train cabs, greatly reduces radio signal properties. All radio users are challenged by these engineering issues. New NXDN simulcast software is being refined to solve low signal coverage issues. New Fiber Optic(Distributed Antenna Systems (DAS) are being deployed to provide coverage within insufficient areas, be it within large buildings or coverage in depressed terrain along open tracks.

7.5 Fuel Storage Areas

Oil storage and handling facilities on site are identified in the Spill Prevention, Control and Countermeasures (SPCC) Plan for the site (TTCI Document Number SI-002-PP04). The plan identifies the size and location of each tank, product type, construction, operational use, and containment and diversionary structures in place to control a potential release of product should it occur. Tanks not listed in this reference document include propane tanks, which are not regulated under the Oil Pollution Prevention requirements under the Code of Federal Regulations, 40 CFR, Part 112.

Heating oil (diesel) is used in mechanical boilers for hot water circulation systems in the WLF/CTL, and URB buildings. Propane-fired boilers are used in the OPS, PMB and CSB. Propane fired unit heaters are used at the SMB, ERTC, PSB, and FAST Facility buildings. TMB uses diesel fired unit heaters. The RDL and DC Rectifier Substations use electric unit heaters for building heat. Natural gas is currently not available at TTC.

Two primary diesel storage and dispensing areas are used for locomotive servicing, located at the FAST Service Facility and CSB Service Facility. Both have large capacity above ground tanks to receive fuel in bulk quantities by truck transport. Fuel at both stations can be dispensed to locomotives, heavy equipment, and on-site fuel transfer trucks for remote fuel dispensing. Building fuel tanks are serviced directly by truck transport, or with on-site fuel transfer trucks. Gasoline is dispensed to on-site road vehicles at a service station facility located adjacent to the southwest corner of the CSB motor pool area.

Although propane tanks are not regulated under the SPCC Pan, they are regulated by the Colorado Inspector of Oils if storage capacity exceeds 2,000 gallons at any one location. TTC has two 18,000 gallon propane tanks, one servicing the OPS and CSB, and the other servicing the PSB.

Abbreviations and Acronyms

AAR	Association of American Railroads
AC	Alternating Current
APTA	American Public Transportation Association
AREMA	American Railway Engineering and Maintenance-of-way Association
ASME	American Society of Mechanical Engineers
C&TC	Communications and Train Control
CBR	Crude by Rail
CEM	Crash Energy Management
CNC	Computer Numerically Controlled
CSB	Center Services Building
CSHA	Cross-sectional Head Area
CTA	Chicago Transit Authority
CTC	Centralized Traffic Control
CTL	Component Test Laboratory
CWR	Continuous Welded Rail
DAS	Distributed Antenna Systems
DC	Direct Current
DOT	Department of Transportation
FAST	Facility for Accelerated Service Testing
FRA	Federal Railroad Administration
HDPE	High-density Polyethylene
HTL	High Tonnage Loop
HVAC	Heating Ventilating and Air Conditioning
IP	Internet Protocol
KBR	Kershaw Ballast Regulator
LAN	Local Area Network
LEED	Leadership in Energy and Environmental Design
LIMRV	Linear Induction Motor Research Vehicle
MIG	Metal Inert Gas
MGT	Million Gross Tons

OCC	Operations Control Center
OSCOTM	On-site Contracting Officer’s Technical Monitor
OPS	Operations Building
PCD	Pueblo Chemical Depot
PMB	Project Management Building
PSB	Passenger-Rail Service Building
PTACV	Prototype Tracked Air Cushion Vehicle
PTC	Positive Train Control
PTT	Precision Test Track
RCFS	Rolling Contact Fatigue Simulator
RDL	Rail Dynamics Laboratory
RDU	Roll Dynamics Unit
RDTF	Rail Defect Test Facility
RTT	Railroad Test Track
SERTC	Security Emergency Response Training Center
SMB	Storage and Maintenance Building
SMU	Simuloader
TDT	Train Dynamics Track
TIG	Tungsten Inert Gas
TLRV	Tracked Levitated Air Cushion Vehicle
TMB	Transit Maintenance Building
TTC	Transportation Technology Center (the facility)
TTCI	Transportation Technology Center, Inc. (the company)
TTT	Transit Test Track
TTX	TTX Company
TWC	Track Warrant Control
URB	Urban Rail Building
VTU	Vibration Test Unit
WIU	Wayside Interface Unit
WLF	Warehouse/Laboratory Facility
WRM	Wheel Rail Mechanism Loop