



Square Robot provides in-service internal robotic inspections for aboveground storage tanks. By keeping the tanks in-service, Square Robot removes the need to put people into confined spaces, removes unnecessary release of carbon emissions, and allows the tank to continue to produce revenue.



TIS provides environmental and industrial services to railroads, mid-stream oil & gas, and industrial clients throughout North America. Focused on top-tier service and safety, services include environmental management, tank services, facility maintenance, and hazmat & OSHA training.



Headquartered in Kansas City, Mo., Kansas City Southern is a transportation holding company founded in 1887 with two primary subsidiaries, The Kansas City Southern Railway Company and Kansas City Southern de Mexico, S.A. de C.V., which form a cross-border rail network. Visit [www.kcsouthern.com](http://www.kcsouthern.com) for more information.



# Robot performs in-service tank inspection – keeps railroad’s locomotives on time.



TANK CONSTRUCTION	
Year built	1979, re-erect
Tank Diameter	114.5 feet
Tank Height	35 feet
Capacity	2.7 million gallons
Foundation Type	Earthen
Bottom Type	Lap-welded Double Bottom
Product	Diesel, red-dyed

## INTRODUCTION

In May 2022, Square Robot, Incorporated performed a Phased Array Ultrasonic Thickness (PAUT) Robotic Internal Inspection and API 653 External Inspection of Diesel Tank HVN T-105 for The Kansas City Southern Railway Company (KCSR) at their Heavener, Oklahoma fueling facility. The results of this inspection were used to provide an evaluation per the applicable criteria of API Standard 653, Tank Inspection, Repair, Alteration, and Reconstruction, 5th Edition, November 2014, Addendum 1 (April 2018), and Addendum (May 2020).

## PROJECT PLANNING

Our approach was to perform the inspection while keeping the tank in service, supplying an average of 80,000 gallons a day to the locomotive fueling rack, with fueling events taking place around the clock with no interruption in service. KCS increased the normal fuel level of the tank to 23’ to account for the fuel loss over the course of the inspection, as we could not take pipeline fuel deliveries while the inspection robot was inside the tank, and we needed a minimum of 15 ft. in the tank while the robot was submerged.

## ROBOTIC INSPECTION PROCESS

The inspection robot (vehicle) is craned from the ground to the tank roof, then launched through 24” diameter roof manway/inspection hatch, into the tank. During launch and recovery, the vehicle is electrically bonded via the lift assembly and steel cable to the portable davit crane, which is itself bonded securely to the tank. Once the vehicle is fully submerged the lift cable is removed. It autonomously powers on upon reaching a depth of 3 meters (10 feet), fully submerged in the tank product. Real-time communications between the robot and the operations computer in the support trailer outside the tank are through a 1/4 inch fiber optic tether, attached to the robot throughout operations.

The vehicle autonomously executes its mission behaviors in the tank, which include:

- Performing navigation initialization and calibration
- Executing PAUT survey while in contact with tank bottom through 3 omni-directional wheels
- Executing annular plate surveys (APS) all the way up against the shell

The robot navigates through the product using 8 thrusters and its 3 omni-directional wheels. Through this, it carries out constant altitude visual surveys of the tank bottom and shell. Upon completion of a tank inspection, the vehicle autonomously positions itself underneath the roof manhole on the tank bottom. The operator shuts all systems off and begins recovery by lifting the robot up using the fiber optic tether that has a 1300 lbs tensile strength, hooked to the lift cable, and removed through the manway.

The robot is designed for Class 1, Division 2, Group D Hazardous Locations and the robot’s Non-Destructive Testing (NDT) data has been qualified in accordance with API 653 standards. Simultaneously while performing NDT surveys, bottom elevation data is collected via the inspection robot’s onboard pressure sensor. The robot collects over 1 terabyte of visual and PAUT data which includes 18,000 UT data points per square foot scanned.

## RESULTS

The robot was deployed in the tank for approximately 10 hrs./day and removed each night. The robotic inspection including setup and tear down project took 3.5 days.

The robot successfully inspected 81% of the tank bottom and 95% of the accessible inspection area. PAUT data revealed two areas of remaining thickness at or below 0.202-inch (19% wall loss) on the bottom plates. This corrosion was determined to be on the soil side of the bottom plates. The lowest remaining thickness of the area is 0.174-inch (32.6% wall loss). Based on this remaining thickness, the recommended next internal inspection will be in 17.8 years.

A double bottom was discovered during the external inspection by Square Robot crew chief, Billy Yackel. The double-bottom interstitial space was identified as being filled with sand and cathodic protection anodes with the dead shell between the two bottoms stitch-welded containing 2-inch gaps. The foundation was found to be in acceptable condition. The tank edge settlement was measured and determined to be within tolerances.

After 3 weeks of data analysis the final API 653 internal and external inspection report was presented to KCS.

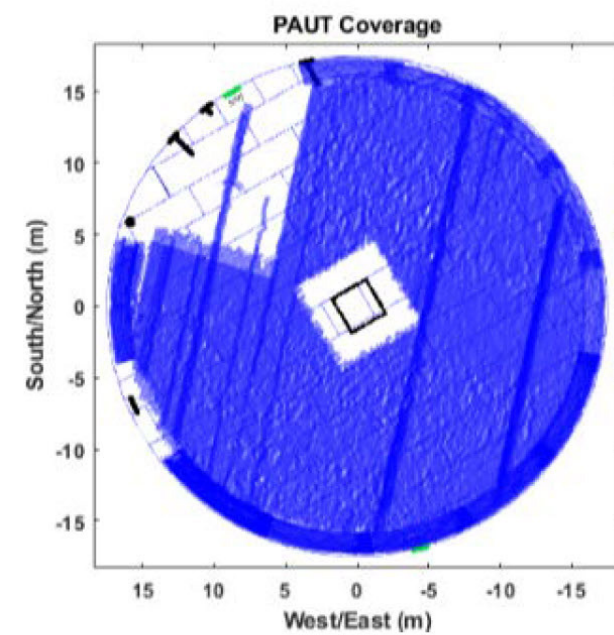
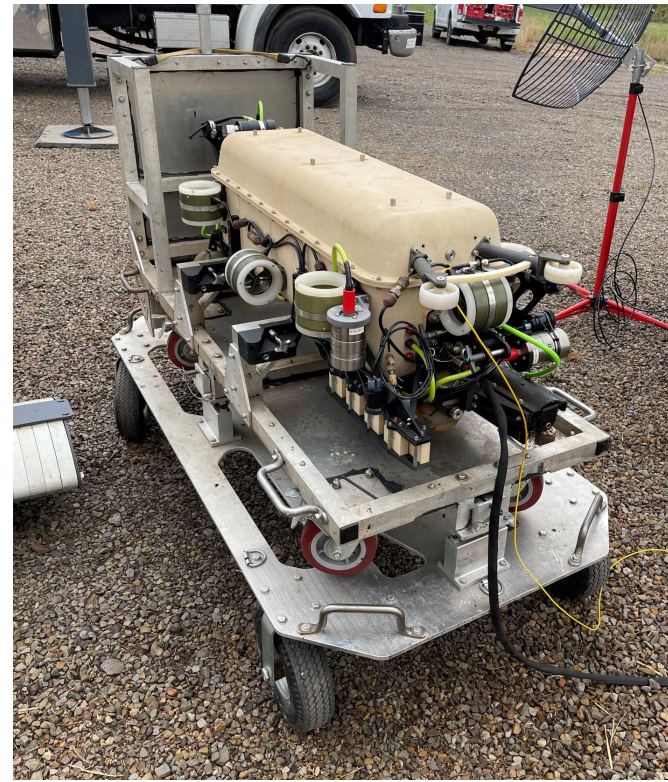


Figure 1 - Robot Survey Tracklines (blue)

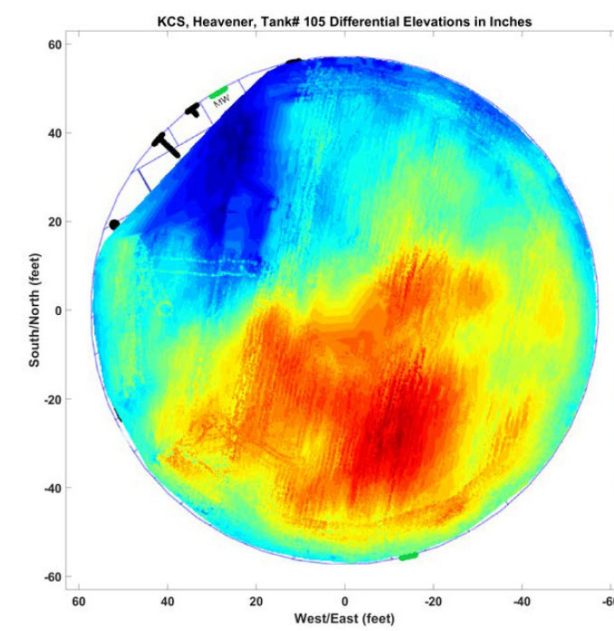


Figure 4 - Contour Plot of Differential Elevation (in)

## CONCLUSION

The robotic inspection was 100% successful with all equipment performing as designed. Being able to perform the inspection robotically, without draining the tank and taking it out of service was a significant cost savings. On top of the cleaning and disposal costs, since this is a single tank installation, KCS would have to construct a temporary fuel storage facility capable of delivering 80,000 gallons/day for locomotive fueling. We were able to justify extending the next out of service inspection date to 2039 giving the Railroad more time to plan for eventual replacement of the tank.