1.0 WAYSIDE VEHICLE HEALTH MONITORING SYSTEMS

The heavy haul railways around the world are increasingly moving toward detector and performance-based rolling stock maintenance to improve efficiency by reducing the cost of maintenance and inspection. Advances in sensors, data collection systems, computer software and communications have enabled the development and deployment of sophisticated, reliable and accurate wagon and track monitoring systems capable of automating many train inspection processes; offering opportunities to replace, supplement and enhance the safety and productivity of railway operations. In many instances automated wagon health monitoring systems are capable of examining vehicle performance attributes while in motion, providing additional insight on vehicle behavior in a dynamic on-track environment.

Currently, the various car health monitoring systems are being used to identify poorly performing cars and bogie components. In the near future, technology will allow for the detector systems to be integrated in order to assess the overall condition of the car and its components and to plan shorter and longer term and proactive maintenance actions. Automated wayside and onboard wagon condition monitoring devices are expected to free wagon inspectors to concentrate on freight wagon repairs to improve productivity of rail operations. As a result inspection cycles for rolling stock will be extended, and maintenance will be performed when needed.

The detector data management systems store the detector data and provide users with the capability to make predictive, condition-based maintenance decisions rather than having to rely solely on visual inspection. It also makes data available to a wider range of stakeholders than possible before. This means that wagon owners, who did not previously have access to inspection data, can (given railroad permission and a password to access the data) manage their assets remotely. These databases use a variety of automated equipment identification systems located at detector sites to determine vehicle location, direction of operation, and load condition. This information is than utilized to determine optimal maintenance locations.

In the following, a brief description of the automated wagon inspection research conducted by Transportation Technology Center, Inc., under the Association of American Railroads Strategic Research Initiatives Program is given.

1.1 MACHINE VISION INSPECTION OF WAGON COMPONENTS

The potential to increase both the effectiveness and efficiency of car inspections using advanced vision technologies offers an opportunity to lower costs and increase productivity. Vision systems can objectively inspect railcars without tiring or becoming distracted and can also focus on certain parts of the railcar not easily seen by an inspector on the ground. Currently, carmen inspect hundreds of cars during their shift. Monotony and fatigue may affect the efficiency of inspections. Also, since the inspection results are not normally recorded, a railcar’s health cannot be tracked over time, making planned maintenance and monitoring defect trends difficult. Capacity in yards is increasingly at a premium. Automated inspection of train cars as trains are entering or leaving terminals has the potential to improve yard capacity by eliminating the need to hold a train for manual inspection.

1.1.1 Wheel Profile Monitor and Brake Shoe Measurement

The first applications of machine vision to rail cars were on wheels and brakes. This takes advantage of the commonality of these items on every car. Existing standards makes it relatively easy to establish objective measures of these components. Wheel profile measurement (WPM) systems and brake shoe measurement (BSM) systems have been applied in North American railways and worldwide. Figures 1 & 2 show example wheel profile and brake shoe images from LynxRail[1]. The technology enhances the inspection process because of its objectivity and it produces historical data that can be used for trending and preventative maintenance.

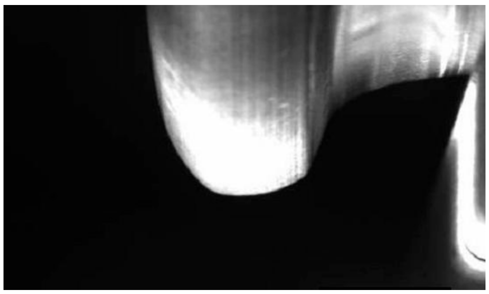

Figure 1. Wheel Profile Module Image

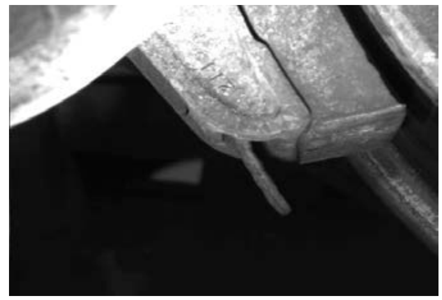

Figure 2. Brake Shoe Module Image

1.1.2 Machine Vision Inspection of Rail Vehicles

Adaptation of machine vision to broad inspection of rail cars presents greater challenges than inspecting wheels and brakes shoes. The wide variation of car types, safety appliance locations, and undercarriage configurations requires very robust recognition algorithms as well as extensive image acquisition. Careful consideration must be paid to camera angles and views. Also, lighting solutions can be very challenging. Varying ambient light and shadows make it difficult to get consistent images of every component in all night and daytime lighting conditions. Although significant, these challenges are being addressed.

Three machine vision based systems are being development under the guidance of the Association of American Railroad's (AAR) Strategic Research Initiative (SRI). The Automated Inspection of Safety Appliance System (ASAIS) assesses the condition of a railcar's safety appliances (ladders, hand holds, sill steps, etc.) and the Automated Inspection of Structural Components (AISC) system evaluates the condition of the railcar's underframe and related structural members. The third system, referred to as the Fully Automated Train Scanning System sums the capabilities of these systems plus others to create a complete image of the top, sides and undercarriage of every carriage.

1.1.3 Automated Safety Appliance Inspection Systems (ASAIS)

Automatic Safety Appliance Inspection (ASIAS) on coal cars from Beenavision[2] of Norcross, GA, underwent extensive testing at Transportation Technology Center (TTC) in Pueblo, Colorado, USA and is now under test on a North American railroad. As a train passes at track speeds up to 35 mph, the ASAIS records digital images of the train cars. Machine vision algorithms identify the safety appliances and detect defects on all coal cars passing the system.

Figure 3. Beenavision Automated Safety Appliance System on a North American Railway

The automated algorithms are currently for coal cars only. Other car types will come later. Testing of the ASAIS indicates that the system is capable of detecting safety appliance defects with a success rate of greater than 98%. Figures 4, 5 and 6 show examples of ASAIS images.

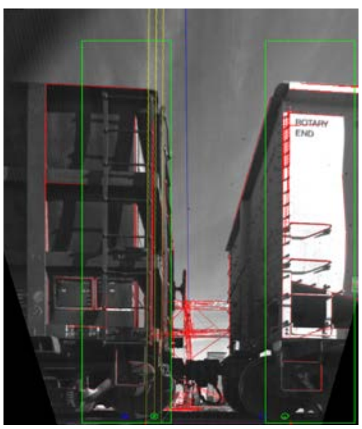

Figure 4. Object Detection

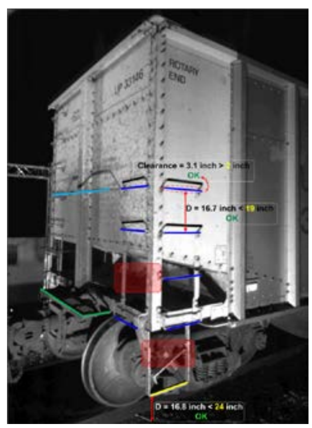

Figure 5. Object Assessment

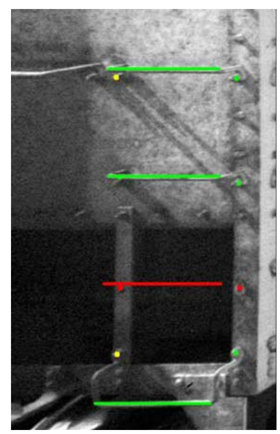

Figure 6. Missing Ladder Tread

1.1.4 Inspection of Bogey components

Under the sponsorship of the AAR strategic research initiative, TTCI is testing emerging systems for inspecting the condition of components on carriage bogeys. Companies involved are Beenavision, KLD Labs[3], and LynxRail. Inspections include bearing end cap bolts, missing springs, broken springs, friction wedge missing or high, and broken journal bearing adapters. Figure 7 shows example images from the bogey inspection cameras. These images can be used to detect load imbalance, diagnose spring condition, measure wedge rise, count end cap bolts, and find broken bearing adapters. Test systems at TTC demonstrate automatic detection of spring condition and bearing end cap bolts.

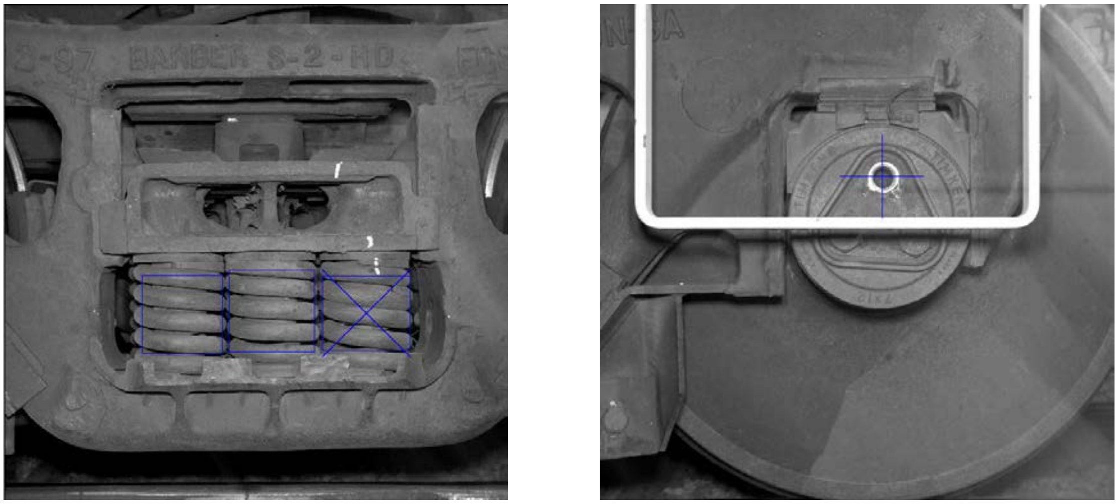

Figure 7 Spring condition, load balance, wedge condition, end cap bolts, and bearing adapters are diagnosed.

1.1.5 Automated Inspection of Structural Components (AISC)

In cooperation with the Federal Railroad Administration, TTCI and AAR are testing AISC systems capable of fully automated train structural component inspection. Two companies, Beenavsion and DuosTech are developing these systems. Beenavision has one AISC system on a revenue service trial on a US railway. The AISC systems evaluate the condition of the railcar's underframe and related structural members. The systems use computer algorithms to positively identify components of interest and objectively assess their condition. Inspection time and inspector subjectivity is eliminated and a vehicle condition report can be generated with exception reports automatically transmitted to the appropriate locations. Algorithms currently exist for coupler pin retainer bolts and brake rigging.

Figures 8 through 11 show images generated by the Beenavision AISC prototype system and a photo of the installed system.

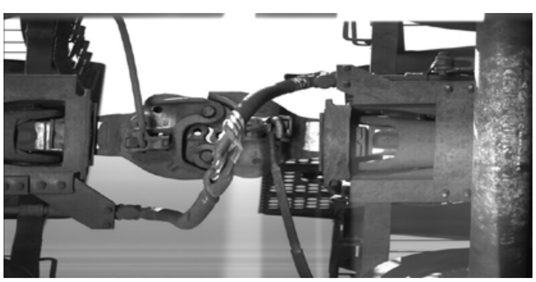

Fig. 8. Coupler & Draft Arrangement

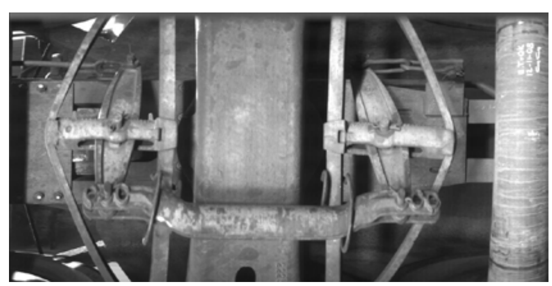

Fig 9. Truck Bolster and Brake Rigging

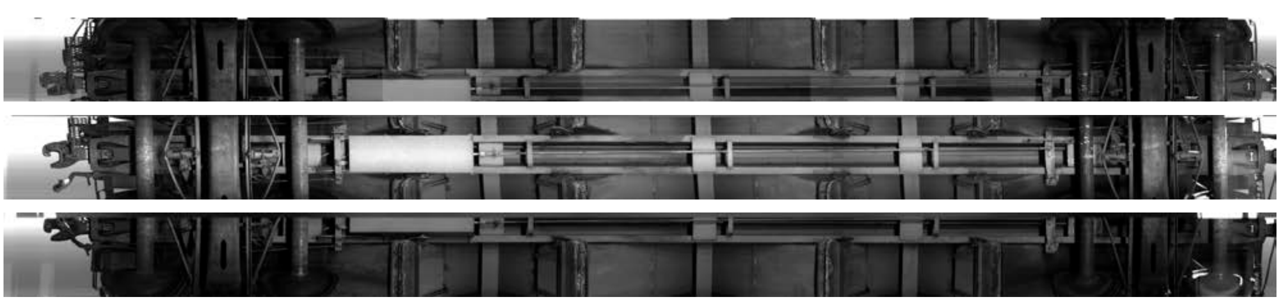

Figure 10. Complete Car Undercarriage

Figure 11. The Automated Car Undercarriage Inspection System installed on a US Railway

The initial proof-of-concept testing of an undercarriage inspection system (AISC) showed that the system was capable of capturing processable images at speeds up to 35 mph. Machine vision applications hold great promise for the future of train inspection. Many challenges remain but progress continues in meeting and overcoming these obstacles.

1.1.6 Fully Automated Train Scanning System (FATSS)

The imaging and processing capabilities demonstrated by the Automated Safety Appliance Inspection System (ASIAS), the Automated Inspection of Structural Components (AISC) system, and the Bogey inspection system has prompted the development of a Fully Automated Train Scan System (FATSS). Figure 12 shows the prototype system installed at Transportation Technology Center (TTC) in Pueblo, Colorado. This system uses an array of cameras and lights to create a complete image of the top, sides and undercarriage of each car in a train. Figure 13 shows the top, side, and underside images of the carbody.

Figure 12. Fully Automated Train Scanning System installed at TTCI's FAST Facility

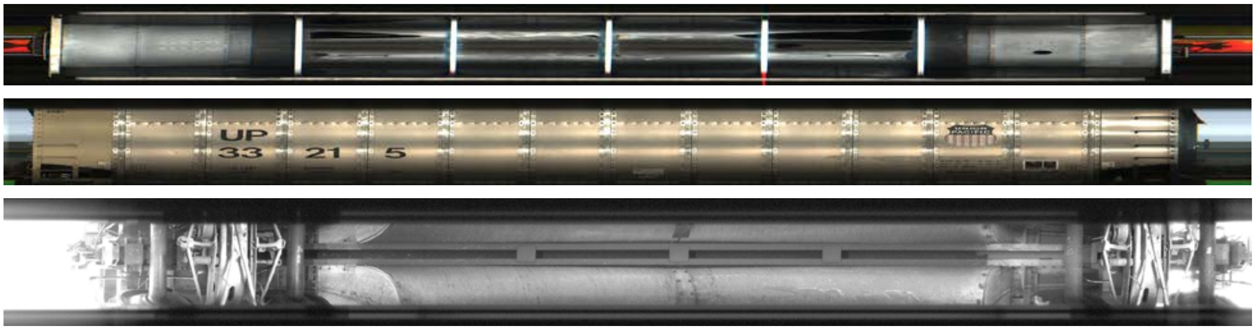

Figure 13. Top, side, and underside views from the FATSS system.

The ability to image the entire railcar opens the possibility for several applications. Lower positioned cameras provide detailed images of truck, brake rigging and draft pocket components that can be scanned for defects and unusual wear. Side mounted cameras offer an opportunity to quickly identify imbalanced loads, unsecured lading and various car body defects. A top mounted camera allows for easy evaluation of top chord and interior bracing in coal hoppers. In addition to enhancing traditional inspections, the FATSS provides an excellent opportunity to add security applications such as foreign object detection and tank car assessment.

The potential to increase both the effectiveness and efficiency of rail car inspections by utilizing machine vision technologies enhances the railcar inspection process and offers an opportunity to improve safety, lower costs, and increase productivity. Results of the tests conducted so far clearly indicate that the use of a combination of technology driven car inspection equipment and performance-based inspections is feasible to replace the current in-bound and outbound inspections performed by yard inspectors. Machine vision applications hold great promise for the future of the train inspections. Many challenges remain but progress continues on improving the overall inspection process.

References:

1. Lynx Engineering Consultants Pty Ltd, 30 Brown Street, East Perth, W.A. 6004, Australia
2. Beena Vision Systems, Inc., 600 Pinnacle Ct, Norcross, GA 30071, USA
3. KLD Labs, Inc., 300 Broadway, Huntington Sta, NY 11746, USA
4. Duos Technologies, Inc., 6622 Southpoint Drive S., Suite 310, Jacksonville, FL 32216, USA
5. Robeda, Jim, Gonzales, Kari and Jones, MaryClara, "**Development of Automated Inspection of Structural Components Algorithm**," TTCI Technology Digest, TD12-001, January 2012.