Conrail's Integrated Automated Wayside Inspection

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ABSTRACT

Wayside detector devices, over the years, have proven to be valuable assets to a railroad in enhancing safety and improving efficiencies. Currently, devices such as hot box detectors, dragging equipment detectors, high car detectors, wheel impact detectors have routinely prevented accidents or damages from occurring. Some of the detectors were invented in the past out of desperation. For instance, bearings in distress are impossible to detect from visual inspection of the trains. Certain outside defects such as loose or broken backing rings or end caps are readily seen. Other defects such as internal brinelling or spalling will be completely invisible to the car inspectors. Therefore, hot box detectors which use infra-red detection technology were installed to substantially aid to detect defective bearings. While these detectors are not perfect in the sense they occasionally give false alarms and the spacings are such that there is still a chance a bearing can get hot and burnt-off in between two detectors, a lot of burnt-off's potentially causing millions of dollars in accident cost were prevented over the years, because of existence of these detectors.

With the advent of electronics in terms of its sophistication, capability, cost and miniaturization, a lot of interests arose recently to other invent wayside devices to further improve efficiencies and reduce manual inspection requirements of freight car components. The integration of these devices between each other and their integration into the railroad maintenance system increase the potential for efficiency gains.

At this juncture, Conrail has re-examined the usage of electronics and has advanced the use of technology in fault detection of freight car components. This paper gives an account of freight car failure detection devices and what are currently available in service and what are being developed in 1998. Conrail's integration of some of the devices and the automation of reporting the faults and rerouting of defective cars will also be presented.

INTRODUCTION

Conrail has focused in the past two years on the use of wayside detection as part of the effort to implement the concept of managing by prevention. The automatic inspection has concentrated on wheels and bearings of the rolling stock. An analysis of the derailment costs and the maintenance costs revealed that these are the two obvious components to be focused in. Figure 1 below shows the 1996 and 1997 mechanical caused derailments on Conrail and their root causes. In 1996 wheel defects were found to cause the most derailments. In 1997, a big part due to the help of the wayside detectors, the wheel derailments were reduced from number 1 to number 2 and the brakes became the number one cause, although the number of brake caused derailments has not increased.

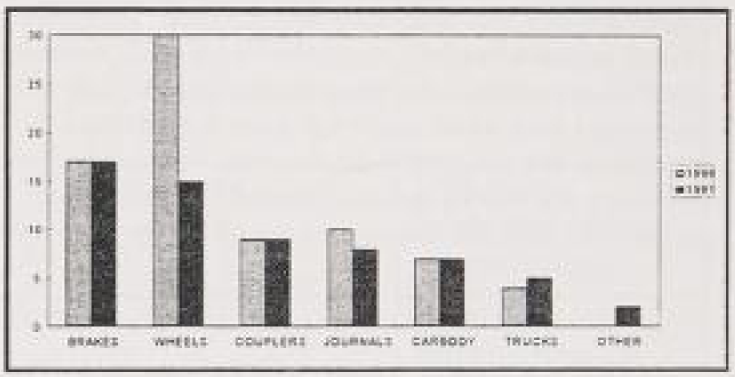

FIGURE 1 - TRAIN DERAILMENTS ON CAUSED BY MECHANICAL COMPONENTS

It should be pointed out these devices cannot completely replace manual and visual inspection especially the train departure inspection at this time. Most of these devices concentrate on wheels and bearings which happen to be ones with the highest maintenance cost and derailment cost. However, other FRA defects such as cracks on underframes, side bearing clearances, safety appliances etc still have to be found by visual manual inspection. There is no intent on Conrail's part to develop a fully integrated automatic inspection station which does it all. Even if it is possible with today's technology, it may not be economical feasible at this time.

Automated Freight Car Component Failure Detection Devices

Table 1 is a list of existing traditional and non-traditional wayside detectors on Conrail. Traditional type detectors are those that have been around for 20 years and rely on axle counting to find the defective component. The message normally received from the traditional type detectors is a radio broadcast to the train crew. Most of the non-traditional type detectors have been invented within the last five to ten years. Some of these devices do communicate with another device to form a basic level of integration. For an example, impact detectors can receive car numbers for the AEI (Automatic Equipment Identification) systems to identify the freight car and physical location on the car. The non-traditional type detectors will also automatically dial up preset locations to broadcast messages including alarms. Users can also dial into these non-traditional system for inquiries and in most cases will have memory to store the data for the last 100 trains.

Some of the non-traditional detectors are in the development stage and have only been in service for less than two years. A short description of the mechanism and the function of each of these detectors is included in Table 1, however a more detailed description on each is presented further in the paper.

The integration of the devices and their communication among them started on Conrail in 1992 with the first wheel impact detector communicating with the AEI. Since that time all new devices are integrated with the AEI. Recently Conrail has integrated the wheel impact detector, AEI and the straight plate wheel detector at a site in Middlesex NJ. In addition, the cooperative development with the AAR on improving the bearing acoustic detector, will eventually integrate the acoustic, impact, and the AEI at the same site.

TABLE 1. TRADITIONAL AND NON TRADITIONAL DETECTORS ON CONRAIL

Type detector	Detector	Status	Primary Detection	Other devices integrated with	Prevention/Benefits
Traditional	Hot Box Detector	Existing on Conrail Functions continuously being improved.	Defective Bearings	none	Burnt-off derailment
Traditional	Hot Wheel Detector	Existing on Conrail Functions continuously being improved.	Dragging Brake;Non-released handbrake	none	Derailment from broken wheel; Reduced brake shoe wear
Non-traditional	Stuck Brake Detector	Existing on Conrail Needs to expand more system-wide	Unsatisfactory brake valve performance	AEI Conrail 's Autoshopping	Reduced train delay; Improved train performance
Non-traditional	Wheel Impact Detector	Existing on Conrail	Flat Spot; Spalling; Shelling; and Out of Round Wheels	AEI Conrail's Autoshopping	Derailment from broken wheel; Reduce equipment and track damage.
Traditional	Dragging Equipment Detector	Existing on Conrail	Broken car parts especially brake riggings	none	Derailment
Traditional	Boxcar Door Failure and load off-center Detector	Existing on Conrail	Boxcar door failure, load/trailer detector	none	Accidents to humans when doors fall off trains
Traditional	High Car Detector	Existing on Conrail	Excessive height of equipment	none	Derailment; Equipment damage; Bridge damage
Non-Traditional	Sliding Wheel Detector	Existing on Conrail	Brakes locked up on freight car and wheels sliding	AEI Conrail's Autoshopping	Derailment from Built up tread on wheels
Non-Traditional	Wheel Profile Detector	Existing on Conrail	AAR Rule 41 Wheel Defect	AEI Conrail's Autoshopping	Derailment; Optimized maintenance schedule; road failures and train delay
Non-Traditional	Bearing Acoustic Detector	Existing on Conrail and working with AAR on improved performance	Defective Bearings	AEI Impact Detector Conrail Autoshopping	Burnt-off derailment; Better planned preventive maintenance
Non-Traditional	Truck hunting Detector	Existing and under development on Conrail	Defective or worn trucks	AEI	Derailment; Reduced rail and truck wear;

Non-Traditional	Straight Plate Wheel Detector	Existing on Conrail	Determines wheel plate profile, works in conjunction with impact detector	AEI Impact Detector	Expedites the removal of straight plate wheels
Non-Traditional	Low and Worn Air hose Detector	Existing on and under development on Conrail	Low or worn freight car air brake hoses	AEI	Undesired brake applications and train delays
Non-Traditional	Wheel Crack Detector	Under development with AAR and Conrail	Fracture on wheel	none	Derailment; Wheel life; preventive maintenance

DESCRIPTION OF DEFECT DETECTION DEVICES

Each of the devices, their main functions, development status, and operational benefits are reviewed in the following sections.

Hot Box Detector

Hot box detectors are the most commonly used wayside defect detector device in the railroad industry. These detectors, placed every 20 to 30 miles, employ pyrometer technology to scan the heat signature of the journal bearings. Conrail has approximately 320 inboard scanning systems on its railroad. These inboard scanners are mounted on the rails and are positioned to aim at the inboard side of the journal bearings. These are newer type than the side mounted scanners planted in the ballast and scan mostly on the bearing end caps. Conrail has phased out all of these side mounted scanners. In the latest development, sophisticated microprocessor technology is used to perform digital processing of the signals. The detectors are able to distinguish plain bearings from roller bearings and apply appropriate criterion. With the digital processing, other appropriate criteria can be put into place too. For an example, if the differential between the left and the right bearings is too high, a hot box alarm will be indicated. The digital processing has proven to greatly enhance the accuracy of these detectors. On the average, the detectors catch about 300 verified setouts each year. Usually, ten (10) are not caught per year leading to expensive derailments. These can be attributed to quick burnt-off mechanism when the journal bearings suddenly have a thermal runoff inside the spacing between two detectors. Occasionally, even after the hot box is detected, a burnt-off occurred during the setting out process. Figure 2 shows the freight car bearing failures on Conrail between 1989 through 1997. Without this detection, there is a high possibility that any one of these setouts can cause a burn-off and a serious derailment.

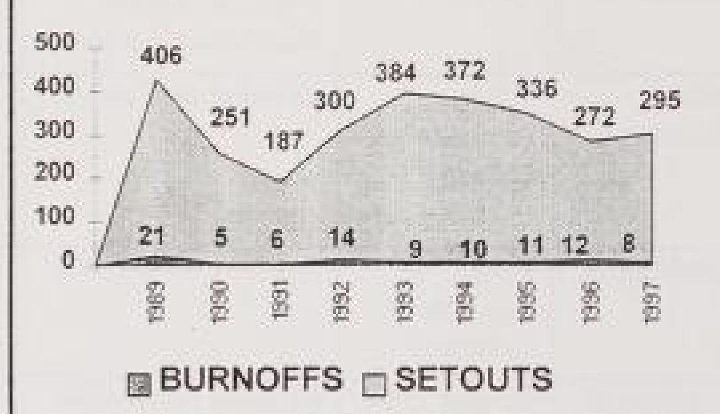

FIGURE 2. FREIGHT CAR WHEEL SET BEARING FAILURES ON CONRAIL

There are some drawbacks on these detectors. The detectors sometimes give a false indication of hot boxes because of other causes. Heat generated from wheel braking can cause the detectors to mistake the heat to be from the bearings. Sometimes because of the configuration or design, some roller bearings are mistaken as plain bearings. There are still other false alarms without any good reasons. These false alarms will cause the locomotive engineers to stop and inspect the trains leading to unnecessary train delay which can cost $2,000 per hour. Conrail has taken extensive steps to reduce these "False Stops". Figure 3 shows the result of a five year effort to reduce false stops to less then 100 per month.

FIGURE 3. HOTBOX DETECTOR FALSE STOPS ON CONRAIL

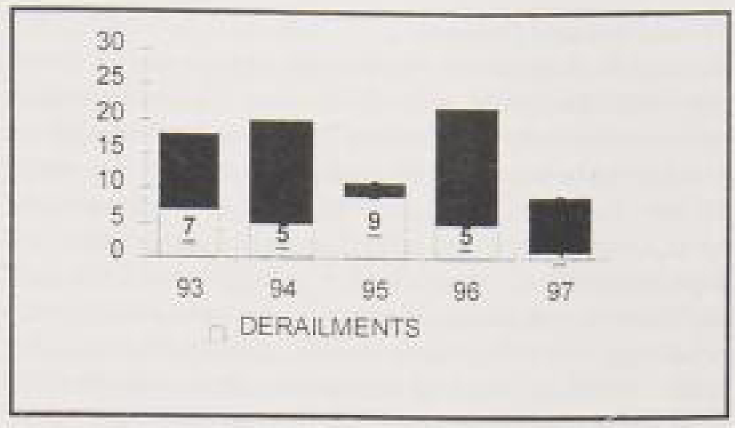

FIGURE 4. WHEEL FAILURES ON CONRAIL

Hot Wheel Detectors

The technology used in the hot wheel detectors is the same as the hot box detectors. However, instead of aiming at the inboard end of the journal bearings, the detectors focus on the wheel a few inches above the top of the rail so that a high temperature on the wheel plate near the rim can be detected. These detectors are used mainly to check for stuck brake, and non-release of handbrake which can lead to stress reversal in the wheels resulting in cracked and broken wheels. Therefore, the most strategic location for these detectors is near the outbound point of a yard or at the end of a grade. If the wheel is permitted to travel too far with the high heat it will cause high enough temperature on certain areas of the wheel which can then be transformed into martensite microstructure. Micro-cracks as well as brittle microstructure can eventually lead to a broken or fractured wheel. On the average, Conrail has between five and ten broken wheel incidents a year causing derailments. Figure 4 shows wheel failures on Conrail and the number causing derailments.

In 1997, there was only one broken wheel derailment on Conrail. That failure was actually caused by a manufacturing defect rather than excessive thermal input. This record low number of broken wheel derailments was a result of not only utilizing the traditional detectors such as hot wheel detector better but also the employment of wheel impact detectors and the sliding wheel detectors to be discussed later.

To set up a proper alarming temperature criterion for hot wheel detectors is rather difficult. In the past, when we calibrated the alarming temperature to be about 600 degrees F above the ambient, there was an excessive number of false alarms arising from wheels getting hot with normal braking. The temperature was changed to 800 degrees F above the ambient then, but it was found that it could miss truly hot wheels. Currently, the temperature was set at 750 degrees F above the ambient.

Stuck Brake Detectors

With the advent of microprocessor and the AEI system, the hot wheel detectors can be made more intelligent so that false stops can be avoided. In 1997 Conrail placed two digital hot wheel detectors in service in traffic areas where the brakes of the freight car are normally not applied. The alarm levels are set lower than the traditional hot wheel detectors, 500 to 600 degrees F. The alarm can be broadcasted to the train, but can also be transmitted to Conrail system computer. When the car is emptied, it is shopped and the air brake system is tested.

With the new microprocessor system being used on the stuck brake detector, additional alarms can be developed to assist in the mechanical inspection of freight car braking systems. For an example, temperatures of all the wheels within a train can be analyzed. If a site is selected where normal braking is being applied in the train for a short period, all wheels should attain a certain minimum temperature. This site can be programmed to look at wheels with no heat. No heat would indicate a malfunctioning brake. These unexplored opportunities to expand the use of the stuck brake detector integrated with an AEI system will only result in further cost saving to the railroads.

Wheel Impact Detectors

Damage from defective wheels costs the railroads a significant amount of dollars every year. The damage on rails, track structure, car structure, bearings and lading is resulted when wheel impact loads greatly exceed nominal values. The bad wheels which are out of round due to flat spots, chipped-off tread surface, or spalling can induce high impact loads. Once they are no longer round, the defective area of the wheel can strike the rail on each revolution two to five times higher than the normal wheel loads. Normally, the only way to detect these bad wheels is by a visual inspection during initial train departure, until the advent of wheel impact detectors. Using specially designed track mounted strain gages and state of art high speed computer technology, the wheel impact detector eliminates the need for manual inspections and the need to delay trains. This system inspects each wheel electronically at normal track speeds and alerts the railroad to the exact identity of the bad wheel in the train.

Conrail has installed several wheel impact detectors manufactured by Salient Systems on its system. These detectors measure high impact forces on the rail caused by flat spots, shelling, built-up tread and out-of-round conditions. When a impact load limit is exceeded, the car number and the wheel number of the problem freight car are identified for inspection. Conrail has developed the alarming criteria for impacts into three severity levels. The alarm is given in kips (1000lbs). Trains are required to slow down to 30 mph for alarms over 150 kips. A train with an alarm over 170 kips is required to stop for an inspection. When it is determined that there is no FRA or other safety defect, the train then can proceed at a maximum of 30 mph for setting out the car at the next designated location. When the alarm level is between 100 kips and 149 kips, the automatic shopping function is utilized to transmit the alarm to the Conrail system computer. When the car is emptied the car is shopped for wheelset changeout, and air system test.

Dragging Equipment Detector

The dragging equipment detectors are basically made up of feelers which are activated when dragging broken components still attaching to cars hit the feelers. Like the hot box detectors, these can be connected to talkers to inform the crew through the voice radio when dragging equipment is detected. This is not sophisticated technology, but has saved quite a few potential disasters before they happened, especially in cases of broken brake beams. In the past, there were occasions that the dragging equipment detectors actually caught derailments in time to limit the extent of damage to a few cars instead of a long string of cars. The damage to the track was substantially reduced because of the early derailment indication. This system works well as it is and would have limited efficiency gain from any upgrading. However, integrating the dragger with the AEI system would enhance the process to speed up the inspection upon train stops.

Boxcar Door Failure and Load off-center Detector

These detectors are based on the same principle as the dragging equipment detectors. Feelers are set on the side to detect the extreme width of the equipment. If this width intrudes into the envelope set by these detectors, the feelers will be hit and alarm will be activated. Conrail has used this principle to put this type of detector in the Philadelphia area. The main purpose is to detect failed and leaning boxcar doors. It also detects an open boxcar plug doors or car leaning due to off-center loads, fouling the adjacent track. Again, this system works well as it is and would have limited efficiency gain from any upgrading. However, integrating this detector with the AEI system would enhance the process.

High Car Detector

The high car detectors use laser beams for determination of the extreme height throughout the train. These detectors are situated at strategic locations to protect bridge structures where high cars may intrude into the height of the clearance envelope on the route. Typical corridors with these detectors are where double stack cars operate with a height of 20' 2".

Unless new corridors for high cars are opened up, Conrail has a sufficient number of these detectors. Again, this system works well as it is and would have limited efficiency gain from any upgrading. However, integrating this detector with the AEI system would enhance the process.

Sliding Wheel Detector

The sliding wheel detector was jointly developed by Conrail and S.A.I.C. in 1996. Conrail was having a chronic problem with built -up tread coming down a steep grade in western Pennsylvania and causing derailments in the town of Altoona. The operation of the train coming down this mountain requires the brakes applied on the train for the entire descent down the grade typically for 45 minutes. If there is a malfunctioning brake control valve on an empty car, it usually will result in locking up wheels from excessive brake cylinder pressure. The wheels slide on the rail and metal build up from the heat causes the built-up tread to form. With this built-up metal on the wheel treads, the car will tend to bounce drastically if the brake is released. At the bottom of the grade, in the middle of Altoona, when the trains brake is released, a derailment sometimes occurs. In 1996 Conrail experienced a very high rate of derailments from this mechanism. Out of desperation, Conrail initiated and successfully developed the sliding wheel detector with S.A.I.C. The system, employing thermal imaging and digital image processing techniques, is "one of a kind." Using an infrared line scan camera, the heat signature of the wheel under braking can be captured as a thermal image by a PC type computer. During normal brake retardation, the wheel continues to rotate. As a result, the wheel is heated evenly all around the wheel rim. However, if a brake control valve is malfunctioning or excessive pressure is built-up in the airbrake cylinder, wheels will be locked up and will be sliding rather than rotating. Heat will be concentrated at the interface between the wheel and the rail, that is, at the bottom of the wheel. Figure 5 shows an example of the image that is generated from a sliding wheel as compared to that of a normally braked wheel. Through testing and development, it was verified that the other areas around a sliding wheel are relatively cool compared to the sliding bottom area. As a result of this research effort, a sophisticated algorithm analyzing the thermal images was developed by SAIC for Conrail to detect sliding wheels.

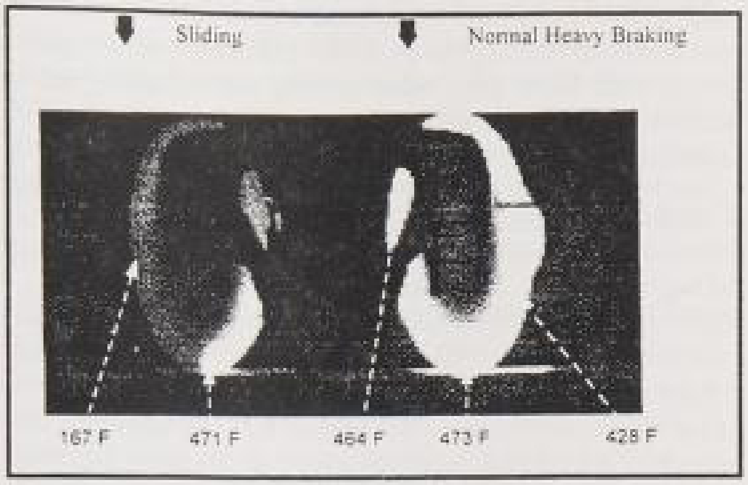

FIGURE 5. THERMAL SCAN OF SLIDING WHEEL

This development integrated various technologies such as infrared linescan camera technology, Automatic Equipment Identification (AEI), digital computer architecture, high speed data processing and telecommunication. This results in a system available for the first time to broadcast alarms of sliding wheels for prompt intervention, before any mishap occurs such as broken wheel or derailment due to built-up tread and slid flats.

Figure 6 shows the derailments on Conrail form the built-up tread cause. The significant improvement in 1997-98 came from the elimination of the derailments in Altoona from the sliding wheel detector, which was installed at about 3 miles from Altoona control tower.

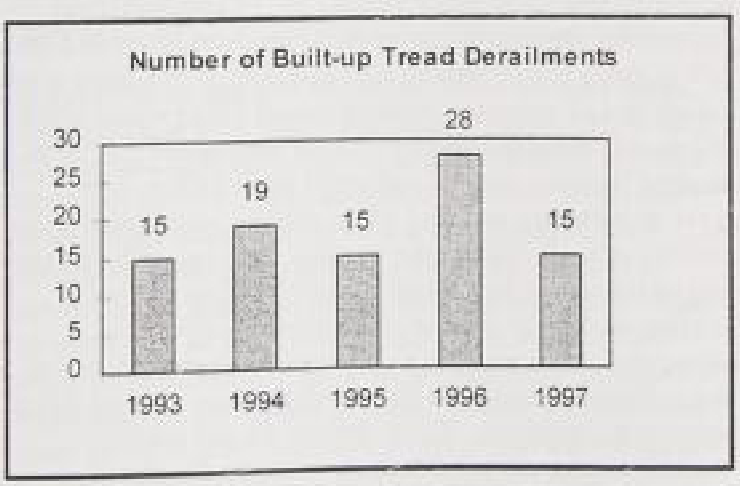

FIGURE 6. BUILT-UP TREAD WHEEL FAILURES ON CONRAIL

Wheel Profile Detector

Wheel defects can be classified into excessive wear, surface defects and cracking. Surface defects and cracking are failures from abnormal service. Excessive wear however is a result of deterioration from normal service. Attention is still required for wheels with excessive wear or else performance and safety can be compromised. Therefore, as an effort to develop a wayside device to automatically detect excessive wear condition. Conrail has installed the LORAM AWIS (Automatic Wheel Inspection System) at the hump operation at Elkhart IN. The LORAM system is a laser and camera system which measures the wheel profiles of every wheel in the train as it is being processed through the humping operation. This detector checks basically for defects such as high flange, thin flange, and thin rim. Figure 7 illustrates the computer processing of the laser beam reading and the profile generated by mathematical manipulation. Figure 8 shows the dimensions measured and output by LORAM AWIS. With some further development, other defects such as hollow tread can be analyzed also.

Currently, Conrail and the AAR are looking at integrating the profile detector and a truck hunting detector to pick up the hollow tread defects. The AAR Interchange Rules define the condemning limits for wear with flange thickness, flange height and rim thickness. Possibly due to the difficulty of measurement, there is no criterion for condemning hollow profiles. Recently in the last several years, several major derailments in the industry have been identified to be caused partly due to hollow wheels forming abnormal rolling radii and contact points at the wheel and rail interface. This, coupled with truck warping from excessive wear condition of the truck, can lead to excessive lateral curving forces and undesirable contact point location and consequently derailments. The LORAM wheel profile detectors present a possibility in the management of removal of problem "hollow worn" wheels that are not yet condemnable by the AAR criteria before they cause problems in the railroad operation.

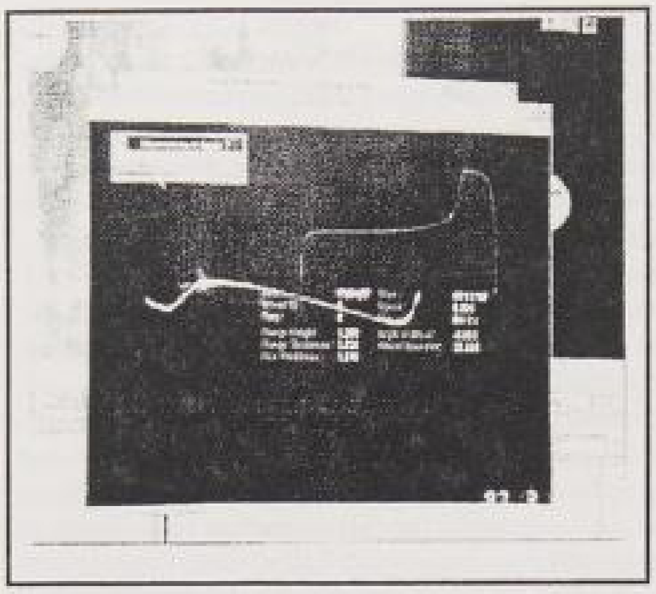

FIGURE 7. WHEEL PROFILE ANALYSIS OF LORAM AWIS

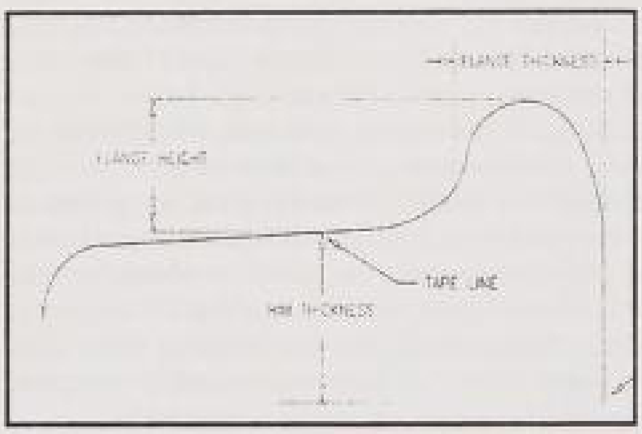

FIGURE 8. DIMENSIONS MEASURED BY LORAM AWIS

Bearing Acoustic Detector

The bearing acoustic detector is based on the principle that any roller bearing with a defect should emit an unique and distinguishable acoustic signature. Intensive research in this field was initiated in 1986. Both Harmon and Servo dedicated resources in this field. Burlington Northern, Norfolk Southern and Conrail had at least one acoustic detector made by Servo installed at one time on their system for development purpose. When a train passes by, it triggers the microphone to record noise generated by the train. This noise is analyzed by the microprocessor to first segregate the noise and assign to each roller bearing. Then with signal processing method, the noise signature in terms of the frequency spectrum of each roller bearing is further analyzed to check for defects. However, all railroads have found out back then that while this theoretically is feasible, a lot of research, enhancement, and refinement was still required.

What Conrail found, as did the railroad industry, was that the 1986 designed device can generate false alarms. The alarmed bearings were found to be in good condition by the teardown process. In addition, it was found that some of the cars after alarming can run, sometimes up to 20,000 miles, without the failure as a hot bearing. Based on the use of the 1986 vintage acoustic detector, one interesting statistics was found in that a bearing being alarmed a second time going past the detector would show spalling and damaged raceways every time. Although the acoustic detector has found some roller bearing defects one of the predominant roller bearing defects, loose cones, was not detectable with the 1986 design.

Currently, the AAR has further developed the acoustic technology to identify the loose cone signature with the use of neural network. This method can be used to find other defects more accurately also. An attempt is being made to transform this method into a more practical detector for use by the railroads. Conrail in working with the AAR has installed their prototype at Middlesex NJ. The initial objective is to capture bearings from various types and sizes of freight cars and correlate the defects into a large database of acoustic signatures from which an alarm level will be established.

Once the alarm level for each type of defect is established the acoustic detector will be integrated into the automatic shopping program where the alarm is transmitted to the Conrail system computer. When the car is emptied the car is shopped and the wheelset removed and the bearing inspected. This process will gradually build up the database of bearing acoustic signatures for the neural network.

Truck Hunting Detector

Each freight car designed today has a threshold speed for high speed instability. When the car reaches this speed the truck oscillates, sometimes violently, between the rails. This phenomenon is called truck hunting. When trucks hunt violently, derailments can occur. Excessive lateral forces from the violent lateral oscillation can result in high L/V (Lateral Force/Vertical Force) ratios. When there is an excessive L/V ratio, rail rollover, wheel lift or wheel climb can occur. Several defects in the car can induce this truck hunting problem, e.g., mis-adjusted side bearing, worn truck components, and bad wheel profile. Additionally the steering of the axles and the warping stiffness of the trucks can be influenced by broken or worn bearing adapter, friction wedge elements or other components. Low warping stiffness and low rotation stiffness can aggravate the problem. Conrail has had derailments in the past due to some of these defects. These defects are not readily visible, and therefore difficult to detect by the car inspectors.

Conrail has installed and is currently testing and developing a Salient truck hunting detector. The detector basically consists of strain-gages mounted to the bottom flange of rail. These strain gages measure the lateral and vertical forces of each wheel passing through a curve. These forces are then turned into an L/V ratio. The alarm criterion for the L/V ratio is being developed. Once the alarm has been established the hunting detector will be integrated into the automatic shopping system. The alarm will be transmitted to Conrail's system computer and the car when emptied will be shopped and the truck inspected.

Wheel Plate Detector

Straight plate wheels in the railroad industry are known to be more susceptible to high stress from both mechanical and thermal loads. Therefore, they tend to fail or break more easily than the newer design of the curve plate wheels. Figure 9 illustrates the difference between straight plate and curve plate wheels. Figure 10 reveals that while cars with straight plate wheels constitute only 20% of our traffic, 84% of the broken wheels that cause derailments are the straight plate type.

Conrail has installed a wheel plate detector furnished by KLD Labs. in Middlesex NJ. The plate detector works hand in hand with the wheel impact detector by supplying the identification of the plate type to the wheel impact detector. Once fully developed, the alarm level can be lowered for straight plate wheels so that the phasing out of bad straight plate wheels can be accelerated.

Low and Worn Freight Car Air Hose Detector

The number one train delay cause is emergency braking from separation or bursting of trainline. Separation usually is caused by low hanging hoses hitting high ballast, debris or crossing. Bursting of trainline is caused by weak and worn air hoses. The air hoses are usually worn on the underside, and such a condition is very difficult to detect by visual inspection.

Working with Ensco, Conrail is setting up a "LAW" (Low and Worn) detector site at Little Ferry, New Jersey to automatically scan the train for both low hanging and worn hoses. A vertical array of light beam curtain is erected to detect the low hanging hoses. Initially, the condemning criterion of less than 3 inches above top of rail will be set up. If a condition is found, the car will be inspected for adjustment of hose hanger or other trainline arrangement.

Video imaging analysis is used to detect worn air hoses. This station is at an open deck bridge (Figure 11), so that lighting and camera can be installed underneath the track conveniently. A mirror assembly is used to divert the video image to the camera with a 90^0 change from a vertical to a horizontal path. Logic is incorporated to determine the timing of taking the images of the air hose couplings for all possible car types. The images, once acquired as shown in Figure 12, are analyzed for elliptical worn rings on the surface of the air hoses. Two different alarm levels will be established. When the worn rings are detected to the extent that they exceed the primary alarm criterion, alarms will be sent to set out the car at the next location. Secondary alarm criterion which is not as critical as the primary alarm will also be established. Under the secondary alarm criterion, the car will be shopped when it is empty, so that loads will not be delayed.

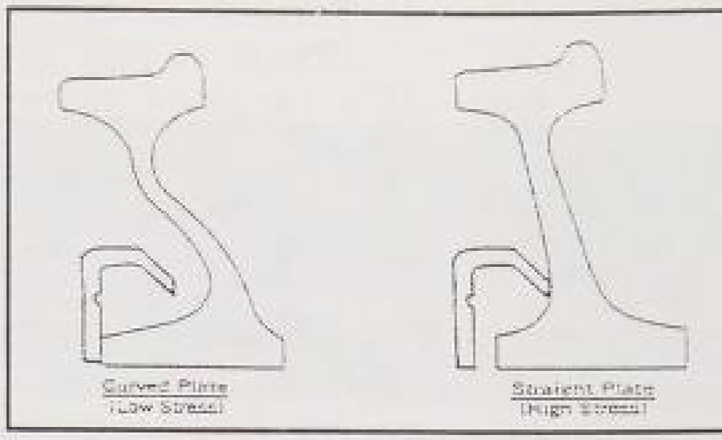

FIGURE 9. ILLUSTRATION OF STRAIGHT PLATE VS. CURVE PLATE WHEELS

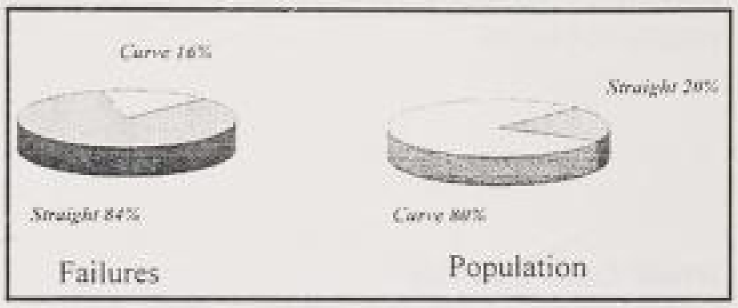

FIGURE 10. DISPROPORTIONATE FAILURES OF STRIGHT PLATE WHEELS

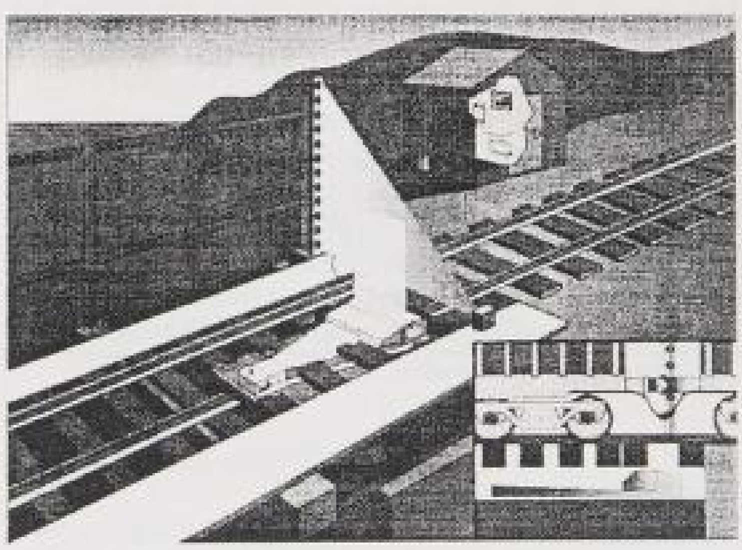

FIGURE 11. LAYOUT OF THE LAW (LOW AND WORN) AIR HOSE DETECTOR

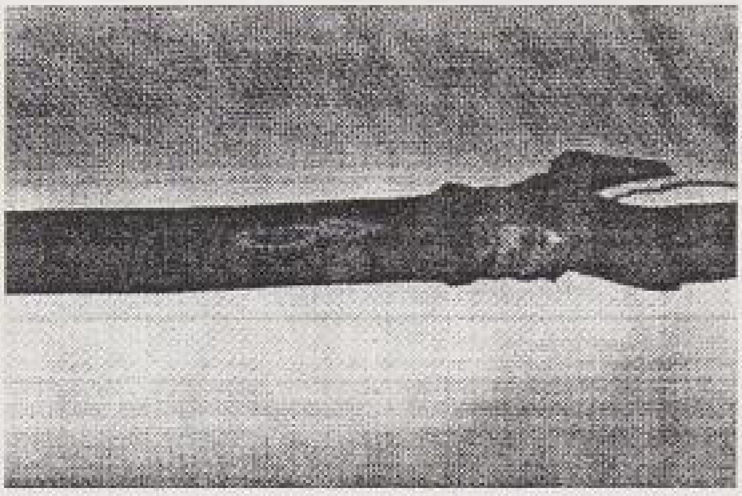

FIGURE 12. COMPUTER ACQUIRED IMAGE OF A WORN AIR HOSE

Wheel Crack Detector

Cracked wheels, while not a predominant defect, can have a detrimental consequence. Cracking in a wheel is a prelude to breaking. A broken wheel in every incidence can lead to a derailment. Conrail has on the average five to ten derailments a year due to broken wheels. Because of the potential loss from derailments, cracking in wheels perhaps is more important to detect than any other defect. Unfortunately, because of the complexity involved in the detection of cracked wheels, there is no commercial unit available. Conrail is working with the AAR and Krautkramer Branson to develop a wayside crack detector. Preliminary testing performed to date has shown that a wayside device is plausible. The device is to be based on ultrasonic emission using a technique called "ultrasonic immersion bubbler probes" as described in Reference 5 (Hackenberger & Lonsdale, 1998).

INTEGRATED DETECTORS

The integration of the wayside detectors on Conrail started in 1992 with the hooking up of the AEI tag reader with the Salient Impact detector. This process has grown substantially on Conrail. The first integrated system telephoned Conrail headquarters by modem and reported the wheel load impact alarms to the paper printer. This paper report was then interpreted by a mechanical clerk and the car was located. Manually a special code was assigned in the network computer system to route the car to a shop. To select a shop for the repair, the clerk would have to manually check where the freight car was, where it was going, when would it be empty, and then call the shop or fax the paper report to the shop. Once the repairs were complete the clerk would then have to manually change the shop code to release the car back to revenue service. This clerk would process 30 - 50 of these reports a day when all three impact sites were reporting in. Severe bottle necks were encountered as balancing of the shoppings would sometimes clog up a yard.

The new integrated Conrail system solved a big portion of this problem. The new automated system takes the integrated Impact/AEI system and reports the information directly to Conrail's mainframe. The software program, costing approximately $90,000.00, determines the direction of the freight car and decides on the best location out of the 24 Conrail repair facilities to repair. The program automatically notifies the repair facility of the arriving failures and updates a report indicating what cars are at a facility and the attention for each car that is required. The program balances the cars destined for each shop. If a shop is filled, the program will automatically change the transportation code to reroute the car to the next available shop. The software program also creates an alarm history file which includes the date, time, car number, alarm level, train symbol, axle count, wheel location, and whether the car is empty or loaded. Once the car is shopped and repaired, the shopping code is automatically removed.

This software program is modified to accept alarming messages form several different type of detectors. Figure 13 shows an example of the computer reports that are available at each repair location to determine what cars are on the way and for what reason. The indicators on the left of the screen indicate the type of defect. i.e. W I = wheel impact, S B = stuck brake, S W = sliding wheel, T R = thin rim, N B = noisy bearing, L H = low hose. The program was designed for further expansion as new wayside detectors come on line. Currently the system covers the three impact detectors, the sliding wheel detector, and the stuck brake detector. At the time of writing this report the LORAM AWIS was being included and arrangements for the AAR's Acoustic detector to call in were being made. By mid-1998 the straight plate and Low and Worn air hose detectors will also be hooked in. Figure 14 shows an example of the reports that each repair facility can use to identify the problem wheels and their defects immediately.

/98 FREIGHT CARS SHOPPED FOR INSPECTION/REPAIR PAGE

DUE TO TRIPPING WAYSIDE DEFECT ALARMS

PAUL STEETS - 333-4833 - STEVE AGOSTINI - 333-1249

DESTINATION	CAR INIT NUMBER	L OR E	CAR TYPE	CURRENT LOCATION	CONSIGNEE	TERM DIGITS	INDICATORS W I	S B	S W	T R	N B	L H
OAKISLANDNJ	ACFX055117	E	I5A	MANVILLE NJ	SLIDWHEEL	WHEL			Y			
DICKINSONWV	ACFX086906	E	T04	DICKINSONWV	WHLIMPACT	WHEL	Y					
CONWAY PA	ADMX016331	E	T04	CONWAY PA	WHLIMPACT	WHEL	Y					
OAKISLANDNJ	CNW 490138	E	I5C	OAKTRANSFNJ	WHLIMPACT	WHEL	Y					
ALTOONA PA	CR 000022	E	W10	ALTOONA PA	STKBRAKE	WHEL		Y				
CHIFOUSTVIL	CR 369267	E	N6B	IHB	STKBRAKE	WHEL		Y				
ASHTABULAOH	CR 486977	E	H06	PATRON	WHLIMPACT	WHEL	Y					

FIGURE 13. CONRAIL SCREEN REPORT SHOWING AUTOMATICALLY SHOPPED CARS

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*****************************************************
*        AXLE AND WHEEL FAILURE LOCATIONS           *
*     LOCATION AS PER WAYSIDE DETECTOR READINGS     *
*****************************************************
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CAR NUMBER		TYPE	DATE	WHEEL
CR	488116	STKBRK	01/12/98	Wheel=1
CR	488332	STKBRK	01/12/98	Wheel=3
CR	488486	IMPACT	01/11/98	Wheel=1
CR	490107	SLDWHL	02/03/98	Wheel=2
CR	490107	SLDWHL	02/03/98	Wheel=3

FIGURE 14. CONRAIL SCREEN SHOWING CAR WITH FAILURES AND WHEEL LOCATIONS

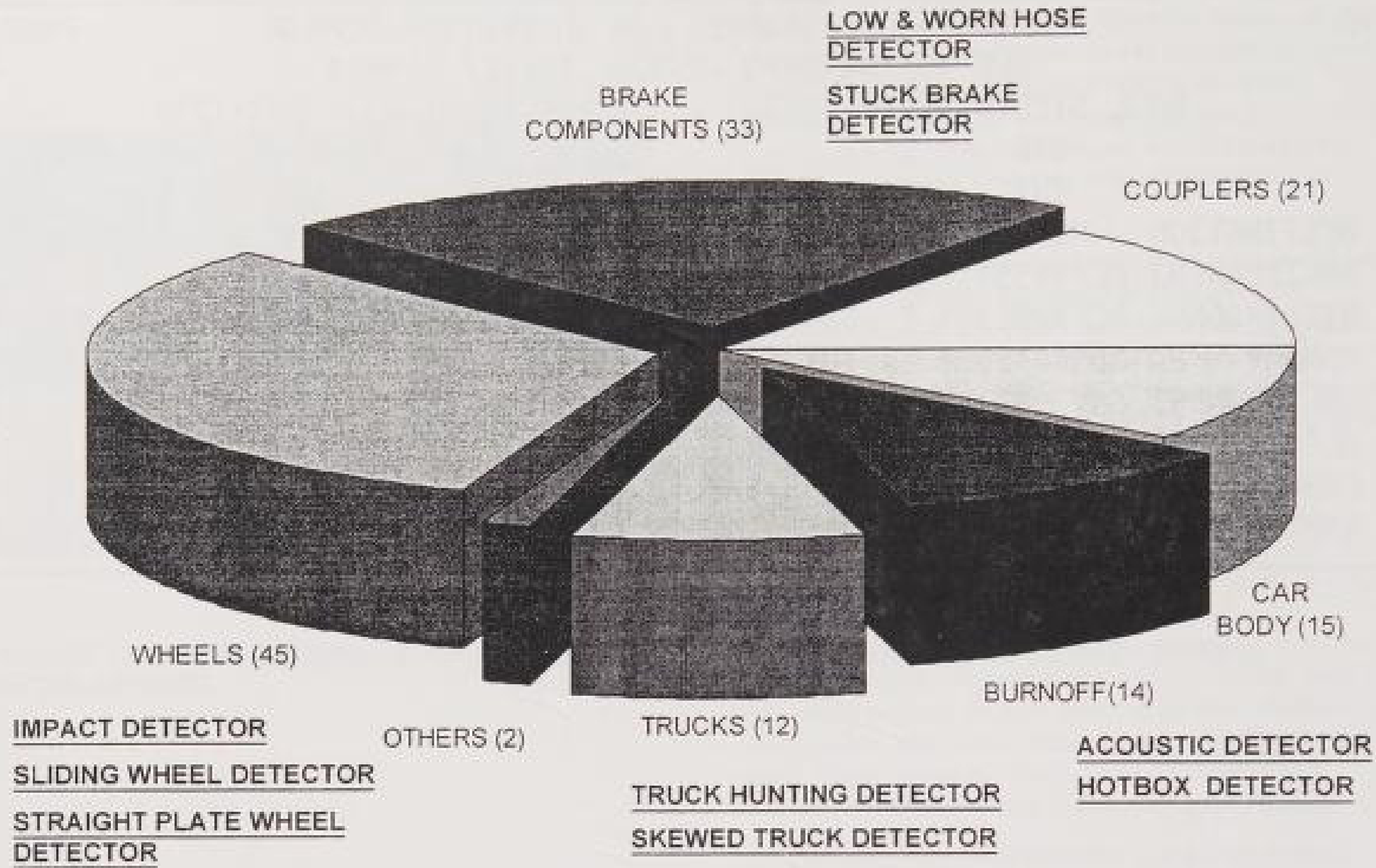

FIGURE 15. DERAILMENT PREVENTION BY WAYSIDE DETECTORS

CONCLUSIONS

In order to improve reliability of service and eliminate derailments from the mechanical standpoint, it seems logical to integrate and install more wayside devices to supplement preventive maintenance and visual inspection and gaging. These devices do pay back substantially as evidenced from the number of derailments and the amount of potential damage which have been prevented by alarms given by the existing traditional detectors, hotboxes, dragging equipment and most recently the wheel impact detectors. This experience convinced Conrail that more different types of detectors are needed to implement "Management by Prevention". In 1994, at least three major derailments could have been prevented if there was enough coverage by wayside devices:

(1) Train BAPI-2 at Conpit, December 2, 1994
Cause of Derailment - Truck Hunting
Could be detected by Truck Hunting Detector

(2) Train INSE-6 at Mentor, OH, August 17, 1994
Cause of Derailment - Broken Wheel, from shelling
Can be detected by Wheel Impact Detector

(3) Train BUBH-2 at N. Ridgevil, OH, October 22, 1994
Cause of Derailment - Truck Hunting
Can be detected by Truck Hunting Detector

Each of these derailments cost a few million dollars. Figure 15 shows the number of mechanical caused derailments by components and the detectors designed and installed in Conrail to detect these defects. Thus, it is obvious that if a detector prevents one derailment, it pays more than for itself. Figure 16 show data for 1996 and 1997 for mechanical caused derailments on Conrail. Wheel and bearing failures are the high cost items. With the addition of the wheel impact and sliding wheel detectors the wheel derailment costs were reduced significantly on Conrail from 1996 to 1997. This reduction justified their further development for better detection and higher degree of integration and automation. Conrail is also continuing their evaluation for additional installations. The bottom line is that the detectors are money savers and with the state-of-art technology to make them more user friendly and reliable, it makes their adoption by the mechanical personnel a must in the modern railroading.

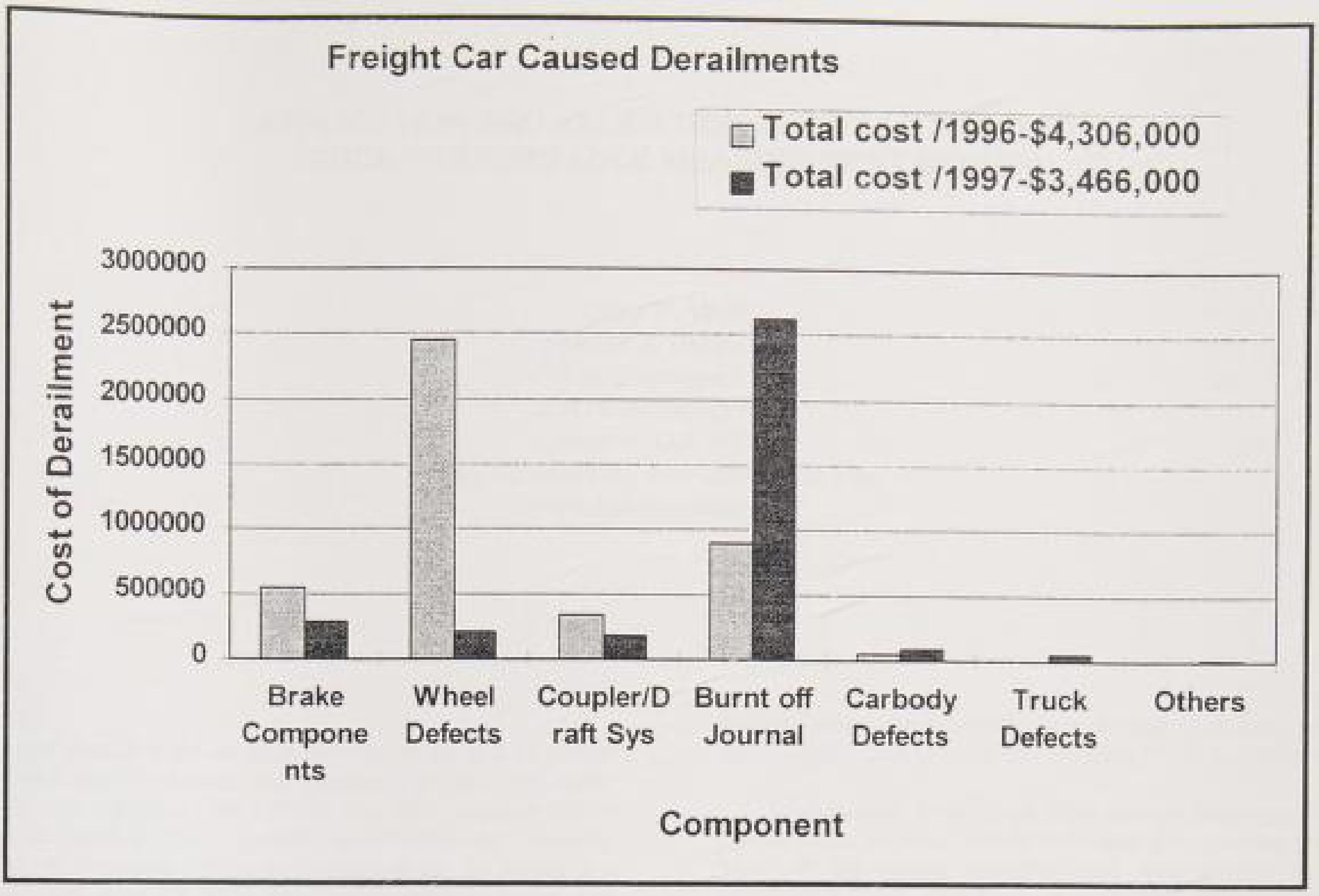

FIGURE 16. COST OF FREIGHT CAR CAUSED DERAILMENTS

V. References

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