IMPROVED RAILROAD TRACK SRM PLANNING THROUGH RAILER® EMS AND GIS

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INTRODUCTION

The Department of Defense (DoD) owns and operates thousands of miles of railroad track that serves a vital role in equipment mobilization. In order to ensure the safe and reliable mode of transportation, and protect the nation's investment, these track networks have to be periodically inspected and continually maintained. But with ever shrinking budgets and an aging rail infrastructure, it is also important to ensure that the track networks are maintained cost efficiently. RAILER® Engineered Management System (EMS) was designed as a knowledge based track management program that gives planners decision support in the sustainment, restoration, and modernization (SRM) of their track network. It combines track assessment, work plan generation, and spatial analysis through a companion Geographic Information System (GIS) program to help provide informed decisions for managers (1).

RAILER EMS IMPLEMENTATION

The first step in the RAILER implementation process is the collection of track inventory. This is a physical survey of what makes up the track network, and includes pertinent information about the rail, ties, fastenings and other track material, switches, appliances, culverts, curves, and grades (2). A key part of this inventory process involves establishing a track naming convention and stationing scheme. This step is an integral part of the GIS spatial analysis and reporting features to be discussed later. The stationing helps to establish a reference point and location for each track. It also makes it easier to locate defects during the inspection and subsequent repair. In addition to stationing, each track can also be divided into track segments. Because a designated track can potentially involve several miles, sectioning provides a smaller management unit for the SRM process.

In addition to inventory, a baseline inspection is needed to establish a Track Structure Condition Index (TSCI). Once defects are recorded and compiled, RAILER automatically computes the Track Condition Indexes and assigns speed restrictions based on standards (3). From here, the work planning process can commence.

WORK PLAN FUNDAMENTALS

During the detailed track inspection process, several problems in the track are sure to arise. Some problems are minor and have existed for a long time without getting worse. Other problems may have serious and immediate implications if not fixed. The key to creating an effective work plan under constrained budgets is recognizing which work and corrective actions will have the most significant impact on operations and long term condition. The traditional way to adequately accomplish this is through a detailed engineering analysis and subsequent cost estimate. However, this approach can be costly and time consuming. The RAILER approach to SRM planning attempts to improve this process with a computer generated analysis based on logical business rules.

Work Plan Generation

The RAILER approach to track management generates some very informative metrics to help in the decision process. The periodic detailed inspections and more frequent safety inspections can identify a catalog of problems and deficiencies that exist on the network. As is most usually the case, there is not enough resources and funding available to repair and address all of the problems and defects present. It is reasonable to assume that some defects have a more drastic effect on the network operation than other defects. This may be attributed to the nature of the problem, the location of the problem, or the presence of minor defects clustered together. Whatever the case, there is usually some subset of defects that if addressed and repaired, would have the most beneficial impact on the network as a whole. The problem is finding this optimum subset of work in what can be a very large "job jar" of work items. To efficiently produce a plan of fundable work actions from the job jar requires logical standards and business rules, a scheme for prioritizing work, and a tool to spatially view where corrective actions are to be done.

Through the process of a detailed track inspection, a list of deficiencies is generated for the track network. In addition to the type of defect that exists, the physical location is recorded, along with the quantity, length, or density of track affected. Each recorded defect is associated with a condition level based on a predefined standard, including those of the U.S. Army, U.S. Navy, and Federal Railway Administration (FRA) (4,5,6). In addition, most tie, rail, fastenings and other track material (F&OTM), ballast and subgrade defects are associated with a deduct value that affects the condition index calculated for the track segment (7). The existence of a defect at a given standard level may restrict the speed or level of train operations on the track segment in which it exists. Therefore, based solely on an inspection, RAILER will instantaneously report the track condition metric and operations level.

Once the deficiencies have been identified, a work plan can begin to be assembled. Using the condition index and standard level in a set of business rules can help to narrow down the job jar to a filtered list of the most important work based on the condition and operations for the track. But when deciding what deficiencies to repair and which ones to defer based on a limited budget, it is also useful to consider the relative location of problems on the track network. This can be accomplished by consulting the RAILER GIS detailed track inspection view (1).

Figure 1 shows that by displaying the defect locations for several different component groups together, one can see the interactive effect of clustered defects on the track system as a whole. For example, where deteriorated tie clusters exist on the network, the GIS may also show concurrent drainage and subgrade defects at the same location which may be the underlying contributing cause to the tie deterioration.

Standard Level as a Business Rule Metric

A standard level of operations is created for each track segment based on the deficiencies recorded during the detailed track inspections and any intermittent safety inspections. Every defect in the RAILER database has a level of operation associated with it based on each of track standard. When one of those defects is found and recorded during an inspection, it limits the level of operations on the segment until the defect is fixed.

The direct relationship between the standard level and the defect makes it very easy to incorporate that relationship as a business rule during work plan creation. For example, if it is important for a given track segment to permit operations at a given speed, then defects on that segment that restrict operations below that level would get a higher importance or priority assigned to them. The Condition Assessment View in RAILER GIS is particularly useful for viewing the location of defects on the network based on their standard level, as is seen in Figure 2.

Condition Index as a Business Rule Metric

If the goal of a work plan is to raise or sustain a high level of operations, then the standard level is the only metric needed. However, drastically improving the level of operations on the track does not necessarily improve the condition or quality of the track. For example, a track segment may be in good condition, but may still be at a No-Operations level per the U.S. Army Standard if two center-cracked joint bars exist at a single joint. Here, the standard level clearly does not reflect the fact that the track in is good condition. Alternatively, a track segment could be in poor condition overall, but contain no catastrophic defects. In both cases, focusing solely on the standard level as a performance metric will not improve the actual condition significantly.

For this reason, the condition indexes are also a very important metric (3). It provides a better representation of the level of effort needed to restore track condition. If the goal of a work plan is to sustain a high level of track quality for a given segment, or to restore the quality of a track, then the condition indexes will be an important parameter in the prioritization of work items. The computed condition indexes can be displayed for each track segment in the Condition Assessment View in RAILER GIS. Figure 3 illustrates how this view can be used to report track condition spatially.

Track Certification as a Business Rule Metric

The US Navy certifies their track for operation based on the track inspection and the subsequent defects identified and recorded. (8) The inspector recommends a level of certification based on the inspection, and then the certifying official certifies the track taking the inspector's recommendation into account. The RAILER program has a new certification module designed to support this process electronically. Based on the results of the inspection, a default certification is provided for each track segment. A list of any found critical and catastrophic defects is also provided for each segment. The inspector can then review this data and make a recommendation to either accept the default certification or change it based on his or her judgment. The inspector then electronically "signs" the record. Finally, the certifying official reviews the information and also signs electronically.

A track certification view was added to the RAILER GIS system to display the data from the certification module in RAILER. The track certification theme gives a spatial view of which individual track segments have a full certification, restricted certification, and non-certification, as is illustrated in Figure 4. In addition, there are individual themes for each of the major track component groups to display the location of critical and catastrophic defects causing the restriction in certification. (see Figure 5) The track certification gives an important view from a network operations perspective, and serves as yet another metric in the SRM planning process. For example, if a particular route comprised by a group of segments is important to operations for an upcoming rail movement, the GIS will show if any locations along that route that may have a restricted certification, as well as the defects causing those restrictions. Corrective action for these defects can be given a higher priority when deciding which work to accomplish from the job jar.

In addition to the spatial track certification data displayed with the route themes, formatted certification reports run from RAILER and saved as a Microsoft™ Word document can be linked in the GIS. This allows the user to bring up the detailed certification report for a track segment by simply clicking on the track segment

Policies

A policy is a consistent business practice on how to address defects on the track. In RAILER, policies are created to specify a work action to correct a specific type of defect. In addition, the standard level associated with a defect can be changed from the suggested level to something lower if track managers deem that defect particularly detrimental to operations. A policy allows the business practice for correcting the work to be tailored to the specific needs of the network. RAILER also allows the creation of multiple policies, so that separate policies can be applied to different parts of the network.

To illustrate the use of policies, when a five-tie cluster exists on the track (No-Operation defect by the Army Standard), the "minimum" policy to restore operation per the standard would be to replace the middle tie in the cluster. However, the "best practice" policy would be to replace all defective ties in the cluster. Therefore, if a certain area of track is only used for storing cars, it can be maintained at a lower track quality just above the minimum operational level. However, it may be more efficient in the long run to sustain mainline access tracks using a "best practice" policy.

Local Versus Global Work Actions

A local work action corrects a defect recorded at a discrete location on a track. This is displayed in Figure 6. For example, if excessive overflow is recorded, the local work action may be to grind the rail affected. Local work actions are generally aligned with the sustainment portion of the SRM process. Spot repairs to correct recorded defects and sustain condition and operational levels would fall under this sustainment. Local work actions may also address restoration issues due to premature or unexpected failure. This may include problems caused by a washout or derailment occurring at a discrete location.

A global work action is work accomplished over an entire track segment. Global work not only addresses sustainment, but the modernization portion of the SRM process as well. The global work action is not tied to specific defects in the RAILER database, and therefore does not necessarily raise the condition or standard level unless specific defects are corrected in the process. An example of a global work action would be to upgrade the rail weight in a given segment to present day standards. If the rail is excessively worn or in poor condition because it is nearing the end of its useful service life, this work would be considered sustainment. However, if the rail is in good condition, but increased wheel loads mandate that the rail weight be increased, then modernization is required.

Although a global work action does not necessarily address specific defects, it may be the best solution for a pattern of defects. For example, a large number of loose or broken joint bar bolts on a light rail section may suggest that the best solution would be to upgrade the rail to a heavier section, as is the case illustrated in Figure 7. By displaying the track rail weight and F&OTM defects themes concurrently, the GIS reporting features can show problems not readily apparent unless the data is viewed spatially. Therefore, the GIS proves an invaluable tool in decisions of whether to perform a global work action.

WORK PLAN VIEW

When preparing a work plan for sustainment, restoration, or modernization to a railway network, it can be beneficial to take a spatial view of where work is to be performed. There are many options in deciding what level of operations and track quality needs to be maintained, where to apply certain policies, and whether to perform local sustainment repairs or global modernization upgrades. Therefore, the ability to display work plan data in RAILER GIS was a recently added feature. For each work plan that has been generated and exists in the RAILER database, a GIS view is created to view the contents of that work plan. Each track component is represented by a different theme in the view illustrated in Figure 6. Since the RAILER work plan module allows the creation of multi-year plans, the GIS was designed to show color-coded work actions by year.

For defects that occur at a discrete location on the track, the M&R view represents their location with a point feature. These include joint defects, defects at a turnout, culvert problems, etc. For defects that occur over a length of track (geometry, ballasts, grade crossing defects, etc), the M&R view represents their location with a line feature to highlight the affected portion of track. It is particularly important to focus attention on areas where several defects are clustered together or overlap each other. These are possible areas where simply repairing the localized defects are not enough. Instead, underlying problems may need to be investigated at these places, and global work to the entire area may be the best solution.

When investigating these problems, the M&R view provides important information about each specific defect. By clicking on a defect in the M&R view, a detailed list of attribute information can be displayed. This includes the type of defect, the policy applied at that location, the recommended work action for correction, the cost of repair, etc. This can be seen in the "Identify Results" screen shown in Figure 6. This information is intended to provide support in the decision process as the work plan is created and revised.

In addition to viewing attribute information for an individual work action, a detailed spreadsheet of all information can be brought up in the GIS, and individual work actions from this spreadsheet can be highlighted. For example, if a stretch of track between two control points is of particular importance, work actions along that route can be selected in the M&R view. These selected items will then be highlighted when the work actions spreadsheet (Figure 8) is brought up. This is yet another method in creating a limited list of highest priority work items from the job jar. The work actions spreadsheet accessed through the GIS can also be exported to Microsoft™ Excel for formatting or refinement.

Since RAILER GIS displays each work plan as its own separate view, multiple views can be opened simultaneously to allow for comparison between two or more competing plans. In addition, separate but concurrent plans can be developed for particular areas of the track network, to allow for the application of different policies, or to distinguish between local and global work actions. These plans can be shown in separate views or copied into a single masterplan to be displayed in unison.

WORK HISTORY VIEW

A work History module exists in RAILER to record the work performed over the track network over time. In addition to keeping a historical record of when work was accomplished, it also lets managers in charge of the sustainment and restoration of the track network see where historical and reoccurring problems have occurred. There are two ways work can be entered and stored into work history. The first is by directly entering what work was accomplished to what segments, and when. The second occurs following the creation and execution of a M&R project. Once the user specifies that the project has been completed and enters the completion date, RAILER removes the defects addressed by the project and updated the condition index accordingly. In addition, it stores the project details of what work was accomplished in the Work History module.

A Work History view was added to the RAILER GIS program to give track managers a means for viewing historical work records across the network. In this way, reoccurring problems and historical problem areas are easily recognizable. The GIS program automatically creates a new theme in Work History view for each project work order number in the Work History database. In addition to displaying the spatial location of work projects, additional information can be called up to show the estimated and actual cost of work, project order number, contract number, and completion date. Figure 9 shows the Work History view, as well as the additional attribute information available for a work history project.

ADDITIONAL GIS FEATURES

Although the route themes are the main means of displaying important track information from RAILER spatially, overlaying additional spatial coverages can sometimes provide an enhanced picture of overall network operations. These additional coverages can include, buildings that the track may serve, roads that the track may cross, or rivers that the track may traverse. Also, RAILER GIS has recently been expanded to allow aerial photos to be brought in as a background to the network. Figure 10 shows how the aerial photos can give a very realistic view of the track right-of-way and surroundings. In addition, Figure 11 shows how segment names and end station locations can be turned on as a coverage overlay to help the user easily determine where they are in the network. These aerial photos and coverage overlays add another dimension to the work plan presentation and visualization.

CONCLUSIONS

The use of RAILER and RAILER GIS allows for a logical process of work plan creation in a fraction of the time compared with the previous process. Once the inventory is collected and inspection deficiencies are recorded, the SRM plan itself can be generated almost automatically based on a set of business rule parameters. Detailed cost estimates and engineering analysis beyond the inspection itself are usually not required. Plans can be tailored very easily to identify and address specific problem areas or focus on important corridors of operation. In addition, because the RAILER database and the GIS viewer are linked dynamically, intermediate safety inspections information as well as work history information can be displayed real-time. The entire process provides an improved means of track management.

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DISCLAIMER

The views of the authors do not purport to reflect the views or policies of the U.S. Army or the Department of Defense.

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LIST OF FIGURES

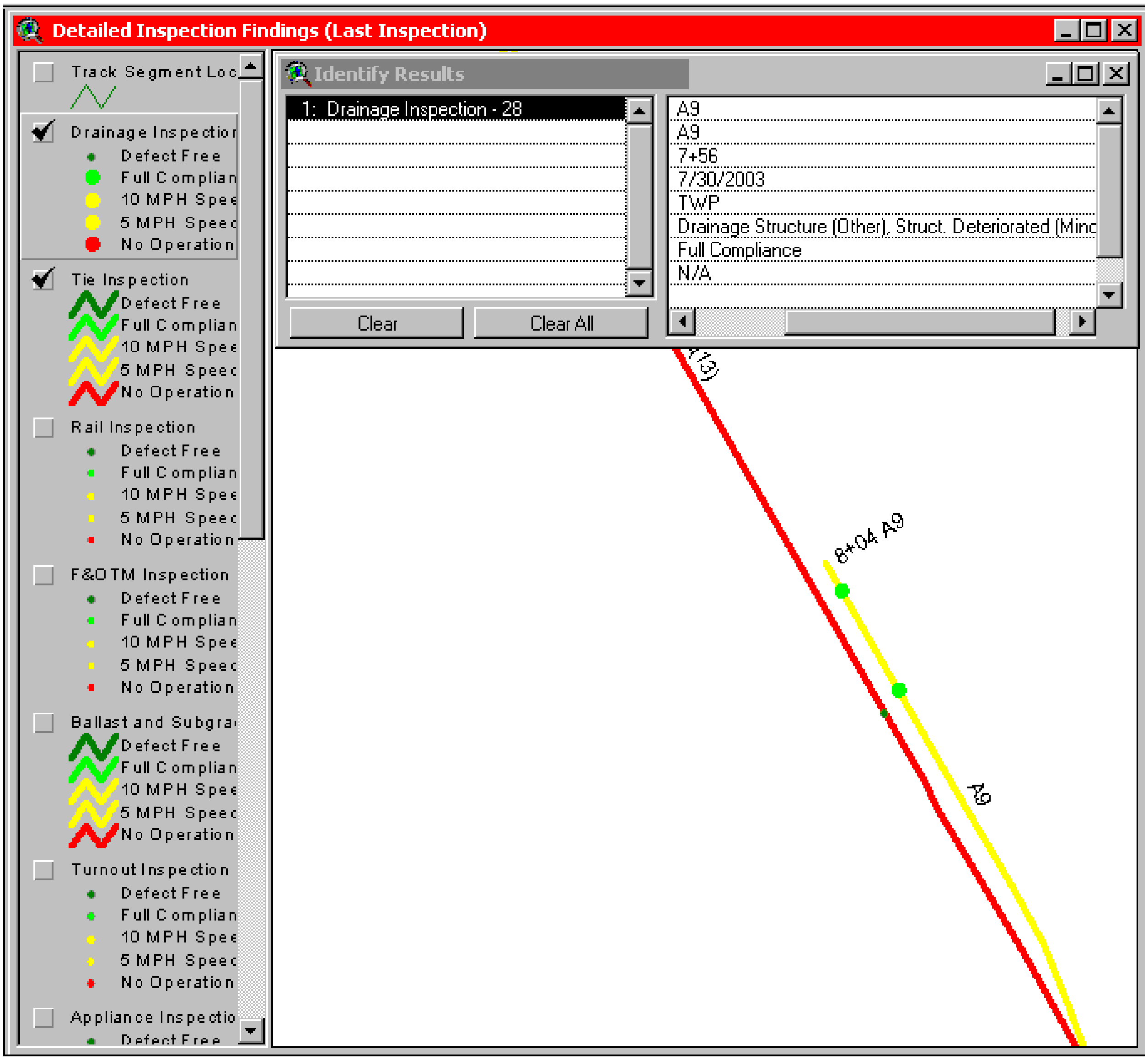

FIGURE 1 Detailed Inspection Findings View showing the interactive effect of drainage and tie defects.

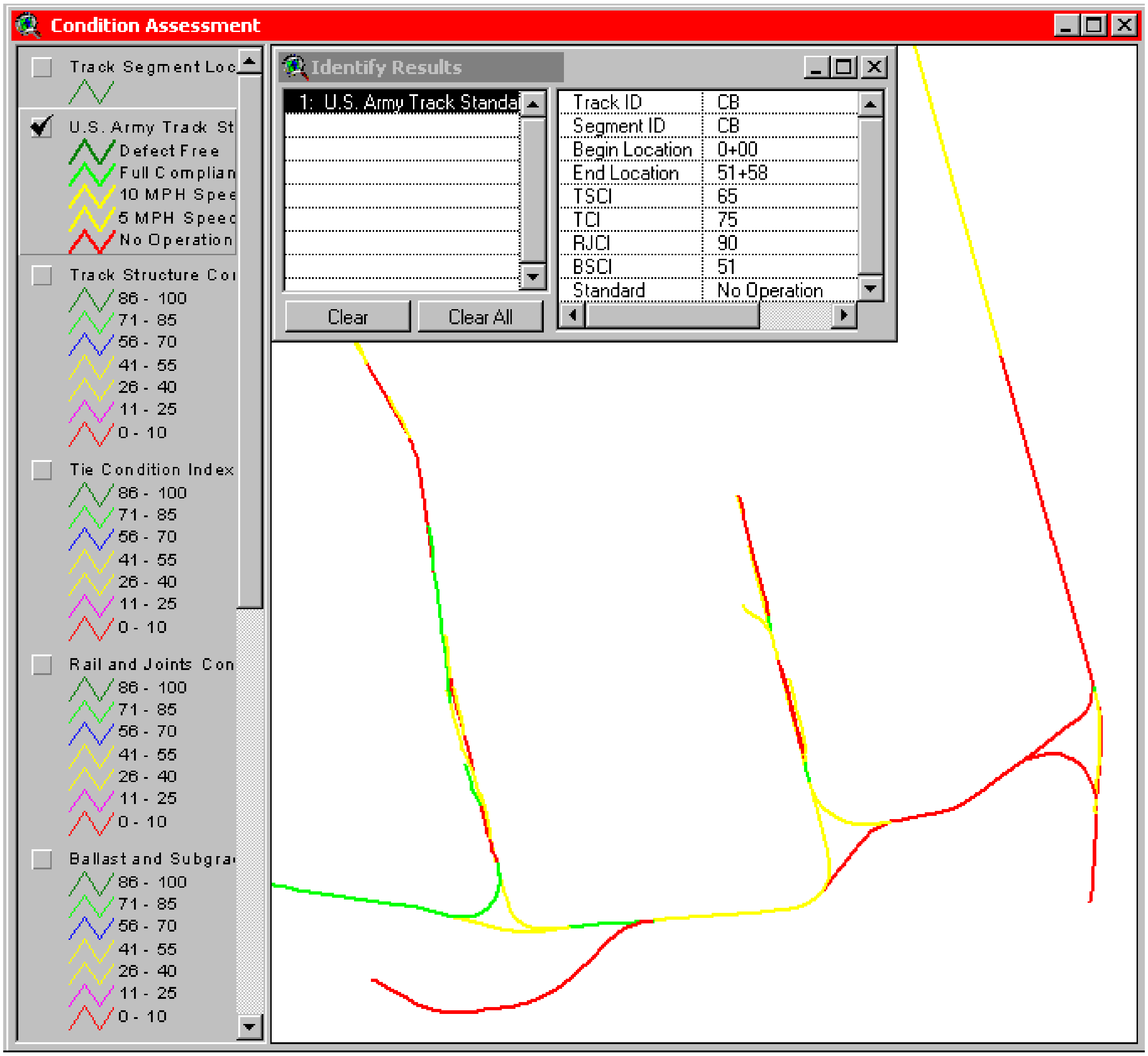

FIGURE 2 Condition Assessment View showing location of speed restrictions per the U.S. Army Track Standard.

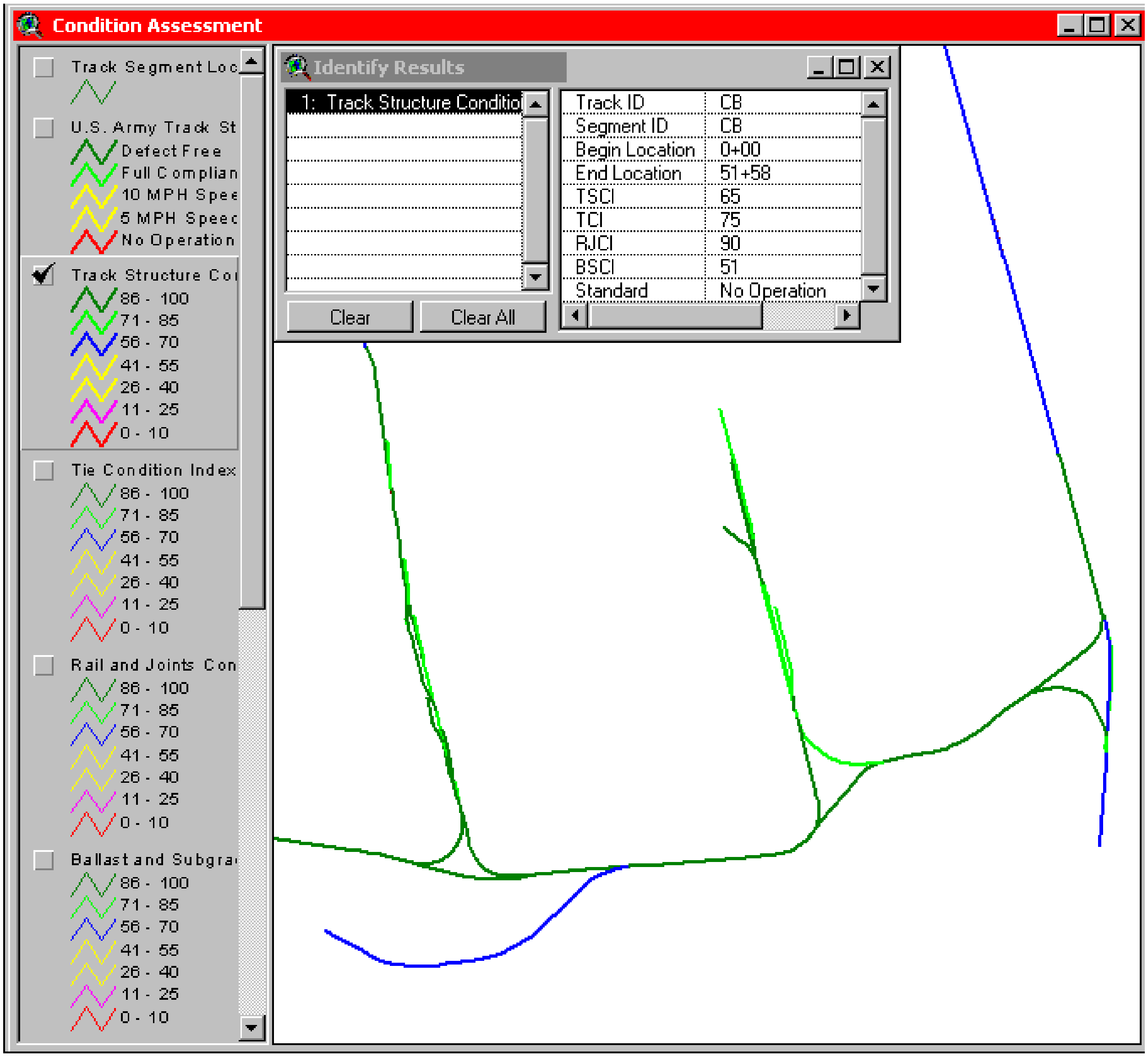

FIGURE 3 Condition Assessment View displaying TSCI ranges for network.

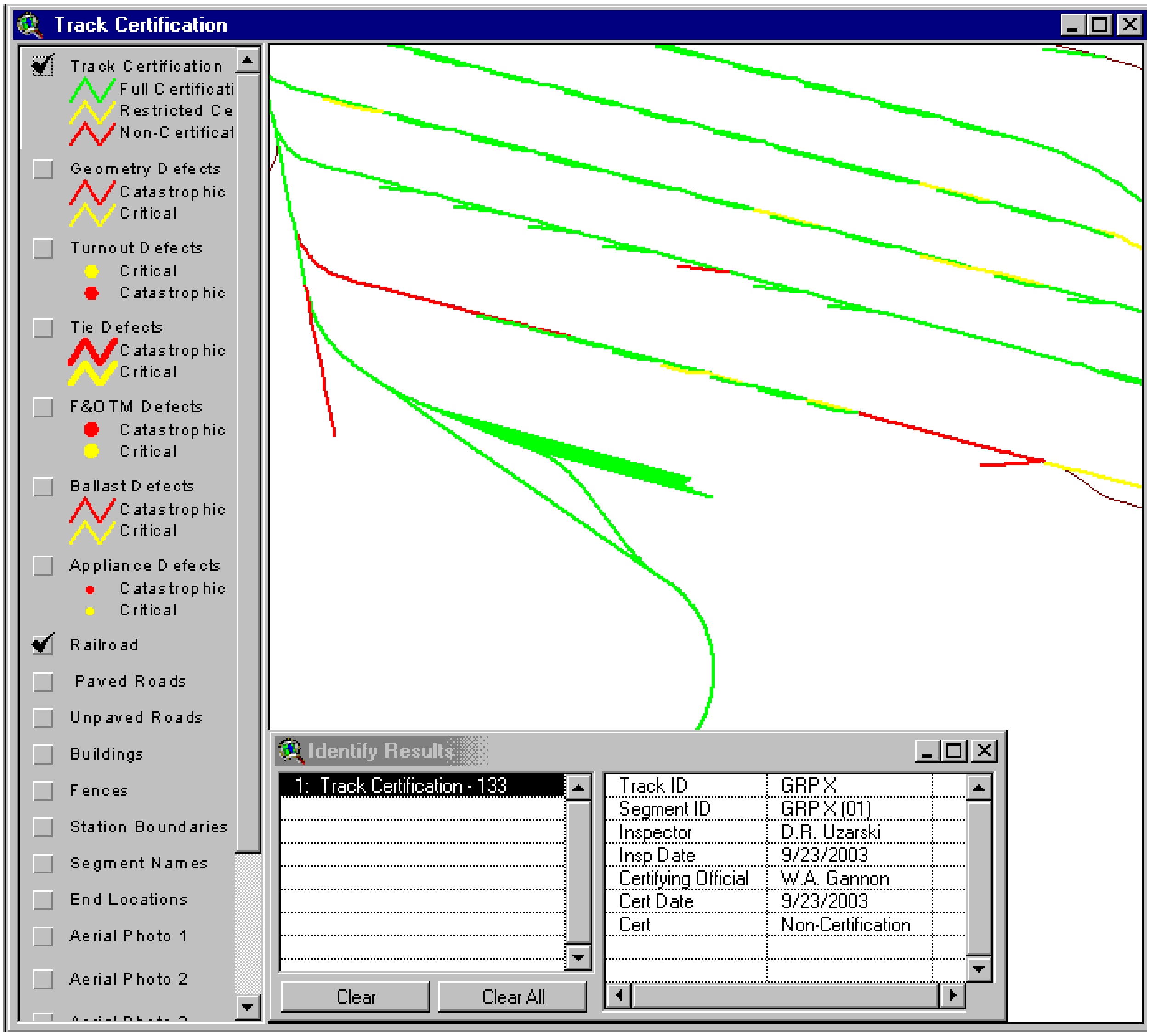

FIGURE 4 Track Certification View displaying areas of Non-Certification.

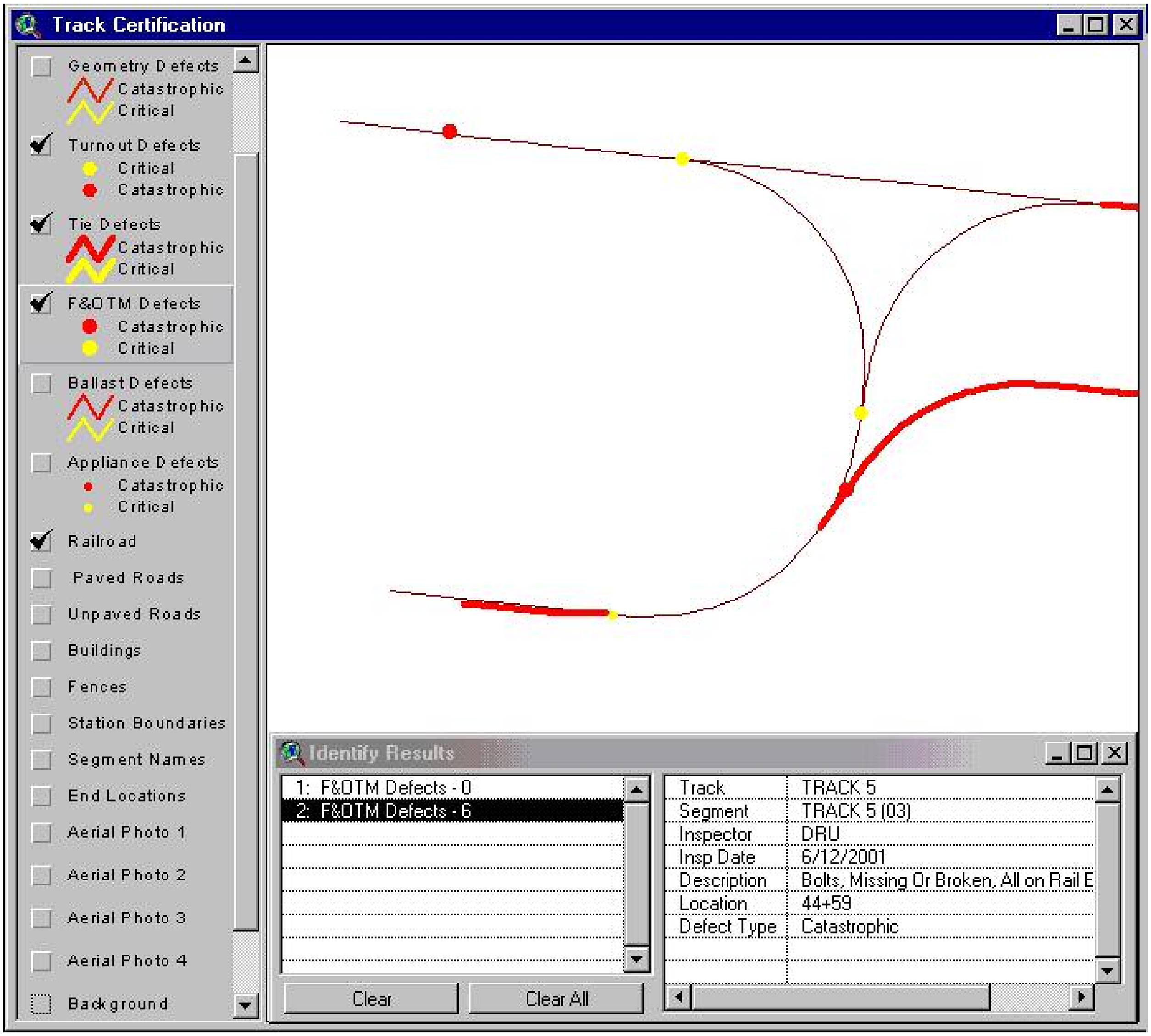

FIGURE 5 Track Certification View displaying critical and catastrophic defects causing certification restrictions.

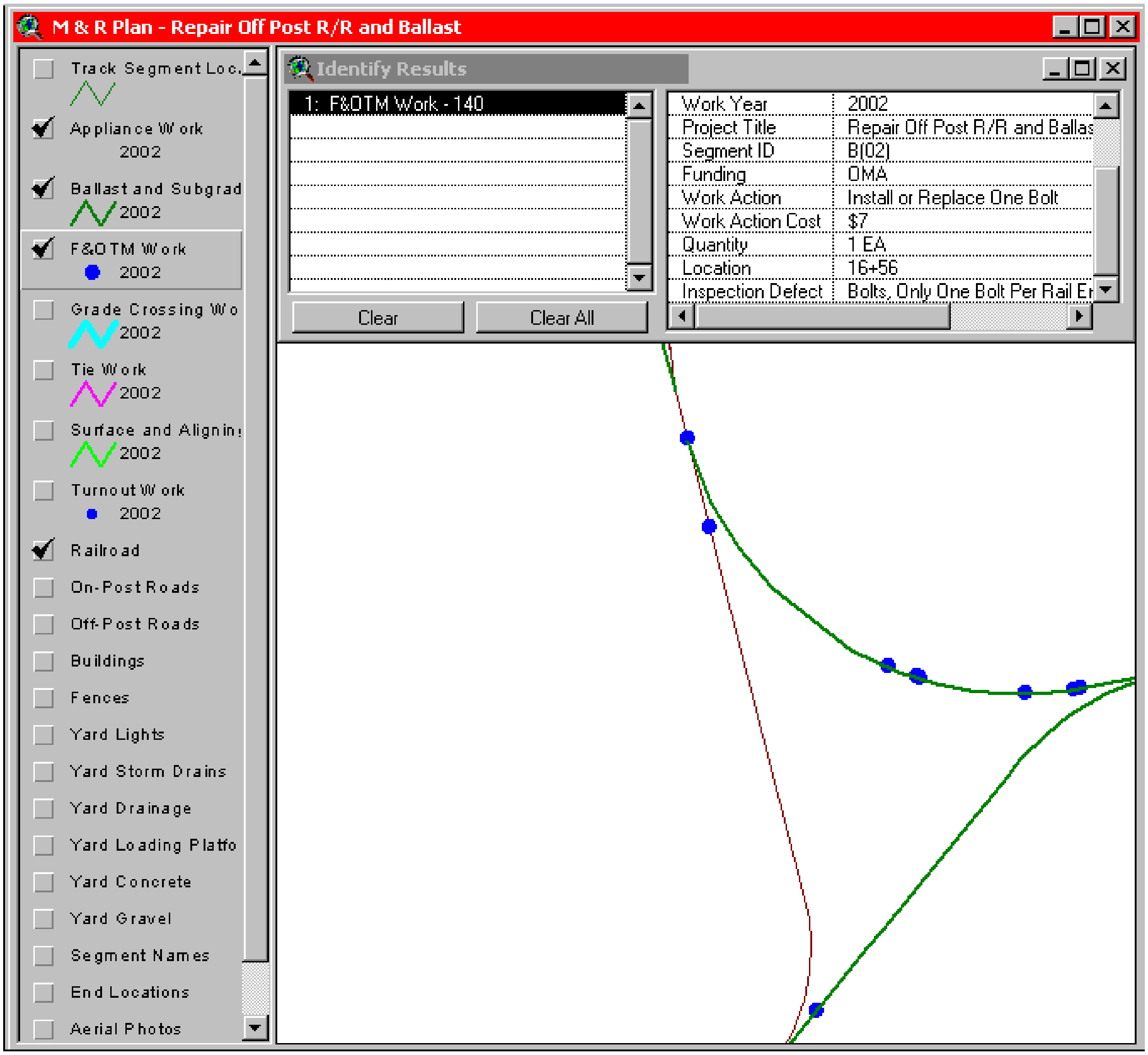

FIGURE 6 M&R Plan View displaying the location and other information for individual repair items.

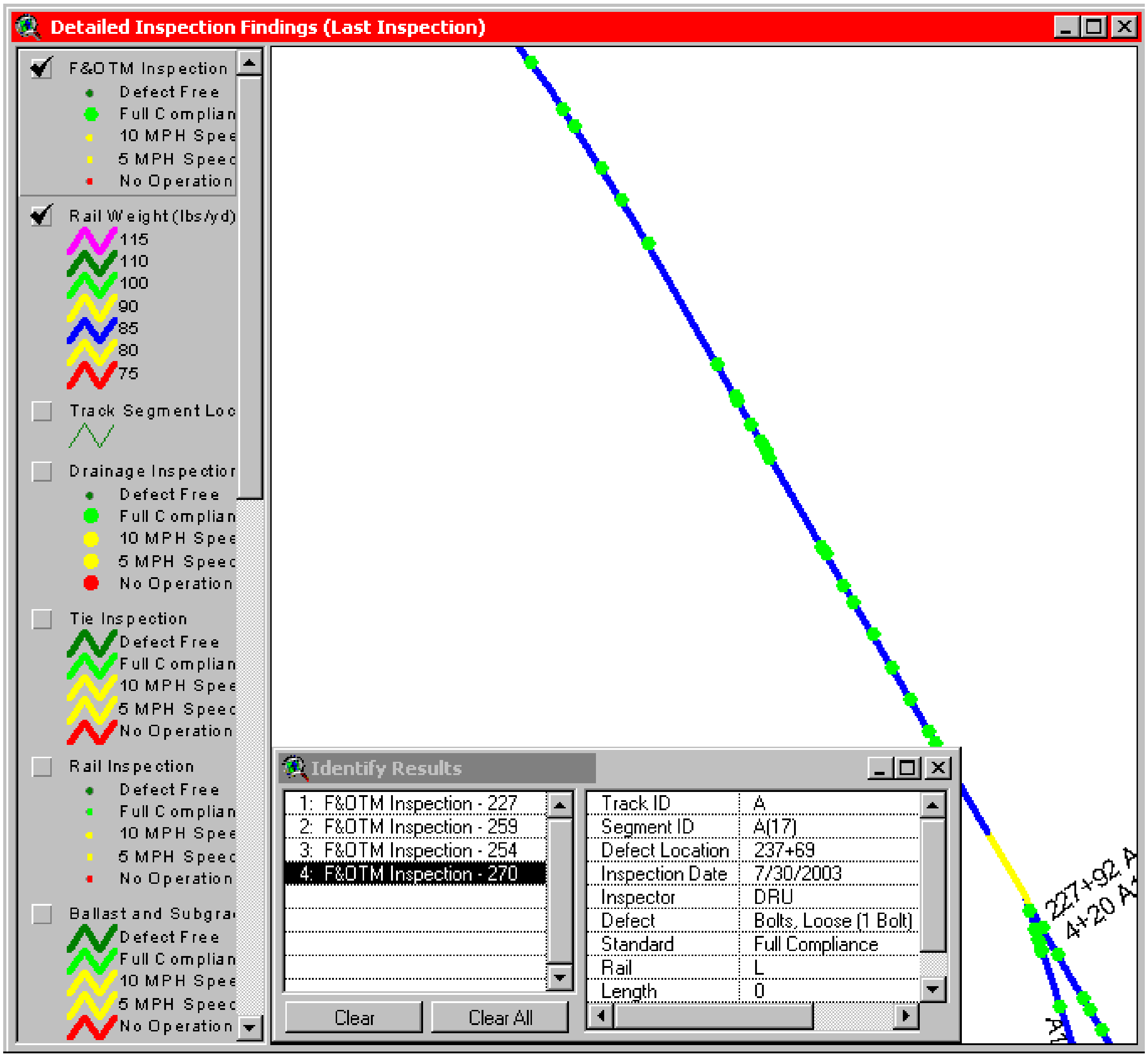

FIGURE 7 Detailed Inspection Findings View showing the high number of joint defects on light weight rail (85 lb).

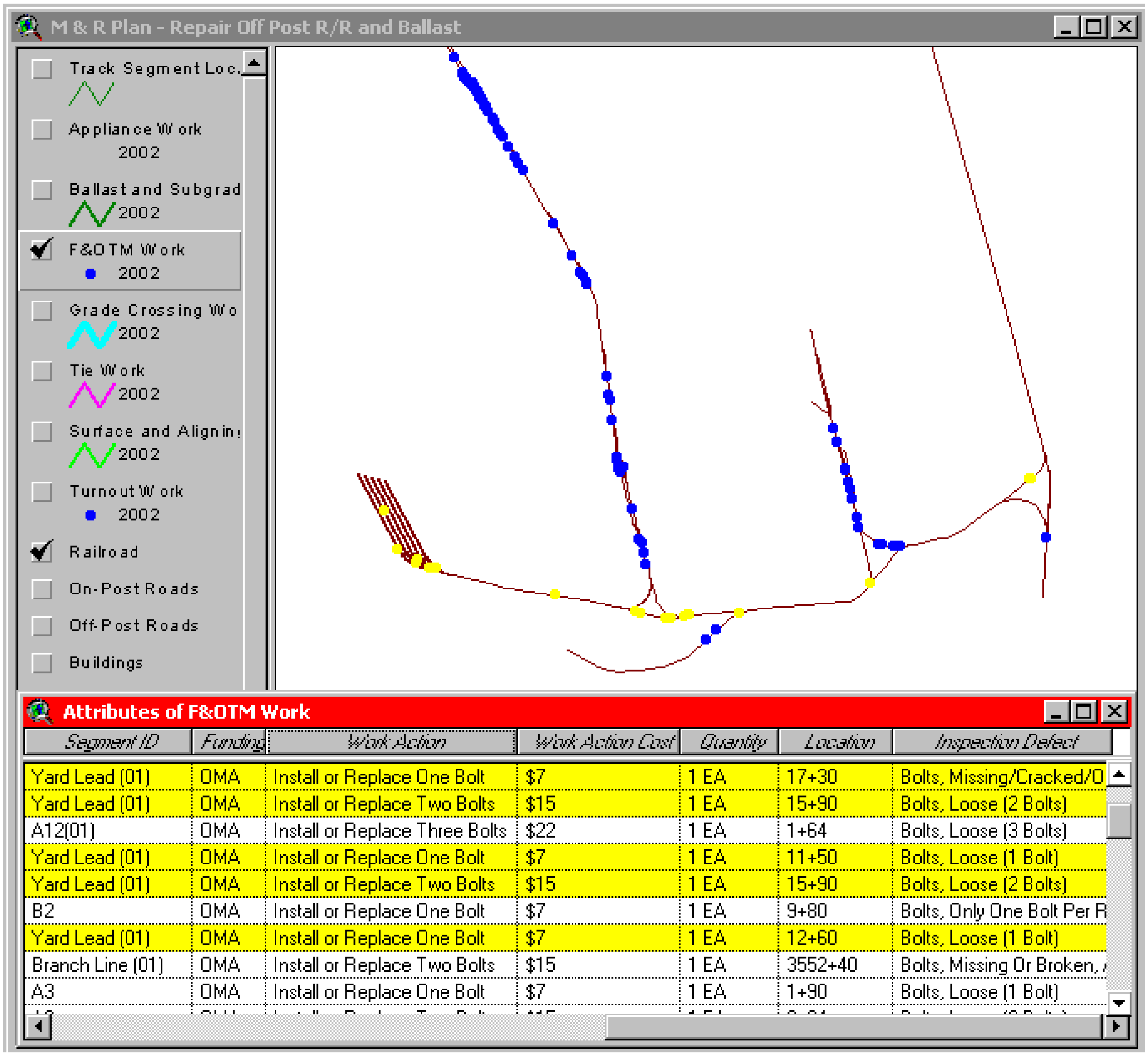

FIGURE 8 M&R Plan View illustrating individual work items on network highlighted for inclusion into plan.

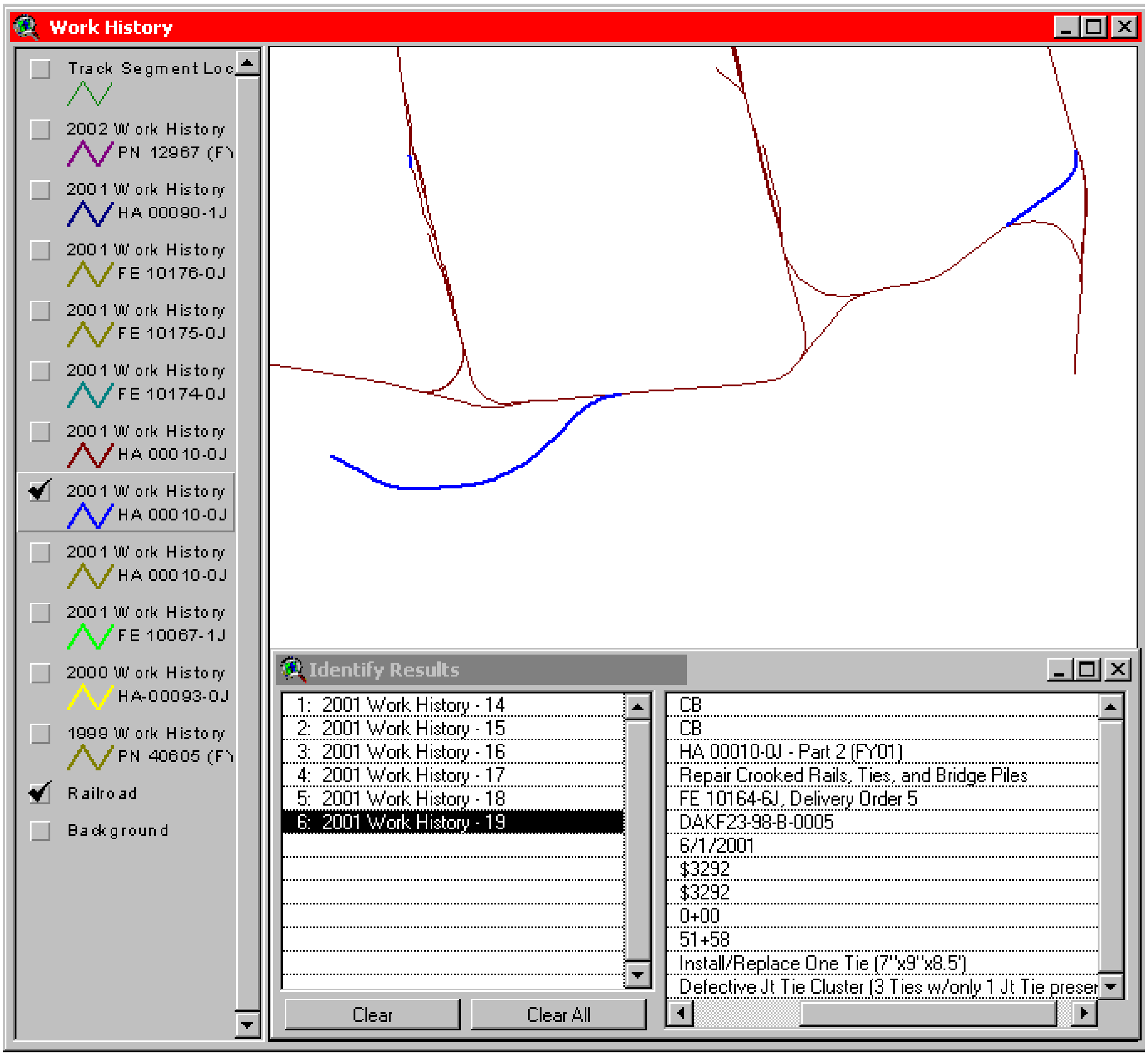

FIGURE 9 Work History View displaying location of work and other project information.

FIGURE 10 Track Information (Other) View illustrating use of overlaid aerial photos.

FIGURE 11 Track Segment Query View displaying overlay of segment names and end station locations.