UTAH TRANSIT AUTHORITY

UTA/Bentley Final Report

Transit Asset Management Grant

April 2013

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Executive Summary

The Federal Transit Administration State of Good Repair (SOGR) initiative is an opportunity to resolve asset management concerns that affect transit agencies all across the country. Over the last 18 months, UTA and Bentley/InspectTech have worked to grow and expand the existing Asset Management System (AMS) that UTA now utilizes to a system which tracks inspections and maintenance for a number of UTA's assets, adds additional tools which will aid in determining if an asset is in a State of Good Repair (SOGR) and also outlines processes which will help to keep it there.

This Final Report will document the initial scope as proposed by UTA and Bentley including results of functionalities, processes achieved, and lessons learned during the development of the new process. In UTA's system, the basic foundations of AMS come from the inventory and inspection processes which focus on the safety and functionality of our system. Additional modules have been developed that supplement and facilitate an objective and comprehensive approach to the SOGR initiative. One module in particular, the Risk Module, is one function which UTA feels will become more and more important to the SOGR initiative and to agencies nationwide. Risk can have several different meanings. Agencies will need to define what it means to them individually, but whatever the meaning it is the opinion of UTA that risk must be considered in any system relating to SOGR.

This report is written from the perspective of an agency that has implemented a comprehensive SOGR program. This report serves as a practical model for other agencies. Topics relating to how agencies should approach this effort are addressed as well as some insights to the critical lessons learned while trying to implement this process. This report addresses what UTA has determined to be SOGR best practices for our agency. While these practices may not be relevant at other agencies, they will provide an experienced perspective that will be helpful as agencies implement their own AMS programs.

When developing an intuitive AMS several needs for key components surfaced.

1. Inventory Module: This module will store all asset information and characteristics. Benefits include the ability to attach photos, drawings, PDF files, past inspection reports, or any other relevant file type. The inventory module also includes a GIS (Geographic Information System) map which visually presents each item.
2. Inspection Module: Using user specific inspection forms, UTA employees can perform, input and submit all inspections in the field. The inspections can be monitored, reviewed, and approved from a mobile or office location.
3. Condition Rating Module: The condition rating of an asset is based on the inspection reports, field observations and asset age. The condition rating works in conjunction with Term Lite
4. Deterioration Module: This module predicts the rate an asset deteriorates. The module takes information from the Inventory, Inspection and Condition Rating modules and plots a deterioration curve based on values from TERM Lite. Output from this module will provide information when to rehabilitate or replace an asset.

5. Budget Module: Once the asset deteriorates to the point of rehabilitation or replacement the data is automatically feed into the Budget module. The module will give UTA significant lead time to sort, prioritize, and start the budget preparation process to address deteriorating assets.
6. Risk Module: Risk-based approaches are commonly used in private industry and by highway agencies. These approaches evaluate assets not only based on their condition but also based on their criticality according to factors such as safety, operational importance, and likelihood of failure. Those items that are the highest risk may not necessarily be in the worst condition but should be considered for repair or replacement actions based on the high risk the failure would pose to the overall operation of the system.

It is UTA's expectation that other transit agencies will be able to take the principles outlined in this document and use them to develop an AMS that meets the needs of their individual agency. UTA believes that while there may be differences in the AMS due to agency size, age, and geographic location, there are some core principles to an effective AMS that relate to all entities. If applied, agencies will benefit from this document and be able to develop the best approach for implementing a comprehensive asset management system.

Introduction

UTA is the provider of public transportation throughout the Wasatch Front of Utah, which includes the metropolitan areas of Ogden, Salt Lake City, and Provo. UTA operates light rail (TRAX), commuter rail (Frontrunner), fixed route buses, express buses, ski buses, Bus Rapid Transit (BRT) and Paratransit buses. The Asset Management department consists of 4 employees and resides in the Capital Development Business Unit. This group has two full time staff employees as well as one Manager and one Senior Program Manager who devote some of their time to the asset management efforts.

The final report includes three main elements that are important to finalize the commitment UTA made in the solicitation for the grant. These three elements are:

1) How UTA addressed and followed the original scope
2) Budget- How UTA utilized the FTA funding
3) Lessons Learned

While the SOGR effort at UTA has evolved over the last 18 months, the final commitment has remained the same. UTA and Bentley set out to develop a product that would add value to the transit industry as a whole. The final product needed to have a:

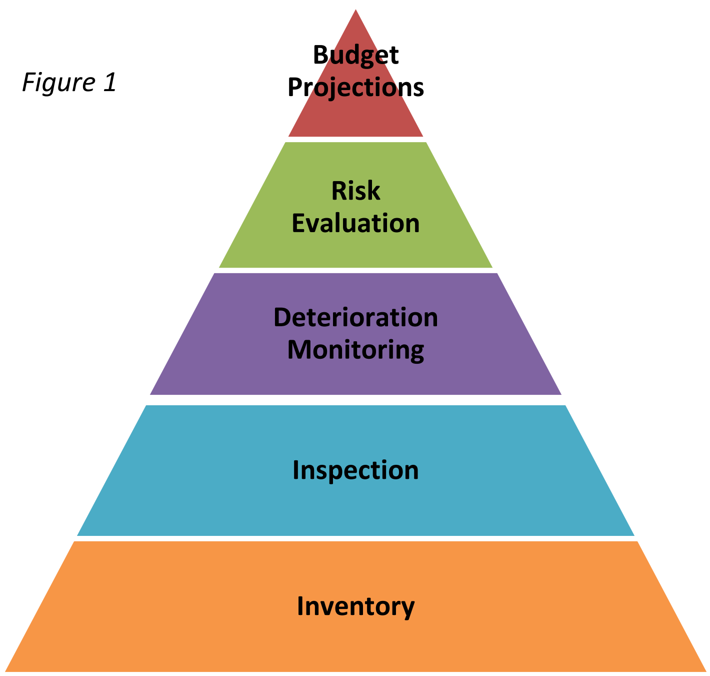
- means of developing an accurate inventory of assets,
- a mobile based system that would accommodate the need to perform inspections in the field with operations field staff,
- a tool to allow tracking of both scheduled and unscheduled maintenance activities,
- a system that allows specific data on specific assets to be stored and tracked to develop agency specific deterioration curves,

- a method to allow risk associated with operational failures and safety to be applied to the prioritization of select projects,
- an overall prioritization tool and
- a predictive financial component that allows budgeting in upcoming years of specific maintenance and SOGR needs.

Before the implementation of the TAM program the asset management system at UTA was insufficient. Some capital assets were logged into JD Edwards individually. Other items were entered as capital projects. Previously the asset management system was simply physical items kept in a database format.

To move forward UTA identified several important components necessary to develop an intuitive AMS. Other agencies may have needs in addition to the components shown in figure 1. Through development of the AMS for UTA it has become our opinion that these elements are critical to an effective asset management system for any agency.

Figure 1



The success of the AMS is measured in several metrics. First, to provide a safe, reliable and cost effective transportation service. Second, provide a system to track, analyze, and predict the performance of asset over its useful life. Third, identify and prepare rehabilitation and replacement activities. The development of a comprehensive asset management system is a journey rather than the destination. While the end product is visible, how a group gets there will be continuously refined. It is important to note that refinement and reassessment are not bad things, but allow for a better product in the end.

Module Overview

During development of the UTA AMS a common sense logic based approach has been used. This has allowed for critical input from those groups who will be utilizing and inputting data into the system on a daily basis. Throughout the development a key goal has been present to help steer and guide decisions. That goal is “does it add value to the agency and will it help in our goal to locate and repair problems before failure.” The system is based on a flexible web-based architecture with standalone field components that will allow the AMS system to be accessed via any authorized web browser. This is ideal for servicing a wide and diverse user set spread across different locations in the UTA system. Authorized users will be able to access or enter information from any location at any time. Additionally, software has been included that allows managers to monitor progress of field inspections and also evaluate the type of problems that may be identified.

The granularity of each inventoried asset has been clearly defined and understood. This provides tracking at a level that complements the maintenance of the assets while not bogging down the system with too much data or information.

UTA will use several metrics to measure the performance of its assets in the AMS. To set the baseline, UTA will use TERM Lite's time based asset deterioration curve. The FTA has set up predetermined decay curves using term codes. The values of each term code have been loaded in the deterioration module in the AMS. As condition ratings are applied UTA can measure how the assets are performing. Over time two decay curves will be established. First, the time based curve from TERM Lite will be prepopulated for each applicable asset. The second will represent the actual deterioration of each asset. This measurement will be valuable over time comparing the two methods.

To measure the current state of UTA and strategize future funding UTA's inventory has been uploaded into FTA's TERM Lite. The analysis provided has proven to be a valuable tool. TERM Lite can measure metrics such as backlog and needs. This will prove useful when reporting on the state of good repair for the organization.

Inventory Module

UTA's inventory information module allows for the organization of assets along with user permissions and the overall asset hierarchy. The software will store all basic and advanced inventory information on the asset characteristics. In addition to standard text input, the software allows for attachments to be added to the asset's data inventory. This includes pictures, drawings, sketches, PDF files, past inspection reports, or any other file type which is relevant. The inventory module has the ability to contain archived asset details for the entire history of the asset. Included in these details are past inspection reports, pictures, drawings, maintenance and rehabilitation information which can be queried and viewed like any other type of information. The inventory module has an extensive GIS map which visually presents each item and its properties in relation to other system components on an interactive map. The GIS map allows users to see the location of an asset in relation to other assets, zoom in and out of the map to see the roads and other surroundings, view the asset from several different vantage points and search and query only certain assets of interest to be viewable on the map.

Assets can also be logically divided into their primary components. Inspections and information can be collected on any level to the asset tree. The inventory module allows the information to be created and used when doing inspections and management on the structure.

Each asset has been identified by a specific asset code. An asset code for a rail item follows a format which can tell someone which rail alignment an asset belongs to, which piece of track it is adjacent to (either direction wise or geographically laid out), whether it is part of the guideway, electrification, or train control. From there it is possible for the choices to become more diverse. UTA and Bentley have chosen to drill down six sub-element levels on some capital inventory items. Following the sub-elements, the mile post designation will be given showing where an asset is along the alignment. This has been rounded to the nearest tenth of a mile. Following the mile post designation, there is an identifier listed indicating which construction or as-built drawing set was used to identify the asset.

An example of the asset code is:

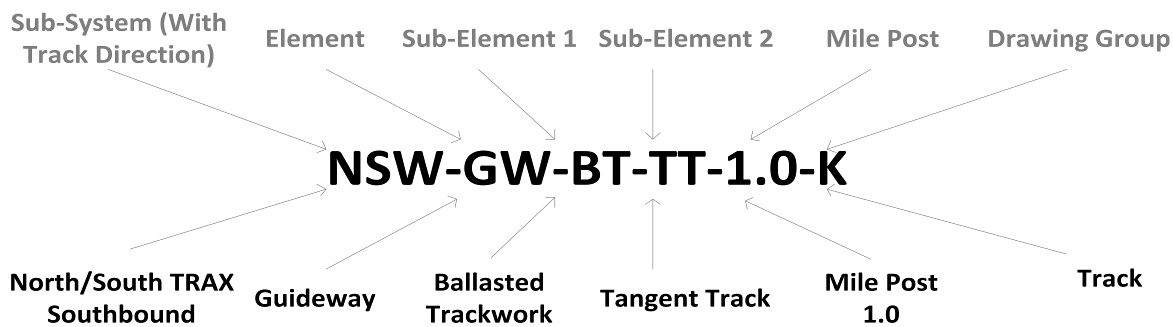


Figure 2

While the information seems basic, there is critical information which can be gleaned from looking at the asset name as well as the asset code. The example above is descriptive of what information can be gathered from the asset code.

As development of the inventory module began, it became evident that the inventory data collection process took longer than anticipated. Presently UTA has completed the inventory for all rail assets currently in service. UTA has recognized going forward that new construction contracts must require the contractor to extract and provide as part of the project deliverables a complete list of all required assets in a format that can be imported directly into the AMS.

Existing at UTA is a very accurate and detailed inventory of the Bus and Mobility fleet. The AMS will mine the necessary information from existing systems for tracking and monitoring of the bus assets. Also, UTA facilities have a functioning inventory system for UTA occupied locations that are not part of the rail system. The AMS will mine this data from existing sources to monitor and track the condition of the assets. Going forward some additional functions may be added to the existing systems that will add value to the overall AMS. However, the asset management group recognized early on that for a system to be developed and implemented in a very short duration, we needed to identify, evaluate and use existing data where possible.

The data in the following table illustrate what information was pulled from JD Edwards. UTA's IT department pulled the data from the JD Edwards tables and created server space to store the information. The data set is refreshed daily.

JD Edwards Vehicle Asset Data				
Fleet Type	Serial Number	Cost	Date of Purchase	Location of vehicle
Mileage	Vehicle Type	Replacement Schedule		
JD Edwards Component Data				
Part Number	Price	Date of Install	Vehicle Usage	System Usage
Description	Serial Number	Mileage	Hours	
JD Edwards Work Order Data				
Work Order Number	Work Order Cost	Date of Service	Maintenance Schedule	Failure or Preventative Maintenance

Figure 3

Establishing the inventory database is the foundation to the system. Without a complete inventory the AMS cannot function correctly. To compile the inventory it required coordination from several departments such as asset management, capital development, information technology, property management, bus and rail operations/maintenance, facilities, accounting and finance.

The GIS component plays a key role in the success of the AMS. UTA is currently plotting the GPS coordinates of the inventoried assets in the ArcGIS program. UTA will extract the GPS coordinates for each inventoried asset and tie it directly to that asset. This has the potential to reduce errors by insuring that the right component at the right location is being inspected and entered into the system. Not all assets will be plotted in the GIS system. It was determined that during the initial development of the AMS that items critical to revenue service would be plotted. In the future other assets may be added to the GIS system. Here is a screenshot of the current progress.

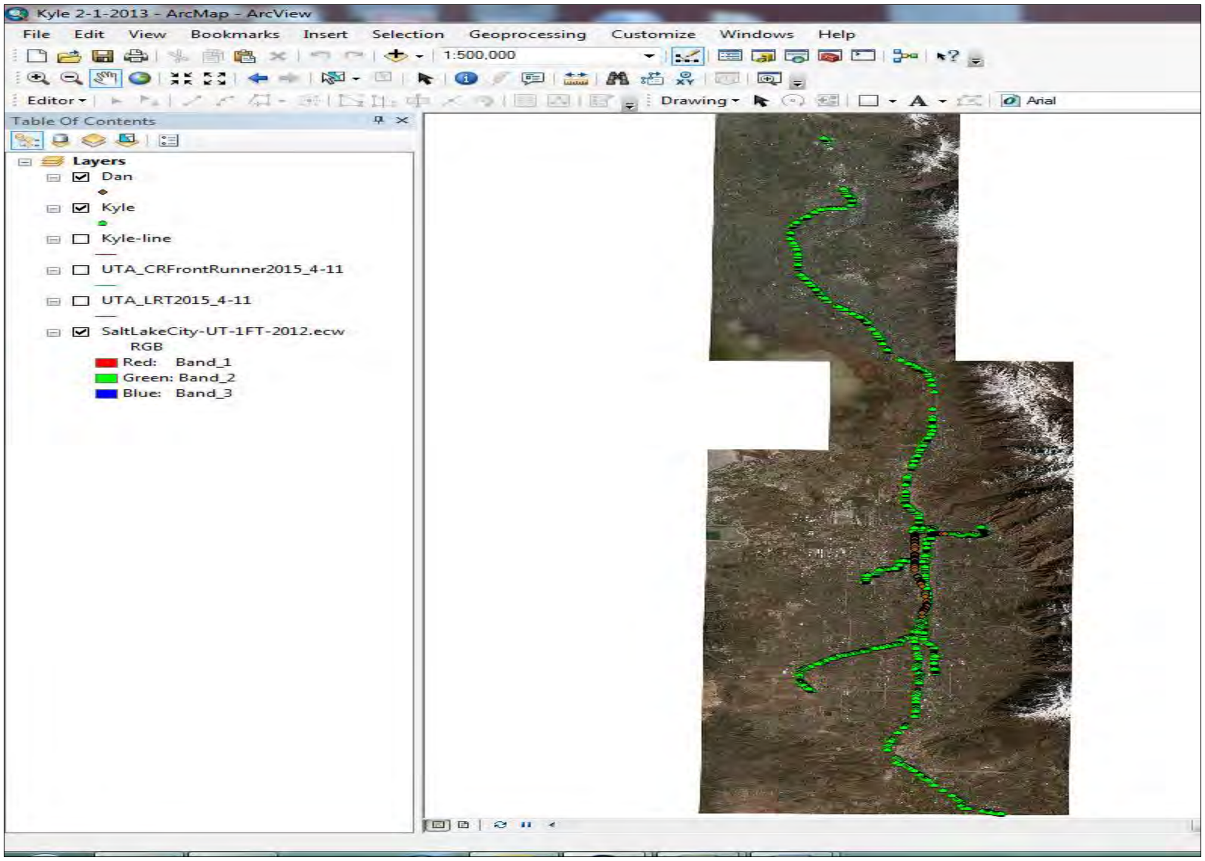


Figure 4

Drawings and other important files for the rail guideway can be been uploaded for use by the inspectors in the field. Figure 5 on the following page shows track drawings are available for the track inspectors to reference should they need to. All an inspector needs to do to access these files is to select the link for the Track Full Set.pdf. This will provide full access to the drawings in the field.

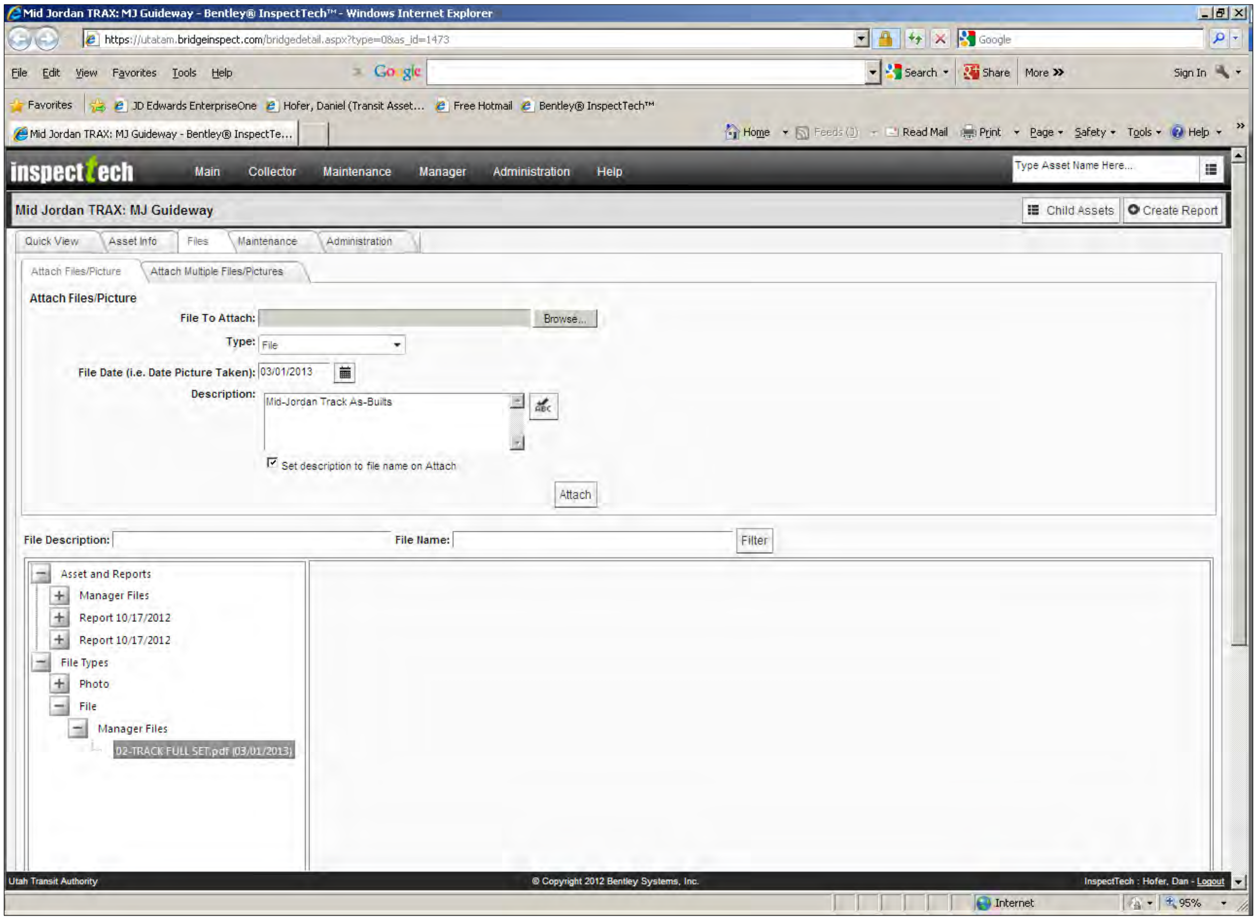


Figure 5

Inspection Module

Obtaining high quality and accurate inspection data is fundamental to having a good asset management system. The goal was to design a system that inspectors with basic computer skills could use. The inspection module has an interface that can be used on thousands of assets of all types. The system is being utilized by Maintenance of Way personnel in the field to handle all of their inspections relating to guideway, electrification, and train control. It contains customized data forms which an inspector can use to enter the inspection data directly into the designated fields. To help reduce the errors, the software provides dropdown menus, selection lists, and relevant information. There are also text options present where inspectors can outline the issues they may encounter as well as enter any other text data which may be pertinent to the inspection.

The software allows for inspectors to submit their inspections from the field. These inspections, once submitted, can be accessed and reviewed by office personnel who can monitor the progress and more importantly have access to the completed inspection, perform a quality control check and submit for immediate approval. This is a drastic improvement from inspectors having to return to the office and fill out paper documents that could be lost or destroyed in the office location.

One of the many time saving features of the software is the ability to pre-populate inspection reports. This option allows an inspector to generate a new report with past inspection data, highlighting every field in the past report that has or has not changed. This is an excellent tool to spot trends and changes within an asset inventory and reduce the time of entering the same data repeatedly.

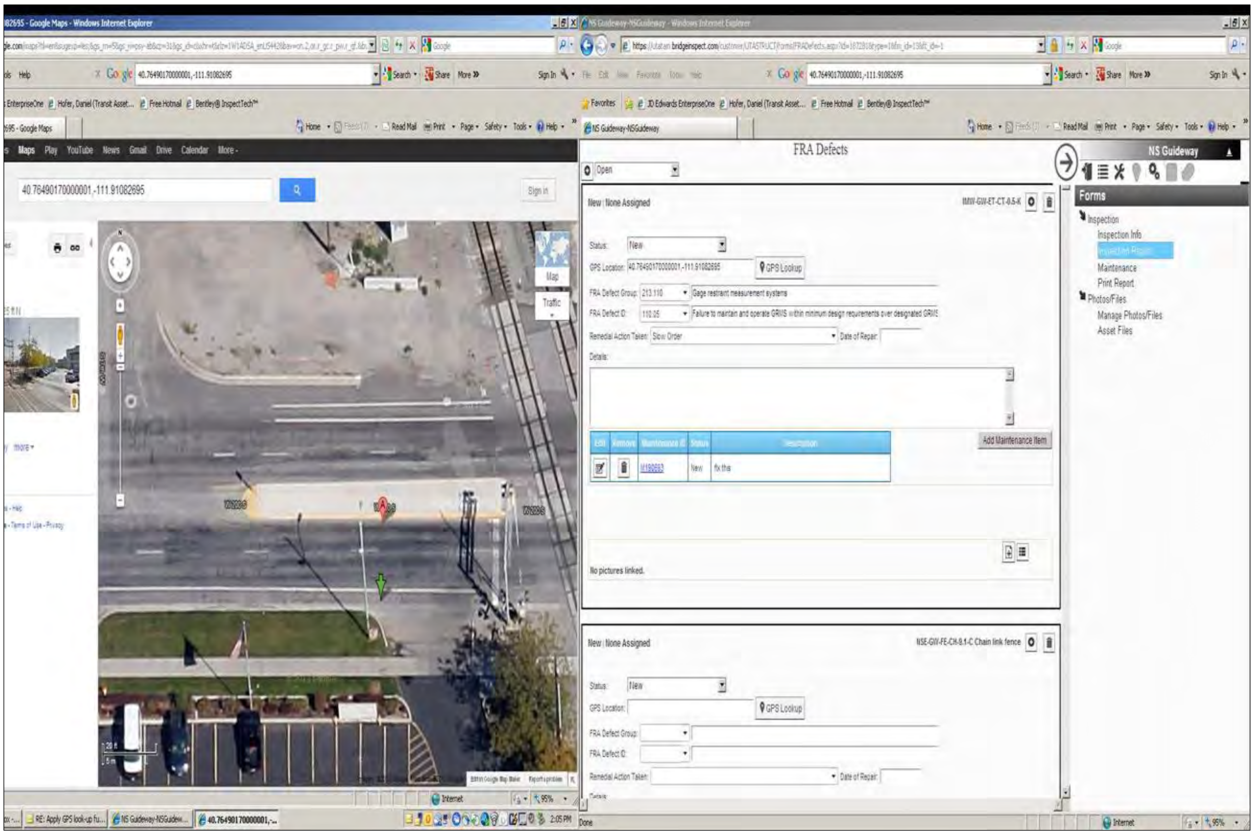


Figure 6

Finally, UTA and Bentley added a key piece of functionality to the inspection module that was not outlined in the scope. This is the capability for inspectors to apply a GPS coordinate to a defect or maintenance item. This has been implemented and has shown to be within acceptable levels of accuracy. Figure 6 shows GPS coordinates (used just for training purposes) in the inspection screen on the right and compared to the actual placement on a Google map. For perspective, the tester was sitting on the rock next to the light pole just down from the green arrow in the left picture. This gap between the two points is approx. 10-15 feet. Coupling this capability with the ability for inspectors to attach photos to their inspections will provide a powerful reporting component for the MOW staff. In order to facilitate the inspections in the field, UTA has purchased 60 tablet computers to be distributed throughout the organization.

Condition Rating Module

The condition rating module has evolved through the development of the AMS. It has become part of two other modules present in the system- the Inspection and Deterioration modules. The main output of the condition rating component of the system is reporting.

Once the asset is input into the inventory system a term code is applied. The term code is taken from Term Lite. This condition rating information is the baseline for our deterioration module. As we progress, the condition ratings from our inspections will more accurately represent UTA's condition rating rather than the time based condition assessment in Term Lite.

Supervisors and inspectors are responsible to apply condition ratings to the assets. The condition rating is based on the inspection reports, field observations, and asset age. Employees will have access to see what previous condition rating have been on a specific asset through the Inspection module. Application of the condition rating is more easily accomplished and more accurately applied through the deterioration module. There supervisors can more readily access specific asset codes.

TERM uses a scale of 1-5. UTA determined it would be more applicable to use the scale of 1-10. This gives the flexibility to track the gradual deterioration rather than having items make a more drastic deterioration drop. The larger scale will give UTA the opportunity to better plan rehabilitation and replacement activities.

Below is a breakdown of UTA's condition ratings:

10) Excellent - New asset; no visible defects. Only preventative maintenance has been performed. Asset has completed less than approximately 15% of its minimum useful life.

9) Very Good- Only minor adjustment repair work completed. Asset has completed approximately 15%-30% of its minimum useful life.

8) Good - Asset showing minimal signs of wear; some (slightly) defective or deteriorated components(s). Asset has completed approx. 30%-45% of its minimum useful life.

7) Satisfactory- Asset has past repair maintenance history, but no current noted items. Asset has completed approximately 45%-60% of its original useful life.

6) Adequate - Asset has some moderately defective or deteriorated components(s). Asset has completed approximately 60%-75% of its minimum useful life.

5) State-of-Good Repair- An asset is in the state of good repair when the physical condition of that asset is at or above a condition rating of 5.The level of investment required to attain and maintain a SOGR is therefore that amount required to rehabilitate and replace all assets with an estimated condition of 5 or less. Asset performs its assigned function without any limitations. Asset has past repair maintenance history and may have current repair items noted that do not limit the asset function. Asset has completed approximately 75%-90% of its minimum useful life.

4) Marginal - Asset reaching or just past the end of its useful life; increasing number of defective or deteriorated component(s) and increasing maintenance needs. Maintenance and reliability costs begin to become more expensive. Continued maintenance program required to bring up to the level of State-of-Good Repair. Asset has completed approximately 90%-105% of its minimum useful life.

3) Concern- Asset performs its assigned function with limitations. Asset cannot function without limitations unless maintenance is performed.

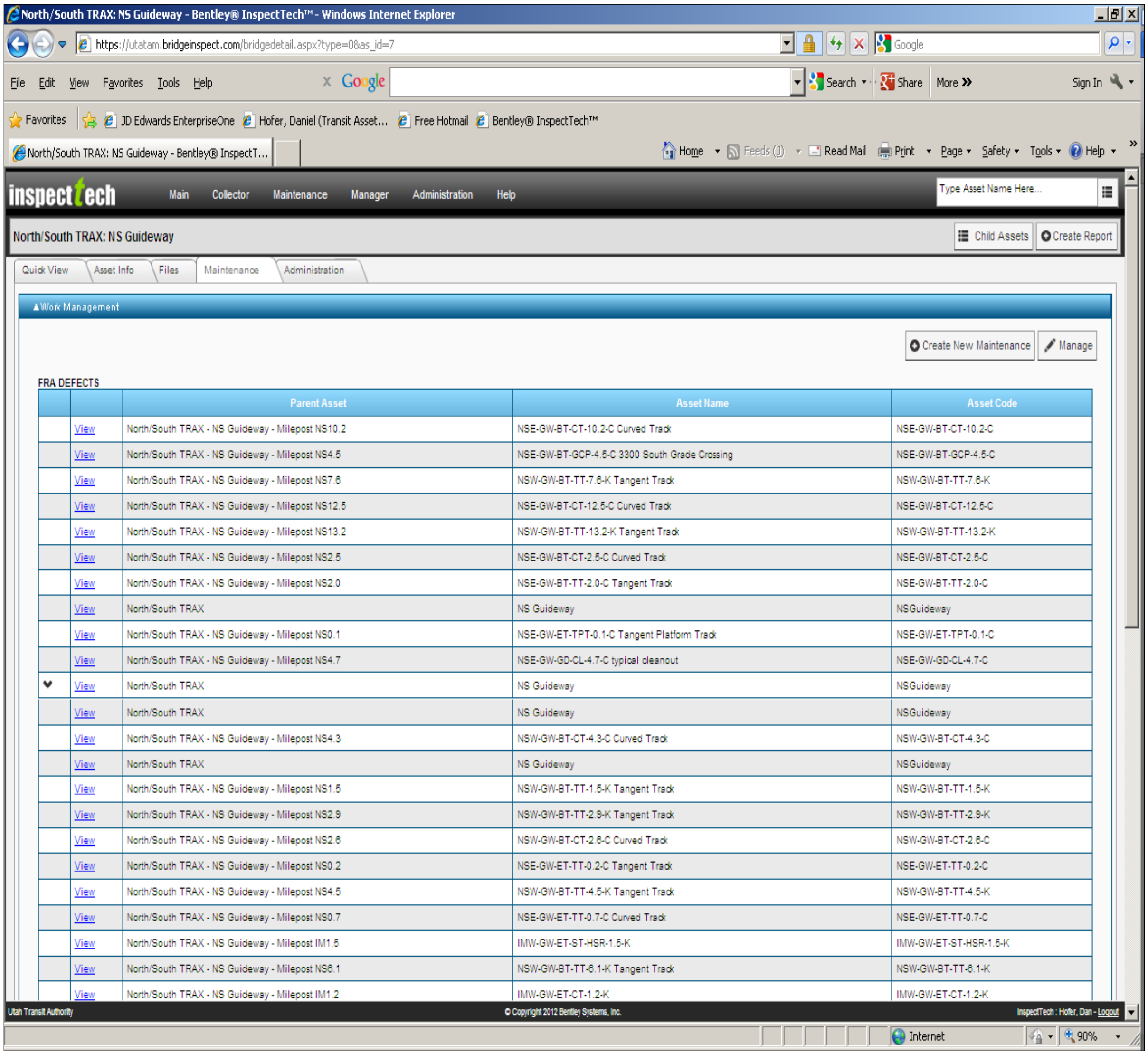
2) Poor - Asset is past its useful life and is in need of immediate repair or replacement; May have critically damaged component(s).

1) Critical- Immanent failure or safety risk. Asset out of service.

* Note: Rehabilitation maintenance can be performed at any condition stage and the asset's minimum useful life may be increased. Maintenance Module

The maintenance module is integrated into the inspection and management software. The inspection software allows users to enter specific maintenance needs or deficiencies that they identify during the course of the inspection.

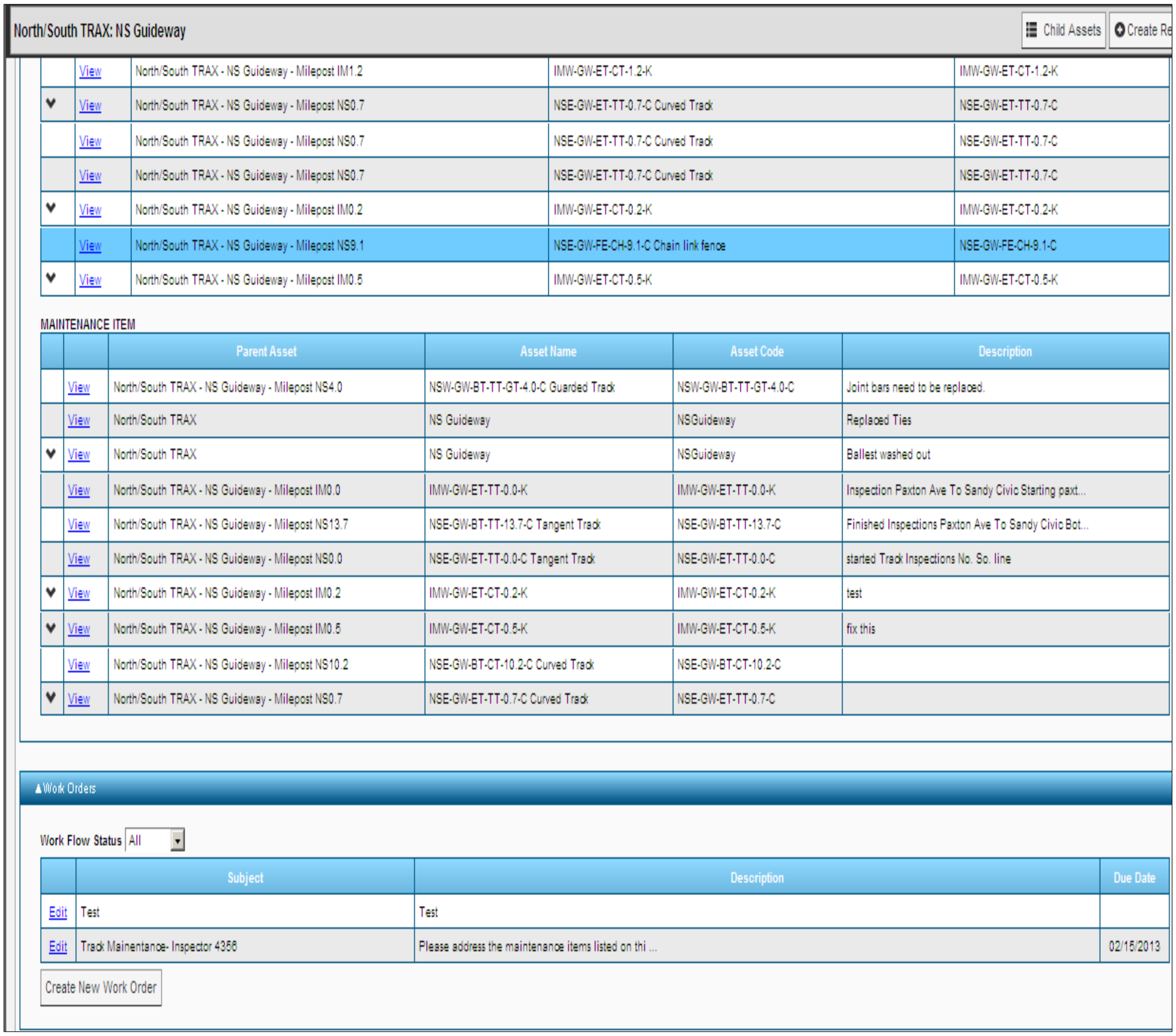
On the maintenance screen, supervisors can see the maintenance items identified as well as the work orders which have been created from the inspection process. Critical items that are identified during the inspection process are flagged and routed to the appropriate supervisor when the inspection is completed and submitted. This allows for management to evaluate and access what action must be taken to fix the situation.



FRA DEFECTS

		Parent Asset	Asset Name	Asset Code
	View	North/South TRAX - NS Guideway - Milepost NS10.2	NSE-GW-BT-CT-10.2-C Curved Track	NSE-GW-BT-CT-10.2-C
	View	North/South TRAX - NS Guideway - Milepost NS4.5	NSE-GW-BT-GCP-4.5-C 3300 South Grade Crossing	NSE-GW-BT-GCP-4.5-C
	View	North/South TRAX - NS Guideway - Milepost NS7.6	NSW-GW-BT-TT-7.6-K Tangent Track	NSW-GW-BT-TT-7.6-K
	View	North/South TRAX - NS Guideway - Milepost NS12.5	NSE-GW-BT-CT-12.5-C Curved Track	NSE-GW-BT-CT-12.5-C
	View	North/South TRAX - NS Guideway - Milepost NS13.2	NSW-GW-BT-TT-13.2-K Tangent Track	NSW-GW-BT-TT-13.2-K
	View	North/South TRAX - NS Guideway - Milepost NS2.5	NSE-GW-BT-CT-2.5-C Curved Track	NSE-GW-BT-CT-2.5-C
	View	North/South TRAX - NS Guideway - Milepost NS2.0	NSE-GW-BT-TT-2.0-C Tangent Track	NSE-GW-BT-TT-2.0-C
	View	North/South TRAX	NS Guideway	NSGuideway
	View	North/South TRAX - NS Guideway - Milepost NS0.1	NSE-GW-ET-TPT-0.1-C Tangent Platform Track	NSE-GW-ET-TPT-0.1-C
	View	North/South TRAX - NS Guideway - Milepost NS4.7	NSE-GW-GD-CL-4.7-C typical cleanout	NSE-GW-GD-CL-4.7-C
	View	North/South TRAX	NS Guideway	NSGuideway
	View	North/South TRAX	NS Guideway	NSGuideway
	View	North/South TRAX - NS Guideway - Milepost NS4.3	NSW-GW-BT-CT-4.3-C Curved Track	NSW-GW-BT-CT-4.3-C
	View	North/South TRAX	NS Guideway	NSGuideway
	View	North/South TRAX - NS Guideway - Milepost NS1.5	NSW-GW-BT-TT-1.5-K Tangent Track	NSW-GW-BT-TT-1.5-K
	View	North/South TRAX - NS Guideway - Milepost NS2.9	NSW-GW-BT-TT-2.9-K Tangent Track	NSW-GW-BT-TT-2.9-K
	View	North/South TRAX - NS Guideway - Milepost NS2.6	NSW-GW-BT-CT-2.6-C Curved Track	NSW-GW-BT-CT-2.6-C
	View	North/South TRAX - NS Guideway - Milepost NS0.2	NSE-GW-ET-TT-0.2-C Tangent Track	NSE-GW-ET-TT-0.2-C
	View	North/South TRAX - NS Guideway - Milepost NS4.5	NSW-GW-BT-TT-4.5-K Tangent Track	NSW-GW-BT-TT-4.5-K
	View	North/South TRAX - NS Guideway - Milepost NS0.7	NSE-GW-ET-TT-0.7-C Curved Track	NSE-GW-ET-TT-0.7-C
	View	North/South TRAX - NS Guideway - Milepost IM1.5	IMW-GW-ET-ST-HSR-1.5-K	IMW-GW-ET-ST-HSR-1.5-K
	View	North/South TRAX - NS Guideway - Milepost NS6.1	NSW-GW-BT-TT-6.1-K Tangent Track	NSW-GW-BT-TT-6.1-K
	View	North/South TRAX - NS Guideway - Milepost IM1.2	IMW-GW-ET-CT-1.2-K	IMW-GW-ET-CT-1.2-K

Figure 7



	View	North/South TRAX - NS Guideway - Milepost IM1.2	IMW-GW-ET-CT-1.2-K	IMW-GW-ET-CT-1.2-K
˅	View	North/South TRAX - NS Guideway - Milepost NS0.7	NSE-GW-ET-TT-0.7-C Curved Track	NSE-GW-ET-TT-0.7-C
	View	North/South TRAX - NS Guideway - Milepost NS0.7	NSE-GW-ET-TT-0.7-C Curved Track	NSE-GW-ET-TT-0.7-C
	View	North/South TRAX - NS Guideway - Milepost NS0.7	NSE-GW-ET-TT-0.7-C Curved Track	NSE-GW-ET-TT-0.7-C
˅	View	North/South TRAX - NS Guideway - Milepost IM0.2	IMW-GW-ET-CT-0.2-K	IMW-GW-ET-CT-0.2-K
	View	North/South TRAX - NS Guideway - Milepost NS9.1	NSE-GW-FE-CH-9.1-C Chain link fence	NSE-GW-FE-CH-9.1-C
˅	View	North/South TRAX - NS Guideway - Milepost IM0.5	IMW-GW-ET-CT-0.5-K	IMW-GW-ET-CT-0.5-K

MAINTENANCE ITEM

		Parent Asset	Asset Name	Asset Code	Description
	View	North/South TRAX - NS Guideway - Milepost NS4.0	NSW-GW-BT-TT-GT-4.0-C Guarded Track	NSW-GW-BT-TT-GT-4.0-C	Joint bars need to be replaced.
	View	North/South TRAX	NS Guideway	NSGuideway	Replaced Ties
˅	View	North/South TRAX	NS Guideway	NSGuideway	Ballest washed out
	View	North/South TRAX - NS Guideway - Milepost IM0.0	IMW-GW-ET-TT-0.0-K	IMW-GW-ET-TT-0.0-K	Inspection Paxton Ave To Sandy Civic Starting paxt...
	View	North/South TRAX - NS Guideway - Milepost NS13.7	NSE-GW-BT-TT-13.7-C Tangent Track	NSE-GW-BT-TT-13.7-C	Finished Inspections Paxton Ave To Sandy Civic Bot...
	View	North/South TRAX - NS Guideway - Milepost NS0.0	NSE-GW-ET-TT-0.0-C Tangent Track	NSE-GW-ET-TT-0.0-C	started Track Inspections No. So. line
˅	View	North/South TRAX - NS Guideway - Milepost IM0.2	IMW-GW-ET-CT-0.2-K	IMW-GW-ET-CT-0.2-K	test
˅	View	North/South TRAX - NS Guideway - Milepost IM0.5	IMW-GW-ET-CT-0.5-K	IMW-GW-ET-CT-0.5-K	fix this
	View	North/South TRAX - NS Guideway - Milepost NS10.2	NSE-GW-BT-CT-10.2-C Curved Track	NSE-GW-BT-CT-10.2-C	
˅	View	North/South TRAX - NS Guideway - Milepost NS0.7	NSE-GW-ET-TT-0.7-C Curved Track	NSE-GW-ET-TT-0.7-C	

▲Work Orders

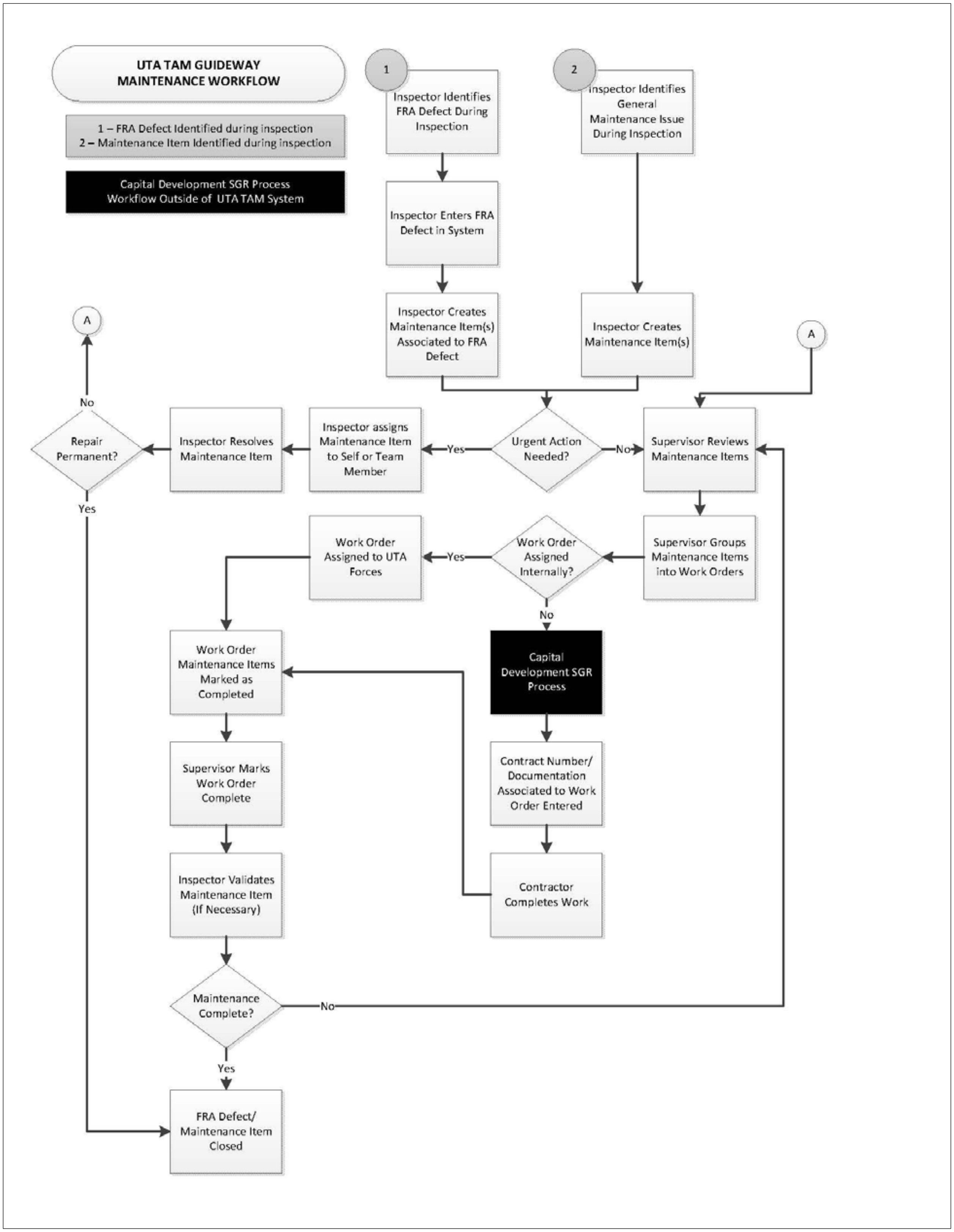
Work Flow Status All

	Subject	Description	Due Date
Edit	Test	Test	
Edit	Track Maintenance- Inspector 4356	Please address the maintenance items listed on thi ...	02/15/2013

Create New Work Order

Figure 8

Figures 7 and 8 above show the main maintenance screen. Supervisors can see the maintenance items or if applicable, FRA Defects, which have been identified and will be able to group them into workorders by tapping on the "Create New Work Order" button located in the lower left-hand corner of the screen. The workflow is presented below.


UTA TAM GUIDEWAY MAINTENANCE WORKFLOW
1 – FRA Defect Identified during inspection
2 – Maintenance Item Identified during inspection
Capital Development SGR Process Workflow Outside of UTA TAM System
1
Inspector Identifies FRA Defect During Inspection
2
Inspector Identifies General Maintenance Issue During Inspection
Inspector Enters FRA Defect in System
Inspector Creates Maintenance Item(s) Associated to FRA Defect
Inspector Creates Maintenance Item(s)
A
A
Urgent Action Needed?
Yes
No
Inspector assigns Maintenance Item to Self or Team Member
Inspector Resolves Maintenance Item
Repair Permanent?
No
Yes
Supervisor Reviews Maintenance Items
Supervisor Groups Maintenance Items into Work Orders
Work Order Assigned Internally?
Yes
No
Work Order Assigned to UTA Forces
Capital Development SGR Process
Contract Number/ Documentation Associated to Work Order Entered
Contractor Completes Work
Work Order Maintenance Items Marked as Completed
Supervisor Marks Work Order Complete
Inspector Validates Maintenance Item (If Necessary)
Maintenance Complete?
No
Yes
FRA Defect/ Maintenance Item Closed

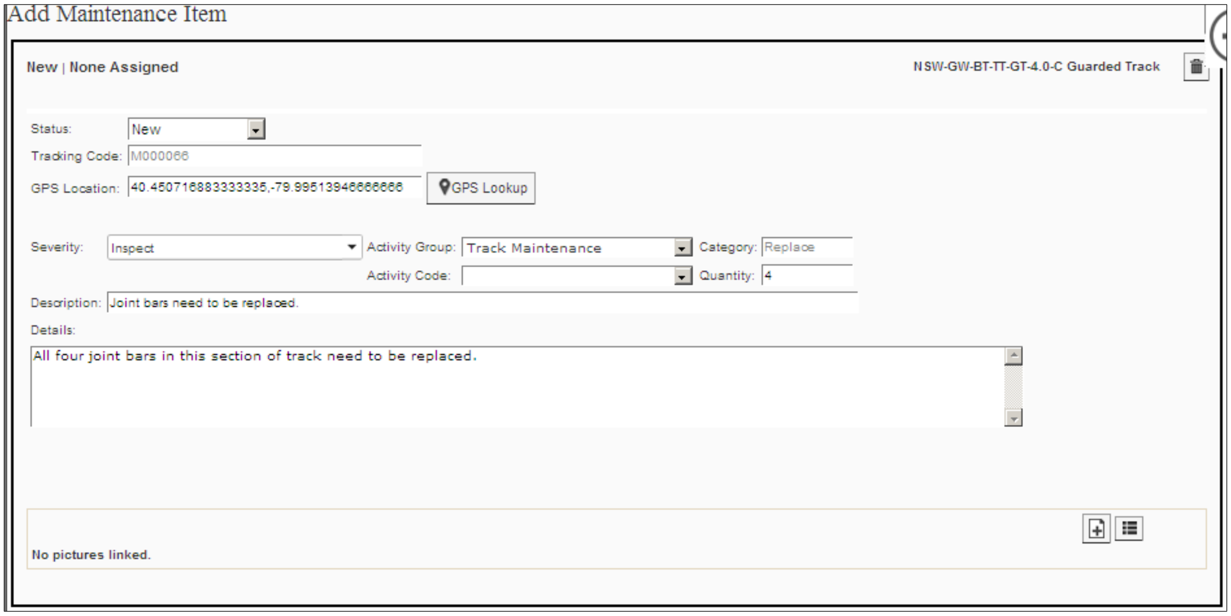


Figure 9

Description of Maintenance Activities

The maintenance activities (figure 9) that have been identified are shown by different searchable items. Examples of these are:

- Location of Maintenance Need (specific area where the problem is)
    - It allows for inspectors to acquire a GPS location for the specific need. Inspectors must also select an asset code to apply the maintenance item, which also provides a general location of the issue.
- Maintenance activity code (can be defined by owner/consultant)
    - UTA identified a number of activity groups which are high level activity categories. The activity code is just a list of common activities which were created with UTA Maintenance of Way input. Additional codes or groups can be added as time progresses and the need presents itself.
- Quantity/Unit of problem (i.e. 100 sq. feet)
    - Quantities are allowed to be entered in the quantity box. Units have been determined by the asset management group and are kept in the database. . It was felt that the possibility of receiving multiple units for similar elements was something that wanted to be avoided. Also, it was felt that limiting inspectors to a certain amount of unit options might inadvertently force them into using a unit that was not correct. If it were possible at this time to know all components that an inspector might report as a maintenance item, then units might be more easily applied. Until that option exists, inspectors are encouraged to write up the details of the problem in the details section including the

unit of measure they decide. Over time, as patterns and tendencies manifest themselves, the unit box can be added.

- Severity of the maintenance need
    - Inspectors can choose from different options, namely:
        - Immediate Action Required
        - Address Before Next Inspection
        - Monitor
- Text description of the problem
    - This can be applied in the details section.
- Photos, drawings, or other electronic data
    - These can be added to the individual maintenance items.
- Priority of the repair needed (scale from immediate to long-term can be defined by the user)
    - This is captured also under the severity of the maintenance need.
- Flag categories (safety hazard, aesthetic, evaluation needed, etc.)
    - This can be captured by using the severity box as well as the details box.
- Estimated cost (can be derived from standard unit costs) - this information is kept in the database and is used for budget projections.
    - Below is an example list of some activities and sample costs associated with maintenance. Currently, programmed rehabilitation activities can be managed in the deterioration module. The managing of these activities includes keeping the costs updated for replacement. The program allows for costs to be updated as a cost percentage of the asset being rehabilitated, as an absolute cost, or as a unit cost. This functionality is currently handled on Bentley's end, but these cost changes can be added by submitting a request outlining the desired inputs.

Maintenance Activities Identified								
		Cost						
Code	**Activity**	Materials	unit	multiplier	Labor/hr	Units (hours)	Multiplier	Total Unit Cost
100.00	**Track Inspection**							
100.01	Weekly Track Inspection- Walking				$26.30	1	80.00	$2,104.00
100.02	Weekly Track Inspection- High-Rail				$26.30	1	80.00	$2,104.00
101.00	**Crossing Tests- 4 hrs for monthly**							
101.01	Ground Test				$34.71	1	0.28	$9.83
101.02	Standby Power Test				$34.71	1	0.28	$9.83
101.03	Visibility and Damage Test				$34.71	1	0.28	$9.83
101.04	Gate and Mech Conditions Test				$34.71	1	0.28	$9.83
101.05	Gate Operation Test				$34.71	1	0.28	$9.83
101.06	Warning System Operation Test				$34.71	1	0.28	$9.83
101.07	Traffic Signal Pre-Empt Test				$34.71	1	0.28	$9.83
101.08	Cutout Circuit Test				$34.71	1	0.28	$9.83
101.09	Track Condition				$34.71	1	0.28	$9.83
101.10	Alignment and Flash Rate Test				$34.71	1	0.28	$9.83
101.11	Lamp Voltage Test				$34.71	1	0.28	$9.83
101.12	Hold Clear Test				$34.71	1	0.28	$9.83
101.13	Warning Time Test				$34.71	1	0.28	$9.83
101.14	Time Release Time Relay Test				$34.71	1	0.28	$9.83
102.00	**Signal Tests**							
102.01	Ground Test				$34.71	1	0.40	$13.88
102.02	Standby Power Test				$34.71	1	0.40	$13.88
102.03	Signal & Housings Inspection				$34.71	1	0.40	$13.88
102.04	Impedance Bonds				$34.71	1	0.40	$13.88
102.05	Track Condition				$34.71	1	0.40	$13.88
103.00	**Relay Test**				$34.71	1	0.25	$8.68
104.00	**Locking Tests**							
104.01	Section Locking Test				$34.71	1	1.00	$34.71
104.02	Signal Indication Locking Test				$34.71	1	1.00	$34.71
104.03	Switch Indication Locking Test				$34.71	1	1.00	$34.71
104.04	Time Locking Test				$34.71	1	1.00	$34.71
104.05	Approach Locking Test				$34.71	1	1.00	$34.71
104.06	Route Locking Test				$34.71	1	1.00	$34.71
104.07	Traffic Locking Test				$34.71	1	1.00	$34.71
105.00	**Switch Tests (Signaling)**							
105.01	Switch Obstruction Test				$34.71	1	0.20	$6.94
105.02	Switch Circuit Controller Test				$34.71	1	0.20	$6.94
105.03	Electric Lock Timing Device Test				$34.71	1	0.20	$6.94
105.04	Electric Lock Quick Release Test				$34.71	1	0.20	$6.94
105.05	Shunt Fouling Circuit Test				$34.71	1	0.20	$6.94
106.00	**Substation Inspections**							
106.01	Monthly Substation Inspection				$34.71	1	2.00	$69.42
106.02	Yearly Substation Inspection				$34.71	1	6.00	$208.26
107.00	**OCS Inspections**							
107.01	Quarterly OCS Inspection- Walking				$34.71	1	2.00	$69.42
107.02	Quarterly OCS Inspection- High Rail				$34.71	1	2.00	$69.42
108.00	**Insulation Resistance Test**				$34.71	1	8.00	$277.68
200.00	**Track Maintenance**							
200.01	Cut In Rail Plugs	$1,000.00	plug		$26.30	4	1.00	$105.20
200.02	Line/Surface Track	$100.00	hr		$26.30	1	1.00	$26.30
200.03	Replace Ballast	$17.30	ton		$26.30	1	1.00	$26.30
300.00	**Electrification Maintenance**							
300.01	Catenary Adjustments				$34.71	1	1.00	$34.71
300.02	Replace Negative Return Cables	$135.30	each	1	$34.71	1	1.00	$170.01
300.03	Replace OCS Wire	$15.30	ft		$34.71	1		$0.00
300.04	Replace Pole Grounds	$100.00	each		$34.71	1	1.00	$34.71
300.05	Replace Substation Component		each		$34.71	1		$0.00
300.06	Reset Substation				$34.71	1	1.00	$34.71
300.07	Weight Stack Adjustment				$34.71	1	5.00	$173.55
400.00	**Grade Crossing Maintenance**							
400.01	Replace Bulbs	$350.00	each		$34.71	1	0.50	$17.36
400.02	Replace Gate Arm	$996.00	each		$34.71	1	1.50	$52.07
400.03	Take Gate Out Of Service					1	0.50	$0.00
500.00	**Switch Machine Maintenance**							
500.01	Replace Switch Machine	$15,500.00	each	1	$34.71	1	4.00	$15,638.84
500.02	Switch Heater Work				$34.71	1	1.00	$34.71
500.03	Switch Machine Adjustment				$34.71	1	1.00	$34.71
600.00	**Revenue Maintenance**					1		$0.00
600.01	Replace TVM Tickets				$34.71	1	1.00	$34.71
600.02	Revenue Issues				$34.71	1	1.00	$34.71
700.00	**Housekeeping Maintenance**							
700.01	Animal Removal				$34.71	1	1.00	$34.71
700.02	Graffiti Removal				$34.71	1	1.00	$34.71
700.03	Snow Removal				$34.71	1	1.00	$34.71
700.04	Trash Removal				$34.71	1	1.00	$34.71
700.05	Weed Cutting				$26.30	1	1.00	$26.30
700.06	Weed Spraying	$120,000.00	year		Contracted out	1		$120,000.00
800.00	**Emergency Response**					1		$0.00
800.01	Emergency Response to Accidents				$34.71	1	1.00	$34.71
900.00	**Other**				$34.71	1	1.00	$34.71
	Rail Grinding	$7,500.00	8 hours				5.00	
	Rail Tamping	$7,500.00	8 hours					
	UT Testing	$3,000.00	8 hours					
	Geo. Car	$3,000.00	8 hours					
	Concrete Tie testing car	$3,000.00	8 hours					

The routine preventive maintenance and work order process work together to ensure all maintenance activities are addressed. By separating the two activities it provides management a prioritization system to address maintenance needs. All activities can be monitored from the main dashboard to make sure items are addressed in a timely manner.

Deterioration Module

As work on the grant progressed it became apparent that the Deterioration Module was going to become the lynch pin of this program. The deterioration module provides the rate of deterioration of the individual assets. In reality, this has become the brains of the program. What the deterioration module does is combine parts of three different modules, the condition, deterioration, and budget module into one element.

The deterioration module is intended to show the rate of asset deterioration over time. It has become evident that development of agency specific deterioration curves will provide the most accurate information with respect to life cycle of specific assets, however, development of the specific curves must include the collection of real data over time. This means that without the data the best deterioration models for an aged based asset management system are provided by FTA in TERM Lite. In some cases vendors may have curves that can be used with the understanding that their curves are an average of life cycle in a wide variety of conditions. The deterioration module as developed will allow UTA to track decay, show bumps in the decay curves indicating maintenance efforts (improved condition ratings), manipulate scenarios, and share data with the budget module to provide projections based on UTA input factors. In the end, this module has become much more important to the end functionality of the system than was previously thought.

An important result immediately surfaced once UTA started analyzing the data from the deterioration module. The module can be used to assist prioritization and budgetary functions. As an assets condition rating deteriorates the result is represented on the curve. Once the asset reaches a 6 or lower on the condition rating curve the asset would be classified as needing planned maintenance such as rehabilitation or replacement. This condition rating will be considered with other factors such as location and overall risk to the system or organization. The asset management team, in consultation with the responsible business unit, would prioritize when the maintenance activity would take place. Once the project is approved the asset management team would prepare required budgetary documentation to start the capital project.

Figure 10 below shows a typical asset and their deterioration curve:

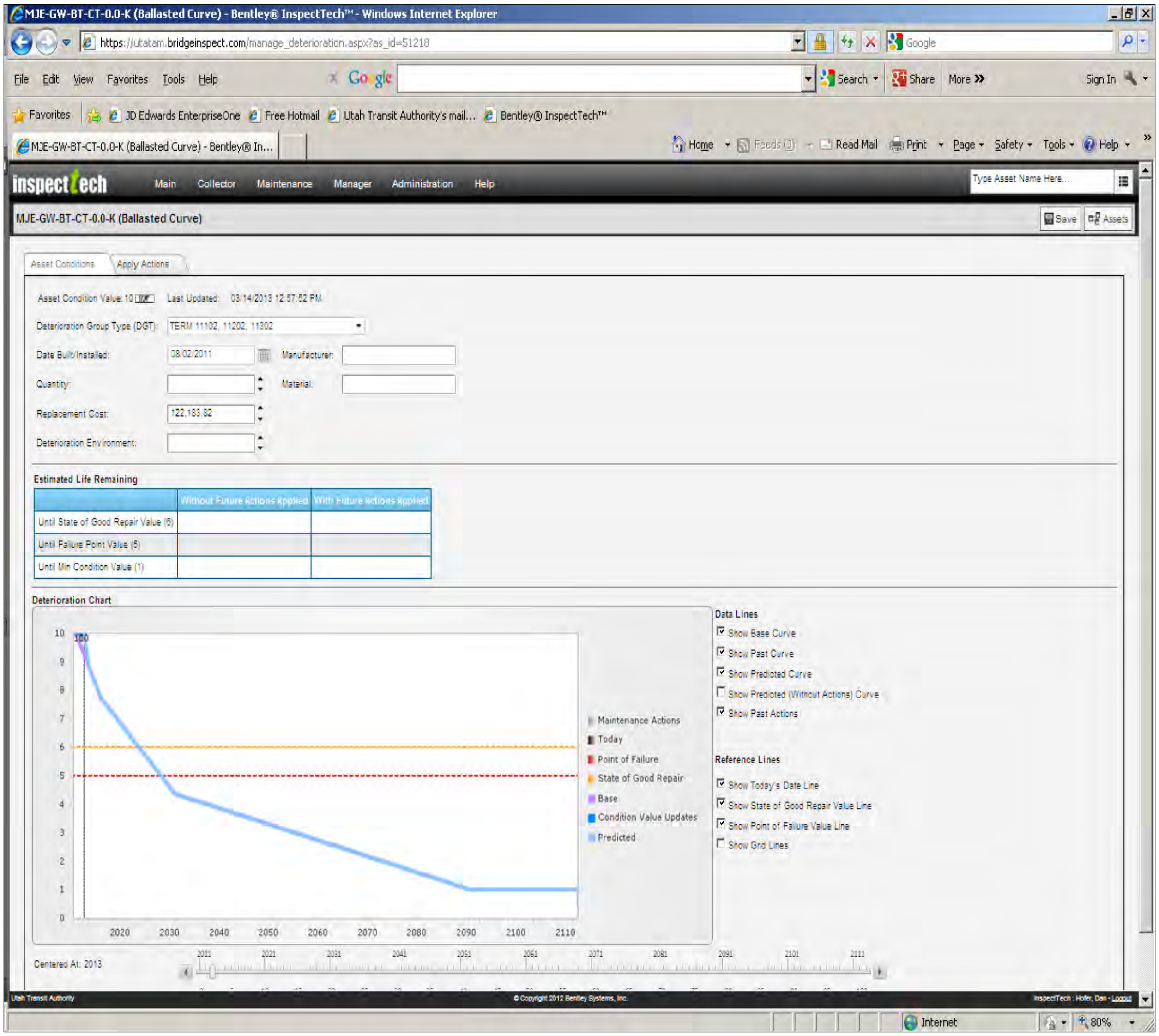


Figure 10

Life Cycle Cost Module

It is the intention of UTA for this module to track costs through all stages of an assets life. These costs can range from the design and construction costs to the regular on-going costs of inspection and maintenance. Just as an automobile might have regular maintenance, rail assets can also be given a predetermined maintenance schedule. When a clear schedule is determined for critical assets and the work is completed on time it insures that the maximum life and value are obtained for the asset.

As UTA progressed further into development of the AMS it was determined that full development and implementation of the life cycle module was perhaps premature at this point given UTA's current state and situation. This reasoning relates to the fact that it became apparent the AMS would need to have a more robust and functional deterioration module than was initially thought. The deterioration module needed to be more interactive for it to be a true benefit of the system. This increased functionality and cost-tracking capabilities allow UTA to not only see anticipated deterioration curves, but now UTA can add “actions” in through the deterioration module which allow UTA to develop deterioration curves relative to its own operating conditions. These actions can also capture costs which play into the life cycle costs of the assets. When UTA is defining these actions, it can state the effect the actions will have on the asset relative to condition. By defining these actions, associated costs, and new condition ratings, UTA begins to develop a clearer picture as to what the true life-cycle cost of an asset might in reality be.

UTA believes the Life Cycle Cost module is a key component to a complete AMS and will continue to pursue development. Development of an accurate life cycle module depends heavily on agency specific deterioration curves. UTA has a complete inventory of the assets in the system. With this information it is possible to gather the maintenance costs of specific assets as reported in the system. This data, when tied to the deterioration data, provides the building blocks to begin population of the life cycle module.

Budget Module

The ability to project budget requirements for maintaining the existing transit system in SOGR is critical data for executives to have. For a transit system to be maintained at an acceptable level clear budget models are necessary. There are many ways to develop accurate budget models. UTA has chosen at the present time to use an age based budget model that will transition to a hybrid system based on age and inspection data. The budget module will not define specific projects but will identify areas of concern that can be packaged into reasonable project packages. The budget module interacts with the maintenance and deterioration modules in allowing items to be prioritized and when budgets are limited to sort by priority, cost, and other factors.

To assist the budgetary preparation process the AMS reports on several metrics.

Reporting Function	Description
Budget Projection Forecast - Replacement Costs	30 year projection of replacement costs for assets that will reach their failure point.
Budget Projection Report - Replacement Costs 0-10 Years	All Assets set to reach the failure point in the next 10 years.
Budget Projection Report - Replacement Costs 11 - 20 Years	All Assets set to reach the failure point in the next 11 - 20 years.
Budget Projection Report - Replacement Costs 21 - 30 Years	All Assets set to reach the failure point in the next 21 - 30 years.
Budget Projection Forecast - All Costs	30 year projection of replacement & feasible action costs for assets that will reach their failure point.

Budget Projection Report - All Costs 0 - 10 Years	10 year projection of replacement & feasible action costs for assets that will reach the failure point.
Budget Projection Report - All Costs 11 - 20 Years	11 - 20 year projection of replacement & feasible action costs for assets that will reach the failure point.
Budget Projection Report - All Costs 21 - 30 Years	21 - 30 year projection of replacement & feasible action costs for assets that will reach the failure point.

In its current form, the budget module is intended for budgetary projection purposes. UTA views this functionality separately than historical cost tracking. The historical costs will play a role as replacement costs are updated to help produce better budgetary projections over time. Historical cost tracking will be approached later in the development of the Life Cycle Cost Module.

Risk Based Management Module

In addition to standard asset condition based approaches, it was very important to UTA that we develop an AMS that allows for the inclusion of risk for specific assets in specific locations. Risk-based approaches are commonly used in private industry and by highway agencies. These approaches evaluate assets not only based on their condition but also based on their criticality according to factors such as safety, operational importance, and likelihood of failure. Those items that are the highest risk may not necessarily be in the worst condition but should be considered for repair or replacement actions based on the high risk the failure would pose to the overall operation of the system. After evaluation it was determined that the greatest risk for our rail alignments is failures of vehicles or infrastructure in the core area of the light rail system. One of the key considerations when determining risk for any area or component was the impact it would have to the operation of the system that is directly tied to meeting the expectations and needs of our customers. Failures in some areas cause a big enough disruption to service that service expectations become unrecoverable for the remainder of that service day. Buses can be rerouted, problems at facilities can be mitigated or eliminated, but failures in the rail system where passengers may be stuck on a train and sufficient resources are not available to activate a bus bridge may become unrecoverable for the remainder of that service day.

The criteria for the risk area classifications

High

- Service disruption occurs and we cannot safely remove our customers from the affected area.
    - Little to no emergency response capability along the route
- Service disruption occurs and it cripples the system.
    - Rail traffic density cannot pass through the affected area
    - Presence and characteristics of railroad facilities

- Single versus double track territory
- Little to no access to track turnouts

Medium

- Service disruption occurs and it is difficult to safely remove our customers from the affected area.
    - Limited emergency response capability along the route
- Service disruption occurs and once it is resolved the system cannot recover till end of day.
    - Rail traffic density has difficulty passing through the area
    - Presence and characteristics of railroad facilities
    - Single versus double track territory
    - Limited location of track turnouts

Low

- Service disruption occurs and it is we can safely remove our customers from the affected area.
    - Adequate access to emergency response capability along the route
- Service disruption occurs and once it is resolved the system can recover before end of day.
    - Rail traffic density can pass through the affected area
    - Presence and characteristics of railroad facilities
    - Single versus double track territory
    - Adequate access to track turnouts

UTA defined the risk (figure 11 and 12) based on the rail traffic the different areas of the alignments over the course of the day.

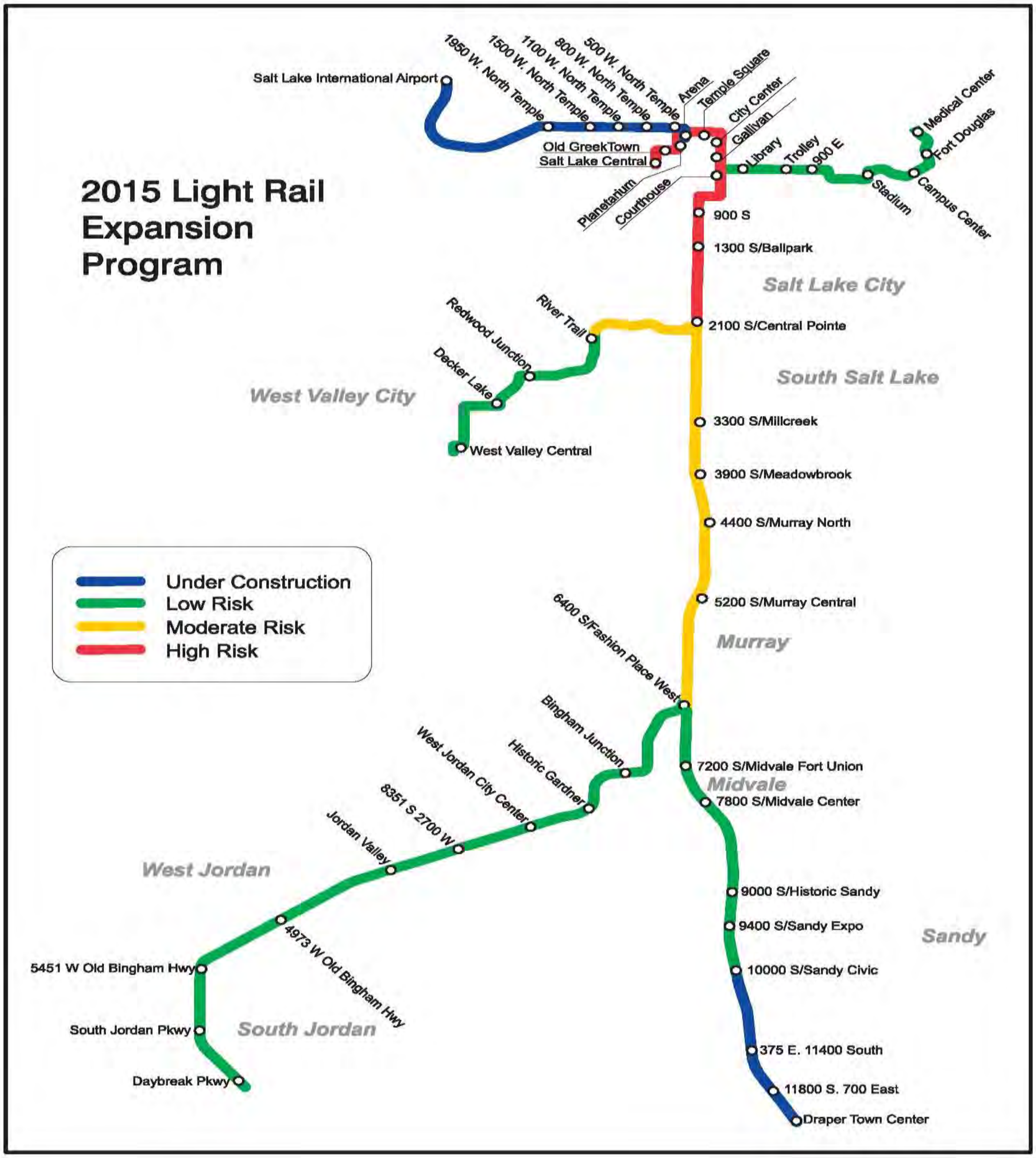

2015 Light Rail Expansion Program
Under Construction
Low Risk
Moderate Risk
High Risk
Salt Lake International Airport
1950 W. North Temple
1500 W. North Temple
1100 W. North Temple
800 W. North Temple
500 W. North Temple
Arena
Temple Square
City Center
Gallivan
Old GreekTown
Salt Lake Central
Planetarium
Courthouse
Library
Trolley
900 E
Stadium
Medical Center
Fort Douglas
Campus Center
900 S
1300 S/Ballpark
Salt Lake City
2100 S/Central Pointe
South Salt Lake
River Trail
Redwood Junction
Decker Lake
West Valley City
West Valley Central
3300 S/Millcreek
3900 S/Meadowbrook
4400 S/Murray North
5200 S/Murray Central
Murray
6400 S/Fashion Place West
Bingham Junction
Historic Gardner
West Jordan City Center
8351 S 2700 W
Jordan Valley
West Jordan
4973 W Old Bingham Hwy
5451 W Old Bingham Hwy
South Jordan Pkwy
South Jordan
Daybreak Pkwy
7200 S/Midvale Fort Union
Midvale
7800 S/Midvale Center
9000 S/Historic Sandy
9400 S/Sandy Expo
Sandy
10000 S/Sandy Civic
375 E. 11400 South
11800 S. 700 East
Draper Town Center

Figure 11

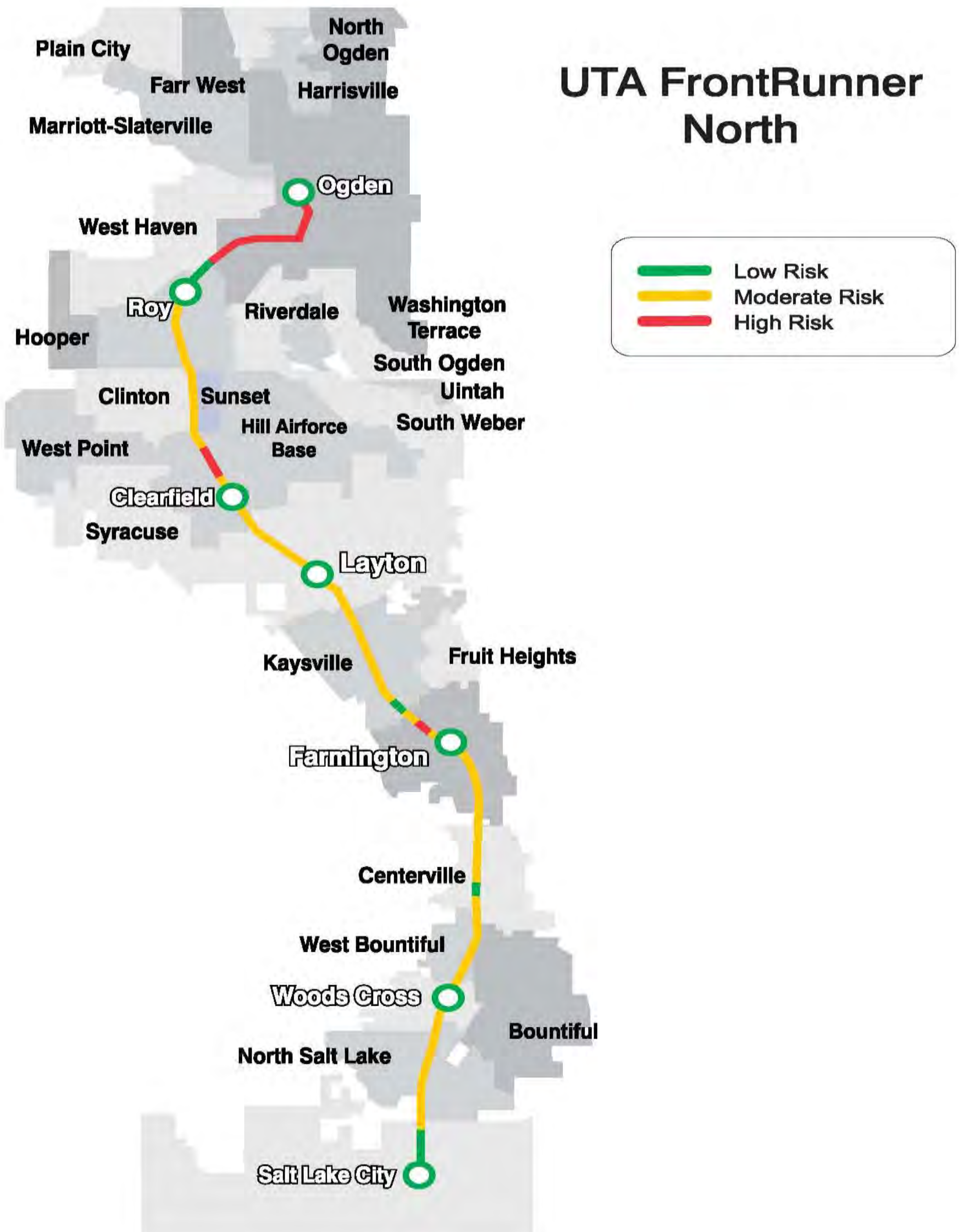


Figure 12

The different colors indicate the different areas of risk along UTA's rail system. On light rail, this is dependent upon the amount of rail traffic going through a certain area. The FrontRunner North diagram reflects single track areas or areas which are very difficult to access should the need occur to evacuate riders.

The boundaries for the different risk areas on the light rail and commuter rail lines have been determined. UTA currently has flags built in the AMS that can show assets with an advanced condition rating value in the high risk or medium risk areas.

Training

Throughout the course of the grant process, UTA's asset management group has given two trainings to the Maintenance of Way group on the use of the tablets and the software. The first testing took place on October 15th, 2012 and was directed at a smaller test group. Based on that initial round of testing, comments were received and changes made accordingly. Another round of testing was given on January 18th, 2013. This testing highlighted some of the changes incorporated into the system based on the initial group's feedback.

Additionally, realizing that using a system in a classroom and actually using it in the field can be two very different experiences, UTA's asset management group has gone out with inspectors in the field to help inspectors with any issues they may have encounter while they are doing their inspections.

UTA and Bentley held an official three days of training March 26th through March 28th, 2013 here at UTA's offices in Salt Lake City. Each training session blocked off four hours of training time which provided an overview of the system as well as allowing UTA's inspectors the opportunity to demo the system on both the tablet computers as well as a normal desktop computer. Bentley provided this more in-depth training which focused on the MOW inspectors, MOW supervisors, as well as providing additional training for managers and administrators who will be using this system more for analysis rather than inspections.

In total, Bentley provided UTA with a total of six training sessions over the course of these three days and trained 28 UTA employees. The training covered basic tablet operation, camera operation, specific inspection procedures, work order process, form management, and AMS theory. As part of the grant requirements, UTA and Bentley agreed to provide 40 hours of training and presentations on the system to transit authorities who are interested. UTA and Bentley are willing to provide these presentations to interested transit authorities for the requested 40 hours. The curriculum is detailed below.

Training Outline

- SGR and UTA
- UTA and Bentley Partnership
- Developing an accurate inventory
- Benefits of a mobile based system
- Inventory Module
- Inspection Module
- Condition Rating Module
- Maintenance Module

- Deterioration Module
- Budget Module
- Risk based management
- Lessons learned
- Moving Forward

Demonstration Presentation

Please provide at least three weeks' notice when requesting a presentation. This will ensure UTA can provide the training at the most economical value possible.

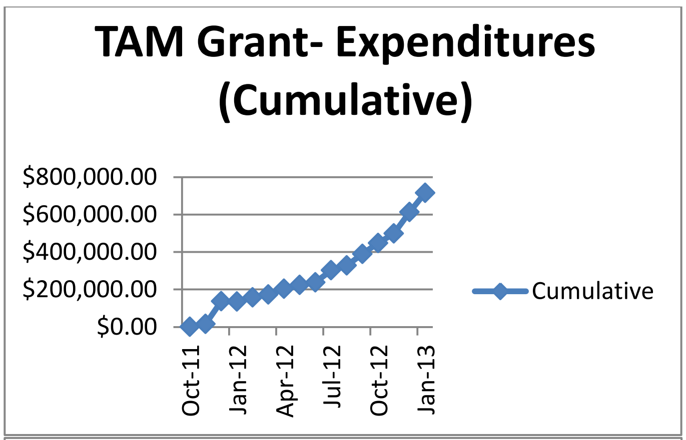
Architecture Documentation

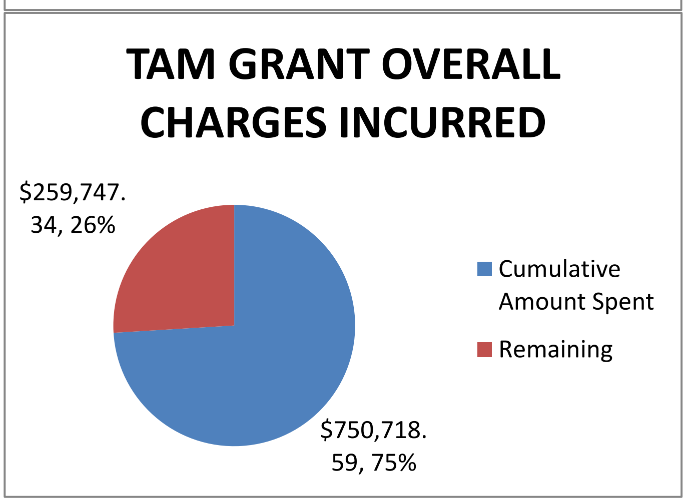
Detailed documentation on hardware and software can be found in Appendix A. Information provided details the architecture used to store and organizes all assets and information, key development concepts, and data flow application.

Project Budget- As of March 1st, 2013

Description	Account Number	Budget Amount	Cumulative Amount Spent	Remaining
UTA Personnel Charges	2606-551480.12010.045510	$300,000.00	$216,614.00	$83,860.00
Managerial Technical and Professional	2606-551480.12010.045514	$257,000.00	$167,201.00	$89,799.00
Travel- UTA and Contractors	2606-552080.12010.045520	$33,000.00	$5,712.00	$27,288.00
Equipment UTA Physical Assets	2606-554050.12010.055540	$100,000.00	$101,666.09	-$1,666.09
Contractual	2606-555050.12010.055550	$310,000.00	$259,999.50	$50,000.50
	Totals	**$1,000,000.00**	**$750,718.59**	**$249,281.41**

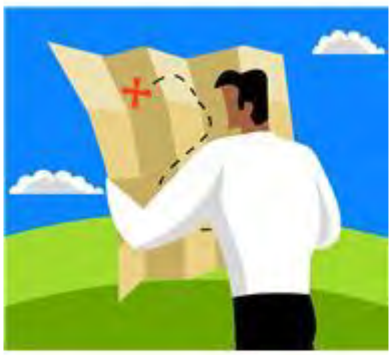
Month	Amount	Cumulative
Oct-11	$405.00	$405.00
Nov-11	$15,159.00	$15,564.00
Dec-11	$121,212.00	$136,776.00
Jan-12	-$849.00	$135,927.00
Feb-12	$21,100.00	$157,027.00
Mar-12	$16,309.00	$173,336.00
Apr-12	$29,981.00	$203,317.00
May-12	$20,688.00	$224,005.00
Jun-12	$14,331.00	$238,336.00
Jul-12	$63,885.00	$302,221.00
Aug-12	$25,327.00	$327,548.00
Sep-12	$61,829.00	$389,377.00
Oct-12	$58,090.00	$447,467.00
Nov-12	$50,646.00	$498,113.00
Dec-12	$114,130.00	$612,243.00
Jan-13	$102,981.00	$715,224.00
Feb-13	$20,075.66	$735,299.66
Mar-13	$15,418.93	$750,718.59





Lessons Learned Developing a Plan (Identify Target and Work Backwards)

When UTA began development of the AMS it was started by a brainstorming session that covered how to begin development of an asset management program. This included discussions about what was needed by the different organizations in the agency, what information they currently had, what information they would like to have, and how is the best way for it to be presented. These early discussions were very high level and did not try to address how to achieve what each group wanted but rather just define what would add value if there are no limitations.



If leaders are unsure on what their final output should be, it would be beneficial to research and identify what components are critical to their agency.   Critical components required of any transit agency that have been identified in MAP-21 are:

- To have a written Asset Management Plan
- To have an inventory of all assets
- To have an investment/prioritization plan
- And to certify that the agency is in a State of Good Repair

Requirements for FTA in MAP-21 are:

- To define State of Good Repair
- To set performance targets
- To expand reporting requirements in the National Transit Database(NTD)
- And to establish technical assistance to the industry

UTA will have all the necessary components required by MAP-21 in our AMS, but will continue to expand and improve the system to realize the full benefit of the investment made into the assets and the AMS. Through development of the UTA AMS there have been other resource materials used as references and guides. These documents include:

- International Infrastructure Management Manual
- PAS 55 (British Standards Institution)
- TCRP Report 157- State of Good Repair: Prioritizing the Rehabilitation and Replacement of Existing Capital Assets and Evaluating the Implications for Transit
- FTA Transit Asset Management Guide authored by Parsons Brinkerhoff
- ISO 55000 Draft International Standard for Asset Management

As UTA has worked to achieve the goals and requirements of the FTA grant we have identified items that we consider lessons learned. These lessons learned will be discussed below and may be beneficial to other agencies just starting to develop their AMS.

Lesson Learned Example #1: Defining a system to track linear assets

In any asset management system it is easy to identify, track and maintain assets in a physical location. When applying the criteria to linear assets it becomes more difficult. The two assets groups most affected are track and wire runs. In the case of track the linear run may be anywhere from 6’ to 6000’. UTA developed a system to aid the designation of these items.

Assigning specific properties to the specific asset was key. It is important to know how long each asset is. Also, assigning a starting location for each linear run. In congested areas you may have 20 track sections in a 200’ span. Using as-built drawings, UTA was able to get the lengths and spans of each linear run. Using a simple mathematical formula, UTA was able to convert stationing numbers on the as-builts to milepost numbers. Each run was given a unique asset code. The milepost identifier was placed at the lowest milepost end of the run. This gave a logical beginning and end of each run. For track assets, essentially UTA identified each section of curved or tangent track and assigned it a unique asset code. For catenary systems, UTA essentially identified each wire run and assigned those assets a unique asset code. To some, this may seem excessive however; UTA felt it was important to make this designation because of the potential wear/deterioration differences likely to affect these different assets. One tangent piece may deteriorate differently than another tangent piece and one curved piece may deteriorate differently than another curved piece due to different conditions at a specific location.

Lesson Learned Example #2: Tablet selection

Before UTA started the selection process a decision needed to be made on purchasing ruggedized or standard tablets. The initial thought was these tablets were going to be used on the rail alignment in all conditions so purchasing the ruggedized tablets was the appropriate option. After performing some cost estimates the price for each tablet with accessories was approximately $3900 each. In comparison the standard tablets were approximately $1,400 each. This excludes any software licensing costs. It was determined that the cost for the ruggedized tablet could not be justified.

UTA tested several tablets. After using those in our environment UTA came up with selection criteria.

- Tablet cellular service: With our inspectors working in the field it was determined that real time uploading is utilized.
- GPS availability: The assets in our system are tracked with their latitude and longitude coordinates. The tablet must be able to help the inspector identify the assets. Also, when reporting a problem the inspector would be able to provide a coordinate where the location of the problem is.
- Camera: Photo and video quality must be at a resolution level that minor details could be shown.

- Protective case: The case option must be robust enough to protect the tablet but not inhibit the tablets use.
- Protective screen covers: The scree protectors should prevent damage and not inhibit tablet use.
- Car Charger: This will give the inspectors the ability to charge their tablet in the field.
- Warranty: Provide an extended warranty to help protect the tablet from damage and function.
- Screen visibility: The ability to see the screen in direct sunlight.

After evaluating each tablet the result was the Fujitsu Q552 had the highest final score.

Need For A Champion

It is critical to have support and direction from the Executive Staff or Team. To obtain this direction it is important to have a champion at that level that can provide support and backing at the highest levels in the organization. To perform this process just to comply with MAP-21 is not a beneficial activity. Agencies can achieve improved efficiencies, reductions in delay, and overall cost savings by developing and using a comprehensive asset management system.

Developing and mentoring a champion may prove to have varying degrees of difficulty depending on where an agency is at in its life. Newer agencies that are in the system expansion phase may be less open to discussions of rehabilitation efforts. Older agencies which have entered the rehabilitation phase may be more open. Regardless of the agency's age, it is important that an agency begin to plan for these rehabilitations and to identify where these rehabilitation efforts need to take place in their Transit Development Plan. Having a champion makes it easier to promote this message throughout an agency at an executive level where it can then permeate down through the organization to the employees who are actually maintaining the assets.

Agencies will find that simply designating a group to handle asset management and State of Good Repair efforts is a good start, but if their message does not get out and permeate the organization, it is likely to get buried before it has a chance to take root.

Developing a Paradigm Shift

For agencies that have been focused for many years on expanding their transit system the task of maintaining what has already been constructed may require a re-evaluation of priorities. It is a simple trap to fall into by forgetting that transit systems built very recently require investment that is greater than routine maintenance. The earlier this adjustment takes place the greater the potential savings that can be realized over the life of the assets.

With the passage of MAP-21, and with the State of Good Repair initiative as a whole, this could cause a shift in the thought process which needs to be considered. Replacement and rehabilitation efforts can be costly. The reality is that assets have a certain life expectancy and with everything being new at once, when it comes time for rehabilitation or replacements, it can have price tag which may be in excess of what an agency is able to afford. Planning for these events well into the future can help achieve success when critical maintenance, rehabilitations, and replacements are done on time.

Expansion and growth are still needed and encouraged when they are equally balanced against the needs of the existing system.

Development of an Asset Management Philosophy

A written philosophy for asset management is important to help guide and direct when decisions are necessary during development of the system. At UTA the Asset Management Group has adopted the following as our philosophy.

> *Asset Management is the key to identifying problems before failures occur that can cause unplanned outages and disruptions in service. An effective Asset Management Program will maintain a safe, efficient and reliable transit system for our customers and keep the public investment in a State of Good Repair.*

Identify existing resources within the Agency

While developing an inventory of "hard" assets that are owned and maintained by the agency it is also important to develop an inventory of what data may already exist within the agency. Experience has shown that most agencies have large amounts of data but they may be in silo's throughout the organization and not generally available to the agency as a whole. Identifying this data, where it exists, who the owner is, and determining how it will help the AMS is critical.

A principle that UTA applied throughout development of the AMS was to fully use the processes that are working and are in place to gather critical information. It was believed that if the AMS required wholesale changes in how work processes were done that it would severely hamper our ability to successfully implement the overall system.

While developing the AMS it was also made very clear from inception that all the data would be completely transparent. There are levels of access within the system, but all the data obtained and generated is available to the groups who provided it and other groups who may need the same information. It is believed that asset management MUST BE completely transparent to be successful across all boundaries in the agency.

Identify and Involve Internal Customers

For a system to be successful you must know who your internal and external customers are. For some changes within an agency implementation can be difficult. The asset management group recognized early that to insure success we had to understand the needs of our customers and involved them in the process. By doing this we understood that final implementation would be much smoother if this was not perceived by the working staff to just be another "directive" from management that needed to be done. Malicious compliance was not going to provide the accurate and detailed information necessary for a comprehensive AMS to add value.

Prioritization Process

There are several system triggers that identify upcoming rehabilitation and replacement activities. Once the condition rating reaches 6 or below the asset is flagged. This gives UTA adequate time to research the appropriate course of action to retire, rehab, or replace the asset.

Assets are evaluated by criteria such as safety, risk area, remaining useful life and cost. Combining assets with similar maintenance activities into projects enables UTA to reduce costs and expedite the rehabilitation or replacement activity.

The Asset Management core committee prepares the scope and compiles budget information prior to the formal budget request submittal. The project is entered into Decision Lens and weighted against other projects based on similar criteria for final approval. Once approved the project gets handed off to UTA's Capital Development project management group to administer.

Proactive vs. Reactive

Reactive maintenance will always be necessary at an agency. Proactive maintenance efforts have also been present although at a lesser degree. One lesson learned is that proactive maintenance holds several benefits over reactive "fix it when it breaks" maintenance. Here are some benefits agencies can experience by planned proactive replacements vs. reactive maintenance replacements:

1) Higher customer satisfaction
    a. By planning out replacement activities, agencies can mitigate disruptions to service and to riders.
2) Reduced costs
    a. By planning out replacement activities, agencies can better control the cost impacts which might come with reactive efforts due to sudden component failures.
    b. Reduced costs will likely be found on material procurement, contractor labor costs, and on intangible costs such as potential loss of ridership.
    c. Costs on extra service which might need to be provided to accommodate riders due to the service disruptions.

Many agencies get caught up in the fact that it may not appear less expensive to replace something in advance of the failure. Why would we want to spend money on a replacement when there doesn't appear to be an apparent need and we could use those precious funds on something else? This is a valid question and it will likely come up in agencies across the country. When disruption to service and risk considerations are factored into the decision matrix, it becomes more clear why proactive maintenance or replacement pays dividends. If transit agencies placed a value on each customer mile traveled on the system, it would help justify investment prior to failure. In a market where UTA customers have a choice whether they use transit or not, it is a significant savings to retain riders rather than provide them reasons for not using transit. Once a customer has a negative experience, the risk increases that UTA may lose that rider.

The first steps of developing a basic system are time consuming but not difficult. The basic building blocks are depicted in figure 13 below.

Figure 13

If an agency, regardless of size, begins at this basic level the extra benefits that will come from having the basic information can be developed as the process continues.

Conclusion

It is likely that as agencies begin to implement a proactive asset management system that rehabilitation costs will likely increase but as deterioration projections and budgetary figures become more refined, the actual cost of maintenance over time will actually be reduced without negatively affecting ridership in a long-term significant way.

One of the most important lessons learned throughout this process has been that continual improvements needs to be made in regards to an agency's State of Good Repair efforts. If notable progress is not made, efforts are likely to come to a crashing halt. It is recommended that agencies designate or create a single department to handle the State of Good Repair efforts. This can be relative to the agency's size. They will need to meet with all departments who will be involved in these efforts.

Without a comprehensive asset management plan, accounting for agencies assets are little more than simple line items in an Excel spreadsheet.   The intuitive nature of creating an inventory, collecting condition ratings and assigning deterioration curves is essential in a risk based program. The goal for UTA is to provide a safe and reliable transit system for our customers while being fiscally responsible with public funds provided.

The UTA asset management group has adopted a philosophy that states:

"Development of a comprehensive Asset Management System is not a destination but a journey"

The intent of this statement is to make sure everyone agency wide and within the group recognizes that as you develop a system like this you never get to the end. There are always ways to improve the system and improve the benefits it provides to the organization as a whole.

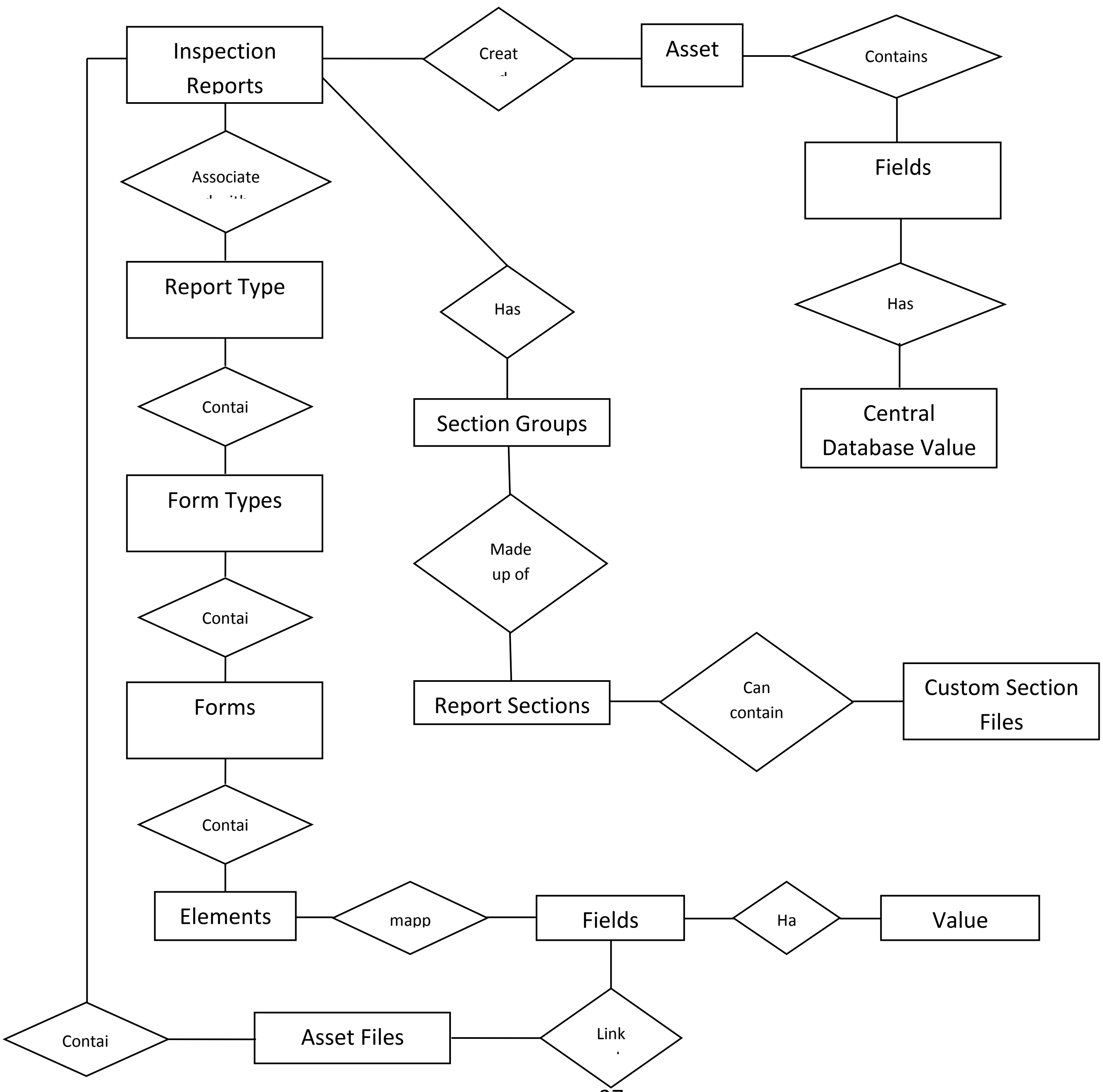
Appendix A

InspectTech Conceptual Data Model

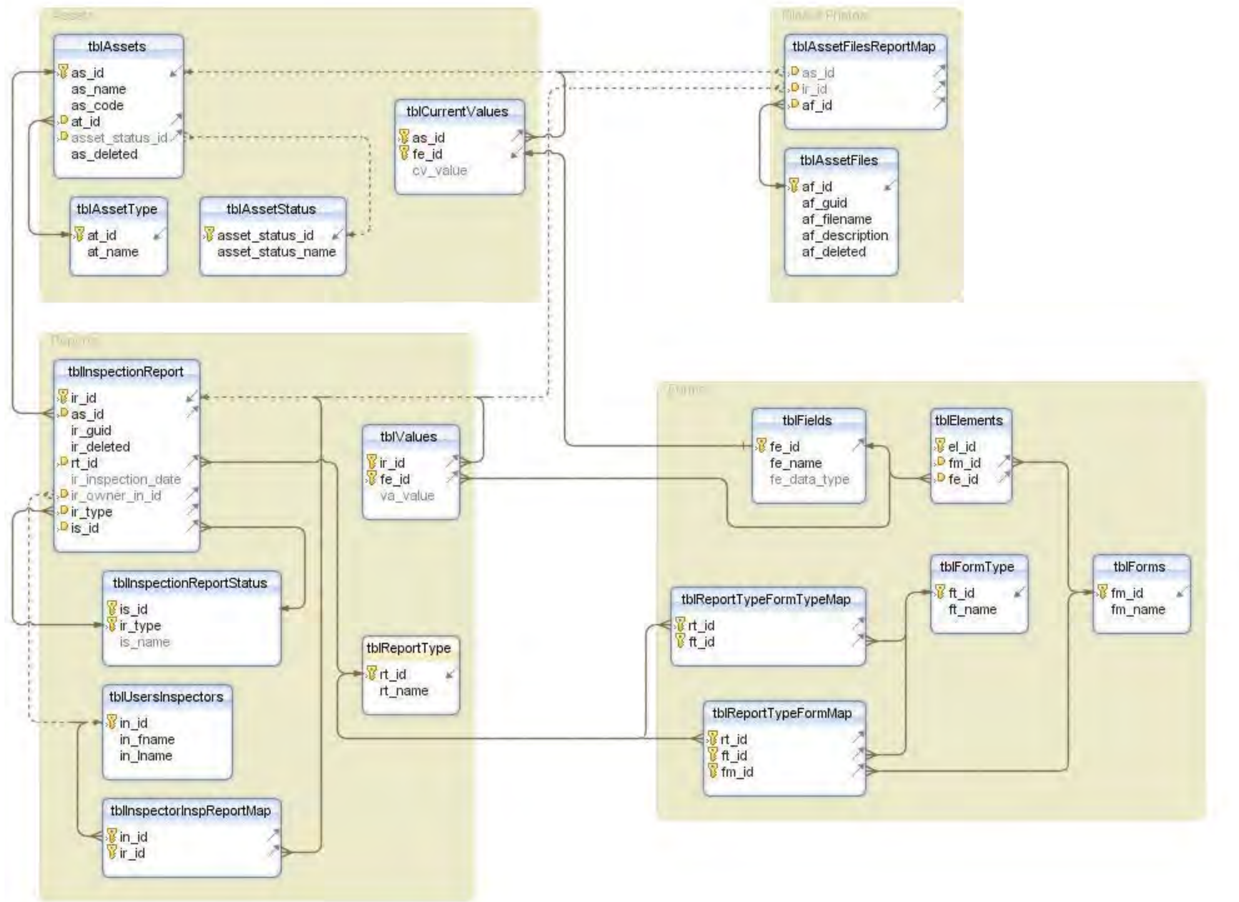
Purpose

This document is not meant to serve as a comprehensive reference for the InspectTech data model. Rather this is simply intended as a high level overview of the InspectTech data architecture and how the key components are represented and interrelate.

Diagram of Key Concepts



Entity/Relationship Diagram – Input Data



Key Concepts

Assets (tblAssets)

Every entity in the software is generically referred to as an asset. Assets are the basic, most fundamental elements that inspection reports can be created upon. An asset can represent a physical bridge, a component of a bridge, or an entire geographic region that contains other assets. Assets can be arranged hierarchically in any pattern or depth required.

Column	Description
as_id	[PK] Auto increment integer column
as_name	Asset name (Bridge Number)
as_code	Asset code (NBI Number)
at_id	[FK] Asset type as detailed in tblAssetType
asset_status_id	[FK] Asset status as detailed in tblAssetStatus
as_deleted	Deleted flag – if set to true, the asset is deleted and not visible in the application

Asset Types (tblAssetType)

The database can be configured to include any number of asset types depending on the desired configuration. Each asset has exactly one "type" associated with it.

Column	Description
at_id	[PK] Auto increment integer column
at_name	Asset type name

Asset Statuses (tblAssetStatus)

An asset can be assigned a status like Active or Archived.

Column	Description
asset_status_id	[PK] Auto increment integer column
asset_status_name	Asset status name

Central Database Values (tblCurrentValues)

Central Database Values are similar to an inspection report Value, but the difference is they are stored in relation to the particular Asset not an Inspection Report. These Central Database Values will be updated based on the most recent approved Inspection Report but also provide an opportunity for users to modify outside the context of performing an inspection.

Column	Description
as_id	[PK] [FK] Asset as detailed in tblAssets
fe_id	[PK] [FK] Field as detailed in tblFields
cv_value	The central database value for the given asset and field

Inspection Reports (tblInspectionReport)

An inspection report is created to capture some set of data values that need to be stored at a particular slice in time. An inspection report has a particular report type associated that defines exactly what forms and report sections (output reports) should belong to the report.

Column	Description
ir_id	[PK] Auto increment integer column
as_id	[FK] The asset that the report is created for as detailed in tblAssets
ir_guid	GUID unique identifier for the report. This is ideal for linking to external systems
ir_deleted	Deleted flag – if set to true, the asset is deleted and not visible in the application
rt_id	[FK] Report type as detailed in tblReportType
ir_inspection_date	The report's inspection date
ir_owner_in_id	[FK] The report inspector that is the owner of the report
ir_type	Reports will have an ir_type of 0
is_id	[FK] Report status as detailed in tblInspectionReportStatus

Report Types (tblReportType)

Each inspection report has one report type associated with it. The report type is used to determine which forms are displayed for the report and the format and content of the report output PDF.

Column	Description
rt_id	[PK] Auto increment integer column
rt_name	The report type name

Report Statuses (tblInspectionReportStatus)

Each report has a status that corresponds to the reports progress through creation, submitted for approval, and approval.

- 1 = in progress on laptop
- 2 = in progress on server
- 3 = submitted for approval
- 5 = approved

Column	Description
is_id	[PK] Auto increment integer column
ir_type	Report statuses will have an ir_type of 0
is_name	Status name

Inspectors Mapped to Reports (tblInspectorInspReportMap)

Each report can have inspectors assigned to it.

Column	Description
in_id	[PK] [FK] Inspector as detailed in tblUsersInspectors
ir_id	[PK] [FK] Report as detailed in tblInspectionReport

Report Values (tblValues)

Every piece of data associated with an inspection report is stored as a Value – a 3-tuple identifying what field, inspection report and value combination should be stored.

It is updated based on the most recent approved Inspection Report but also provide an opportunity for users to modify outside the context of performing an inspection.

Column	Description
ir_id	[PK] [FK] Report as detailed in tblInspectionReport
fe_id	[PK] [FK] Field as detailed in tblFields
va_value	The report value for the given report and field

Users (tblUsersInspectors)

Each user of the system is registered in tblUsersInspectors. This includes inspectors and central office personnel.

Column	Description
in_id	[PK] Auto increment integer column
in_fname	User first name
in_lname	User last name

Asset Files (tblAssetFiles)

The data model allows for any type of digital file to be uploaded and tagged to either the Asset level, the Inspection Report, or a particular Field level. All such files are generally referred to as Asset Files (even if they are tied to an Inspection Report or File they will ultimately be tied to an Asset).

Column	Description
af_id	[PK] Auto increment integer column
af_guid	Another unique identifier for the asset – this is also the binary name on the file system when asset and report files are stored on the file system
af_filename	The file name
af_description	User entered description for the file
af_deleted	Deleted flag – if set to true, the asset is deleted and not visible in the application

Asset Files Mapped to Assets and Reports (tblAssetFilesReportMap)

The linking of an asset file to a report or asset is stored in the tblAssetFilesReportMap table.

Column	Description
af_id	[FK] The asset file that is detailed in tblAssetFiles
as_id	[FK] The asset, detailed in tblAssets, that the file is linked to – null if only tied to a report
ir_id	[FK] The report, detailed in tblInspectionReport, that the file is linked to – null if only tied to an asset

Fields (tblFields)

Fields are defined dynamically, allowing additional pieces of data to be collected simply by defining a new Field and adding it to be visible on a particular Form. This design allows the set of data that is collected to be very flexible and dynamic rather than creating a new static database column for a new piece of data – requiring a schema change for every new piece of data that is desired to be collected.

Column	Description
fe_id	[PK] Auto increment integer column
fe_name	The field name
fe_data_type	The field's data type (String = 0, Integer = 1, Decimal = 2, Date = 4)

Data Entry Forms (tblForms)

A form is a collection of controls that are used for data entry. When editing report values or central database values, they are typically edited in the context of a form.

Column	Description
fm_id	Auto increment integer column
fm_name	The form name

Form User Interface Controls (tblElements)

An element is a control that is read-only or editable. A read-only control is a label or a line. An editable control is a textbox, dropdown, or a checkbox.

Column	Description
el_id	[PK] Auto increment integer column
fm_id	[FK] The form as detailed in tblForms
fe_id	[FK] The field as detailed in tblFields

Form Types (tblFormTypes)

A form type is a collection of forms. From the application's perspective, form types are the top tabs seen when viewing the editable inspection report.

Column	Description
ft_id	[PK] Auto increment integer column
fm_name	The form type name

Linking Report Types to Form Types (tblReportTypeFormTypeMap)

The form types available to an inspection report are limited to those mapped to the report's report type.

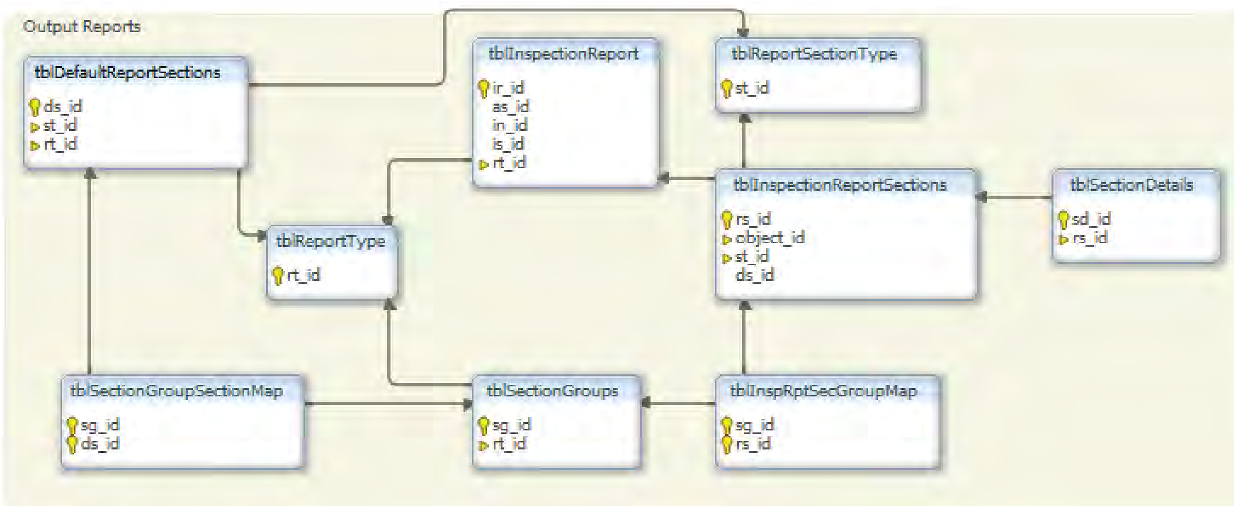
Column	Description
rt_id	[PK] [FK] The report type as detailed in tblReportType
ft_id	[PK] [FK] The form type as detailed in tblFormType

Linking Form Types to Forms (tblReportTypeFormMap)

The forms available to a form type, in relation to a report type, are detailed in tblReportTypeFormMap.

Column	Description
rt_id	[PK] [FK] The report type as detailed in tblReportType
ft_id	[PK] [FK] The form type as detailed in tblFomType
fm_id	[PK] [FK] The form as detailed in tblForms

Entity Relationship Diagram – Output Reports



Default Report Sections (tblDefaultReportSections)

A report section is configured with default values in tblDefaultReportSections which are not associated with an Inspection Report. These default values are copied into tblInspectionReportSections once an Inspection Report is created.

Column	Description
ds_id	[PK] Auto increment integer column
st_id	[FK] The section type in tblReportSectionType
rt_id	[FK] The report type in tblReportType

Inspection Report Sections (tblDefaultReportSections)

An Inspection Report has its own distinct copy of report sections so that the function and appearance of those sections can vary between reports.

Column	Description
rs_id	[PK] Auto increment integer column
object_id	[FK] The asset or inspection report mapping
st_id	[FK] The section type in tblReportSectionType
ds_id	[FK] The default section id in tblDefaultSections

Section Groups (tblSectionGroups)

A section group allows for a conceptual grouping of sections to produce a customized PDF output. There will always be 1 section group (typically called "All") for a default collection of the sections.

Column	Description
sg_id	[PK] Auto increment integer column
rt_id	[FK] The report type in tblReportType

Mapping Default Sections to Section Groups (tblSectionGroupSectionMap)

Default sections can be contained within one or more groups, which are mapped in this table.

Column	Description
sg_id	[PK] [FK] The section group in tblSectionGroup
ds_id	[PK] [FK] The default section in tblDefaultReportSections

Mapping Report Sections to Section Groups (tblInspRptSecGroupMap)

Sections assigned to a specific Inspection Report can be contained within one or more section groups, which are mapped in this table. Ordering and viewing properties are set here.

Column	Description
sg_id	[PK] [FK] The section group in tblSectionGroup
rs_id	[PK] [FK] The report section in tblInspectionReportSections

Report Types (tblReportTypes)

A report type allows for different categories of Inspection Reports (Routine, Special, Fracture Critical, etc…) but also segments the output report sections, allowing for each report type to have distinct collections of sections.

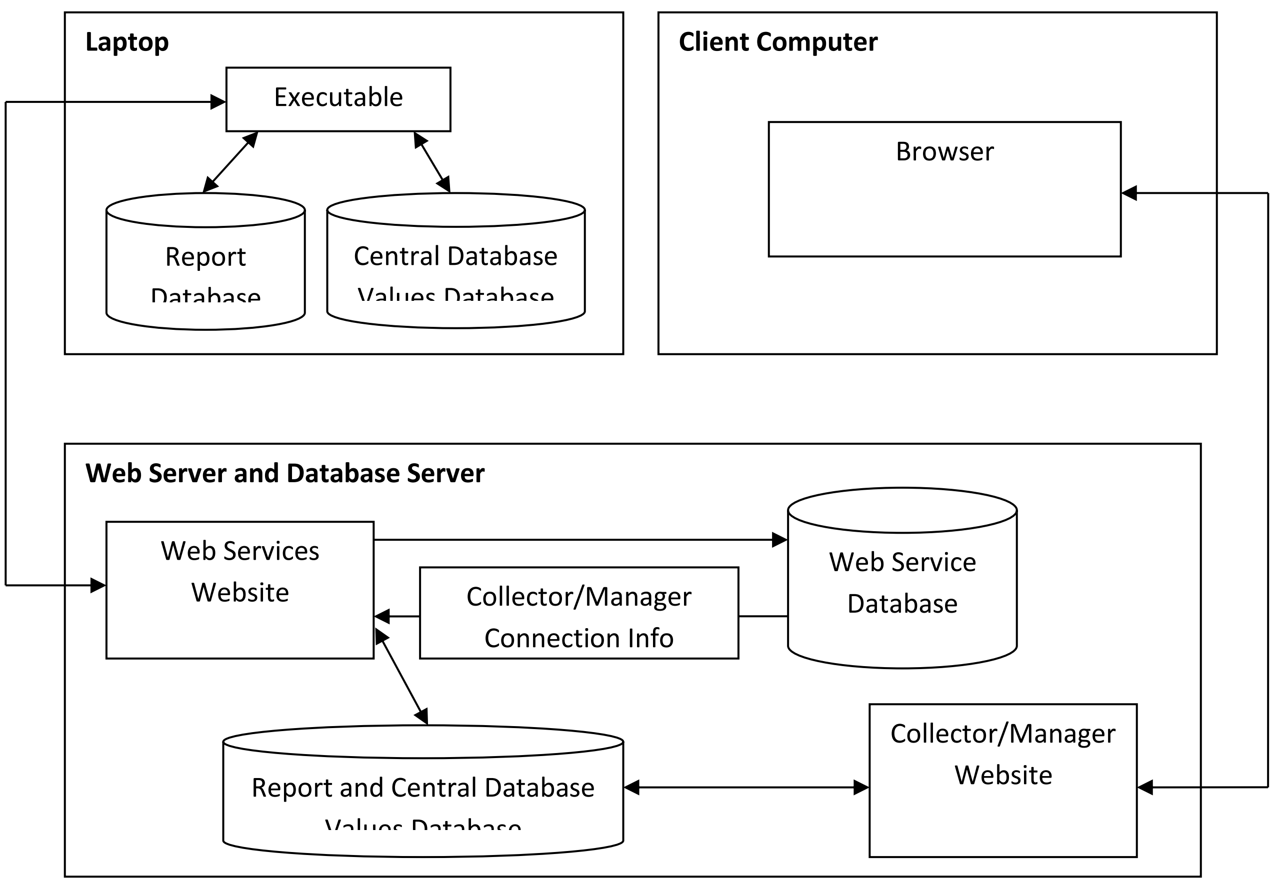
Column	Description
rt_id	[PK] Auto increment integer column

Report Section Types (tblReportSectionTypes)

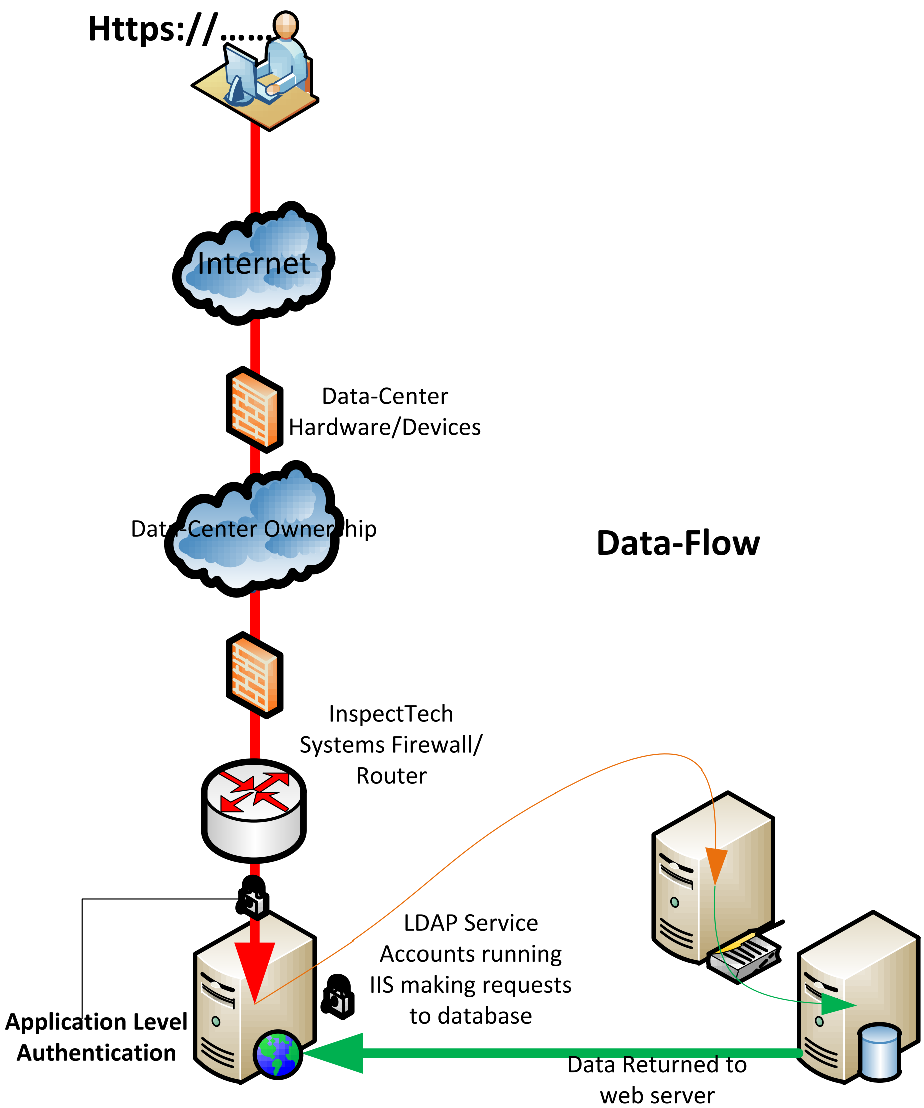
Each report section can have a type assignment, which helps to distinguish between the functionality of a body report section and a section such as a Table of Contents.

Column	Description
st_id	[PK] Auto increment integer column

Architectural Overview



InspectTech Application Architecture



Server

The server is comprised of a web server and a database server. They can be located on the same physical server or be separate.

- Web Server
    - Collector/Manager Web Sites
        - This web site is an ASP.NET web site that is hosted on a server with IIS 6 or IIS 7.
        - The collector and manager web sites utilize the same file system directory and files, but exist as separate web sites or a single web site with two virtual directories.

        - The web sites or virtual directories should reside in their own application pools.
        - The URL entry point will dictate whether the collector or manager view of the web site will load.
        - These web sites will access the collector/manager database.
    - Web Services Web Site
        - This web site is an ASP.NET web site that is hosted on a server with IIS 6 or IIS 7. Typically, the web service web site resides on the same machine as the collector/manager sites.
        - The web services can be setup as a virtual directory or a separate web site.
        - This site or virtual directory should exist in its own application pool.
        - This web site will access the collector/manager database and the web services database. When a request is received from the laptop, the web site uses the credentials to identify the manager/collector database connection. It then uses this connection information to read data from, or persist data to the collector manager database.
- Database Server
    - The web sites utilize two databases. These databases can be hosted in Oracle or SQL Server. The databases can be installed on the same server that hosts the web sites, or they can be installed on a separate data server.
    - Collector/Manager Database
        - This database contains the inspection report data and data used to manage the application.
    - Web Services Database
        - This database contains a small amount of data used to facilitate communication between the laptop executable applications and the collector/manager database.

Client

Client access to the collector and manager data is available through two methods. User can access to the online web sites directly, or access the data with the laptop InspectTech Collector application.

- Browser
    - The user must have a connection to the web site.
- InspectTech Collector Laptop Client Application
    - This application requires an installation on the user's computer.
    - The application will utilize a database installed on that computer. The data is synchronized with the server database. By having the data local to the computer, it allows for offline access. Data is synchronized in both directions. Updates from the server are synchronized down to the laptop and any data updated on the laptop is synchronized to the server. The synchronization is triggered manually by the laptop user.

- The data on the laptop can be a mirror of the data on the server, or it can be a subset of data based on a limited view of the data for the user.