SYSTEM INTEGRATION TESTING

OF A

START UP LIGHT RAIL SYSTEM

BY

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I. Introduction:

A. Overview of Transit Projects

Transit projects are certainly not a new concept. They date back to when people first gained mobility. From the first caravan for hire to high-speed rail systems transit projects have been part of human development. People use public transit for a number of reasons. Necessity, availability, convenience, and recreation are just few of the reasons public transportation has been enjoyed by generations of people. As the speed and technology grows with these systems, the way we approach commissioning the system equally grows in complexity.

At the beginning of the 20th century the United States experienced a renaissance in technology as the industrial revolution came into fruition. As cities and towns gained electric power, they also obtained electric modes of transportation. These were commercially owned endeavors, which later became publicly owned. The earliest was the trolley system in Salt Lake City. This was provided as an agreement with the City and the electric company. The agreement being the electric company was allowed to build its infrastructure of providing electric power, in exchange they built and operated the first trolley system. As with many of these systems, the boom of the automobile in the 1950s saw the system disappear. In Salt Lake, the only remains of the old system are the trolley poles being used for streetlights and the old car barn now a shopping mall (Trolley Square).
In the 1970s a new era of electric transit was born. That was with the advent of the Standard Light Rail Vehicle (SLRV) being brought into use on two of the countries oldest transit properties. One was the San Francisco Municipal Railway, which is the second oldest public transportation agency in the US. And the second was the Massachusetts Bay Transportation Authority (MBTA). The MBTA has the honor of having the oldest underground subway station in the US, in which the SLRV operates today.

The concept of light rail has been a huge success. They have been put into operation in cities across the country. Their success has been due to their passenger carrying capability, superior acceleration and deceleration, and articulation. This allows them to be able to operate in urban and interurban conditions. They have the ability to use existing trolley systems, city streets, and short line rail systems.

Due to their success, many of these systems have been put in service in cities that have not had recent rail service of this type. Salt Lake City was one of these cities. Old timers still reminisce of when the trolley system was in operation. But in more recent years the Utah Transit Authority (UTA) has developed into a bus transit company. But UTA was given the challenge of designing; building, and testing an electric, rail, transit
system. UTA met this challenge. But this paper is not on how they
designed and constructed the system; this paper is on how the UTA
developed a program to verify that all of the system elements work in a
unified integrated method.

II. The Salt Lake City Light Rail Project:

A. Salt Lake Demographics

The Salt Lake metropolitan area is made of three large cities. To the north
is Ogden, Salt Lake City in the center, and Provo to the south. Between
these cities are number of townships and unincorporated county areas.
Within this region resides 80% of the population of the State of Utah.
These cities are surrounded by number of natural barriers. To the east is
the Wasatch mountain range; and to the west is the Great Salt Lake and
the Okers Mountain. As winter storms come from the west, the Salt Lake
produces lake effect snow. The lake effect produces champagne powder
snow, which makes the skiing in Salt Lake the finest in world. It is no
wonder the 2002 winter Olympics will be held there.

The livable area in Salt Lake is confined to a narrow valley. This allows
for only one north-south freeway (I15), and a belt loop south of Salt Lake
City. This belt loop is connected to the only east-west freeway (I80).
Given the high density of population, and the natural barriers, the
transportation needs of the valley are obvious. In the later portion of the
1980s, Salt Lake looked into long-term solutions for this obvious problem.
The decision was made to improve the highway system (now in
construction), build an inter-urban rail system, and provide commuter rail
services (now under planning). It was decided that the inter-urban rail
system was to be a light rail system.

This decision was made after long deliberation over various technologies.
Improving the bus system and monorail were some of these
considerations. Light Rail was chosen because of its proven ability,
passenger-carrying capability, and construction costs.

B. The Right-of-Way

Rail is not uncommon in Salt Lake. The golden spike for the
transcontinental railroad was driven at a place in the northern part of the
State. Since that time rail has been installed throughout the valley. One of
Union Pacific Railroad lines runs in the center of the valley, which
provided freight service for the sugar beet farmers. This was later
converted into a short line. This line connected to the UP mainline at
Union Station in Salt Lake City. The southern end of the line goes near I15 at a place called the Point of the Mountain.

The alignment is a straight north-south line. Over the years the farms have gone and the townships have grown into the metropolitan area it is today. This rail line has the perfect attribute for an inter-urban transit system. So UTA purchased the rail line from the Union Pacific Railroad. Part of the purchase agreement was that UTA must maintain the short line that operates there.

So UTA decided to use 13 miles of the existing rail line. On the north end, it was decided to add 2 miles of new embedded track to service downtown Salt Lake City. The 15-mile line services 5 communities. Starting from the north the alignment terminates at the Delta Center in Salt Lake City (where the Utah Jazz play), goes through South Salt Lake, Murray, Midvale, and terminates in Sandy. While in route, it passes through some of the unincorporated Salt Lake County areas.

This allows for 2 miles of 25 mph street running operation, and 13 miles of 55 mph private right-of-way running. On unique facet to this system, is due to the short line, the right-of-way is connected to the national railway system. As such, UTA is one of the few public transit agencies that the Federal Railway Administration (FRA) has some interest. Due to the buff
strength differences between light rail and freight, the transit system is
time separated from the freight line.

C. The Project

Preliminary engineering was performed for the system, which established
the basis for final design. Three engineering service contracts were
awarded. The first contract was for Engineering Management Services
(EMS). Given UTA’s limited experience in rail projects, it was decided to
hire a firm with experience in program management of these types of
projects. The selected firm was tasked to work directly with UTA
personnel in overseeing the final design, construction, and commissioning
of the system. The other two engineering contracts were for the final
design of civil and systems elements.

UTA was able, under a three party agreement, to assume San Diego’s
procurement contract for light rail vehicles. San Diego had 23 light rail
vehicles remaining under contract. Resulting from final design,
construction contracts for downtown civil (two separate contracts),
railroad corridor civil (for existing 13 mile right-of-way), park and ride
civil work, vehicle support center civil, and systems work (OCS, traction
power, and signals). Also, procurement contracts were made for traction
power substations, ticket-vending machines, crossing panels, and rail.
All contracts were awarded and construction began. A separate engineering service contract was awarded for construction management. The EMS remained to oversee the construction, and the design firms were retained for engineering services during construction. An early portion of the track was completed to facilitate commissioning of light rail vehicles. Soon portions of the system were becoming complete and the time for integrated testing was nearing. It was at this point that UTA asked the EMS to provide support in developing and implementing a system integration-testing program. Earlier, a safety certification program was developed under the scope of work for the construction management.

III. What is System Integration Testing:

A. Overview

Integrated testing simply put, is an assurance that all system elements work together in an integrated fashion. Remember when you were a child playing with your new train set. You built the track, tunnels, bridges, any you could think to try. When you drove the train down the track for the first time you were in fact doing integrated testing. When the train glided down the track smoothly your test was successful. When the train derailed or could not make hill you built, your test was unsuccessful.
Once all of the facilities are in place, and prior to opening it for public use, a series of tests are conducted to ensure everything meets your expectations. Your test results will certainly be less dramatic as it was with your toy train set. But the results will guarantee your confidence of a safe operating system.

During the course of the project you have a number of construction contracts all of which have contractually required tests. These tests are intended to assure you that the system was built in accord to the contract, meets your expectations, and most importantly assure public safety. Where one contract or discipline stops, and another starts, there are always going to be more things that can be done to prove compatibility. In some cases these tests are performed under contract. For example, simultaneous start testing is performed to verify the protective relay settings of the substation. But while performing this test you can also measure the performance of other system elements such as the vehicle, catenary, track, and other related systems.

These test also have other benefits. It provides an excellent training ground for the maintenance and operations persons. During the testing you will encounter more operating scenarios and system performance characteristics than you would ever find under normal operating
conditions. Another benefit is that it establishes the resources that are needed for some of the tests that are contractually required.

B. Contracts and Contractual Tests

In the course of the Salt Lake project there were a number of construction and procurement contracts. A number of the construction contracts used owner furnished material. Most of this material had long lead times and so were obtained under procurement contracts. Doing this, UTA was able to increase the speed in which the system was built. Each contract, procurement or construction, had requirements for testing.

Items that were procured, and supplied as owner-supplied material, were the traction power substations, the rail, grade crossing panels, and concrete pavers. For the civil construction the alignment was broke into three segments. One was the “railroad corridor”, where the mainline is ballasted. The “Central Business District”, for the downtown imbedded track section. And third segment was the yard and shop area. The systems work, traction power and signals, was done in one contract for the entire system.

For the civil contracts, besides concrete and materials testing, the most significant testing was stray current testing. Since light rail uses DC for its
propulsion, all of the civil work is built so as to isolate the track from earth ground. The contractor was required to measure the rail to earth resistance and take remedial measures as necessary. Another significant group of test is for all the machinery that is used in vehicle support facility.

The systems contract was the one that probably had the most testing requirements. For example, each segment of the overhead catenary system was high potted and given a loop resistance test. Under the procurement contract, the manufacturer tested the traction power substations. In the factory, the substations were given standard production testing and design qualification testing. The systems construction contractor installed the substations and tested the ground mat, and performed the loop resistance test noted above. Once the power was on the manufacturer came to the field and performed a series of field tests. Similarly, the signaling and grade crossing system was tested at the factory and in the field.

Once the facilities and electrical works were in place it was time to operate the train. Within the contracts there were requirements for validation of some of the system integration. One was in testing the protective relay settings of the substation (simultaneous pull away test), and another was in video tapping the overhead contact system. But there
were a number of things that had to happen before these tests were performed. These were done under integration testing.

C. Types of Integration Tests

To decide what test you should run requires an analysis of all contractual tests and an analysis of what remains. Remember, most tests require a light rail vehicle and a number of people. To pull that off requires an organization and a plan. Some of the contractual tests have the same requirement. So some of the contractual test can be performed under the organization for integrated testing. For Utah, the following list of tests were performed:

1) Verification of Safe Braking – This test is to validate the safe braking distance between signals. Given that the performance of light rail vehicles is well known, this test was only performed as a representative sampling. It was only tested where the grade was -.5% or better, or the block distance was less than 2,200 feet.

2) Safe Braking Validation – The safe braking test (above) used a three-car train with the brakes off on one car, giving it 33% de-ration. However, since not all of the test could be
performed at the same time (due to construction sequencing) the logistics of loading the train to AW3 several times was too difficult. In this test we loaded one car to AW3 and tested it under slippery rail conditions. We took a AW0 car and made the same test. This created a multiplication factor, which was applied to the three-car train.

3) Visibility of Signals – There was a contractual requirement to sight the signals to 1,000 feet. We found that this was not always possible due to obstructions such as OCS poles. Each signal was tested with a light rail vehicle and adjusted for optimum sighting.

4) Signal Operational Testing – Using two trains, all routing scenarios were tried including following moves. The construction contractor using track shunts conducted the same testing, so the live test was merely a final validation.

5) Approach Timing Validation – Train is operated at track speed and the crossing warning time verified.

6) Near Side Crossing – Where a station is near side to a crossing, a timer delays the start of the gate to allow the train
to stop at the station without holding up street traffic. This test verifies proper advance warning with a desired dwell time.

7) Visibility of Motorman – Light rail trains have such good braking that it is worthwhile to provide an indication of the crossing status. This indication is known as a motorman indicator. This test was performed in the same manner as visibility to signals.

8) Simultaneous Start Test – Using three substations, the center one off line, two trains are started at the same time going in opposite directions. This test is performed right after the bolted fault test and while the instrumentation is still in place. The bolted fault test verifies the protective relay setting on the DC breaker. The pull away test verifies that the breaker settings won’t trip the breaker under a real load. It also validates the substation design spacing, so it should be performed where the substations are spaced the furthest.

9) Dead Car Tow – This is the first step in commissioning a section of track. The LRV is towed and dynamic envelopes checked. While performing this test the OCS contractor rode
the top of the vehicle to verify installation of the OCS. This test and the previous tests are good examples of integration tests, which also support contractor testing.

10) Live Wire Run – This tests the trains ability to run on its own power, and that the system elements in support working properly.

11) High Speed Run – The LRV incrementally increases speed in a section until full civil speed is obtained. This is followed by the video tapping of the pantograph to OCS interface by the contractor.

12) Mini High Block to Vehicle – In Utah the LRV uses mini high blocks for ADA loading. This verifies the on board ramp of the LRV has a proper angle and is within ADA tolerance for the slope of the ramp.

13) Visibility of Pedestrian Access – Placing personnel at pedestrian access points an LRV enters the station. A review is then conducted to see from the passenger’s and train operator’s perspective as to the visibility.
14) Rail to Ground Voltage Test – As mentioned earlier, the rail is a different potential from earth ground. That means there will be a voltage difference. The question is, “Does the voltage difference pose a public hazard?” So while a train is accelerating out of a station the voltage is measured.

15) Vehicle Support Center Equipment Tests – In the vehicle support facility there are train hoists, turntables, wheel truing machines, jib cranes, and a wash track. These tests are performed by operating the train with them to ensure system capability.

16) Insulated Joints and Section Insulator Interface – In the shop the rails are at ground potential (to avoid personnel hazard). To isolate the grounded rails from the ungrounded mainline, insulated joints and section insulators are used. This test verifies the transition is complete within the interior of the two powered trucks.

17) Bus Clearance – Multiple busses are used to verify the intended operation of the park and ride bus bays.
IV. How To Set the Program Up:

A. The Organization

System integration testing requires a lot of personnel and resources. It comes at a time when the project is the busiest. Construction is nearing completion, the vehicles being prepared for revenue, train operators are being trained, and maintenance groups are preparing to assume maintenance of the system. The tests to be performed will have an effect on everyone involved in the project. So it is very important that the team is carefully selected to ensure the successful completion of the testing.

The chart above is the organization used by UTA for integrated testing. These members form a committee, which will serve to prepare for and conduct the testing. At the head of the committee is the committee Chairperson. It is absolutely essential the head of the committee have the full authority to arrange for resources, and make final decisions on a
number of issues. If the person is subordinate in position, delay and inefficiencies will likely prevail.

The support of the Chairperson is the Systems Integrator and Project Controls. Both parties provide a very key role. The Systems Integrator needs to be a person who is very familiar with all aspects of the system. This person will act as the main spokesperson to the committee on all technical issues. In support of the Systems Integrator should be the engineers who have responsibilities in the various disciplines. Equally important is the Project Controls person. This person is responsible for keeping track of all activities including schedule, test to be performed, discrepancies, resolutions, final documentation, and support of system safety certification.

The next three members of the team are the core players. They are the managers for Maintenance of Way, Vehicle Maintenance, and Operations. These managers will provide the lion share of the manpower and equipment. It is very important that the committee members fulfilling these roles are high enough in the organization to be able to commit personnel and resources. Like the committee Chairperson, the success of the organization is dependant upon the speed in which resources can be produced and decisions made.
Next, and extremely important, is the Safety Officer. During the testing process you will be conducting operations that may not have occurred in the community. In Salt Lake, the track they were using has been for years a class I track (low speed). We were the first to operate a train at such a high speed (55 mph) on that track. Also, the testing was conducting while construction was still underway. Therefore, close supervision of the safety aspects is essential.

As mentioned before, the testing was conducted at a time where the construction was still underway. As areas of the project were complete we immediately tested that area. We were literally right behind the construction. We were the last precursor to public use. Therefore, close coordination with the construction effort, as well as forecasting completion dates are very important. That is why the final person on the organization is the Construction Manager. As with all other positions, this person must be high enough in the organization to make commitments.

Several other persons were involved during our meeting, which are not mentioned in the organization chart. These persons varied from the Track Access Coordinator, engineers, line supervisors, and other support persons. Their presence was determined on the weekly activates or out of pure interest. The meetings were always open to who ever wished to attend. Remember, the testing provides an excellent learning opportunity.
B. Test Questionnaire

Typically the Systems Integrator develops the test procedures. When other parties want to perform a test, a test questionnaire is very useful to produce the information needed for the procedure. The information on the questionnaire should include all information found on a typical test procedure. Once filled out, the procedure is written and presented to the committee.

C. Purpose of the Team

The first duty of the committee was in the approval of the test program plan for integrated testing. This document was part of the overall project’s test program plan. This plan defines the roles and responsibilities of all parties as well as the process of performing and documenting the work.

Next, each test procedure and test report is developed and presented to the committee for approval. Upon approval, the test is scheduled, resources made available, a test coordinator assigned, and the test performed. Upon completion of the test, either the System Integrator or the Test Coordinator (many times it is one in the same), presents the findings of the test to the committee.
If the test is complete and successful, it is noted as such by the Project Controls, and the documentation is archived. If there is a discrepancy, the committee decides how to resolve the discrepancy. In Salt Lake, UTA used the services of an Engineering Management Services (EMS) contractor to manage the project. So in many cases the EMS was involved in managing the removal of the discrepancy. In fact the Manager of Systems (EMS) doubled as the System Integrator. This made the interface between the testing organization and the project management very smooth.

Once the discrepancy is removed the test is rescheduled. In some cases it is unnecessary to reschedule the test. For example, if a signal is partially blocked by foliage and the signal can be set at its optimum position, you only need to verify the foliage is removed. Once complete, the results are archived. If the discrepancy still exists, or a new one is discovered, a new discrepancy report is generated for resolution.

The last activity of the committee is in the safety certification process. Working with the Safety Officer, the committee identifies the safety critical items and puts them on a Critical Items List (CIL). These items are signed off as they are completed.
Another function of the committee is in reviewing how the tests are being performed and modifying the test procedures/reports as necessary. In the example below “Visibility of Signals”, it was found that a number of signals needed adjustment. It was found to be better to put the train at 1,000 feet from the signal and adjust the signal. 1,000 feet is the contractual requirement for sight distance. So the procedure and report were modified as such and approved by the committee. The OCS poles are numbered and the contract drawings reflect the chainage. So it was found to be easier to set the train based on the poles instead of actually measuring the track. This simplified the test and produced a better result.

D. Test Procedures

The test procedure is the core of the testing organization. It needs to define all things necessary to perform the test. Each procedure would include a tracking number; name of test; contracts involved; test objectives; test description; test prerequisites; resources required; time required; and acceptance criteria. The following is an example of a test procedure:

1) SIG02 – this is the tracking number for this test and is kept on the header of the procedure. The “SIG” (signal) denotes the type of test and the “02” is the number in that series.

2) Name of Test: - Visibility of Signals
3) Contracts Involved: - L54 - Traction Power and Signaling System
4) Test Objectives: - To verify the signals provide proper site distance
5) Test Description: - Operate a light rail train approaching each signal. Note the location of the LRV once the signal is sighted. Measure the distance from where the signal is sighted to the signal. Operate the LRV up to the signal and note when the signal aspects are no longer visible. Note the distance from the Train Operator to the Signal.
6) Test Prerequisites:- Track, OCS, and Signal systems installed and in final alignment/configuration.
7) Resources Required: - Personnel: One Train Operator Two Signal Technicians Survey Crew Test Coordinator Flag personnel as required Equipment: One LRV Portable radios Track Measuring Device Facilities: All trackage in test area
8) Time Required: - 4 hours
9) Acceptance Criteria: - Signal is visible from the cab of the LRV within 1,000 feet and can be seen up to within 15 feet of the signal.
The complexity of the test report depends on the ability of who is performing the test. Using the example above, if the test is performed by persons familiar with rail operations and signal work, a simple test report is all that is needed to archive the data. It does require that the Test Coordinator ensure the procedure is adhered to. If the team performing the test does not have enough familiarity, then a more comprehensive report is needed. The report would be a recapture of the procedure customized for site-specific items. It would include checklists for each step and a place to put in the data.

An example of a simple test report is as follows:

1) SIG02
2) Name of Test: Visibility of Signals
3) Date of Test: ___/___/___ Weather__________________
4) Test Coordinator: ________________ x______________
5) Signal Location: S1200
6) Distance First Sighted _______
7) Distance Last Sighted _______
8) 1000 Feet _____Pass _____Fail
9) 15 Feet _____Pass _____Fail
10) (Signal is visible at range noted)
As you can see in this report information is provided as to test number; name of test; date of test and weather; test coordinator; signal to be tested; the test results; and an indication of pass/fail.

F. Executive Summaries

On the test report there is not much administrative information. Only the date and Test Coordinator, and there are no signature boxes for the committee. This information could reside in the test report, but would be very redundant if multiple similar tests are performed. For example, the “Dead Car Tow” is performed once an area is turned over by construction. Usually it would encompass several miles. The test reports are listed by tension section. You could easily perform tests on 20 tension sections in one day. That would mean 20 test reports would have the same information on it.

The solution is an Executive Summary. A summary is provided listing all of the tests performed on a given day for a specific procedure. If two different tests were performed on the same day, two different summaries are produced. Even if performed by the same people. This avoids confusion. The summary should include the test number; name of test; the key persons involved; a signature line for the Test Coordinator, Systems Integrator, and Chairperson; and a brief summary.
G. Discrepancy Reports

As mentioned before, a discrepancy report is produced if a test fails. A discrepancy report is attached to each test report reflecting a “fail” on the pass/fail box. Once the discrepancy is corrected a new test report is produced and the test performed. If a discrepancy occurs again a new discrepancy report is attached to the re-test report, and so on. In some cases there was no solution to the problem. In which case the discrepancy reports the exception and the test is closed out. A good example is one of the signals that was not visible due to it being a dwarf signal, on a curve, and blocked by an MSE wall (mechanically stable earth wall, used on one end of a single track bridge). It was concluded that since the signal was an absolute signal (restrictive signal in which all trains would have to stop anyway) the shorter sight distance was acceptable.

The discrepancy report should include the test number; name of test; date; the discrepancy; the resolution to the discrepancy; a signature box for the person verifying the resolution; and an indication of if the re-test was successful.
H. Keeping Track

System integration testing is fun. It is a time in which the concepts people have dreamed about are finally coming true. It is an opportunity to perform activities with a rail vehicle that are very rare. But amongst the enjoyment of performing these tests, there is the paper work. It is not as charismatic as testing but is certainly a challenge. The key to success is start early, be as detailed as you can, and never give up. The last thing you want to do is get behind, because it will slow the program up.

The committee should meet weekly. There should be a master spreadsheet, which lists all tests and test location, and the status. This should be discussed at each meeting. The objective is to archive all final test reports, ensure all tests were performed, and all discrepancies resolved. UTA achieved this by developing two volumes of reports. Each volume included the policy, test procedure, and current spreadsheet. The first volume is labeled “to be tested”, the second “completed tests”.

As a test is performed the executive summary is put in the completed volume. The test reports with no discrepancies are also put there. The failed reports and discrepancy reports are put in the to be tested volume. Test reports that have been prepared, but not conducted, are also in the to be tested volume. For a failed test, the test report and discrepancy reports
remain in the to be tested book until finally resolved. If the test continue to fail all of the test reports and discrepancy reports remain. Only completely satisfied reports are in the completed book. This includes the discrepancy reports for that test.

In the end, you should be able to look at a test, and by turning to the next page follow the activates that brought the test to completion.

V. The Results:

The results were varied and in the end nearly all test discrepancies were satisfactorily resolved with a few items left that we were not able to solve. The example of the dwarf signal discussed early is a good example of this. We found a number of visual impairments; some were obvious and should have been taken care of during construction. Others were not so obvious.

The tests took a great deal of effort but the end product was worth it. During the whole process the system was finely tuned. When you look at the final product you realize that all of the effort that was put into this, made the system what it is today.

The results in the testing can be categorized in three areas. They are discussed in these final sections.
A. Dynamics

There were a number of dynamic tests. The first of these was the live wire runs. The system as designed operated perfectly. There was some fine-tuning that resulted from the dead car tow. Some OCS anomalies and a few planter boxes at the CBD stations needed adjusting. But once done the track and catenary system operated flawlessly.

The simultaneous start testing proved to be successful with no further adjustment of the protective relays. We found that when we operated with a substation out of service the voltage drop did cause a momentary under voltage condition on the vehicle. Also, the acceleration curve was greater. But the test was deemed successful as it did meet the requirements in the design criteria. So with a substation out of service the rail operations will have very little reduced capability.

Another area fined tuned was in the grade crossing system. All of the crossing approaches are fixed to 55 mph normal direction, and 35 mph in the reverse direction. All tests were successful. The near side crossing timers did need adjustment. We found getting the timing perfect to be difficult due to the different variables. It would differ on entering speed, deceleration curve, and dwell time. In the end we made a test late at night
with no distractions from the construction. Using a skilled operator and closely timing the dwell made the adjustment easier. One other complication is that the crossings are all microcomputer. So there is no timer knob to turn, it can only be done by an EPROM change. For that nights test we had the programmer on site with an EPROM burner. Previous attempts were via Email.

B. Visual Impairments

During our testing we found a number of visual impairments. In the CBD trees on the station platform made it difficult to see passenger entry points and the LRT signals. The CBD stations were designed to be architecturally pleasing. And looking at the 3D imagine of the station (used to work with the City during final design) you would not have seen these obstructions. It took being on the train with people at the station to see that.

Another area that cause problem was in the many berms in the railroad corridor. The old alignment held an amount of lead and arsenic in the soil. The EPA ruled that the soil could be kept on site or removed to suitable dumping site. Keeping the soil on site was obviously the most economic. The contractor installing the berms hydro seeded them for ground cover.
Unfortunately, the contractor used daises. It looked great, but the flowers block dwarf signals and passenger access points.

On one part of the alignment there is a long curve going under I15 to the yard. I15 being under construction, the construction crews put an outhouse in the interior of the curve blocking the signal.

Someone asked us why we were looking a station access points with the LRV, when it can be done by analyzing the station drawings. Well at one station there is a curve prior to it. On the interior of the curve is the fence to the parking lot, and at this spot was a green zone. The contractor had three trees extra and planted them in by the fence blocking the train operator view. This was never on the plan and would not have been discovered until we did our testing, or an operator complained.

Some of the items were taken care of by train operator comment. During our testing train operator training was being conducted. One train operator commented that the motorman indicator at a particular station could not been seen at night. Sure enough, when the station lights are on the signal was washed out. To make the correction a discrepancy report was generated. Since the test passed when we tested in the daylight, the test report was in the completed file. So it was removed, the discrepancy report attached, and placed in the to be tested file.
C. System Performance

There are very few things that you can do to test system performance. We
designed the system with the engineering concepts to optimize
performance. You can test all of the operational features, and make sure
the system has the ability to support your operations. What it takes is to
perform simulated operations. The train operations group as part of their
planning and training, and not as integrated testing effort did these
exercises. Similarly, this exercise was part of the test program plan and
part of the safety certification.

Of course the real test came the day the system was opened. The number
of people showing up to ride the train was phenomenal. For the most part
the system operated as hoped. There were a few vehicle problems, but
that was attributed to the number of passengers exceeding the limits of the
vehicles.

The system is a great success. The daily rider ship in the first months was
up to design year. As time has passed the rider ship has not diminished.
Making UTA one of the most successful start up systems in recent history.