

**Monitoring Balance Weight
Assemblies and Protecting
OCS**

**Catenary Safety
Monitoring System**

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Abstract

There is new, cutting edge technology available that will lower maintenance costs and provide greater reliability for light rail transit systems through an automated Catenary Safety Monitoring System (CSMS). Most LRT's utilize balance weight assemblies (BWA's) to insure proper overhead wire tension. The BWA's play a critical role in maintaining a safe and healthy line, and must be monitored and maintained frequently. What if you could eliminate the need for daily visual inspection and have real-time access to the overhead wire system 24/7? New technology can remotely monitor the overhead system. This automated system identifies potential maintenance problems, increases the safety and reliability of a LRT, while saving time and money. One location, in the elimination of just visual maintenance cost alone, can pay for itself in less than one year. The CSMS uses a highly accurate magnetic linear position sensor to monitor the actual BWA position. A PLC calculates the predicted position of the BWA using characteristics of the wire run and the temperature of the wire via resistance temperature detectors. If a variance between actual and predicted positions occurs, it automatically sends an alert which identifies the anomaly, including catastrophic wire failures such as a break or cut wire due to theft. All information is stored for maintenance records. The CSMS operates by solar power or can be powered directly from the overhead system line using a DC-DC inverter. No utility connection is required which allows remote monitoring anywhere along a light rail transit system. Through a password protect website (via e-Cloud), you can observe real time movement and review past data. Maintenance can track system history towards a proactive service plan versus reactive, which in turn can offer huge savings. Every transit property can benefit from this new technology, providing the highest safety and reliability needed for today's transit systems.

Chapter 1. Balance Weight Assemblies (BWA)

Maintaining proper wire tension is crucial for proper operation in all overhead contact systems. Due to linear thermal expansion, overhead copper lines will expand and contract as temperature changes. As the temperature increases the line will expand and cause the tension to decrease. As the temperature decreases the line will contract and cause the tension to increase. The longer the wire run, the more dramatic the change. If the tension gets too high it can form a hog in the line and if the tension gets too low the catenary will begin to sag. Either scenario will cause improper pantograph operation.

Since maintaining proper wire tension is so critical to the health of a system the implementation of balance weight assemblies are used. Balance weight assemblies are especially useful on longer wire runs since those are affected more by temperature than shorter ones. Balance weight assemblies counter the affects of temperature change and keep a constant tension on the line. They do this by using a large weight to provide the tension. This weight will then move up and down along with the temperature change and will therefore be able to provide a constant tension. See **Figure 1**. The balance weights come in different varieties but the basic concept is the same for all style.

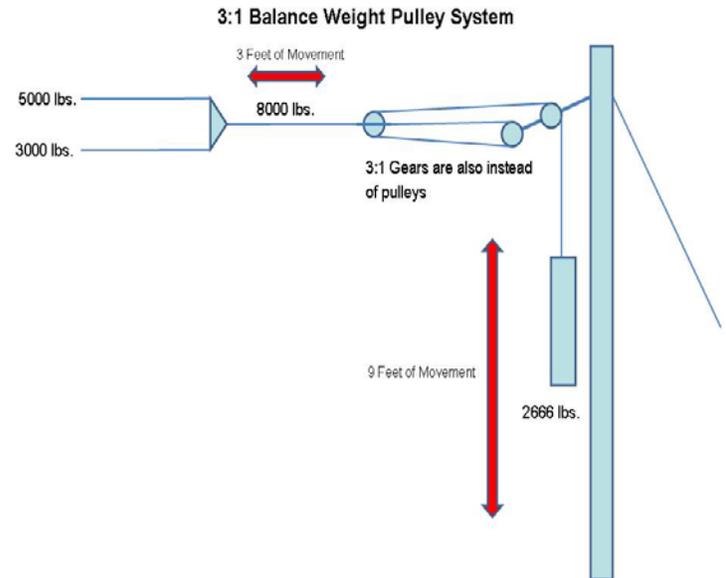


Figure 1 Balance Weight Pulley System

Chapter 2. Challenges Associated With Maintaining Balance Weight Assemblies (BWA) and Protecting Your OCS

These balance weight assemblies are critical for maintaining proper wire tension on long wire runs but they do come with some problems.

One problem is that the weight has a limited range of motion. Once the weight gets too high it will hit a cold stop and when the weight gets too low it will hit a hot stop. See **Figure 2**. If one of the stops is hit the wire tension will begin to change since there is no movement left in the counterweight stack to compensate for the expanding or contracting wires.

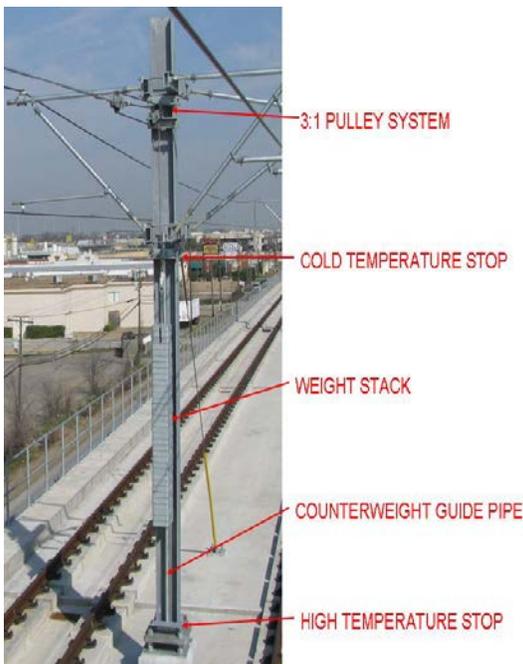


Figure 2 Labeled Balance Weight Assembly

Another issue is copper creep. Copper will gradually elongate when placed under tension. The creep is the worse when a system is first installed and once a system settles in the creep will lessen but it never completely goes away.

See **Figure 3**. The main problem associated with creep is that the balance weight will hit the hot stop too soon causing wire sag.

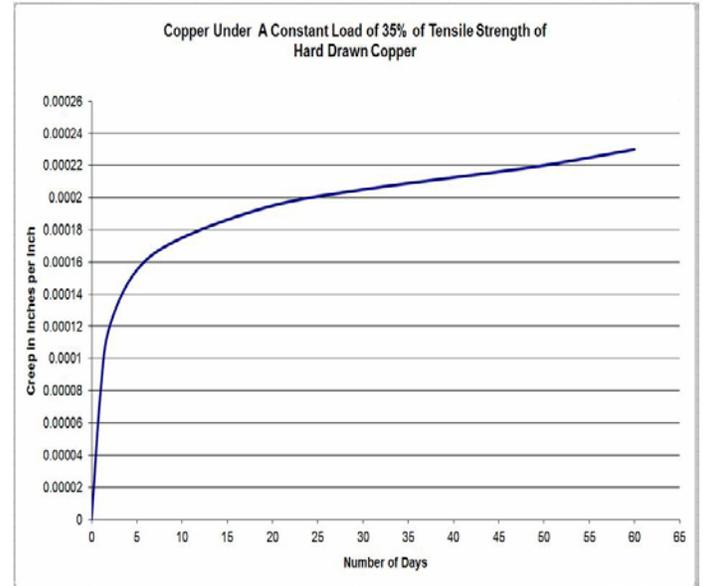


Figure 3 Hard Drawn Copper Wire Creep Characteristics

A stuck pulley wheel is another issue that will result in less than optimal system health. A pulley can get stuck for a variety of reasons including manufacturing issue, installation or maintenance issue, parts get damaged in service, etc. A stuck pulley will cause the wire tension to change, increase the wear on the wire rope and the pulley. This will cause the weight stack to move up and down in hard jumps rather than a smooth up and down motion and may cause a variety of other problems.

One unfortunate problem with all overhead contact systems is copper theft. The copper on very long wire runs are of particular interest because it is the same amount of work for more copper. These thefts will happen during installation or at night when a system is down. When this happens the system is completely shut down and there is a huge cost associated with replacing the copper and replacing the damaged hardware. Then if no one reports the crime in time the thief will usually get

away and be free to cut it down again once the wire is back up.

Other issues are not exclusive to balance weight assemblies but are still problems. Things like a tree or other object falls on the lines, a line breaks, dump truck or other vehicle tears down some overhead lines, pantograph hangs up, etc.

So even though balance weight type assemblies are critical for most long wire runs they do have some inherent problems. Most of these problems go unmonitored and therefore undetected. It is tough to be proactive about problems if there is no way to get reliable data and feedback about what the problem even is.

Chapter 3. Solutions for Handling Balance Weight Assembly (BWA) Issues

There are several ways of dealing with the problems associated with balance weight assemblies. One common method is to manually check the balance weight assemblies as part of scheduled maintenance. To make sure the BWA is functioning correctly crew members will usually stand under the weight stack and lift the weight stack up. Based on the discretion of the line crew they will decide if the BWA is functioning correctly. However, this is difficult when the right of way is located on the side of hills, on bridges, in underpasses or tunnels without service roads and must be serviced with high rail equipment during the ever shrinking maintenance windows.

Some authorities will go one step further and make marks on the pole with a marker to indicate the height of the weight stack at different temperatures. This can lead to a lot of overlapping data but it does give some indication as how the weight stack is moving with respect to temperature.

These types of solutions will give you some idea as to the health of a BWA but they do not really give a full picture. These methods only give you a snap shot as to what the BWA is doing at that specific time and at that temperature. A better method would be to have an automatic system which could continuously monitor the BWA.

If you could continuously monitor then you could see what the BWA is doing at all hours including while trains are passing. You would be able to be more proactive about problems instead of reactive. You could know immediately if something was wrong with that BWA.

Chapter 4. The Catenary Safety Monitoring System (CSMS)

The CSMS is a new cutting edge technology that has been developed by IMPulse NC LLC to provide a solution to monitoring balance weight assemblies (BWA). The CSMS will continuously monitor the position of any BWA and will signal maintenance personal should a problem arise. The device can easily be installed on any new or existing BWA and can be solar powered or line powered. **Figure 4** shows a solar powered CSMS.

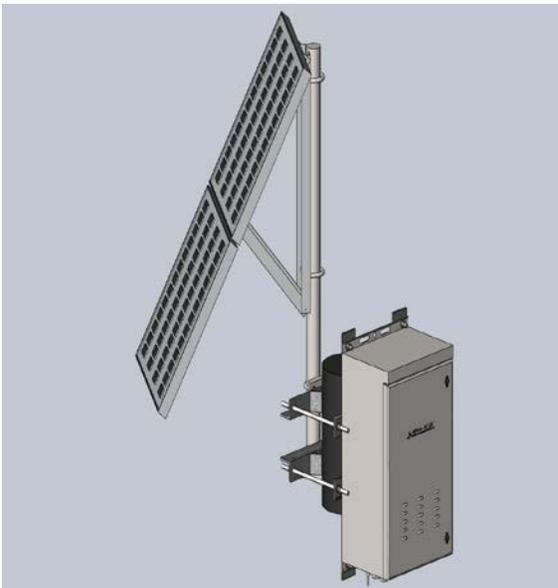


Figure 4 Solar Powered CSMS

4.1. Features: Online Monitoring

The online monitoring will allow information to be collect from every BWA. The user will be able to monitor past and present movement, predicted (proper movement), the outside temperature and battery health.

With CSMS you will have the ability to monitor the movement of your system and will be able to compare that movement to the proper or predicted movement. **Figure 5** shows an actual example of the movement of a properly functioning

BWA compared to its predicted movement over the period of 5 days.



Figure 5 Real movement of properly working BWA compared to the predicted movement

The online monitoring will allow the user to compare movement from past years to see if there have been any changes. The user can monitor a specific day or night. There is also the option to get real time updates every five minutes. With all of this data you will easily be able to tell if a BWA is functioning properly.

4.2. Features: Text Message/ Email Alarms

The CSMS also has the ability to let you know when there is a problem. The data collected from the online monitoring is very helpful for lots of things but if there is a real problem you will want to know right then. If any of your balance weight assemblies get out of position for any reason you will receive a text within 15 seconds alerting that there is a problem. A balance weight can come out of position for a variety reasons including but not specific to; a tree falls on the line, ice on the line, stuck pulley, balance weight hangs up, line tear, line cut down (theft), wire creep, hits hot/cold stop, etc... All of these problems will be detected and you will be alerted of immediately.

Figure 6 shows how the alarms will be sent to a phone and how to acknowledge alarms.

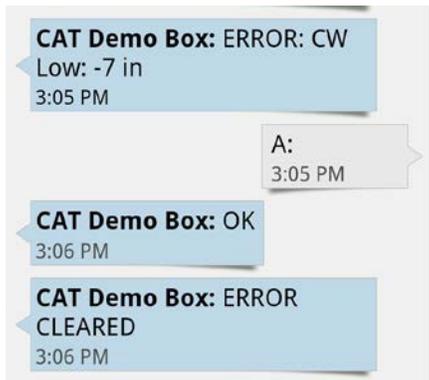


Figure 6 Screen Shot of Alarms

Once the alarm is received someone from the operation control center or maintenance will have to acknowledge the alarm and take appropriate action to fix the problem. Once the problem is fixed the CSMS will send another message saying the problem has been resolved and system is functioning correctly once again.

4.3. Features: Easy of Use

After initial instruction on the system, all needed personal will be able to operate (interact) with the system with no additional support. In fact, any one who can log onto a website and knows how to send a text message is fully capable of using the CSMS. Once the Box is installed onto the pole the user will setup all of the parameters using nothing more than a cell phone. After installation the user never has another reason to open the box. Since there is no reason to get inside the box the user can mount the system up high so that no one can easily access or vandalize it. Using the text language created for the CSMS the user will simply text in four commands: position of hot and cold stops, length of wire run and then a command to calibrate or zero the system. **Figure 7** shows a screen shot of how easy it is to program the CSMS.

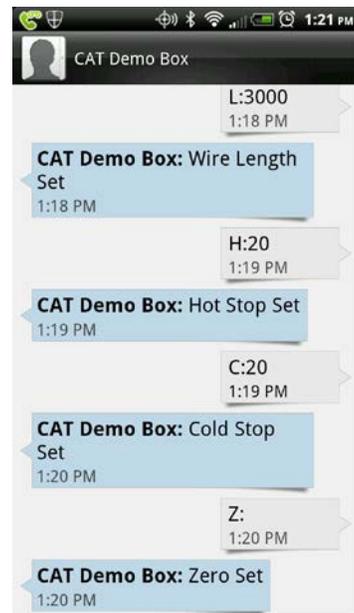


Figure 7 Four Programming Commands Being Inputted

The user also will have the ability to query the CSMS. If the user has no immediate access to the internet it is still possible to receive real time data from the CSMS. Using simple text commands the user can check current position, temperature, battery health and input variables.

Chapter 5. Conclusion

With current methods there is no way of truly knowing if a systems balance weight assemblies are functioning correctly. With the CSMS you have the ability to know if the balance weight assemblies are functioning correctly. Your system will be safer because of the CSMS. Instead of waiting for a pantograph to become damaged and possibly cause the catenary to tear down and conceivably injuring someone, you can know if there is an issue and fix it before it becomes serious.

You get peace of mind from knowing that there are no issues with your balance weight assemblies. You can check the movement real time or you can monitor the movement from the past days, weeks or even years. If there is a problem the CSMS will alert to what the problem is and give a pole location. Then proper maintenance crews can be sent out to fix the problem and you can again know that your system is functioning correctly.

You will save money and time with the CSMS. You will no longer have to send crews out to check balance weight assemblies. If the CSMS alerts you of a problem then you can send out a crew to that pole and you will already know what needs to be addressed. There will also be a record kept as to who acknowledged the alarm and when the problem was resolved. You will be able to use the small window of down time more efficiently by not checking balance weights and having the crew members perform more specific and necessary tasks.

There is no way to get around the fact that most all systems need some type of weight tensioning system to insure proper system functionality. These balance weight assemblies are critical and must be constantly monitored in order to maintain a safe and healthy line. Current methods are not effective and due to ever shorter maintenance windows there is no time to perform these visual tasks. The CSMS gives you all of functionality necessary to

help you properly maintain your system without the restrictions.

Every Transit property can benefit from this new cutting edge technology, providing the highest safety and reliability needed for today's Transit Systems.