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INNOVATIVE ANALYSIS

ROBUST ROADWAY REFLECTORS

1. BRIEF DESCRIPTION OF THE SITUATION

A roadway reflector is a plastic or metal housing, several inches wide and a couple inches high, holding a retro-reflective element that reflects the headlights of approaching vehicles. These reflectors are either glued to the surface of the roadway or mounted recessed into the roadway. Plastic reflectors cost about $3 each whereas metallic reflectors cost about $24 each. The problem is that snowplows, when clearing away ice and snow, damage or completely remove the reflector from the roadway. It is not uncommon for a state to be faced with replacing hundreds of thousands or even millions of these reflectors each spring costing several million dollars not to mention the increase in danger arising from not having the reflectors marking the roadway during subsequent bad weather when they are needed the most. Many state transportation departments have made the decision that it is cheaper to replace inexpensive reflectors each year than to purchase the much more costly reflectors.

Surface-mounted reflectors protrude above the surface. The snowplow blade either breaks the housing, shearing off part of the reflector body, or dislodges the housing from the glue. Sometimes the blade travels underneath the glue itself and lifts the entire assembly from the road, glue and all. Recessed reflectors partially allow the snowplow blade to travel over the reflector housing. This reduces, but does not eliminate, the likelihood of damage. However, the recessed reflector is not as effective in bad weather because it easily becomes covered with rain, slush, mud, ice, or other material obscuring the reflector.

Needed is a roadway reflector design maximizing the ability to mark the road while minimizing damage caused by snow removal equipment.

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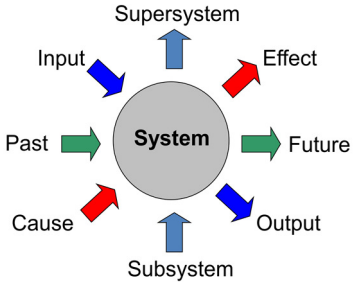
2. DETAILED DESCRIPTION OF THE SITUATION



The roadway reflectors are designed to aid drivers in the identification of lanes of travel, turning lanes, medians, and the shoulder of the road. Robust roadway reflectors are critical in highly populated heavily congested areas as well as rural areas which have low light available to view the road. Certain types of weather conditions such as heavy rain or fog are also conditions under which roadway reflectors aid drivers with lane identification and sides of the roadway because they allow visibility despite these conditions. Road reflectors are often important conspicuously in areas that are prone to accidents and also areas where the roads are more likely covered with snow, rain and water. Roadway reflectors are made of ceramic, plastic and sometimes metal. Reflectors are used to solve various problems on the road. This depends on the pattern in which they are installed. When a ceramic road reflectors are placed closed together in rows stretching over the width of the road, they can form a traffic rumble strip. When they are installed in a shape of a diamond, they can be very useful in designating the HOV lane. Also, some the crossings zones in the pedestrian crossings are created with road reflectors. Without these reflectors, accidents on the road could increase and roads can be very unsafe. To increase motorist safety and reduce installation labor and part cost, we must redesign or reconfigure the current system.

2.1 SUPERSYTEM/SUBSYSTEM ANALYSIS

Parts of the robust roadway reflector system:

- Reflective Material
- Housing for Reflective Material
- Stem
- Adhesive

Systems located nearby:

- Roadway

System interacting with the fan and air conditioning system:

- Snowplow
- Vehicles
- Light

Conditions around the system:

- Environmental Conditions

The robust roadway reflector is made from various types of material. Roadway reflectors have the option of being glued onto the roadway with an epoxy, others have a stem protruding from the base allowing then to be more stable. The advantage of these reflectors is that under limited light or other reduced visibility environmental conditions (such as fog) the reflectors provide drivers clear identification of lanes of travel and width of the road. The problem is that under specific environmental conditions such as snow, sleet, or ice or any combination thereof which may cause city, county, or state road maintenance crews to scrape the roadway's dislodging the roadway reflectors from their position. Southeastern and Southwestern states who do not have a large annual snowfall accumulation are unprepared to scrape roads effectively without the removal of the roadway reflectors.

2.2 INPUT/OUTPUT ANALYSIS

Roadway reflectors require some type of light source for the reflection to aid motorist in the identification of lanes in roadway. The lens or reflective button consist of high quality pigment for the reflective color of the lenses and an ultra violet coating treatment to resist fading. Most roadway reflectors are adhered to the road with epoxy to secure them in place, while other use a stem which is driven into the pavement. Light from motorists strikes the reflective lenses illuminating the division of lanes or sides of the roadway.

The primary function: Roadway Reflectors aid drivers in the identification of both lanes of travel, turning lanes, medians, and the shoulder of the road.

Input: light source, reflector, road, mounting application, installation.

Output: reflection of the light, improved traffic condition, reduction of motor vehicle collision.

2.3 CAUSE/EFFECT ANALYSIS

Most roadway reflectors are compression resistant between 20-30 tons allowing for traffic to run over them causing no damage. Roadway reflectors are especially useful in aiding drivers during foggy or dark rainy days due to their reflective properties and the fact that they are at the level of road providing a visual point of reference for drivers.

Problem to be resolved: Redesign Roadway Reflector so when there are natural environmental disaster and snow plough is needed to clear the road, the reflectors would not get ripped off of the pavement.

Cause of the problem: The problem is that under specific environmental conditions such as snow, sleet, or ice or any combination thereof which may cause city, county, or state road maintenance crews to scrape the roadway's dislodging the roadway reflectors from their position. Southeaster and Southwestern states who do not have a large annual snowfall accumulation are unprepared to scrape roads effectively without the removal of the roadway reflectors.

Snow plough dislodges the reflector with the blades that are on the plough. The blade scrapes the up the reflector by impaction by the blade, scraping right underneath the reflector and the glue that holds the reflector down onto the pavement, and lifting up the reflector from the pavement.

Surface-mounted reflectors are squared reflectors that are glued onto the pavement. When road crews scrape roadways in snow events the roadway reflectors are removed with the snow. Some of the roadway reflectors are undamaged and other broken. Some roadway reflectors are thrown off the roadway and are lost forever. Replacing these roadway reflectors can be costly and labor intensive for states experiencing unusually large snowfall events. The addition of roadway reflectors allow motorists to travel at higher rates of speed under reduced visibility conditions.

Recessed reflectors sits inside of the pavement, which are less likely to be removed by snow ploughs, but when dirt, snow, rain, slush, and trash covers the recessed reflector, reflection from the reflector is limited. Limiting the reflection coming off the reflector limits in aiding drivers in the identification of both lanes of travel, turning lanes, medians, and the shoulder of the road. It would also decrease motorist safety and increase motor accidents.

Stem reflectors are basically like the surface-mounted reflectors. They still protrude above the surface. The difference between the surface-mounted reflectors and the stem reflectors is stem reflectors are fixed to road by an anti-twist stem for added stability and the surface-mounted is adhered to the surface with epoxy glue. Stem reflectors will not get easily dislodge by motor vehicles, but they will get dislodge by

the snow ploughs. The snow plough's blade will scrape right under the reflector causing impaction to the stem, which the blade will break the stem and dislodge the stem reflectors like it would with the surface-mounted reflectors.
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Undesirable consequences if the problem is not resolved: Continuous replacement of reflectors on roadway. Areas where reflectors are needed most and are more prone to accidents may take time to replace which will cause accidents to increase in those areas. Cost of replacing the roadway reflectors is minimal when consider price per unit, when having to replace hundreds, thousands, or tens of thousands due to unexpected weather conditions can become costly not only for the reflectors but also for the labor to physically replace them.

2.4 PAST/FUTURE ANALYSIS

Past:

In 1934 Percy Shaw patented the Catseye roadstud in which he embedded reflectors to aid drivers in foggy conditions; this resulted in modern roadway reflectors. Drivers previously had nothing but painted lines to indicate to them the lanes of travel on the road. During night driving (reduced visibility) or certain types of weather conditions such as heavy rain, fog, or snow the lines in the roadway became difficult to see, especially at higher rates of speed. Roadway reflectors started by the use of polished metal discs placed in the roadway to reflect the light of motorist headlights. The reflectors have evolved into ceramic, fiberglass/plastic and even aluminum housing holding extremely reflective colored material. Some reflectors even have a reflective flag type attachment for increased visibility in high populated and traffic congested areas. Older versions of reflectors were big, bulky, and sat above the pavement. This cause the reflectors be displaced if impacted.

Future:

Current reflectors are designed in a way where it is much small, smoother, and not as bulky but it still have the same problem as the old version. Current design limitation do not eliminate the reflectors being dislodge from impact of snow removal equipments. Future reflectors need to be made so that states which normally do not experience large snowfall amounts do not damage roadways be the removal of the reflectors while attempting to remove the snow.

3. RESOURCES, CONSTRAINTS, AND LIMITATIONS

3.1 AVAILABLE RESOURCES

glass beads = silica, sodium bicarbonate, limestone, heat
rubber = latex
iron
glue
light = in order for it to work there has to be light

3.2 ALLOWABLE CHANGES TO THE SYSTEM

Drastic change to Robust Roadway Reflectors are allowed

Reduction in reflections/reflecting off lights are absolutely not allowed

Reduction in strength of Robust Roadway Reflector is unacceptable

3.3 CONSTRAINTS AND LIMITATIONS

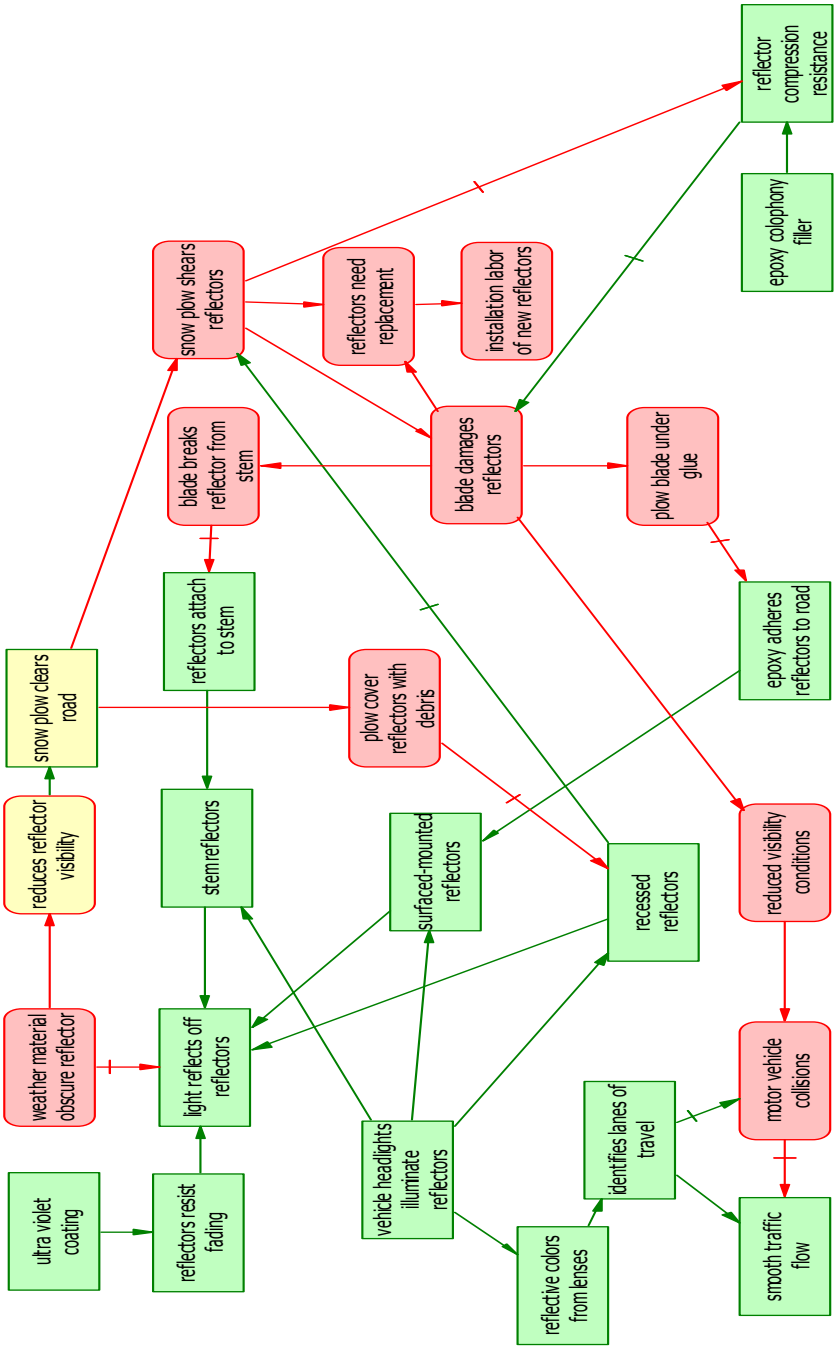
Reduce damage to Robust Roadway Reflectors cause by environmental disasters

Cost efficient

Up to six months to design a new Robust Roadway Reflector

One year to implement the new design

4. PROBLEM FORMULATION



5. IDEAS

1. **Remove a required part from an object**

Dome shaped metal reflector that is surface mounted and is coated with Tritium. We used the Remove a required part from an object operator with this solution by removing the reflective materials and replacing it with tritium, an element that gathers light and emits a glow.

2. **Change to a variable shape**

Reflective conveyor belt that is partially surface mounted and partially recessed. We used the Change to a variable shape operator with this solution by changing the current reflector style to a rubber reflective belt that is wrapped around a rolling rod.

3. **Use dynamic elements**

Sloped surface mounted base with recessed reflectors. We use the Dynamic Elements operator with this solution by recessing the reflectors. They are no longer damaged by snow plow.

4. **Apply multiple actions**

A spring loaded flat faced flag. Spring holds flag up under normal condition. The weight of snow causes the flag to recess back into mounting. After plow clears snow, flag pops back up. The flag is made of double sided reflective material. The flag can be used for single lane roadways.

5. **Concentrate energy**

Dome shaped surface mounted LED lane markers. Dome shaped allows plow to go over lane marker without damage. The batteries can be easily replaced.

6. **Replace field with more effective (structured) one**

Electronic reflector is a signal emitting device which is recessed below roadway surface. GPS and Cellphones receive signals and display on screen view of the separation of lanes or division of lanes.

7. **Transform the environment**

Clear disk shaped recessed container with biological light emitting organisms. Plow blade has been altered to have brush along bottom of blade. The brush will sweep snow off the reflector allowing for normal functionality.

8.**Look for prototype to improve**

Surface mounted angled reflector. Angled metal base sprayed with reflector paint. Plow scrapes paint off, but paint easily reapplied either by hand or by mechanical sprayer.

9. **Use other systems**

Sponge reflector is partially recessed and easily replaceable. Sponge reflector is more cost effective then current system. The sponge can always be replaced.

10. **Combine known systems**

metal pyramid shaped surface mounted base for single lane road travel with reflective tape. The tape is on a roll and is recessed below mount. The plow strikes tape removing tape, pulling the next piece of tape onto reflective base.

11. **Separate opposite requirements in space**

Plastic clear polycarbonate ball with reflective granules inside ball. The ball is partially recessed below roadway with spring action beneath to protect ball from damage by the plow blade. The ball rolls further protecting it from damage.

12. **Separate an impeding part from an object**

Polycarbonate mount partially recessed at an angle with reflective poly paper. Each piece of paper is perforated so when the plow blade hits it, it tears off the top sheet exposing the next sheet. Pads are cost effective and easily replaceable.

13. **Remove a required part from an object**

"A" shaped reflective flags that have metal or plastic spines (on the sides) which acts as springs. The additional flags are recessed below the pavement inside the mounting box. One flag protrudes above the surface and if the plow removes flag, the next one in the box pops up. The box is refillable.

14. **Use another dimension**

Protective metal grill/cover mounted with Spikes at both ends. These are easily applied to the existing system and easily replaced. This can be used to protect the existing system from the plow blade as they are angled tapering down at both ends.

15. **Use the reverse side**

Using a square reflector which is 50% recessed and hinged with a pivot on both side so when the snow plow hits and shears the top of the reflector of, it flips over revealing the reverse side which has another reflector attached to it.

16. **Nesting**

Metal angled surface mounted base which has short (1/4") walls on both sides to protect the reflector from snow plow blade.

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17. **Separate opposite requirements in space**

Cylindrical recessed/surface mounted reflector. The dispenser is recessed in the pavement while the cylindrical, cup like shaped reflector sits above the road surface. If snow plow hits reflector, taking it off, the next reflector pops up. It is refillable and can hold 10 reflectors at a time.

18. Use interchangeable objects

Reflective triangular shaped poly rubber flags. The mount is recessed containing 100 flags beneath the road surface. The flags are attached to one another and when the plow strikes a flag, the flag is cut by metal protruding edge on the mount. The compression releases next flag.

19. Poly System with Shifted Characteristics

Recessed mount which is filled with a spray foam reflector. The plow blade will remove the foam reflector when struck, but new foam will be injected by a mechanized system attached to a truck only

requiring one person to operate it.

20. Inversion

Partially recessed gel reflectors which are stacked on top of each other so when the plow strikes the exposed one, the next one in line is pushed to surface by spring activation in the mount.

21. Inversion

Solar reflective liquid. The liquid retains light due to a light gathering property for more than 24hours at a time. The liquid is stored in dome shaped partially surface mounted unit. The dome Shape surface mounted has a gasket to help cushion the shock from the plow blade which alleviates damage from the snow plow.