Development of the In-Roadway Warning Light Signal Module
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In 1993, I received authorization to experiment from the California Traffic Control Devices Committee (CTCDC) to implement “warning lights” in the road to alert pedestrians to the potential presence of a pedestrian. We presented the concept to the City of Santa Rosa, CA, and the City Council unanimously approved the concept. However, they mandated that we receive the proper authorization to try this novel concept. Both excited and a bit nervous, we now had this Authorization to Experiment, but had no idea of exactly how this device would be produced or how well we could get it to perform!

The City of Santa Rosa offered three locations in which to begin, along with one “beta” test location at the City Corporation Yard that would allow preliminary evaluations. This proved to be most beneficial in getting on the right track very early in the process.

The CTCDC, which is made up of industry professionals, recommended a number of things early on. One recommendation was the unidirectional mandate. Another recommendation was to have the color of the lights match the color of the crosswalks! Not many people know that in California, there are two colors of crosswalks: White “like the rest of the country”, and Yellow. Ask MOST people, and not many can tell you the reason WHY! The answer is Yellow is for the School Routes that children would most likely be using on their way to and from school.

This request posed a number of challenges. The first was - What is a white flashing light supposed to mean to a motorist? The second, how are we going to make a product that would or could be seen easily by a motorist in bright sun conditions? We developed a unit using Xenon flash tube technology which is like a camera “flash”. This required a lot of electronics to be incorporated into the unit (later dubbed IRWL). We manufactured our first prototypes and installed them at the City Yard for experimentation. As one would expect, this early prototype worked pretty well in darkness, overcast and darker days. In the bright sun, not so good! In addition to that, the rain! And, did I mention “electronics”? Yes, the moisture in the electronics proved to be a problem. Don’t leave your camera in the bathtub!

Luckily for us, we were guided to a very talented and highly experienced Applications Engineer, Mr. David Evans, who worked for Hewlett Packard. Dave met with us to determine if he could help us out with this product.

At our next meeting on a bright sunny day at the City Yard, Dave brought out a small test unit, about the size of a match box, and told me to stand back about 100 feet from him. He pushed a button on this unit, and a beam of “amber” light shot out at me like a laser! My immediate reaction… Eureka!
This of course was an amber LED, powered by a small battery in the test unit. The amber color was a solution to the “School” crosswalks, but we still had a problem, as there were no white LED’s of that caliber available at the time. These were the early days of implementing LED’s into the U.S. traffic industry. We needed a solution to this problem.

Our decision was to report back to the CTCDC with our findings on initial testing, and to request that they change the mandate from white to amber for ALL crosswalks. After a grinding 3 hour presentation from Mr. Evans on all the reasons why the amber color spectrum was better for the human eye, and a more meaningful information delivery to the motorist, we had our authorization to change.

We developed our first successful prototype unit, Model 3. (Model 1 failed before we ever completed building it and Model 2 was the “flash tube”.) We placed this unit in operation at the City Yard, and observed it for a number of months. It seemed to perform well in all conditions. And, you could see it pretty well in daytime.

Then in 1996, we moved on to the very first actual street test location in Santa Rosa, CA at the Matanzas Elementary School on Yulupa Avenue. As this was an “experiment”, we didn’t really have any clear plan for installing, with the exception that we knew where we wanted the units placed. The City of Santa Rosa’s Public Works Department was kind enough to offer their manpower and equipment to install our first test product, which was by then “Model 4” unit.

This Model 4 unit was made with Delran® material, a highly rugged “plastic” that could (we assumed) best handle the rigors of the road. It looked like a brick, over an inch high, with the front and back cut down at a 30 degree “ramp” on both ends. The LED’s were embedded into only one side of each unit -- remember, we were restricted from allowing the pedestrian from seeing the lights flashing. We placed them onto the roadway in the depressions provided by the City at locations chosen by us. A saw cut was made into the road for the wiring that provided power to each unit. A small “base plate” was anchored to the street with a two-part epoxy.

This location was chosen by the City, as a “tough” crossing. It was four lanes, with a 35 MPH posted speed limit, and a high volume of traffic at peak times. If we were successful there, we could be successful most anywhere. The studies proved that our theory was correct, and that the motorists would react favorably to the “system”.

The CTCDC authorization guidelines set a 90-day period for experimentation and data collection. We built the initial prototypes to last for that period of time. We expected that once the data and human factors aspect was completed, we would abandon the sites and begin work for a more permanent design. However, this was not the case. As the product appeared to increase the level of safety, the system was kept in place for several years. The LED’s and boards that they were mounted on held up considerably well.

We then moved on to the second and third authorized locations in Santa Rosa, again high volume and high risk locations, with the Model 4 units. The three major changes to occur were: 1) we implemented the Enlighten1™ flash rate for greater motorist recognition, 2) we added IRWL’s at each outer edge (parking lanes) per the recommendation of the preliminary study and findings, and 3) we placed a “Patented Lens” in front of the LED’s to more accurately direct the available light source to the motorist’s eye. In those days, the LED’s were about half as powerful as the ones we have available to us today.

A year or so later we were completing the second phase of testing at four additional cities who also had received Authorization to Experiment, as well as other cities through Federal Authorization such as Kirkland, WA and Orlando, FL. Without going through each site and the
progression, from this point we will just go through the design changes to the point of where we are today.

What we learned from early testing has become our “mantra” today on our design work. Manufacture with these three things in mind: “Installation, Maintenance and Reliability™”. We needed to design an IRWL that was very easy to install and replace. We knew that if crews constantly needed to perform repair work, we would fail. And in order to sleep at night, it had to be reliable, and work 24/7. This is why we stayed clear of wireless and internal solar powered devices. It is just not practical for this harsh environment in which we need to operate. We considered these factors early on… Remember the electronics?

The Model 5 was a more “street friendly” design. It was rounded (Igloo shape), made of aluminum, still quite high at over an inch, and could be powder coated white or yellow to match the crosswalk. These units also used a base plate and epoxy to adhere to the road. The Model 5A had a slight change to the base plate that allowed a “seal” to be placed like a piston “O’ ring in the unit to assist in preventing moisture creeping in from the bottom.

The Model 6 was lowered to ½ inch by decreasing the two rows of 6 LED’s, one over the top of the other, to one line of 12. We also changed the front window that we believed would stop the moisture from getting into the units from the front end. This was a design that was accomplished through an amazing new technology at the time called Stereo Lithography, created through computer aided design (CAD). Then the prototype is “made” by a box that dips a plate down into a vat of and epoxy type material. The plate rises, and some light beams are generated onto the material, hardening it at those locations. When the process is complete, the prototype is handed to you! It really is a “magical” process in engineering.

We used this prototype to actually form the mold for the aluminum production units. We also created a base plate that maintained the same “bolt” pattern for the units, so we could install the Model 6 units back to the locations where we had installed the Model 5’s. -- a legacy design that we incorporate to this day. It still attached to a base plate set in the roadway in the same fashion as previous units.

We found that the “fat” lens assembly that was on the Model 6 unit was fairly durable. However, we also found that because of the way light travels through a solid material, and the way light enters and exits from an angled surface, we were loosing about 30% of our available light source.

So, enter the Model 6A. This unit was manufactured from the Model 6, with modifications to the front window area using a very thin window, to allow nearly 100% of available light to penetrate. This process required a very exacting method of assembly using aircraft quality sealant and a design that allowed the window to “float” in the front end like being on a rubber band when struck by tires. It would bounce back and forth in the front end, without loosing or breaking its seal.

This design worked pretty well, however it proved to be very expensive to produce, and it still ultimately succumbed to the environment and inevitable moisture problems. The main reason that this was an issue is that an area of air gap was required to allow the light to pass through the front window area and be directed to the motorists’ eyes. Without this air gap, the light beams would exit the front window surface and would be directed 90 degrees off the front surface and 30 degrees above the motorists’ eyes!

We then moved to a design that made a significant leap forward to the durability design of the units. The Model 6B! The significant change here was actually to the base plate itself. We designed the base plate to be the part of the IRWL that absorbed most of the vehicle/tire impact! The signal head design was changed to fit “down into” a cavity in the base plate, greatly
reducing the impact to the actual signal head itself. These models were still aluminum, with anodized coatings.

With the Model 6BC we shifted our focus in material selection and changed towards a composite base plate (thus the “C” in the model number) with a fiberglass fill. This material is very rugged and has proven itself in the roadway for over 10 years. The same basic physical design was maintained, and its legacy was retained to allow new generations of signal module to be retrofitted, even going back to nearly the early original locations.

I will skip the details on the Model 7 design attempt… Remember the Edsel? I think every company has at least one! The Model 8 was a rescue from the Model 7 design. We went back a step to a design that we knew would last while we worked on our next generation. At last, we are at a design that had some significant improvements to combat the “moisture” that we have been dealing with all along.

Model 9 – This design incorporated a new Patent Pending design feature, the Dove Prism. This is a solid piece of acrylic material that is imbedded in front of the LED’s. Acrylic material was selected because it maintains UV resistance for clarity. This Dove Prism is mirrored in order to bounce the light so that it exits the front of the window toward the motorist’s eyes. This prism fixture is permanently embedded with a highly durable potting compound. When assembly is complete, the module is nearly one solid “hunk” of material, with minimal chance for moisture to intrude or form. It is not a repairable unit. If it fails, it is replaced with a new one.

Our current unit, the Model 9X, increases the number of LED’s by over 30%. We now incorporate 16 LED’s per module. The design is the same as the Model 9. It has base plate and signal head legacy conversion all the way back to our early installation locations as well. We are currently working on our next generation, the Model 10 … It will be a radical new design.