

# Design Team 4 – Cracked Spike Detector Design Issues Paper

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This semester, Design Team 4 has been building a device for Norfolk Southern Corporation to detect flaws in railroad spikes before they fail, the Cracked Spike Detector (CSD). The device prototype uses ultrasound to image the interior of railroad spikes looking for cracks. In going from prototype to production, many issues must be addressed. These issues include product lifecycle management (PLM), universal design, and environmental impact.

## PRODUCT LIFECYCLE MANAGEMENT

Product Lifecycle Management (PLM) is concerned with all stages in which the product will exist. This includes its manufacture, its operation and maintenance, and its disposal.

### Manufacture

As the device first goes into manufacturing, it is important to start keeping records of all models that are produced. A product number should be assigned to all models so that if any errors or failures of the device are reported by users they can be studied later on. A database should be established to store this information and to track which components fail and why the failure occurs. In cases where the cause of error was not a component failure, a record of device 'shortcomings' should be kept so that when future models are being designed, the areas where improvement is needed are known. Also at this point, a repair center should be established so that any defective units can be sent in for repair and testing to determine the cause of the defect for use in the database.

### Operation and Maintenance

Once there is an established way to track and repair models, the mid-cycle management will be relatively simple. Design Team 4 recommends a warranty be offered on the product, where the repair center will be equipped to handle all such

repairs under warranty. This plan will make the database considerably more accurate, as users will send in failed products to be analyzed for possible improvements.

Besides the circuit boards, every part of the device is interchangeable. As such, it should be easy to repair and have a long field life. Since parts are separated by part number, parts can be swapped out without tainting the data collected by the repair center.

### Disposal

Most of the parts of the CSD are capable of recycling and/or reuse. There are a few parts that need to be upgraded so that the disposal is more environmentally friendly. (See the “environmental impact” section for details.) At the end of the device’s production life, a study of the parts should be taken to determine how much longer the product will be viable on the market. With data collected over the lifecycle of the product it can be determined which parts need to be improved, so that the next generation of the product will be of superior quality.

## UNIVERSAL DESIGN

The purpose of Universal Design is to develop products which are adaptable to different user needs, including both able and disabled users. The key idea is that by developing a product that can be used by a person who is physically challenged, the product also becomes easier to use for the general population. The Center for Universal Design ([http://www.design.ncsu.edu/cud/about\\_ud/udprincipleshtmlformat.html](http://www.design.ncsu.edu/cud/about_ud/udprincipleshtmlformat.html)) has seven principles of Universal Design, considered below.

### Equitable Use

“The design is useful and marketable to people with diverse abilities.” This principle poses a problem for the CSD, because it is a bulky device meant for use in rugged outdoor situations. Thus, a person with limited mobility would find it difficult to use. This is an unavoidable consequence of the nature of the task; nothing can be done to correct it.

### Flexibility in Use

“The design accommodates a wide range of individual preferences and abilities.” The CSD’s pole design is symmetrical, with no concern for right-handed vs. left-handed users, so users are free to use it in whatever configuration they desire. However, positioning the device’s probe in an appropriate position to test a spike requires precise maneuvering, which might be a problem for a person with diminished motor function. In order to correct this, a guard could be placed to help position the probe correctly. Additionally, a level could be placed at eye level to assist in this task.

### Simple and Intuitive Use

“Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level.” The feedback the CSD provides is very simple; either a green light for a normal, functional spike, or a red light and a buzzer for a spike which has a flaw. Since this is a yes/no answer, it requires no special knowledge of ultrasound or of railroad spikes to interpret, and since it is non-verbal, it makes no assumptions of the user’s language skills.

### Perceptible Information

“The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.” Since the CSD communicates with the user via both a pair of LEDs and a buzzer, users with a wide variety of sensory capabilities can use the device. Users who are hard of hearing can see the lights, while users who have difficulty seeing can hear the buzzer. Also, in bright sunlight, the lights may not be easily visible, but the buzzer can still be heard, and in noisy conditions the buzzer may be difficult to hear, but the lights can still be seen.

### Tolerance for Error

“The design minimizes hazards and the adverse consequences of accidental or unintended actions.” The CSD is simply a detection device, and its accidental use has few hazards. If the CSD is activated while its probe is not over a spike, all that will happen is that a meaningless test will be performed. This is good, because as discussed above, it is difficult to correctly place the probe.

### Low Physical Effort

“The design can be used efficiently and comfortably and with a minimum of fatigue.” Ergonomics was a key design criterion for the CSD. Although bulky, its PVC construction makes it easy to carry for long periods of time. Also, operating the device requires little physical effort: it is as simple as pressing a button.

However, the planned application of the device requires repetitive action as the operator proceeds down the railroad testing each spike. One possible solution to this issue would be to design the CSD in the form of an automated device which rolls down the railroad track testing each spike without human intervention.

### Size and Space for Approach and Use

“Appropriate size and space is provided for approach, reach, manipulation, and use regardless of user's body size, posture, or mobility.” In order to satisfy this design principle, different heights of pole will be needed for different heights of user. The CSD could be produced in multiple different heights in order to meet his requirement, but this might be impractical. A better solution might be to develop a telescopic pole, so that one CSD could be adapted to users of many different heights.

## ENVIRONMENTAL IMPACT

When considering environmental impact we must look at both the operation and components of the device. Operation of this device must be safe for both the operator and the surrounding environment. Materials and components used in the construction of the CSD must be selected to minimize the impact on the environment and health of material providers.

### Ultrasonic Impact

The CSD is designed to generate a directed ultrasonic wave that during improper use could at most irritate sensitive organisms in the environment. Frequencies used in non-destructive testing devices such as the CSD are by definition non-destructive, causing little to no damage to any material tested. During proper use of the CSD the ultrasonic wave will be limited to the railroad spike itself and the transducer of the device thus minimizing the impact on the surrounding environment.

## Reusable Parts

The majority of the cost of the CSD is embodied in the transducer. Our prototype incorporates a transducer that can be easily removed, and it is our recommendation that this be carried over into production. A removable transducer will allow a functional transducer to be removed from a defective or worn-out CSD to be reused in either other CSDs or ultrasonic devices using the same model transducer.

## Poly Vinyl Chloride Construction

Poly Vinyl Chloride (PVC) was the prototyping construction material used by Design Team 4 in order to facilitate speed. The manufacture of PVC exposes plant operators to vinyl chloride monomer which causes increased risk of angiosarcoma – a rare cancer of blood vessels of the liver, according to PVC.org. Modern manufacturing facilities have drastically reduced the exposure of workers to this carcinogen mitigating any health and environmental impact. Though PVC is a recyclable material, it is our recommendation that future production models use aluminum or stainless steel construction to increase the incentive for users to recycle the housing of the CSD.

## Batteries

The current CSD prototype is designed to run on AA size batteries with emphasis on using NiMH rechargeable batteries to allow a lower cost of use. These batteries provide energy for high power devices and can be recharged many hundreds of times. Nickel itself is a natural component of soil in concentrations up to 43 parts per million; it also is easily passed through the human body causing dermatitis in only a small fraction of the nickel-sensitive population. NiMH batteries are therefore considered non-hazardous waste though they are profitable to recycle since the recovered nickel has many applications.

## Couplant

Couplant used in our prototype contains less than 50 ppm halogens (chlorides) and less than 50 ppm sulfur, meeting environmental regulations. It is the recommendation of the design team to continue using a couplant that meets these regulations or replace it with a water-based couplant if possible.