REMOTE DRIVEN VEHICLE

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SCOPE

This paper outlines the Strategic Highway Research Program (SHRP) sponsored Remote Driven Vehicle (RDV) project. The function of the RDV system, including the technical aspects, are summarized.

INTRODUCTION

The RDV concept is intended to reduce highway worker fatalities by removing the drivers of shadow vehicles from the driver's seat and placing them at a remote roadside location in the work-zone. The driver would control the vehicle by a small control console that is radio linked to the shadow vehicle. With the control console, the driver has full control over the vehicle.

The RDV concept was developed as a product of SHRP. This concept was motivated by ever increasing incidence of highway worker fatalities due to collisions involving shadow vehicles. In December of 1990, SHRP directed ENSCO to implement the design of a RDV vehicle. Minnesota Department of Transportation (MnDOT) participated by donating a new 1990 FORD L8000 Dump truck (see figure 1) from their maintenance fleet. Ten months later, ENSCO delivered the prototype RDV to MnDOT. This system is currently being used by MnDOT in the field where data is being collected for the development of a second generation system and overall concept evaluation.

The RDV system consists of a set of actuators, digital control circuits, a radio link and sensors to provide for the remote control of trucks that are being used as shadow vehicles. The system can be installed without extensive modifications to most shadow vehicles. Basic premises of the system are durability and safety. The RDV system has multiple levels of safety systems to reduce the possibility of accidents due to equipment failure.

A second generation design is in the planning stages. It eliminates the central control computer and replaces it with a digital logic board. This reduces the system cost, enhances reliability, and simplifies maintenance. With the second generation system, it should be possible for state maintenance agencies to purchase the basic system in kit form and adapt it to their shadow vehicles.

DESCRIPTION OF THE RDV SYSTEM

The RDV system has the following layout. An electronic enclosure is mounted inside the cab of the truck (see figure 2). This enclosure contains the system safety circuits, and controllers for the actuators and any power supplies that might be necessary. The electronic equipment inside the enclosure is designed in a modular fashion to facilitate maintenance and enhance reliability.

The radio control system implements the following vehicle functions from the hand-held transmitter (see figure 3):

- steering - full steering from lock to lock
- brakes - proportional brake control
- throttle - controls vehicle throttle throughout it's whole range

Figure 1 MnDOT Ford L8000 Truck.

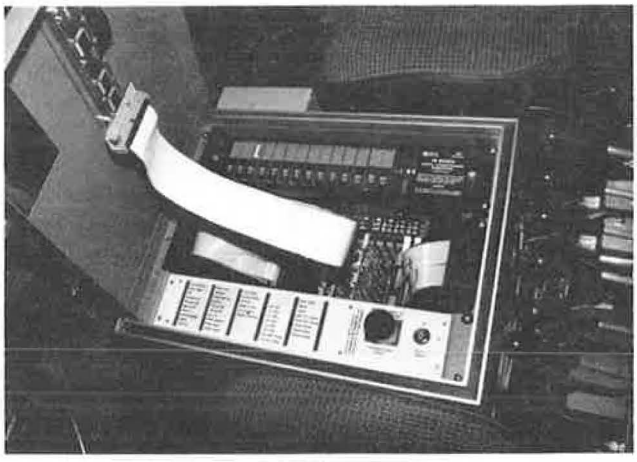

Figure 2 Electronic enclosure between front seats.

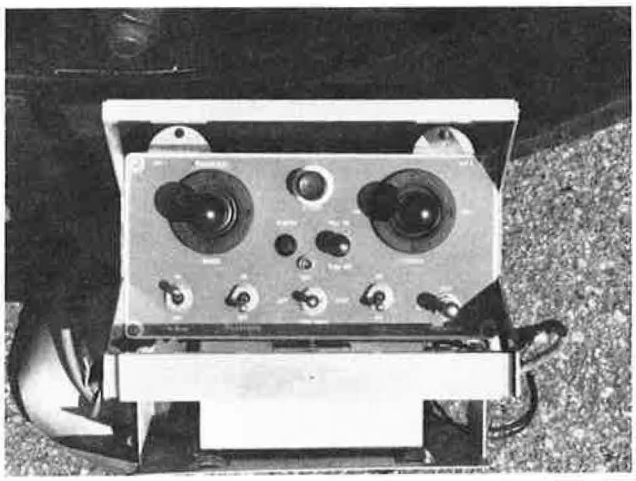

Figure 3 Hand-held transmitter.

- transmission - three position switch for neutral, park and drive
- horn
- headlights
- parking brake
- flashers
- emergency stop
- turn signals

Functional Requirements

The following requirements are built into the RDV system:

- The equipment installed on the truck does not impair the function of the driver controls while the truck is being driven in a normal manner.
- The RDV system is protected against aberrant behavior such as power failures and air pressure loss. The braking system stops the truck automatically in case there is an air pressure loss or electrical power failure.
- The RDV system has an all weather capability from 20°F to 110°F. All external components are corrosion protected from road salt.
- The system electronics are modularized to allow for the quick replacement of a defective subsystem.
- The radio transceiver system has a range of 1000 feet. It is battery operated and uses rechargeable batteries.
- The RDV system has proximity sensors that detects objects that are 15 feet in front of the truck.

Pneumatic System

All the actuators are pneumatically driven with position feedback for closed loop control. These actuators use the truck's air supply system that is modified to deliver a minimum of 100 psi. The RDV system is integrated into the truck's air brake system. In case of emergency conditions or equipment failure, the spring brakes on the truck activate automatically. An electrical failure or system pressure loss also will activate the spring brakes making the RDV system inherently safe.

Safety Equipment

The truck's oil pressure, coolant temperature, and engine run status are constantly monitored to preclude any system damage. The emergency brake system is designed such that regardless of either an air pressure loss or an electrical power failure, the emergency brake system engages.

The safety system is multi-layered. Primary protection safety is provided by the emergency stop hardware circuit. If this circuit finds any error conditions with the truck, the emergency stop system is engaged. If there is a communication problem with the radio equipment, the truck will stop. Sensors in front of the truck sense objects and stop the truck if they detect some obstruction. On both sides of the truck are large push-button switches that are pressed to stop the truck. These switches work with the emergency stop button on the transmitter. If the operator trips and falls, a tilt-switch inside the transmitter will detect this and stop the truck. The last level of protection is built into the mechanical equipment. If there is an electrical power failure or an air pressure loss in the system, the air control valves will default to a position that will engage the emergency stop spring brakes. Overall, the system is designed to preclude any accidents due to equipment failure.

Reliability

The RDV is designed for enhanced ruggedness and reliability. All actuators are of premium industrial quality and tolerant of salt spray environments. Second generation systems will have the following enhancements:

- All connectors will have a 1000 hours salt spray rating.
- The enclosures will be gasketed and will be constructed out of fiberglass, aluminum, or stainless steel.

- Wire runs between equipment will be minimized.
- Electronics will be mounted on circuit cards for added strength and rigidity.

In case of circuit failure, the primary circuit card can be replaced by removing the card and inserting a replacement card.

Transmitter/Receiver

The transmitter/receiver has extremely sophisticated anti-interference protocols. The transmitter is powered by ni-cad batteries and is supplied with a battery charger that will reside inside the cab of the truck. This charger will continuously charge the spare battery in case it is required. Currently, the transmitter has two joysticks for controlling throttle, brakes, and steering. The second generation transmitter will have a single joystick for controlling throttle, brakes and steering. The transmitter will be designed to be handheld but will have a shoulder harness and chest strap for securing the unit to the operator.

SYSTEM USAGE

The RDV system is used in the following manner. The shadow vehicle is placed a couple of hundred feet behind the work-zone with a message board. As the work crew moves along the work-zone the shadow vehicle is moved forward with the RDV system. Typical operation scenarios are pothole filling, crack sealing and trash pickup. The current RDV in the remote operation mode has a maximum speed of 5 mph so normal walking speed is easily attained.

FUTURE PLANS

It is envisioned that the RDV system capabilities be expanded by making it completely autonomous. This would entail using a vision system to follow a lead vehicle. This system would be appropriate for snow-plowing, line painting and other fast moving highway maintenance operations. Several prototype systems are currently available but are not yet cost effective.