Route Clearance and Interrogation System

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Final Report: Technical Summary

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INTRODUCTION

As the techniques being used to emplace Improvised Explosive Devices (IEDs) are evolving, there is emerging a growing need for a system capable of remotely removing rubble, which might be covering/concealing, these devices and clearing paths to these devices, which might otherwise be inaccessible. The small Unmanned Ground Vehicles (UGVs) currently being used to counter IEDs are often not capable of removing the rubble due to the size and weight of the material. While there are several commercial vehicles capable of removing the rubble to uncover the IED or to clear a path through the rubble, none of these vehicles currently possess the capability to be remotely operated.

In order to meet the emerging threat an experiment to determine the feasibility and potential capabilities of such a system is required. Information obtained in this assessment is to be presented to DoD to make prudent decisions on research and development investments for future system to meet these capabilities. Modifying a current Commercial on the Shelf (COTS) vehicle and developing the necessary unmanned system control capabilities presents the quickest and least expensive method of conduction the assessment.

The efforts performed by this assessment provide a system to remotely uncover potential explosive hazards thus allowing the application of other systems and techniques to perform neutralization. A secondary mission is to clear small rubble/debris from a route after determining whether it contains an explosive hazard, to avoid impeding the movement of ground forces or leaving a location suitable for concealing an explosive hazard. The vehicle/system must not increase the number of vehicles or trailers in current units. This system must be capable of being towed by currently available unit vehicles such as the HMMWV.

Key Point Parameters (KPP) taken from the Statement of Work (SOW)

The SOW defined two operational vehicles that are to be operated manually and remotely and made to meet the following Key Point Parameters (KPP):

1. Vehicle speed: 0-6 MPH Threshold (T) 0-10 MPH (Optimum)
2. Operate on paved roads, limited off road, in urban terrain and up to 20% front and side slopes.
3. Total system weight: =<4200lbs (T) <3200lbs (O)
4. Range: 4-hours of continuous operation (T) and 8-hours of continuous operation desired (O).
5. Reach of digging attachment not less than 132 inches
6. Digging depth of not less than 36-inches (T) 72
7. Provide removable integrated payloads to support remote clearing of suspected explosive devises as follows: 16-inch regular bucket, grabbing and lifting device, and ripper blade.

8. Provide a system to conduct high-speed transport of the digging equipment by Government provided equipment such as a HMMWV or similar system.
9. Shall present a system to demonstrate and access changeover from manual to remote operations of the vehicle. Such tasks include but not limited to:
    a. Remote system start
    b. System steering
    c. System brakes
    d. System speed control
    e. System payload control
    f. Emergency stop functions

MANUFACTURING PROCESS

A commercial model was selected as the operation vehicle based on the KPP weight requirement. Changes required to the commercial design by the KPP under the SOW were implemented by using existing components or components that can easily be made at Terramite's facility. Purchased parts are COTS items that were easily implemented into the monocoque frame assembly. Changes made to the commercial vehicle to meet the KPP for the RCIS are listed:

1. Vehicle speed was increase by replacing the closed loop hydraulic propulsion system with an open loop singular pump system. In addition the drive motor was resized for optimum speed and torque.
2. No changes were needed to allow the vehicle to operate on paved, limited off road, and in urban terrain with up to 20% side and front slope.
3. Modifications were required to the arm, front bucket, and rear backhoe assemblies to keep the system weight within the limit defined.
4. Existing fuel tank capacity allowed the vehicle to be operated in excess of 8 hours of continuous testing.
5. Modifications were required to the backhoe assembly to allow the full reach requirements.
6. No modifications were required to meet the (T) level. Actually testing shows that the unit will dig in excess of 80-inches.
7. No modifications were required to allow quick replacement of the rear bucket, grabbing and lifting device and ripper assemblies.
8. Modifications were required to the front and rear axle assemblies to allow the vehicle to be towed, without a trailer, at speeds up to 35 MPH. Changes also made to the front bucket assembly to allow attachment of the NSN tow bar assembly.
9. A fully functional Operator Control Unit (OCU) was installed do allow the following functions to be performed at a distance to 300m.
    a. Remote system start
    b. OCU unit ON/OFF, and frequency change
    c. Engine RPM control
    d. Vehicle lights, front and rear
    e. Parking brake, On/OFF

f. Travel speed, HIGH/LOW
g. Emergency stop (OCU shutdown)
h. Outrigger assembly, UP/DOWN
i. Backhoe/loader, MODE
j. Joystick control, Travel (Forward-Reverse). Arm control (Dump-Load)
k. Joystick control, Steer (left-Right), Front Bucker control (Load-Dump)
l. Joystick control, Boom (UP-Down), Swing (left-right)
m. Joystick control, Crowd (Up-Down), Rear Bucket (Curl in-Curl out)

The OCU is a Controller Area Network (CAN) with a Digital Control System (DCS) that has high repeatability using digital inputs. The CAN system reduced the wiring and complexity, allowing redundant safety features, and allowed components to be preprogrammed and then be plugged in. The User programmable controller allowed the exact application need and provided ease of modification if needed with software programming. The modular system allowed components to be added, thus changes where made quickly as needed. On-board diagnostics consists of a controller LED with fault codes that are set for specific functions. Serviceability and diagnostic tooling can be implemented and changed with laptop computer system software.

ON-SITE TEST SUMMARY

Initial meeting presented to the Test Soldiers by FLW staff was that IED systems are becoming more sophisticated. IED weapon systems are being buried deeper and placed under heavy loads, thus making it very difficult if not impossible for current IED detection/deletion systems to expose the threat. Current small robotic systems, which weigh less than 150 pounds, cannot lift these heavy weights, nor dig down to expose the bombs. The next robotic system in place is that called Buffalo, which weighs over 44,000 pounds. This vehicle can perform the functions but its size is a limiting factor in many applications and uses.

The RCIS system would serve as an immediate tool to assist these two existing systems, and thus assist our Soldiers to detect and delete IEDs.

Over the test period both units performed very well and met each of the KPPs. Neither machine failed to operate. Nothing had to be replaced, nor broke (other than the boom chain due to operator error). Each machine is in excellent condition, so much so that if the units were touched up and thoroughly cleaned each would look like a new unit.

PROJECT IMPROVEMENTS (Recommended)

The SOW and KPP were met by the initial design. From on-site testing additional improvements were recommended. Listed are these recommendations:

Recommended: To tell if engine is running
Solution: Installation of strobe light on vehicle that activates when engine stops

Installation: Installed on RCIS vehicles at end of 2nd day of testing.

Recommended: To tell if radio signal is lost
Solution: Installation of light signal system on vehicle
Installation: Attach light on vehicle that turns off if signal is lost. Was discovered that the work lights serve this function.

Recommended: Vehicle RPM indicator attached to the OCU
Solution: Modification to the OCU to allow a RPM LED indicator gauge
Installation: Would require new OCU unit, also vehicle would need transmitter and receiver to send signal to OCU

Recommended: Difficulty steering unit with current joystick configuration
Solution: Place both vehicle forward/reverse and steering on same joystick function
Installation: Reconfigure the CAN system, replace the OCU control panel, and reprogram software.

Recommended: Need for steering wheel positioning indicator
Solution: Replace current steering cylinder with cylinder that has in place direct current liner variable differential transducer (DC-LVDT) with signal generator, with modifications to the OCU to allow operator to tell front wheel position.
Installation: Have cylinder system made, with changes to the OCU and operational software.

Recommended: To determine the outrigger (stabilizers) position
Solution: Place tandem DC-LVDT with signal generator to allow outrigger position to be displayed on the OCU.
Installation: Have cylinder system made, with changes to the OCU and operational software.

FLW-Robotic senior staff asked what are three things that could quickly be added to the design to improve its performance based on our observations of the vehicles performance, test environment, and operators. These are listed below:

Recommended: Difficult to operate the vehicle in tow mode if the NSN tow bar is lost
Solution: Modify the front bucket assembly to allow the tow bar to remain with the RCIS, or make a tow bar that is unique to the vehicle, but cannot be removed.
Installation: Easy modifications can be made to the front bucket assembly to keep the NSN tow bar with the vehicle. This tow bar can be modified such that it cannot be taken from the RCIS.

Recommended: Serviceability of the grease points
Solution: Replace all grease points with greaseless bushings
Installation: Can quickly be done using COTS components. Doing so will greatly reduce the service requirements of the vehicle.

Recommended: Probability of flat tires.
Solution: Have installed in each of the tires a run flat compound
Installation: Can quickly be done using COTS products.

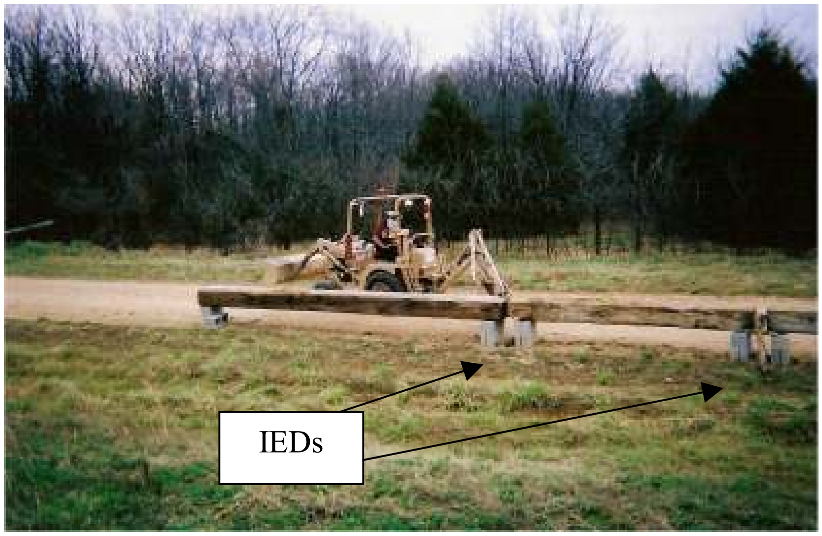
Machine clearing a rubble pile that is blocking the road.

Note: The base Safety Officer required someone to sit in the vehicle during testing. This person did not control the vehicle. His primary function was to stop the vehicle if it lost its radio signal and became erratic. The vehicle never required the operator to stop it.

Machine searching and finding an IED by roadside rubble pile

Machine searching a damaged building for IEDs at night

Machine searching in a culvert/drain pipe for IEDs



Machine searching for IEDs along a guardrail.
Note: two IEDs are shown between the blocks.

Machine searching for IEDs placed in a parking lot at night.

Machine shown attached to a HMMWV, with test team

Test team shown with Base Commander, Major Castro (full right), and, Brigadier General Johnson (full left).

Note: The 2nd and 6th Soldiers from the left have returned from Iraq. The Soldiers in gear, 5th and 7th from left, are going to Iraq.