

**IMPROVING SAFETY OF OFF-HIGHWAY TRUCKS THROUGH USE OF RTK GPS AND  
WIRELESS COMMUNICATIONS NETWORKS  
(RP-6)**

| Year      |                            |   |
|-----------|----------------------------|---|
| <b>-2</b> | <b>Planned deliverable</b> | Literature search on GPS and wireless Communications Networks; Research Niosh accidents statistics<br>GPS and Radio Equipment acquisition ; Software Development and testing at the CSM Labs  |
|           | <b>Achieved</b>            | Literature search on GPS and wireless communications networks identified the players and available technologies<br>NIOSH accidents statistics supported the reasons for undertaken the research<br>Three Trimble RTK GPS receivers and three 900 Mhz. radio communication equipment are purchased. GPS base station is installed at the Brown Building<br>Initial version of the software is developed in Visual Basic<br>Initial test of the concept and software was carried out at the CSM laboratories  |
| <b>-1</b> | <b>Planned deliverable</b> | The Dump Edge Proximity Warning System Software development in Visual Basic and Virtual Reality Mark Up language<br>Additional equipment acquisition for the field testing to be carried out at the operating mines<br>Field tests at a quarry and a metal mine   |
|           | <b>Achieved</b>            | Fully functional Dump Edge Proximity Warning System software is developed to work with two different wireless communication network protocols and Differential GPS receivers from Trimble and Caterpillar. The wireless communication systems are based on TCP/IP networking protocol. One protocol is 2.4 G. Hertz 802.11B technology with bandwidth of 11 Megabits per second. The other is 900 megahertz Trimble proprietary technology with a bandwidth of 56K bits per second.<br>The hardware and software system is tested at Holnam’s Portland Cement Quarry and Phelps Dodge Morenci Copper Mine under rugged operating conditions.<br>Tests were documented. The system functioned well under the test conditions and the results received very favorable reviews from the operators.   |
| <b>0</b>  | <b>Planned deliverable</b> | Further tests and refinement of Dump Edge Proximity Warning System and integration of that technology into development of Vehicle Collision Avoidance System.   |
|           | <b>Achieved</b>            | Fully functional Dump Edge Proximity and Collision Avoidance System is developed and beta tested. Initial tests are carried out at the CSM Survey field, Phelps Dodge Corporations Morenci Open Pit Copper Mine in Arizona, and Holnam’s Porland quarry near Colorado Springs. The system was tested at the Morenci mine by installing the developed system on multiple vehicles including a 793 Cat truck . The dump edge mapping was performed by using a vehicle simulating a dozer and this information was transferred wirelessly to the truck to check the viability of the dump edge proximity warning system. The mine management in these operations were impressed with the tests results. The results also are all documented and published in the form of a Ph.D. dissertation and two conference papers. The dump edge proximity warning system was also modified to be used as vehicle collision avoidance system. The initial preliminary tests were carried out in the lab and also in an operating mine. These test indicate significant potential in this technology. Wireless network was designed and new testing methodology was developed for extensive testing of the system at an operating quarry under day to day working conditions. A journal publications was prepared For IJSME. The hardware to establish a complete wireless network at an operating quarry has been acquired and built. Wireless networking software is designed and implemented into existing Virtual Mine software. Two GPS receiver equipment along with radio antennas are installed on the operating trucks Lafarge Quarry. The developed wireless network hardware and software was tested at Lafarge Quarry near Golden with success. |

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| <b>1</b> | <b>Planned deliverable</b> | Deployment of the developed technology into selected operating mines for reliability tests under scientific conditions for extended periods of time involving multiple vehicles.<br>Integration of the developed system with other technologies such as radar and RF recognition systems into a reliable product that will prevent injuries and fatalities in the focused areas   |
|          | <b>Achieved</b>            | Currently reviewing the ruggedized equipment available for purchase and mine site implementation. The system design is modified to accommodate actual field conditions at an operating aggregate quarry for collision avoidance system checks to prevent possible injuries and fatalities during the poor visibility conditions. The wireless network hardware parts are purchased and being put together for implementation in the quarry for full scale system tests. The system is also being re-designed to accommodate PDA's for recognition of humans within a certain proximity of trucks. |
| <b>2</b> | <b>Planned deliverable</b> | Deployment of the developed technology into selected operating mines for reliability tests under scientific conditions for extended periods of time will continue. The test and development of the system with respect recognizing PDA's carried by workers within the proximity of a given vehicle will continue.<br>Integration of the developed system with other technologies such as radar, RF and Stereo Vision will also be investigated such that a reliable product that will prevent injuries and fatalities in the focused areas becomes a reality.                                    |
|          | <b>Achieved</b>            |   |