

Projektkronym

WROOMM

Projektnamn

*Wireless and remote
operation of mobile machines*

1 Projektfakta

Total projektbudget: 9.9 MSEK

Sökt belopp från VINNOVA: 4.95 MSEK

Sökande organisation: Luleå tekniska universitet

Projektledare:

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Projekttyp: FUI-projekt

Fokusområde: Anläggningstillgänglighet

Projektperiod: 2014-09-01 – 2017-08-31

2 Projektets idé

The idea of the project is to develop and demonstrate concept solutions for tele-remote controlled operation for underground excavation and truck loading with bigger-sized wheel-loaders, as well as efficient tele-remote monitoring of such machines. This is to achieve better facility availability and process efficiency by enabling excavation and loading on trucks directly after blasting and during ventilation when personnel cannot work underground. The idea is further to use obtained findings in the wider scope of smaller wheel-loaders for general construction work, aiming for improved efficiency and safety in other applications where wheel-loaders are used.

The problem addressed is how to use available knowledge about issues and challenges in tele-remote controlled excavation and loading with specialized LHDs to define and develop efficient tele-remote control and monitoring concept solutions for more general wheel-loaders and targeting different but related tasks. Part of this problem is how to obtain good-enough wireless communication, operator station integrated training and machine monitoring and maintenance.

The particular issues addressed are the following:

- What extended operator feedback for tele-remote controlled excavation is needed to improve the bucket filling targeting comparable efficiency as for local operation, and how can this feedback be used for operator training of tele-remote operation?
- How should control algorithms use bucket positioning sensors and force measurements for operator assistance targeting improved safety and efficiency?
- How should available wireless protocols and mechanisms for end-to-end communication be combined and tuned for efficient and robust messaging with best achievable performance for tele-remote control and monitoring of mobile machines?
- What information from mobile machines should be presented to process operators and maintenance staff, partly in machine vendor systems and partly in the industry control system (ICS) for best overall process efficiency?

The approach of the project is to address the issues in the context of a use case defined for the project on underground excavation and loading on truck. The project partners make available mobile machines, ICS, a control station and locations for development and demonstrations to this use case.

Deliverables of the project are concept solutions and demonstrations, documented requirements on tele-remote control and communications, recommendations for how to improve end-to-end communications, and system analysis. Deliverables are made in three phases, stepwise moving forward improving applicability, maturity and refinement. The industrial partners Volvo CE, Boliden and ABB are together the main receivers of these deliverables, which constitutes input for strategic decisions on product plans and product development based on findings of this project.

3 Projektets bakgrund

The use of construction machinery is broad; certain machines - especially load carrying machines - are commonly used in industrial process applications. Early attempts to integrate and automate Load Haul and Dump machines (LHDs) in the process has been done by LKAB in the Kiruna mine in the 1990's and the 2000's where the iron ore was transported by semi-automatic tele-remote controlled loaders in the underground mine.

Subsequent investigations have pointed out the potential for improved efficiency with the integration of mobile machinery in process industrial applications ("Mobile and Connected" - Vinnova Analysis 2013 05). The assessment is that the next evolutionary step is to go from local isolated systems at the machine level to the systems where the mobile machine is an integral part of the process, including tele-remote operation and monitoring.

Automatic and/or operator assisted excavation relates to the research field "autonomous earthmoving". A wide overview of the subject with focus on autonomous loading of bulk material including on-going research activities is found in Hemami and Hassani (2009) "An overview of autonomous loading of bulk material", 26th ISAR 2009:405-411, where the authors conclude (p. 409) that "the subject still demands further work and funded research" and that "strong industry support can speed up the process".

Communications in mines are now moving from multiple and dedicated networks to multi-service approaches for wired and wireless connectivity. While being beneficial for automation since connectivity becomes more ubiquitous, this development also pose problems due to the unpredictable nature of many currently deployed multi-service networks. Ensuring sufficient quality of communications is hence essential for successful tele-remote operation, monitoring and automation, for many if not all mining companies.

4 Projektets bidrag till utlysningens mål

Deliverables of the project aims at providing findings that raise the tempo at which tele-remote controlled and monitored mobile machinery become increasingly used in underground mines for better facility availability and thereby higher production of ore per hour. In medium to longer term, this is expected to lead to wider use of tele-remote controlled machines and fully autonomous operation of such machines.

The competitiveness for involved industrial partners is expected to increase. Boliden's increased competitiveness will come from improved site effectiveness through better

capacity in excavating, loading and transporting ore from its underground mines. Volvo CE will benefit from both demonstrable solutions in underground mines to gain market share and in developing efficient solutions for tele-remotely operated and monitored wheel-loaders. ABB's increased competitiveness will come from integration with Volvo CE for tele-remote operations and monitoring for maintenance, and Oryx will strengthen its position as supplier of control stations for training and extend their business with Volvo CE as supplier of control stations for tele-remote controlled wheel-loaders.

The project will hence contribute to solutions for the Swedish process industry and its suppliers by developing knowledge that leads to increased capabilities for innovations in the area of process IT and automation systems for mining site operations as well as the wider use of construction vehicles and machines.

5 Projektets aktörskonstellation

Boliden will make available a test site in an underground mine and also contribute with requirements from an end-user perspective on the remote control and monitoring system. The use case addressed by the project is directly related to this test site, which means that Boliden will be the host for testing and demonstrations of the project deliveries.

Volvo CE will make available to the project at least one wheel-loader, an L110G, and one simulator platform adapted for tele-remote operation, acquired from Oryx. Also, they will offer expertise in controlling their wheel-loaders as well as provide interfaces to ABB for monitoring vehicle status. This equipment will be used for testing and demonstrations, firstly at off-site locations made available by LTU and later in the project at the test site provided by Boliden.

ABB will contribute to the project with the integration with Volvo CE machines of the monitoring system in the 800xA system in the Boliden test mine as well as contributing with requirements on functionality and user aspect of the tele-remote control station.

Oryx will contribute to the project with method development of the simulator platform to function as a remote operator station for wheel-loaders as well as a platform for training and testing during development.

LTU will contribute with expertise related to the research areas; Dependable Communication and Computation Systems, Industrial Electronics, Embedded Systems and Control Engineering. LTU will coordinate and lead the project, and be responsible of work packages on driver assistance and communications.

SICS will contribute by system analysis and implementation of new concepts for IT systems in an integrated mine IT environment. SICS will be responsible of a work package on monitoring and maintenance.