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Viable Alternative Mine Operating System: A novel underwater robotic excavation system for flooded open-cut mines.

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Abstract

The ¡VAMOS! Project (Viable Alternative Mine Operating System) is developing a novel underwater excavation system to test the technological and economic viability of the mining of inland mineral deposits in flooded open-cut mines, currently uneconomic using conventional methods. A floating launch and recovery vessel has been built, and in July 2017, work will be completed on a remotely-operated underwater roadheader and robotic assistance vehicle. After completion, the first of two European trials will commence. During these trials, the road-transportable system will be tested on a range of rock-types and its technological and economic viability and socio-environmental impact will be analysed.

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1. Introduction

¡VAMOS! (Viable Alternative Mine Operating System) is a 42-month international project which began in February 2015 and is part-funded through Horizon 2020 (Grant Agreement 642477), the European Union's framework programme for research and innovation. The project consortium is developing a multi-component mining robotics system to test the technological and economic viability of the underwater mining of inland mineral deposits located in flooded open-cut mines. If the technique is proven viable, ¡VAMOS! will enable access to deposits whose excavation has been historically limited by stripping ratio and hydrological and geotechnical factors.

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Advantages of the ¡VAMOS! solution include:

- *Simple transportation:* The LARV, the largest system component, is modular and can be disassembled into multiple sections which can be transported by road together with the other system components.
- *Quick implementation:* Its self-contained power generation system and road-transportable modules mean that ¡VAMOS! can be used in abandoned remote mines with poor infrastructure, without needing to commission significant preliminary civil engineering works.
- *Potentially cheaper mining operations:* The transition to an underground mining strategy can lead to high capital expenditure and downtime, and in addition, in areas of high tectonic stresses, it might not be possible to open an underground mine. ¡VAMOS! could offer another way for open-cut mines to remain in production as they approach their economic limit.
- *Safer mining operations:* Less personnel will be exposed to high risks in the pit such as sidewall collapse and blasting.
- *Mitigation of hydrological limitations:* As the water level within the pit should remain constant and the system operates underwater, there will be no aquifer drawdown and no need to remove water ingress. ¡VAMOS! therefore offers a cheaper solution for mines with high dewatering costs and environmental penalties and restrictions.
- *Less environmental and social impact:* With ¡VAMOS!, the environmental footprint of the mine is significantly reduced by the absence of blasting noise and vibrations and equipment noise, in addition to the preservation of high air quality due to rock dust being contained within the pit.

By demonstration of a safe, silent, clean and low-visibility system, the ¡VAMOS! Project hopes to encourage investment in abandoned and prospective EU mines by providing an alternative and more cost-effective excavation technique, ultimately aiming to reduce the EU's reliance on strategically important raw materials imports. Following a design freeze in October 2016, work is set to be completed on all system components and software by July 2017, shortly before the first European field trial in 2017 in England. Post-trial microeconomic, environmental and strategic foresight analyses will guide the future development of the technology vision.

2. Background

2.1. Horizon 2020 (H2020) Application

The original 18-member ¡VAMOS! Consortium applied for a Horizon 2020 Research and Innovation Grant to address 2014-2015 H2020 Work Programme no. 12, entitled 'Climate action, environment, resource efficiency and raw materials.' Under Work Programme 12, the consortium was granted 9.2 Million Euros in European funding to address Societal Challenge 5-11a (SC5-11a-2014), 'Mining of small and complex deposits and alternative mining', a sub-category of Societal Challenge 5-11 'New solutions for sustainable production of raw materials' [1].

2.2. Motivation

With Europe having been mined over many centuries, and in certain localities, millennia, many easy-to-access mineral deposits are depleted. Major opportunities to extract raw materials within the EU lie at greater depths, in remote areas, abandoned mines, and in smaller deposits [2]. It is estimated that the value of unexploited EU mineral resources at 500-1,000 metres depth approximates to 100 Billion Euros [3]. Currently accounting for only 3% of the world's ore production whilst consuming approximately 30% of the world's metals production, the European Union has a high reliance on imports of many common and strategically important minerals. As an example, EU mineral use includes an import dependence on ~90% of copper ore to up to 100% of certain rare earth elements and platinum-group metals [4]. In response to more technically challenging EU deposits being abandoned and EU mineral needs being met by imports, H2020 funds were awarded to ¡VAMOS! to develop a novel inland mining

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