

# Towards a Prototype Low-Cost/ Multi-Rf Based Positioning System for Underground Marble Quarry Management: Design Considerations and Preliminary Results

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## SUMMARY

Current activity at marble mining sites relies extensively on arbitrary, case dependent and, to certain extent, manually-based systems and procedures. Such systems focus on recording and updating machinery utilization and maintenance needs aiming solely for the purpose of reducing down-time due to unexpected failures. As a result, inherent limitations in the traditional supervision systems and procedures: (a) underpin the potential of operations productivity, (b) confine the improvement of safety and security conditions, while (c) minimizing quarry environmental footprint reduction.

Nevertheless, as the underground quarry industry makes a rapid shift towards digitization and automation, the provision of related positioning information in an accurate and robust manner is increasingly important for maximizing the benefit of related life-cycle operation management systems. Evidently, underground marble quarry operations can benefit using accurate positioning data, enabling real-time tracking of personnel and equipment. INSPIRER® project aims at setting the foundations for the development of an innovative management system for the integrated supervision of marble quarries based on Geo-location, IoT (Internet of Things) and BI (Business Intelligence) techniques.

In this study, as part of the overall project, an underground positioning system based on multiple radio frequency (RF) technologies and dedicated signals of opportunity (e.g., Wi-Fi, Bluetooth and/or LoRa) is designed, developed and tested. Key design considerations and system development aspects are presented both in terms of equipment justification, assembling and operational functionalities (hardware), as well as adopted positioning techniques (software). Moreover, this study provides an overview of the specific requirements sought in marble quarry machinery (i.e., cutting machinery, loaders), gateway characteristics and personnel, followed by the analysis of the developed data processing methodologies and the positioning techniques.

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Preliminary evaluation of the performance of positioning system under controlled environment provides valuable feedback for the refinement of the proposed system including guidance of the on-site system installation. Early testing of the system suggests that the proposed methodology relying on combined positioning techniques (e.g., multi-lateration, fingerprinting, etc.) and low-cost multi-sensor tools may provide more robust solutions over single-based technological approaches leading to precision in location better than  $\pm 6$  m for 80% of the time.

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