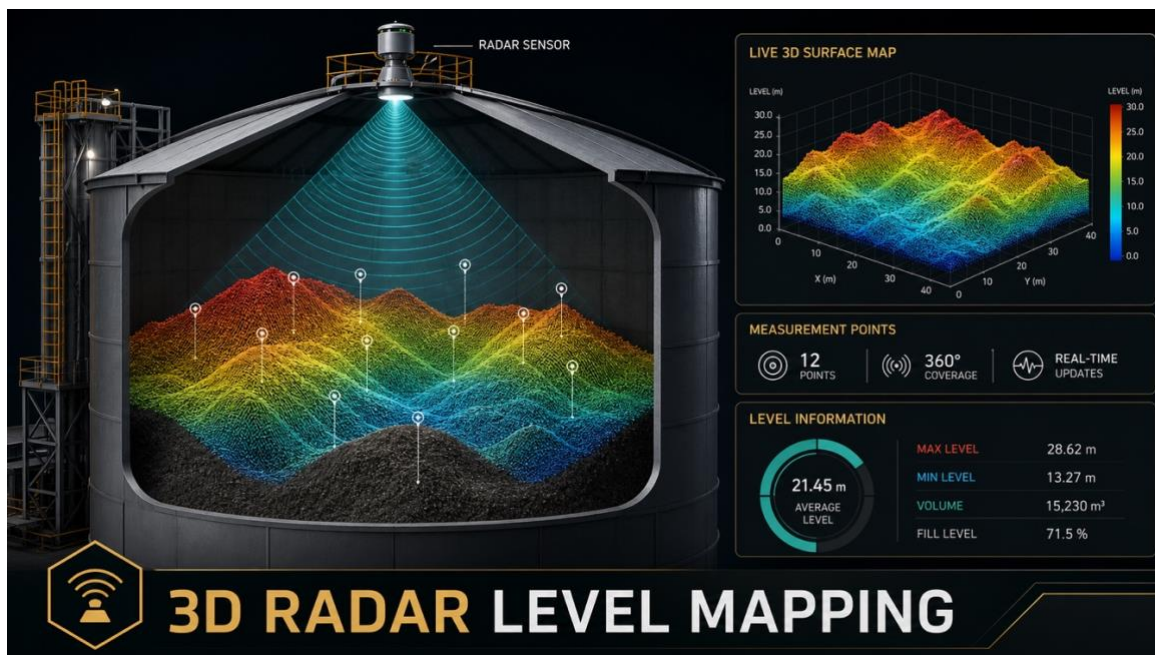


TOWARDS AN ADAPTABLE RADAR-BASED SENSING SOLUTION FOR HARSH INDUSTRIAL ENVIRONMENTS

Concept note – Robust radar sensing for quarries, mines, and industrial process sites



INTRODUCTION

Industrial sites such as quarries, mines, bulk storage facilities, process plants and other demanding operating environments require reliable sensing solutions to monitor activities, materials and safety-critical situations. In such contexts, visibility is frequently degraded by dust, fog, steam, splashes, darkness or strong lighting contrasts, while access to the sensing area is often constrained by explosion risks, high temperatures or structural limitations.

Camera-based systems are effective in controlled, well-lit environments. However, their performance degrades significantly when the optical path is obstructed, when lighting conditions are extreme, or when the scene is subject to rapid environmental changes. In these situations, operators need sensing technologies that remain effective regardless of optical visibility — and that deliver actionable outputs rather than raw imagery.

Radar addresses these challenges directly. It propagates through dust, smoke, fog and darkness without degradation, operates without any contact with the monitored medium, and can be processed to extract quantitative information about the sensed environment. Combined with dedicated signal processing, radar enables reliable sensing for a range of industrial applications: personnel presence detection, level measurement in silos and tanks, and material characterization.

SDR-Engineering proposes a solution in which the radar hardware is designed and mastered in-house, and the signal processing is developed specifically for each targeted application. This end-to-end control — from the sensor to the exploitable output — guarantees performance, flexibility and adaptability to real industrial constraints.

In a nutshell, the proposed solution allows operators to:

- | Deploy a robust sensing capability in harsh and constrained environments where optical sensing reaches its limits.
- | Obtain application-specific outputs — presence alerts, level estimates, material signatures — through ad hoc processing developed by SDR-Engineering.
- | Integrate the solution into existing industrial architectures, with edge or centralized data delivery according to operational needs.

DETAILED CONCEPT

In this setup, one or several radar units are installed on the industrial site according to the geometry of the monitored area and the operational objective. Depending on the use case, the radar may be positioned to supervise an access zone, observe a transfer point, monitor the filling level of a storage vessel, or analyse the dynamics of a material flow.

Personal presence and safety monitoring

The radar detects the presence, movement and persistence of persons in defined zones, regardless of visibility conditions. This capability is particularly relevant in hazardous areas, restricted zones or poorly illuminated environments where camera systems become unreliable. The processing can be tuned to differentiate humans from machinery or background clutter, enabling reliable alarm generation and operator protection.

Level measurement in silos and tanks

The radar is pointed at the surface of stored material — whether solid (grain, ore, aggregate, powder) or liquid — and the processing derives an accurate level estimate from the measured time-of-flight and signal characteristics. The approach is contactless, unaffected by dust clouds above the material surface, and adaptable to a wide range of vessel geometries. The illustration below shows a typical configuration for a silo.

Material characterization

At a more advanced level, the radar return signal carries information about the physical properties of the target medium — its surface roughness, dielectric characteristics and dynamics. SDR-Engineering develops processing algorithms that extract discriminating features from these signals, enabling material classification, flow regime detection or anomaly identification, depending on the application.

In all cases, the processing is implemented on embedded computing resources co-located with the radar, enabling edge analysis and the transmission of only the relevant, processed information to the supervision system. This architecture reduces unnecessary data transfer, improves system responsiveness and simplifies integration into existing industrial networks.

A system engineering study is conducted to define the most appropriate radar configuration, installation approach and processing chain, based on the customer's requirements and the realities of the site.

Offering	Description
Radar hardware	Radar platform designed and mastered by SDR-Engineering, adaptable in frequency, waveform, antenna and integration format.
Application processing	Ad hoc signal processing algorithms developed for each use case: presence detection, level estimation, material characterization.
Field study	Pre-deployment assessment of site constraints, installation options, coverage geometry and integration requirements.
Edge integration	Embedded computing layer for on-site data processing and interface to supervisory or IoT systems.
Maintenance & support	Long-term hardware and software support, recalibration, algorithm update and performance improvement based on operational feedback.

Advanced processing developments combine deep physical understanding of the monitored environment with real-time embedded software. This enables intelligent edge computation — anomaly detection, clutter mitigation, false alarm reduction — directly within the sensing unit, without dependency on cloud connectivity.

CONCLUSIONS

The proposed solution is designed as a robust and adaptable radar-based sensing architecture for harsh industrial environments. It is particularly suited to situations where dust, darkness, atmospheric disturbance or hazardous operating conditions limit the relevance of optical approaches.

By mastering the radar hardware and developing the associated processing in-house, SDR-Engineering delivers application-oriented performance rather than generic sensing. The solution is inherently modular and can be tailored to a broad range of industrial needs — from personnel safety to process control — while remaining integrable into existing site infrastructure.

Its open and adaptable architecture, combined with SDR-Engineering's expertise in radar signal processing, makes it a reliable and future-proof choice for industrial operators seeking robust sensing in the most demanding environments.



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