Formula 1

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Formula 2

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Formula 3

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Related Content

Title	Type	Slug
Blast Design Excel Template v4.2	resource	blast-design-excel-template
Drill Rig Maintenance Inspection Checklist	resource	drill-rig-maintenance-checklist
Rock Mass Rating (RMR) Field Survey Sheet	resource	rmr-field-survey-sheet
Drilling Energy Benchmarking Dashboard (Power BI)	resource	drilling-energy-dashboard
TBM Advance Rate Prediction Curve Library	resource	tbm-advance-rate-library

Detailed Explanation

Sensor fusion in mineral exploration and grade control demands rigorous cross-sensor calibration to overcome fundamental differences in measurement physics, resolution, field-of-view, and environmental sensitivity. LiDAR provides high-fidelity 3D topography and surface geometry but no compositional information; hyperspectral imaging delivers continuous reflectance spectra (400–2500 nm) enabling mineral identification via spectral absorption features; XRF yields quantitative elemental concentrations (e.g., Fe, Cu, Zn, Si) but with limited penetration depth (~10–100 µm) and coarse spatial sampling. The protocol establishes hierarchical calibration steps: (1) geometric registration using shared fiducial targets and iterative closest point (ICP) or bundle adjustment; (2) spectral radiometric correction via reference panels (e.g., Spectralon®) and atmospheric compensation (e.g., QUAC or FLAASH); and (3) XRF signal calibration against certified reference materials (CRMs) and matrix-matched standards, including dead-time correction, background subtraction, and fundamental parameter (FP) modeling. Crucially, the protocol incorporates uncertainty propagation—assigning confidence intervals to fused voxel-level estimates—and mandates metadata logging (e.g., illumination angle, humidity, integration time, detector temperature) to support AI model training robustness and regulatory auditability. In practice, it enables pixel- and voxel-level fusion where each 3D point (LiDAR) carries aligned hyperspectral bands and XRF-derived elemental abundances, forming a unified 'mineralogical point cloud' used as ground truth for supervised deep learning models that predict ore grade, lithology, or alteration intensity.

Key Components

#	Component
1	Geometric Co-Registration Framework
2	Spectral Radiometric Normalization Pipeline
3	XRF Quantitative Calibration & Matrix Correction

Applications

#	Application
1	AI-powered real-time ore boundary delineation during blasthole logging
2	High-resolution grade control for selective mining units (SMUs)
3	Automated lithological and alteration mapping in drill core scanning systems

Related Concepts

#	Concept
1	Multi-Sensor Data Fusion
2	Geospatial Uncertainty Quantification
3	Mineral Spectral Library Matching

Tags

> mining, geospatial AI, multi-modal sensing