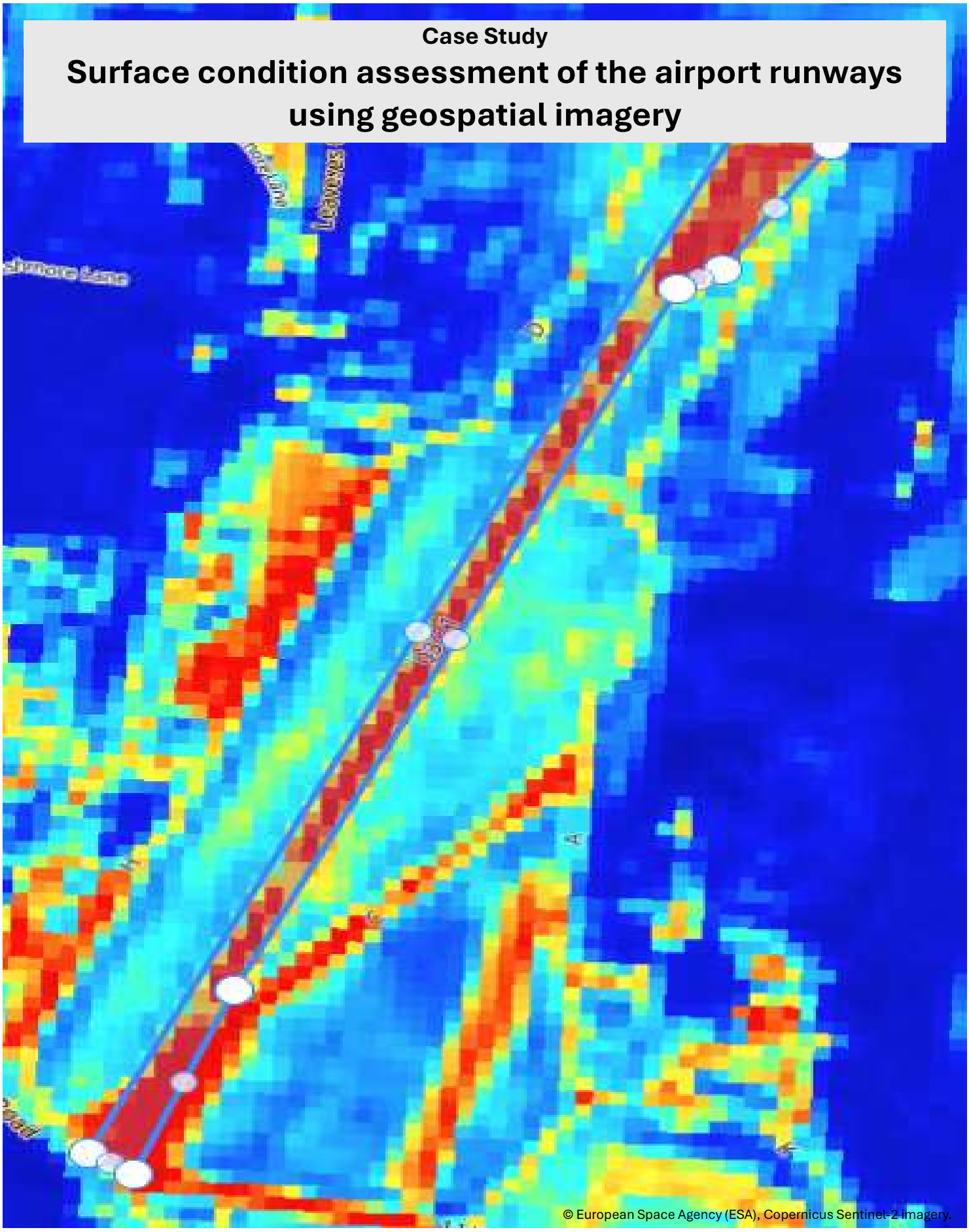
Case Study

Surface condition assessment of the airport runways using geospatial imagery



GEOSPATIAL IMAGERY COMPLEMENTS AND OVERCOMES MANY LIMITATIONS OF MANUAL INSPECTIONS, ESPECIALLY FOR BROAD, FREQUENT, AND LOW-DISRUPTION MONITORING

sequetrics

Surface Scanning for Safe & Efficient Operations

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Summary

Runway surfaces are critical to safe aircraft operations. Over time, runway structure degrades due to aircraft loads, weather, rubber deposits, fuel spills, and environmental factors. Traditional inspections, manual visual surveys and occasional friction testing are effective but resource-intensive, subjective, and infrequent.

Satellites can capture the entire airport and surrounding areas in a single pass, helping identify large-scale issues (e.g., extensive rubber build-up, major surface patching, grass growth, or flooding) that warrant closer inspection. Regular satellite acquisitions allow for time-series analysis to spot changes in surface reflectance, water and moisture retention, colour, or texture, highlighting areas where deterioration may be progressing and prioritising on-site inspections. Importantly, after extreme weather events (storms, heavy rain, heatwaves), satellite imagery can quickly indicate if standing water, debris, or damage is visible before dispatching ground crews. Using satellites for routine, low-frequency scans can help identify which runways or section of runways require UAV or manual inspection, optimising resource allocation. Satellite data can be fused with other localised inspection, imagery, and friction test results to provide a multi-scale, layered understanding of runway health.

The aim of this case study led by Sequetrics team is to present our capability on using geospatial imagery (using Sentinel-2) which can enable accurate and efficient surface assessments, improving runway safety, regulatory compliance, and proactive maintenance decisions.

Challenges

Limited frequency and coverage: Manual inspections are time-consuming and often require partial or full runway closures, limiting how often they can be conducted and reducing the likelihood of detecting rapidly developing defects.

Trend and change detection: Manual inspections does not allow for time-series analysis to spot changes in surface reflectance, colour, or texture in areas where deterioration may be progressing.

Event-triggered assessment: After extreme weather events (storms, heavy rain, heatwaves), manual inspection cannot be used as a quick process and cannot easily indicate standing water, debris, or damage.

Subjectivity and human error: Visual assessments rely heavily on inspector experience and perception, leading to inconsistent results between inspectors and potential misclassification of defect severity.

Operational disruption and safety risks: Inspectors working on active runways needs coordination with air traffic control, increasing safety risks and potentially disrupting flight schedules, especially at busy airports.

Approach

The approach for satellite-based runway inspection involves acquiring high-resolution imagery at regular intervals. Preprocessing steps include atmospheric correction and image enhancement to improve visibility of surface features. Automated change-detection algorithms can identify alterations in surface conditions, flagging areas potentially affected by cracks, rubber deposits, temperature, moisture, flooding, or debris. These flagged sections are overlaid on airport GIS maps and prioritised for UAV or manual follow-up inspections. Machine Learning (ML) models can analyse geospatial imagery to quantify runway surface defects and predict deterioration trends, enabling proactive maintenance and enhancing safety through accurate, data-driven condition assessments.

Impact

Our results showcase the potential of currently possible high-resolution geospatial imagery technology for early detection of large-scale defects, rubber deposits, effect of temperature change, potential location of

undergrowth, or standing water reduces the risk of aircraft accidents caused by compromised surfaces. It enables frequent, broad-area assessments without runway closures, ensuring continuous oversight of runway conditions. It reduces reliance on costly, labour-intensive manual inspections and optimises deployment of UAVs or ground crews for targeted follow-ups. It supports proactive planning by identifying deterioration trends, improving asset management and budgeting decisions.

Challenges	Manual inspection	Geospatial imagery analysis (Sequetrics)
Limited frequency and coverage	Time-consuming and often requires runway closures, limiting inspection frequency and area coverage.	Enables frequent, **wide-area monitoring** without runway closure, increasing coverage and regularity.
Trend and change detection	Lacks capability for time-series analysis; unable to systematically track surface changes over time.	Supports **time-series analysis** to detect changes in surface reflectance, colour, or texture, enabling trend identification.
Event-triggered assessment	Slow and resource-intensive after events; difficult to quickly assess standing water, debris, or damage.	Rapid post-event imagery can quickly highlight affected areas, **enabling prompt response** and targeted follow-up inspections.
Subjectivity and human error	Relies on inspector judgment, leading to inconsistent assessments and possible misclassification of defect severity.	Provides objective, **data-driven analysis** minimising human bias and improving consistency through **automated defect detection**.
Operational disruption and safety risks	Requires coordination with air traffic control; exposes inspectors to runway hazards and can disrupt flight schedules.	Remote sensing causes **zero disruption or safety risk**, as inspections are conducted without any physical runway presence.

Conclusion

Geospatial satellite imagery offers an accessible means to monitor runway conditions. Although resolution limitations may necessitate supplementary data sources for detailed assessments, it provides valuable insights into large-scale surface degradation, enabling timely interventions to ensure aviation safety.

About Sequetrics Limited

Sequetrics Limited specialises in providing innovative solutions for runway infrastructure inspection and maintenance. Focusing on integrating technology and data analytics, Sequetrics empowers clients to enhance safety, efficiency, and compliance across various sectors.

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