Hyperspectral Moisture Detection Coupled with LIDAR Mapping to Characterize R-Reactor Seepage Basin Concrete Cap

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Introduction

Concrete and asphalt cracking in the R-Reactor Seepage Basin Cap poses a risk to the safety, durability, and longevity of the infrastructure.

Figure 1 R-Reactor

Objective

To detect early signs of concrete degradation using drone-mounted hyperspectral imaging for faster, non-destructive structural assessment.

Methodology

Using a drone equipped with the Headwall NanoHP hyperspectral camera and LiDAR sensor package, we captured light reflectance data (wavelengths 400-1000 nm) to detect early concrete damage. The hyperspectral data shows material changes invisible to the eye, enabling identification of cracks and degradation through unique spectral signatures.

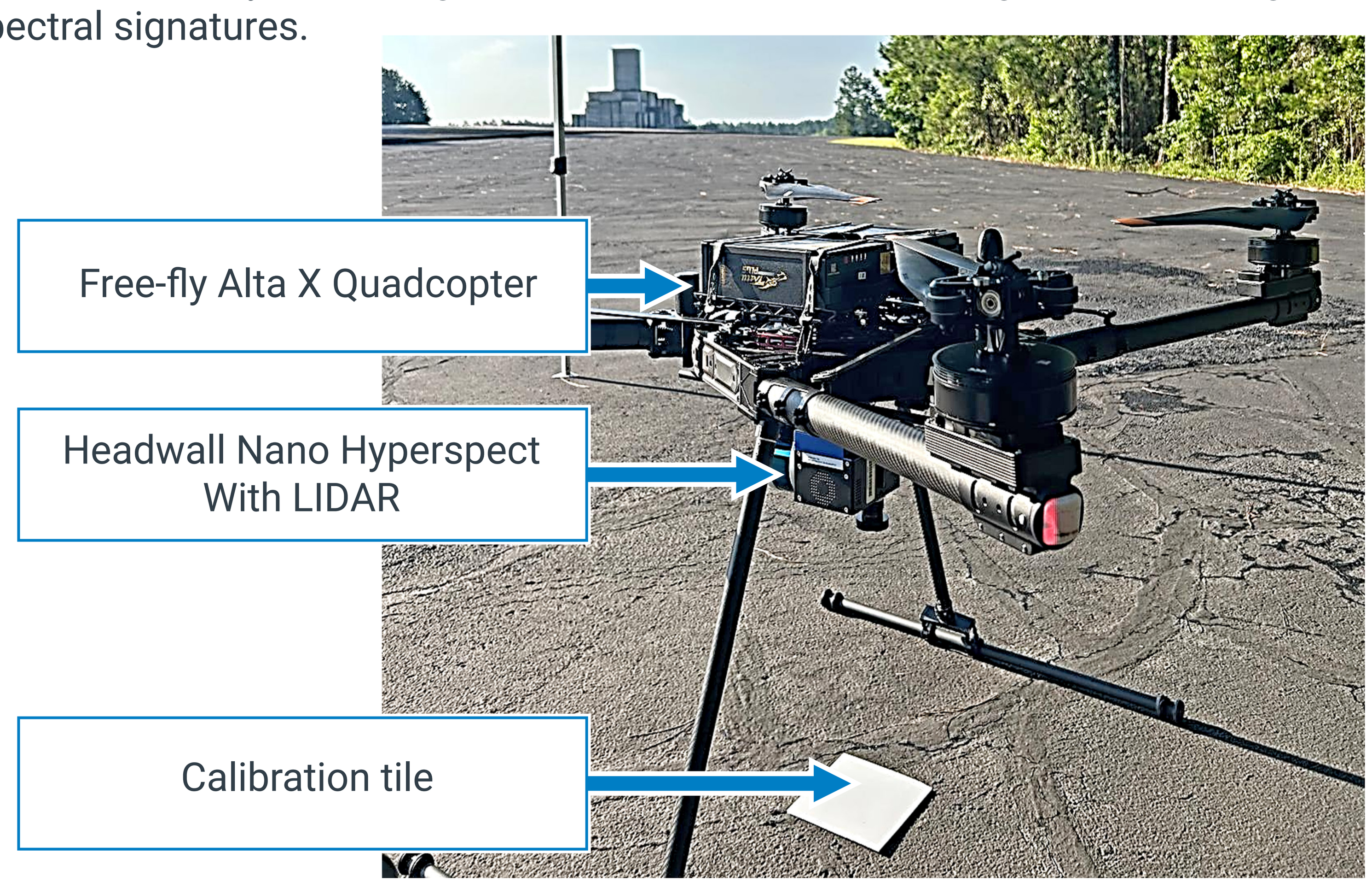

Figure 2. AltaX hyperspectral scan deployment

R-Reactor Seepage Basin Current Condition

Concrete degradation begins microscopically. Cracks introduce spectral anomalies in the 750–950 nm range. These changes are detectable with hyperspectral imaging even before the crack becomes visible.

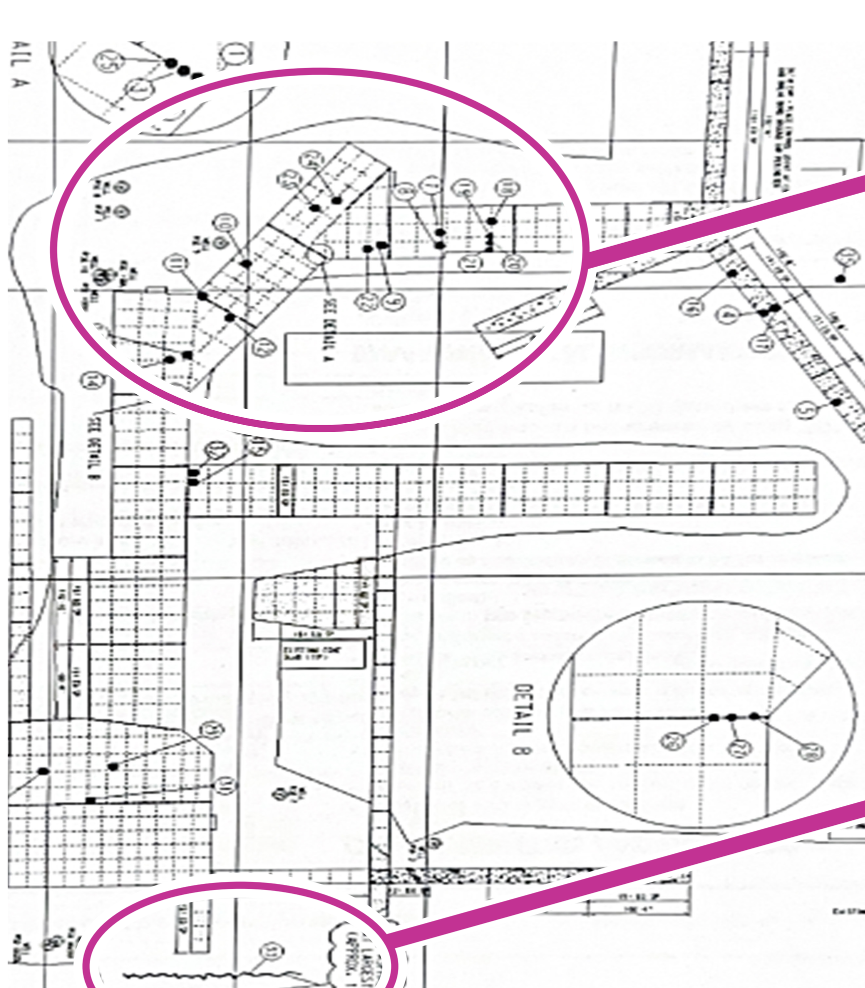

Figure 3. R-Area see page basin repair map

Figure 4. Concrete cracks

Figure 5. Asphalt cracks

Data Collection: Hyperspectral Imaging

Zone 1: concrete scan

Figure 6. Aerial scan of zone 1

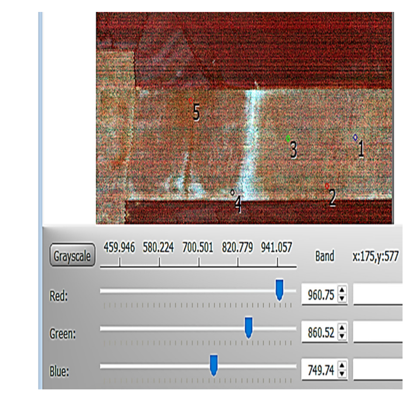

Figure 7. False RGB for Concrete Scanning

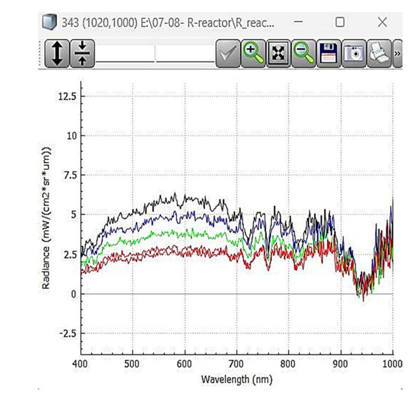

Figure 8. Concrete Radiance vs Wavelength

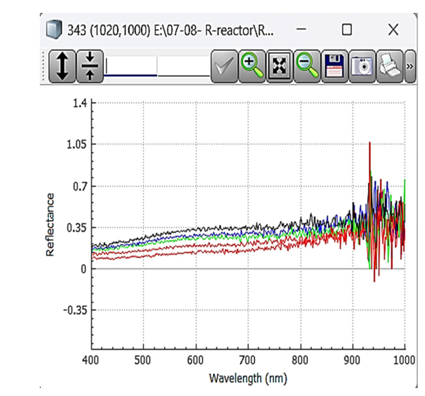

Figure 9. Concrete Reflectance vs Wavelength

Zone 1: Asphalt scan

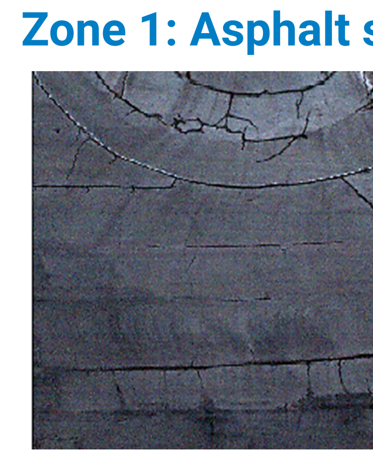

Figure 10. Aerial scan of zone 2

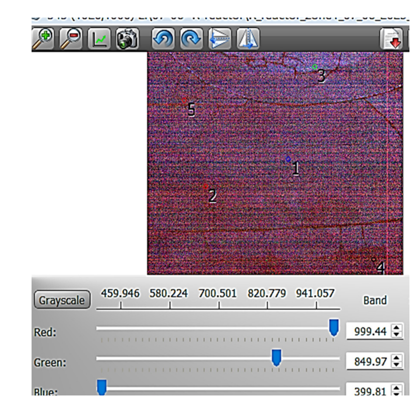

Figure 11. False RGB for Asphalt Scanning

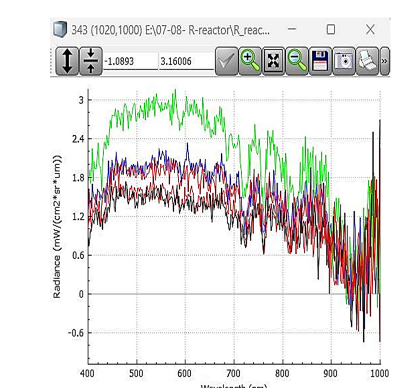

Figure 12. Asphalt Radiance vs Wavelength

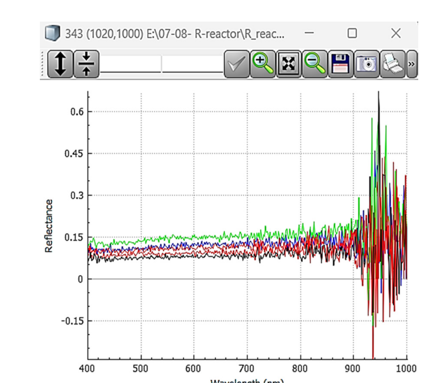

Figure 13. Asphalt Reflectance vs Wavelength

Data Collection: LiDAR

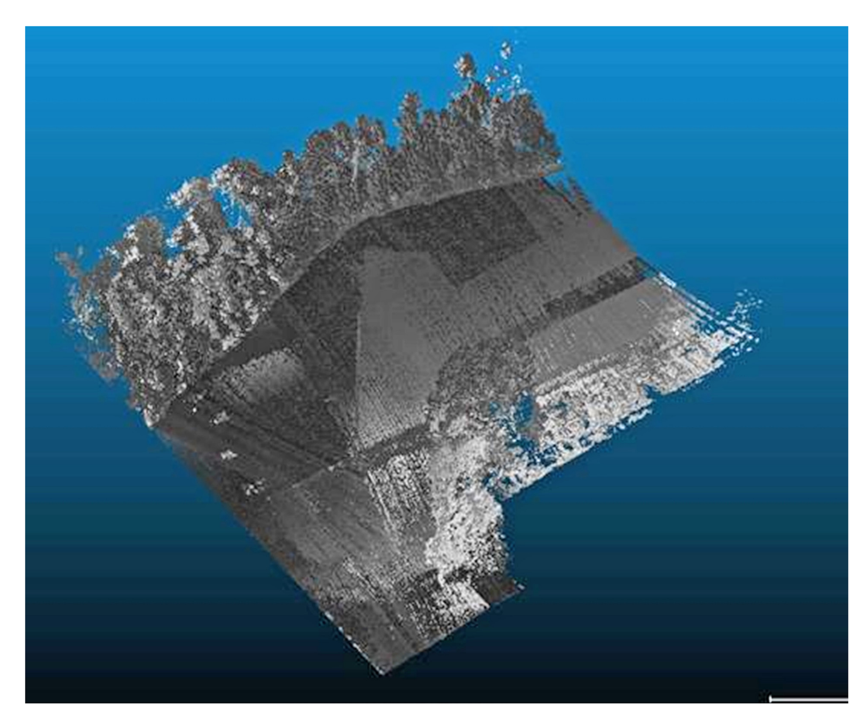

Figure 14. Zone1 Intensity LIDAR Scan

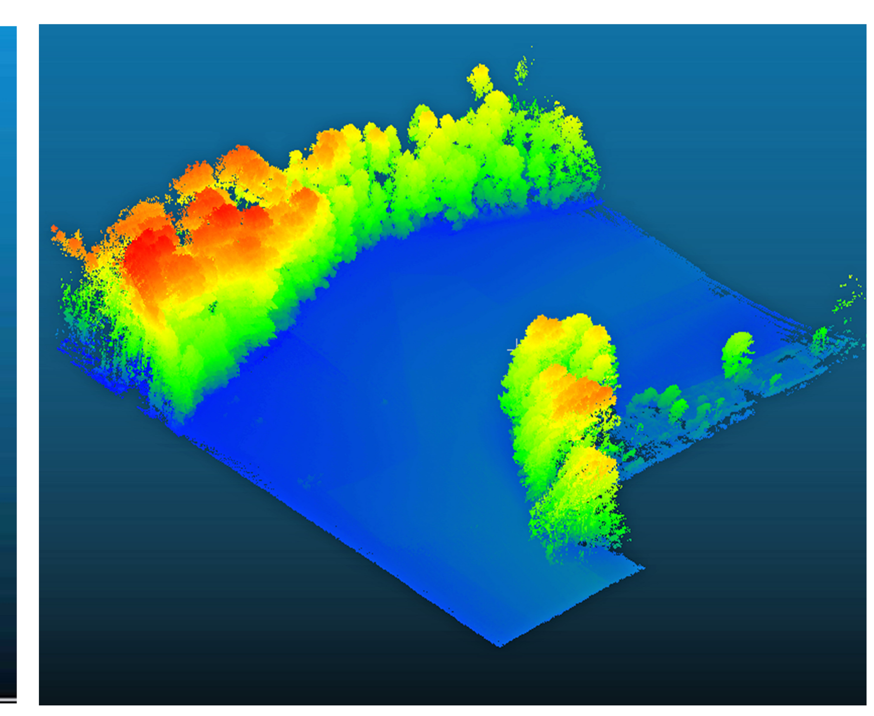

Figure 15. Zone1 Altitude LIDAR Scan

Conclusions

- Radiance remained consistent across all probe points, confirming stable lighting and sensor performance.
- Reflectance values varied between damaged (Concrete points 1 & 2) and undamaged areas (concrete point 3,4,5), indicating material differences.
- Changes were most noticeable in the near-infrared range (750–950 nm), where degradation alters how concrete reflects light.
- The Increase and decrease in reflectance between different probe points provides clear spectral evidence of surface deterioration changes.

Future Work

- Integrate LiDAR and hyperspectral data to create a Spectral Angle Mapper (SAM) model for automated detection of damaged zones based on reflectance similarity.
- Scanning and mapping of other structures such as P-reactor concrete roof.

References

- Headwall Photonics, Inc. (2014). Nano-Hyperspec® installation and operation guide (Rev. r4) [Technical manual]. Headwall Photonics.
- R-Area seepage basin concrete and asphalt repair specification non-permanent repair, revision 2, 22APR2025, Revision in bold.
- Record of Decision for the R-Area Reactor Seepage Basins (904-57G, -58G, -59G, -60G, -103G, -104G) and 108-4R Overflow Basin Operable Unit (U).

Acknowledgements

- Mackenson Telusma, Anthony Abrahao, Leonel Lagos, Oscar Gonzalez, Santiago Cuartas, Eduardo Rojas.
- This work was supported by the Department of Energy Office of Environmental Management (DOE-EM) University Engagement Internship Program managed by the Savannah River National Laboratory under Battelle Savannah River Alliance (BSRA). Funded by the Department of Energy Office of Environment Management Technology Operations Office Program.

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