

From Riverbed to Superstructure: Full-Scene Bridge Inspection with UAV LiDAR & USV Multibeam Solution

Brief

This case study demonstrates an integrated UAV–USV inspection workflow combining SatLab’s HydroBoat 1200MB with the Apus-MX LiDAR on DJI M350 RTK. The solution *enables seamless data acquisition from riverbed to bridge superstructure*, delivering a true 3D view from riverbed to deck that enables accurate assessment, safer operations, and smarter lifecycle management.

Challenges

The project site was a major cross-river bridge with submerged pier foundations, narrow channels, shallow wetlands, and elevated structural elements. Traditional inspection methods face multiple limitations:

- **Accessibility limitations**

Diver surveys and manned vessels are constrained by water flow, turbidity, and tight pier areas.

- **Safety risks**

High-altitude or underwater manual inspections expose personnel to hazards.

- **Fragmented datasets**

Above- and below-water surveys rarely integrate seamlessly, making complete 3D modeling and structural assessment difficult.

An **integrated above-and-below-water solution** was required to provide a complete, accurate, and safe structural assessment.



Figure 1. Survey Site Overview

Solution

SatLab implemented a dual-platform inspection workflow:

© HydroBoat 1200MB — USV Multibeam Solution

- Provides high-resolution bathymetric mapping and pier foundation surveys
- Supports rapid deployment and flexible supplemental surveys
- Navigates autonomously with obstacle avoidance in confined or complex areas
- Measures accurately without SVP, maintaining precision, reducing workflow complexity, and improving efficiency while lowering survey costs
- Performs reliable data acquisition even in low-visibility waters

© DJI M350 RTK + Apus-MX LiDAR — UAV LiDAR Solution

- Rapid, high-density 3D point cloud acquisition of bridge decks, piers, soffits, and surrounding terrain
- Detects fine-scale defects such as cracks, spalling, or corrosion
- Agile flight paths enable coverage of complex structural geometries with no blind spots



Figure 2. HydroBoat 1200MB



Figure 3. DJI M350 RTK + Apus-MX LiDAR

© SLHydroBeam Processing Software — Data Integration Platform

- Integrates sonar and LiDAR datasets into a single 3D digital twin
- Supports automated modeling, defect detection, and analytical reporting

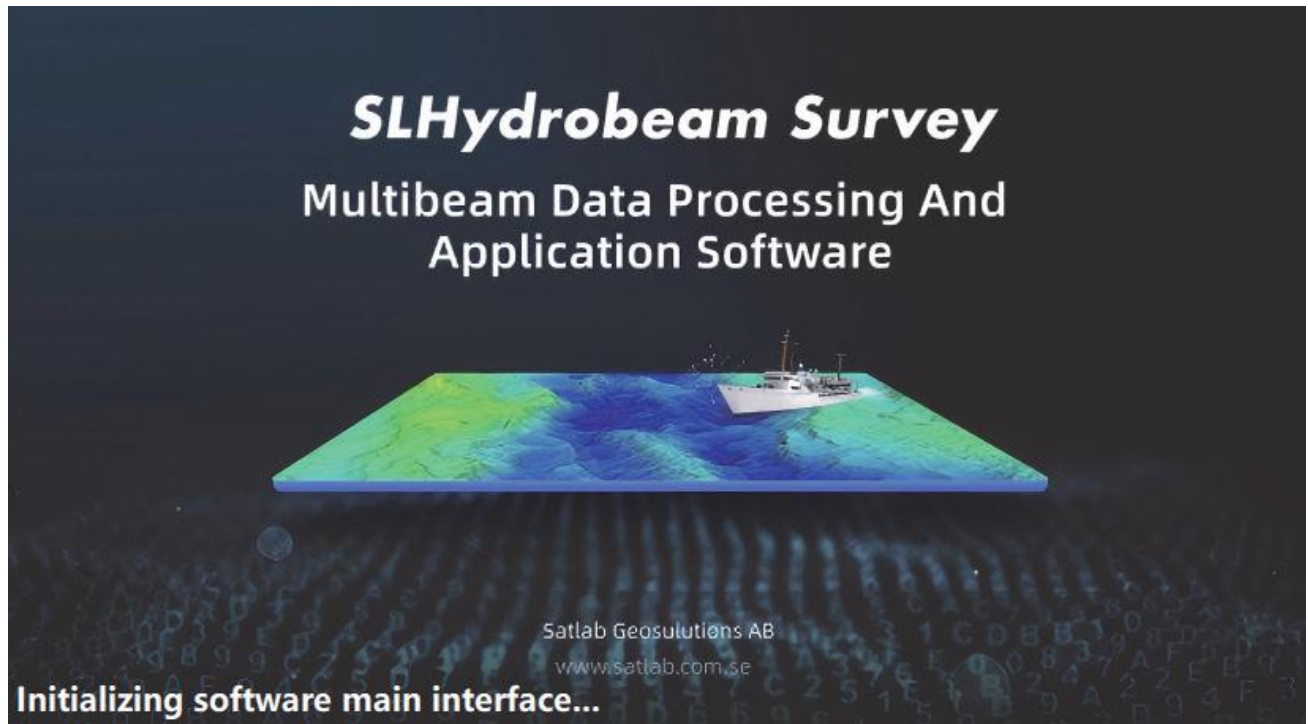


Figure 4. SLHydroBeam Processing Software

By synchronizing UAV and USV operations, the solution delivered seamless data fusion — bridging the gap between underwater and aerial inspection.

Operational Workflow

1. Plan Missions

Define USV routes and UAV flight paths based on design drawings and terrain; align control points and coordinate systems.



Figure 5. Mission Planning

2. Acquire Data

USV runs sonar lines along pier axes; UAV performs cross-hatch LiDAR passes over deck and soffits simultaneously.



Figure 6. Automated Underwater Survey in Progress

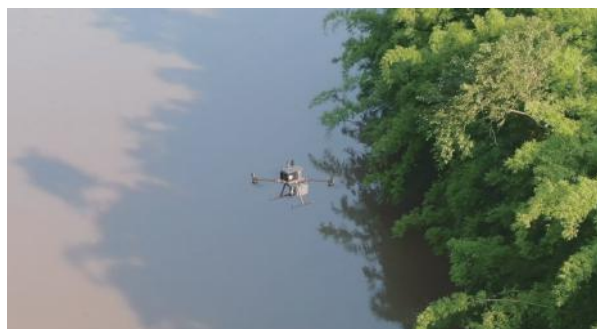


Figure 7. Automated Aerial Survey in Progress

3. Verify On-Site

Real-time monitoring of coverage and overlaps; cross-checks with control points to ensure positional accuracy.

Generation time	2025-08-25 15:09:32.363
Current grid	PointCloud- 20250729_163519_covert_202508251509 01.xyz
Reference grid	Combine_Export_20250825150453
Measurement class	SpecialOrder
Total number of points in the grid	3410
Above IHO model error points (red)	17 (0.50%)
Below IHO model error points (green)	3393 (99.50%)
IHO Error Model	SpecialOrder (a=0.25m, b=0.0075m)

Figure 8. Overlay Analysis for Accuracy Verification

4. Process & Fuse Data

- Multibeam: motion/tide corrections, filtering, bathymetric gridding
- LiDAR: strip adjustment, intensity calibration, fine registration
- Fusion: seamless alignment into a superstructure-to-substructure model

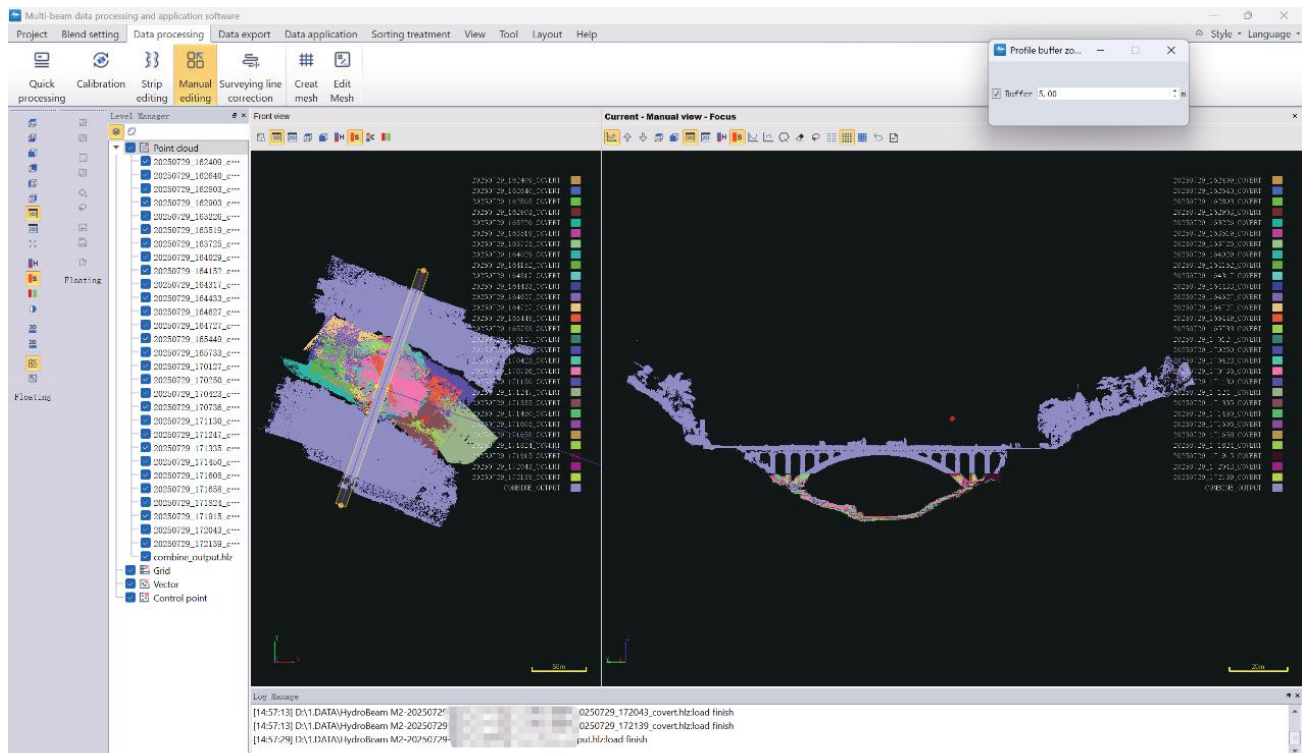
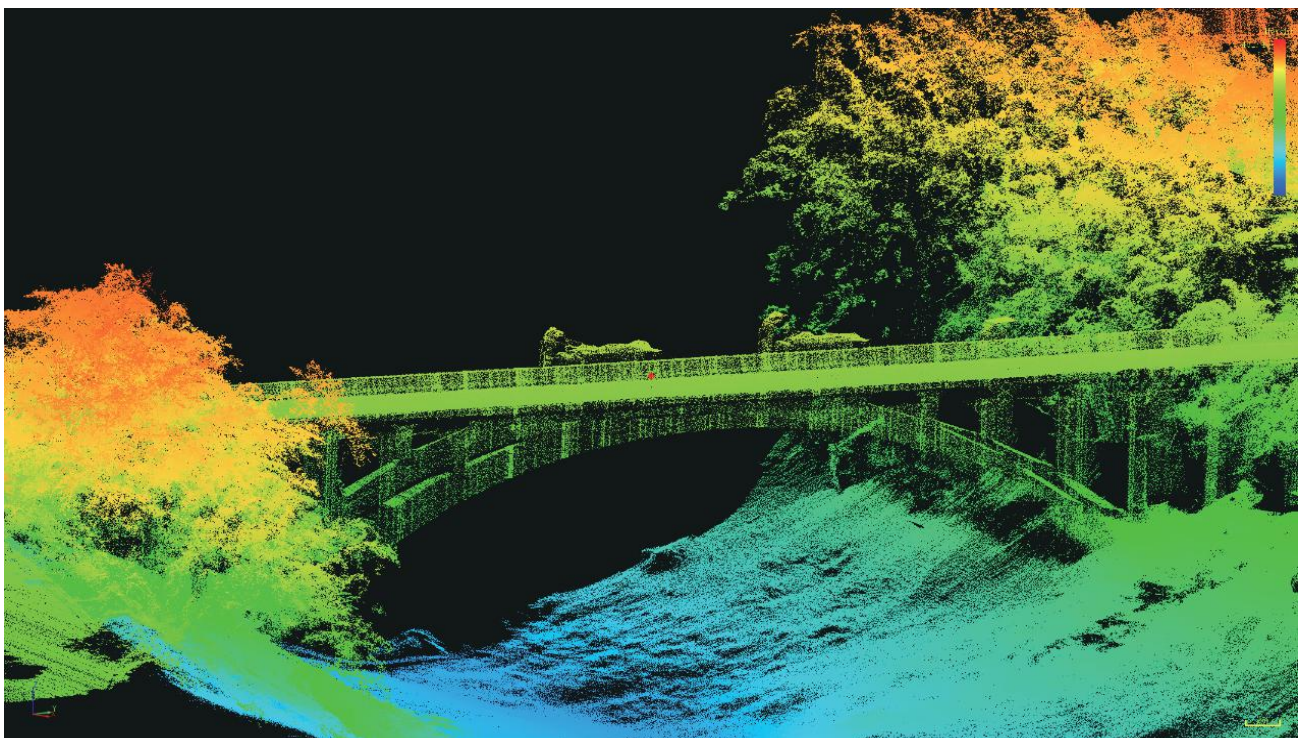


Figure 9. Data Processing

Deliverables

The project *delivered a comprehensive 3D digital twin that seamlessly integrates sonar and LiDAR datasets*. The model contains detailed thematic layers, including scour depth, pier geometry, crack distribution, and clearance profiles, providing a complete structural dataset ready for inspection and analysis.



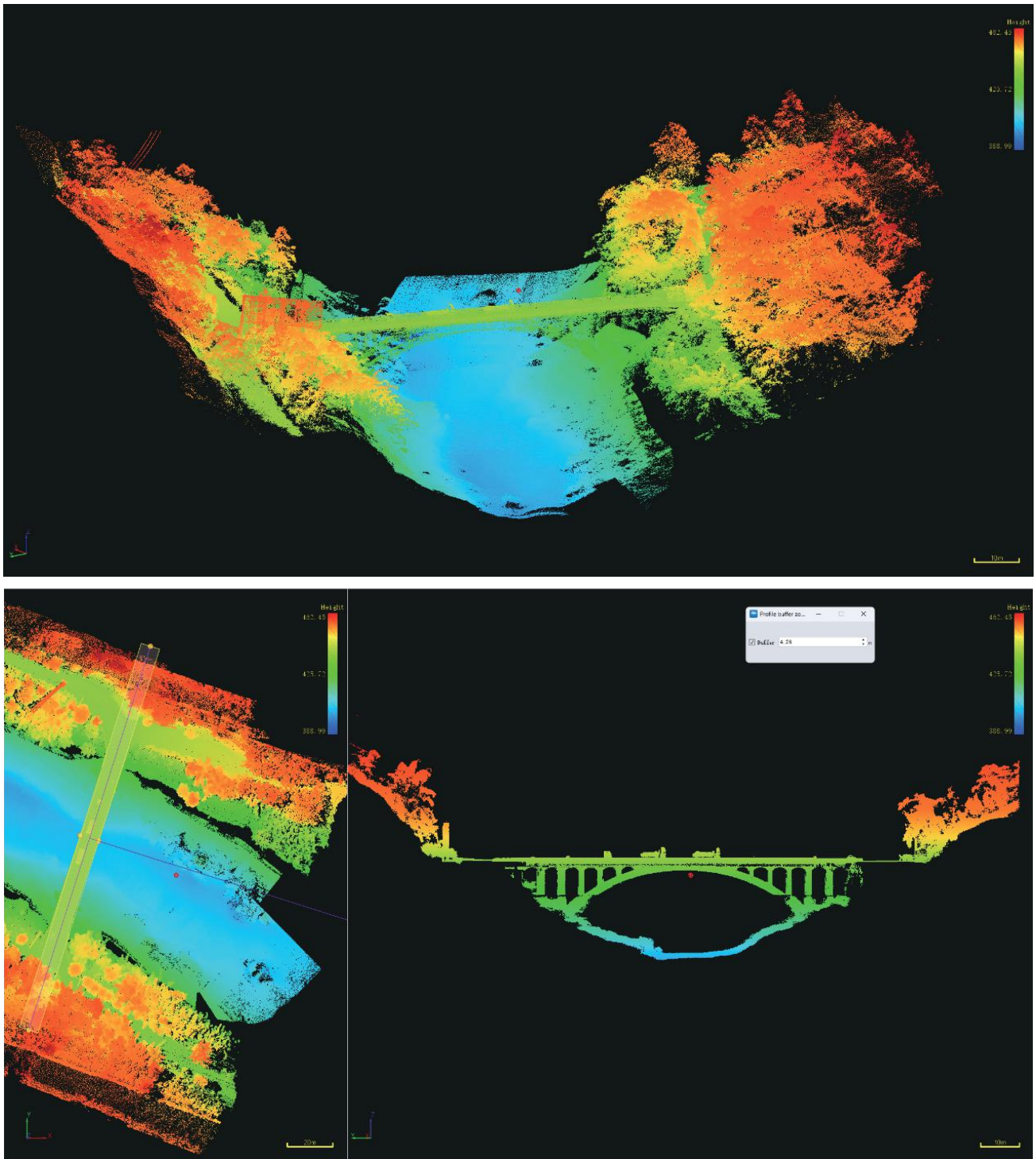


Figure 10. 3D Point Cloud of Bridge and Riverbed

Benefits

- Complete Full-Scene Coverage

Unlike traditional methods that often miss underwater or high-altitude zones, the integrated sonar and LiDAR workflow ensured full coverage from riverbed to superstructure.

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- **Enhanced Efficiency & Safety**

Inspection time was significantly reduced, while human exposure to hazardous underwater and high-altitude operations was minimized.

- **Digital Twin Output**

Delivered a fully integrated 3D model, enabling continuous monitoring, condition assessment, and predictive maintenance planning.



Figure 11. Integrated Above- and Underwater Operations

Conclusion

The coordinated use of UAV LiDAR and USV multibeam sonar provides true surface-to-subsurface inspection, empowering operators with a smarter, safer, and more complete way to manage bridge infrastructure — from today's inspections to tomorrow's predictive maintenance. *SatLab's integrated workflow delivers reliable, comprehensive, and decision-ready data for efficient and fully-informed infrastructure management.*