STRUCTURAL HEALTH MONITORING

Case Study: Smart Impact Assessment for Low-Clearance Bridges

Low-clearance bridges across the U.S. face frequent, costly vehicle impacts. About half of the 100,000 railroad bridges are over a century old and have clearance standards below modern standards, making them susceptible to collisions. A US National Highway Traffic Safety Administration (NHTSA) study found that low-clearance bridges are struck by over 10,000 vehicles annually. Industry regulations mandate full inspections and possible closures after any impact, regardless of severity. StructureIQ offers a proprietary, real-time solution to assess impact severity, helping bridge owners prioritize repairs and avoid unnecessary disruptions.

Problem

Costly and Inefficient Mandatory Inspections

The traditional response to a reported bridge impact is a mandatory inspection, which frequently requires traffic restrictions or a total bridge closure. While severe head-on impacts necessitate immediate attention, the vast majority of impacts (scrapes) cause negligible or no structural damage.

The core problem is the inability to quickly and reliably differentiate between minor and major impacts. For bridge owners, this results in significant financial losses and traffic delays:

- **Financial Loss:** The minimum estimated cost following a minor impact that causes service disruption is about $10,000 per incident.
- **Operational Inefficiency:** Limited inspection resources are wasted on minor events.
- **Data Reliability:** Traditional visual inspections are subjective and prone to errors, and automated systems typically only detect impacts without assessing severity.

Solution

A Low-Cost, Real-Time Impact Severity Assessment using remote wireless IoT sensing and SaaS

StructureIQ's solution offers a cost-effective, scalable, and reliable way to assess impact severity on low-clearance bridges.

The system converts raw vibration data into practical severity ratings, removing the need for mandatory closures after minor events. The core of the solution is a two-stage Artificial Neural Network (ANN) that processes data captured by standard accelerometers (vibration sensors) mounted on the bridge.

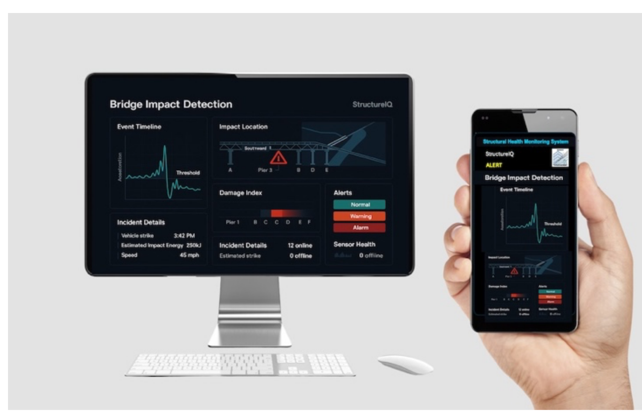

Image 1: StructureIQ's User Dashboard for Bridge Impacts

This solution was successfully deployed and thoroughly tested in a real-world pilot program with a major Class I railroad in North America.

Image 2 - StructureIQ's Sentinel sensor deployed with solar panel for continuous electrical power

Key Benefits:

1. **Prioritized Response:** Enables railroad owners to confidently and remotely triage impact events.
2. **Revenue Protection:** Minimizes unnecessary bridge closures.
3. **Scalability:** Uses low-cost, existing wireless smart-sensor platforms, making large-scale deployment practical across a network of vulnerable bridges.
4. **Records data** for reporting and investigation needs.

Technology

Cascaded Artificial Neural Network (ANN)

The StructureIQ system uses an advanced neural network (ANN) architecture trained on extensive data to detect structural impacts accurately. It addresses the challenge of measuring permanent displacement by using indirect metrics, enabling cost-effective, practical monitoring. The system employs a two-stage classification process to achieve high accuracy in identifying impact severity, ranging from minor scrapes to potentially damaging impacts. It has demonstrated 96.71% accuracy on simulated impacts and successfully classified real-world impact events, confirming its reliability. Key benefits include rapid, precise impact assessment and real-time monitoring using wireless sensors, which provide critical data without the need for invasive or costly inspection methods.

Image 3 - StructureIQ's Sentinel wireless IoT sensor

Market Opportunity

Immediate Operational Savings

The target market is operators of older, low-clearance bridges, which are statistically the most affected type of structure. The solution provides an immediate, significant Return on Investment (ROI) by turning costly inspections into data-driven decisions. If the system prevents just a few unnecessary closures each year, the deployment cost is quickly recouped.

- **Value Proposition:** Move from a reactive, regulatory-mandated inspection model to a proactive, intelligence-led resource allocation model.
- **Target:** Railroad owners and infrastructure management companies seeking to reduce operating expenses, minimize service delays, and optimize their structural health monitoring programs.

Conclusion

StructureIQ's impact severity assessment model provides a reliable, cost-effective solution to a common challenge in the transportation industry. Using advanced machine learning on existing sensor data, it transforms unclear impact reports into precise, actionable severity ratings. This innovation ensures that limited resources are directed toward genuine structural risks, reducing unnecessary bridge closures while protecting public safety and revenue. The results from the North American Class I railroad deployment demonstrate the system's effective operation and immediate benefits.