Making an Impact - Train Car Crash Characterization with LabVIEW

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NI Products Used
LabVIEW
Two NI cDAQ-9178 8-slot chassis, synchronized via NI 9469, with multiples of following modules;
NI 9237 – Bridge Analog Input
NI 9205 – 250 kS/s Analog Input
NI 9207 – Voltage/Current Analog Input
NI 9485 – SSR Relay
NI 9234 – IEPE and AC/DC Analog Input

Industry
Transportation and Heavy Equipment

Application Area
Test cell measurement and control

Challenge
Create a measurement system to collect information during controlled collisions of railroad cars on a test track, to help a major train supply company evaluate performance of their car coupling components.

Solution
We leveraged the NI cDAQ platform to easily and transparently expose the force and strain physics that our customer needed to investigate, while still affording flexibility to dynamically add new measurement channels to adapt to their changing needs.

Background
For 25 years, Data Science Automation® (DSA) has been a premier automation systems integrator, leveraging commercial off-the-shelf tools in the design and implementation of custom-engineered, complete, and highly-adaptive solutions in laboratory automation, embedded/new product development, manufacturing and test automation. The company provides an extensive array of automation engineering, programming, consulting & training services to dramatically improve research, manufacturing, government & business operations. DSA is fast and methodical, staffed with exceptional, multi-disciplinary, NI Certified professionals that consistently apply CSIA-certified best practices to deliver the lowest total cost of ownership.

A leading manufacturer of railroad car components sought to upgrade and modernize their methods of testing and characterizing the railroad car coupling components that they produce. The key channel they wanted to record was strain on their car knuckles, ensuring that the shock-reducing components behind those forged knuckles effectively dampened the collision. Since forces could spike into hundreds of thousands of pounds for extremely brief periods in these collisions, this required a high data rate and large range with low noise. They also wanted flexibility to add measurements of car velocities, accelerometer channels, temperature, humidity, and numerous other metrics that may change per test and may be determined.

Figure 1 Stress and Strain analysis of car knuckles

The R&D group at this manufacturer has some LabVIEW expertise, and wanted to continue utilizing the National Instruments platform for purposes of flexibility and interoperability. However for this larger project they chose to involve DSA in order to ensure a modular, future-proof implementation of their collision track measurement system that they could continue to use and maintain internally for years to come. They also wanted to speed the development of this new test system since their competitors were known to be advancing their abilities, and they needed to keep ahead of these rapidly advancing validation standards in the industry.

Stressing Out Over Strain

Our client had sent railroad couplers to another vendor of theirs to be instrumented with an array of strain gauges built into the interior of the coupler. They put 24 individual gauges into each coupler, in groups of four type-III full-bridge gauge assemblies, where two of each quartet compensate for axial strain. We connected these gauges to the expected cDAQ channels and took some readings to evaluate signal levels and connection integrity. We compared these readings against a manual measurement from an analog strain gauge readout box.

At first, our customer doubted the NI measurement levels since it did not agree with the manual readings. However we quickly identified that it was actually correct, whereas the customer's readout procedure was actually not compatible with the older Vishay (now Micro-Measurements) strain gauge readout. The gauge did not back-calculate axial strain for different types of full bridge measurements, whereas the NI channel was configured to automatically do this back-calculation. When the proper Poisson factor was used with the manual reading, close agreement was achieved (within ~0.1%). The ease and power of NI Measurement and Automation explorer made these initial confirmation steps fast and stress-free, and the configured channels could be directly used from within the LabVIEW application we had ready.

Powerful, Adaptable and Interoperable

The LabVIEW application we designed to suit our customer's needs had to satisfy strict requirements on certain known signals, as well as be extensible for additional measurements that were to be determined on a per-product basis. We leveraged NI Measurement and Automation Explorer for comprehensive channel setup interface, greatly speeding overall project effort in this time-sensitive deployment. Our application easily allowed reference to these global channels, as shown in the application screenshot below.

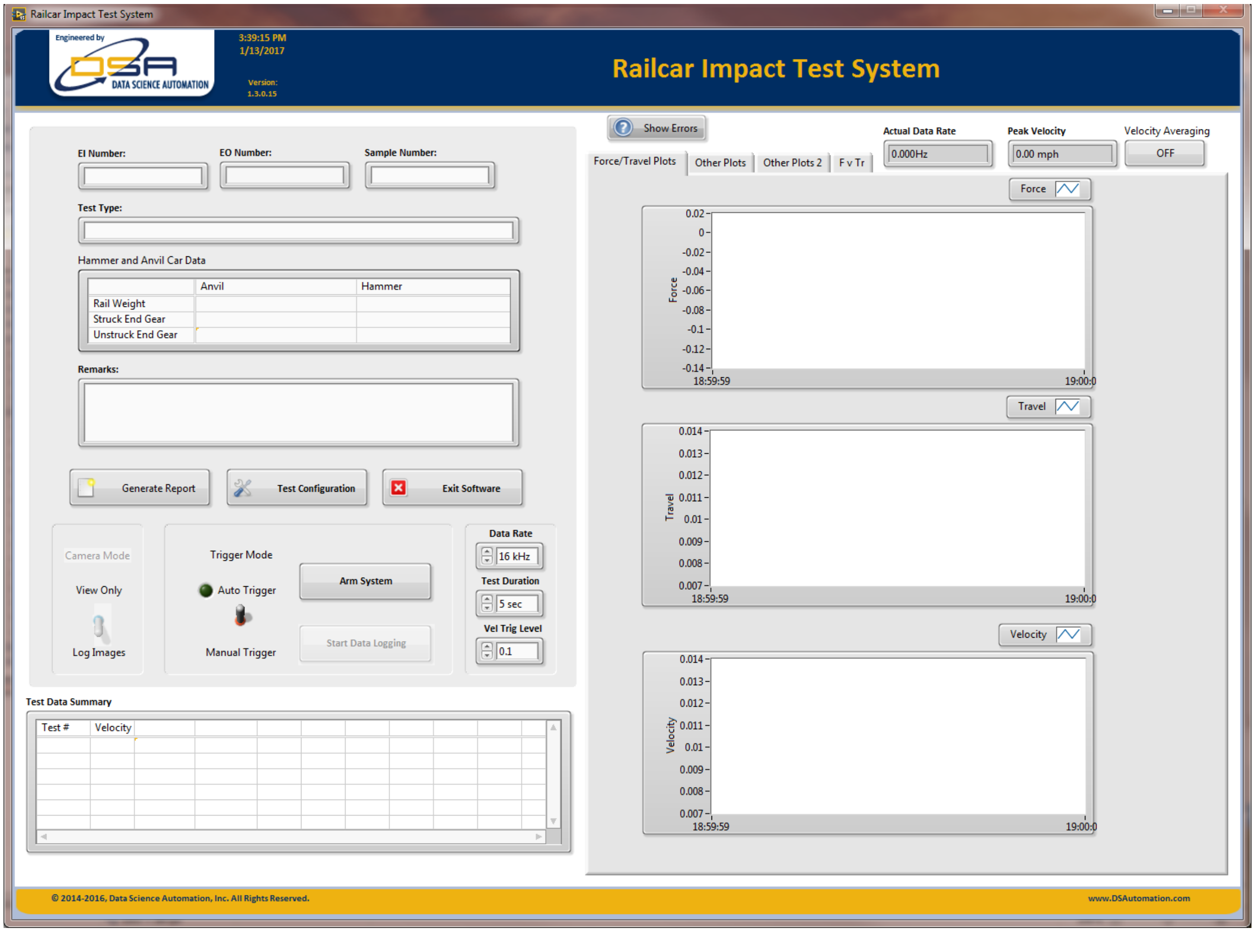

Figure 2. Custom Test Configuration and Run Interface in LabVIEW

Data collection was verified at rates of up to 20 kHz on all channels, which was necessary in order to investigate and/or rule out any short, high-frequency spikes in strain as the rail cars collided. Easy synchronization of measurement across multiple chassis was achieved through the NI 9469 Chassis Synchronization module, allowing a high degree of extensibility to many data channels in the future. A velocity channel was derived in from a laser distance measurement channel and displayed in real time, while configurable graphs could show many other channels in real time through the operator simply picking an X and Y axis channel from drop-downs.

The data collection start could be triggered either manually or at a fixed velocity threshold. Each channel could be configured for rolling averaging at different levels in order to eliminate unwanted high-frequency noise on some channels (such as on distance, where small noise at very short timescales could otherwise lead to large variance in the velocity measurement). After each test, data was logged using the NI TDMS data interface for excellent read/write efficiency and easy incorporation of metadata.

Lastly, the interoperability of LabVIEW allowed us to easily integrate with an IP camera and management software from GeoVision, to provide a linked record of video of each test collision. Automatic triggering was configured such that only the critical period of the crash was recorded at a high framerate, reducing requirements for disk space and network transfer bandwidth.

Conclusion

NI LabVIEW and the NI cDAQ platform allowed us to create a powerful, adaptable, and interoperable hardware and software solution for our customer in the railroad sector. The diagnostic framework of NI MAX allowed us to quickly understand the strain physics of compression of their rail car coupling components, and the ease of LabVIEW for software development allowed us to meet their compressed schedule for system deployment.

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