# Mine Explosion Propagation Studies Using CompactRIO

by

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**Category**:
Academic/Research

**Products Used:**
LabVIEW 8.5
NI FPGA 8.5
CompactRIO 9014
CompactRIO 9104

**The Challenge:**
Develop a software system able to perform rapid, synchronized data acquisition across a distributed network. Very short experimental times existed, with low tolerance for jitter between sampling areas. Due to the violent nature of mine explosions, the application required a reconfigurable and robust system.

**The Solution:**
Using a distributed real-time and field-programmable gate array (FPGA) architecture on CompactRio (cRIO) systems across a fiber optic network, DSA was able to perform synchronized triggering and data acquisition with timing precision of one millisecond. FPGA flexibility allowed multiple sensor configurations between platforms, while using the same program architecture.

**Abstract:**
A government agency needed a more robust network system for recording test explosion in experimental mines. A fiber optic network replaced the fragile and high maintenance copper wires that previously ran from every sensor, hundreds of feet, back to the surface. DSA used the rapid processing power and flexible configuration of the CompactRIO platform to deploy hardware to each data station, able to readily communicate date back across the network to the host computer. The CompactRIO combined the needed data acquisition with relay actuators and built-in networking capability to enhance and improve the previous system.

**The Real Goal: Safety**
When considering difficult applications it can be easy to get caught up in the technical aspects of the job at hand, but the real goal of the government work was in this case very simple: Save lives. Mine explosions have always been – and continue to be – a major hazard when people go underground to earn a living. However, in order to develop the safety equipment and mining disaster rescue procedures that save lives, you have to understand the chaotic conditions within a mine explosion

(Figure 1). To gain this knowledge, a government agency has an experimental mine, where it can set off simulated explosions and monitor the results remotely.

**Figure 1 – An explosion escapes from the experimental mine.**

**Extreme environment**

The data gathering system for these simulated mine explosions must be capable of monitoring as many as 64 channels of data from as many as 40 locations, hundreds of feet underground. Initially the system utilized copper wire to connect the diverse network of sensors to a central computer. However, the effort required to maintain the continuity of each wire proved to be extremely costly. To reduce this cost Data science Automation (DSA) replaced the network of copper wires with a fiber optic network interconnecting the data gathering stations. All that was now needed was a scalable acquisition system capable of withstanding the explosive forces within the mine.

**Hardware selection**

Due to its robust nature, the CompactRIO FPGA platform lends itself well to the process of gathering data from within the mine. In addition, the 40 MHz processor allows rapid communication and triggering of the systems over the network. Each of the 40 data gathering stations deployed in the mine has its own networked cRIO 9014 sitting on a 9104 FPGA 8-slot backplane.

The extreme speed of the explosions requires the full capabilities of the cRIO, sampling at much higher than the typical 1000 Hz limit of other competing acquisition systems. The speed of the cRIO also allows it to react to a network wide trigger within 5ms – thus allowing very tight synchronization of all the data gathering systems.

**Communication and Triggering**

To support fast response to commands and file transfer across the network to and from the host PC, the application leverages LabVIEW built-in connectivity to implement a low-overhead UDP-based communication protocol (Figure 2).

Another complication for which LabVIEW provides an elegant solution is configuration of the data gathering systems. Each of these systems has different requirements for data recording, which often vary from test to test. The inputs include thermocouples, pressure sensors, light sensors and gas quality sensing. The flexibility of the FPGA allows for dynamic configuration changes as different cRIO modules are used for each test, merely with the exchange of a new FPGA bitfile and



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configuration. In addition, the cRIO relay module is utilized for remote calibration of the sensors. This module replaced another full set of copper control wires previously used for relay functions.

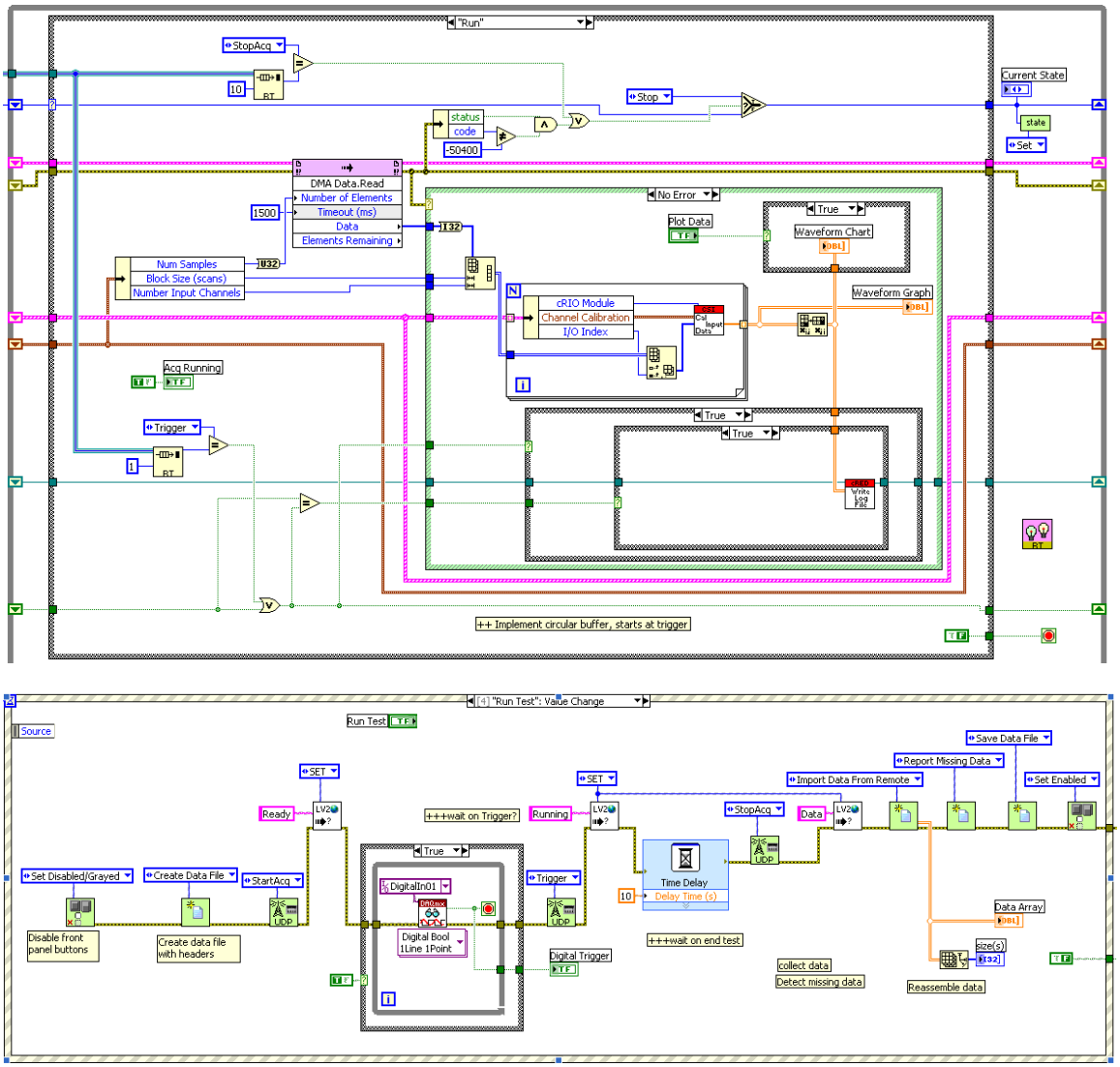


**Figure 2 - The FPGA data gathering code on the remote cRIO system, along with the host PC UDP communication code**

## Tying it Together

Thanks to the flexibility and power of the National Instruments product base, NIOSH has a tool that will gather the data necessary to accurately gage the effects and propagation of underground explosions. And at the end of the day, if that means even one miner gets to go home that otherwise might not; it's been more than worth the effort.




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