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# Ballistic Ejection Seat Testing

## *using the WaveBook™*

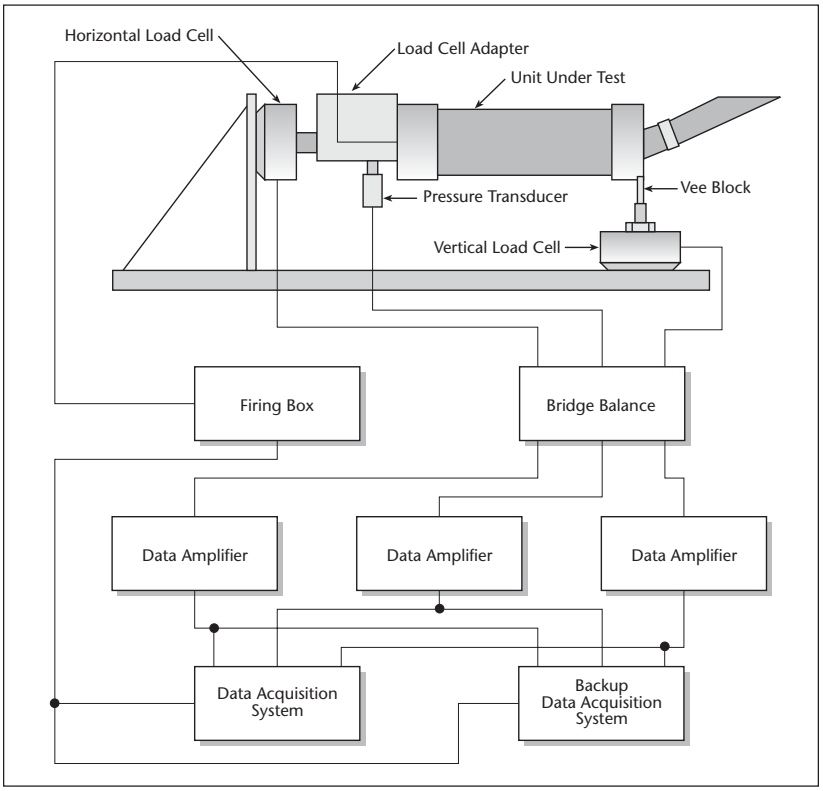
*Aerospace*

**Application Note #85**

## Application Summary

Ejection seats thrust pilots from flying craft quickly and safely when their lives are in imminent danger or they lose control of the craft and are unable to land it safe and sound. Modern ejection seats contain a certain amount of intelligence that decide how the pilot will be released from the seat once outside of the craft. Onboard sensors measure the altitude and velocity of the pilot and seat, and calculate when the seat should drop away from the pilot and when the parachute should open. Below 15,000 feet, the parachute receives a signal to inflate rapidly, but above 15,000 feet, the opening is delayed until the 15,000 ft target is reached.

A small rocket motor attached to the seat ejects the pilot in a particular trajectory to make certain he is safely clear of the canopy, wings, and tail of the craft. In addition, a variety of seat actuators use ballistic-driven components such as explosive bolts and shear pins to deploy the ejection seats, remove the pilots from the seat at the optimal time, and inflate their parachutes. Solid propellants are the primary energy source used for actuating the various mechanical components in this safety system, so during product development testing, technicians have only one chance to measure how well the detonators do their job. The instruments used to record the chain of events leading up to the final detonation must be highly reliable and sensitive enough to ensure that the initial electrical trigger signal enables the system so a complete data set can be captured and analyzed.




*A typical instrumentation stand for testing ballistic-driven mechanical actuators and rocket motors for aircraft ejection seats consists of load cells to measure vertical and horizontal forces, and a pressure transducer to measure the ignited gas pressure. A completely independent back-up data acquisition a system is used for redundancy to ensure that a complete set of data are collected in the unlikely event of a primary system failure.*

## Potential Solution

A senior test engineer at a leading US aerospace components manufacturer is responsible for setting up the data acquisition systems for ballistic component tests at their facility. She initially used relatively expensive, four-channel recording oscilloscopes for data acquisition, and some contained outdated 5.25-in. floppy diskettes for data storage. When it was time to expand the lab's measuring capability and replace the existing equipment, the engineer found a few drawbacks with newer oscilloscopes; they were much more expensive than they had been earlier, they still had inadequate storage capacity, and only four channels per unit were just not enough to satisfy the needs of the larger lab.

## IOtech's Solution

After some investigation, the test engineer found that IOtech WaveBook™ data acquisition systems were much better suited to her needs. "The WaveBooks are versatile and portable, and they can even be put in a brief case when needed in the field," says the engineer. "The WaveBooks are easy to use, less expensive than the oscilloscopes, have eight channels each, and contain only those features that we really need." These attributes allowed her to purchase eight WaveBooks for the lab. Says the engineer; "The measurements are so critical that we use two independent systems during one test to capture the data in case one system should fail. But these units are used every day without failure – they get a big workout – and they have proved to be very durable and robust."

Rocket motors for ejection seats come in two basic types, straight nozzle or canted nozzle. During testing, strain-gage load cells on a test stand measure the force the rocket produces in both vertical and horizontal directions. Pressure sensors have either strain gage or piezoelectric elements that measure the detonation pressure in the gas chamber. Accelerometers connect to the WaveBook through a

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bridge-balance amplifier to measure accelerations of the unit under test.

The firing box outputs an electrical pulse of 5A for 10 ms to detonate a fuse. The fuse is a bridge wire in a slurry of energetic material that carries out a chain reaction. The output charge generates the pressure, which energizes a gas-fueled actuator or a rocket motor. A pressure transducer measures the resulting ignited gas pressure, typically 600 to 13,000 psi, but some units develop 30,000 psi.

The WaveBooks also measure numerous other variables, including temperature using a WBK10™, which expands each unit to 15 channels. Also, WBK15™ isolated signal conditioning modules are used in the field with strain gages to expand the input to 16 channels when needed for free flight, small missile testing and rocket-sled testing.

In addition to writing a lot of test procedures, the engineer wrote a program in LabVIEW® to examine the raw data before sending it to a separate department for data reduction. She is able to zoom in on certain views that she finds to be critical such as the variables measured in components that use a shear pin. Pressures measured are 400 to 600 psi, and an extremely small change in signal – a time shift between the time of the detonation and breaking the shear pin – must be measured. The variables are set up in a folder that all test personnel are required to use. The program provides a uniform, consistent format for all tests so the same inputs and ranges are assigned repeatedly to the same channels. This ensures that all data will be analyzed rapidly and contain fewer errors — or no errors.

## Conclusion

A leading aerospace components manufacturer uses IOtech WaveBooks to measure ignition pulses for ballistic detonators on aircraft ejection seat systems and the rocket motors that propel them. The WaveBooks also measure force and acceleration produced by the rocket engines and pressures used in firing mechanisms that contain shear pins.

## WaveBook Series

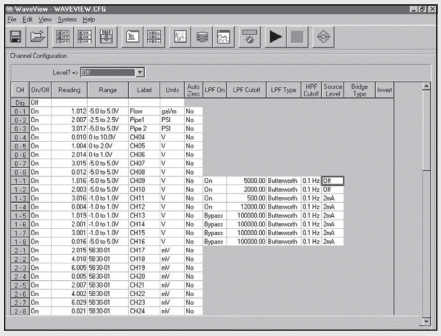
The WaveBook/516E™ digitizer offers multi-channel waveform acquisition and analysis for portable or laboratory applications. The WaveBook includes 8 built-in channels expandable up to 72 channels of voltage, accelerometer, microphone, strain gage, thermocouple, position encoder, frequency, high voltage, and other signal types. For applications beyond 72 channels, up to four WaveBooks can be combined within one measurement system, for a total capacity of 288 channels. You can also add up to 854 thermocouples, without consuming measurement bandwidth of the WaveBooks, using the WBK40™ series, and DBK90 signal conditioning options. The 12-bit WaveBook/512A™ and 16-bit WaveBook/516A™ attach to the WaveBook/516E via their built-in parallel port interface. Other than the interface, the WaveBook/512A and WaveBook/516A are identical to the WaveBook/516E.

### Features

- PC connection via Ethernet
- 12-, and 16-bit/1-MHz A/D
- 1 µs/channel scanning of any combination of channels
- Single and multichannel analog triggering with programmable level & slope
- Digital TTL-level and pattern triggering
- Pulse trigger and external clock
- Programmable pre- and post-trigger sampling rates
- Sixteen digital inputs can be scanned synchronously with analog signals
- Operable from AC line, a 10 to 30 VDC source, such as a car battery, or optional compact rechargeable battery module
- Expandable up to 288 high-speed channels
- SYNC connection allows multiple units to sample synchronously
- Add up to 854 lower-speed thermocouple channels
- DSP-based design provides real-time digital calibration on all channels

### Signal Conditioning

- ICP® dynamic signal inputs
- Strain gages
- Programmable filtering
- Simultaneous sampling
- Quadrature encoder inputs
- Pulse/frequency measurements
- Thermocouples
- High-voltage measurements
- Vehicle bus network



*WaveView graphical data acquisition and display software is included with all WaveBooks*

### Software

- Includes WaveView™ for *Out-of-the-Box*™ setup, acquisition, & real-time display:
  - Scope mode for real-time waveform display
  - Logger mode for continuous streaming to disk
- Optional eZ-Analyst™ for real-time spectrum analysis
- Export data in third-party formats
- Includes support for Visual Basic®, C/C++, LabVIEW®, MATLAB®, and DASYLab®
- ActiveX/COM development tools