Flyable Electro-mechanical Actuator (FLEA) Testbed Data Sets
Frequently Asked Questions

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We will try to keep this FAQ as up-to-date as possible. If the question you have is not answered below, please feel free to contact us by sending a message to Edward Balaban through the DASHlink website. If the question is of a general interest, we will also add it to the FAQ.

- **What are the data formats used in the data sets?**
- **Why do some of the data sets contain TDMS binary files, some BIN, and some contain both?**
- **Where can I find descriptions of the various types of laboratory experiments?**
- **Why do some laboratory scenarios have 30-second duration, while others have 2-minute duration?**
- **Why does the set of variables recorded differ from data set to data set?**
- **What do actuator (motor) names refer to? What do the channel (variable) names mean?**
- **What do the terms high- and low-speed data refer to?**
- **How can I find out more details on the testbed and the experiments?**

What are the data formats used in the data sets?

Format	Description
.data	This is a plain text data format that can be processed by a variety of applications (such as Excel, Matlab, etc). The .data files are also the largest, by far, in terms of disk space.
.tdms	TDMS stands for Technical Data Management Streaming. This is a searchable, structured NI LabVIEW binary format. You can find out more information on it at http://zone.ni.com/devzone/cda/tut/p/id/3727. It was used, for a time, for high-speed data recording until switch to a more basic, but faster .bin format was made.
.bin	A high-performance binary LabVIEW data format. This is the format currently used in recording data from FLEA experiments. For more information on how to read data from bin files please see http://zone.ni.com/reference/en-XX/help/371361G-01/lvhowto/reading_from_binary_files/

Why do some of the data sets contain TDMS binary files, some BIN, and some contain both?

TDMS format was used for some time in recording FLEA data, then it was decided to switch to a more basic, but faster .bin format in order to support real-time data graphing. Both formats were used for a period of time, then .tdms writing was discontinued.

Where can I find descriptions of the various types of laboratory experiments?

Please see file titled "Laboratory Scenarios Description" (https://c3.nasa.gov/dashlink/resources/329/)

Why do some laboratory scenarios have 30-second duration, while others have 2-minute duration?

Scenario length was chosen to represent approximately the typical length of an actuator extend/retract operation in the aerospace context. This could, for example, be a flap or a landing gear extend/retract operation or control motion of an aileron. In fact, most such operations complete much faster than in 30-seconds, but it was decided that in this case it is better to err on the conservative side. In some of the data collection sessions the scenario length was extended even further, to 2 minutes. While it would be rare for an actuator to move continuously for this long in real-world applications, these scenarios are useful for testing tracking capabilities of prognostic algorithms not just from scenario to scenario, but within the same scenario as well.

Why does the set of variables recorded differ from data set to data set?

There are two reasons for this:

- FLEA is a research tool for us and is in a state of continuous improvement. The variable set has changed over time with changes in the hardware setup and DAQ software.
- The variable set is often changed depending on the needs of a particular experiment we run. For instance, if we run a motor windings deterioration experiment, we may not have the need for accelerometer data, so it is not recorded.

We try to do our best to describe the variable set for each of the experiments in an accompanying file named ChannelOrdering or similar (this also changed over time). If you see this file missing from a data set or not matching the actual data, please let us know. For a period of time we tried an automated system of downloading and recording channel names in an Excel spreadsheet before each experiment. These spreadsheets are named Channel_Ordering_High and Channel_Oredring_Low (for high and low speed data). Certain hardware changes made this automated recording difficult, so now the channel descriptions are updated manually.

We are in the process of unifying and standardizing file formats based on the accumulated experience. The plan is to record all new data files in this standard format and convert all of the important previously collected data sets to it as well.

What do actuator (motor) names refer to? What do the channel (variable) names mean?

There are three actuators utilized in the FLEA. Each has one motor, referred to by the same letter as the actuator (X,Y, or Z)

Actuator	Description
Actuator X	Fault-injected test actuator
Actuator Y	The nominal (non-fault injected) test actuator
Actuator Z (also known as Load Actuator)	The actuator imposing a load on one of the two test actuators

Here are the channel names you may see in our data files:

Channel (variable) name	Unit	Description
Act {X,Y} – Channel {X,Y,Z} or Act {X,Y} Acc {X,Y,Z}	g	Vibration data from accelerometers installed on actuators X and Y (on the nut of the ballscrew mechanism). The accelerometers are 3-axis (X is in the direction of actuator motion, Y is vertical, and Z is horizontal). The X, Y, and Z axes of the accelerometers are not to be confused with the X, Y, and Z labels for the three actuators. There are no accelerometers installed on the load actuator.
Actuator {X,Y} Nut Temperature	deg C	Data from the thermocouples embedded into the nut of the ballscrew mechanism
Actuator {X,Y,Z} position	mm	Position from fully retracted
Ambient temperature	deg C	Ambient temperature, as supplied by the Cold Junction Compensation (CJC) module of the data acquisition system
Desired load	lbs	Current value from the load profile
Desired position	mm	Current value from the position profile
Load actuator position	mm	Same as Actuator Z position
Load Cell, Load	lbs	Force imposed by the load actuator on the current test actuator, as measured by the system load cell
Load Duty Cycle	%	PWM duty cycle of the load actuator (actuator Z)
Motor {X,Y} voltage {A,B}	V	Paired voltage values for differential voltage measurement
Motor {X,Y,Z} current	amps	Current supplied to a motor
Motor {X,Y,Z} temperature	deg C	Temperature measured on the motor housing
Motor {X,Y,Z} torque	N*m	Torque supplied by the actuator motor. Roughly linearly proportional to the supplied current.
Test Actuator Duty Cycle	%	PWM duty cycle of the currently operating test actuator (X or Y)
Time	s	Time from the beginning of the experiment

What do the terms high- and low-speed data refer to?

Accelerometer measurements were recorded at high sampling speed (20-50 kHz). The rest of the measurements were done using low sampling speed (usually 1 kHz). The latter measurements include currents, torques, voltages, temperatures, positions, and duty cycles.

How can I find out more details on the testbed and the experiments?

Please see the publications posted here: https://c3.nasa.gov/dashlink/projects/45/resources/?type=pub

We welcome your feedback on improving the data set content and descriptions. We would also like to hear about your projects utilizing these data sets.