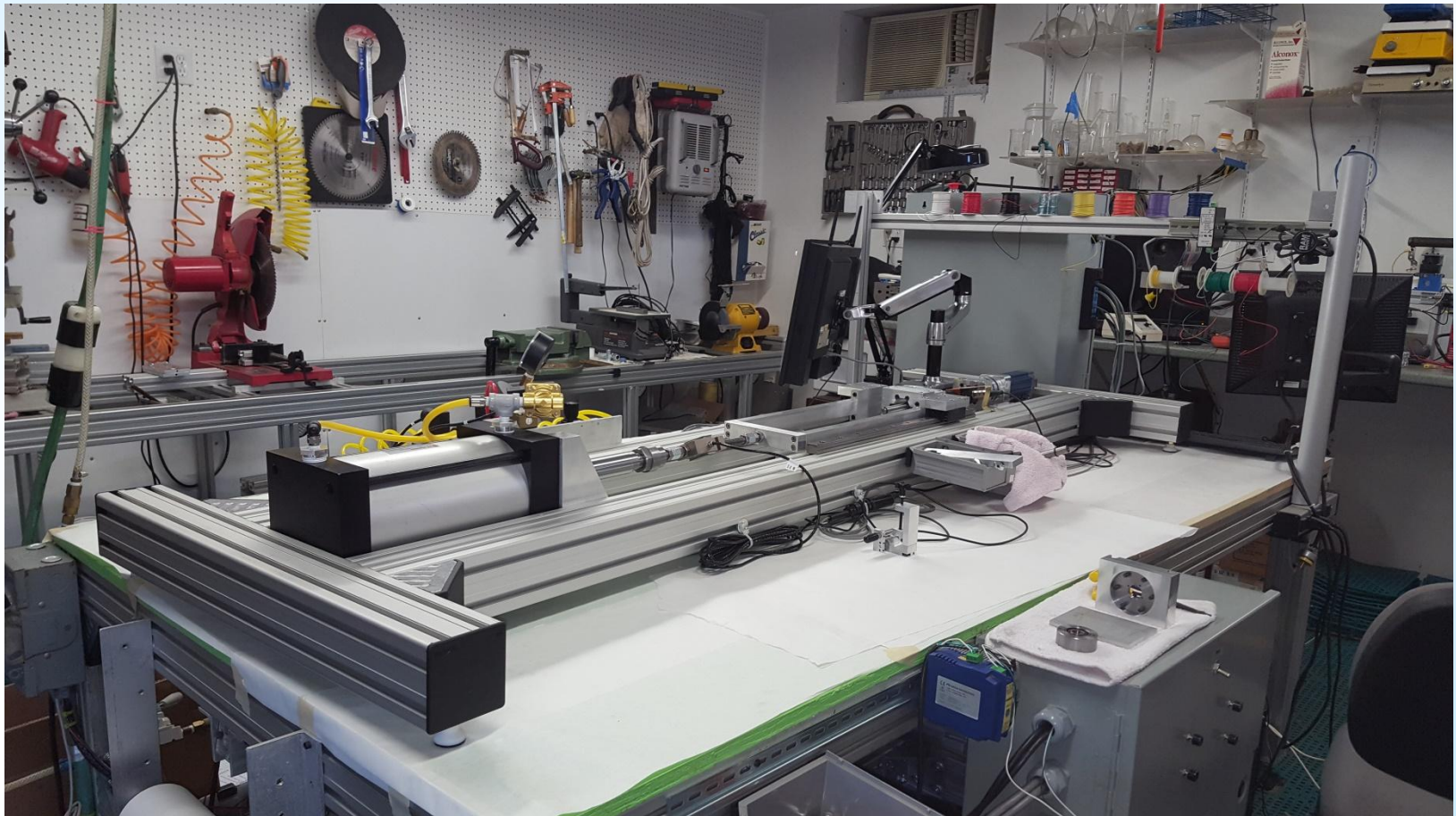


Case study: Ball Screw Test Rig

Although we are normally engaged in the development of new technology and product, LTB recently had the opportunity to design and build a ball screw test rig. The project was in conjunction with Industrial Product Reports, Inc. Needless to say, all of the requirements and specifications were met, on time and on budget. Instead of reciting the specs, this case study focusses on the novel approaches, i.e. cool innovative technical stuff, employed to yield the final machine.



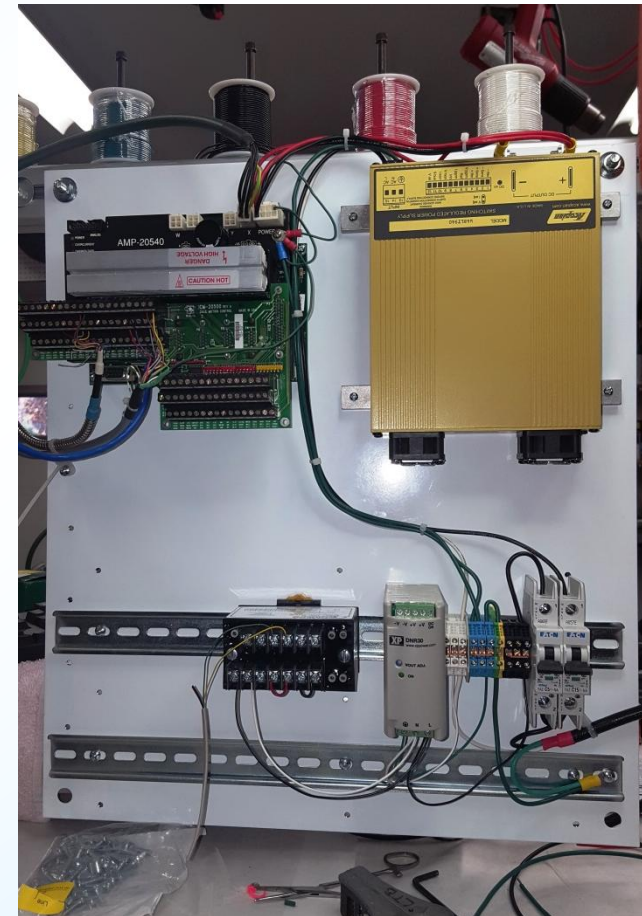
There were four aspects of ballscrew performance targeted for measurement;

- accuracy,
- efficiency,
- smoothness and
- stiffness.

Each has its own set of challenges, especially when adapted for a wide range of screw configurations.

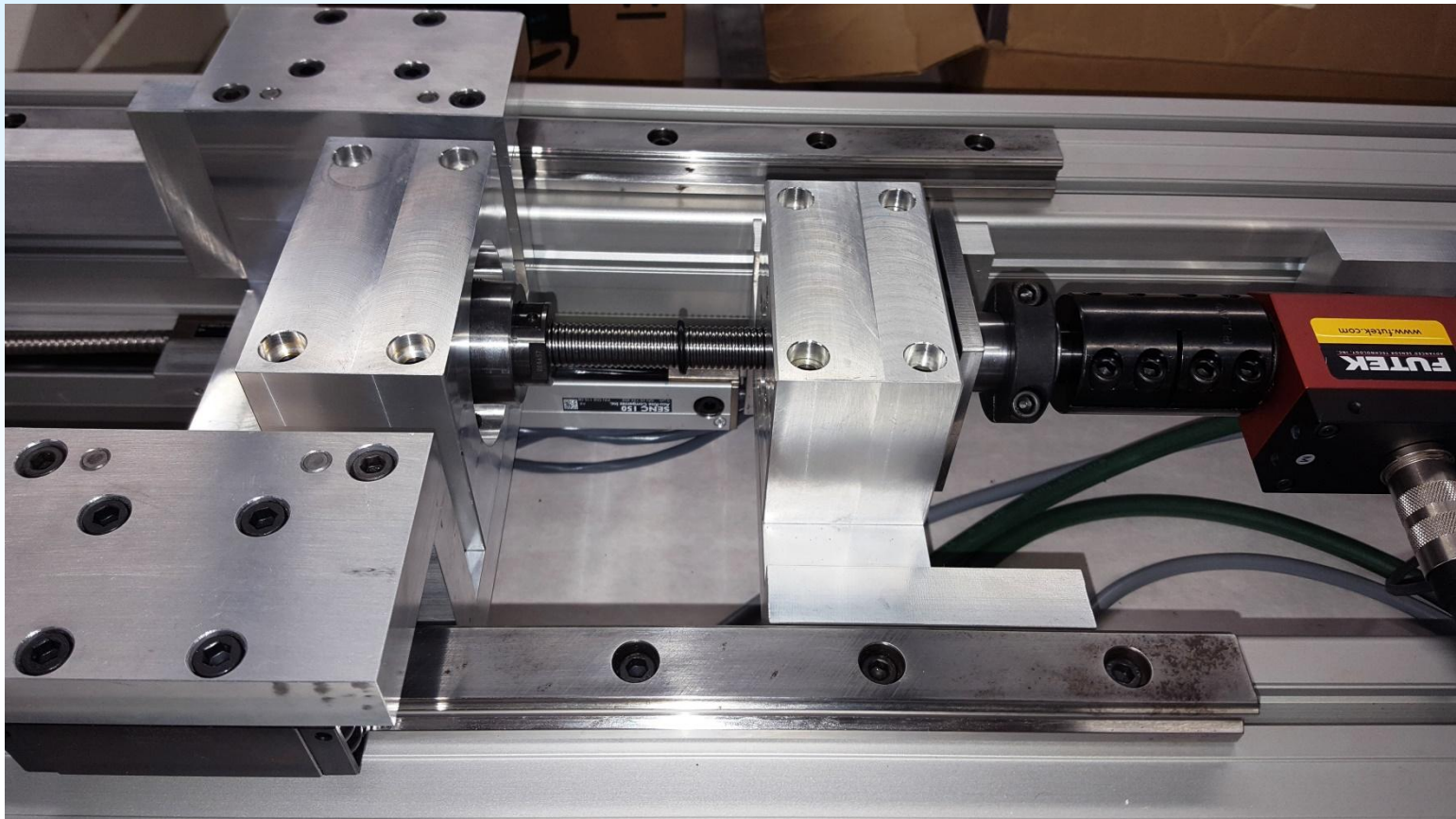
At the heart of the test rig was a Galil 4 axis motion controller. Although only one axis was employed to turn the screw, the other axes were utilized in interesting ways.

Axis	Description	Function
X	Primary motor	Provides torque to screw, encoder provides rotary position
Y	Glass scale encoder input	Quadrature input for linear position in X
Z	Torque command output	0-10 Vdc output converted to 4-20 mA to drive pneumatic transducer for axial load application



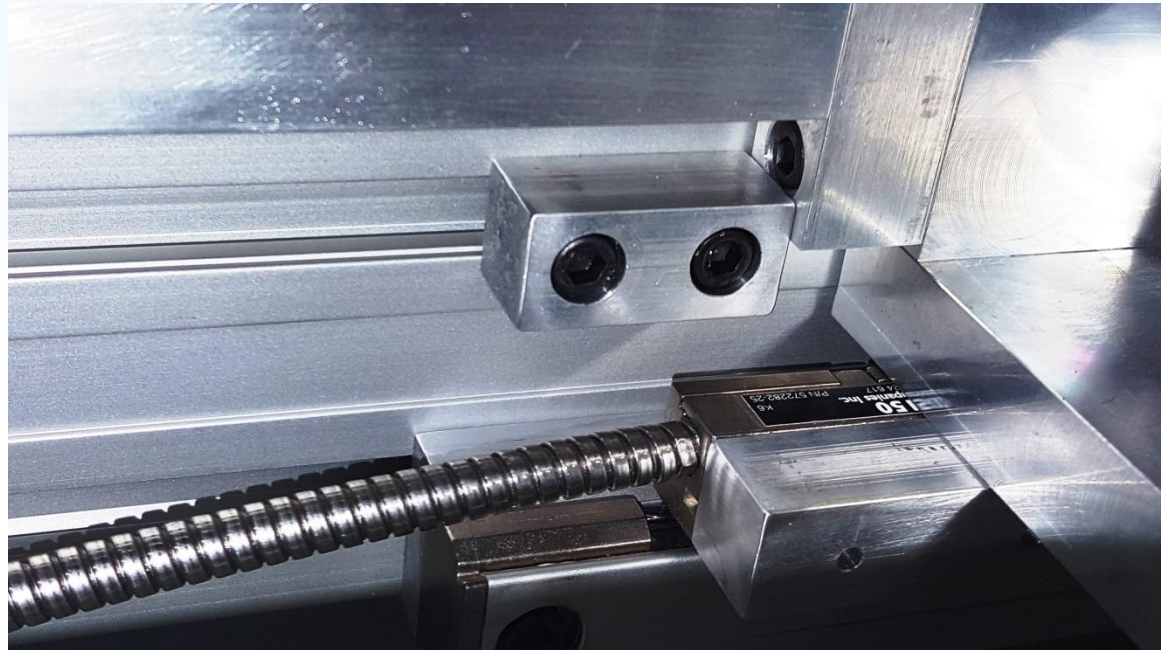
Early on in wiring. Controller left, Accopian power supply right.

The test specimen was mounted in a special carriage where the linear bearings were mounted in-plane with the centerline of the screw, eliminating any overturning moment. This defines the X (test) axis. This also simplifies the mounting of the test specimens; they simply drop over locating pins and are then affixed in place.



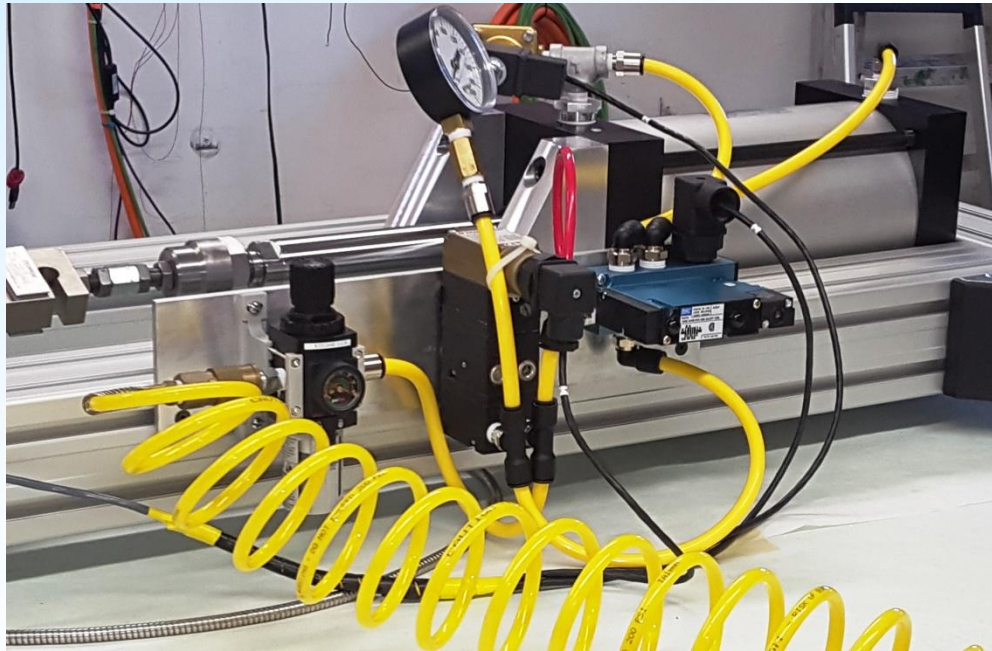
Test specimen in rig

Accuracy measurement is pretty straight forward: the commanded position vs the actual position in the X axis. The commanded position was determined from the motor encoder position. The actual position was determined by a glass scale mounted under the test rig, and processed through the Y encoder inputs. The carriage was slowly driven along a given length and the linear and rotary positions recorded simultaneously.

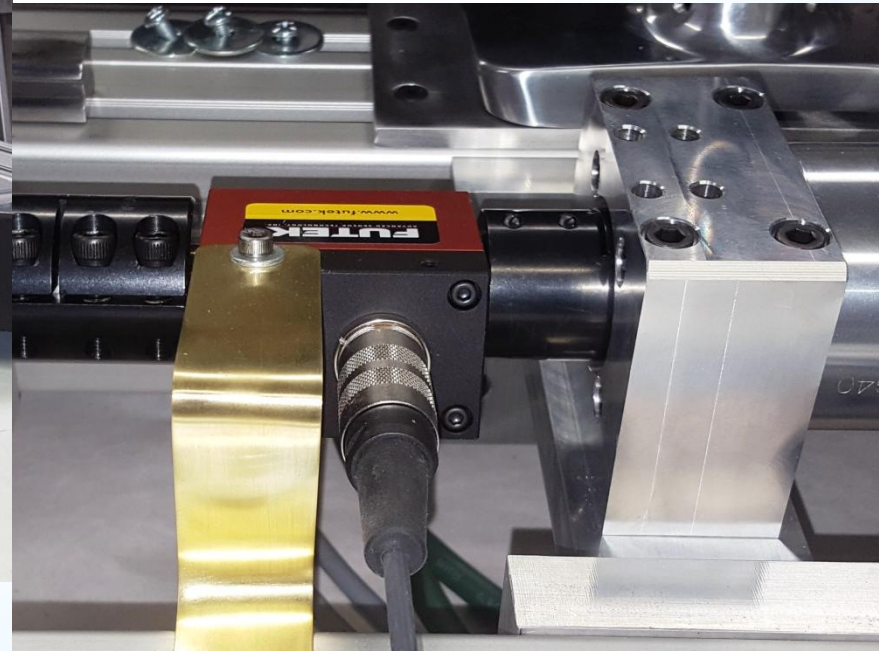


Glass scale under carriage

In the measurement of efficiency an axial load needs to be applied to the ballscrew under test. Efficiency is the ratio of linear work (force x one pitch) to rotary work (torque x one revolution). The axial load was applied in a novel way. An air cylinder was pressurized via a Fairchild 7500 piezoelectric pressure transducer, which was in turn controlled by a voltage to current transducer driven by the Z axis torque output command voltage. The axial load loop was closed by an inline load cell, thus eliminating the error from cylinder seal drag. Torque was measured by way of a torque cell situated between the gearhead and ballscrew.



Axial load pneumatics, load cell at left



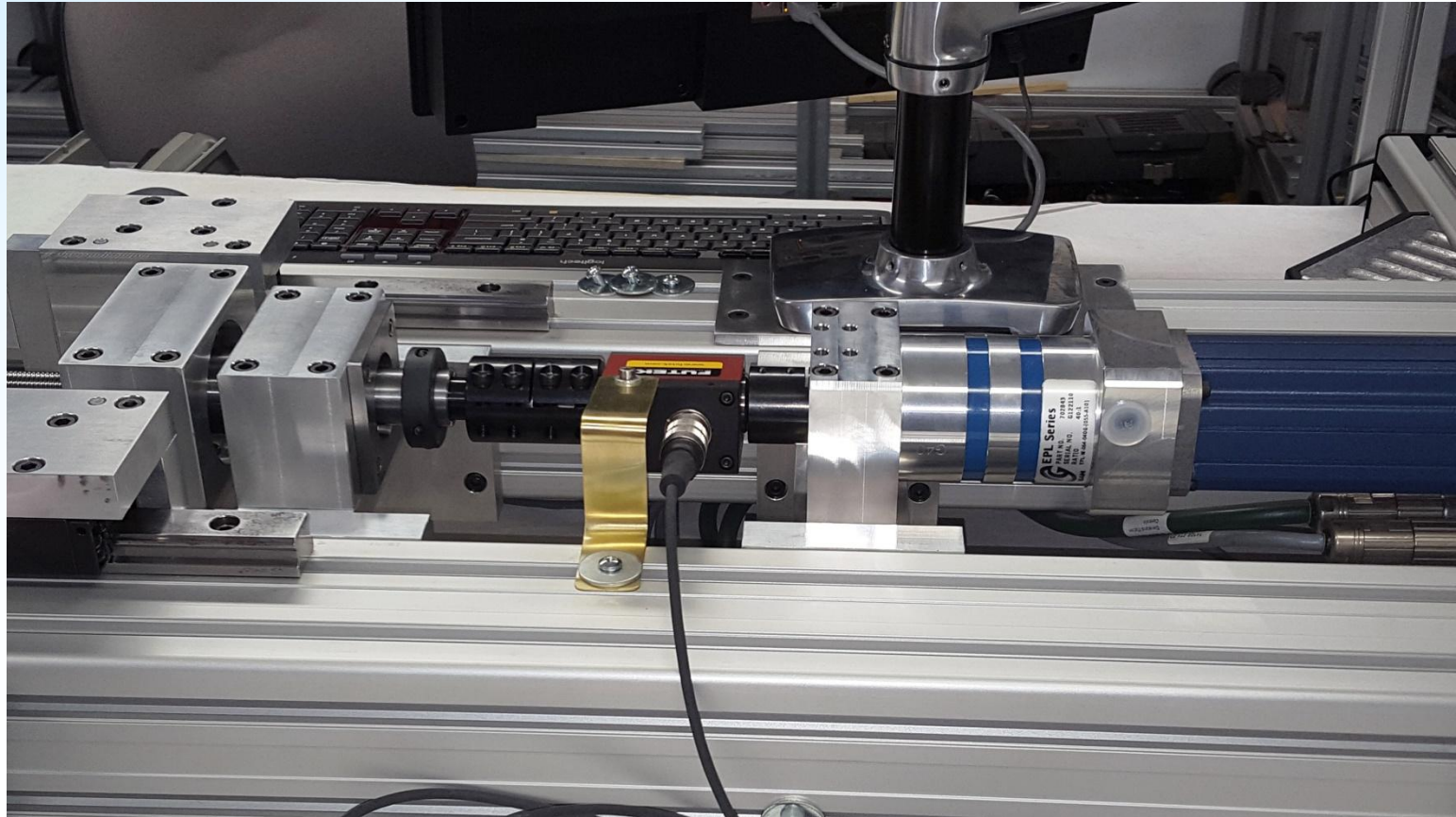
Torque cell

A yoke assembly was employed to provide load communication between the axial loading system and the test carriage. Again, the test carriage, ballscrew centerline and loading axial were mounted in the same plane.



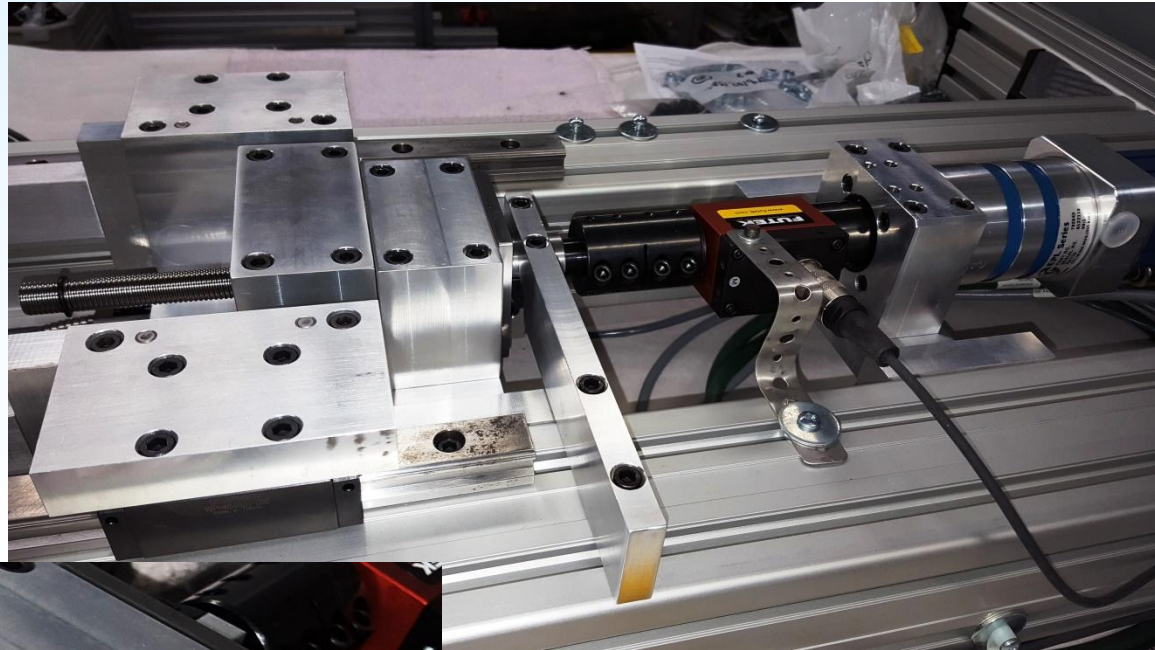
Pneumatic cylinder, load cell and yoke

The measurements of smoothness and efficiency were combined, eliminating the requirements for two different tests. The axial load as controlled by the air column and pressure transducer afforded a very stable load. The signal from the torque cell was amplified by a high speed signal conditioner, so that the variations in torque as a function of time could be plotted.



Smoothness and efficiency testing

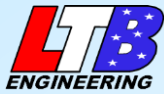
Measuring stiffness in a ballscrew can be a challenge. With an axial load, the screw is subject to backdriving, so the screw has to be securely locked in place. A brake was applied to avoid inadvertent rotation. The second challenge is to measure only the deflection between the nut and screw, not the mounting bearings. In our rig, we accomplished that by staging a Linear Variable Displacement Transformer (LVDT) right on the screw. A fine adjustment slide was provided to zero the transducer. Load was applied in both tension and compression to define the stiffness curve



Brake applied to screw



LVDT and holder staged on screw to measure displacement of nut block



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Finally the whole test was coded on both the controller in Digital Motion Control (DMC) language and on an industrial PC in .NET. The tests run automatically and the operator has full control of the test parameters including speed, distance, load, etc.

The rig was packaged, shipped and set up at the client's site where two engineers were trained in its use. The customer was very happy, and will hopefully order more rigs!