DRILILNG AUTOMATION – BUILDING AN ADVANCED ROBOTIC SYSTEM FOR DIRECTIONAL DRILLING. E. F. Akita[1] and F. Dyer[2], [1]The University of Oklahoma, 660 Parrington Oval, Norman, OK 73019, efakita@ou.edu, [2]The University of Oklahoma, 660 Parrington Oval, Norman, OK 73019, forrest.a.dyer-1@ou.edu.

The purpose of this paper is in two-fold;

a. to provide detailed description of design ideas for a fully automated drilling rig that can physically simulate a full-scale directional drilling rig,
b. to present the results of the functioning drilling rig, as it drills a directional well.

We present an overview of directional drilling, and the multiple design ideas for the individual rig sub-systems that come together to make up the drilling system as a whole. In addition, we present a new BHA design for directional drilling. The rig sub-systems include the rig structure, hoisting system, rotary and circulation systems, drillstring, new BHA design, measurement, instrumentation and control system. These sub-systems are selected based on different criteria: i) Intelligent control (computer-based) and real-time measurements of performance parameters, mechanical specific energy, (MSE), rate of penetration (ROP), rotational speed, torque, WOB, and vibration, ii) Precise control of WOB and mitigation of stick/slip phenomenon, iii) rig mobility to allow rig accessibility for educational and demonstrational purposes, iv) Operational safety aspects, v) Feasible rig construction time, and vi) Economic practicality of each sub-system relative to the added improvements to the drilling system and its ease of integration with the other sub-systems. The estimaed total cost of the automated rig construction is $7000, including 20% contingency cost.

This work builds on a previously available drilling rig system that was designed for vertical wells. This old system boasted a high rate of penetration through more durable drill pipe connections, improved hammer drilling methods, and intuitive visual display and user interface through LabVIEW^{TM} software.

This directional rig design focuses on building a new top and bottom assembly to achieve directional drilling, and the utilization of downhole sensors for a closed feedback loop in the controls. The controls employed were aimed at optimizing drilling parameter set points through extensive testing. Downhole sensors employed allows for azimuth and inclination control by means of a step motor system attached to the drill pipe which adjusts direction of well path trajectory in real time.

The result is a robotic drilling system that drills through a 24-inch sandstone block in record time, with approximately 18^0 of deviation from the central axis. The system accurately approaches the drilling target and operates without any human interaction.

This rig prototype currently employs redundancies based on correlations developed from the Buckingham pi theorem, but further work is aimed at moving to a full AI system using machine-learning algorithms to optimize controls and drilling efficiency. The hope is that this technology will improve on autonomous drilling and core-sampling systems in off-world environments, where real-time human control is impossible.