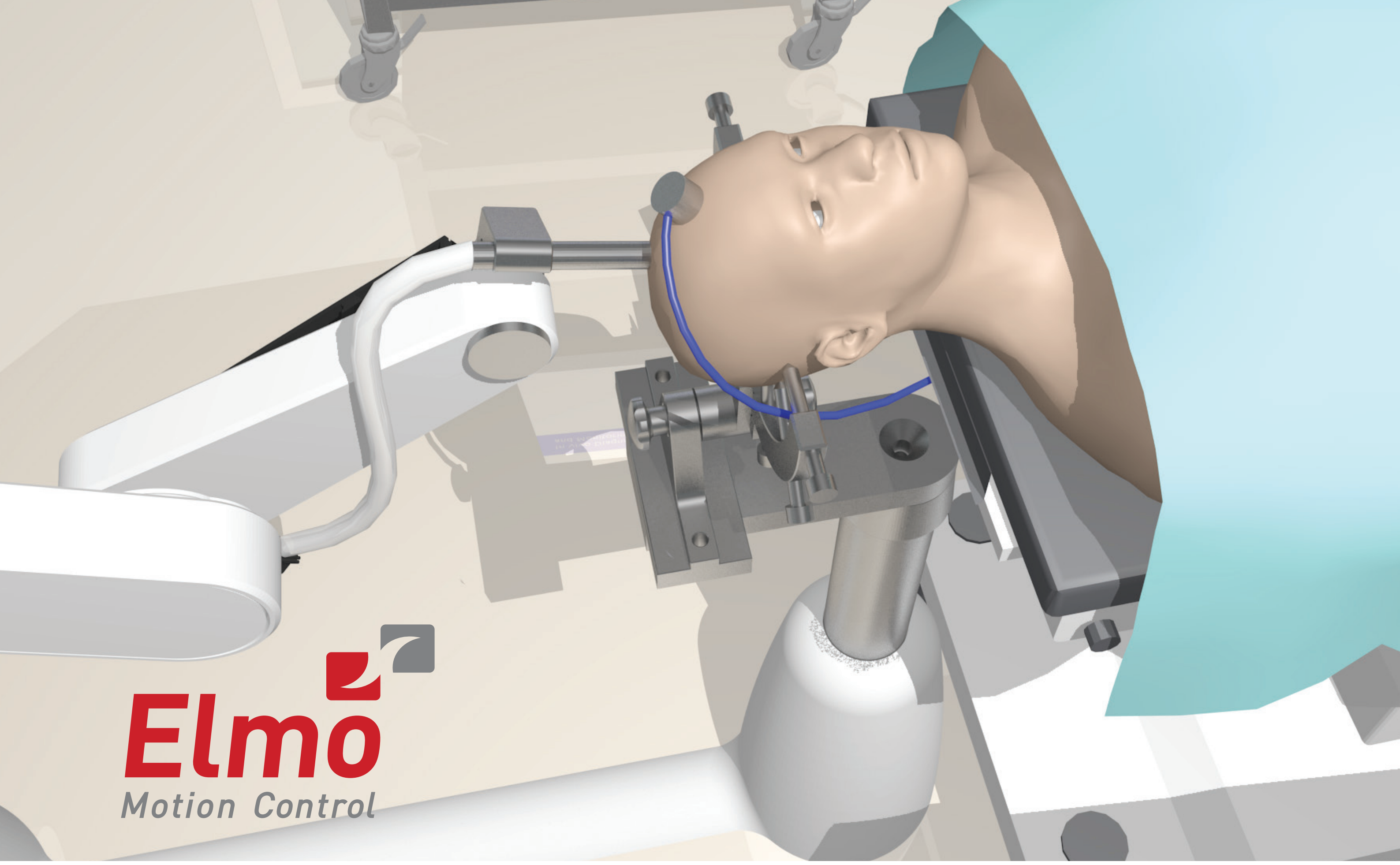


Compact Drives and High-Performance Controllers Steer Flexible Needle Through the Brain

First, do no harm. Hippocrates wrote those words more than 2000 years ago and they still apply to medicine today, particularly in the case of neurosurgery. In neurosurgery, an error of a few hundred microns can result in irreversible brain damage. The risk has led to growing focus on minimally invasive surgery. Surgeons perform procedures using increasingly sophisticated robots rather than scalpels and lasers. In the EU-funded EDEN2020 project, for example, researchers are developing a robotically steered catheter that can precisely deliver anticancer drugs directly to a brain tumor in situ. The system is only as good as its ability to position the needle as commanded, however. When it came time to specify the motion controller and drives for the four-axis robotic system that steered the catheter, researchers wanted compact, low-EMI, high-performance components. They found them with Elmo Motion Control.

EDEN2020
Enhanced Delivery Ecosystem for Neurosurgery in 2020

> *"In addition to the core benefits of the Elmo Motion Control technology, a key factor in our choice of control solution for the project was the reduced development time."*
>
> **Eloise Matheson, PhD candidate at the Mechatronics in Medicine Laboratory**

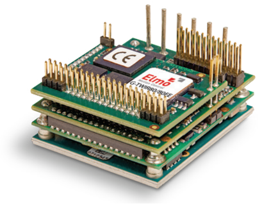
Elmo's values in this application

Making Smart Machines **Smarter**

- Perfect Servo
- Smallest & Lightest
- Efficient Power Conversion
- Highest Power Density
- Ruggedness
- Negligible EMI
- Utmost Reliability
- Easy & Simple to Operate
- Precise & Efficient Networking
- Utmost Safety

PLATINUM-MAESTRO

The Ideal Controller for High Performance Multi Axis Technologies



GOLD TWITTER

The NANO Servo Drive that provides over 4000 qualitative Watts

A steerable needle

The EDEN2020 system is based on the Programmable Bevel-tip Needle (PBN), a flexible needle that is capable of advancing through the brain along a precisely-defined route that minimizes tissue damage. The goal is for the robotic motion system to reference preoperative MRI scans and intraoperative ultrasound imagery during the procedure to generate path commands. When the PBN arrives at the tumor, it delivers a chemotherapy payload to the tissue.

The PBN consists of four interlocking longitudinal plastic segments nested together, each of which incorporates a drug delivery channel. The channel also contains a fiber-optic cable used for shape sensing. Each segment is driven at its distal end by an ironless motor. By pushing one segment or another forward so that it slides over the others, the system can cause the tip of the needle to curve by a specific amount. This process enables the needle to be gently navigated through the structures of the brain to reach even deeply embedded tumors.

It is an ambitious program with high performance demands. The task of controlling the robotic, steerable catheter through the brain is no simple matter. The four-axis system requires high synchronization and high precision, as any errors could cause irreparable harm. At the low-level control range, the system needs to operate with an accuracy of 10 μm.

Performance is only one part of the challenge. Space is always at a premium in an operating theater. The components used in the PBN need to be as small as possible. They also need to be quiet, both in terms of audible noise and EMI. Operating rooms are packed with instrumentation. The robot cannot interfere with imagery or the signal of a crucial instrument.

Drives and controllers

The PBN features four motors, each of which requires a drive. In addition, the overall system requires a high-performance motion controller to perform path planning based on closed-loop feedback and input from the MRI and ultrasound units.

For adrive , the Imperial College team selected the Elmo Gold-Twitter (G-TWI) servo drive. Just 35 mm x 30 mm, the compact Gold Twitter drive is essential for minimizing the overall footprint of the portable surgery station. In addition, the servo drive's extremely low EMI, resulting from a highly efficient pulse-width modulation (PWM) switching process, proved vital in this critical medical application. In an environment in which safety is a primary concern, the Gold Twitter, the smallest STO (SIL-3) certified drive available on the market, offers a huge advantage.

Guiding the PBN requires the system to analyze the MRI and ultrasound data, then independently drive the four segments of the needle to direct the payload to the tumor. This needs to happen accurately, precisely, reliably, and at very high speeds. For a controller solution, the Imperial College team chose the Platinum Maestro (P-MAS) multi-axis motion controller.

The Platinum Maestro incorporates a multi-core processorand advanced multi-axis features, , making it effective for highly synchronized systems. It includes a library of motion algorithms to simplify the implementation and control of machines and robots that need to be both fast and accurate. The Platinum Maestro features enhanced fieldbus support, including EtherCAT, cycling at a rate of 250 μs in the Imperial project.

"The system will be able to sense and perceive intraoperative, continuously deforming brain anatomy at unmatched accuracy, precision and update rates," explains Prof. Ferdinando Rodriqugez y Baena, Project Coordinator for EDEN2020.

The Platinum Maestro includes a number of features for ease of use. "In addition to the core benefits of the Elmo Motion Control technology, a key factor in our choice of control solution for the project was the reduced development time," says Eloise Matheson, PhD candidate at the Mechatronics in Medicine Laboratory. The P-MAS is an off-the-shelf motion controller that provides users with many tools and features that streamline motion integration. Key features include the simple interconnection of the P-MAS to all drives, and automatic EtherCAT configurations to all nodes. In addition, the ability to control all drive parameters at the P-MAS level helps simplify regular maintenance operations, minimizing downtime.

The EDEN2020 project has an ambitious set of goals. To meet those goals, the Imperial College team needs to focus on the PBN, on guidance software, and on integrating diagnostics into their system. They don't want to spend hours of engineering time just getting motion elements to operate together. The Elmo Motion Control Gold Twitter drives and Platinum Maestro controllers deliver high performance and reliability in compact, low-noise solutions. Special features designed for ease-of-use simplify integration. As a result, effective motion is a given. The group can concentrate its efforts on the important business of revolutionizing neurosurgery and saving lives.