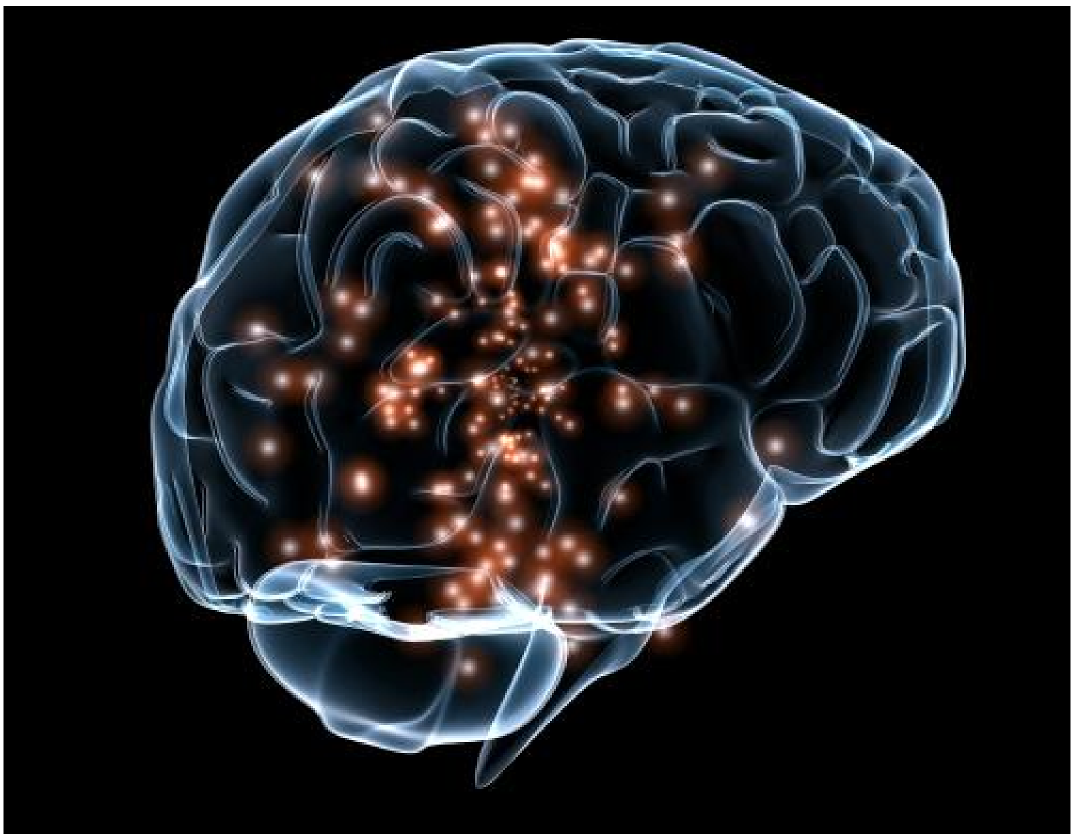
Journey of discovery starts toward understanding and treating networks of the brain

May 28 2014



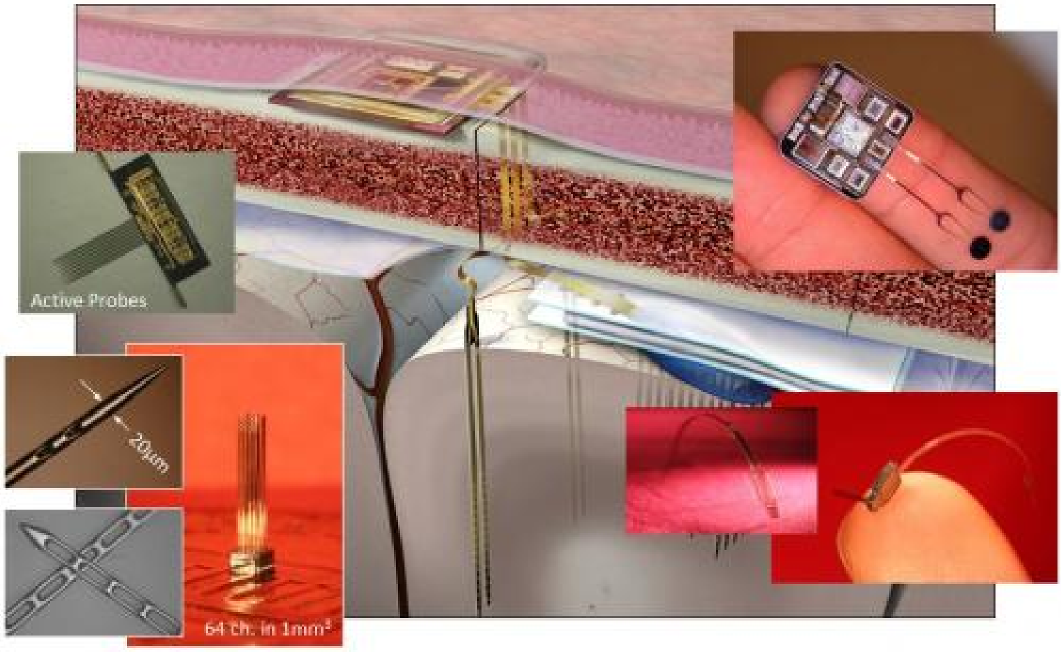
DARPA’s SUBNETS program seeks new neurotechnology for analyzing neuronal activity across sub-networks of the brain to enable next-generation therapies tailored to individual patients. Credit: DARPA

Work on DARPA's Systems-Based Neurotechnology for Emerging

Therapies (SUBNETS) program is set to begin with teams led by UC San Francisco (UCSF), and Massachusetts General Hospital (MGH). The SUBNETS program seeks to reduce the severity of neuropsychological illness in service members and veterans by developing closed-loop therapies that incorporate recording and analysis of brain activity with near-real-time neural stimulation. The program, which will use next-generation devices inspired by current Deep Brain Stimulation (DBS) technology, was launched in support of President Obama's brain initiative.

UCSF and MGH will oversee teams of physicians, engineers, and neuroscientists who are working together to develop advanced brain interfaces, computational models of neural activity, and clinical therapies for treating networks of the brain. The teams will collaborate with commercial industry and government, including researchers from Lawrence Livermore National Laboratory and Medtronic, to apply a broad range of perspectives to the technological challenges involved.

SUBNETS is premised on the understanding that brain function—and dysfunction, in the case of neuropsychological illness—plays out across distributed neural systems, as opposed to being strictly relegated to distinct anatomical regions of the brain. The program also aims to take advantage of neural plasticity, a feature of the brain by which the organ's anatomy and physiology can alter over time to support normal brain function. Plasticity runs counter to previously held ideas that the adult brain is a "finished" entity that can be statically mapped. Because of plasticity, researchers are optimistic that the brain can be trained or treated to restore normal functionality following injury or the onset of neuropsychological illness.

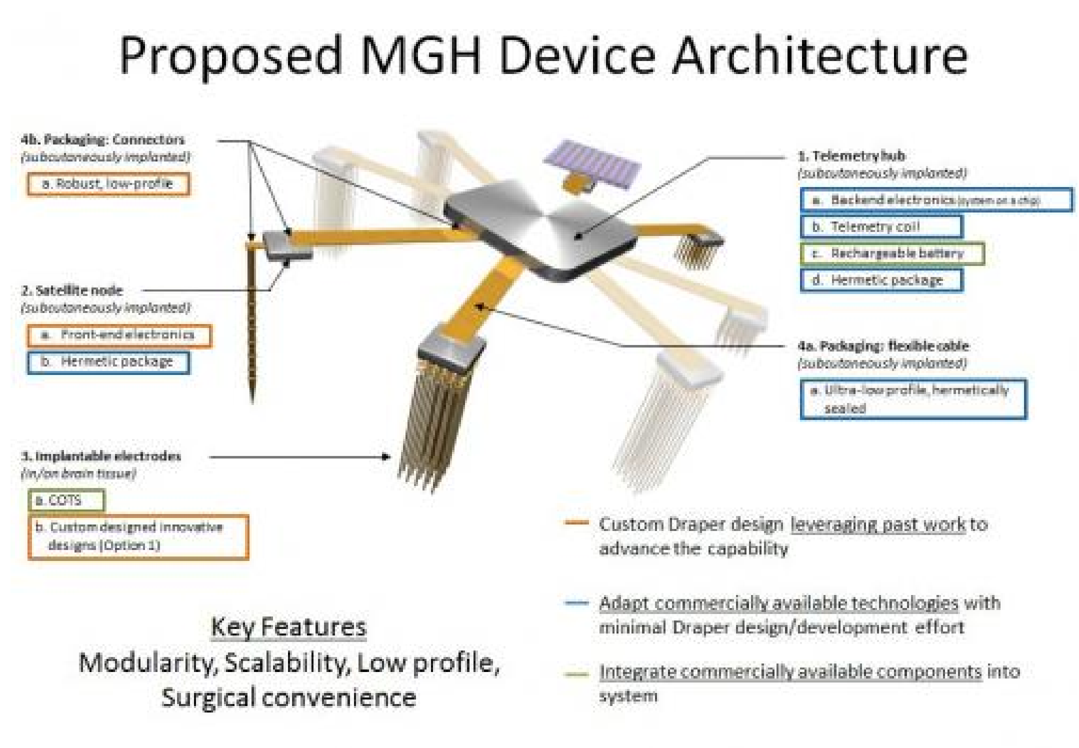


n this artist’s concept, a miniature electronic device placed between a patient's skull and scalp would serve as an interface between a series of electrodes placed at varying depths in different regions of the brain and a clinician who could wirelessly review neurological data recorded by the electrodes and communicate with the device to prescribe tailored therapies. Photos on either side show a sampling of existing devices that could serve as inspiration or building blocks for SUBNETS technologies. DARPA will evaluate multiple designs from both performer teams over the course of the program. Credit: Massachusetts General Hospital and Draper Labs

"The brain is very different from all other organs because of its networking and adaptability," said Justin Sanchez, the DARPA program manager for SUBNETS. "Real-time, closed-loop neural interfaces allow us to move beyond the traditional static view of the brain and into a realm of precision therapy. This lack of understanding of how mental illness specifically manifests in the brain has limited the effectiveness of existing treatment options, but through SUBNETS we hope to change that. DARPA is looking for ways to characterize which regions come into play for different conditions—measured from brain networks down to the single neuron level—and develop therapeutic devices that can record activity, deliver targeted stimulation, and most importantly, automatically adjust therapy as the brain itself changes. The research teams we selected for SUBNETS will pursue bold approaches to reach those goals and we're excited to get started because this research could prove to be transformative for people with mental illness."

The UCSF team's approach is to develop a device that focuses on regions of the brain involved in an individual's psychiatric or neurologic disease. The device will use direct recording, stimulation, and therapeutic approaches to encourage neural plasticity, with the aim of rehabilitating the circuits that appear to be driving pathology and free an individual from psychiatric or neurologic symptoms. If successful, the approach would allow for the eventual removal of the device.

The MGH team will pursue a "trans-diagnostic" approach to assessing common components of psychiatric and neurologic diseases—traits common to many such syndromes, including increased anxiety, impaired recall, or inappropriate reactions to stimuli—through qualitative and quantitative behavioral testing combined with high-fidelity, real-time single-neuron recordings. If successful, this method will allow investigators to follow the traces of pathology from individually firing neurons, up through imaging studies of neural network behavior, and into tests that can be performed in the clinical setting. It could also lead to more targeted treatments for psychiatric disease and advance clinicians' ability to make accurate diagnoses. The MGH team will also work with Draper Laboratories to deploy state-of-the-art advances in micro-fabrication of electronics, with the goal of generating a sophisticated, implantable device that will remain safe and effective through the lifetime of the recipient.



(Artist Concept) The research team led by Massachusetts General Hospital will use a combination of commercial-off-the-shelf electrodes and custom technology developed by Draper Labs to create novel systems. The proposed design will focus on an ultra-low-profile, hermetically sealed interface device capable of being recharged through inductive coupling. Credit: Massachusetts General Hospital and Draper Labs

The SUBNETS program plan calls for research to be conducted over the next five years along a schedule of prescribed milestones, culminating in technology demonstrations and submission of devices for approval by the U.S. Food and Drug Administration.

"DARPA is in the business of creating not just science, but new technologies," Sanchez said. "The neurotechnologies we will work to develop under SUBNETS could give new tools to the medical community to treat patients who don't respond to other therapies, and new knowledge to the neuroscience community to expand the understanding of brain function. We believe this will be a foundational program."

Provided by DARPA