NINscan TD: Toward Imaging Brain Function in Spaceflight
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INTRODUCTION
Spaceflight poses numerous risks to the brain and central nervous system, including high-energy radiation, toxic gasses, chronic stress, sleep deprivation, fluid shifts, hormone imbalances, and injury 1. Unfortunately, the standard technologies for brain assessment—MRI, PET, or CT—are not suitable to the flight environment, as they require excessive mass, power, and volume. Near-infrared neuroimaging (NIN) can be used to measure the key cerebral variables of blood volume and oxygenation 2 and can also be miniaturized for flight. Existing mobile NIRS devices, however, can only make point measurements, whereas many applications require spatial or imaging information.

METHODS
We have been developing a series of prototype near-infrared neuroimaging (NIN) systems to enable monitoring of cerebral hemodynamics in a form factor suitable for spaceflight 3. Compared with previous devices, our newest approach employs an embedded microcontroller and time-division multiplexing (TDM). This provides maximal system flexibility, and also minimizes power consumption regardless of the number of light sources used.

RESULTS
The resulting system, NINscan TD (Fig 1) is powered by two embedded rechargeable Li-ion batteries, provides 8 optical channels, and weighs less than 500 grams. The system includes 16-bit A/D conversion and programmable light power and detector gain for optimized data acquisition on different subjects. Most important, the TDM microcontroller design can be scaled to develop whole-head imaging devices with similar size and power requirements. In laboratory performance tests, the system was highly sensitive to Valsalva maneuvers (Fig 2) and cardiac signals (Fig 3) even at modest light levels and detector gains.

DISCUSSION
NINscan TD demonstrates the feasibility of sensitive mobile NIN measurements with a microcontroller design implementing time-division multiplexing. This design is a key stepping stone to developing a whole-head imaging system with characteristics that are suitable for spaceflight.

REFERENCES