FEDERALLY FUNDED RESEARCH DRIVES AMERICAN INNOVATION

THE iPAD RODE THE WAVE OF FEDERAL RESEARCH

The iPad is an extraordinary invention by Apple but, as author Mariana Mazzucato has written, technologies like this "ride the wave" of past federal investments in research.

Microprocessors

Microprocessors control computation, text editing, multimedia display, and internet communication in the iPad. The microprocessor depends on an integrated circuit (IC), a set of electrical circuits contained on a single plate or chip of semiconductor material. In the 1960s, the Air Force and NASA, needing ever more sophisticated versions for missiles and the space program, were the sole consumers for ICs and made possible development of those ultimately used in the iPad.

LCD Displays

A liquid crystal display (LCD) is a visual display that takes advantage of the light modulating properties of liquid crystals. LCDs can display fixed images, as in digital clocks, or arbitrary images, as in televisions and the iPad. A vital component of LCD technology is the thin-film transistor, which was developed by Peter Brody at Westinghouse, funded almost entirely by the U.S. Army. Brody was given a contract by the Defense Advanced Research Projects Agency (DARPA), and then established a company to develop LCD technology.

Lithium-ion Batteries

Lithium-ion batteries are rechargeable batteries commonly found in consumer electronics like the iPad. They enable smaller and lighter portable devices because they store large amounts of energy, take up little device memory, and lose their charge very slowly when not in use. John B. Goodenough at the University of Texas at Austin conducted critical research underlying lithium-ion batteries in 1980, with funding mainly from the Department of Energy and the Air Force.

Digital Signal Processing

Digital signal processing allows real-time processing of sound, such as during a phone call or when playing a movie on an iPad or other portable device. It frequently uses the "fast Fourier transform," a mathematical algorithm developed through a grant from the Army Research Office and advanced through additional federal funding from the National Science Foundation (NSF) and the Commerce Department's Advanced Technology Program.

Internet

The internet was created almost entirely through federal research funding. During the Cold War, the U.S. military needed a decentralized communication network that would survive a nuclear attack. From the 1970s to the 1990s, DARPA funded and created the communication protocol, operating system, and email programs needed for communication. Researchers supported by NSF began development of the first high-speed networks.

SIRI

SIRI, the iPad's personal assistant application, uses voice recognition software to answer questions, make recommendations, and perform tasks with other apps. In the 1980s, NSF supported research on speech recognition technology. In 2000, DARPA funded the Stanford Research Institute (SRI) to coordinate the "Cognitive Assistant that Learns and Organizes" (CALO) project, which made major advances in the technology. In 2007, SRI formed a start-up called SIRI, which was acquired by Apple in 2010.

Multi-Touch Screens

A multi-touch screen, used in the iPad and other devices, can recognize two or more points of contact with its surface. Shortly after leaving Oak Ridge National Laboratory for the University of Kentucky, Samuel Hurst and his colleagues developed the first resistive touch screens, which recognized only single-touch gestures. Wayne Westerman and John Elias at the University of Delaware, with NSF support, added multi-touch scrolling and gestures. Apple acquired the company they formed to commercialize the technology.

Global Positioning Systems

The global positioning system (GPS) is a satellite-based navigation system that accurately reports time and location information, providing important capabilities and information to civilian, military, and commercial users. GPS was originally developed in the 1970s by the Defense Department to enhance coordination and accuracy of deployed military assets. Although civilian use of GPS is now far greater than military use, the Air Force remains at the forefront of maintaining and enhancing the system.