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From the battlefield to space: How NASA and DARPA orchestrated the development of telepresence robotic surgery

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Early Developments with NASA

1985: Researchers at the NASA-Ames group were investigating virtual reality to allow astronomers to interact with data from exploratory planetary probes. With Scott Fisher, PhD and Joseph Rosen, MD, they developed the first stereoscopic head-mounted displays and haptic-glove user interfaces (Fig 1a).

Fischer and Rosen envisioned using these tools for “telepresence” surgery in which the surgeon is not physically present at the surgical site (Fig. 1b). They collaborated with Phil Green, PhD of the Stanford Research Institute (SRI) to develop a remote surgical unit and telepresence surgeon's workstation. Although Green ultimately pivoted to using a stereoscopic monitor and handles of actual surgical instruments, the early head-mounted displays and haptics laid the groundwork for virtual reality technology.

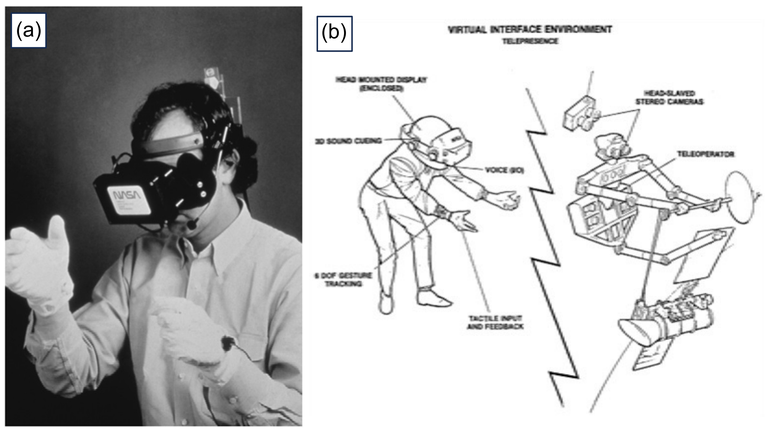

Figure 1. (a) Scott Fisher wearing one of the first head-mounted displays at the NASA-Ames Research Center, 1985. (b) Fischer and Scott’s early conceptualization of telepresence surgery, 1986

1989: After watching a recorded laparoscopic cholecystectomy at the Society of American Gastrointestinal and Endoscopic Surgeons conference, the team switched their focus to laparoscopic surgery. Their robotic system was specifically advantageous for laparoscopic surgery because it eliminated the fulcrum effect, enhanced dexterity, reduced tremor, and scaled motion.

Historical Significance

Public-private partnerships involving NASA and DARPA propelled the development of remote surgical systems that have gone on to shape the modern robotic surgery landscape.

Applications with DARPA

1993: After Green presented the results of their telepresence surgery project at Walter Reed Medical Center, Col Richard Satava, MD was assigned to the Defense Advanced Research Projects Agency (DARPA) to apply the system to improving emergency medical care to combat casualties.

The initial concept was to locate the telepresence surgeon's workstation at the closest mobile army surgical hospital unit, while the remote surgical unit was transported to the patient in an armored vehicle, allowing for medical forward advanced surgical treatment (MEDFAST).

1996: Experiments were done with the remote surgical unit and telepresence surgeon's workstation 5 km apart, proving the potential for remote surgery implementation.

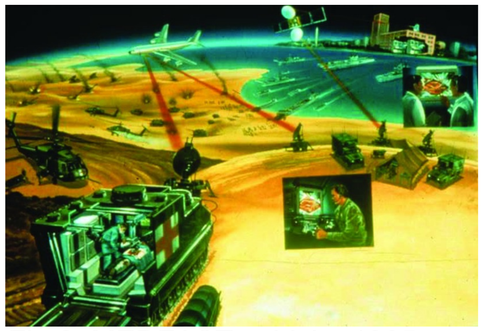

Fig 2. MEDFAST vehicle, 1995.

Commercialization and Implementation

1993: With DARPA funding and NASA's Jet Propulsion Laboratory Small Business Innovation Research grant, Yulun Wang, PhD developed a laparoscopic camera holder allowing voice-controlled intraoperative maneuvering. NASA hoped to utilize the technology to remotely service the space station with greater dexterity. Wang also developed ZEUS, a complete robotic surgery system similar to the SRI team’s surgical system prototype (Fig. 3b).
1995: Fred Moll, MD acquired SRI’s intellectual property and developed SRI’s surgical system prototype into the da Vinci robotic surgical system (Fig. 3a).

1997: First robotic cholecystectomy was performed in Belgium with the da Vinci surgical system.
2001: First transatlantic cholecystectomy surgery (“The Lindbergh surgery”) was performed with ZEUS.

From 1994 onward, the ZEUS and Da Vinci surgery systems developed concurrently. Remote applications of robotic surgery were eventually abandoned due to the high cost and latency issues associated with telecommunications. Over time, the DaVinci system became the predominant robotic surgery system used in the United States due to its ability to create an immersive intuitive interface and imitate wrist motion for greater dexterity.

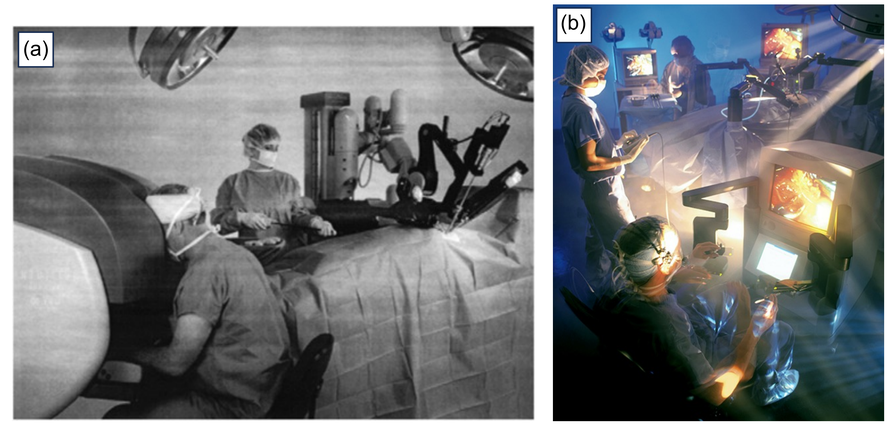

Figure 3. (a) da Vinci robotic telepresence surgery system, 1999. (b) Zeus robotic system.