SRI International

Da Vinci, Taurus, and Opportunities in Teleoperation

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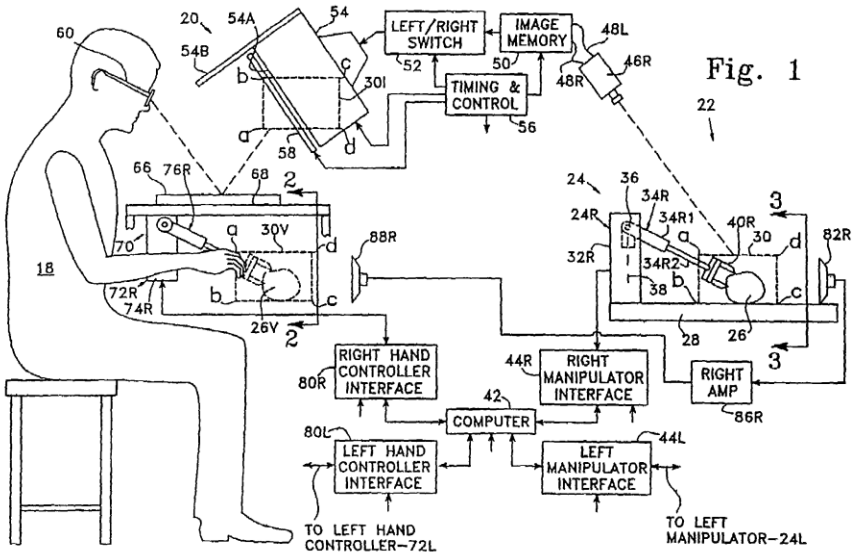
M4 1992-1994

- Created by Phil Green of SRI
- Four DOF plus Gripper x 2
- High fidelity haptic feedback
- Stereoscopic – proprioceptive display
- Motion, force an video scaling
- Developed with support of SRI, NASA, and DARPA
- Goal was remote battlefield surgical control of hemorrhage.



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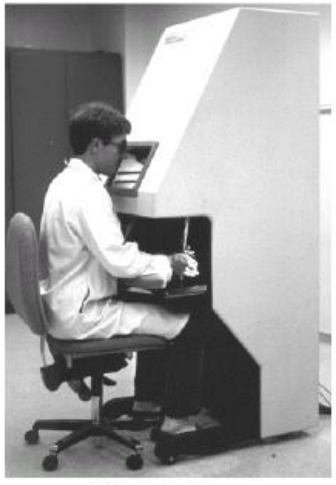
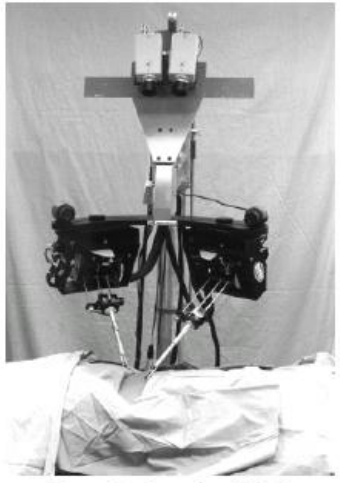


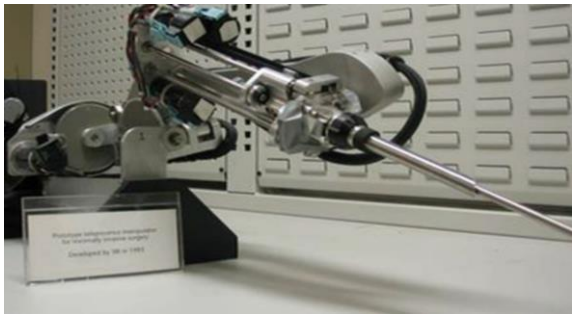
Workstation



Remote Surgical Unit

First MIS 1994

- After fruitless effort to convince VC's in the value of long-distance surgery, the new target of improving the effectiveness of Minimally Invasive Surgery was identified, and Intuitive Surgical Inc. was created.

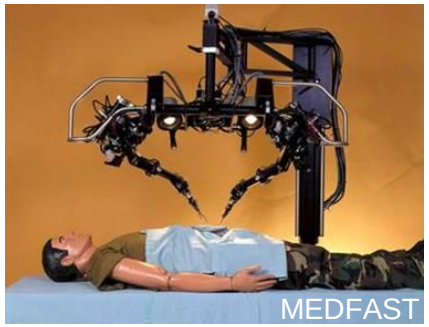


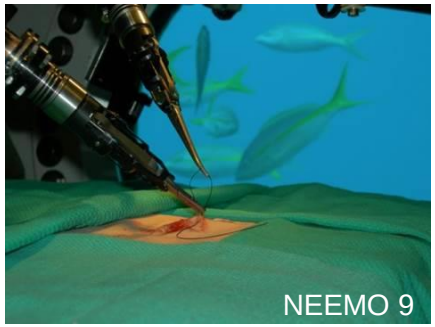
M7 1998-2011

DARPA interest in remote open surgery on the battlefield remained strong. Supported the development of "Medfast" and the M7 Telemanipulator.

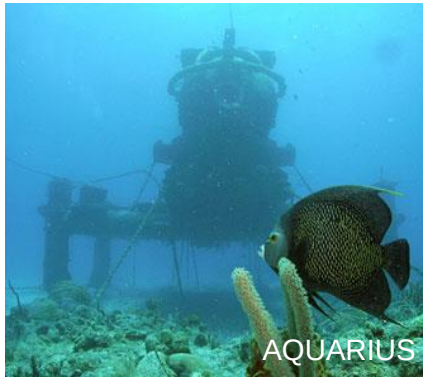
- 6 DOF plus gripper x 2 arms
- Haptics on all axis
- Counter-balanced design
- Similar Master and Slave hardware

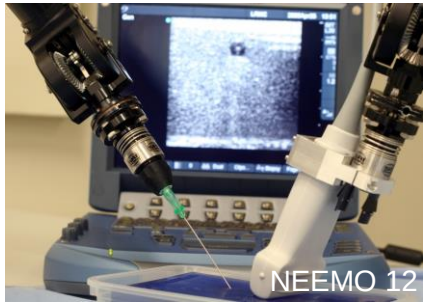
- Led to a series of experiments and demonstrations
  - NEEMO 9: Ontario (St. Josephs Medical Center) to Key Largo (Aquarius) testing long distance surgical and sample sorting with variable delay
  - NEEMO 12: Autonomous needle targeting and vessel cannulation
  - NASA micro gravity: Robot mediated surgical tasks in dynamic environment. Developed motion compensation algorithms
  - Plugfest: University of Washington led interoperability experiments

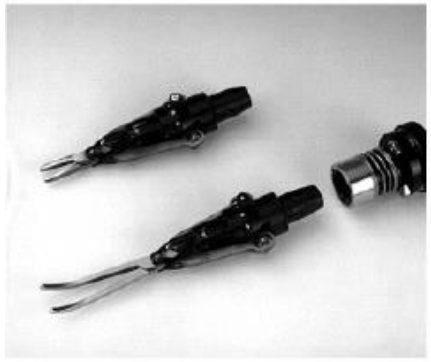

MEDFAST


NEEMO 9


MICRO-GRAVTY


AQUARIUS

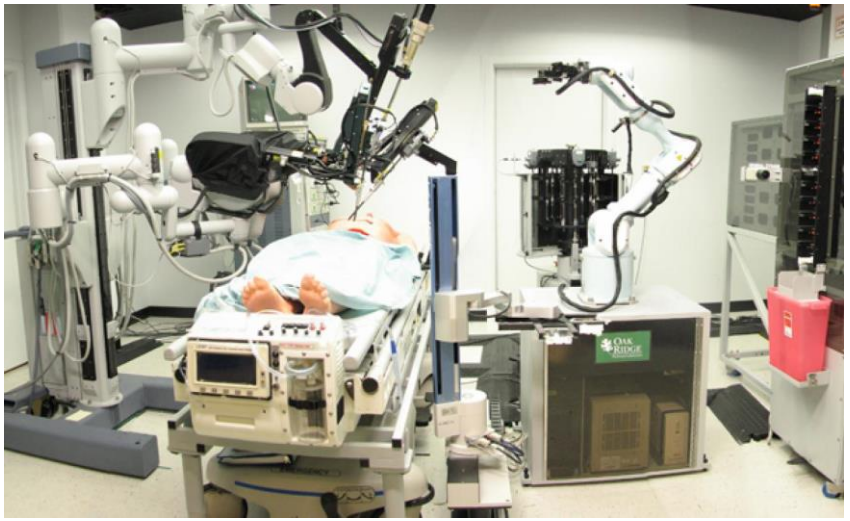

NEEMO 12



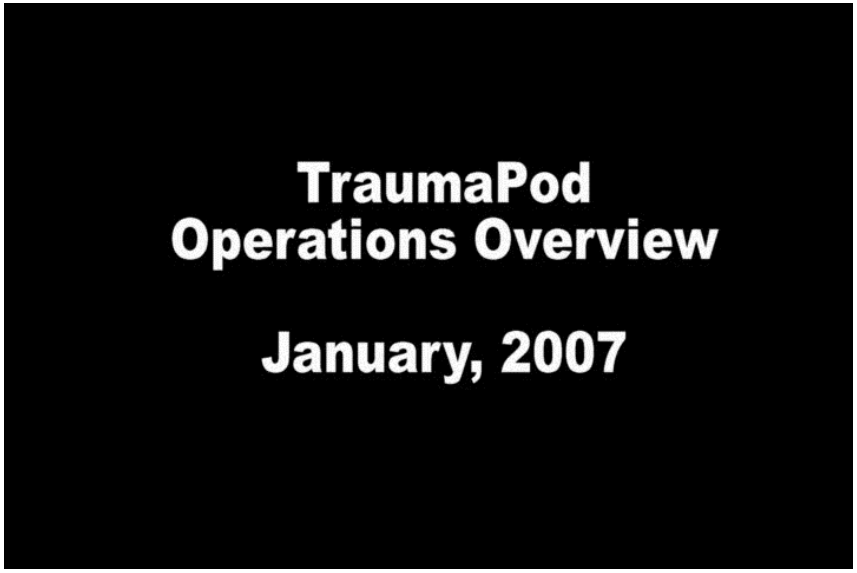
M7 Capabilities and Applications

DARPA Trauma Pod 2007

- Eliminate all human presence from battlefield stabilization surgical OR
- Manage operator workload and provide Situational Awareness
  - Voice and gesture control
  - Patient 3-D scanning and remote assessment
  - Integrated preoperative CT registration and navigation
  - Automated tool changing, supply unpackaging, dispensing, disposal and tracking
  - Concurrent system simulation and visualization



Integrated Robotic Operating Room



TAURUS

- Enhance capabilities of existing IED robot platforms with da Vinci like dexterity, visualization and precision at affordable cost

SRI Robotics™

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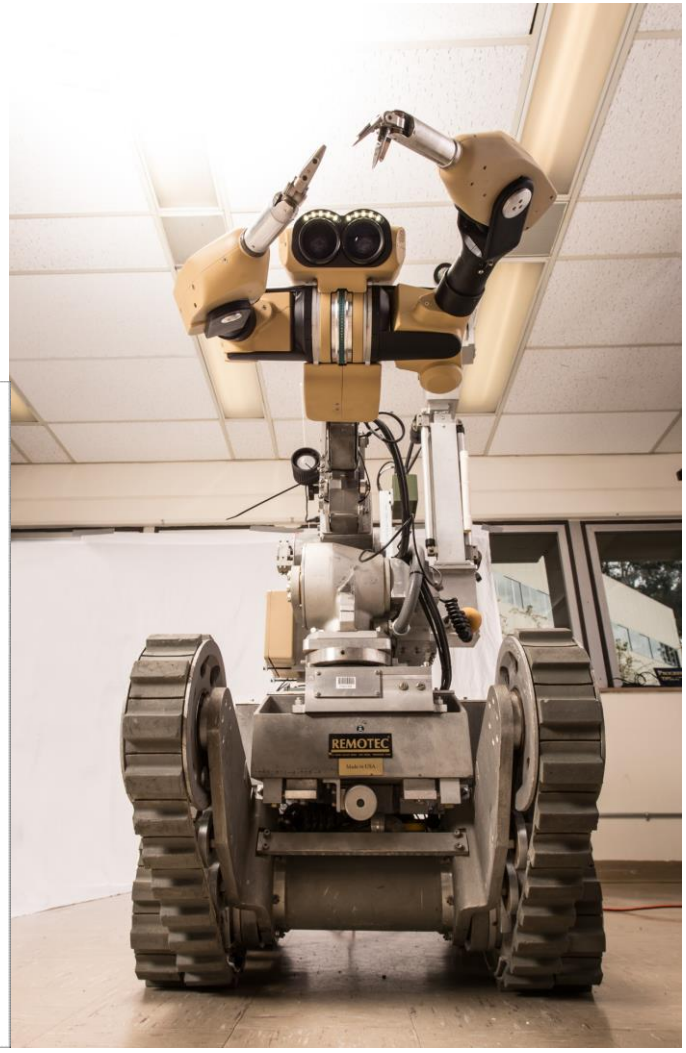
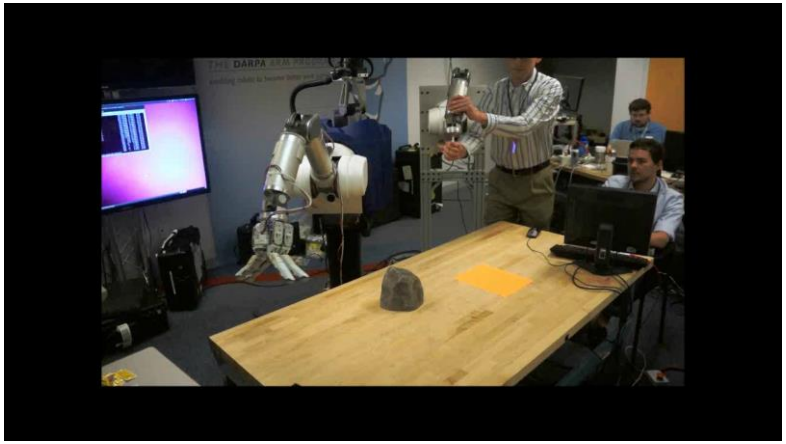
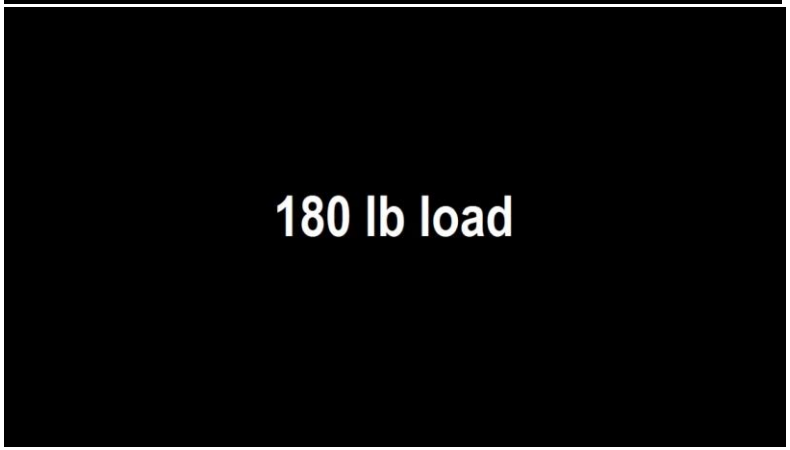


The Taurus Dexterous Telemanipulator on ANDROS platform

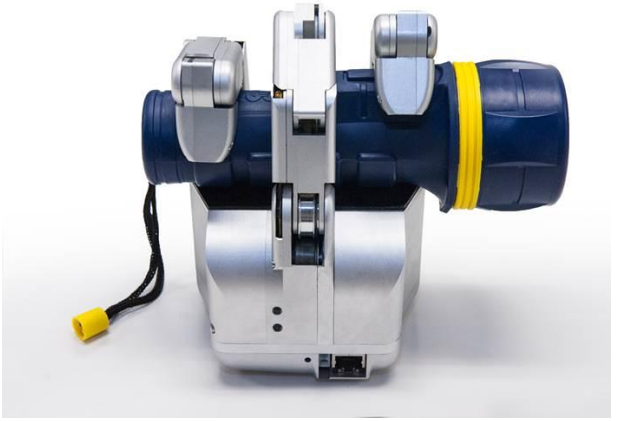
HAND (DARPA ARM-H)

- Develop high dexterity and low cost hand for IED defeat and DARPA robotics challenge





Low Cost Dexterous Robot Hands



DARPA DRC Hand
Rugged hands for humanoids

Operator Tracking

- Mouse
- Joystick (rate control)
- Kinematic model of slave
- General 6 DOF (Mechanical, Optical, Magnetic, RF)
- 3D visual tracking
  - LIDAR, structured light , stereo processing

OCU Alternative OCU input devices: Phantom Omni (left), SpaceNavigator (center), Falcon (right), Omega.7 (Bottom Center), Razer Hydra (Left)

Operator Display Options

- 2-D or stereoscopic screen
- Autostereoscopic screen
- Immersive binocular displays
- Head Mounted Display

Challenges

- Telepresence: How hard can it be?
  - Getting a robot to mimic your motions is the easy part. 95% of the effort is in
    - Startup and closedown
    - Singularities
    - Workspace limits
    - Clutching and workspace scaling
    - Effective User Interface and providing Situational Awareness
    - Direct low latency arm control
    - Safety
    - Real-world communications
    - Mapping X DOF input to X+n DOF output

Opportunities

- Early adoption will be in domains where value is highest
  - Operator Safety: Hazardous materials or device handling, environments incompatible with survival.
  - Remoteness: Occasional need for specialized expertise in geographically remote and distributed areas
  - Security: Activities where prohibited personnel action can have grave societal consequences
  - Clean handling of contamination-sensitive materials
- Labor force flexibility
  - Production near point of consumption with remote labor force
  - Labor flexibility and scalability
  - Labor force economics

Topics for discussion

- Haptics
- Clutching and Alignment
- Stereopsis
- Audio Cues
- Autonomy
- Precision
- Latency
- Safety
- Security
- Situational Awareness
- Bandwidth
- Control Update Rate
- Metrics
- Tools and tool changers
- Mobility

What's Next?

- We are continuing to push the boundaries of both autonomous and teleoperated systems
- Out focus has been on efficiency and affordability (neither of which have been significant concerns before now)
- Humanoid form has advantages, but comes at a significant cost
- High performance 7 DOF arms in final stages of development
- Application of telelabor has the potential to be disruptive, both in terms of energy use, and in impact on global labor markets.