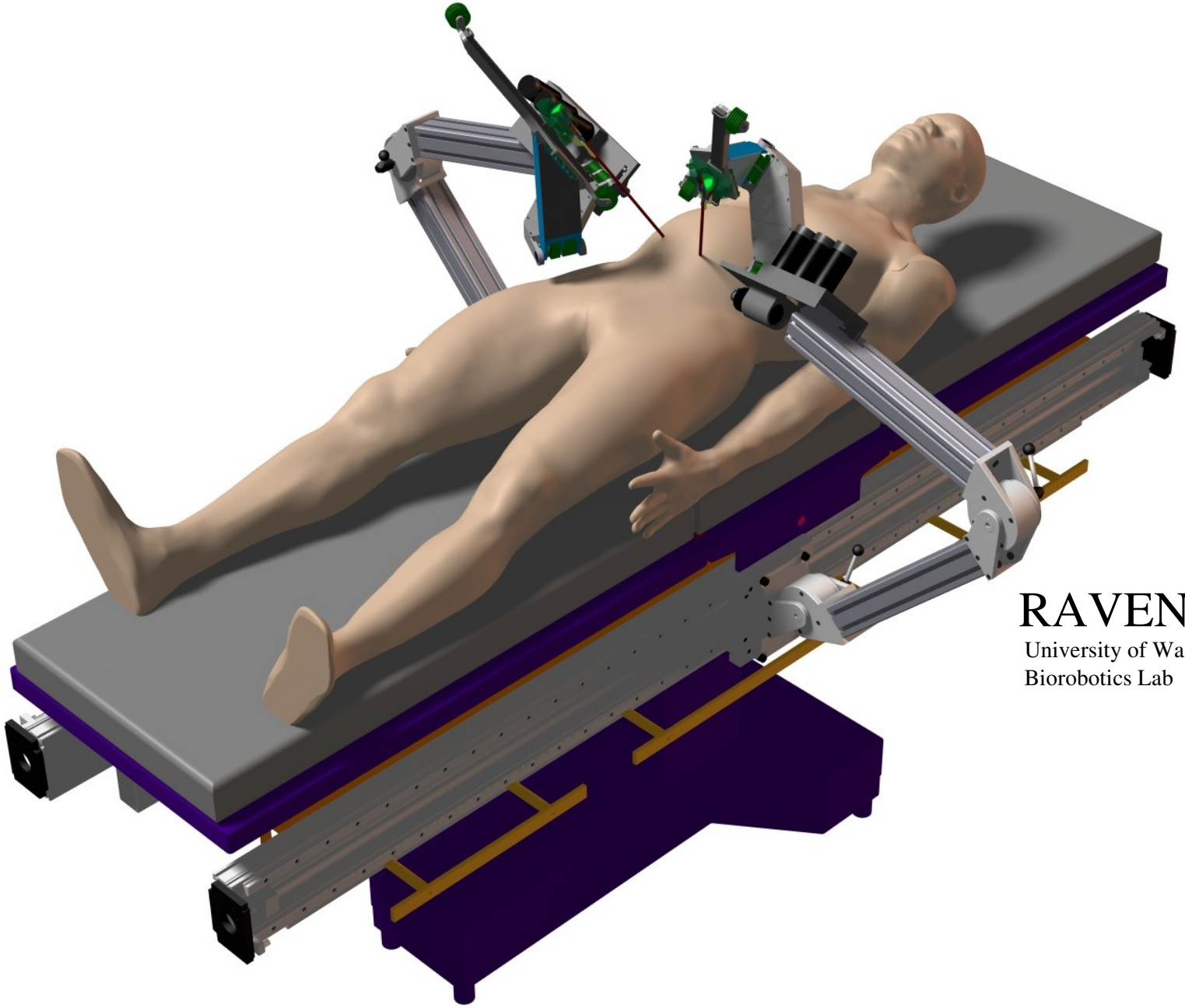
Raven Surgical Robot: Overview

Blake Hannaford, Ph.D., Jacob Rosen Ph.D.

Biorobotics Lab, Department of Electrical Engineering
http://brl.ee.washington.edu

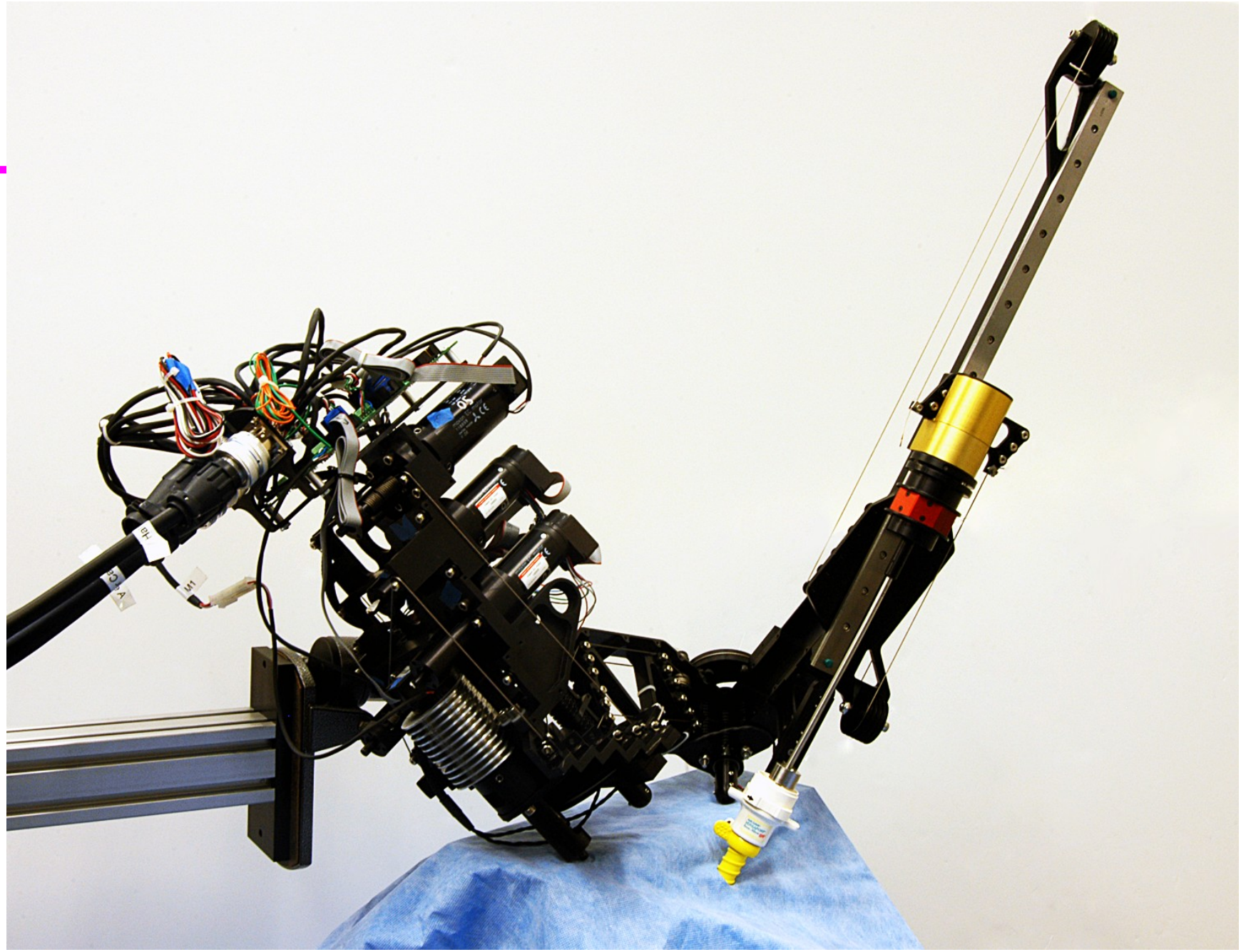
People / Thanks

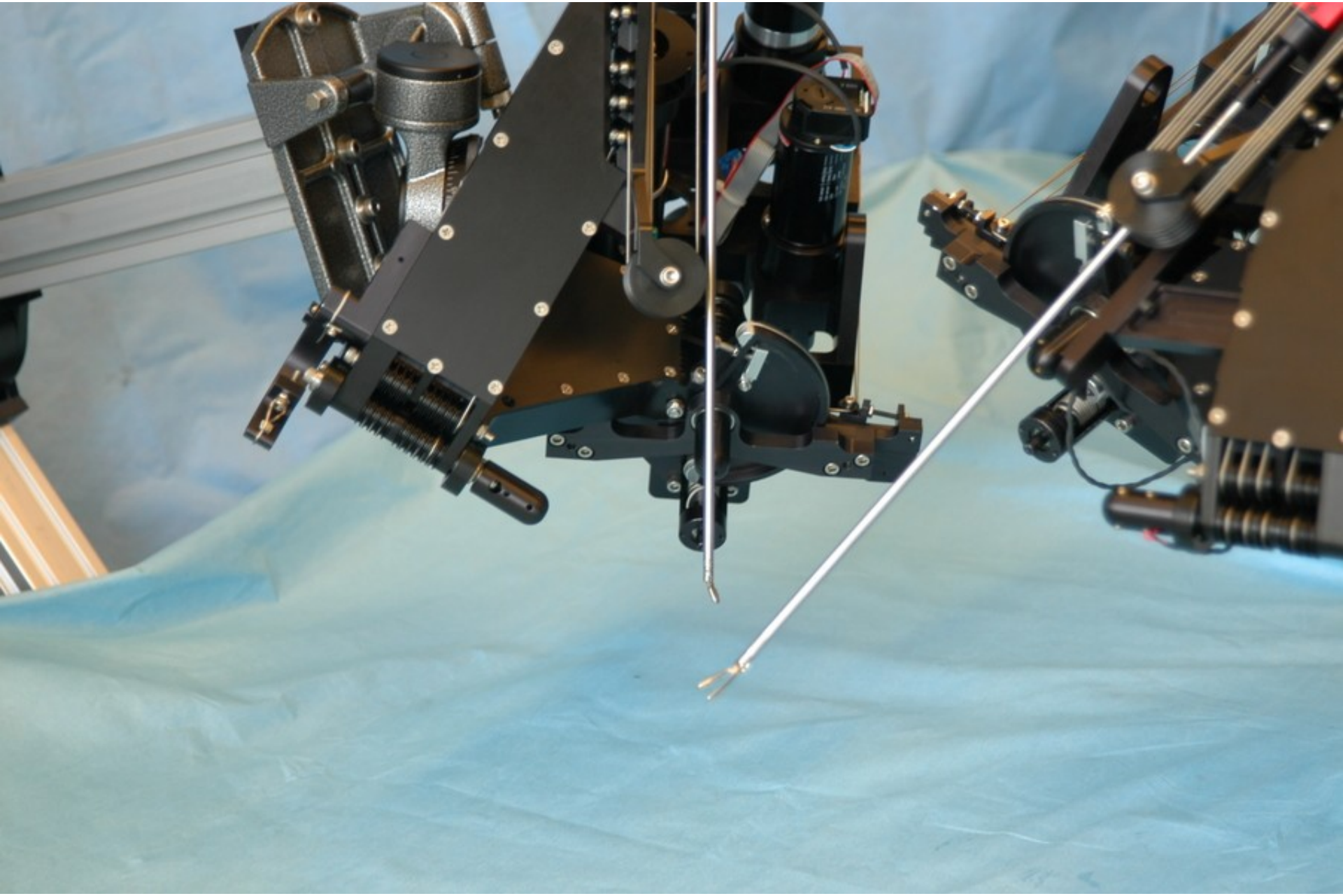
- **Surgeons: Timothy Broderick, Mika Sinanan, Rick Satava**
- **Bioengineers, Prof. Jacob Rosen, Mitch Lum, Diana Warden,Gina Donlin, Shane Draney, Rainer Leushke, Manuel Moreyra, Tim Ramsey, Denny Trimble,**
- **Software Engineers: Ken Fodero, Hawkeye King, Jesse Dosher, Ganesh Sankaranaranyananan, Clint Bland**
- **Sponsors:** Washington Technology Center, DARPA, Tyco-US Surgical, Whitaker Foundation (Brown), WRF-Capital, **US ARMY Peer Reviewed Medical Research Program**, **TATRC**, UW Telemedicine Program, Rockefeller Fund.

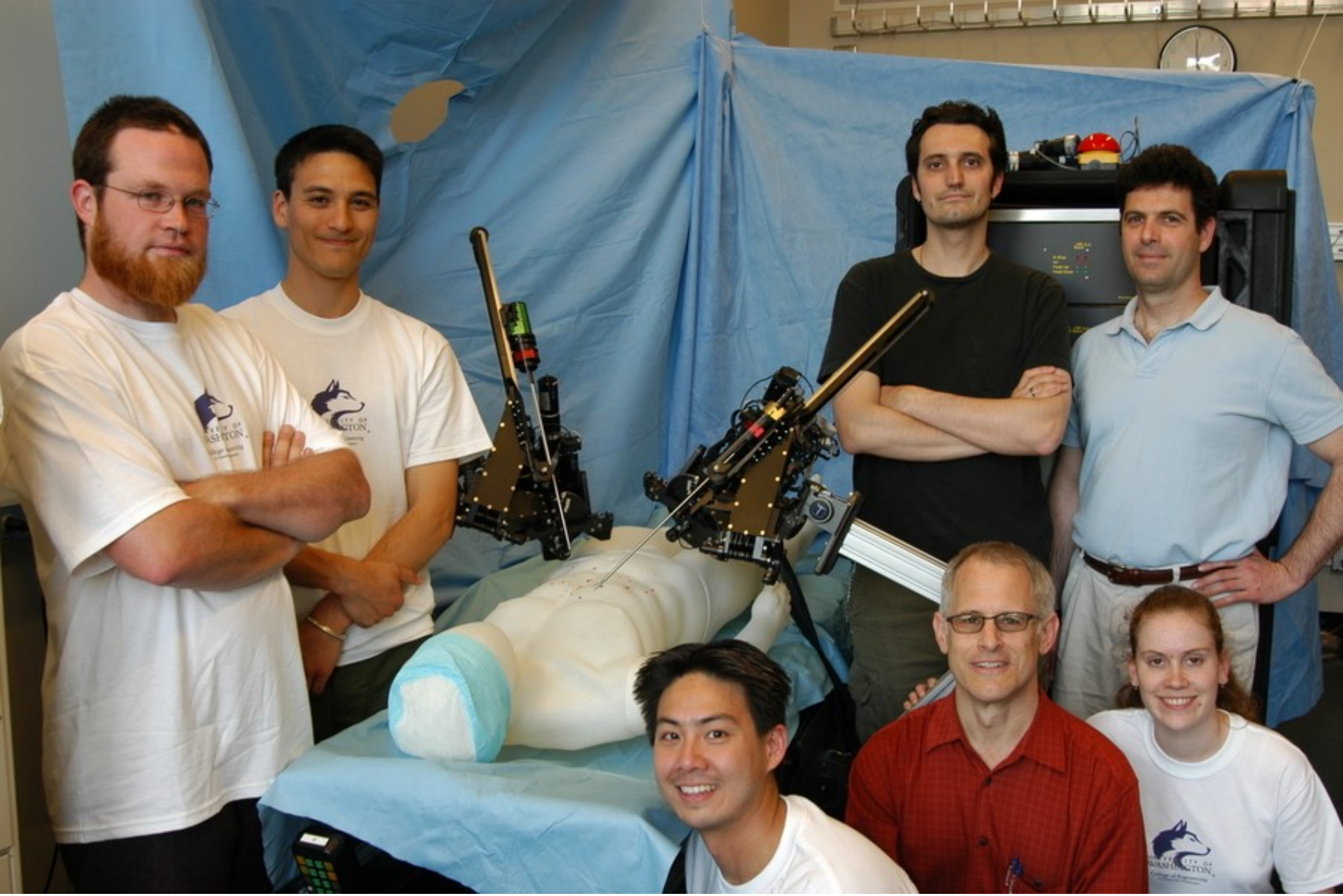


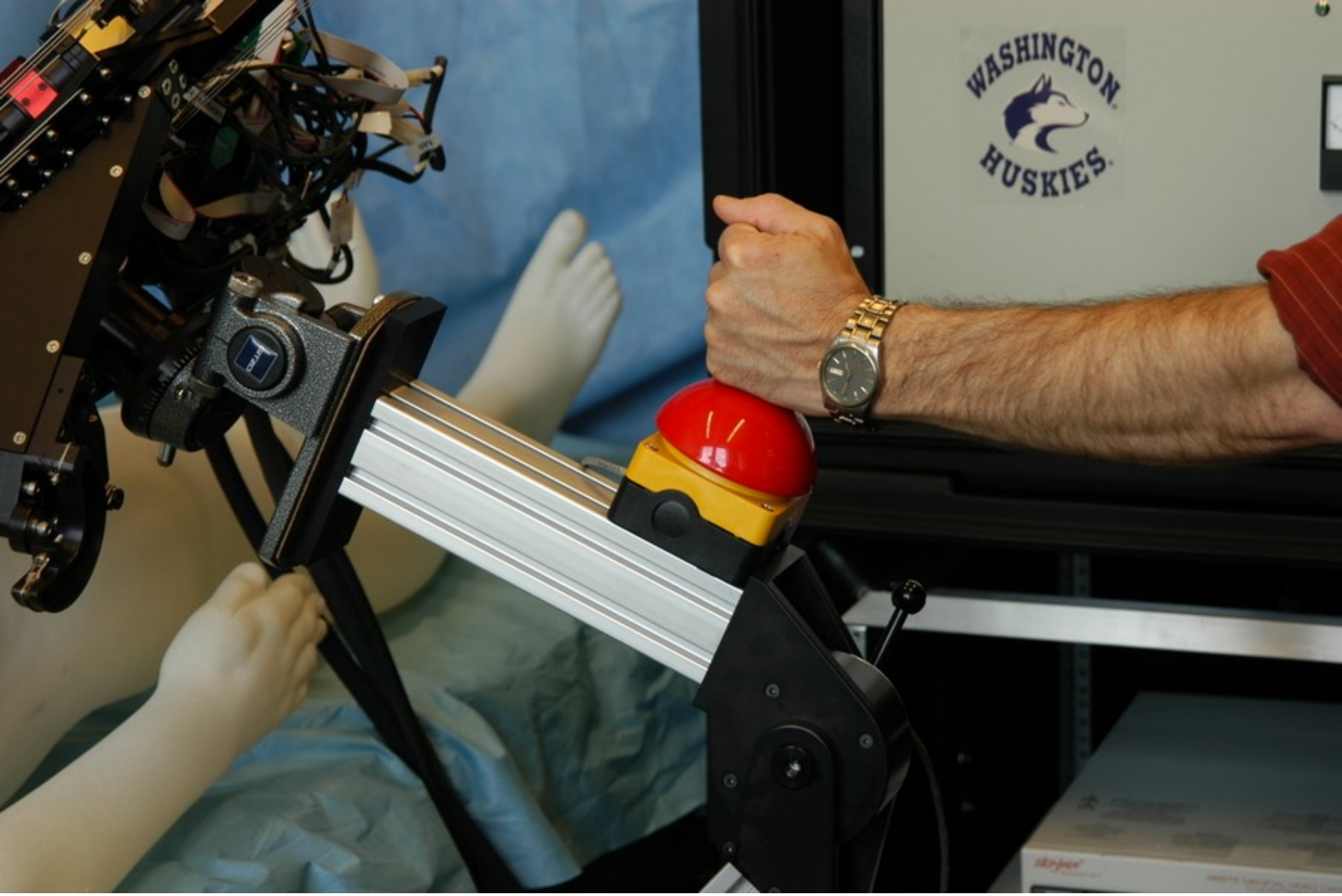
RAVEN

University of Washington
Biorobotics Lab








WASHINGTON
HUSKIES

‘Safety’ system

- 4-state machine in hardware (PLC)
  - `E-Stop`
  - `Init`
  - `Pedal Up`
  - `Pedal Down`
- RTAI-linux software follows

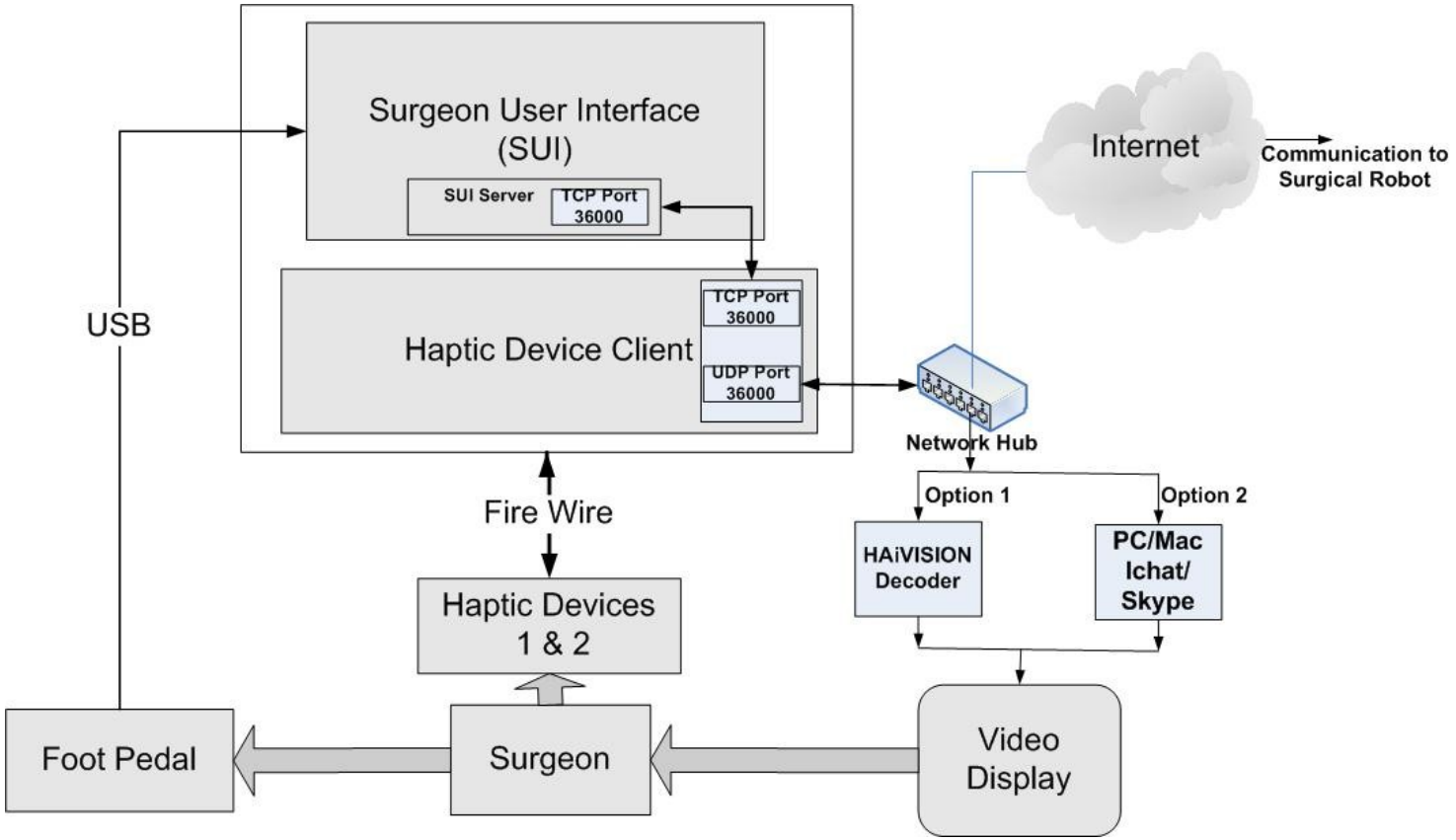
Portable Surgery Master Station

- Objective
  - Low cost
  - Off the shelf hardware
  - Interoperability with multiple surgical robots
  - Use of Internet protocols
    * Communication flexibility
  - Data collection for analysis

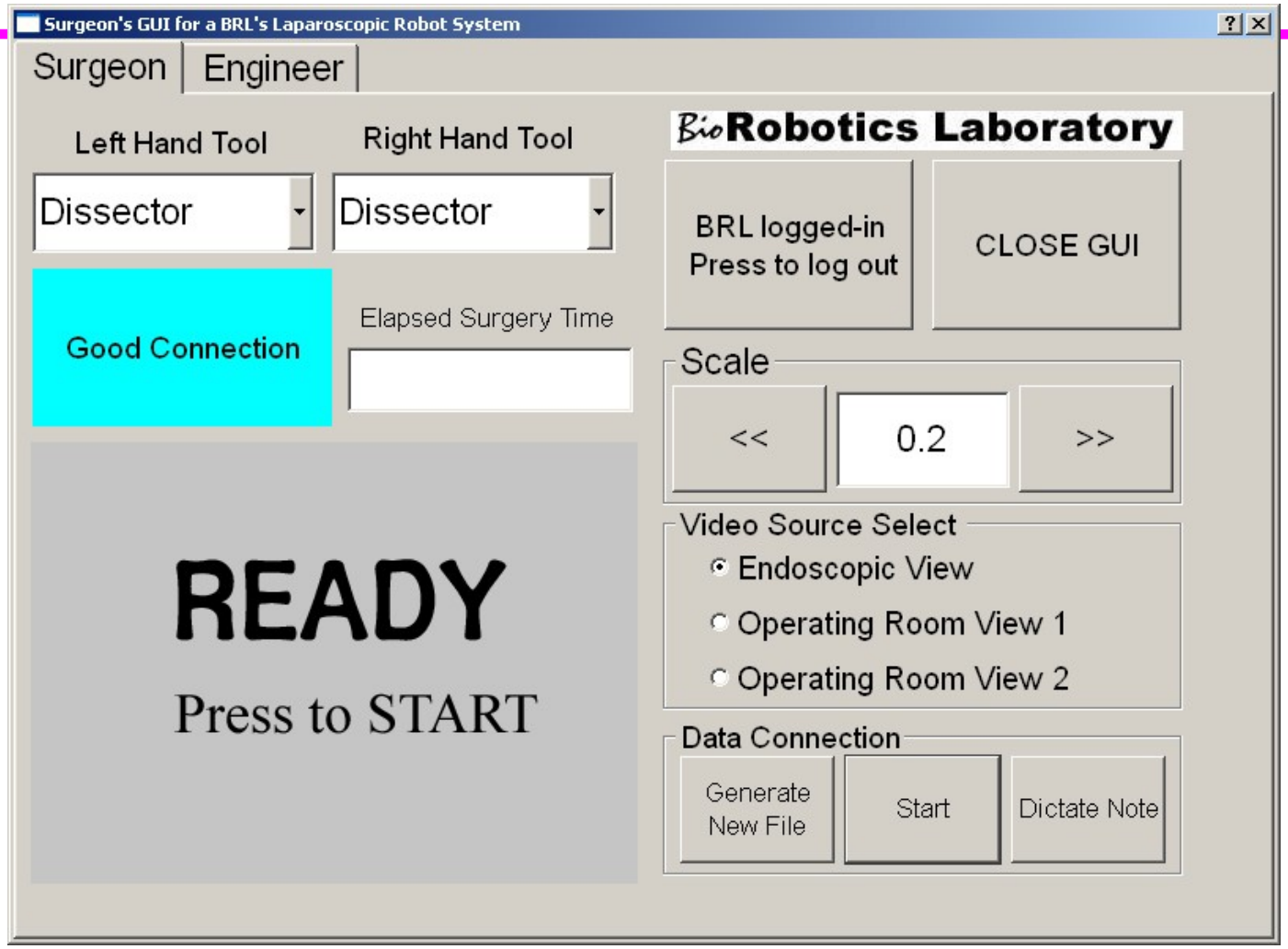
Functional Blocks

- Hardware
  - PC laptop
  - Two Omni haptic device
  - USB foot pedal
  - Video display (NTSC and PC Video)
- Software
  - SSS (surgeon site software)
    * SGUI (surgeon's graphical user interface)
    * HDC (haptic device client)

Functional Block Diagram



SGUI


Surgeon's GUI for a BRL's Laparoscopic Robot System
Surgeon
Engineer
Left Hand Tool
Right Hand Tool
Dissector
Dissector
BioRobotics Laboratory
BRL logged-in
Press to log out
CLOSE GUI
Good Connection
Elapsed Surgery Time
Scale
<<
0.2
>>
READY
Press to START
Video Source Select
Endoscopic View
Operating Room View 1
Operating Room View 2
Data Connection
Generate New File
Start
Dictate Note

SGUI

- Allows execution of high-level commands
- Written using Qt 4.1.2 from Trolltech, Inc.
- Surgeon tab
  - Allows setting
    * Scale factor
  - Status display (System status)
  - Tool selection (For future)
- Engineer tab
  - Remote IP address of surgical robot

HDC

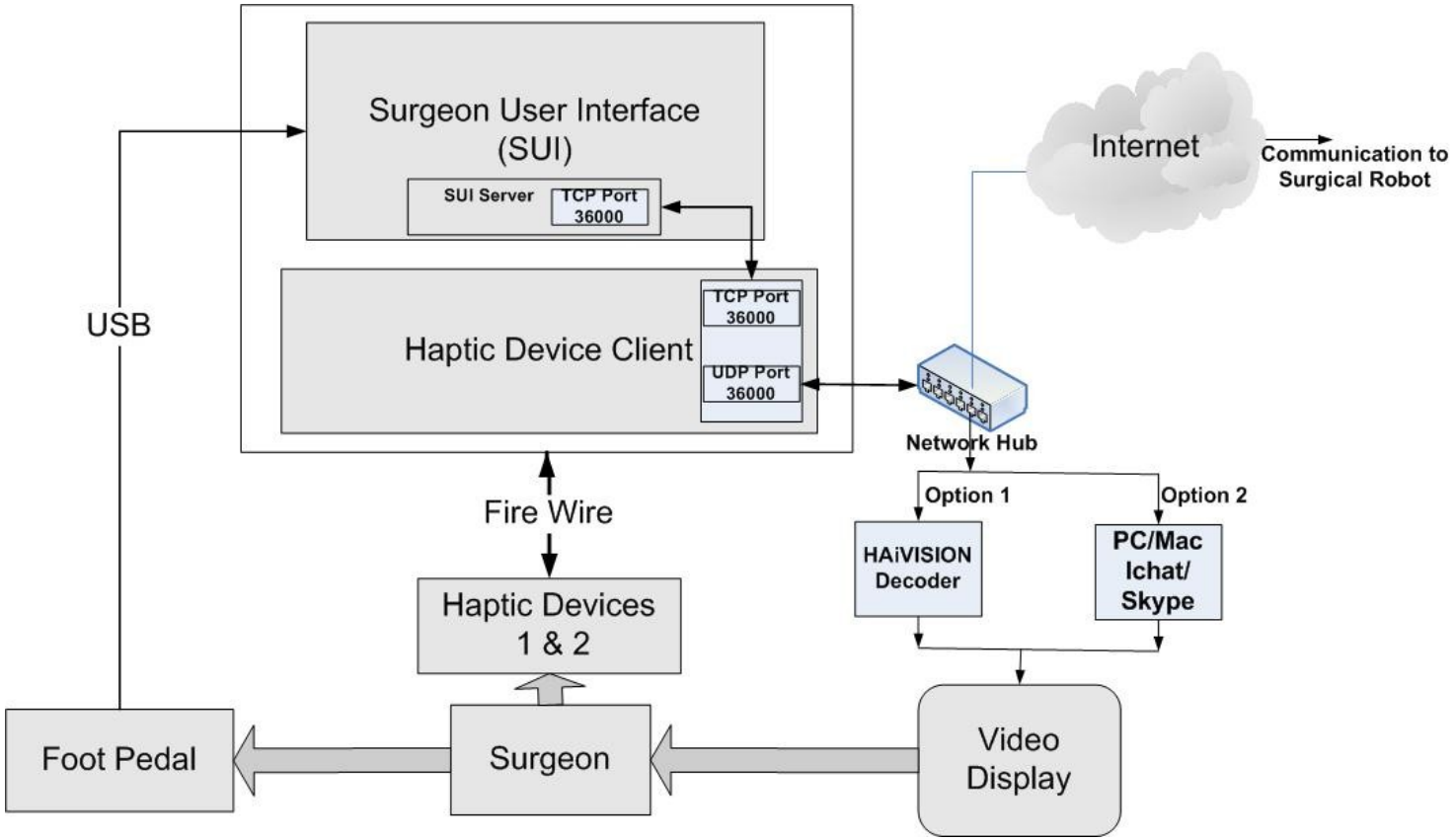
- Haptic device client
  - Sends commands, and position and orientation increments to surgical robot
    * Position increments – micron units
    * Orientation increment – micro-radians units
    * Use UDP for data communication
      - Low overhead
      - Fast
  - Haptic device mapping
    * Mapping of Haptic Interface Device (HID) to the motion of surgical robot
      - Pitch is mapped to tool wrist
      - Roll is mapped to tool shaft roll
  - Indexing
    * Allows surgeon to operate within the comfortable workspace of Omni
    * Foot pedal is used to engage indexing

Master Station Setup

Communication Protocol

- UDP packets
- 100-1000 packets per second
- Incremental motion commands

Surgeon Station Block Diagram



Data Packet Structure

```
typedef struct {
unsigned int sequence;
int c_timestamp;
int s_timestamp;
int delx[2];          // microns
int dely[2];
int delz[2];
int delyaw[2];        // micro-rad
int delpitch[2];
int delroll[2];
int buttonstate[2];
int footpedal;
int checksum;
}masterToRobot_data;
```

Video Feedback

- Features
  - Video picture quality
  - Low encoding/decoding latency
  - Robustness to network jitter, loss
  - Low cost
- Types
  - HaiVision Hai 500 codec and hardware
  - VLC, skype and ichat
    * Free video chat software