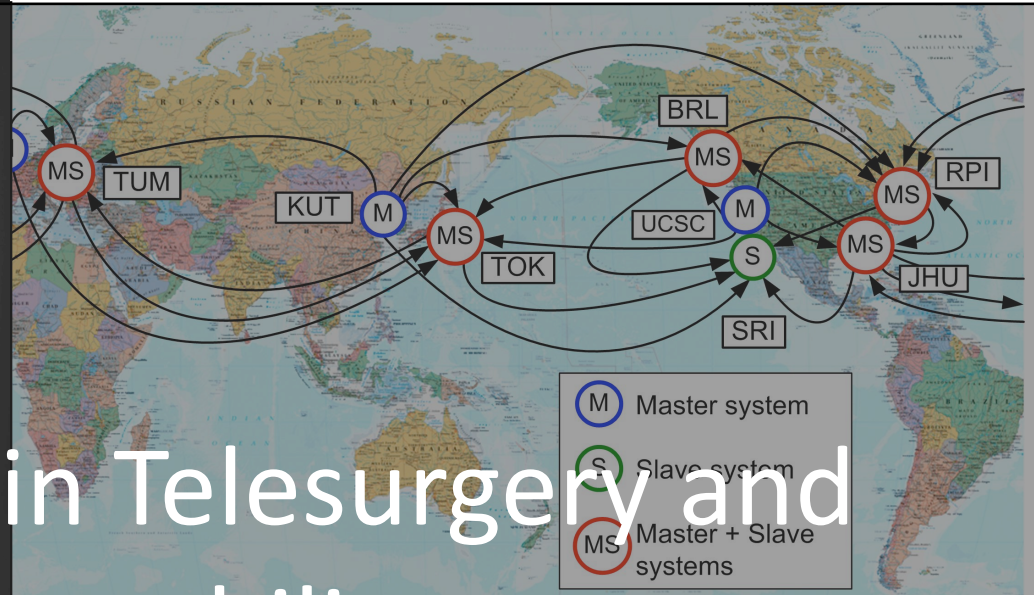# Developments in Telesurgery and Interoperability

Hawkeye King
BioRobotics Laboratory
University of Washington
Seattle, WA USA
Surgical Robotics Sumer School,
LIRMM, Montpellier, France
September, 2009

High Altitude Platforms for Mobile Robotic Telesurgery (HAPs/MRT)


- Goal: Demonstrate teleoperated surgery delivered to battlefield, disaster area or "extreme environments".
- Simi Valley, CA – May 2006
- Surgeon and Patient sites separated by 100m
- SUAV with DDL flying 1km away
- Result: UC Cincinnati surgons performed suturing, cutting and path following tasks in extreme environment.

Collaborators: University of Cincinnati, AeroVironment (Simi Valley, CA) and HaiVision (Toronto, Canada)
Funding: US Army TATRC

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Surgical Robotics Summer School
Montpellier, France, Sep. 2009
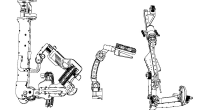
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NASA Extreme Environment Mission Operation (NEEMO) XII
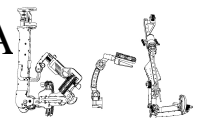

Photos Courtesy of NASA

Key Largo, FL – May 2007

Collaborators: University of Cincinnati, NA
NOAA, NURC, SRI International

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Surgical Robotics Summer School
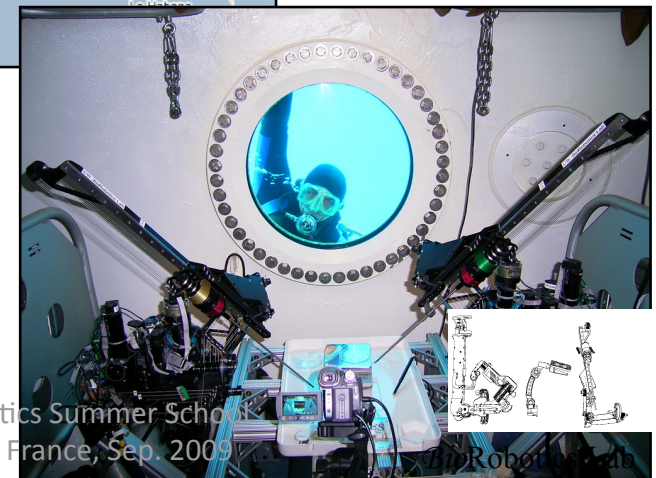Montpellier, France, Sep. 2009

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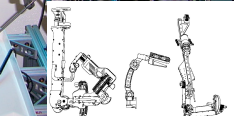# NASA Extreme Environment Mission Operation (NEEMO) XII

Surgeon Site: Seattle, WA
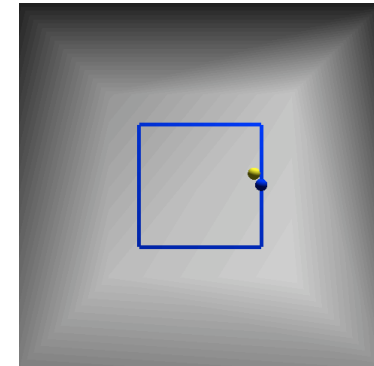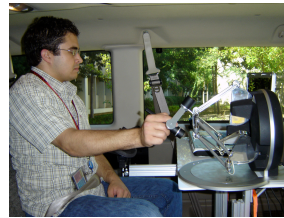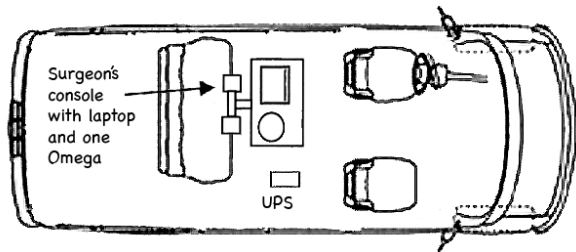
Patient Site:

Aquarius

Undersea Habitat

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Surgical Robotics Summer School
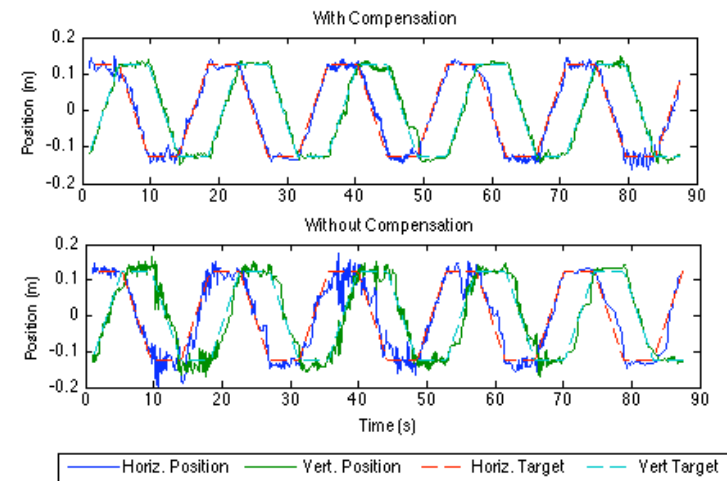Montpellier, France, Sep. 2009

Acceleration Compensation for Vehicle Based Telesurgery on Earth or in Space (SRI International)

- Motion is compensated using variable damping, proportional to acceleration in each axis.
- This is strictly passive and cannot cause unintended motion by the user.

$$K_{di} = inf[K_{max}, |A_i|C_d]$$

$$F_i = K_{di}V_i$$
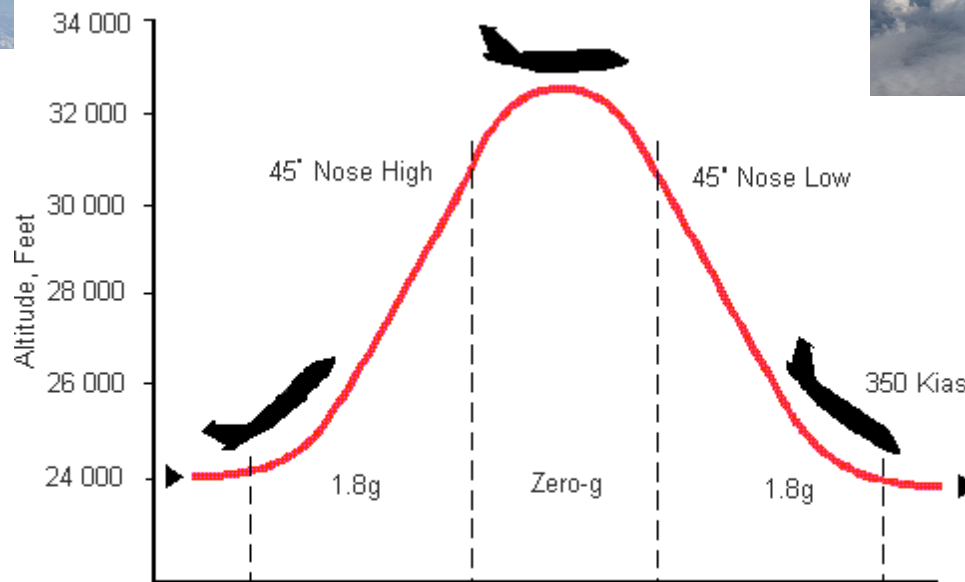

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Acceleration Compensation for Vehicle Based Telesurgery on Earth or in Space (SRI International)

NASA C-9 Reduced Gravity Laboratory "Vomit Comet"

Images courtesy of NASA
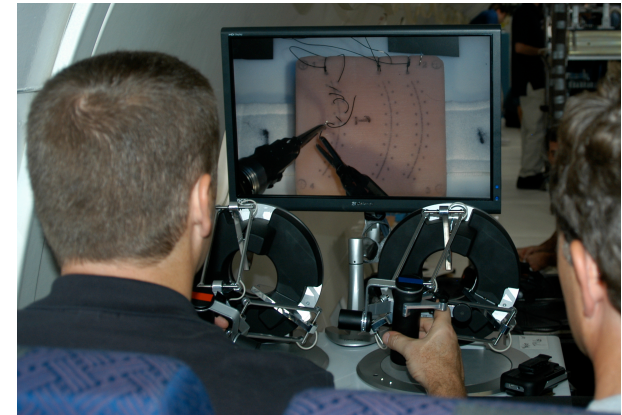
hawkeye1@u.washington.edu

C-9 Tests

- Sutured tissue silicon phantoms* using manual tools and with the M7 Robot.
- Compared robotic operation with vs. without variable gravity compensation.
- Collected robot kinematic data and user surveys.
- Explored deployment of telerobotic surgical systems in space environments.
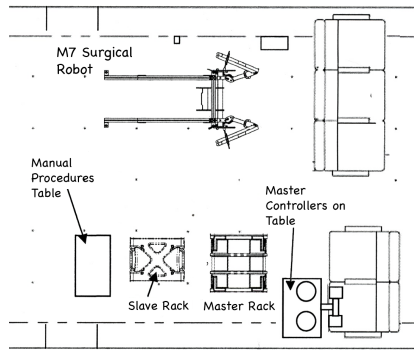
hawkeye1@u.washington.edu

Plugfest 2009
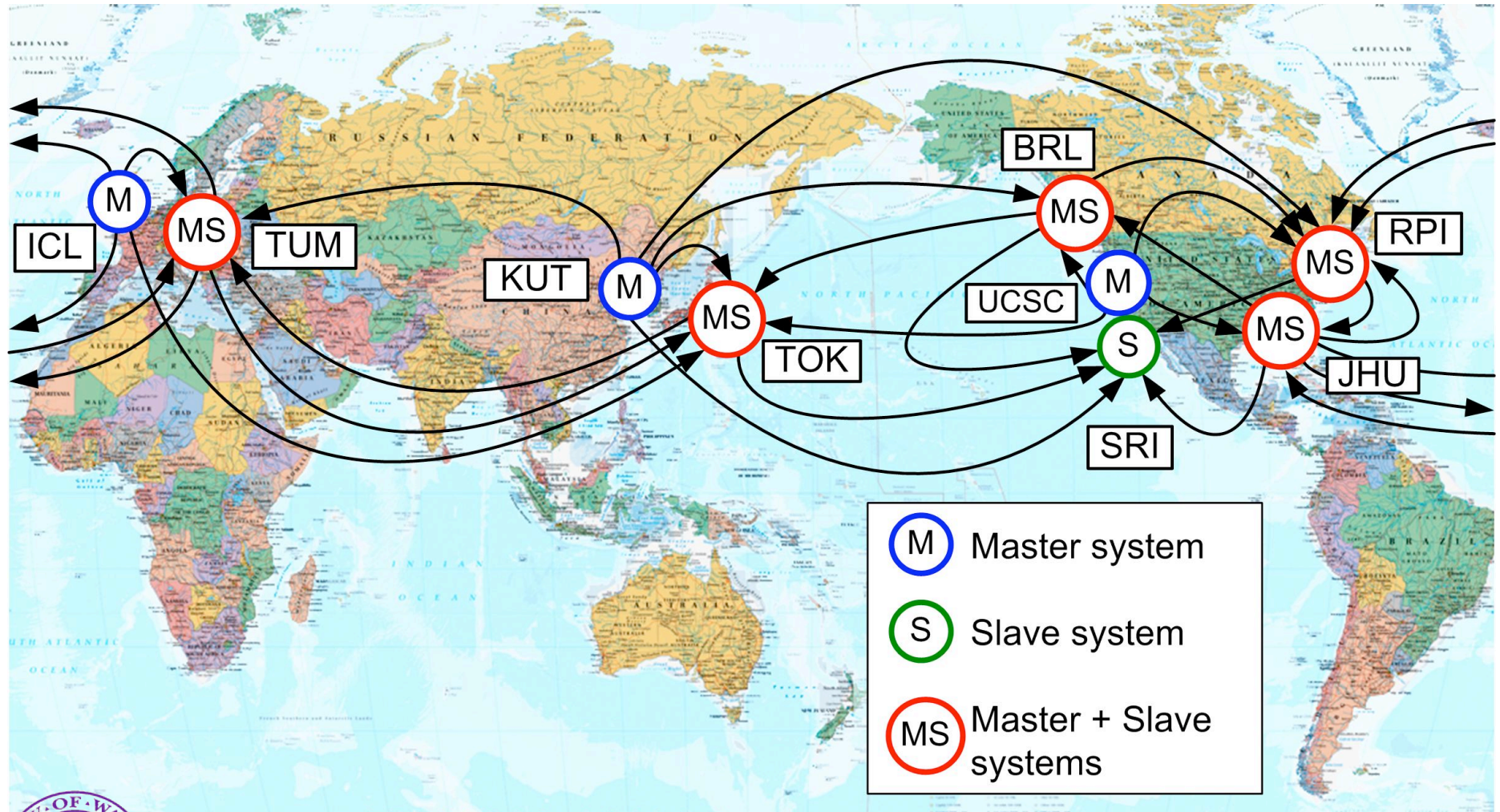
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Plugfest 2009
Master Systems
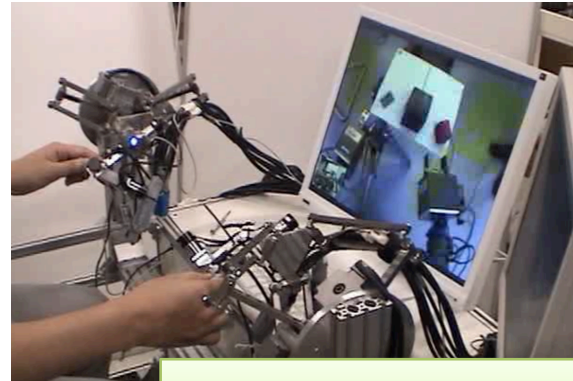
Tokyo Tech Delta master

JHU: Custom DaVinci System

UCSC Upper limb exoskeleton

UW BRL, ICL, and RPI: inexpensive, commercial hardware with free software from the UW. KUT used standard hardware with custom software
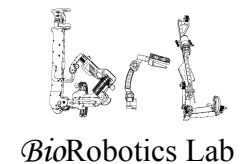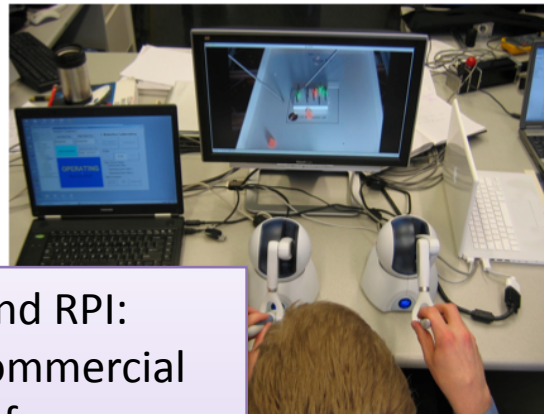
TUM LSR, general purpose, redu... teleoperation

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Plugfest 2009 Slave Systems

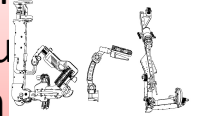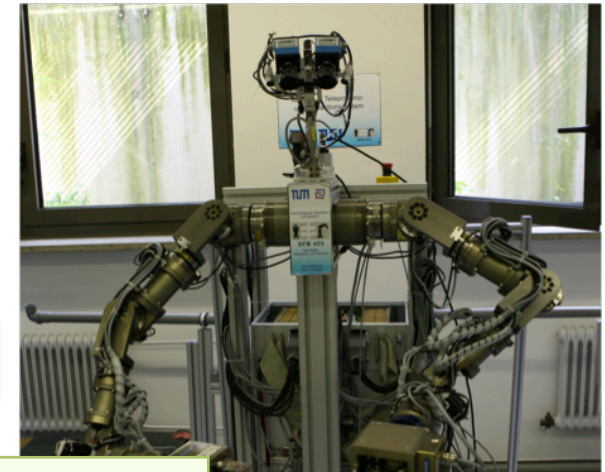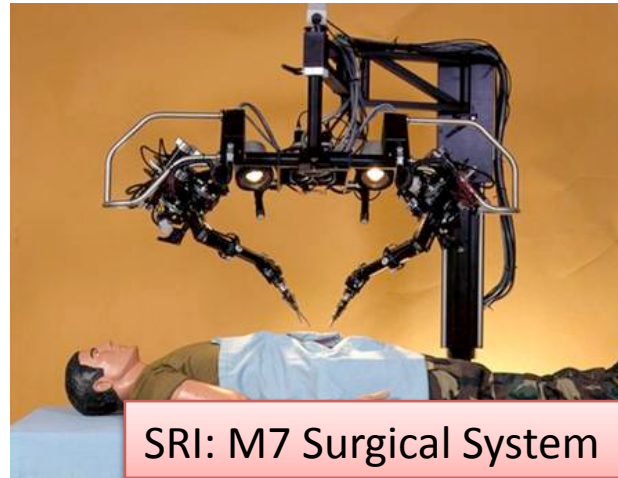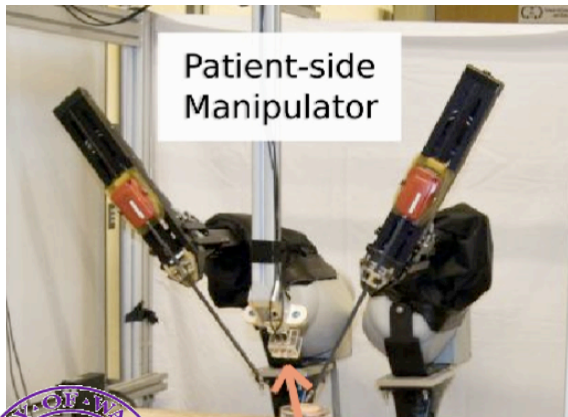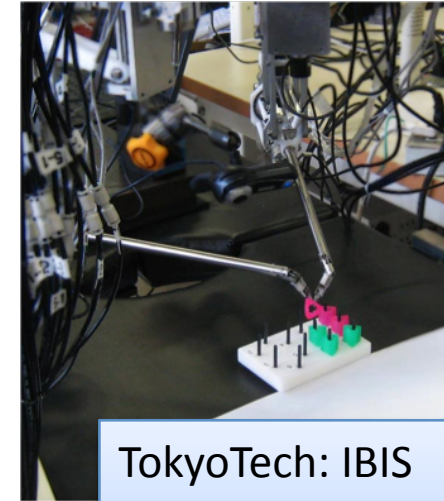RPI: vBlast surgical simulator

UW: BRL Raven MIS surgical robot

TokyoTech: IBIS Pneumatic MIS robot

Patient-side Manipulator

JHU: Custom DaVinci System

SRI: M7 Surgical System

TU Munich (LSR): general purpose mobile teleoperator
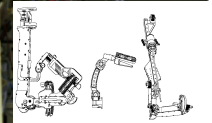
Plugfest Connection Results

```
struct u_struct {
    unsigned int sequence;
    unsigned int pactyp;
    unsigned int version;
    int delx[2];
    int dely[2];
    int delz[2];
    int delyaw[2];
    int delpitch[2];
    int delroll[2];
    int buttonstate[2];
    int grasp[2];
    int surgeon_mode;
    int checksum;
};
```

- Thirty connections, with twenty eight successful tasks.
- One operation failed due to incompatible transmission rates.
- One failed due to inoperable orientation mapping.

Slave

	BRL	JHU	RPI	SRI	TOK	TUM
BRL			12	14	15	
ICL		11	6		5	7
JHU	9		7	X		X
KUT	6		6	4	6	13
RPI	8	13		2		
TOK	16			12		4.5
TUM		1	4		2	
UCSC	13	4	5	9	30	

Master

Number of blocks transferred in ten minutes.

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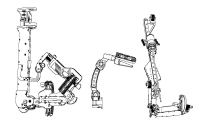
Telerobotic FLS:

- An "open source" assessment tool based on the Fundamentals of Laparoscopic Surgery test by SAGES (Society of American Gastrointestinal and Endoscopic Surgeons).

- Surgery-like manipulation

- Pick-and-place task

- Scoring:
  - Completion Time
  - Path length
  - Dropped blocks

- Plugfest scoring: blocks transferred in ten minutes
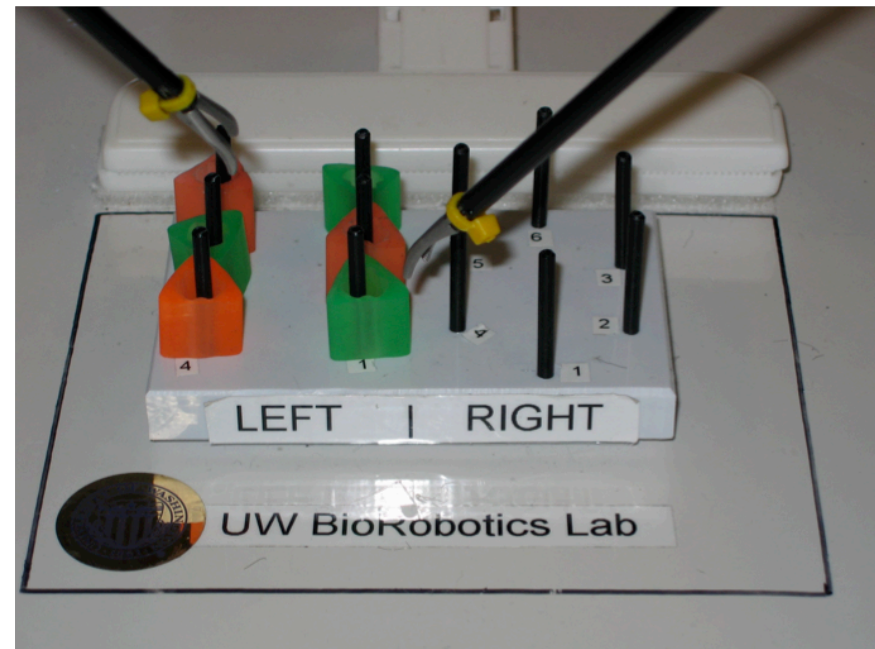
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Interoperability of Teleoperation Systems Using Internet Standards
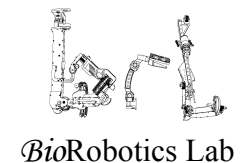
Master — UDP — Slave
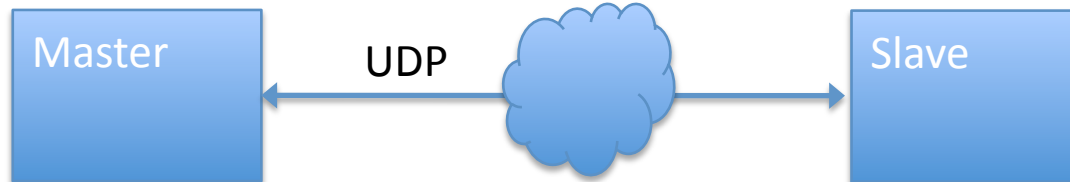
The old way:
- Master and slave connect directly using open UDP ports.
- Data type, bitrate, addresses and other teleoperation parameters are pre-negotiated offline.
- "Session" is poorly defined or uses an arbitrary connection method.

Master — Slave

SIP/XMPP: Session initiation

SDP: Codec selection

RTP: Teleopration transport

XML-RPC: Teleopration session control

Codec: teleoperation data transform and exchange
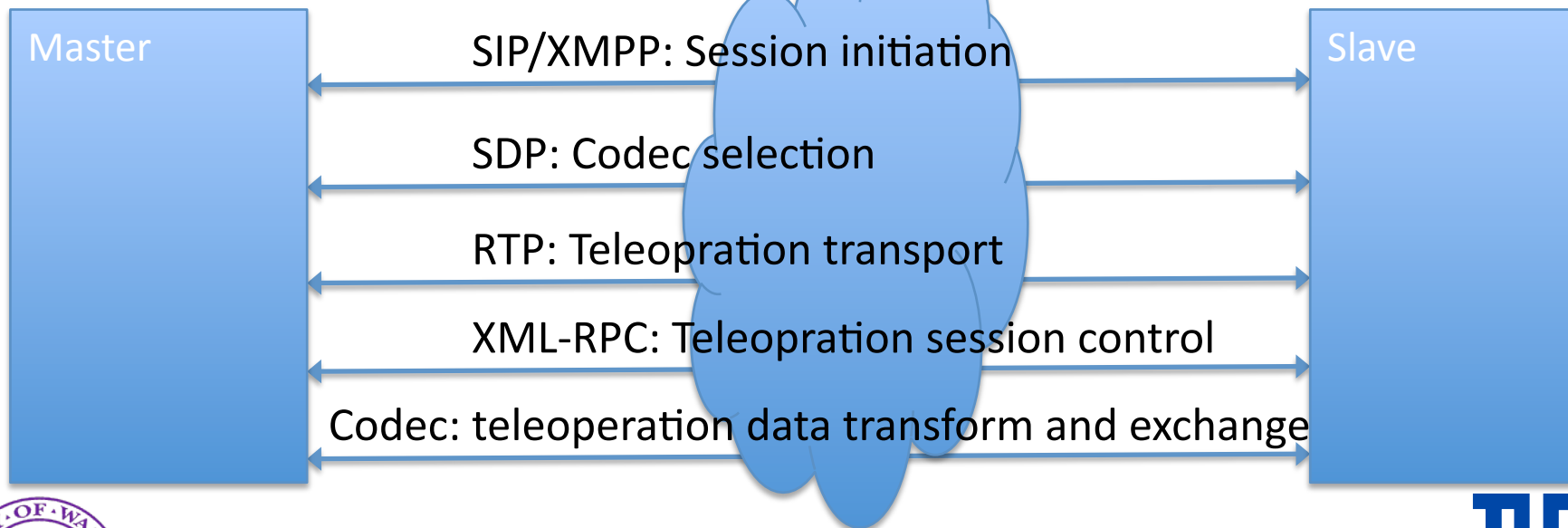
SIP Session

Master and slave log into SIP server and register "presence".

Master invites slave to multimodal session. Master "offers" several possible codecs and ports (SDP).

Slave "answers" with acceptable codecs and ports (SDP).

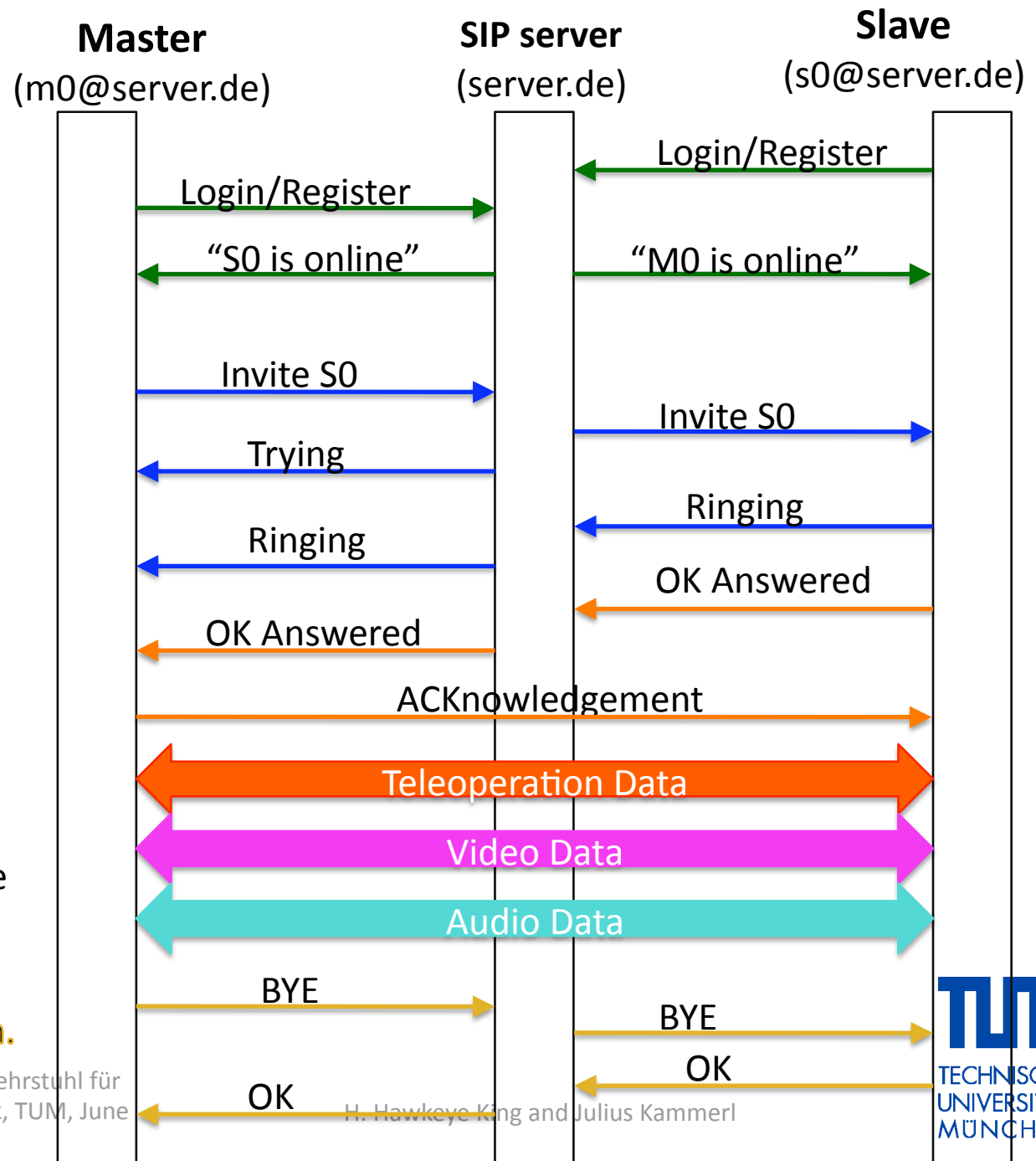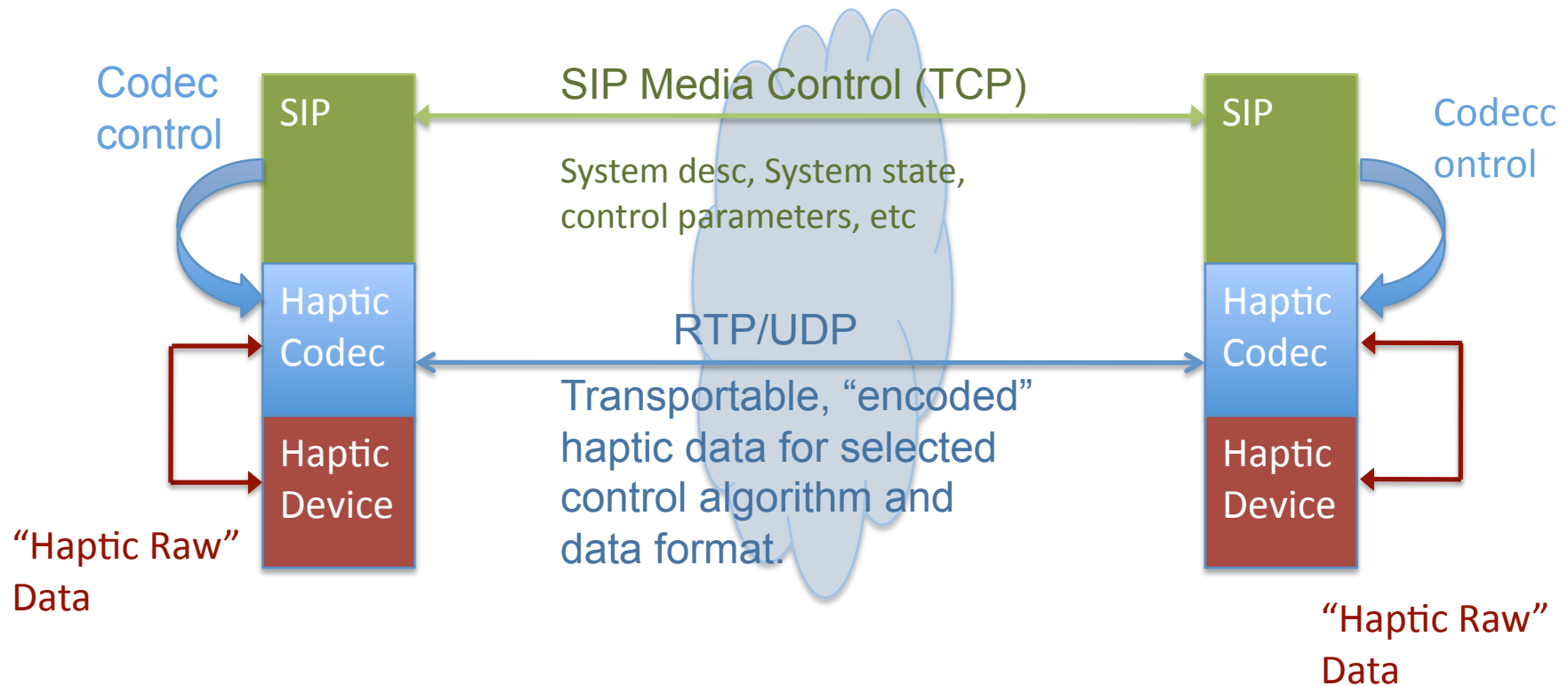**Standard** multi-modal/multimedia data codecs are used.

Master (or slave) terminates connection.

Master (m0@server.de)	**SIP server** (server.de)	**Slave** (s0@server.de)

Login/Register →

← Login/Register

Login/Register →

← "S0 is online"

"M0 is online" →

Invite S0 →

Invite S0 →

← Trying

← Ringing

← Ringing

OK Answered →

← OK Answered

ACKnowledgement →

⟷ Teleoperation Data

⟷ Video Data

⟷ Audio Data

BYE →

BYE →

← OK

← OK

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Haptics & Teleoperation Codec

Demonstrator System

- Uses Opal VOIP open source SIP implementation.
    - Added haptics media type and codecs
- Phantom Omni master and slave.
- Logitech camera.
- SIP negotiates Audio, Video and Haptics codecs.
- Haptic RAW codec implemented.

H. Hawkeye King and Julius Kammerl

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Thank you!

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Mitch Lum, Diana Friedman, Gina Donlin, Jesse Dosher, "others", University of Washington

Julius Kammerl, Prof. Eckehard Steinbach,
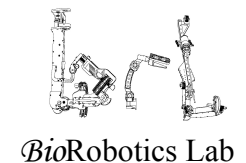Technische Universität München

Thomas Low,
SRI International
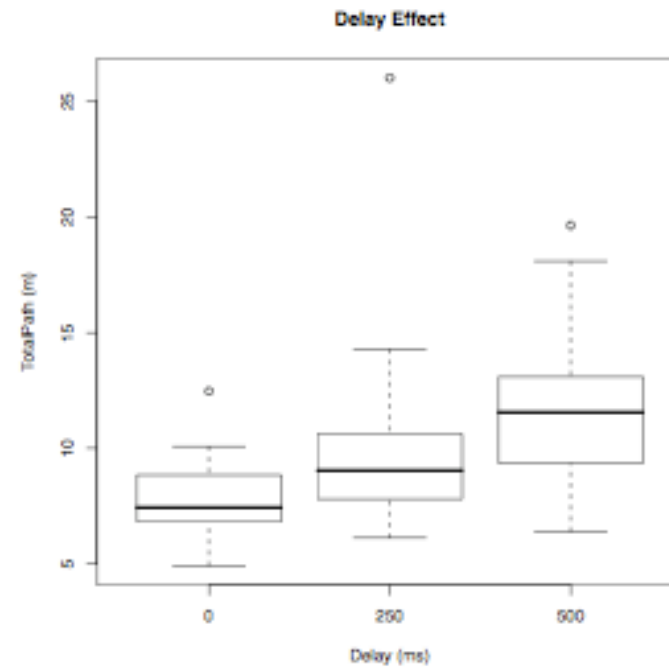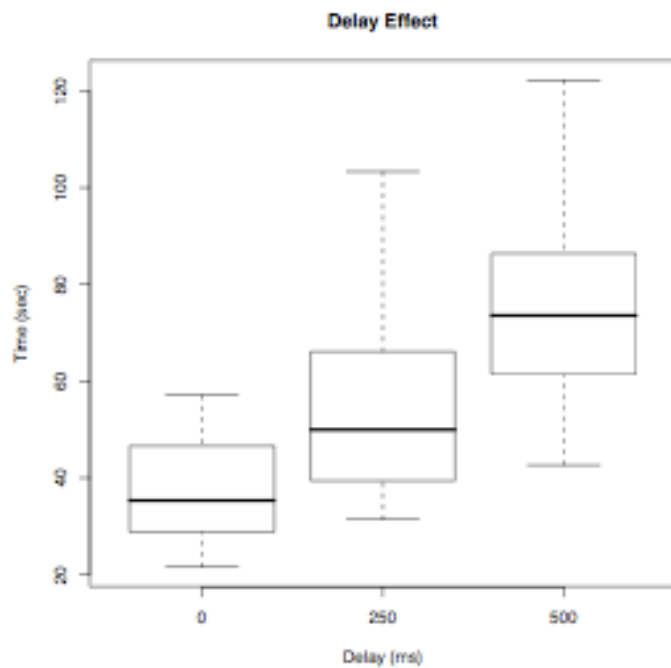
Tim Broderick,
University of Cincinnati

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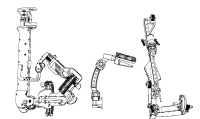Surgical Robotics Summer School
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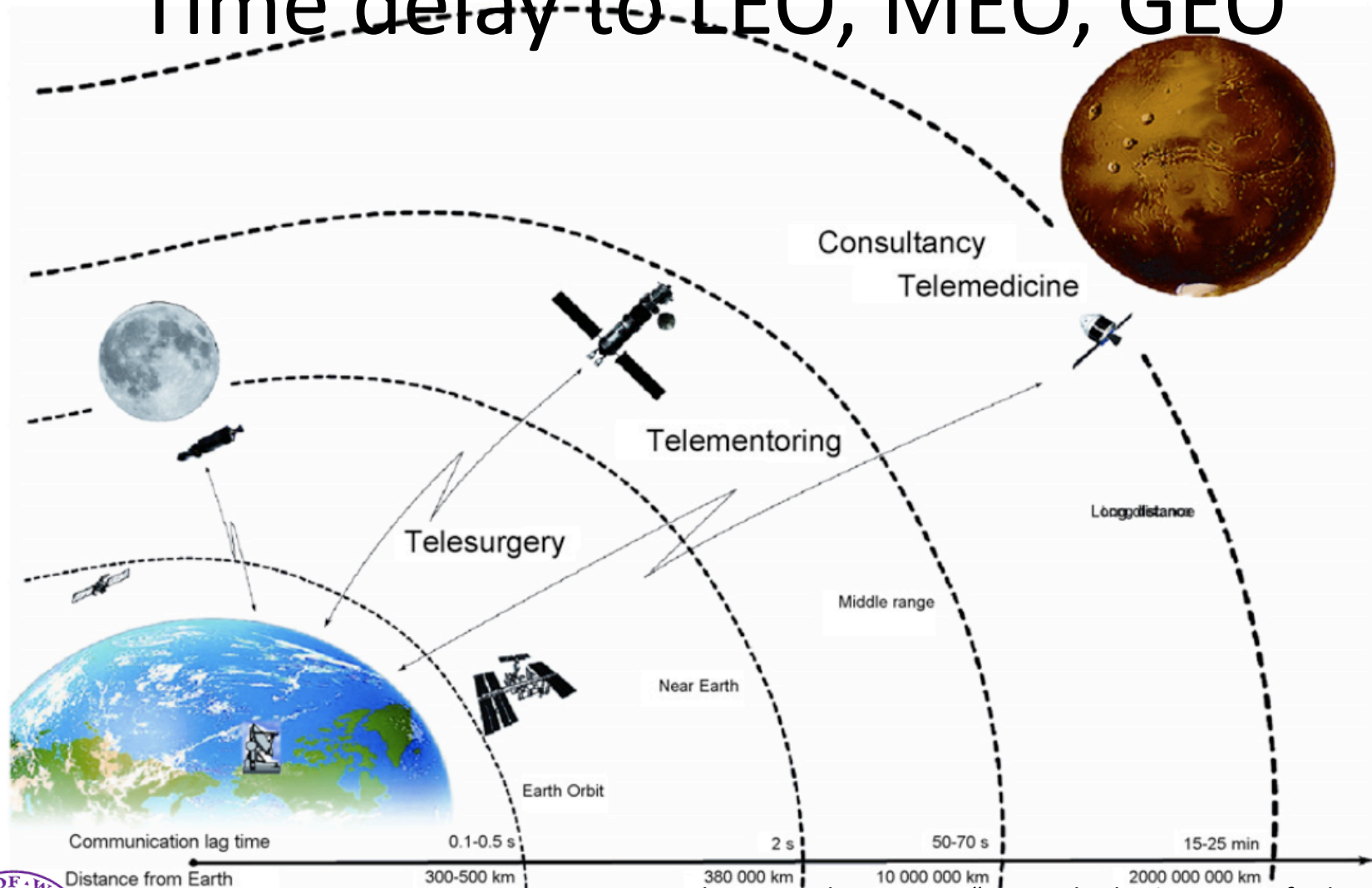# Emulated Telesurgery Under Network Delay

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*Bio*Robotics Lab

Time delay to LEO, MEO, GEO

Consultancy
Telemedicine

Telementoring

Telesurgery

Long distance

Middle range

Near Earth

Earth Orbit

| Communication lag time | 0.1-0.5 s | 2 s | 50-70 s | 15-25 min |
| Distance from Earth | 300-500 km | 380 000 km | 10 000 000 km | 2000 000 000 km |

T. Haidegger and Z. Benyoa "Surgical robotic support for lona duration space missions"

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