# Taurus-M: Teleoperative and Semi-Autonomous Surgical Control Frameworks for High Latency Surgical Assistance

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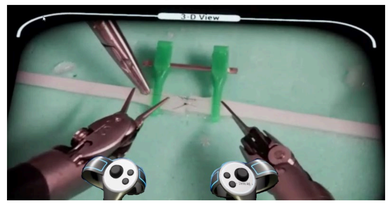
The Taurus-M Robotic Surgical Assist Platform

## Background

- Possible future conflicts may require faster access to time critical interventions and surgery, further limiting the availability of specialized surgeons at point of need[1]. Telerobotic surgical platforms can thus provide overwhelmed deployed surgeons through teleoperated specialist assistance[2].
- Telesurgical technologies will be hindered by the stochastic unpredictability of real networks with low bandwidth from operational communications

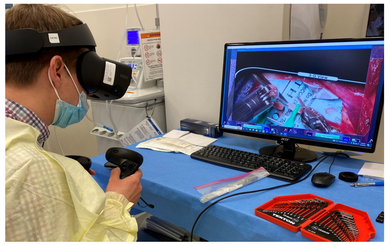
## Objective

- Develop a surgical robotic platform capable of teleoperative and semi-autonomous control frameworks to provide safe surgical assistance in specialized vascular repair surgeries.
- Conduct a proof-of-concept animal study demonstrating teleoperated and semi-autonomous surgical assistance in vascular repair procedures while inserting simulated latency into the robotic control network, representative of long-range teleoperative assistance.

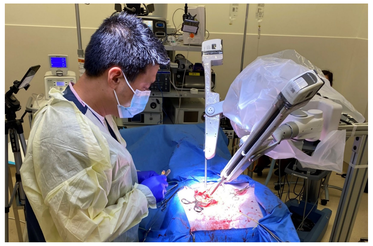



3D View inside the Operator Control Unit of the Taurus-M

## Teleoperation in Latency Constrained Conditions



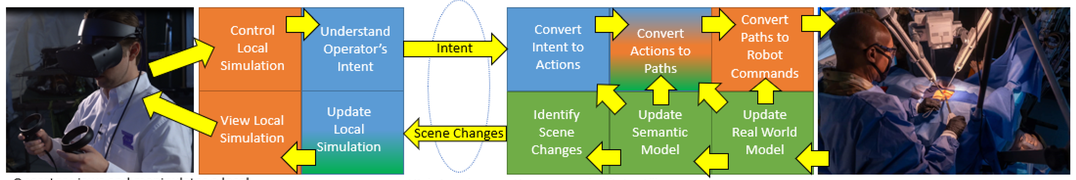
Teleoperation



Taurus-M robot can assist in specialized surgeries through teleoperation using a VR headset and shown here assisting a temporary vascular shunt (TVS) placement procedure

## Intent Based Semi-Autonomous Control

Intent-Based Control Reduces Network Performance Requirements

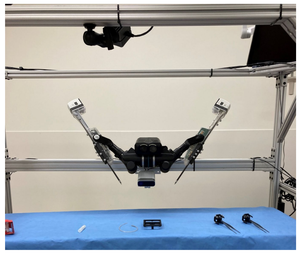


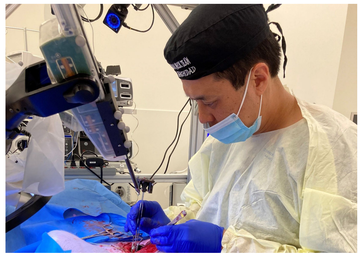

Operator views and manipulates a local simulation of the remote robot and world to complete tasks.

High-Level semantic commands ("Intent") enable operation over Low-capacity networks.

Actual robot responds to commands and provides sensed information.

## Semi-Autonomous Proof-of-Concept Animal Study



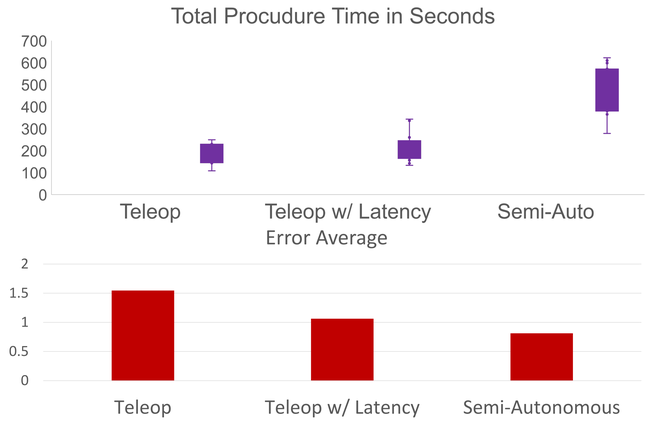


Semi-autonomous control setup for the Taurus-M and performing assistance in a TVS procedure

## Results

Results from the March 2023 proof-of-concept animal study of the Taurus-M assisting temporary vascular shunt placement procedures. Latency inserted in the network ranged from 250ms to 3000ms for direct teleoperation and 6000ms for semi-autonomous control.

| Animal Study Group | Success / Trials | Success Rate |
|---|---|---|
| Teleop | 9/9 | 100% |
| Teleop with Latency | 18/18 | 100% |
| Semi-Autonomous | 16/16 | 100% |




## Conclusion

- High latency telesurgical assistance is possible through semi-autonomous control frameworks.

**References**

[1] U.S. Army Medical Department. Memorandum: U.S. Army Medical Department's Position for the Employment of Robotic and Autonomous Systems in Support of Combat Casualty Care, Casualty Evacuation, and Medical Logistics in Army Health Support Operations. 2018.

[2] U.S. Army Medical Center of Excellence. (2021). Army Futures Command Concept for Medical 2028.

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