

# Autonomy in Surgical Robotics – Opportunities and Challenges

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A large, high-resolution image of the Earth as seen from space, showing the curvature of the planet, blue oceans, white clouds, and green landmasses. The image is positioned in the bottom right corner of the slide.

Knowledge for Tomorrow

# German Aerospace Center (DLR)



## In numbers

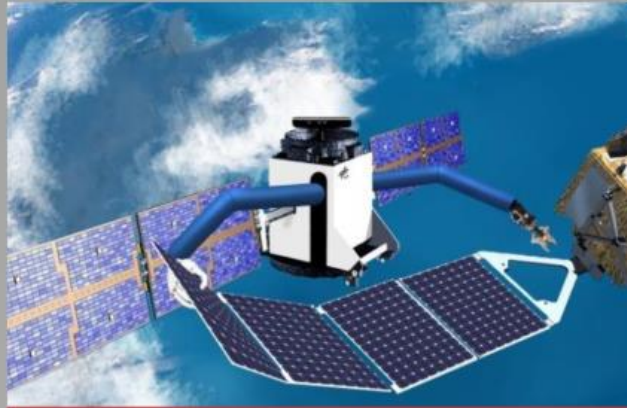
- ~10 000 employees
- 55 institutes and facilities
- 30 locations in Germany



# Institut of Robotics and Mechatronics



Space Assistance



Orbital Robotics



Planetary Exploration Robotics



Intelligent Service Robotics



Medical & Healthcare



Future Manufacturing



Field Robotics

# MiroSurge for Minimally Invasive Surgery



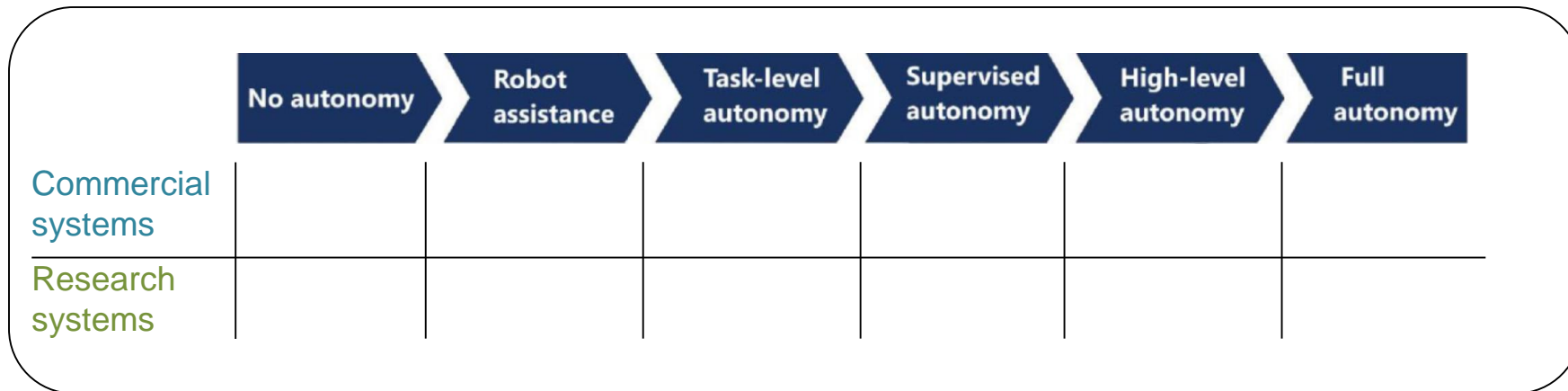
## ***DLR MIRO: Changing the control mode via robot-integrated buttons***

DLR – Institute of Robotics and Mechatronics



# Outline - Autonomy in Surgical Robotics

Opportunities



Challenges

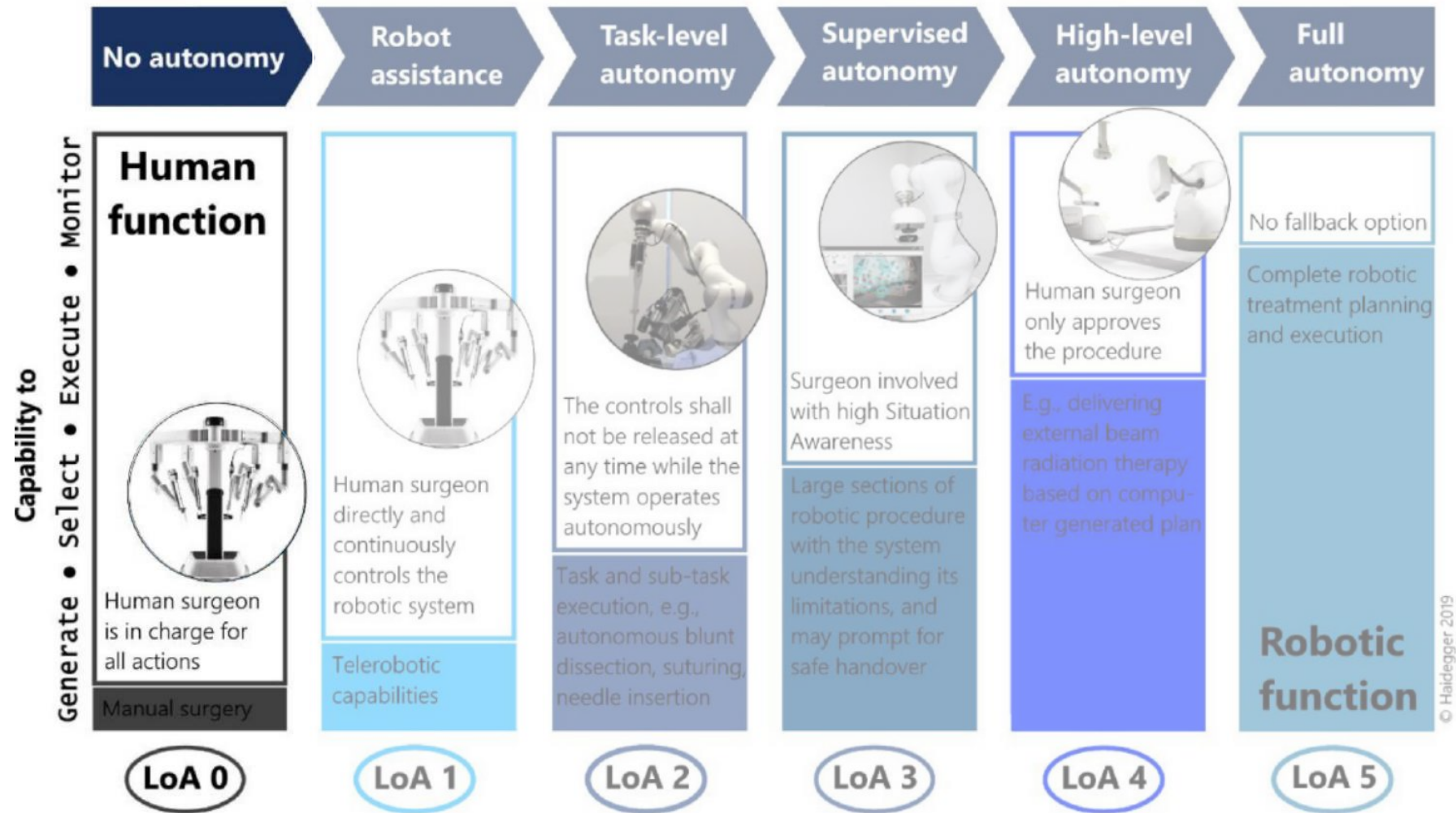


# Opportunities

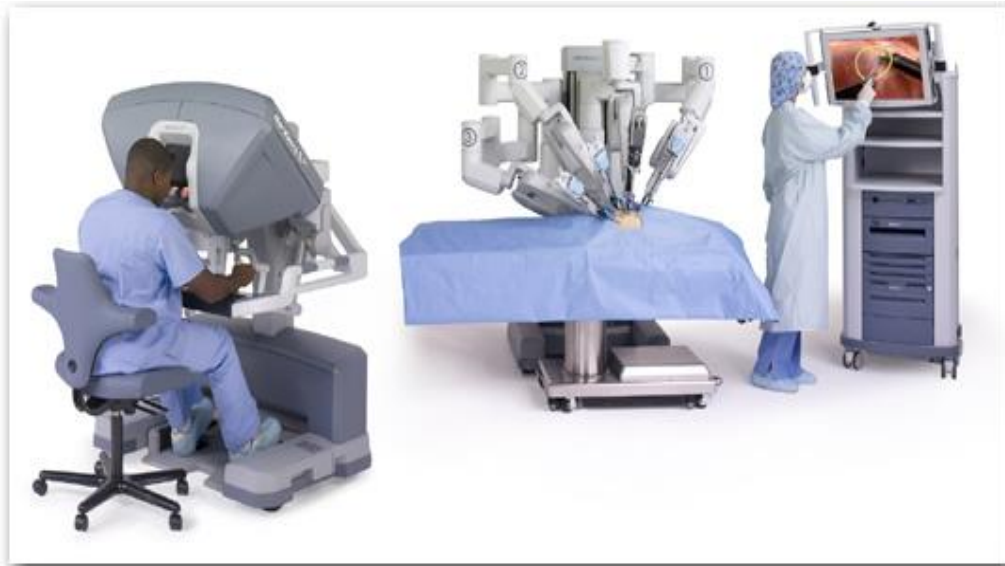
- Standardized patient outcome
- Support of novice surgeons
- Simplify surgical workflow



# Level of Autonomy in Robotic Surgery



## No autonomy– commercial systems



[3]

DaVinci (Intuitive Surgical)



[4]

HugoRAS (Medtronic)

No autonomy

Robot  
assistance

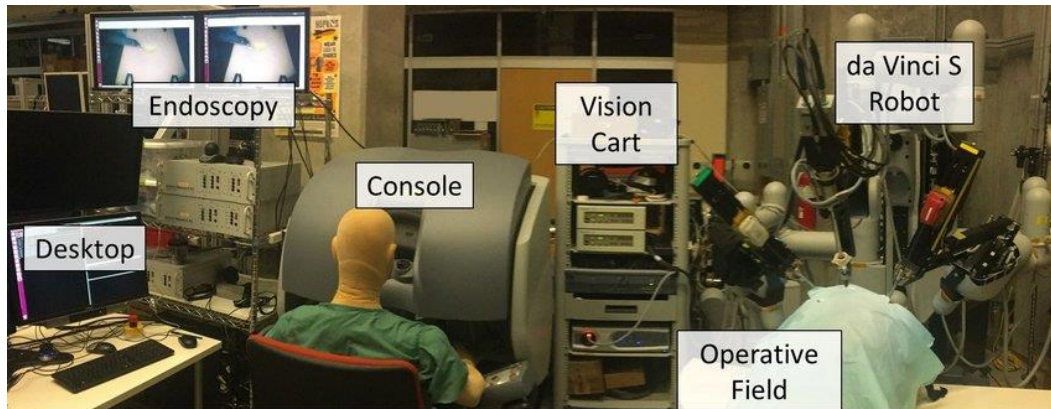
Task-level  
autonomy

Supervised  
autonomy

High-level  
autonomy

Full  
autonomy

## No autonomy– research systems



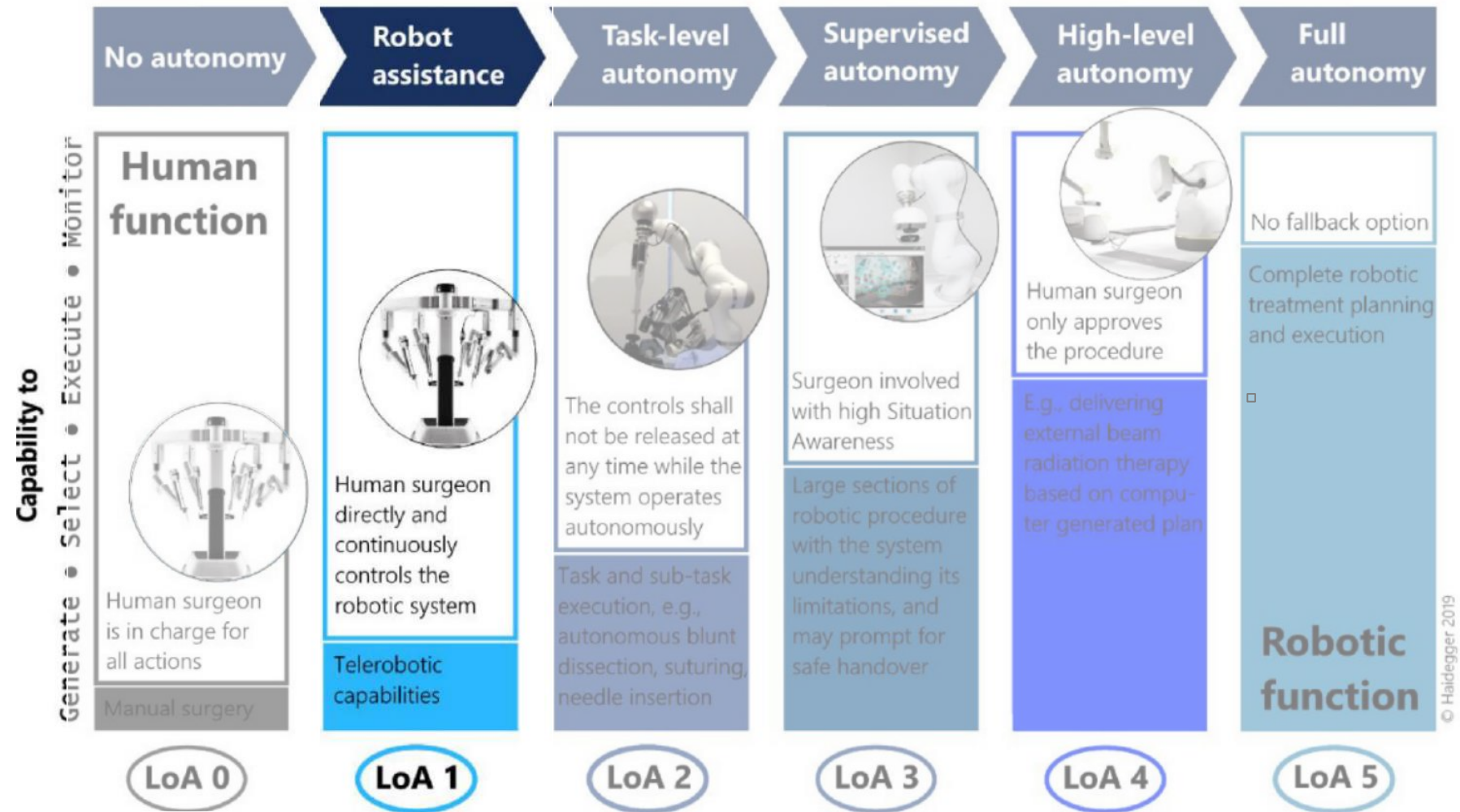
DaVinci Research Kit

[5]



MiroSurge (DLR)

# Level of Autonomy in Robotic Surgery



## Robot assistance– commercial systems



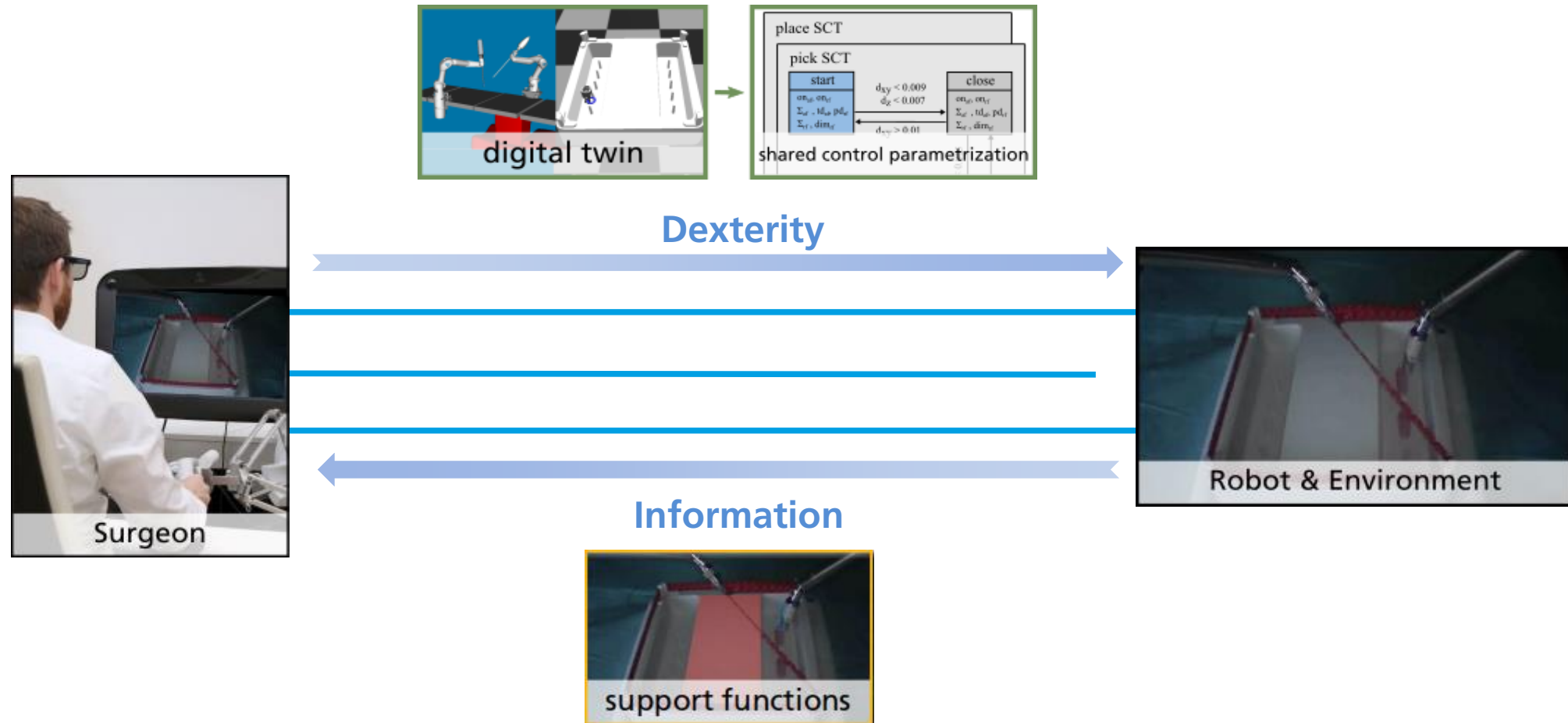
Mako (Stryker)

[6]

No autonomy

Robot  
assistanceTask-level  
autonomySupervised  
autonomyHigh-level  
autonomyFull  
autonomy

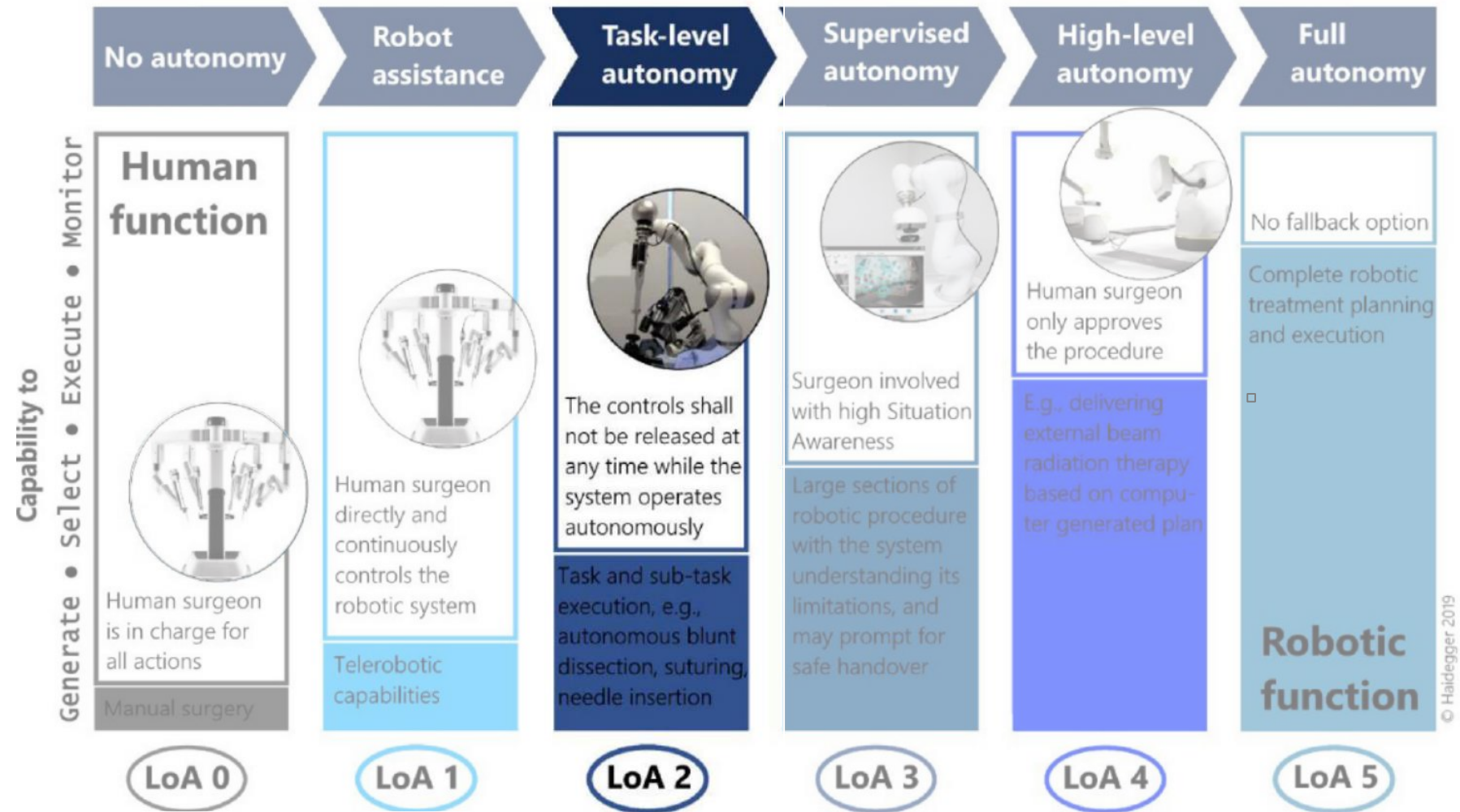
# Robot assistance – research systems



MiroSurge (DLR)

Hagmann, K., Hellings-Kuß, A., Klodmann, J., Richter, R., Stulp, F., Leidner, D. (2021). A Digital Twin Approach for Contextual Assistance for Surgeons<sup>[6]</sup> During Surgical Robotics Training, *Frontiers in Robotics and AI* 8, 305.

# Level of Autonomy in Robotic Surgery



## Task-level autonomy – commercial systems

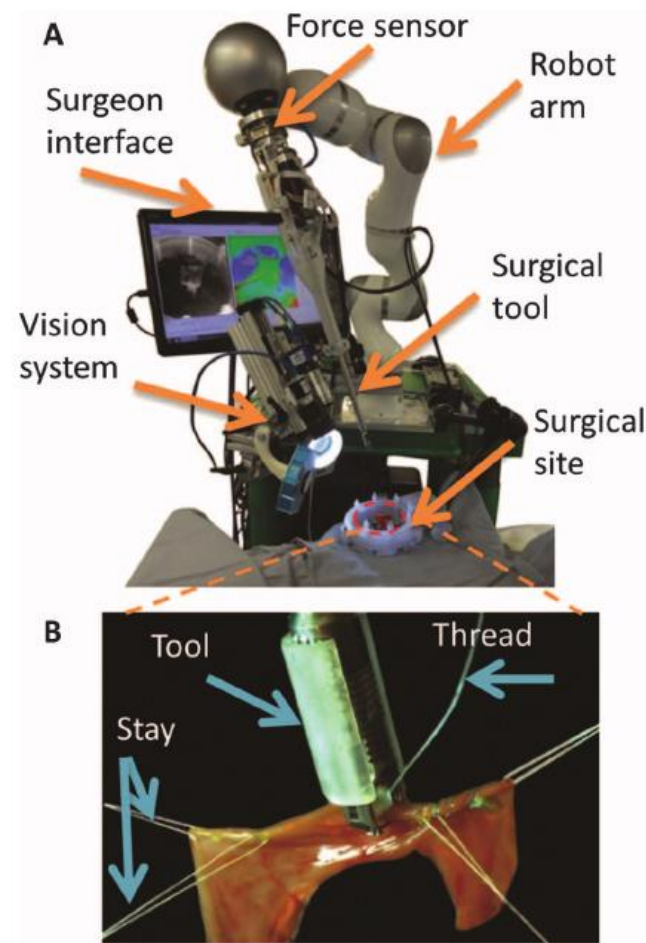


AutoLap (MST)



[7]

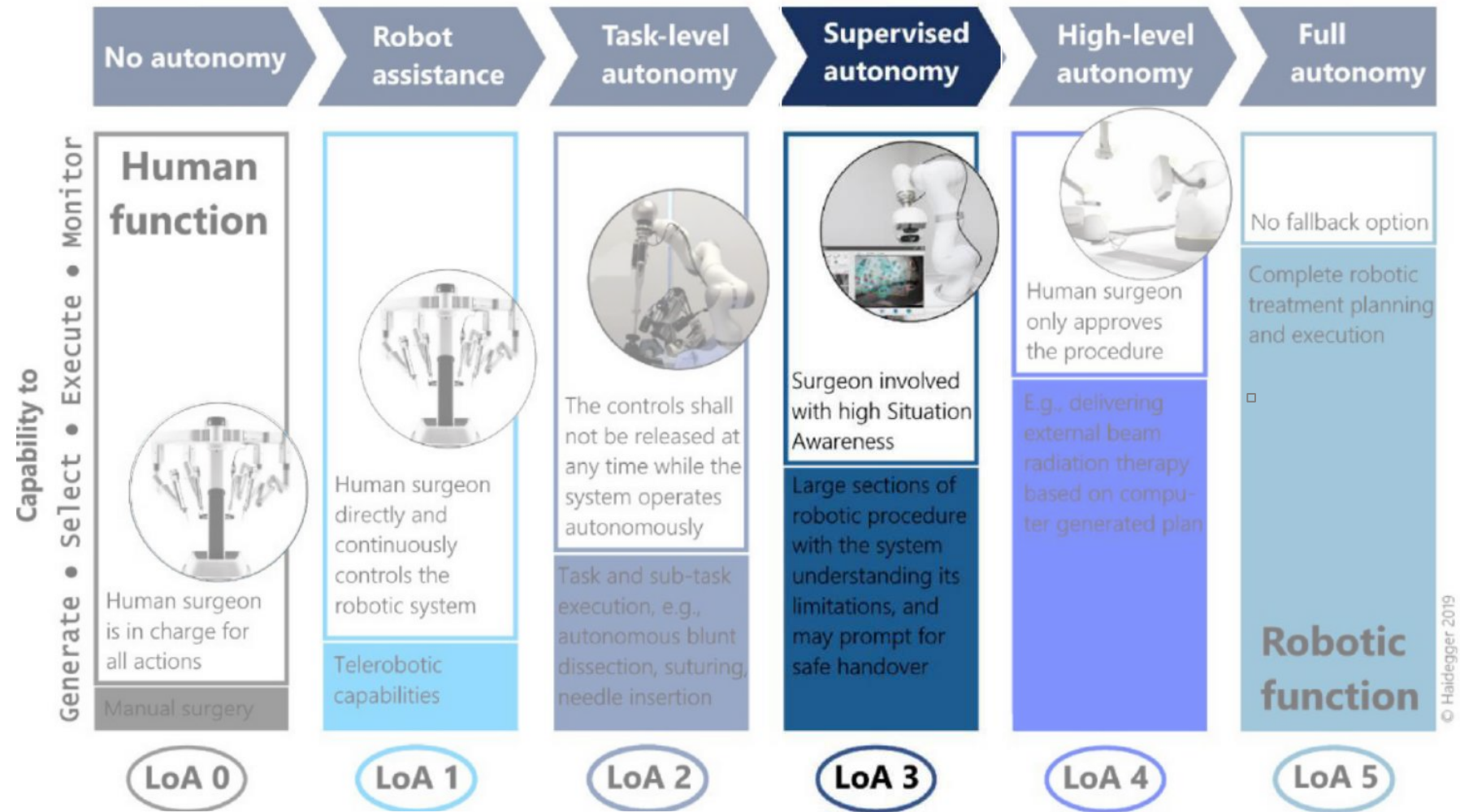
## Task-level autonomy – research systems



STAR

Shademan, A., Decker, R, Opfermann, J., Leonard, S., Krieger, A., Kim, P. (2016). Supervised autonomous robotic soft tissue surgery, *Science Translational Medicine* 8, 337.

# Level of Autonomy in Robotic Surgery



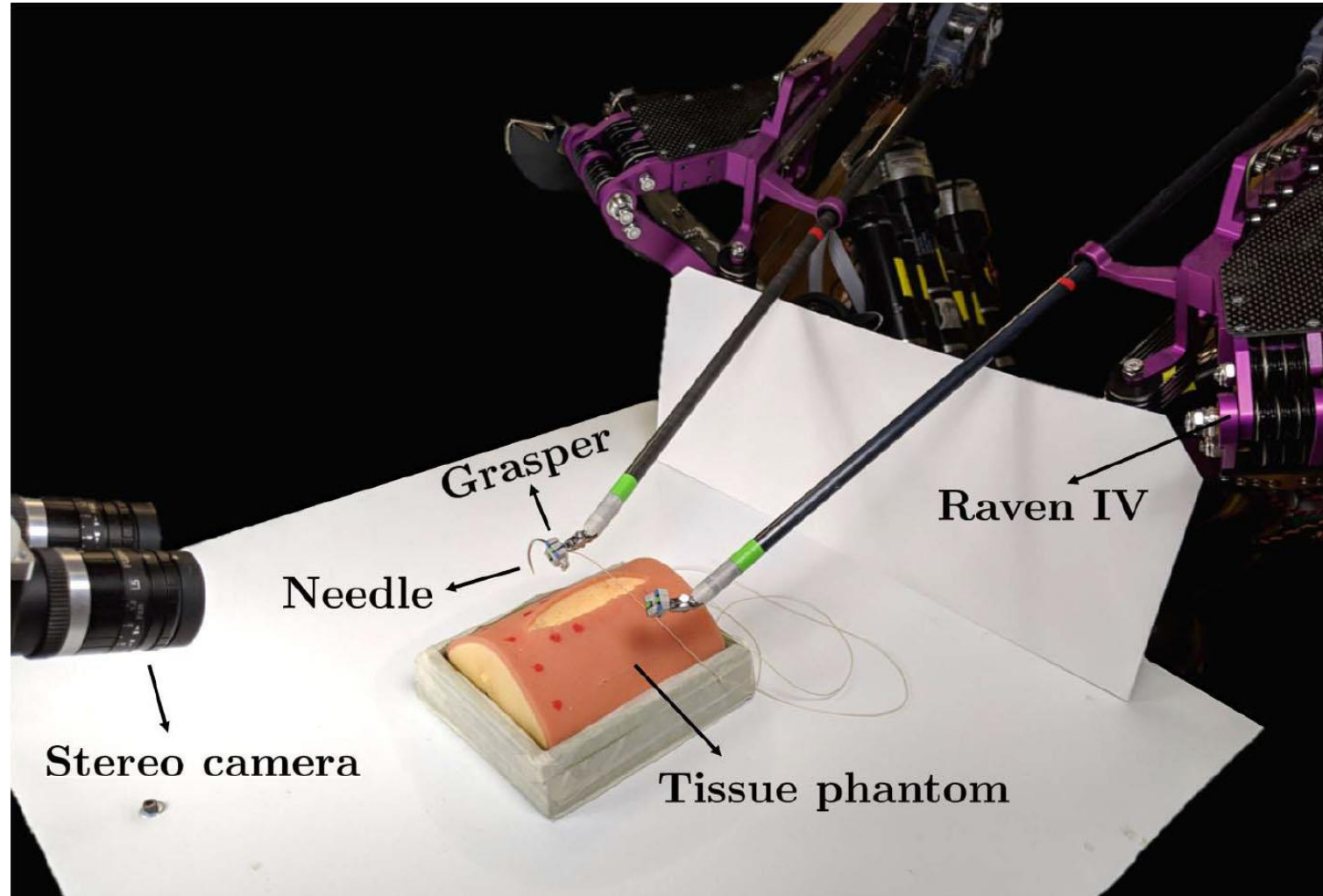
## Supervised autonomy – commercial systems



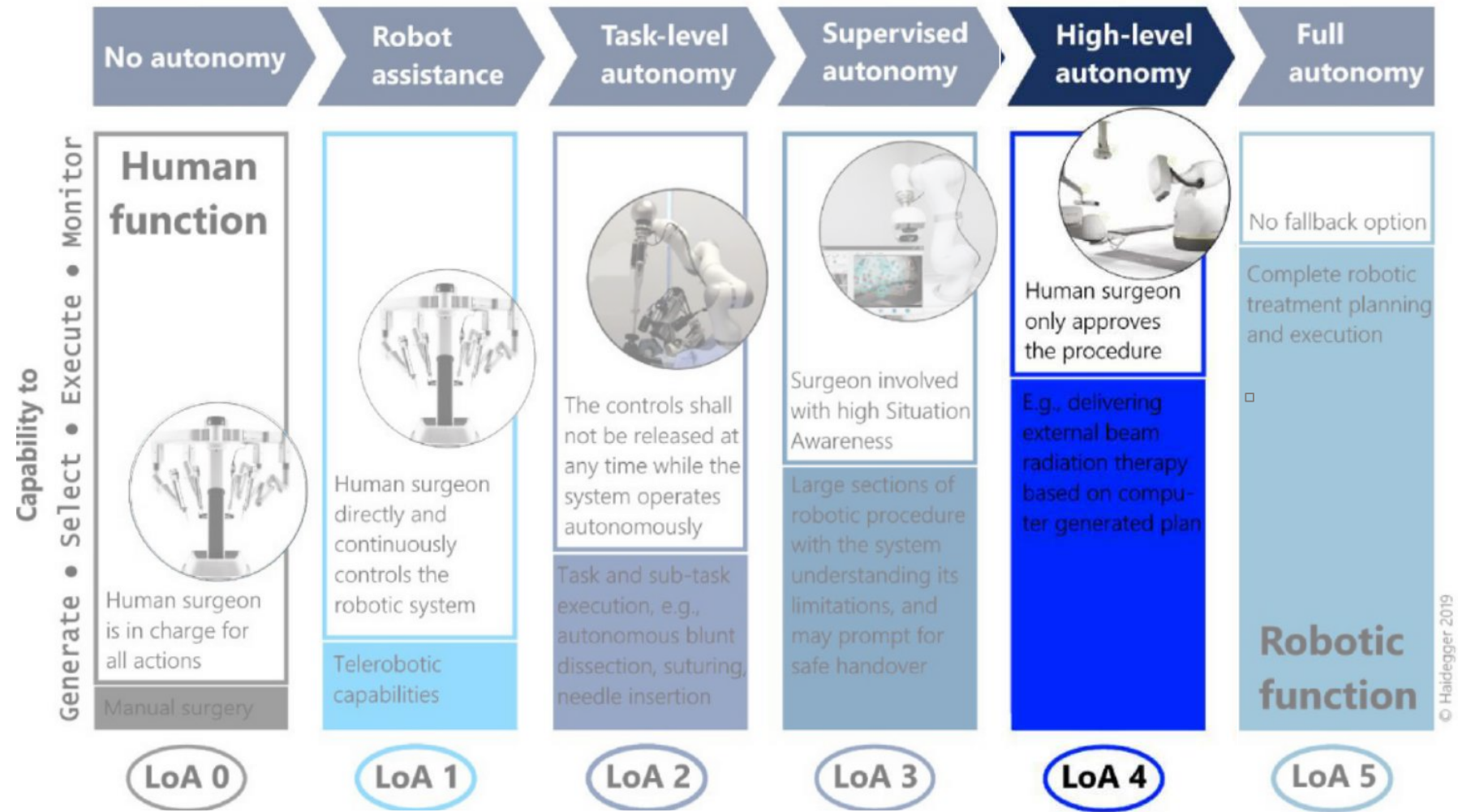
[8]

TSolution One (THINK Surgical)

## Supervised autonomy – research systems



# Level of Autonomy in Robotic Surgery



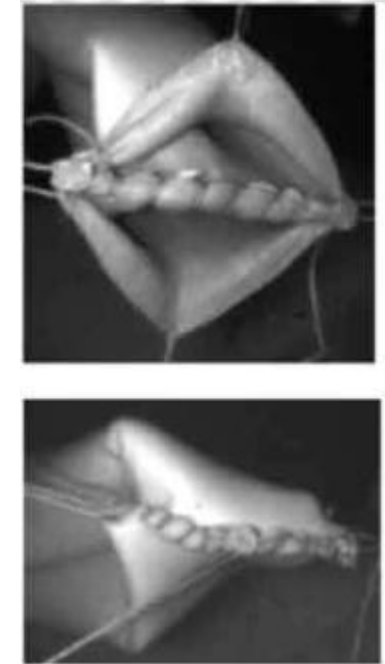
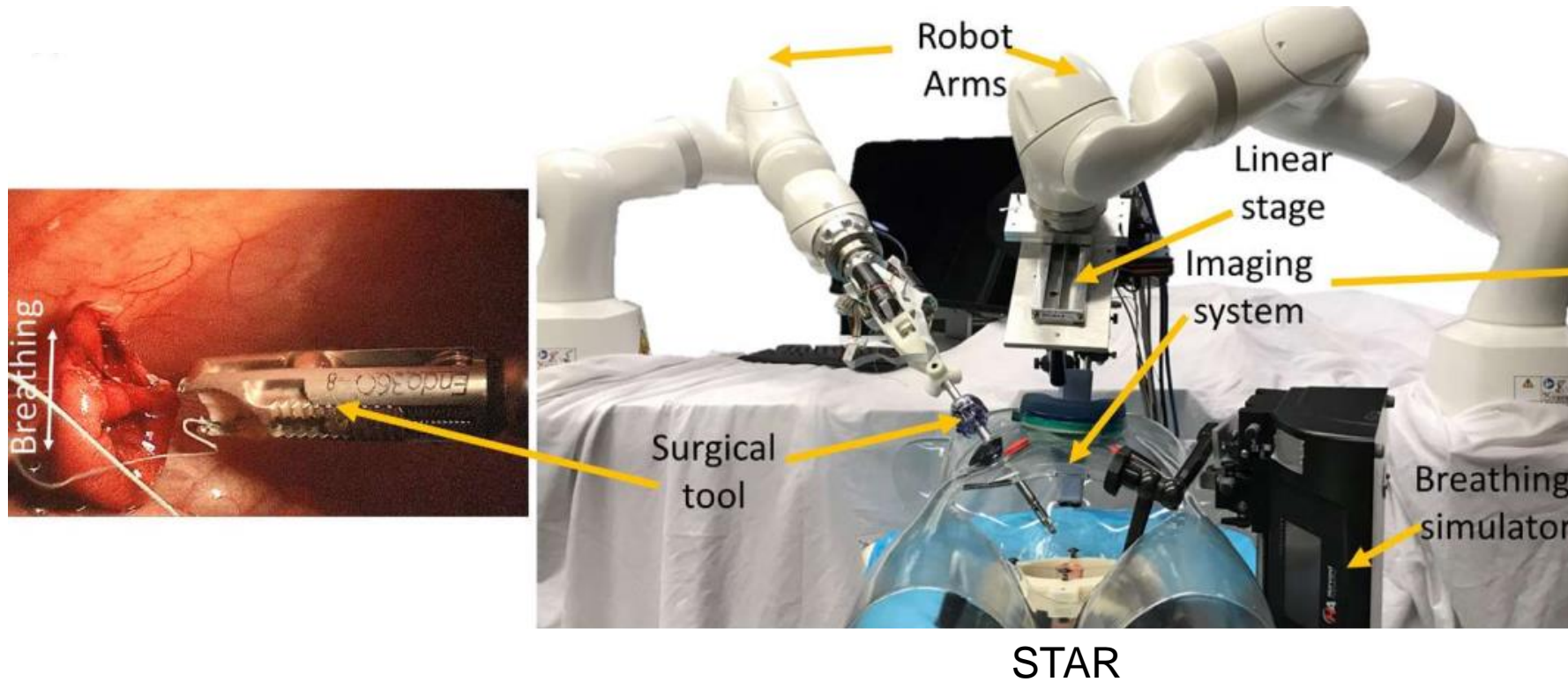
## High-level autonomy – commercial systems



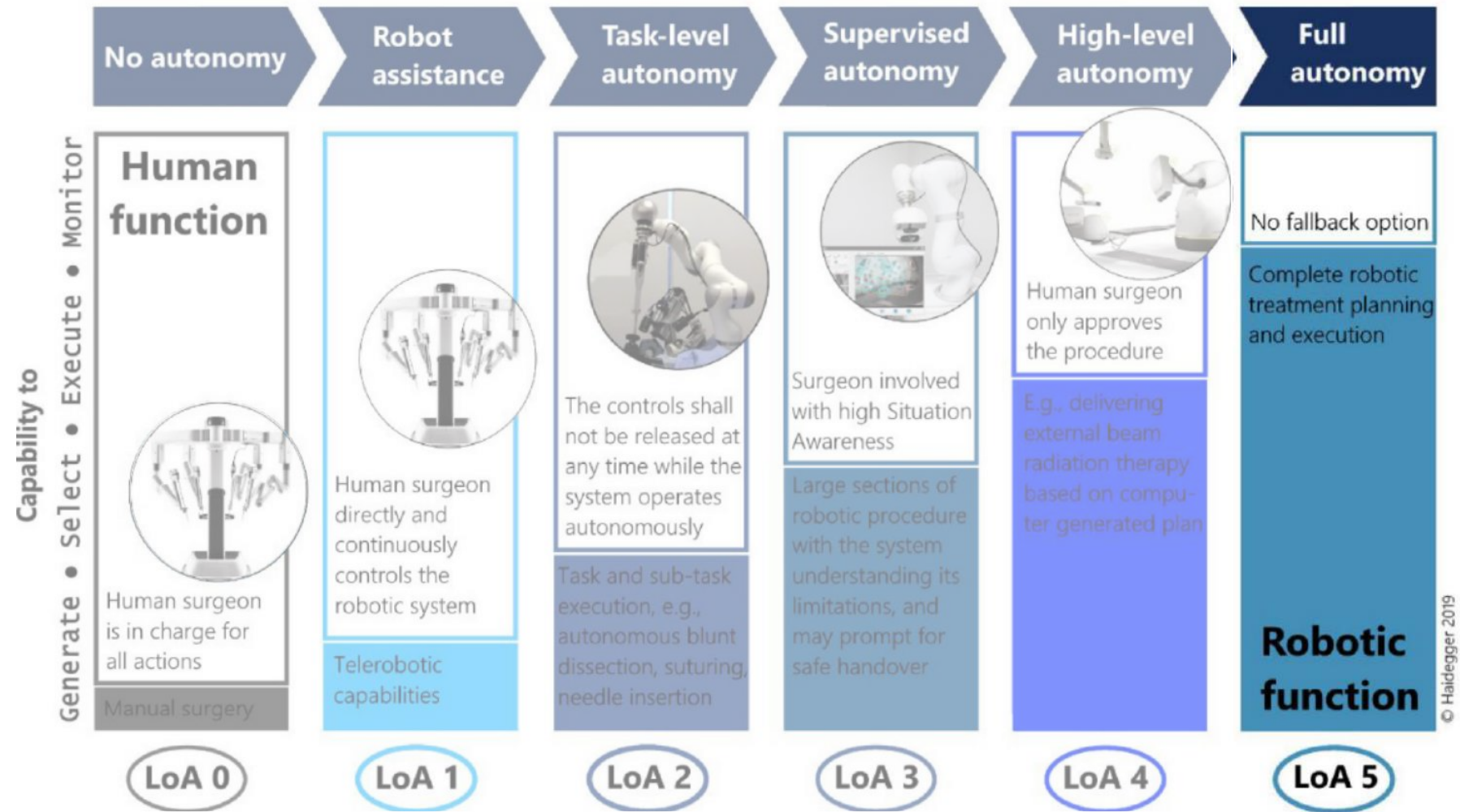
CyberKnife (Accuray)

[9]

# High-level autonomy – research systems



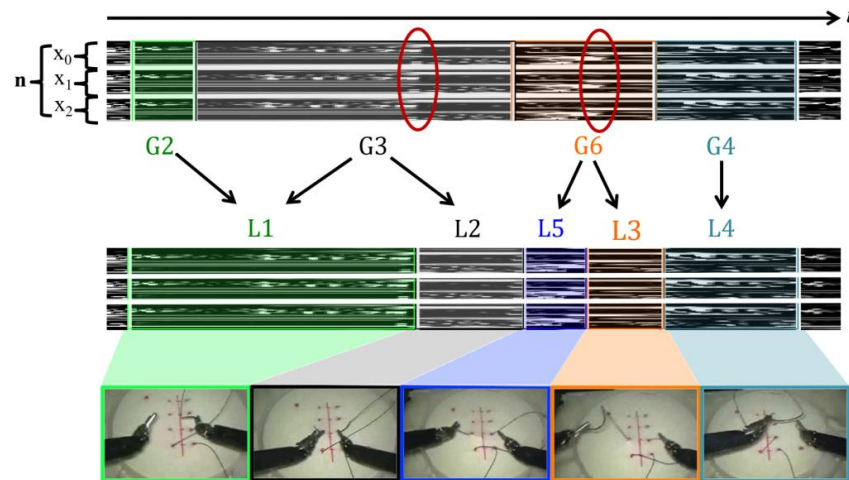
# Level of Autonomy in Robotic Surgery



No autonomy

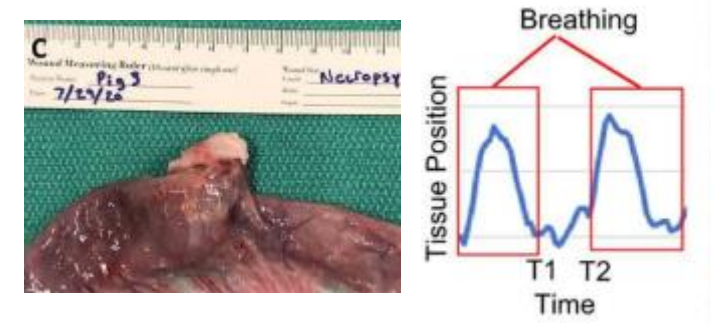
Robot  
assistanceTask-level  
autonomySupervised  
autonomyHigh-level  
autonomyFull  
autonomy

# Challenges



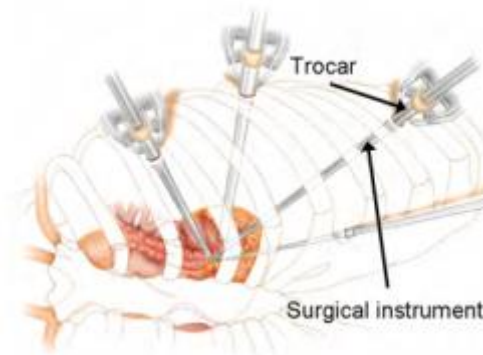
## Gesture Classification

van Amsterdam, B., Nakawala, H., De Momi, E., Stoyanov, D. (2019) Weakly Supervised Recognition of Surgical Gestures, *ICRA*.



## Soft Tissue Interaction

H. Saeidi, J. D. Opfermann, M. Kam, S. Wei, S. Leonard, M. H. Hsieh, U. Kang, A. Krieger (2022). Autonomous robotic laparoscopic surgery for intestinal anastomosis, *Science Robotics* 7

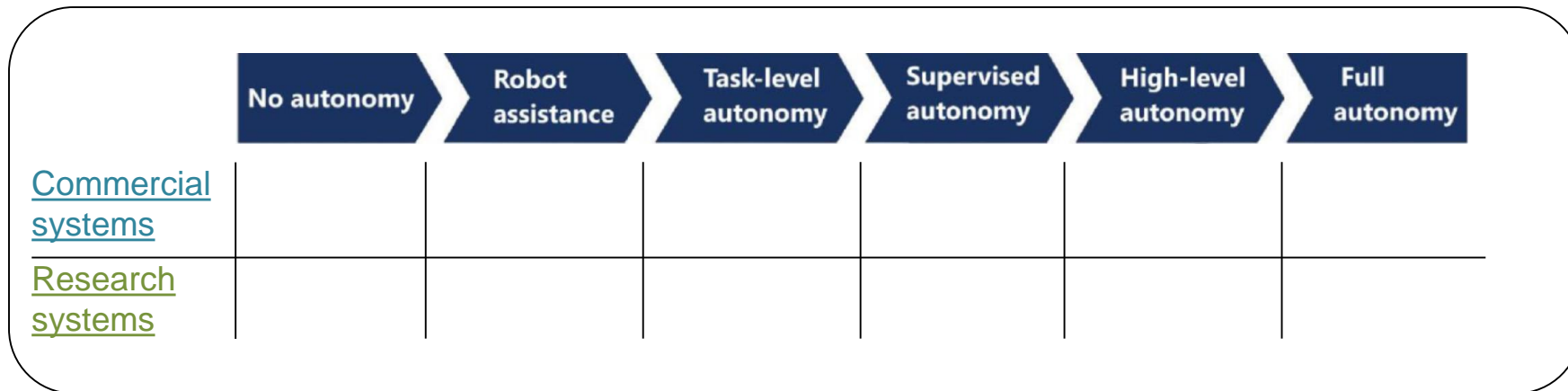


## Setup Planning

Konietschke, R. (2007) Planning of Workplaces with Multiple Kinematically Redundant Robots

# Conclusion

Opportunities



Challenges

