# ROSA® ROBOTICS

## ROSA Knee System and ROSA ONE® Spine and Brain Systems



ZIMMER BIOMET

# ROSA ROBOTICS: INDUSTRIAL ROBOTIC ARM TECHNOLOGY WHITE PAPER

February 2021


ROSA Knee System


ROSA ONE Spine and Brain Sytem

## Introduction

The use of robotics to assist surgeons in surgical procedures is seeing increased usage in a growing number of medical specialties where enhanced precision, repeatability, dexterity and stability is required. A robot's capabilities and the way it is integrated into the OR's existing surgical workflow is crucial for increased adoption of this technology by the surgeon community.

With this purpose in mind, Zimmer Biomet Robotics has designed their surgical robotic platform with the goal in mind to improve surgical outcomes and to make surgery reliable. The ROSA ONE Brain and Spine robot and the ROSA Knee system make up the Zimmer Biomet robotics platform, supporting several surgical disciplines with two different robotic platforms, but utilizing the same robotic arm technology in supporting those procedures.

## ROSA Robotic Arm Design Rationale

Zimmer Biomet has chosen to design its robotic platform with an industrial 6 degrees of freedom (DOF) anthropomorphic robotic arm (Figure 1 & Figure 2) because its architecture is inspired by the human arm for enhanced dexterity and flexibility of movement in performing surgical gestures. Furthermore, intrinsic characteristics of these kind of robotic arm fit ideally with surgery needs of several medical specialties.

Figure 1. Illustration of the ROSA ONE Brain and Spine robotic arm.

Figure 2. Illustration of the ROSA Knee robotic arm.

## Industrial Robotic Arm Intrinsic Characteristics

The first 6 DOF electric robotic arm was designed more than 50 years ago.[1] Since then, accuracy, repeatability, rigidity, dexterity, work envelope and durability of industrial robotic arms have been proven by many industries where a high level of accuracy, dexterity, safety, and durability is mandatory (aerospace, automobile, pharmaceutic).

### a. Absolute Position Accuracy

The absolute position accuracy is the ability of the robot to reach a specific programmed position with a minimum of error. The ROSA Robotics 6 DOF anthropomorphic robotic arm has an absolute position accuracy of less than 0.75 mm root-mean-square (RMS).[2] This means that when the robotic arm is sent to a planned position, the final placement of the tool attached to the end effector will be inside a sphere with a radius of 0.75 mm (Figure 3).

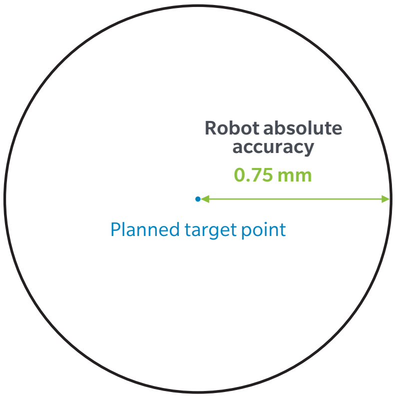


Figure 3. 2D Illustration of the robot absolute position accuracy.

### b. Repeatability

Repeatability can be defined as the closeness of agreement between several positions reached by the robot's end-effector for the same controlled position, repeated several times under the same conditions. Geometrically, the position repeatability can be defined as the radius of the smallest sphere that encompasses all the positions reached for the same requested position. The repeatability of the ROSA robotic arm is 0.03 mm.[3] This parameter is very important as it impacts reproducibility of the surgical gestures (Figure 4).

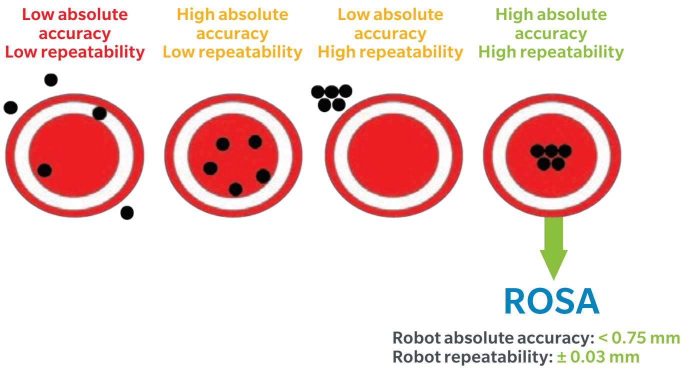


**Figure 4. Illustration of the absolute accuracy and repeatability of the ROSA robotic arm.**

### c. Rigidity

Rigidity is also a crucial parameter for surgical gesture because it drives the stability of the robotic arm in static pose when external forces are applied on the end effector. The ROSA robotic arm allows up to 88 N (≈ 9 Kg) of payload applied on the end effector without any loss of accuracy or repeatability.[4] For comparison the applied force measured for conventional bone drilling, according to one study, is 66 N and 48 N for 600 rpm and 3000 rpm.[5]

### d. Dexterity and Work Envelope

As inspired by the human arm, the comprehensive spherical work envelope (range of action: 920 mm) of the ROSA robotic arm optimizes the surgical workspace while facilitating accessibility to patient anatomy (Figure 5) and offering freedom of movement for surgical gesture.[3]

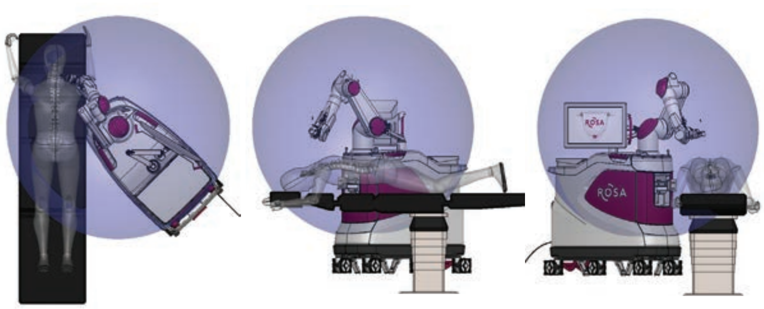

**Figure 5. Illustration of the spherical work envelope of the ROSA robotic arm.**

### e. Durability

The durability of the ROSA robotic arm is designed for extended long-term usage in the OR. The technology has been tested for 5 years of surgical use (cycling test shows that the robot could be used without any loss of accuracy during 480 consecutive hours).[4]

## Additional Design Features

In addition to industrial robotic arm intrinsic characteristics, Zimmer Biomet adapted the design of the ROSA robotic arm by adding specific features for surgical needs.

### a. Robotic Control Modes

The ROSA robotic arm is active meaning that the robot can move and stop automatically, with the aid of motorized joints, to a planned target. In addition to this intrinsic control mode, Zimmer Biomet designed other control modes to fit with surgery needs:

**Cooperative Mode**

The ROSA robotic arm technology has been adapted for surgeon-controlled interactions by adding sensing capabilities. A force sensor mounted on the end effector provides force data monitoring during surgery for advanced haptic capabilities for human to robot interaction. The robotic arm offers the surgeon the possibility to manually guide/co-manipulate the robot and instruments with precision, within defined safety limits. The system interacts with the surgeon to provide them a simple way to benefit all the advantages of robotic movements.

**Constrained Modes**

In addition to free movements, Zimmer Biomet designed specific constrained movement modes, available in both automatic and cooperative mode, depending on surgical procedural needs. The "Axial" mode constrains the robot movement to a defined axis. This ensure the robotic arm to move along planned axis. This specific control mode is suitable with any surgery act involving to follow a planned trajectory for implant or needle positioning. The "planar" mode restricts the robot movement to a defined plane ensuring the robotic arm to move along planned plane. This control mode is particularly useful for cutting according to a pre-defined plane such as in knee replacement surgeries. The "ISO" mode constrains the robot movement to be isocentric around a point defined by the user. This control mode is especially relevant for minimally invasive ventricular neuro endoscopy.

### b. Dynamic Tracking

The ROSA ONE platform is a robotic system coupled/associated with a navigation system, first receiving a CE Mark in 2014[6] and FDA clearance in 2016[7].

Unlike other commercially available robots, the ROSA industrial robotic arm can be used without navigation system (e.g. ROSA ONE Brain) as its movements are controlled by absolute encoders of the robotic arm for positioning and orienting the robot end effector.

For ROSA Knee and ROSA ONE Spine the purpose of the navigation system used in conjunction with the ROSA robotic platform is real-time tracking of key surgical instruments, as well as patient movement relative to the robot. It's distinctive dynamic tracking system not only provides information on the system's screen when the patient has moved, but also relays information to the robotic arm to allow it to move in real-time in concordance with patient movement  thus tracking the patient while assuring that the navigated instruments remain positioned according to the plan.

### c. Safety

The design of the ROSA ONE and ROSA Knee systems incorporates safety features securing use of industrial robotic arm in a surgical environment.

Key safety features are:

- Collision check between the robotic arm and its environment allows to stop in real time robot motions every time it touches an obstacle over a certain threshold as detected by a sensor.
- Constrained robotic control modes were designed to restrict robot movements avoiding unwanted movement near critical anatomy structures.
- A vigilance device (foot pedal) ensures the user a real-time control of robot movements during surgical gesture as the robotic arm can only be controlled when the vigilance device is activated.
- Speed control of robotic arm movements can be adjusted depending on surgical gesture and approach requirements.

## Conclusion

Intrinsic characteristics of the 6 DOF anthropomorphic industrial robotic arm combined with specific features designed by Zimmer Biomet explain why Zimmer Biomet has chosen this kind of technology for use in surgical procedures. The ROSA ONE Brain and Spine and ROSA Knee robotic platforms provide an efficient, accurate, repeatable, surgeon-centered and data-driven OR support tool to assist surgeons in conducting an array of surgical procedures. The robotic platforms designed by Zimmer Biomet offer a state-of-the-art robotic experience for patients, physicians and hospitals.

## References

1. https://www.robotics.org/joseph-engelberger/unimate.cfm
2. https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfpmn/pmn.cfm?ID=K200511
3. https://www.staubli.com/en/file/21193.show
4. Robot endurance test report: TR-F3040-HSDK Robot Endurance rev000
5. Experimental investigations of forces and torque in conventional and ultrasonically-assisted drilling of cortical bone 1,2K Alam,1AV Mitrofanov, 1VV Silberschmidt 1Wolfson School of Mechanical and Manufacturing Engineering, Loughborough University, LE11 3TU, UK. DOI: 10.1016/j.medengphy.2010.10.003 1AV Mitrofanov, 1VV Silberschmidt 1Wolfson School of Mechanical and Manufacturing Engineering, Loughborough University, LE11 3TU, UK. DOI: 10.1016/j.medengphy.2010.10.003
6. https://orthospinenews.com/2014/07/18/medtech-receives-ce-marking-of-rosa-spine-robot/
7. https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfpmn/pmn.cfm?ID=K151511


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