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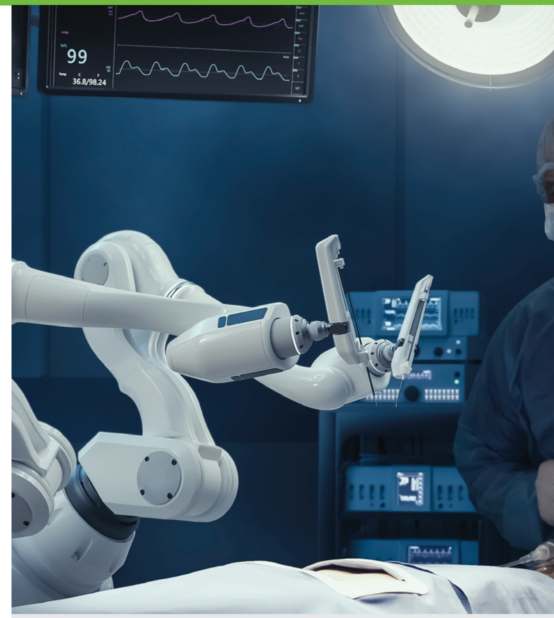
Shaping the Future of Surgical Innovation: MIS, RAS, and the Tools Required for What Comes Next



WHITE PAPER
July 2026

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Minimally invasive surgery (MIS) and robotic assisted surgery (RAS) are based on a simple, long standing surgical goal: to deliver effective therapy inside the body while minimizing external trauma and tissue disruption. For over 2,000 years, early physicians such as Susruta and Abulcasis experimented with hollow tubes and specula to reduce patient trauma.[1, 2] While these early tools may have been crude, the intent behind them was the same objective that drives MIS today. The field advanced significantly as modern optics and illumination became available, and reached a major turning point in the late 1980s when pioneering surgeon Camran Nezhat introduced video laparoscopy.[3] By transferring the surgeon's view to a monitor, Nezhat created a shared visual field for the entire surgical team and opened the door to more precise, more ergonomic, and more scalable minimally invasive techniques.

RAS followed a similar path but was more directly shaped by advances in technology. The very word robot, which was introduced by Czech science fiction writer Karel Čapek in his 1920 play R.U.R., sparked decades of engineering imagination about mechanical helpers.[4] By the mid-twentieth century, research into tele-operation and remote manipulation, much of it driven by defense and aerospace programs, provided the technical foundation for RAS.[5] As computing power, fiber optics, and real time imaging matured in the 1990s, surgical robotics shifted from concept to reality. Early systems evolved to establish RAS as a practical extension of MIS principles—offering enhanced precision, improved visualization, and a gentler experience for the patient

Together, MIS and RAS trace a unified path in surgical innovation: better control, better vision, and a steady push toward interventions that achieve more while keeping the physical impact and tissue trauma to a minimum.

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Precision, Integration, and the New Path Forward

Across the globe, minimally invasive and robotic surgery are shifting from specialized centers to mainstream practice, bringing advanced care closer to patients, wherever they may live. Recent discussions at the ***Clinical Robotic Surgery Association (CRSA) 16th Worldwide Congress on The Present and Future of Robotic Surgery*** reinforce this direction. Clinical leaders have emphasized that the next generation of robotic platforms must deliver higher fidelity visualization, more reliable system performance, smaller and more agile instruments, and consistent data quality to support AI, training, and remote collaboration. They have also stressed the need for robotics to integrate more seamlessly into the surgical workflow, operate reliably in both high and low resource settings, and generate standardized data streams for simulation, coaching, and analytics.

From these discussions, four key technology pillars have emerged:

1) Higher fidelity imaging to support AI driven guidance
2) Adaptive illumination for improved tissue contrast
3) Increasingly miniaturized endoscopic optics for smaller, more agile instruments
4) Reliable high voltage power for increasingly complex systems

Understandably, this complexity means that designers must seek out partners who can deliver integrated, surgery-focused technology platforms rather than isolated components. Suppliers such as Excelitas, with deep expertise in micro-optics, illumination, Optical Coherence Tomography (OCT) imaging, and reliable power solutions can help product designers reduce system level integration complexity, shorten prototyping cycles, and accelerate time to market for new surgical platforms.

Technologies Enabling the Next Surgical Frontier: Photonics, Power, and Optical Intelligence

For over 25 years, Excelitas has been a trusted partner to medical device innovators, delivering advanced photonic components that power millions of procedures annually. Today, the company's broad portfolio, which spans from Chip on Tip (COT) micro-optic 2D or 3D camera modules, high CRI illumination, fluorescence-ready light engines, Swept Source OCT (SS OCT), and power supplies forms the backbone for next generation surgical visualization. These technologies are not just incremental improvements; they are foundational enablers of the new surgical paradigm.

High Fidelity Imaging

Advanced MIS and RAS platforms increasingly rely on imaging not just for visualization but for interpretation, guidance, and decision support. High resolution, depth-resolved imaging enables surgeons and robotic systems to differentiate tissue types, assess perfusion and margins, and navigate complex anatomy with greater confidence. Excelitas' Axsun SS OCT technology delivers the speed, depth range, and resolution required for real time volumetric imaging, with sweep rates up to 800 kHz and wavelengths spanning 1060, 1220, and 1310 nm for optimal imaging across a range of tissue types. Further integration of supporting components with the swept-source, and on-board FPGA based image generation ensure low latency performance suitable for robotic control loops and AI driven analysis in a compact form factor. These capabilities extend from established fields such as ophthalmology and cardiology into emerging robotic applications where subsurface visualization and automated tissue characterization are becoming essential.

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Adaptive Illumination

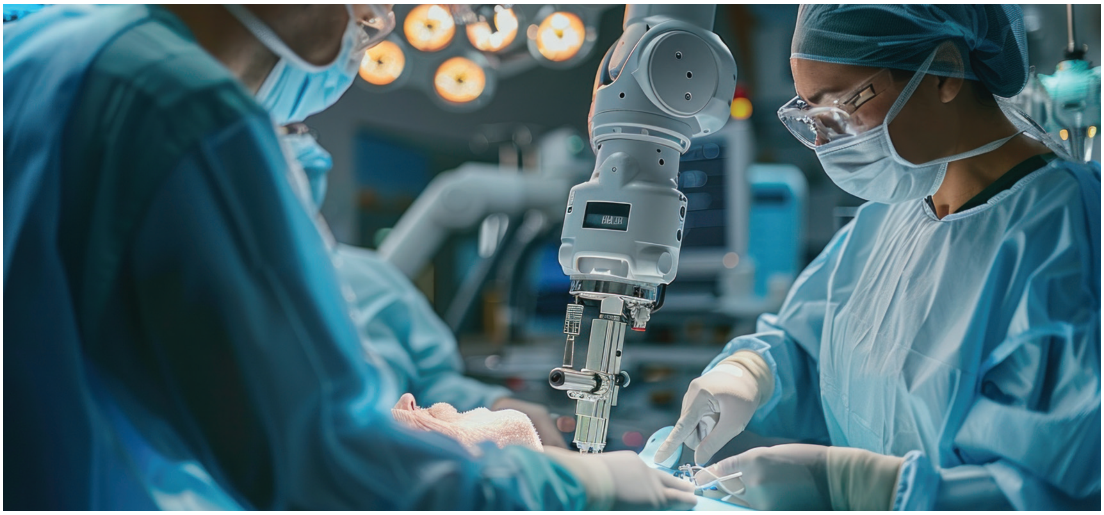
Illumination has evolved from a simple light source into a powerful tool for tissue differentiation. High-CRI white light, multispectral channels, and fluorescence-ready excitation wavelengths work together to reveal subtle anatomical features that conventional imaging might miss. Excelitas' wide illumination portfolio, including Xenon, LED, and tunable hybrid laser LED engines, support bright, uniform, and spectrally precise lighting for advanced MIS workflows. These systems enable fluorescence guided surgery, vascular mapping, and tumor boundary identification, all which are increasingly central to robotic and minimally invasive procedures. The ability to integrate illumination further supports the development of robust, clinically reliable instruments.

Miniaturized Optics

As surgical platforms become more dexterous and less invasive, the optical systems at their core must shrink without compromising performance. Excelitas' chip-on-tip (COT) micro-optic camera modules are engineered to meet stringent customer requirements. With diameters below 2.5 millimeters and fields of view up to 170 degrees, they enable the development of smaller, more maneuverable scopes that align with the move towards reduced incision size and deeper anatomical access. Excelitas assembles image sensors, illumination, and protective housings into compact, sterilizable modules or full endoscopes suitable for both handheld and robotic solutions. As endoscopy advances toward 3D visualization, AI-assisted imaging, and robotic autonomy, the importance of high-performance miniaturized optics will continue to grow.

Reliable AC-DC and High Voltage Power

Behind every advanced imaging system, robotic arm, and therapeutic modality is a power architecture that must operate with absolute reliability. AC-DC and high-voltage power supplies provide the stable, energy dense foundation required for complex surgical platforms, supporting the reliable power for laser engines, electrosurgical tools, interoperative CT systems and robotic actuation systems. Excelitas' power solutions are engineered for medical grade reliability, compact form factor, and thermal stability, enabling OEMs to design systems that are both powerful and dependable. As surgical robotics expand into new clinical domains and more demanding workflows, the importance of a robust and reliable power infrastructure becomes even more critical.



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Conclusion: Evolving the Surgical Ecosystem

MIS and RAS are converging toward a future defined by data-driven, AI-enhanced, and increasingly autonomous surgical systems. As these platforms evolve, illumination, optics, OCT imaging, and power will no longer be distinct subsystems, but tightly integrated technologies that work together to define system performance. High-fidelity imaging, adaptive illumination, miniaturized optics, and stable high-voltage power work together to enable more precise visualization, improved tissue differentiation, and reliable operation of increasingly complex robotic platforms. Chip-on-tip sensors and advanced micro-optics extend access into smaller anatomical spaces, supporting less invasive procedures and AI-assisted interpretation.

In this landscape, Excelitas' ability to unify illumination, optics, OCT imaging, and power within a single engineering platform helps accelerate the development of safer, more precise, and more intelligent surgical platforms while positioning the company as a key partner for innovators shaping the future of minimally invasive and robotic surgery.

References

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