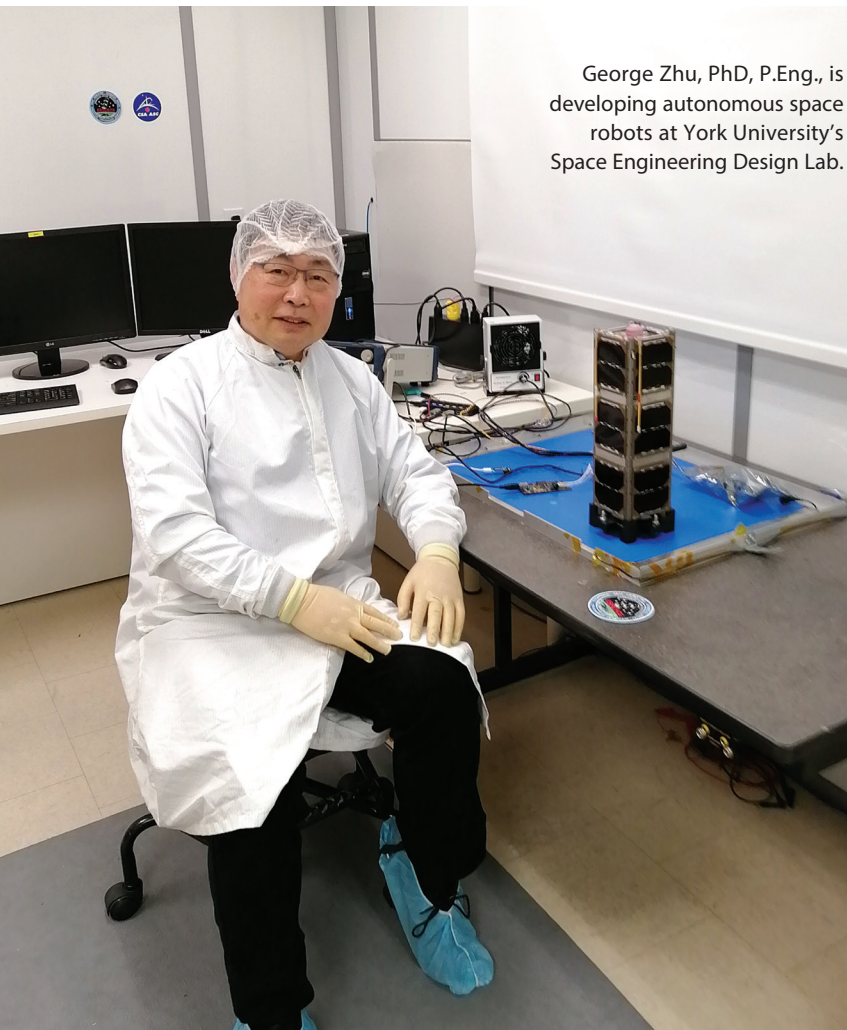


Cleaning Up the Cosmos

Aerospace engineer George Zhu is innovating to make space exploration safer and more efficient.

By Sharon Aschaiek



George Zhu, PhD, P.Eng., is developing autonomous space robots at York University's Space Engineering Design Lab.

With space becoming increasingly crowded with potentially dangerous debris, there has never been a greater need for the novel solutions of world-renowned aerospace engineer George Zhu, PhD, P.Eng.

As director of the Space Engineering Design Laboratory at York University's Lassonde School of Engineering, Zhu studies how to clean up the more than 100 million pieces of junk—including spent satellites, rocket booster fragments and paint flecks from spacecraft—filling earth's low orbit. If uncontrolled material crashes into a satellite, it could disrupt vital information and communication systems. Or when re-entering earth's atmosphere at speeds of up to 30,000 kilometres per hour, it could collide with an aircraft in flight. In fact, Canadian researchers recently determined that there's a 26 per cent annual chance of space debris entering a busy flight area.

"Space debris poses many risks and is a great source of stress for the space industry," says Zhu, winner of the 2024 Ontario Professional Engineers Awards Gold Medal. "If you can imagine all of our skies covered with space debris, we may one day not be able to launch a rocket into space."

THE MAKING OF ROBOTS

For Zhu, clearing out space pollution entails developing specialized robots that can function autonomously with artificial intelligence (AI) and operate in the zero-gravity space environment. He is currently working on a robotic manipulator equipped with a camera that can independently detect and capture a mock satellite set up in the room. Several sensors affixed to the machine provide vital data used to optimize its zero-gravity performance.

Zhu is also researching swarm robotics, a system of small satellite vehicles with powerful computational abilities that can operate independently without centralized control. Inspired by the collaborative behaviours of insects, birds and fish, they can communicate and co-operate with each other to detect and grab space debris.

Both types of robots would push debris into the earth's atmosphere, where it would automatically incinerate—but Zhu says swarm robotics is the more cost-effective option. "Swarm robots are much cheaper and quicker to produce than a single large robot, so we can afford to let them burn with the debris," says Zhu, the Tier 1 York research chair in space robotics and artificial intelligence.

For Zhu, studying how to make space exploration safer and more efficient has also involved researching 3-D printing in space. Referring to a NASA report indicating that astronauts use only 5 per cent of the spare parts and tools they bring along on missions, he notes that printing them in space would significantly lighten the load of rocket ships, thus allowing them to burn less fuel. Zhu's current research projects are funded by almost \$5.5 million in grants from the Natural Sciences and Engineering Research Council of Canada, the Social Sciences and Humanities Research Council, the Ontario Research Fund and the Canada Foundation for Innovation.

THE ROUTE TO SPACE RESEARCH

Zhu's ascent to the global upper echelon of space research was sparked by a childhood fascination with the cosmos. Growing up in China, he recalls marvelling at the moon and stars in the night sky and wondering what else might exist in the dark, vast expanse. Zhu studied mechanical

engineering through to the doctoral level at Shanghai Jia Tong University. After moving to Canada, he built on that education by completing a master's degree in robotic control at the University of Waterloo in 1998 and a PhD in mechanical engineering at the University of Toronto in 2004.

Zhu's foray into aerospace engineering began in industry as a senior stress and structural engineer at engineering design and manufacturing firm Curtiss-Wright EMS-INDAL, where he studied the best way to tether a helicopter to a ship when it lands in high seas. Seeking to further explore and develop engineering innovations for the aerospace sector, Zhu made the switch to academia in 2006 and joined York. Since then, he has served in increasingly senior positions at Lassonde, including chair of the department of mechanical engineering and founding co-director of the Manufacturing, Technology and Entrepreneurship Centre. He was also the inaugural director of York's Research Commons, which funds York researchers.

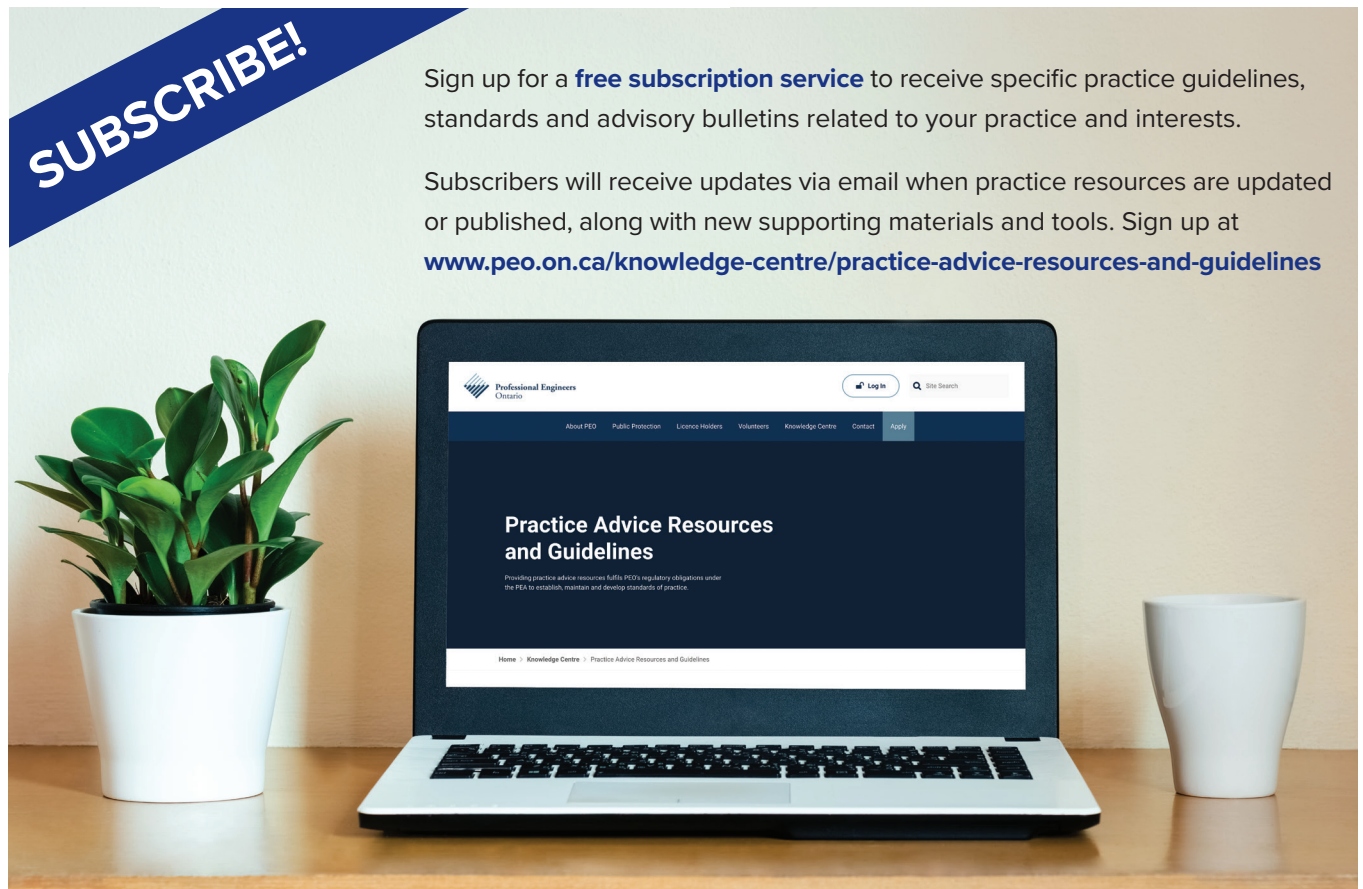
THE SECOND SPACE RACE

The investigations of Zhu and his team—he supervises 14 graduate students and two postdoctoral candidates—have become increasingly relevant in recent years as

technological gains, geopolitical ambitions and growing space tourism have driven what's being called a second space race. Currently, there are approximately 10,000 satellites in space, and this number is projected to significantly increase as more companies and nations join the action. Meanwhile, the emergence of weapons designed to disable satellites could exponentially increase the amount of space debris.

Understanding that enhancing space exploration is a long-term collaborative effort, Zhu generously shares his knowledge with up-and-coming engineers. He has engaged undergraduates from diverse engineering disciplines in designing and building a miniature satellite that, in 2023, was launched into orbit by International Space Station astronauts; equipped with a wide-angle camera, it is monitoring permafrost thawing in Canada's Arctic region. He is also leading a comprehensive multi-university student training initiative focused on AI, computer vision and autonomous robots for space that involves experts from the Canadian Space Agency and National Research Council Canada.

Zhu's intense interest in supporting aspiring engineers extends to his active participation in PEO's York Chapter. Each year, he invites fellow chapter members to serve as industry advisors to fourth-year engineering students at York as they complete a capstone design project. "There are so many unknowns to explore and discover in space...I'm in a lucky position where I can fulfill my curiosity," Zhu says. "But the most rewarding part of my job is training young people, the next generation of engineers, to find their path." **e**



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