My lifelong dream is to improve our society through aerospace engineering. Among various aerospace applications, I see great potential in small satellites and their coordinated operation in constellations, which can directly enhance people's lives by providing services such as universal Internet access. My research interest is at the heart of these technologies - autonomous control. Currently, these applications are challenged by the limited capabilities of small satellites in terms of autonomy and control, and I am keen to tackle this challenge in my graduate studies. The skills I would obtain through the graduate program in Aeronautics and Astronautics at the Massachusetts Institute of Technology will significantly advance my goals.

The turning point leading to my current study was a visit to the NASA Kennedy Space Center when I was a second-year undergraduate. An Atlas V rocket was on a mission to carry NOAA’s Geostationary Operational Environmental Satellite-S. I watched the launch in awe, and as the giant rocket broke through the sky, I started to cry. The spacecraft’s mission was to track severe storms, support weather forecasting, and provide scientific data to better understand the climate. I was stunned by the remarkable amount of energy and resources that were invested in launching the satellite, which represented the cumulative effort of thousands of engineers and scientists to enrich the world. Inspired, I made up my mind to work on satellite development research for the betterment of humanity.

As soon as I returned to my university in Japan, I joined the Q-Li project, in which students are developing a 3U CubeSat to address the issue of space debris. One difficulty we faced was the severe mass and volume limitations, which prohibited a commonly-used three-axis magnetorquer (3MTQ), and only allowed a single-axis magnetic torquer (1MTQ) onboard. As the Attitude Determination and Control System (ADCS) team leader, I addressed these issues through research with Professor Ilya Kolmanovsky at University of Michigan on Non-linear Model Predictive Control (NMPC). My research idea was to apply the NMPC algorithm to a 1MTQ, which could overcome the uncontrollability inherent to such an under-actuated control system. Our theoretical analyses on stability and controllability concluded that the Q-Li is locally weakly controllable, and its detumbling is achievable, even with a 1MTQ. We will demonstrate my NMPC approach with the Q-Li satellite launch in two years, and I am tremendously excited. Moreover, my NMPC methodology potentially adds another layer of redundancy to ADCS because the NMPC approach can ensure controllability, even if two axes of a 3MTQ fail. I have presented this at the AIAA SciTech Forum 2020 and submitted a journal paper for the AIAA Journal of Guidance, Control, and Dynamics.

The Q-Li project has given me experience in satellite development, including learning how large-scale, long-term these projects can be. In our case, it will take two years to test my NMPC approach while in orbit. Therefore, to further explore my research interests, I started collaborating with Professor Ella Atkins at University of Michigan to study control theory for quadcopters, which are more accessible, inexpensive, and require a much shorter period to examine control algorithms than satellites. We have applied the advantages of MPC in terms of handling constraints to geofencing. As conventional MPC approaches are computationally intensive, I have employed an Explicit MPC (EMPC) scheme. The EMPC controller refers to a pre-computed table to save onboard real-time calculation. This offline scheme finds control inputs with faster computation than a traditional MPC scheme. I have built a MATLAB-based simulator to analyze the EMPC controller and have shown that the EMPC scheme can safely control a quadrotor back to the origin with a reduction in computation costs. I am currently building a C++-based simulator and preparing for onboard experiments with F-450 size quadcopters. These onboard tests will explore my EMPC scheme's feasibility in the real-world environment. I am excited to analyze the system, as the opportunity to work with real quadcopter systems is what initially drew me to this project.

My involvement in the Q-Li project has also made me realize how essential the skills in launching and operating satellites are to my future career. Thus, I began research with Professor Simone D'Amico at Stanford and joined the DWARF project to gain more experience working with space systems. The DWARF satellites are two identical 3U CubeSats, which demonstrate new relative navigation and control approaches to advance distributed space systems (DSS). My role is to design the ADCS, and I have been building a C++-based Simulink simulator, which propagates attitude dynamics coupled with orbit propagation. DSS will push the boundary of space use and accomplish missions that are otherwise hard to achieve by a single spacecraft, such as broadband satellite services. I am thrilled to be involved in such a project that can significantly impact our society.

My experiences working in the US and collaborating with US-based researchers thus far have been highly rewarding. To continue to work in such environments with world-class faculty and students, I applied for scholarships to fund my graduate studies abroad. I was fortunately accepted by the Funai Overseas Scholarship, which covers two full years of tuition, insurance costs, and $2,500 living expenses a month.

With this support, I hope to pursue my research interests at MIT. In particular, I would like to work with **Professor Kerri Cahoy** on CubeSat development projects to gain more experience working with real flight systems in all phases of the project - from design and development to integration and test to eventual on-orbit operations. I am confident that my hardware skills and knowledge of ADCS can contribute significantly to such satellite projects. I am also interested in **Professor Richard Linares'** research project on satellite swarms. As I have developed skills in optimal control, such as MPC, I would like to apply these control methods to a satellite constellation. I also want to investigate the theoretical underpinnings of under-actuated satellite systems under his guidance. My previous work has investigated under-actuated control with magnetic torquers; therefore, I would like to explore the possibility of under-actuation with other types of actuators, such as momentum wheels and gas jets. **Professor Olivier de Weck**'s research project, "Platform for Expanding AUV exploRation to Longer ranges (PEARL)," also interests me, as it represents a significant real-world application involving a satellite constellation. I would like to work on this or similar projects to learn more about systems considerations in these real-world applications.

My career goal is to progress in the field of aerospace control in academia. The Q-Li and the DWARF project have shown me how an academic project can expand the horizons of engineering and make an extraordinary impact on society. I, thus, would like to work on autonomous control studies as a researcher and improve others' lives.