EXECUTIVE SUMMARY

In a remark that is frequently quoted, a character of Ernest Hemingway's said that he went broke in two ways: gradually, and then suddenly. So too with drones. Their evolution as a technology has a long history—as long, really, as there has been powered flight. Yet it is an evolution that until the last decade had borne only limited fruit. Militaries around the world experimented with unmanned aircraft, but for most of the twentieth century, drones were only really good enough for target practice. Meanwhile, hundreds of thousands of hobbyists flew model airplanes and helicopters. But the hobbyists flew for the sake of flying; for decades, there was very little their small aircraft could do. So the hobby remained a niche.

As is recounted in **Chapter 1** of this short book, all this changed quite swiftly in the last decade. The Global Positioning System (GPS) came online in 1995, suddenly making precise navigation possible anywhere on Earth. Early GPS units were not so accurate, so small, or so cheap. But this changed. So too with digital imaging sensors. Kodak made a working digital camera in 1975, but it was not until the early years of this century that such cameras became first accessible and then ubiquitous. Accelerometers were etched onto microchips in the late 1970s, but only in the 1990s did such microelectromechanical systems become common, when they were used to trigger automobile airbags. All of these components are crucial to the success of modern drones. (Which is not to say that any given drone cannot operate without a specific constituent technology. There are usually work-arounds.)

What, then, can drones do today? Equipped with sophisticated gimbals that allow cameras to freely rotate, they can get never-before-possible shots for Hollywood action movies. Pared down to the lightest possible weight, with cameras that communicate with small screens embedded in goggles worn by the pilot, they can zigzag through obstacles at speeds impossible for model-airplane hobbyists of decades past to have even aspired to. They are, like the personal computer, a multipurpose device. But though drones might commonly one day act as radio relays or couriers, at present they excel at one task: gathering images.

How drones gather images, and what people can do with the images they gather with drones, are the principal concerns of this book. In particular, we are concerned with images joined together into maps. Maps are among our most powerful social artifacts as humans. For most of history, it was impossible to create accurate maps. Then, for a while, it was very difficult, requiring both specialized knowledge and a great deal of resources. One of drones' many boons is to democratize the process of mapmaking. They are far cheaper than the mapmaking technologies they replace. Together with widely available satellite imagery, they are revolutionizing mapmaking. Though the knowledge required to operate drones is a barrier to entry, it is not an insurmountable one. This book is intended, in part, as a helping hand over that barrier for those interested in making maps with drones who do not know how to begin doing so.

Clear and secure rights to property—land, natural resources, and other goods and assets—are crucial to human prosperity. Most of the world's people lack such rights. That lack is in part a consequence of political and social breakdowns and is in part driven by informational deficits. Maps made by drones—and by unpowered aerial platforms such as kites and balloons—can chip away at these deficits.

Such maps have the capacity to help the weak defend themselves against would-be exploiters who, for instance, might take land that does not rightfully belong to them. But there is nothing to say a map made with a drone will inherently be of any good to anyone. **Chapter 2** of this book, by Mathew Lippincott and Shannon Dosemagen, discusses how one might think critically about the data-gathering process so that it might be of the greatest good to the greatest number. Their case for "people-centric mapping" is a strong one.

Chapter 3 of this book is a brief exploration of some issues in the regulation of drones. It is an odd quirk of modernity that it is safer to fly in a pressurized tube many miles above the Earth, at great speed, than it is to walk down a city street. The safety of air travel is one of the great regulatory successes of our time. And yet, aviation regulators are struggling to adapt to a new reality of a proliferation of small

aircraft. This chapter discusses some pathways for harmonizing drone traffic with manned aviation. It also discusses some of the perils that drones bring with them. Along with other digital technologies that have large memories and fast brains, they have the capacity to chip away at solitude and privacy. This chapter discusses how a reassertion of property rights in the air can both protect privacy and allow for technological innovation.

Chapter 4 is the nub of this work. Though drones have made mapmaking much easier, it is far from a point-and-shoot endeavor. This chapter discusses the sorts of hardware and software that are necessary to make a map, and it explains the principles behind the process—principles that will remain even as hardware gets cheaper and software gets faster.

Chapter 5 narrates a number of examples of mapmaking in practice. It tells the story of Gregor MacLennan, who, together with Wapishana tribespeople, built drones and made maps of Guyana's rain forests and savannahs with the aims of thwarting illegal mining and negotiating just property boundaries. It discusses Walter Volkmann's efforts to update the Albanian cadastre, or record of property holdings, using a drone to accomplish in three hours what might have taken a month using traditional techniques.

Sometimes the maps that drones make come with great urgency, as in the aftermath of a natural disaster. In **Chapter 6**, Patrick Meier discusses his efforts to use drones as part of the response to Cyclone Pam in Vanuatu and the 2015 earthquakes in Nepal, among other calamities. In the chaotic aftermath of an extreme storm or an earthquake, systematic information is invaluable. This chapter discusses how best to go about obtaining such information and how to do so in collaboration with other humanitarian responders.

In the public domain, perhaps the richest experience with using drones to gather data in the last few years has been by scientists, in particular by those seeking to understand wildlife and ecosystems more broadly. Serge Wich, an ecologist who studies primates and tropical rain forests, and a drone pioneer himself, authoritatively surveys the extant scientific literature on these subjects in **Chapter 7**.

There is great hope that drones, with the new capabilities they provide, might help protect the most vulnerable among us when their human rights are jeopardized. **Chapter 8** analyzes the United Nations' use of drones in Haiti, the Democratic Republic of the Congo (DRC), Mali, and Chad, as it wrestles with the difficult task of protecting civilians in troubled and violent parts of the world. It also discusses monitoring efforts in Ukraine by the Organization for Security and Co-operation in Europe. This chapter then turns to nongovernmental organizations that aim to use drones to document human rights abuses and thus hold perpetrators to account, raise awareness, and hopefully reduce such instances in the future. This has not been done much yet; drones remain a new technology, and though they're powerful, the information they can gather is sometimes palliative at best.

This work concludes with two case studies. **Chapter 9** discusses the Peruvian Ministry of Culture's drone mapping program. It is a massive program—in the past two years, Aldo Watanave and his colleagues have mapped nearly 500 archaeological sites. The goal of this program is twofold: it is a scientific endeavor, and it is intended to establish clear legal boundaries around archaeological sites in order to prevent illegal encroachment by developers.

Chapter 10 is an examination of the UN's drone program in the DRC. The eastern part of that country, along the borders with Rwanda and Uganda, has been at war for nearly twenty years, and UN peacekeepers have been present there for the bulk of that time. The Falco drones being flown there are large and expensive, compared with many of the other drones discussed here. But they are far cheaper and more capable, with regards to observation, than the helicopters the UN had previously been using. This chapter points out one of the inherent limitations of drones. Information without the means to act upon it is still of value; however, that value is circumscribed.

On a final note, this book concludes with a look forward, trying to understand what is likely to change about drones as the technology continues to evolve, and what is not.

This primer is being published in conjunction with a website: drones.newamerica.org. That website contains regularly updated information about noteworthy drone flights, as well as a compilation of worldwide drone regulations. §