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Introduction

Berna Akcali Gur, Joanna Kulesza

Space-based Internet connectivity has garnered significant attention in recent years, primarily after the successful deployment of Starlink, the first mega constellation project to achieve global coverage. This milestone has catalyzed a competitive international landscape, with major space-faring nations committing substantial resources to develop independent satellite networks. Simultaneously, private enterprises, particularly within the United States, are engaging in rival projects, further intensifying the race to establish next-generation global broadband infrastructures. From its beta testing phase, Starlink's services have been crucial in diverse scenarios, including disaster and conflict zones, as well as remote and sparsely populated areas where terrestrial infrastructure would be impractical or too costly. As impressive use cases increased, so did the intensity and depth of debates among a wide range of stakeholders regarding the potential implications of this technology, particularly for global power dynamics, security and cybersecurity, sustainable use of space resources, and sustainable development. Civil society, businesses, policymakers, and regulators have all had to rapidly develop policies and take necessary steps to safeguard their interests. Simultaneously, researchers and policy experts from diverse backgrounds have engaged in analysis from the perspective of their expertise, including political economy, communications theory, legal and policy analysis. This book contributes to these discussions by bringing together policy experts, civil society, leading scholars and emerging scholars from diverse backgrounds. This book aspires to reach a broad audience by providing a comprehensive insight into the impact of space-based broadband Internet connectivity. We believe each chapter will captivate and engage readers eager to broaden their knowledge and delve deeper into the subject matter.

Space-based Internet connectivity has advanced significantly with the successful deployment of satellite constellation systems in low Earth orbit (LEO). These systems have the potential to profoundly transform global Internet access by bridging the digital divide and reaching communities in rural or isolated regions. The United Nations (UN) Sustainable Development Goals recognise that

improved Internet access can boost local economies by enabling e-commerce, remote work, and access to global markets while supporting essential services such as education and healthcare, which increasingly rely on digital connectivity. Additionally, space-based Internet can enhance resilience in regions affected by natural disasters or conflict zones, ensuring continuous communication and access to information when other options fail. This technology ensures that even the most remote parts of the world can be connected, which is crucial for achieving universal Internet access. However, the rapid expansion of space-based Internet services has created an urgent need for a review of existing policies and regulations to manage spectrum allocation, orbital slots, and space debris. International cooperation is essential to address these challenges and ensure equitable access. The contributing authors to this volume agree that while it is each jurisdiction's prerogative to determine policies that serve their specific interests, there is a critical need for deliberation on various aspects of this technology at the international level.

Starlink, a Space Exploration Technologies Corp. (SpaceX) subsidiary, has leveraged its parent company's advanced rocket systems and mass satellite manufacturing capabilities to achieve remarkable success. Unlike previous attempts that faltered mainly due to financial constraints, Starlink has deployed thousands of satellites in low Earth orbit (LEO) with unprecedented speed and efficiency, thanks to SpaceX's enabling technologies. Additionally, Starlink achieved diplomatic success by negotiating the placement of ground stations across various jurisdictions, a technical requirement for global coverage. This rapid progress caught competitors, including private companies in the US and other space-faring nations, off guard. As more companies and countries venture into space-based Internet projects, they have become a central feature of the New Space Race. The increasing number of space actors and private companies defines this new era. The Moon and Mars exploration remain distant prospects for many; space-based connectivity concerns everyone, whether space-faring or not. The future of global connectivity may well depend on how effectively these challenges are addressed. Each chapter analyses a different aspect of these challenges.

Compelled by the success of Starlink, several other mega constellation projects are being developed to provide global Internet coverage. As of the time of publication, its closest competitor, Eutelsat OneWeb, had deployed 648 satellites in low Earth orbit (LEO). Eutelsat OneWeb's major shareholders include Eutelsat, a publicly traded company listed on the Euronext Paris stock exchange, the UK Government, and Bharti Global, an Indian company. Another US-based company, Amazon's Project Kuiper, is in the process of deploying a competing system. Canada-based Telesat's Lightspeed project is working on a constellation system in LEO after securing financing from the Government of Canada and the Government of Quebec. China is also entering the market with several satellite constellation projects, including Guowang, Hongyan and Hongyun. These are part of China's strategic efforts to enhance its space-based Internet capabilities and compete globally in the satellite communication sector. The European Union has also approved an

EU-based mega constellation, Infrastructure for Resilience, Interconnectivity and Security by Satellite (IRIS2). It aims to provide secure communication services to the EU and its Member States and broadband connectivity for European citizens, private companies, and governmental authorities. It will support various applications, including border surveillance, crisis management, and secure communications for EU embassies. This new wave of satellite constellations is poised to revolutionise global connectivity. At the same time, they highlight the perceived need to own and control infrastructure for security and cybersecurity concerns by those with the financial and technological capacity to do so. Meanwhile, others are left to figure out how to protect their interests in the global power dynamics where they are merely the users. The chapters in the book reflect both sides of this dynamic.

The book adopts a global governance perspective, focusing on the analysis and understanding of the rules and processes that govern space-based Internet connectivity as a global issue transcending national borders. A balanced approach is pursued, recognizing both the transformative benefits and inherent associated risks. Concerns regarding the space environment, cybersecurity, regulatory control, geopolitical tensions, and equitable distribution are discussed. Although there is not a dedicated chapter, the threat caused by the rapid increase in satellite deployments to the sustainability of Earth's orbits has been raised by the editors and Dan York. Indeed, as thousands of satellites are launched at an accelerated pace, the risk of collisions and the proliferation of space debris grow, further complicating orbital safety—especially in the absence of a globally governed traffic management system. Nevertheless, its significance in enabling connectivity even in the most remote regions remains undeniable, serving as a crucial foundation for universal Internet access—an essential public resource for accessing both public and private goods and services in today's increasingly interconnected world—making it a continued focal point.

The chapters encompass contributions from multiple disciplines, including political science, international relations, economics, and international law, to elucidate the complex interactions between various actors. In addressing the pertinent challenges, the roles, effectiveness, and influence of different actors—such as states, intergovernmental organisations, private companies, and civil society—are examined, exploring how global governance mechanisms can effectively address these issues. Collectively, the essays aim to inform policymaking at national, regional, and global levels by providing insights into how global cooperation can be enhanced and how international institutions can be more effective in addressing shared problems to promote global stability and prosperity. Despite its ambitious goals, the book is a concise contribution and does not claim to address all problems comprehensively. One significant issue, the editors wish to include in a future volume is the light pollution exacerbated by mega-constellations, which disrupts astronomical observations and limits scientists' ability to study the universe. Consequently, several topics are not included in this volume, it is not exhaustive.

The sections are organised into three parts. The first part comprises two sections. The first section introduces the modernised satellite broadband technology and contemporary policy issues, primarily from a global connectivity perspective. The second section analyses historical events and trends, providing insights into how past economic policies and developments influence present-day issues. The second part is dedicated to the security implications of space-based Internet. The three essays are connected by considering cybersecurity as a key security concern. This link also establishes how the digitalisation of communication technologies played a central role in the perception of space-based connectivity. The third part comprises selected essays on regional approaches to space-based Internet. These essays were presented at the Trusted Internet Summer School on Internet Governance and International Law (SSIGIL) in 2024, hosted by the University of Lodz at the Faculty of Law and Administration premises as part of a research project supported by the Internet Society Foundation. Postgraduate students from three continents presented and discussed their work on satellite broadband technology throughout the week. These essays are followed by a commentary by an established policy professional advocating for the Internet Governance multistakeholder model as the model to follow to address global policy issues.

The first contribution by Dan York, a world-renowned Internet technology expert who led a LEOs project team at the Internet Society Foundation. The team researched the use of mega satellite constellation systems in LEO for Internet access and developed a "Perspectives on LEO Satellites" document outlining opportunities, challenges, and enduring questions. The team comprised experts from around the world, representing various stakeholder interests. Their work was guided by the goal of user benefit and addressing the global digital divide. Building upon this project and his extensive expertise in communication technologies and non, D. York introduces contemporary satellite broadband technology and potential policy issues and responses. D. York's contribution delivers a comprehensive outline of the technology and its implications, paving the way for essays focusing on more specific aspects. Following this invaluable contribution is another by Jonathan Liebenau, who explores the satellite industry from three perspectives: economics, history, and business practices. The essay traces the historical context of satellite development from the International Geophysical Year (1957–1958) onwards. In examining the economic relationships within the satellite industry, he highlights the complexities compared to traditional capitalist markets. Lastly, he focuses on the business models of satellite companies and their government predecessors, comparing various revenue-generating approaches. The paper also discusses the broader relationship between digital infrastructure and satellite Internet, providing insights into the economic trade-offs. Although often perceived as a technological marvel, constellation technology has existed for a considerable time. Its financial viability has only recently been realised due to advancements in enabling technologies. J. Liebenau is well placed to conduct this analysis as his expertise on the subject is over 30 years, starting with his research into the LEO

industry in the late 1990s in a project aimed to inform the UK Civil Aviation Authority and their National Air Traffic Control Service, which wanted an assessment as to whether and when space-based infrastructures in LEO would be reliable as well as financially feasible to integrate into their existing communications systems.

Section 2 comprises three essays by leading scholars that focus on the security-related aspects of satellite constellation technology. These essays complement each other by addressing the broader implications of mega-constellations for security on Earth and in the Earth's orbits, as well as the security of human space exploration. These essays illustrate how overlapping and diverging security and cybersecurity concerns impact our present and future activities on Earth, in orbit, and in outer space beyond the Earth's orbits. The section begins with Roy Balleste's insights on the cybersecurity implications for human space exploration in LEO and beyond. He contends cyber operations present significant risks to current and future peaceful space endeavours. The dynamic cybersecurity landscape necessitates new practices and the establishment of a cybersecurity framework guided by the wisdom of scholars who long ago recognised the benefits of space exploration and the evolving nature of peace and security. According to the author, immediate solutions lie in a new cybersecurity framework anchored in Outer Space Law, which will inspire the development of innovative legal principles. R. Balleste's previous research focused on several areas, including astronautical ethics, which explores the ethical dimensions of space exploration; cybersecurity law, particularly in the context of space operations; internet governance, which investigates how internet policies and regulations impact global cyberspace; and space cybersecurity, which addresses the unique cybersecurity challenges posed by space activities and the development of legal norms to protect these operations this work is informed by his extensive knowledge in cyberlaw, space law, and cybersecurity.

Following this, Laetitia Cesari underscores the importance of space security in LEO, given the critical role of space-based assets in supporting essential services, economic activities, and national security. In this chapter, she explores how LEO satellite constellations revolutionise operations for space operators and users, highlighting the increased collision risks posed by the growing population of operational satellites and space debris. The chapter discusses the significance of dual-use space systems in diplomatic dialogues. It offers reflections on potential governance pathways, including law and diplomacy, while acknowledging the complexity of finding straightforward solutions. L. Cesari recognises that addressing these challenges requires coordinated efforts from various stakeholders. States must foster international cooperation and ensure compliance with international obligations. Diplomacy and the rule of law are essential to enhancing space security and protecting activities in LEO. This work is informed by L. Cesari's prior research, which includes numerous publications aimed at improving the understanding and governance of space activities and ensuring their long-term sustainability and security.

The contribution by the editors, J. Kulesza and B. Akcali Gur concentrates on possible domestic governance strategies for satellite broadband, aiming to tackle cybersecurity concerns while leveraging these services to aid developmental objectives. This essay expands upon their prior research regarding space-based connectivity, highlighting the importance of information communication infrastructure and broadband Internet access in achieving the UN sustainable development goals, as mentioned in the Preface. They incorporate a discussion on multistakeholder processes for global cybersecurity efforts and the impact of substantial gaps in expertise, technical capacity and the lack of transparency in effective participation in these processes. The authors argue that the prevailing cybersecurity policies will shape LEOs' future role in global Internet access, international cybersecurity and equitable global digital development.

In Section 3, the book introduces essays on regional approaches to LEOs. These essays were selected from those presented at SSIGIL by postgraduate students representing a diverse range of countries across three continents. The first essay is by Célestine R. Rabouam. She conducted her work in the Canadian Nunavut region—the gradual dependence on Starlink and its impact on Canada's digital organisation of arctic territories. During her PhD research, she made sure to grasp local dynamics during her extended stays in this region. The editors have been impressed with her work, consulted her as an expert for their project, and are very happy that her contribution has found its place among the others. Her research focuses on the geopolitical and technical challenges posed by the increasing hybridisation of terrestrial and satellite telecommunications systems in the Canadian Arctic, particularly in Nunavut. She examines the impact of satellite constellations, like Starlink, on technological dependencies and the digital organisation of networks in the Arctic. Her work highlights how these developments affect the region's political and economic landscape.

This essay is followed by Monica Stachoń's essay on the use of LEO satellites for cybersecurity and broader security strategies of authoritarian regimes, using Iran as a case study. It delves into the impact of space-based systems in LEO on national security, technological advancements, environmental monitoring, and political stability. This study underscores how space technologies, particularly LEO satellites, can become essential to authoritarian states' security frameworks, enhance internal surveillance and intelligence activities, and foster independent cyber capabilities. M. Stachoń's expertise in cybersecurity and her educational background in Iran studies make her well-suited for this analysis. The article provides insight into the space capabilities and use cases of non-aligned space-faring nations that do not have the capacity to deploy a mega constellation system, offering a more holistic picture of the LEO environment. This section is particularly significant given that Iran experienced the unauthorised provision of satellite broadband services by Starlink to protestors whose internet access was obstructed by the government during the 2022–2023 civil unrest. The incident led to a legal reiteration of jurisdictional requirements for licensing and authorisation of foreign service providers

but also sparked a parallel discussion on the human rights implications of these established rules.

The third essay, written by Jason Bonsall, examines why some countries, despite standing to gain significantly from satellite broadband services due to its rapid deployment potential and ability to bridge the digital divide caused by limited infrastructure, are hesitant to authorise and license these services. His article is informed by his previous research on decolonial theory and highlights national regulatory frameworks and geopolitical factors as significant obstacles to the broad adoption of this technology. His analysis focuses on the impact of LEO satellite broadband on connectivity initiatives and the telecommunications industry across the continent by considering the 2Africa connectivity initiative by Meta and the United Nations' Universal and Meaningful Digital Connectivity by 2030 target. He concludes this contribution with a case study that contrasts Nigeria, where Starlink is authorised, and South Africa, where it is not, illustrating different approaches to achieving global connectivity and emphasising Starlink's unique role in the telecommunications sector.

In Section Four, we have a commentary by Mallory Knodel. Drawing from her years of expertise in Internet governance and multistakeholderism platforms, M. Knodel draws parallels between multistakeholder governance models for the Internet and their applicability for space-based infrastructures. The author argues that it is the best-suited model for satellite broadband governance. Her intervention is informed by her work as co-chair of the Human Rights Protocol Considerations research group of the Internet Research Task Force and advisor at the Freedom Online Coalition. Her previous work has a human rights-centered approach to technology, emphasising encryption, censorship, and cybersecurity. We have invited her to contribute this perspective to the sat com governance discussions to provide a complete picture.

The volume concludes with a reflective section by J. Kulesza, who thoughtfully considers the volume as a whole, consisting of contributions offering unique perspectives and showcasing the authors' diverse expertise and preferred methodological approaches. From theoretical frameworks to empirical studies, the chapters collectively enhance our understanding of the role of satellite broadband in global connectivity and underscore its importance in global power dynamics, especially those impacted by security and cybersecurity. This book aims to inform policy and governance of satellite broadband, ensuring it is utilized to connect the millions currently disconnected while addressing security and sustainability concerns. J. Kulesza highlights the significance of the interdisciplinary approaches taken by the contributors, noting how their varied backgrounds and methodologies enrich the discourse on satellite broadband. The reflective section emphasizes the critical need for robust policies that not only promote widespread access to satellite broadband but also safeguard against potential security threats and ensure the long-term sustainability of these technologies. By addressing these multifaceted issues, the book provides a comprehensive overview of the current state and future prospects of satellite broadband.

We hope this volume will serve as a valuable resource for a broad audience, including civil society, scholars, practitioners, and students, fostering further research and dialogue. The insights presented in this volume are intended to inspire innovative solutions and collaborative efforts to bridge the digital divide, enhance global connectivity, and navigate the complex landscape of security and cybersecurity in the realm of satellite broadband.