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Africa-as-a-service: Digital Health and the Rise of Drone Infrastructures

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Content

Abstract

In this working paper, we draw on the case of experimental drone uses in African healthcare systems in order to explore how digital innovation stimulates critical changes in infrastructural provision and the ways in which the global role of places such as Silicon Valley, Rwanda, and Ghana, as well as their connections, are configured in processes of spatial formatting. Developing the idea of "infrastructure-as-service" as a sociological concept, we suggest that data extractivism and fantasies of infrastructural leap-frogging are major forces behind emergent fields of infrastructural experimentality and their spatial embeddedness. Revisiting dominant theories of infrastructure, the working paper scrutinizes the promises of digital infrastructures, sheds light on the specific ways in which regions in the Global South participate in, and offer indispensable services for, infrastructural changes, and theorizes the nexus of infrastructures and spatial formats.

Introduction

In 2016, the Silicon Valley-based tech company Zipline signed a deal with the Rwandan government for the delivery of logistical services in order to support the provision of healthcare in remote, infrastructurally disconnected areas of the country. Promoted as the world's first "fully automated instant delivery system," these services differ from conventional logistics offerings in that they are based on unmanned aerial vehicles, popularly known as drones, whose operation depends on complex software and digital computing. Initially, Zipline's drone services consisted of blood deliveries for medical emergencies to hospitals outside the capital city of Kigali. However, as the company expanded its operations to other countries such as Ghana, their services developed into a full-fledged infrastructural package, including the establishment of regional distribution centers from which medical supplies of all sorts could be delivered via drone. Robotics-based infrastructural innovations such as drones often come with lofty – yet to date unfulfilled – promises, embodied, for instance, in Zipline's boldly formulated mission to "put every human on the planet within a 15 to 30-minute delivery of any essential medical product."[1] In a similar vein, after signing an agreement with Zipline in early 2021 for the delivery of Covid-19 vaccines, the government of the northern Nigerian state of Kaduna stated that drones "will revolutionize access and availability of critical and lifesaving medicines for millions of people."[2]

This raises an intriguing set of questions: Why did Zipline choose to focus on health as a use case for the development of drones? Why did African countries become the frontrunners in the application of this digital innovation? And how do drone logistics and the imaginaries on which they rest, affect existing spatial arrangements and understandings of remoteness?

Our starting point is the observation that infrastructures shape spaces in multiple ways: while often being configured as networks of provision within existing spatial formats such as nation-states or empires, infrastructures are often characterized by their unequal distribution across national territories. Especially transport infrastructures are usually more developed and denser in economic or political centers and in zones of greater population density. The idea of remoteness, or of remote areas, is in this sense often a function of definitions of certain zones as centers. Areas become remote by being

1 See www.bbc.co.uk/sounds/play/w3ct03pq, accessed 23.03.21.
2 See www.urbanairmobilitynews.com/medical-pharmaceutical-transport/zipline-to-deliver-covid-19-vaccines-in-nigerian-state-kaduna/?utm_source=rss&utm_medium=rss&utm_campaign=zipline-to-deliver-covid-19-vaccines-in-nigerian-state-kaduna, accessed 01.03.21.

excluded from the dominant networks of provision and by being placed, in planning discourse, at the periphery of the flows of goods, capital, ideas, people and commodities. In other words, they are placed at the not-yet receiving end of networks and chains.

It is in this context, that the promise of digital technologies and innovation has acquired massive prominence over the last two decades as a way of overcoming the infrastructural exclusions that remoteness is thought to bring about. More specifically, innovations such as drone logistics are assumed to promote important forms of infrastructural leapfrogging whereby nation-states bypass certain infrastructural systems, hitherto thought to be fundamental for economic growth and development. Instead, they allow developing states to make a great leap into the digital age and supply infrastructural services in revolutionarily new ways. While this promise to restructure and reconfigure national infrastructural spaces is central to drone logistics, we show how they also build on commodity chains as spatial formats.

In this sense, we draw on the case of experimental drone uses in African healthcare systems in order to explore how digital innovation stimulates critical changes in infrastructural provision and the ways in which the global role of places such as Silicon Valley, Rwanda, and Ghana, as well as their connections, are configured in such processes. We begin with an empirical puzzle: Even before the beginning of the digital age, technological inventions were concentrated in Silicon Valley and its supreme "ecosystem of innovation." Yet while major digital inventions have been developed, programmed, and built in California as a high-tech context to be used by customers in other high-tech contexts, Zipline's drones learned to fly in African skies. Why was this so and what do we learn from these transregional entanglements about how Africa is connected to the digital revolution? And how does Africa serve the development of new digital infrastructures?

Seeking to answer these questions, our working paper is essentially a story of how a transatlantic cast of human actors and non-human entities has been bundled together in order to produce new ways to realize one of the world's most pressing contemporary concerns: securing healthcare by bringing medicine to people. The cast includes Zipline's data engineers, venture capitalists, and the US Federal Aviation Authority on the American side; governments, fulfillment managers, pharmacists, healthcare workers and "lives to be saved" on the African side; but also nonhumans, such as rugged landscapes, bad weather, data, and, of course, drones. Drawing attention to the divergent interests and sometimes contradictory motivations of these actors, we show how postcolonial legacies of poor infrastructures, underfunded health systems, empty skies, and reliable telecommunication systems become the real-world testing ground for digital infrastructures.

In early 2016, Keller Rinaudo, CEO of Zipline, explained why they decided to start their services on the African continent:[3]

> *A lot of commercial [drone] operators in the US are waiting to get permission from the FAA [Federal Aviation Authority]. But the FAA is saying "we want more data." But no one is actually flying. So, I actually think that [...] one of the best ways that we can work together with the FAA to help this technology take off in the US is by operating in a country where we can basically serve a very clear need and get tens of thousands of hours of safe flight data.*[4]

Two discrete story-lines are woven together in this statement: one that centers on the humanitarian concern to serve "clear needs" by saving African lives, and another one that revolves around the need for data. This statement serves as our point of departure, pinpointing as it does two needs that have helped to entangle Silicon Valley with remote areas of Africa. However, while the CEO anticipates a world in which the production of flight data and the saving of lives smoothly interact in mutually

3 While the global Covid-19 crisis in early 2020 has had a strong impact on aviation authorities, particularly in the US, the Federal Aviation Authority (FAA) has initiated an Integration Pilot Program in which it has granted experimental waivers to some federal states and drone companies to fly over predetermined areas.

4 See http://sustainableskies.org/autonomous-drones-air-drop-medical-supplies/, accessed 09.03.21.

beneficial ways, we suggest that such infrastructural transregional alignments configure healthcare on the ground in ways that are hidden from official scripts.

What we will call *infrastructure-as-a-service* involves a number of disconnecting practices, which these new airspace logistic relies on and enacts. These disconnections threaten to undermine the promise to improve and democratize access to lifesaving medicines beyond region and geography. What subsequently we call "Africa-as-a-service" indicates that the encounter between African countries and Silicon Valley is simultaneously an expression of these disconnections as well as an attempt to invisibilize them.

We begin by situating our account in contemporary research on infrastructures. In doing so, we seek to unravel both the continuities and disruptions that characterize the place of digital infrastructures in existing infrastructural landscapes. The main part of the working paper explores Zipline's fate in African skies and on African soil in order to shed light on the specific ways in which regions in the Global South participate in, and offer indispensable services for, infrastructural innovation.[5]

Drones as Infrastructures

In an influential contribution, Larkin (Larkin, 2013: 328) usefully describes infrastructures as the "built networks that facilitate the flow of goods, people and ideas and that allow for their exchange over space," and as the physical form that shapes "the nature of a network, the speed and direction of its movements, its temporalities and its vulnerability to breakdown." Based on these ideas and on Star's earlier suggestion to view infrastructures as a "system of substrates" (Star, 1999: 380) which carries much of the visible world, most social science research has been concerned with water supply (Björkman, 2015), electricity grids (Schwenkel, 2015), waste disposal (Fredericks, 2018), and transport systems (Harvey and Knox, 2015), focusing on the political rationalities underlying them, the visions in the name of which they have been justified, and the intricate ways in which they are used to serve their purpose.

More recently, scholars have begun to explore the ways in which digital technologies affect infrastructural provision, highlighting, for instance, the integration of sensors and real-time data analytics into existing material forms such as motorways and ticketing service (Knox, 2021). Digital infrastructure is thus taken to mean the digitization of classical infrastructures but also the cables, wires and other material elements that enable digital technologies. Much recent neoliberal economic restructuring has depended on, and been enabled by, digital innovations for which the emergence of new forms of finance and the rise of platform economies provide major evidence (see also Plantin et al., 2018).

Drone systems differ from classical infrastructures in that while serving a classical purpose – transport and logistics – they have (mostly) emerged out of Silicon Valley's tech industries and depend on much more variegated types of data. Therefore, we suggest that drone projects offer valuable insights into the ways that infrastructural formations enmesh digital and material technologies, a nexus that despite its growing real-world implications has not received enough scholarly attention particularly for

5 Our empirical research has also been affected by the global COVID-19 crisis and ensuing bans on international travel. Under normal circumstances we would have engaged in ethnographic field work involving participant observation both at Zipline's distributions centers as well as the receiving facilities, interviews and focus group discussions with Zipline employees, policy makers and health staff. Instead, we engaged in remote research which involved internet research and the use of grey media. This was also because only two brief empirical studies on drone use in Africa exist so far (see Wang 2021a, 2021b on experimental use in Malawi). Our research of Zipline's involvement benefitted from the strong media presence of the company's CEOs and senior employees. The engagement with these media data has shaped the conceptual direction of article.

constellations in the Global South. At the same time, several lines of research in studies on infrastructure are highly useful for understanding drones.

First, infrastructures are an indispensable part of the imaginaries of modernity, of its presumed movement toward material improvement and development. "Instigating waves of societal progress" (Edwards, 2003: 42), they have animated popular fantasies of upliftment and fueled governmental desires to steer emancipatory or economic transformations. Infrastructures are thus marked by particular historicities and temporalities – real and imagined – and are always linked to promises about a particular kind of future which they help realize and to which Larkin (2013, 332) refers as infrastructure's "poetics." On the one hand, today's drones signal a particular promise that links up with how running water, electricity, and railways became synonymous with civilization in an earlier historical period. As we will show, it is the idea of catapulting African countries into the digital age and turning them into sites of digital innovation that has inspired African leaders to embrace drone infrastructures. On the other hand, infrastructure-as-a-service enacted by drone logistics also promises to overcome the shortfalls of earlier infrastructural dreams, of bad roads and non-functioning cooling equipment.

Second, such configurations also remind us, as Harvey and Knox (2015) show in their ethnographic study on large-scale road engineering in Peru, how infrastructures are usually associated with processes of nation-building and state formation. This is because by providing access to valued goods, infrastructures literally connect people to the state, turn them into citizens, and create an imagined community of equals. However, as we will show, the constellation of infrastructure-as-a-service transforms both the role of the state and notions of citizenship compared to other forms of infrastructural provision. Questions of ownership and accountability as well as modes of engagement of users are reconfigured through novel entwinements of digital and material technologies. Making visible these newly assigned roles and responsibilities, our approach is in line with social science scholarship that conceptualizes the interplay between the digital and the material in infrastructures and its political effects (Knox, 2021; Vonderau, 2019).

Over the past decade, the most significant developments in infrastructure innovation have hinged upon cloud computing and software-sharing and have set in motion the concept of infrastructure-as-a-service. In the corporate world, "as-a-service" refers to new digital connections in a business-to-business manner that promise to save labor, time and costs. Not having to build digital and material infrastructure is considered a major advantage and liberation from uncertain investments as services are not owned but rented. Applying the concept to examples of infrastructural provision in the field of Global Health and development cooperation, we hope to add to the existing body of literature that conceptualizes digital infrastructures. The restructuring of medical supply chains in African countries as infrastructure-as-a-service helps us to critically discuss how the newly achieved connections rely on and enact a number of disconnections that threaten to further destabilize already fragmented health systems.

Third, while in the digital economy the term infrastructure-as-a-service refers to corporate solutions based on Google Cloud or Amazon Web Service, these developments have more generally shifted attention to the role of data as new central resources. Whereas water, electricity, and ground-based transport infrastructures are arguably all premised on the material transformation of natural environments, digital infrastructures pivot on "datafication" and "data extractivism" (Morozov and Bria, 2018): in other words, on the ways in which nature and human activities become data to be extracted, coded, and turned into a resource (Gago and Mezzadra, 2017; Mezzadra and Neilson, 2017). As Couldry and Mejias (Couldry and Mejias, 2019: 337) suggest, the social and economic relationships datafication establishes should be construed as "data colonialism," "which combines the predatory extractive practices of historical colonialism with the abstract quantification methods of computing." Below we will show how Zipline's extraction of data from African societies and natural spaces is an integral part of drone development. If infrastructures are "critical locations through which [...] accumulation and dispossession [...] are formed, reformed and performed" (Appel et al., 2018: 3), it is important to ask how such processes unfold through digital infrastructure such as drones.

Fourth, terms such as "data extractivism" warrant comparisons of drone infrastructures and the unlikely connections between Silicon Valley and Africa which they have produced with earlier techno-scientific projects in which Western colonizing states engaged in infrastructural development in Africa. Chiefly, while often justified as bringing civilization and progress, such projects were geared toward extracting raw materials and generating revenues, leading to highly uneven forms of infrastructural integration and provision (van Laak, 2004; Apter, 2002). In their postcolonial iteration, such projects became central components of the "development" agenda that sought to modernize African states, emancipate their citizens, improve standards of living for local populations, and integrate them as producers and consumers into global markets (Monson, 2009). This raises questions as to how these partly contradictory ambitions, oscillating as they do between common goods and private interests, play out in emerging technological fields in which data are the major revenue to be yielded.

Finally, we are inspired by the observation, made in numerous ethnographic studies (e. g., Anand, 2011), that new infrastructures are often grafted onto existing technologies and materialities. In this sense, infrastructures are always premised on some idea of the "public good." As Anand (2015) eloquently suggests:

> *Infrastructures accrete. They gather and crumble incrementally and slowly, over time, through labor that is at once ideological and material […] They are innovated, installed, and brought into being on top of already existing infrastructures that both constrain and enable their form.*

Part of this "enabling," we suggest, is that in their ability to enlist public support (and to inspire the fantasies of private investors), infrastructural innovations depend, in significant ways, on narratives of the breakdown or malfunctioning of these existing infrastructures. How, then, are drone technologies inserted into existing infrastructural landscapes? As we will argue, it is not only the (image of) bad roads, but also the widespread and reliable availability of internet connections that have helped Zipline's drones to fly. In the subsequent analysis, we follow the development of drone infrastructures from Silicon Valley to regional distribution centers in Ghana and Rwanda, and from there through African skies and the way they are transformed into geodata and weather data, all the way to the local health centers which they serve.

Infrastructures Made in Silicon Valley

Zipline was officially founded as a start-up company in late 2013 but was initially born out of another start-up called Romotive, which developed a toy-like smartphone robot. Headed by three Ivy League graduates specialized in biotech engineering, robotics, and business development, Zipline operates a development, research, and testing site on a large cattle ranch at Half Moon Bay (California), a small town on the Pacific coast. During their first three years, before signing the deal with the Rwandan government, the company did their prototype testing rather secretly and without much noise.[6] During

6 The "African drone" (Sandvik 2017) has been promoted globally as a revolutionary technology for the continent's infrastructural deficiencies and less so for Asia or Latin America. Zipline's early engagement with Rwanda can be traced back to the activities of Jonathan Ledgard, a former Africa journalist for the Economist and star architect Sir Norman Foster who promoted the "droneport project" (www.normanfosterfoundation.org/project/droneport/, accessed 20.08.2021). They envisioned drones to take over new logistical functions connecting remote African communities to world. While the project never materialized Ledgard animated Kagame's interest in drones and introduced Zipline's CEO to him (www.newyorker.com/magazine/2019/09/23/jonathan-ledgard-believes-imagination-could-save-the-world, accessed 20/08/2021).

that time, the founders applied for various patents securing corporate legal rights on the different inventions they made while learning to fly (Chambers et al., 2016). They also pushed for a knowledge exchange with US military drone operators, an exchange that eventually resulted in a collaboration that was largely kept out of the media.[7]

Significantly, as drone logistics are based on programming and digital data handling to a much greater degree than classical infrastructures, core principles of the internet such as networking and connectivity have also inspired the way Zipline imagines infrastructural access to medical products. Reflecting on the mission of his company, Rinaudo once suggested that "technology has gotten us to a point where we can deliver products, especially medical products as quickly and efficiently as the Internet delivers information."[8] The way he projected features and practices from the digital world onto the material world of logistics clearly points to the company's intellectual and commercial origins in Silicon Valley (Daub, 2020).

Between 2015 and 2020, the company collected approximately $225 million (US) over three funding rounds. In 2019, Zipline was valued at over one billion dollars, turning it into a so-called "unicorn" start-up and placing the company at the epicenter of digital technological innovation, venture capital, and futuristic ideologies. Importantly, though, the company's funding is adapted to its context of operation; venture capital investment supports scaling up the company's team and technology in the US, government and business customers pay for the use of Zipline's instant delivery service, and key philanthropic partners like GAVI or the Bill & Melinda Gates Foundation help to support the establishment of distribution centers in low and middle-income markets.

Zipline's strongest competitors in the US are currently Google and Amazon, both digital giants that run their own drone programs and were also granted experimental waivers by the FAA in 2019.[9] For Zipline, this competition has been a double-edged sword. On the one hand, Amazon's and Google's investment in drone logistics has helped to generate massive global attention for drones, emphasized their economic potential, and created markets for them. On the other hand, it has subjected all companies in the field to significant pressure, pushing them into use case niches and inducing them to expand aggressively in order to secure market shares before one of the giants can begin to operate. Through this process, Zipline has successively transformed into a big tech company with currently approximately 500 employees.

This orientation toward the principles of monopolistic internet giants is illustrated in the way Zipline offers a "full package service" to its customers, such as the government of Ghana: It provides its own distribution centers, its own inventory system and, of course, its homegrown avionics software. The company positions itself as a logistical intermediary and inserts its service between national medical supply chain management and local health facilities dispersed across the Ghanaian and Rwandan national territories. They operate their services from distribution centers, from which they supply several hundred health centers and hospitals with blood, vaccines, and other medical products on a 24/7 basis. At the distribution centers, professional positions range from medium-skilled inventory and fulfilment managers (who are often trained pharmacists), flight operators, and flight controllers to the low-skilled laborers required for the assembly of Zipline's cardboard boxes and batteries. Once orders have been received via text message, core tasks for launching a vehicle involve pulling items from racks, putting them into the preassembled boxes, placing boxes on the planes, programming the mission with an old iPhone via a bar code onto the plane, setting the plane on the launching catapult, and pushing two buttons. In addition, flight operators are responsible for maintenance of the vehicles and for changing spare parts. Most tasks at the distribution center are highly repetitive and standardized, comparable to the work in Amazon's distribution centers. But this also reflects a general tendency within Silicon Valley start-up rhetoric to overstate the size and scope of one's impact. When Zipline talks of Africa,

7 See: www.cnbc.com/2019/10/22/zipline-testing-medical-supply-drones-with-us-military.html, accessed 08.03.21.
8 See: www.youtube.com/watch?v=1zVe5cQaPSM, accessed 08.03.21.
9 See www.wsj.com/articles/google-wins-first-faa-approval-for-regular-drone-delivery-of-consumer-items-11556053590, accessed 08.03.21.

it currently refers to Rwanda and Ghana; when the company presents its service as "operational at national scale," it refers to two distribution centers in Rwanda and four in Ghana; when it states that "people's lives depend on their services," it usually refers to the one fourth of their daily deliveries that respond to medical emergency situations.[10]

Thriving on Silicon Valley's fascination with autonomous driving, Zipline too describes its drones as autonomous. In reality, once the respective health facility's target coordinates have been programmed onto the drone, a catapult system propels it into the air and it flies along a predetermined route. Upon arrival at its destination, it drops the cargo in low-flying mode. The cargo then glides to the ground on a parachute, where health personnel collect and administer it. Without touching the ground, the drone returns to the distribution center using the same route. When approaching the distribution center, the plane communicates automatically with the recovery system. Through algorithmic programming, the drone is recovered from the air by a wire that catches onto a tiny hook on the plane's tail. Throughout the entire flight, flight controllers watch a visualization of the drone on an iPad screen. If everything goes according to plan, they do not have to do anything. If something unexpected happens, chief technical officer Keenan Wyrobek described the protocol as follows:

> *And obviously designing this from the ground up is key to the operators of a system like this, and then couple that with how we basically fly this fleet of planes in a similarly robust, fault-tolerant way where literally that [flight] controller […] could call somebody in California – and this has happened a couple of times since October [2016] – and someone in California can literally pop up the screen in the same way and fly that fleet of planes basically with no sort of technical hurdle. We designed this into the very core of the avionics, the electronics, and the software that flies the plane.*[11]

This explanation reveals who is in control of the planes. Because flight controllers and engineers in California engage remotely with the vehicles, the drone infrastructures are essentially managed from afar. From a local point of view, they also become a fully black-boxed technology, one which effectively disables appropriation by users. Importantly, the question of who is in control is linked to the ways knowledge is produced and managed in networked societies. Local experts and controllers are excluded from the innovation process chiefly because Zipline's entire research and development is centralized in its San Francisco headquarters. While this type of remote control seems to be a security issue it also significantly touches on issues of the sovereignty of the involved states. Zipline's desire to control knowledge and data largely turns its African counterparts into menial laborers, not unlike workers in the gig economy.

In spite of this, several African political leaders have become highly interested in drone technologies, especially – but not only – those, such as Rwandan head of state Paul Kagame, who see themselves as vanguards of technology-driven state-building. Thus, in 2016 Kagame stated:

> *This use of unmanned commercial drones to transport essential medical products is a milestone for Rwanda in many respects. Rwandans have learned to embrace innovation […] This attitude has enabled us to overcome great odds in the last twenty-two years, and makes us optimistic about how much more we can achieve […] "Good enough" is no longer enough. We need to aim for the best.*[12]

Kagame's words clearly remind us, as Appel et al. (Appel et al., 2018: 19) suggest, how "infrastructures signal the desires, hopes, and aspirations of a society, or of its leaders." Significantly, the fascination and engagement in the drone field echo recent tendencies to address infrastructural deficiencies not

10 The actual average number of daily deliveries per distribution center is unknown. However, we can assume that this varies strongly both according to the daytime and the distribution center, ranging from 10 to 30 deliveries on average.

11 See www.youtube.com/watch?v=-Obmn_uGKVU, accessed 23.03.21.

12 See www.facebook.com/PresidentPaulKagame/posts/10153747881727282/, accessed 22.02.21

by investing in existing supply systems (e.g., around water, electricity, and transport) but by circumventing or "leapfrogging" these by pushing innovations such as solar panels, mobile money, point-of-care diagnostic tests, or drones.

Often, in the wake of the neo-liberalization of Africa, citizens' right to infrastructural provision has been reframed as a customer service to be paid for (von Schnitzler, 2016). But, as we argue, neo-liberalization has also turned states into customers who purchase (or "rent") services from private companies. The way drone infrastructures are managed gesture toward a particular form of infrastructural nation-building, one in which states do not buy and own any material part of the infrastructure but rather contract companies who offer services. Elaborating on the notion of "infrastructure-as-a-service," Dr. Anthony Nsiah-Asare, Director General of Ghana Health Services (GHS), emphasized the following in an interview:

> *Ghana Government is not buying drones. As of now in the technological world nobody buys technology. You use the service of the technology […] so, what we are doing is a "performance-driven strategic service agreement"; it is not a procurement or agreement of buying drones. We bear no risk for the installation, the operation is not to our cost, a contract is purely a service contract. This is not a lease agreement. We are neither buying or leasing the equipment; this is a service agreement. Essentially it is akin to a transportation service. It's like a taxi that's taking you from point A to point B – we're not buying the infrastructure.*[13]

For Ghanaian and other African political elites, the "point B" to which drone infrastructures are supposed to take them is improved access to medicine and healthcare for national populations, but also the realm of the global state of the art of digital technologies. Claiming stewardship of technological progress has long been a central domain through which African rulers have sought to amalgamize political support, a process that is now entwined with the building and contracting of "infrastructures-as-a-service."

At the same time, Ghanaian officials have been eager to dispel criticisms of the costs. Costs incurred through the establishment of distribution centers are borne by national and international donors such as Amazon, leaving the Ghanaian state with only the cost of the flights. Yet, as the following quote from Ghana Vice President Dr. Mahamudu Bavumia suggests, there are efforts to shift even these costs to other shoulders:

> *The cost of this lifesaving technology is not borne directly by Government. The Ministry of Health has engaged the services of a fundraising company to raise funds for the payment of this service. I am informed so far that some organizations have donated money to the ministry for payment of the services and others have made pledges as part of their corporate social responsibility strategies, in particular Ghana National Petroleum Company and Ghana Gas.*[14]

This ability to sidestep most of the costs for drone infrastructures lends state narratives on "infrastructure-as-a-service" further plausibility and demonstrates the extent to which infrastructural provision in the digital age has become subject to, and dependent on, multiple forms of (often unstable and volatile) private engagement.

13 See www.ghanaweb.com/GhanaHomePage/health/Ghana-Health-Service-gives-full-details-of-drone-health-service-delivery-system-706432, accessed 08.03.21.

14 See www.facebook.com/MBawumia/videos/live-commissioning-of-zipline-medical-drones-project-at-vobsi-wale-wale/961844704298577/, accessed 09.03.21.

Why Health and Emergencies?

At first glance, employing drones for speedy interventions in medical emergency situations appears to be an excellent way to make use of this new technology. Gaining time during medical emergencies indeed offers clear benefits for saving the lives of patients. However, as the pressures of identifying profitable market niches stemming from fierce competition demonstrate, the branding of Zipline UAVs as "medical drones" is highly contingent. In this section, we will situate the company's focus on health and medical emergencies within a broader context of increasing proliferation of and competition for drones for civil use. The upshot is that, as a field of intervention, health is construed as a common denominator that is expected to align moral agendas ("saving lives"), market imperatives (i. e., becoming profitable), and safety concerns.

Against their negative use as a weapon in asymmetrical warfare, drones are increasingly being turned into "dual-use technologies" for both civic and military aims. As part of its (re-)branding efforts, the drone industry has stepped up its attempts over the past ten years to turn military drones into "good drones" (Sandvik and Jumbert, 2018) that serve moral purposes such as humanitarian relief and disaster management. Zipline's (and other companies') focus on health, diagnosis, or medical emergencies is part and parcel of this endeavor to change public perceptions of this war technology. Zipline's CEO put the issue as follows: "Drones obviously have a bad rep[putation] because the people that have primarily been using drones are militaries, and they have been used as weapons. But of course, any technology is just a platform, and it can be used for a wide range of use cases."

While being aware of the military role of drones, Zipline's CEO was also eager to relativize military uses by equating technology with platforms, pinpointing the contingencies involved in defining acceptable use cases of certain technologies. However, looming large behind the defining of credible use cases is the mounting competition for market share. Companies are required to find niches to distinguish themselves from competitors and attract venture capital. Spelling out Zipline's unique selling point, CEO Rinaudo argued on a number of occasions that with "every flight saving a human life, [it] certainly helps when you talk to the regulators." While lacking evidence, this statement suggests that it actually matters to regulators if a drone carries a pizza or human blood. The fact that drone projects for Google and Amazon focus primarily on ordinary consumer products raises doubts in this regard.

During public presentations, Zipline representatives often describe themselves as the only drone logistics company in the world to operate at a "national scale," referring to the coverage area of Zipline's distribution centers. This raises questions as to how the distribution centers are integrated into existing national medical supply chain management. While Zipline limited its initial service offering in Rwanda to blood, in Ghana it added a variety of medical products to its portfolio, ranging from different types of vaccines (e. g., measles, rabies) to other essential medicines like paracetamol, oral rehydration therapy (ORT), and anti-malarial drugs. In both countries, Zipline distribution centers therefore rely on a frequent (re-)supply from national medical stores and blood banks. System integration requires that the Ministries of Health and the authorities in charge of supply chain management adapt their delivery patterns in order to accommodate Zipline's demand. While it should be the other way around, the integration of Zipline's service carries the risk to exacerbate the fragmentation of national healthcare sectors that have been observed since the onset of large HIV and AIDS programs.

In Ghana, this mode of integration has been criticized for two interrelated reasons. First, it has been highlighted that as per its contract, the Ministry of Health (MoH) grants Zipline access to all "relevant data owned or controlled by MoH regarding public health supply of the Medical Products list […]." (MoH, 2019: 17). Second, the stocking pattern of Zipline's distribution centers "must be based on how clinics in the 'coverage area' are consuming supplies. In fact, that is why Zipline has unloaded that entire forecasting burden onto the government."[15] This implies that if one of Zipline's distribution centers is running

15 See https://citinewsroom.com/2018/12/review-drone-delivery-contract-to-reduce-ghanas-risks-imani-to-govt/, accessed 09.03.21.

out of stock of a needed product, the company can pass on responsibility to the national forecasting system. Serving a "clear need" like emergency deliveries of blood by air and on demand requires the provision of existing data, but also the production of new data. Serving hospitals through their four distribution centers in Ghana, Zipline has started to generate and collect a significant amount of specific data on the demand and use of essential products. Zipline's head of Global Health has therefore admitted that they are currently "learning all kinds of interesting things about real demand and data."[16]

While the flow and creation of new data is likely to yield political implications in the future, the stocking of medical products in Zipline's distribution centers instead of remote health facilities has severe consequences. Chiefly, this stocking leads to new regional concentrations of infrastructural capacities and the depletion of resources in towns and villages outside the distribution centers. Since its early operational phase in Rwanda, Zipline has repeatedly emphasized that its system has facilitated cutting back on waste of medical products, claiming that it has reduced Rwanda's blood waste rate from seven percent to almost zero percent. Storing blood and other essential medicines in Zipline's distribution centers, so the argument goes, has made physical distribution and storage in health facilities redundant. According to Zipline's CTO, this form of recentralizing the national medical supply has the advantage of there being "no need to maintain thousands of refrigerators." Instead of considering the risks involved in the anticipated technological and infrastructural downscaling of remote clinics, Zipline's Global Health head actually extolled this disconnect between urban centers and rural regions as advantageous: "We do guarantee the cold chain down to the last mile, which frees up a lot of these last mile health facilities from having to have cold chain storage on site."[17]

However, while most of the supplies currently delivered by Zipline are paralleled through ground-based supply via cars and motorbikes, further reliance on drone delivery will likely entail the rolling back of decentralized supply and storage of products. Zipline celebrates this major change in a national health system's distributive logic as an *advantageous liberation*, not only from seasonal flooding of bad roads, but also from the maintenance of cold chains in remote areas. In fact, it is chiefly the image of bad roads and fragile cold chains in remote areas, as well as the promise of "leapfrogging" them, that turns the downscaling of existing local infrastructures and drones' disconnection from them into a liberation. Much STS scholarship and studies of infrastructures have pointed have argued that "artifacts have politics" (Winner, 1980). We suggest that the politics involved in framing infrastructure-as-a-service as liberation exacerbates existing disconnections between urban areas and remote regions. In fact, instead of connecting remote regions, such a politics frames and, to some extent, produces remoteness as a quality of imagined peripheries to imagined centers, by pronouncing the infrastructural dependence of the former on the latter.

Ecologies of Safety Data

We have noted above that Zipline's operations in the field of health and emergency rely on and further its control of certain health-related data sets regarding supply and demand. However, the company's core interest lies in collecting flight data. The CEO outlined these implicit priorities with the following words:

16 See https://pages.devex.com/prescription-for-progress-2020-livestream.html, accessed 09.03.21. During another webinar, she said: "Another one is, you can imagine *all of the data* that is flowing through our system, you know, you saw just a quick cut of that with some of the vaccine data but you can actually think of, you know, being able to have a real-time sense of what is the demand of different things across the system in any corner of the country." (www.youtube.com/watch?v=z50lBJ4Vsjo, accessed 09.03.21).

17 See www.youtube.com/watch?v=z50lBJ4Vsjo, accessed 09.03.21.

> *Obviously, one of the reasons that we've been very careful in recording our safety record in Rwanda is that we're going to need that safety record to convince the FAA to move a little bit more quickly and not allow the U.S. to fall behind in this kind of technology more than we need to.*[18]

Echoing the self-driving car industry in the US, Zipline constantly announces the number of miles that its autonomous delivery service has flown. But using airspace (as opposed to ground-based, terrestrial infrastructures like roads and cars) relies on strategic framings of these two spatial forms. From the beginning, Zipline has highlighted the infrastructural challenges that African states grapple with, particularly in the transportation sector. Ryan Oksenhorn, head of software at Zipline, explained the situation as follows: "Countries like Rwanda face many challenges in terms of how you move things around in the country. We are able to fly over all of these troubles, fly through the rain storms and deliver to places that are entirely cut off from any national scale infrastructure." In this section we interrogate these claims by pointing to some of the technical hurdles and complexities that Zipline's proposed "leap-frogging" faces. In particular, we highlight conceptions of differing airspaces, the availability and use of weather data, and the role of markets.

Zipline's mission to "put every human on the planet within a 15 to 30-minute delivery of any essential medical product"[19] is mirrored in its incessant emphasis on how their service has already become an integral and indispensable part of national health and emergency networks: "So, Zipline's new product is the fastest delivery drone in the world, and we have built that in direct response to customer need because when people rely on us and with the lives of their families… speed is everything when there is a medical emergency."[20] On other occasions, Zipline has stressed the high number of customers, suggesting they are already operating a direct-to-consumer service.[21] Our central point is that Zipline's technical requirements (data) and its moral mission (serving clear needs) are in fact closely intertwined.

For Zipline, responding to emergency orders is chiefly a technical exigency that legitimizes flying in all sorts of weather conditions. Asked during a CNBC interview, "What happens when it is windy?" CEO Rinaudo responded: "I mean, interestingly, it is not enough for us to say we can save a patient's life. When the weather is bad, we have to be able to operate all the time, so we fly in crazy storms day-in, day-out, rain, wind, everything."[22] To put the issue differently: Taking higher risks of, for example, crashing vehicles due to unexpected heavy and uncontrollable wind gusts or accidentally hurting somebody on the ground appears more difficult to justify if the delivery is destined for a normal medical procedure with no immediate threat of loss of life. Engineers responsible for the modeling of flight behavior have emphasized on several occasions that they were caught by surprise by the extreme weather conditions they encountered in East and West Africa, which are very different from the Bay Area climate. Thus, they said:

> *So, the first thing we can talk about what's hard here is we don't get to pick when we fly. I don't get to pick when somebody needs blood in an emergency so if it's a thunderstorm that's fine, we're launching. So, the environment gets to be really, really nasty with the stuff we have to put up with.*

The bottom line of the engineers' explanations is that Zipline is able to collect data on flight behavior in extreme weather conditions. However, they would neither be able nor allowed to fly under such conditions in real-time and real-world circumstances in the US. Thus, the company deliberately takes higher risks in Africa, even though the official service agreement between Zipline and Ghana's Ministry

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18 See www.vox.com/2017/3/10/14875324/transcript-zipline-founder-keller-rinaudo-delivery-drones-too-embarrassed-to-ask

19 See www.bbc.co.uk/sounds/play/w3ct03pq

20 See https://podcasts.apple.com/us/podcast/danny-in-the-valley/id1233991021?i=1000408272739

21 Such statements disregard the fact that that many people in rural Africa do not use national health services, seeking help from private informal services instead, and that people have to travel to health facilities before they can benefit from Zipline's speedy deliveries.

22 See www.youtube.com/watch?v=hvTftP6LvEo

of Health actually permits Zipline to refrain from flying if monsoon-level rains and strong winds create unfavorable conditions.[23] Arguably, in choosing to fly under such conditions, Zipline puts the lives of people underneath their flight paths at higher risk in order to save another person's life elsewhere.

Stereotypical images of poor people without access to health services due to bad roads and unreliable transportation infrastructures serve as the context that justifies risk-taking. Significantly, such risk-taking also creates valuable flight data, a resource in the name of which African skies and the grounds below them are turned into Silicon Valley's distant laboratories. The idea of Africa as a provider of data is thus reminiscent of how through scientific practice in the age of imperialism, African colonies were understood as "living laboratories" (Tilley, 2011) and became "a vast experimental terrain where all kinds of unproven technologies could be tested" (Rottenburg, 2009: 434). On the one hand, the framing of African states as agile and young risk-takers – against Western governments as slow and risk-averse – powerfully resonates with Silicon Valley ideologies and requirements of moving fast and taking high risks. On the other hand, Africa's colonial past together with its experimental histories serve as a justification of risk-taking as presumably African governments and populations have less to lose and are historically grown accustomed to risk.

Taming Terrestrial Geographies

Having learned about the connection between emergency situations and extreme weather conditions and the role this relation plays for the collection of flight data, we now turn to two other challenges for Zipline – and other drone companies – for using airspace in a reliable fashion. Zipline's operation in African airspace stems from the continent's position in the world of global connectivity. The following image (Image 1) shows a (pre-Covid-19-pandemic) real-time snapshot of global air traffic. Compared to the rest of the world, especially Western Europe and the US, the sky over Africa appears largely empty, indicating the continent's comparatively low rate of intra- and interconnectivity and the small role airspace plays for the transportation sector. For Zipline, African skies are ideal real-world testing sites, as the risk of collision with manned aircrafts is comparatively low. Although air traffic is sparse, regulations in Ghana and Rwanda prohibit Zipline from using airspace above a fixed height. The image 2 shows Zipline's "transit plan," indicating all predetermined routes their vehicles take. Obviously, drones do not take the shortest way (following a straight line) but rather take zigzag routes.

This is largely the result of another technological factor, namely the decision not to use cameras and visualizations for orientation but instead flying "blind." On the one hand, waiving the use of cameras has likely helped to cut short discussions with governmental bodies and affected communities over privacy and other issues incited by the use of bird's-eye view technology. On the other hand, not using visualization tools requires manual mapping, building flight plans, and preparing emergency landing spots (dots on the route that have no name). Zipline's GIS team travels physically along every flight path to check for potential elevations and obstacles. Its chief technical officer, Keenan Wryobek, has explained some of the complexities that the team faces in planning flights:

> *We do a drone survey, so we use quadcopters [...] to build a 3D map model that we carefully double- and triple-check, and we manually make this plan to not hit obstacles in the ground area.*

23 The passage in the service agreement puts the issues as follows: "'System Operating Parameters' means the conditions under which the RPAS shall operate, which are: winds less than gale force (less than fourteen (14) meters per second), any precipitation less than violent rain (less than fifty (50) millimeter of rain per hour), no lightning, non-icing conditions, and temperatures less than thirty-five (35) degrees centigrade." (MoH, 2019)

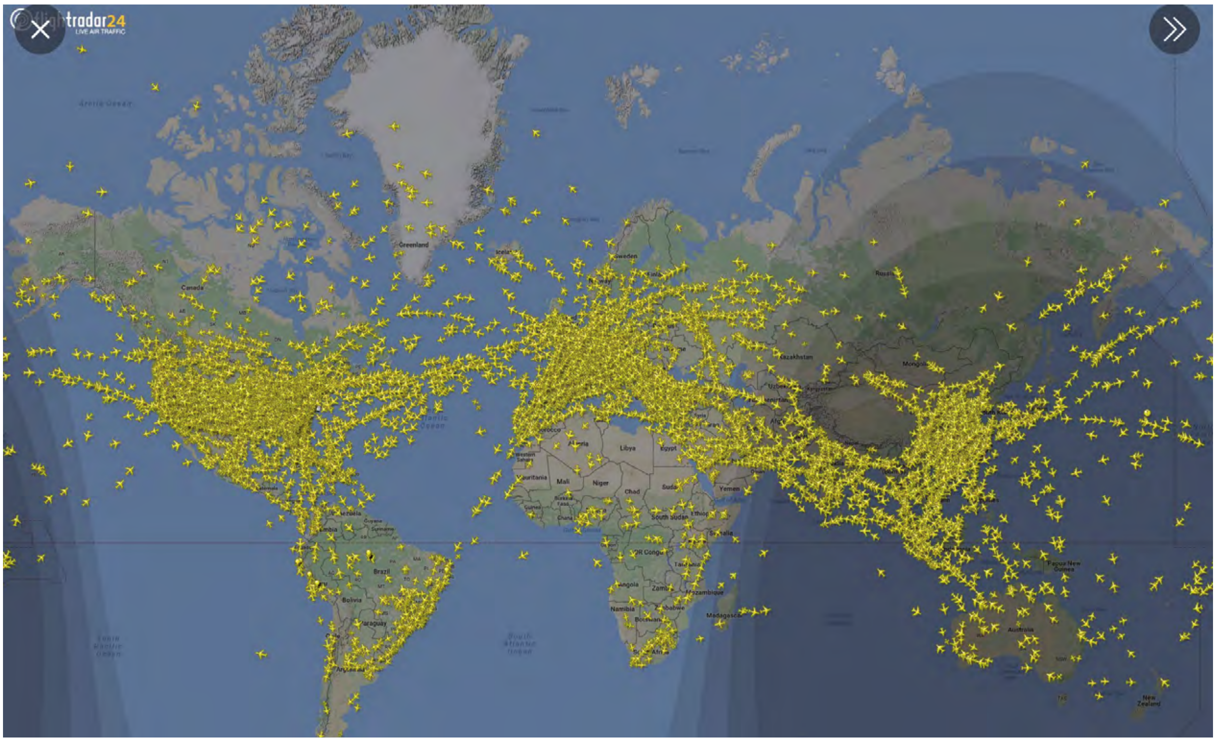

Image 1: **Snapshot of the low airtraffic over the African continent compared to European or the US airspace. www.flightradar24.com/30.06,-13.87/2, accessed 20.12.2019.**

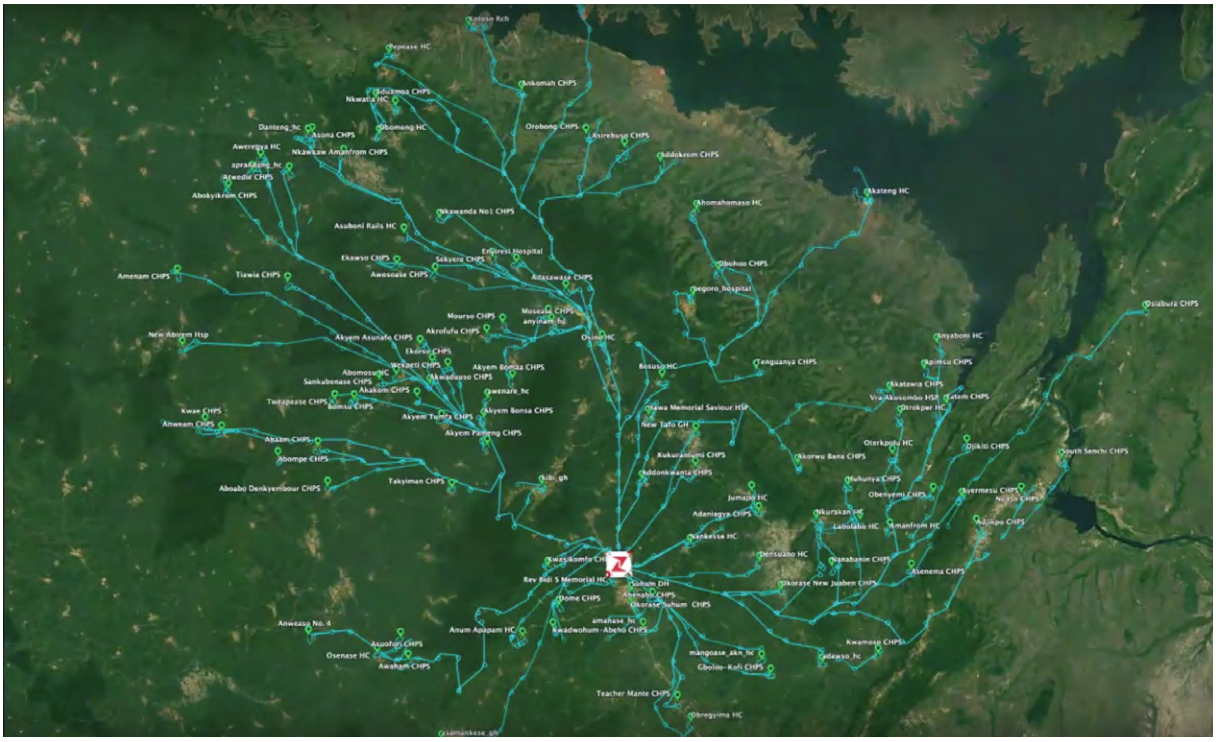

Image 2: **Flight routes from Ziplines Omenako distrubution centres to hospitals and health facilities withtin an 80 km radius. www.linkedin.com/pulse/flexible-supply-chains-times-covid-ghanas-overnight-pivot-marfo/, accessed 03.04.2021.**

> *These are things like tall trees, cell towers – that's the big things that we look out for, as well as terrain – make sure we have that training. [...] Our customers are not rich and, well, they are quite poor, and we have to be very cost-sensitive.*[24]

In this costly and time-consuming effort, Zipline's engineers must pay attention to the particularities on the ground which prevent vehicles from flying in a straight line. In order to better cope with these specific challenges, Zipline has undertaken a commercial agreement with Intermap Technologies, a company that focuses on geospatial data solutions for the aviation industry, governments, and the military. Intermap delivers on-demand, near real-time "geospatial Elevation-as-a-service"[25] data, adding another important element to the extraction and resourcification of digital data.

Importantly, operating flights in comparatively empty African skies does not necessarily prepare Zipline to operate safely in the US. Joseph Marshall, Zipline's head of flight operations in North Carolina, summarized a much more realistic scenario in the Global North, for which African skies do not provide lessons, in this way: "The absolute most challenging part to airspace integration thus far has been how to deal with uncooperative aircrafts or aircrafts that aren't broadcasting their position."[26] While it remains unclear how such problems of airspace coordination will be dealt with in the US, Africa offers empty skies, providing the ideal testing (air-)space for a company seeking to learn to fly its autonomous vehicles.

Another challenge emerges from the fact that Zipline's drones are required to fly at lower altitudes in order to keep the risk of collision as minimal as possible. However, being limited to particular altitudes (90–110 meters) also means that drones have to circumvent large elevations. If drones were to fly in higher mountainous altitudes, they would be exposed to yet another set of challenges such as harsh winds, rainstorms, and other unpredictable weather conditions. Extreme head winds can place a significant strain on the drone's battery, requiring it to return without having made the delivery. Wind gusts may also cause a sudden up- or downdraft, causing the vehicle to lose control, tip over, and potentially crash. In aviation, one way of coping with weather issues is to use weather forecasting data, which are often broadcasted by the weather sensors of planes themselves. Due to the low airport density, however, such data are largely lacking, causing Zipline to fly in "multiple types of weather overseas – windstorms, rain."[27]

As a matter of fact, Zipline operates above African grounds – and beyond the visual line of sight – in the dark. The unevenness of these experimental geographies becomes salient when compared to how Zipline operates in the US, with its sophisticated weather forecasting system. Here, Zipline has suggested, "we are very conservative. If we see an exceedance somewhere, we don't fly most of the time."[28]

How do we interpret these starkly contrasting norms of operation, with the company allowing flights under extreme weather conditions in Africa but not taking any such risk in the US? On the one hand, these practices certainly point to how different airspaces around the world really are. This likely calls into question whether flight data collected in African airspace can actually be accepted as proof of operational safety in US airspaces. On the other hand, Zipline's working in extreme weather conditions clearly resonates with notions of Africa as a laboratory (Tilley, 2011). While the company's openness to risk-taking on African grounds is largely justified by their focus on emergencies, there are serious doubts as to whether regulators in the US would accept such risks, even if Zipline adopted this emergency narrative.

As we have seen, drone technologies are grafted onto existing infrastructures in complex ways: They rely on functioning electricity, telecommunications, and internet services that connect new dis-

24 See www.youtube.com/watch?v=0DoecJzgKlk, accessed 09.03.21.
25 See www.urbanairmobilitynews.com/medical-pharmaceutical-transport/intermap-announces-partnership-with-zipline-to-support-expanding-africa-medical-operations/, accessed 09.03.21.
26 See www.youtube.com/watch?v=l_fDJzqiVm8, accessed 09.03.21.
27 See www.youtube.com/watch?v=l_fDJzqiVm8, accessed 09.03.21.
28 See www.youtube.com/watch?v=l_fDJzqiVm8, accessed 09.03.21.

tribution centers and remote clinics; they fly through skies which low air traffic density leaves comparatively empty (as visualized in image 2) and require the transformation of nature into data (see also Harvey & Knox, 2015); and they are also built upon narratives and imageries of bad roads and fragile health infrastructures in African villages, framed as "remote" and "disconnected." There are thus not only material conditions but also multiple levels of discursive representations of the African countries and the entire continent which facilitate the insertion of drones into existing infrastructural landscapes.

"Push a Button, Get What You Need": Health as Frontend

The increasing dependence of remote health facilities on Zipline's centralized storage is just one instance of the company's overall tendency to disconnect its services and logistics from local capacities. This tendency is in line with a specific framing of end-users, which in the language of software engineers is called the frontend of a service. The following quote from the CEO reveals how strongly Zipline's notion of its end-users resonates with Silicon Valley's technological utopias: "Although we are taking advantage of a lot of technology on the backend to make that experience possible, the experience for the user, the doctor or the nurse, is really, really simple: Push a button, get what you need."

Projecting an idealized user experience of an Amazon order in well-connected American settings onto rural African health logistics is construed as a massive advantage. However, if pushing a button is all that is required for engaging Zipline's services, this also means that there is no need to rely on local expertise and know-how. Significantly, the strong disconnect between infrastructure and end-user engagement is, first and foremost, an effect of the specific technology, namely fixed-wing drones. Systems that use quadcopters and tilt-rotators, by contrast, can hover, take off, and land in rural sites, and both allow and require basic knowledge and training in how to receive or send items. Depending on the context and the actual use case, systems that are open to end-user engagement have the clear advantage of making use of flying back and forth between destinations. Zipline, by contrast, replicates the old logistical problem that vehicles return home empty. The central point is that disengaging end-users from interaction with the technology spares the company the costs of training and reliance on non-experts to keep their operations running.

While Zipline emphasizes the positive aspects of these changes, empirical observations show that securing medical emergency supply is rarely as simple as pushing buttons. Certain complexities trouble the supposed simplicity of Zipline's re-centralized logistics with its core promise of instant delivery. "Pushing a button" involves writing a text or WhatsApp message or making a phone call to place the order at the distribution center. There might be back-and-forth communication and the need to clarify between the Zipline pharmacist and the ordering nurse or doctor, and there is a mixture of additional social, technical, and infrastructural requirements on which Zipline's system still relies. Sending WhatsApp messages requires the availability of prepaid data or credit on a (smart-)phone, which cannot be taken for granted, as many locals are regularly out of credit or data. Similarly, there is the need to have a constantly charged mobile phone, which in rural regions (with the patchy availability of reliable electricity) might become a problem. From an infrastructural perspective, "pushing a button" also relies on the constant availability of network connections, which is not always the case in rural settings. Another issue concerns the need to synchronize the arrival of the delivery with the timing of the emergency itself, or with tasks arising after the message had been sent.

Crucially, even Zipline's central argument – the time saved – only holds true if certain circumstances are kept out of the discussion. Decentralized blood storage in the hospitals Zipline serves has the potential to actually accelerate the availability and applicability of blood. Fetching a pint of blood that is stored in-house takes no more than five to 15 minutes – half or less of Zipline's average delivery time of 30 minutes. In addition, Zipline's depiction of blood storage ignores the role of a local practice called replacement donation. In many rural regions, hospitals stock small quantities of blood. When demand rises, they use the stored blood, but in turn will approach caring relatives of their patients and ask for donations to replace the used blood (Bates and Hassall, 2010). While this system is imperfect, the WHO estimates that 50 percent of blood donations (mostly in developing countries) come from on-site replacement donors (WHO).[29] If we take the reach and amount of national blood banks into account and consider the role of local replacement donations, the need that Zipline serves appears in a different light.

Attention to such local health practices not only relativizes the advantages of drones but also uncovers how disconnections are compounded on this operational level: Apart from disengaging end-users, Zipline's services undermine the decentralization policies in healthcare, which many African countries have implemented. Instead, the company's services require a heavy centralization not only with regards to knowledge production but also of medical resource supply. Relying on a system that caters for only one direction due to its fixed-wing approach, the usefulness of this infrastructure is limited in disconnected regions. However, this ignorance towards the embeddedness of the technical system can also points to severe shortcomings in the political decision-making processes.

Conclusions: Africa-as-a-Service

Our working paper has been an attempt to reveal the implicit and less visible aspects of shifts in infrastructural innovation in the digital age, as a result of which infrastructural provision is framed as a *service*. Chiefly, we suggest Rwanda and Ghana serve Zipline at least as much as the company serves the two countries. Capturing this aspect in the notion of "Africa-as-a-service," we argue that drone infrastructures point toward an important instance in which the role of Africa in the world is framed, an instance that involves frictions, paradoxes, and new experimental entanglements. By way of conclusion, we highlight four central lessons in this regard.

First, James Ferguson (Ferguson, 2006: 5) famously suggested that we should understand "'Africa' as a category through which a 'world' is structured – a category that (like all categories) is historically and socially constructed (indeed, in some sense arbitrary), but also a category that is 'real,' that is imposed with force, that has a mandatory quality; a category within which, and according to which, people must live." With the notion of "Africa-as-a-Service," we point to the mobilization of resources, narratives, and images of Africa that are both constructed and real but never tied to one particular place only.

"Africa-as-a-service" points to how Africa figures in new technoscientific formations that have emerged and thrive under labels such as infrastructure-as-a-service. Actively promoted by African leaders, digital innovations have quickly turned into a top priority of national development agendas and are now treated as a panacea for Africa's most urgent problems. At the same time, such innovations engender changes in the relationship between states and infrastructures, imposing shifts in ownership and access that are fundamentally driven by the dynamics of "data colonialism" (Couldry and Mejias, 2019). We have shown how African actors as well as the continent's geography produce data regarding flight safety, weather, health logistics, and more, without which infrastructural innovations could not advance. What Achilles Mbembé called a "geographical accident" (Mbembé 2002: 632) is an "Africa"

29 See www.afro.who.int/health-topics/blood-safety, accessed 22.02.21.

that is decomposed and recombined in modular ways, serving to convince or please investors as well as regulatory bodies.

Second, African actors and states also provide infrastructural services that are necessary for developing drone infrastructures, turning the continent into an attractive location for product development. Zipline's public presentations inevitably hinge upon images of bad roads, seasonal flooding, and poor healthcare in order to pitch airspace logistics as superior to ground-based transport. However, this image invisibilizes the existence and importance of well-functioning ICT networks and other assets. The case of Zipline shows how this infrastructural unevenness and the resulting frictions are rendered productive in digital economies and platform capitalism. It is also this unevenness that has contributed to configuring connections between Ghana, Rwanda, and Silicon Valley in a seemingly unlikely transregional techno-scientific assemblage.

Third, we argue that drone infrastructures are shaped by, and re-shape existing spatial formats in several ways. In many ways, drone infrastructures seem to develop along two established spatial formats: nation-states (1) and commodity chains (2) (Middell 2019). Drone systems are developed in order to improve the reach of the supply with pharmaceuticals and blood products across national territories. They are thus designed to penetrate far-flung peripheries, connect them to political, economic and infrastructural centers. However, doing so they depend on imaginaries of these peripheries as zones of remoteness and, as we showed, on images of bad roads and disconnection. Yet, from a different point of view, e. g. the integration of national peripheries in borderland networks, these zones may not be remote at all. Importantly, drone systems are only able to connect these areas to the extent that they are already connected to the infrastructure networks that drones requires, especially internet and electricity.

At the same time, drone systems appear to be forged through technological transfers from Silicon Valley to Africa – along established commodity chains. What this perspective misses, are the multiple resources that African actors supply and that are turned into commodity that travel back to Silicon Valley. The know-how produced through the operations on the ground in African logistics and distribution centers and the data produced and extracted or "mined" from these operations are surely commodities without which Zipline could not operate. As resourcified experiences they offer an important, yet often invisibilized element that further scaffolds this spatial format.

Finally, we suggest that the way that drone infrastructures in Africa are managed demonstrates that the interaction between digital and material aspects of such novel infrastructures hinge also on their disconnecting qualities. While many effects might only happen in the future and with increasing reliance on Zipline's service, we have highlighted several important disconnections: drones disconnect African professionals from processes of knowledge production, innovation and related intellectual property; they produce remote areas disconnected from cooling infrastructures; and they disconnect local populations from medical expertise. We have suggested the term infrastructure-as-a-service because of its conceptual capacity to highlight the logics of connecting and disconnecting practices that are required for the successful implementation of digital/material infrastructures. Studies such as ours are imperative in order to decipher the socio-technical impact of these hybrid infrastructures on the biopolitics of health and medicine in the Global South. Despite its promise and hopes to actually connect people and regions to medical services and products, we argue that Zipline's drones potentially disconnect regions, instead of increasing health inequities, in the long run. Engaging with Silicon Valley ideologies and interventions runs the risk of focusing only on the short-term effects and losing sight of long term impact whose costs will almost certainly be higher than the gains of 'simply' renting infrastructural services.

References

Anand N (2011) Pressure: The Politechnics of Water Supply in Mumbai. *Cultural Anthropology* 26(4): 542–564.
Anand N, Gupta, A and Appel H (2018) *The Promise of Infrastructure*. Durham, NC: Duke University Press.
Anand N (2015) Accretion. *Fieldsights*. Available at: https://culanth.org/fieldsights/accretion (accessed 25 March 2021)
Appel H, Anand N and Gupta A (2018) Introduction: Temporality, Politics, and the Promise of Infrastructure. In: Anand N, Gupta A, and Appel H (eds) *The Promise of Infrastructure*. Durham, NC: Duke University Press, pp. 1–38.
Apter A (2002) On Imperial Spectacle: The Dialectics of Seeing in Colonial Nigeria. *Comparative Studies in Society and History* 44(3): 564–596.
Bates I and Hassall O (2010) Should We Neglect or Nurture Replacement Blood Donors in Sub-Saharan Africa? *Biologicals*, *Special Section: Advances in Transfusion Safety* 38(1): 65–67.
Björkman L (2015) *Pipe Politics, Contested Waters: Embedded Infrastructures of Millennial Mumbai*. Durham, NC: Duke University Press.
Chambers A, Wyrobek K, Rinaudo K, Oskenhorn R, and Hetzler W (2016) System and Method for Human Operator Intervention in Autonomous Vehicle Operations. United States Patent Patent No.: US 9,488, 979 B1.
Couldry N and Mejias U A (2019) Data Colonialism: Rethinking Big Data's Relation to the Contemporary Subject. *Television & New Media* 20(4): 336–349.
Daub A (2020) *What Tech Calls Thinking: An Inquiry into the Intellectual Bedrock of Silicon Valley*. New York: Farrar, Straus and Giroux.
Edwards P N (2003). Infrastructure and Modernity: Force, Time, and Social Organization in the History of Sociotechnical Systems. In Misa T J, Brey P and Feenberg F (eds.), *Modernity and Technology* London & Cambridge: The MIT Press, pp. 185–226.
Ferguson J (2006) *Global Shadows: Africa in the Neoliberal World Order*. Durham, NC: Duke University Press.
Fredericks R (2018) *Garbage Citizenship: Vital Infrastructures of Labor in Dakar, Senegal*. Durham, NC: Duke University Press.
Gago V and Mezzadra S (2017) A Critique of the Extractive Operations of Capital: Toward an Expanded Concept of Extractivism. *Rethinking Marxism* 29(4): 574–591.
Harvey P and Knox H (2015) *Roads: An Anthropology of Infrastructure and Expertise*. Ithaca & London: Cornell University Press.
Kenney, Martin, and John Zysman (2016). The Rise of the Platform Economy. *Issues in Science and Technology* 32(3): 61–69.
Larkin B (2013) The Politics and Poetics of Infrastructure. *Annual Review of Anthropology* 42: 327–343.
Mbembé J A (2002). On the Power of the False. *Public Culture* 14(3): 629–641.
Mezzadra S and Neilson B (2017) On the Multiple Frontiers of Extraction: Excavating Contemporary Capitalism. *Cultural Studies* 31(2–3): 185–204.
Middell, M. (2019). Category of Spatial Formats: To What End?. In *Spatial Formats under the Global Condition* (pp. 15–47). De Gruyter Oldenbourg.
MoH (2019) Service Agreement: Ministry of Health (Ghana) and Fly Zipline Limited Ghana. www.myjoyonline.com/full-document-controversial-moh-zipline-medical-drone-agreement/ (accessed 22 January 2021).
Monson J (2009) *Africa's Freedom Railway: How a Chinese Development Project Changed Lives and Livelihoods in Tanzania*. Bloomington & Indianapolis: Indiana University Press.
Morozov E and Bria F (2018) *Rethinking the Smart City: Democratizing Urban Technology*. New York: Rosa Luxemburg Stiftung.
Plantin J C, Lagoze C, Edwards P N and Sandvig C (2018) Infrastructure Studies Meet Platform Studies in the Age of Google and Facebook. *New Media & Society* 20(1): 293–310.
Rottenburg R (2009) Social and Public Experiments and New Figurations of Science and Politics in Postcolonial Africa. *Postcolonial Studies* 12(4): 423–440.
Sandvik K B and M G Jumbert (2018) *The Good Drone.* London, New York: Routledge.
Schwenkel C (2015) Spectacular Infrastructure and its Breakdown in Socialist Vietnam. *American Ethnologist* 42(3): 520–534.
Star S L (1999) The Ethnography of Infrastructure. *American Behavioral Scientist* 43(3): 377–391.
Tilley H (2011) *Africa as a Living Laboratory: Empire, Development, and the Problem of Scientific Knowledge, 1870–1950*. Chicago & London: University of Chicago Press.
Van Laak D (2004). *Imperiale Infrastruktur: Deutsche Planungen für eine Erschließung Afrikas 1880–1960*. Paderborn: Ferdinand Schöningh.
Von Schnitzler A (2016). *Democracy's Infrastructure: Techno-Politics and Protest after Apartheid*. Princeton, NJ: Princeton University Press.
Vonderau A (2019) Scaling the Cloud: Making State and Infrastructure in Sweden. *Ethnos* 84(4): 698–718.

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